WOOL’S FUTURE in WESTERN AUSTRALIA

and the

R&D IMPLICATIONS: A Discussion Paper*

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Summary

The wool industry in Western Australia, as in other parts of Australia, faces an uncertain future, with concerns raised that if low real wool prices continue much longer many woolgrowers will become unviable. Wool specialists already have experienced negative farm business profit in most years of the 1990s.

Scenario analysis, using whole-farm modelling, is used to examine the likely place of the wool industry in Western Australian agriculture in the year 2010. Various scenarios are described with the more probable scenarios suggesting that, in terms of land allocation, wool production will remain one of the largest agricultural areas. The area of pasture that supports wool production is forecast to either slightly increase or to decrease by around 30 per cent, depending on the degree to which there is a recovery in wool prices. The scenario under which the area of pasture declines by around 30 per cent assumes the wool price rises from current (Jan 1999) levels of around 475 c/kg clean to be only 650 c/kg clean in 2010. By contrast, if wool prices rise to 850 c/kg clean then a slight increase in the area of pasture is forecast.

The reasons for wool production remaining an important part of farming systems are described and the implications for wool industry R,D&E in Western Australia are discussed. Because most of this research is funded by taxpayers the likelihood is that increasingly public good and public benefit arguments will lead to a re-focusing of R,D&E activity.
1. Introduction

The wool industry in Western Australia, as in other parts of Australia, faces an uncertain future. For several years woolgrowers have experienced a downward trend in real farm-gate prices for wool. Specialist wool producers have experienced negative farm business profits for several years in the 1990s (Martin, 1998). There are concerns that many in the wool industry will become unviable should low real wool prices continue much longer. A related view, sometimes expressed, is that the wool industry is in irreversible decline.

This paper discusses the future of the wool industry in Western Australia by examining the extent to which the relative profitability of wool production and its place in farming systems will be affected by various economic trends and possible productivity improvements. Also discussed are the likely outcomes of different types of wool research funded within Western Australia. In particular, the merits of on-farm versus off-farm R,D&E are discussed. Conclusions are drawn about the likely future of wool production in Western Australia as well as desirable relativities of on-farm versus off-farm R,D&E.

2. Overview of the wool industry in Western Australia

Recent History

Since 1994 Western Australia has produced around 164 kt of greasy wool per annum or approximately 25 per cent of Australia’s wool clip. Concomitantly, about 26 per cent of the nation’s sheep that are shorn are located in Western Australia. Despite the boom and bust conditions that have prevailed in the wool industry since the mid-1980s, the numbers of sheep shorn in Western Australia have not changed dramatically over that period (see figure 1). By contrast the numbers of sheep shorn in New South Wales rose to peak at 81 million in 1990/91 (ABARE, 1997) and by 1995/96 had fallen to 47 million.

Although the number of sheep shorn in Western Australia has not altered greatly, the profitability of wool production has altered dramatically, especially since the late-1980s. For example, in 1988/89 average farm profit was over $69,000 in the sheep industry of Western Australia (ABARE, 1990). During much of the 1990s, however, average farm profit has been negative. In 1995/96, for example, average farm profit was -$12,423. By contrast, average farm profit in 1988/89 for broadacre farming in Western Australia was $74,540 and in 1995/96 was $49,161. Martin (1998) reported profiles of woolgrowers throughout Australia. He found that specialist woolgrowers in the south-west of Western Australia had average farm profits of -$14,083 over the period 1994/95 to 1996/97.

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1 R,D&E is research, development and extension.
At a time when the wool industry has struggled financially, one of its competitors in the fibre market, the cotton industry, has been highly profitable. For example, in 1996/97 the average farm profit in dryland cotton production averaged $300,639 (ABARE, 1998) with a rate of return on capital of 14.5 per cent. In the same year average farm profit in Western Australia’s mixed livestock-crop industry was $6,700 and -$19,170 in the sheep industry, and the respective rates of return to capital were only 2.2 per cent and -0.3 per cent (ABARE, 1998). For most years of the 1990s average farm business profit in the sheep industry of Western Australia has been negative (ABARE, 1998).

For several years woolgrowers’ incomes have suffered from low wool prices. Since 1989 wool prices have mostly been less than 700 c/kg clean (see figure 2). Several factors in combination have ensured that wool prices have remained low. Firstly, although the wool stockpile administered by Wool International has declined, farmers have increased their on-farm stocks of wool. These stocks of wool plus the levels of annual wool production have prevented an escalation of wool prices. Secondly, the economic downturn in several Asian economies has reduced the demand for wool. Thirdly, substitute fibres for wool have remained price competitive. For example, low oil prices have enabled polyester prices to remain low. Consumer preferences for casual, lightweight clothing have fuelled the rise in cotton prices since the late 1980s. The downward movement in cotton prices since 1994 has placed further pressure on wool prices.
3. Strategic outlook for the wool industry in Western Australia

Developing forecasts, particularly medium or long term forecasts for agricultural industries is known to be difficult (Freebairn, 1975). The collapse of wool profitability in 1990, for example, was not generally predicted. Richardson (1989) in a broad review of the wool industry suggested like many others that “The wool industry is presently in a sound phase of growth and could perhaps be said to be one of the main growth industries in Australia.” (p.13); yet collapse in wool profits was under two years away. Certainly the Australian Wool Corporation (AWC) was not able to forecast accurately wool’s future in the late 1980s. Bardsley (1991) comments that the AWC committed a classic error of interpreting a temporary price spike, caused by a stockout, as a permanent structural shift in demand.

More generally, in commenting about innovation and change in Australian agriculture this and next century, Godden (1999) observes how difficult is the task of anticipating many of the major changes. A range of techniques has been developed for forecasting in light of such difficulties. Blyth and Young (1994) outline these techniques, quantitative and qualitative, and conclude that scenario analysis is a preferred method. Free (1997), for example, used mathematical programming models as part of a scenario analysis for the grains industry in Western Australia.

In this paper we follow the approach of Free (1997) in using mathematical programming models as part of a scenario analysis for the wool industry in Western Australia. Profit-maximising farming system models are used in examining a variety of scenarios.
Farm Modelling
The farming system models were a set of MIDAS (Model of an Integrated Dryland Agricultural System) models first developed by Morrison et al (1986) and subsequently improved by a range of researchers (Kingwell and Pannell, 1987; Abadi et al, 1991; Kingwell et al, 1995). These farm models describe representative farms in the major woolgrowing regions of Western Australia (see figure 1).

Figure 1: The wool-growing region of Western Australia represented by the models

The region covered by the models is the shaded area in figure 1. The region is bounded mainly by the rainfall isohyets of 750mm in the west and 250mm in the east. The pastoral zone which accounts for about 10 per cent of wool produced in Western Australia (Martin, 1998) is excluded from this analysis as is the high-rainfall south coast region because operational models are not available to describe the farming systems in these regions. Conservatively, about 80 per cent of the State’s wool production is described by the aggregation of the MIDAS models.

All the models are based solely on expected values and therefore assume certainty of knowledge about prices, costs and input-output relationships. They are steady-state models based on an expected weather-year and assume the farm manager is profit-maximising, although other managerial goals and behaviour are implicitly accounted for in the structure of activities. For example, soil conservation attitudes are reflected in restrictions on the degree to which feed can be removed by the grazing of sheep. Also animal welfare considerations are reflected in not allowing sheep liveweight condition to fall to a level that would cause sheep to be classed as being in poor condition.
Output from the models is a set of profit-maximising enterprise and rotational activities as well as shadow price information about the marginal value of farm resources and alternative enterprise or rotational options. In all models farm profit is calculated as a net return to capital and management. This return equates to monies left over from production receipts after deducting all operating costs, overhead costs, depreciation and opportunity costs associated with farm assets (exclusive of land).

As explained by Kingwell (1987), the models have been developed in consultation with farmers, researchers, advisers and farm management consultants and emphasize the interdependencies of crop and livestock enterprises. The models comprise matrices of around 470 columns (or activities) with around 300 rows (or constraints). The models' framework is a single period equilibrium structure, inclusive of inter-year effects that allows inter-relationships between phases of rotations to be represented within the planning horizon of a single production year.

Broadly, the models describe the production alternatives on up to 8 soil classes. Up to 20 rotation options are described for each soil class. The crop options include wheat, lupins, canola, barley, field peas, chick peas, faba beans, oats and triticale. The production of over 25 classes of merino sheep based on a self-replacing flock is depicted. The models allow for variable flock sizes and structures as well as regional differences in the type of wool produced. The type and quantity of wool produced by each sheep class in the region is recorded along with their liveweight and wool sale prices. Pasture production on each soil class and in each rotation phase is also described. The non-linear yield responses of cereals to applied nitrogen on each soil class are described using the Duloy and Norton (1975) approximation.

Enterprise interdependencies are a feature of the models. The effects on cereal yields of previous leguminous pastures or legume crops are depicted. The increased weed burden in crops due to previous pastures is described as is the deleterious effect of cropping on subsequent pasture production.

Many sources of feed for livestock are described in the models; green and dry pastures, grain stored on-farm or bought in and crop residues including spilt grain as well as feeding restrictions on lupin stubble because of lupinosis risks. The effect of stocking rate on pasture production is outlined in the models. Also represented on a monthly basis are the energy requirements and appetite of each sheep class and energy sources and feed qualities within the farming system.

The models represent current farm management technology insofar as the types of tillage practices, machinery complements, herbicides used and rates applied, tasks contracted and crop and livestock options considered are all consistent with those used or being canvassed by leading farmers of each region. The maintenance of the models allows changes in farming technology to be incorporated in up-dated versions of the models.

Finally, the models describe the major constraints on farm operations. These constraints include the physical limits imposed by farm size and areas of different soil classes. The limited supply of family labour and working capital are depicted as is the limited work capacity of farm machinery.
For a detailed exposition of the nature and structure of the models readers are referred to Morrison et al (1986), and Kingwell and Pannell (1987).

Models’ Validation
To ensure that the farm models accurately and validly describe the farming systems required inclusion of quality control processes during construction of the models. Several procedures outlined in Pannell et al (1996) were used to minimise the possibility of introducing flaws or errors into the models. Some of the validation procedures for mathematical programming models as recommended by McCarl (1984), McCarl and Apland (1986) and Howitt (1995) were used to assess the validity of results from applications of the models.

Various experts familiar with the farming system in each region, on several occasions, checked or verified the validity and plausibility of various features of the models, including technical assumptions and output of the models. Many experiments were conducted with the models to ensure that model output was consistent with observed farmer practice or response. However, as McCarl (1984) observes, “models can never be validated, only invalidated.” (p.157) and “The outcome of a model validation process is either a model that has been proved invalid, or a model about which one has an increased degree of confidence.” (p.157). By virtue of the rigour of model construction and the range of testing to which the models have been subject, there is a large degree of confidence in the ability of these MIDAS models to describe each region’s farming system.

Because these models describe representative farms in each region, model output can be aggregated to describe regional output, although aggregation bias needs to be minimized (Kennedy, 1975). The mix of enterprises identified as optimal in each model mirrors closely that observed in each region. The only differences concern relative areas of canola and some pulses. The models’ output generally gives greater emphasis to these crops than is currently observed in some of the regions. The explanation for this difference is that in many cases farmers in some of the regions are still experimenting with these crops and are at early stages of adoption. When farmers gain the practical knowledge and confidence in growing these crops then regional output is likely to better match that forecast by the models. It is assumed that by the year 2010 farmers will have gained the required experience in growing these crops.

In using the models to forecast the regional importance of the various enterprises allowance is made for the likely loss of arable area by declining soil quality (see appendix one).

Scenarios
The models are used to forecast the impacts of various scenarios. These scenarios are listed in table 1. Greater detail is given in appendix one. The scenarios specify the commodity and input prices forecast for the year 2010 as well as forecasts of yield changes occurring over the period 1998 to 2010. All price forecasts are in nominal prices. Although not listed in table 1 all the scenarios include the same increases in costs of production and loss of arable area primarily due to salinisation (see appendix one). The yield changes refer to changes in wool cuts, crop yields and pasture yields.
Table 1: Description of scenarios

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Grain Prices</th>
<th>Crop yields</th>
<th>Wool Price (c/kg)</th>
<th>Wool cut</th>
<th>Pasture production</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Best bet</td>
<td>↑ 30%</td>
<td>850</td>
<td>↑ 10%</td>
<td>↑ 30%</td>
</tr>
<tr>
<td>2</td>
<td>Best bet</td>
<td>↑ 30%</td>
<td>650</td>
<td>No Δ</td>
<td>No Δ</td>
</tr>
<tr>
<td>3</td>
<td>Best bet</td>
<td>↑ 30%</td>
<td>1050</td>
<td>↑ 30%</td>
<td>↑ 30%</td>
</tr>
<tr>
<td>4</td>
<td>↑ $40</td>
<td>↑ 50%</td>
<td>650</td>
<td>No Δ</td>
<td>No Δ</td>
</tr>
<tr>
<td>5</td>
<td>↓ $40</td>
<td>No Δ</td>
<td>850</td>
<td>↑ 10%</td>
<td>↑ 30%</td>
</tr>
<tr>
<td>6</td>
<td>↑ $40</td>
<td>↑ 50%</td>
<td>850</td>
<td>↑ 10%</td>
<td>↑ 30%</td>
</tr>
<tr>
<td>7</td>
<td>↑ $40</td>
<td>↑ 50%</td>
<td>1050</td>
<td>↑ 30%</td>
<td>↑ 30%</td>
</tr>
<tr>
<td>8</td>
<td>↓ $40</td>
<td>No Δ</td>
<td>650</td>
<td>No Δ</td>
<td>No Δ</td>
</tr>
<tr>
<td>9</td>
<td>↓ $40</td>
<td>No Δ</td>
<td>1050</td>
<td>↑ 30%</td>
<td>↑ 30%</td>
</tr>
<tr>
<td>10</td>
<td>Best bet</td>
<td>↑ 30%</td>
<td>650</td>
<td>↑ 10%</td>
<td>↑ 30%</td>
</tr>
</tbody>
</table>

An important assumption underlying the scenarios is that future farming systems will comprise existing enterprise and rotation options. In practice, unexpected problems (eg pest, disease or soil problems) or technical innovation may transform farming systems in ways not currently envisaged by the scenarios in table 1. On the basis of current knowledge, scenarios 1 and 10 in table 1 are the more likely. Both scenarios assume feasible yield increases for the various enterprises and the same “best bet” set of crop prices, yet they differ regarding relative prices of wool. Scenario 1 suggests that wool prices will rebound to be 850 c/kg in nominal terms by 2010. Scenario 10 is less optimistic for wool and assumes that prices will increase from the current price2 of around 470 c/kg to be 650 c/kg. What constitutes “best bet” grain prices is described in appendix one. These “best bet” prices are the price forecasts of grain experts within Agriculture WA.

The scenarios listed in table 1 consider three different price forecasts for wool ranging from a slightly pessimistic price forecast to a highly optimistic one. Note that for any particular price scenario for wool, the on-farm prices differ across the regions because of regional differences in wool type and differences in transport costs. For example, the price scenario of 650 c/kg does not mean that wool produced in each region receives an on-farm price of 650 c/kg. Rather on-farm wool prices reflect the wool types produced in each region, along with transport costs, against the backdrop of the AWEX western indicator price being 650 c/kg.

These wool prices and other changes in costs and yields are incorporated in the MIDAS models. Following optimization and aggregation, the output of the models is

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2 At the time of writing in January 1999 the AWEX western indicator was around 470 c/kg.
used as a forecast of changes in farming enterprises. In particular, changes in land use are described.

Modelling Results
Before describing the modelling results a base case is presented. This base case is shown in the first row of table 3 and in table 2 and it describes the place of the wool enterprise and pasture area in the State’s wheat-sheep belt in 1998.

The base case shows wool production is currently a feature of farming systems in the wheat-sheep belt. The area of pasture is 5.87 million hectares in the State’s wheat-sheep belt. This pasture area is usually the sole feed source in winter and spring for sheep and wool production. Hence, changes in the pasture area in the wheat-sheep belt are highly correlated with changes in wool production. In 1998 wool production formed 17 per cent of the gross value of agricultural production of the region.

Table 2: Components of the gross value of agricultural production (GVAP) in the wheat-sheep zone of Western Australia in 1998.

<table>
<thead>
<tr>
<th>Enterprise</th>
<th>Enterprise GVP ($millions)</th>
<th>% of wheat-sheep zone GVAP</th>
<th>% of State GVAP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wool</td>
<td>489</td>
<td>17</td>
<td>12</td>
</tr>
<tr>
<td>Cereals</td>
<td>1,763</td>
<td>61</td>
<td>43</td>
</tr>
<tr>
<td>Grain legumes</td>
<td>256</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Canola</td>
<td>157</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Sheep meat &amp; live export</td>
<td>220</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Wheat-sheep zone GVAP</td>
<td>2,885</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other zones GVAP</td>
<td>1,180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>State GVAP</td>
<td>4,065</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The modelling outcomes that are predictions of pasture and crop areas in each scenario are listed in table 3. Scenario 1 includes a slightly optimistic price for wool (850 c/kg) and the pasture area is thus forecast to increase by 6 per cent from the current area of 5.87 million hectares to be 6.23 million hectares. Scenario 10 assumes a slightly pessimistic wool price (650 c/kg) which although higher than current prices does not translate into an increase in the area of pasture because of the impact of changes in the relative productivity improvements of crop versus wool production. In scenario 10 the area of pasture is forecast to decline substantially by 29 per cent to be 4.19 million hectares. Scenario 9 combines a very optimistic wool price forecast of 1050 c/kg with an optimistic increase in wool cut and this leads to a 64 per cent increase in the pasture area to 9.63 million hectares.

For all the scenarios in table 3 that consider likely productivity improvements, the area of canola and pulses tends to increase, mainly at the expense of cereal production. Hence, the place of pulses and oilseeds in the farming systems is relatively robust. By contrast the relative areas of pasture and cereals are sensitive to their relative prices and enterprise productivity. On balance the more likely scenarios for wool prices and productivity change are scenarios 1 and 10 which suggest the area of pasture will either increase slightly or decrease to be around 4.19 million hectares. Under either scenario wool production remains important and is destined to remain
one of the largest industries, at least in terms of the area of land utilised for pasture production.

Table 3: Enterprise areas (‘000 ha) for each scenario

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Cereals</th>
<th>Grain legumes</th>
<th>Canola</th>
<th>Pasture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current</td>
<td>5078</td>
<td>1187</td>
<td>350</td>
<td>5867</td>
</tr>
<tr>
<td>1</td>
<td>3818</td>
<td>1331</td>
<td>766</td>
<td>6230</td>
</tr>
<tr>
<td>2</td>
<td>6523</td>
<td>1274</td>
<td>726</td>
<td>3621</td>
</tr>
<tr>
<td>3</td>
<td>1843</td>
<td>394</td>
<td>277</td>
<td>9631</td>
</tr>
<tr>
<td>4</td>
<td>1004</td>
<td>109</td>
<td>0</td>
<td>11032</td>
</tr>
<tr>
<td>5</td>
<td>6104</td>
<td>1407</td>
<td>747</td>
<td>3887</td>
</tr>
<tr>
<td>6</td>
<td>4108</td>
<td>1143</td>
<td>725</td>
<td>6168</td>
</tr>
<tr>
<td>7</td>
<td>1741</td>
<td>1060</td>
<td>493</td>
<td>8851</td>
</tr>
<tr>
<td>8</td>
<td>756</td>
<td>66</td>
<td>0</td>
<td>11324</td>
</tr>
<tr>
<td>9</td>
<td>5989</td>
<td>2604</td>
<td>1063</td>
<td>2488</td>
</tr>
<tr>
<td>10</td>
<td>5977</td>
<td>1315</td>
<td>661</td>
<td>4192</td>
</tr>
</tbody>
</table>

Given the large difference in the average profitability of crop-dominant versus sheep-dominant farms observed in farm surveys (ABARE, 1998) the reasons for pasture, and therefore wool production, being retained as part of profitable farming systems may not seem obvious. There are a number of factors at play.

Firstly, there remain large areas of land still not suitable for cropping which restricts the degree to which crop area can replace pasture area. Even though on some of these soils pasture may not grow well, the low cost of inputs required for pasture production often means they can be grown profitably to support livestock enterprises. Characteristics which make soils unsuitable for cropping are terrain, waterlogging and subsurface acidity which cannot always be ameliorated profitably. Waterlogging usually occurs in low lying, poorly drained clay soils. The lack of relief and hydraulic conductivity often makes draining these soils impractical. This is particularly so in the high rainfall zone\(^3\) where most specialist wool producers are situated. However even in the low rainfall areas that are predominantly cropped, there are areas of soil not profitable for grain production.

Secondly, pasture confers benefits on following crops. The benefits are large enough to compensate for the low returns that result in the years of pasture production. Pasture phases are used to improve the control of weeds that pose difficulties in some areas after more than four years of continuous crops (Young, pers. comm. 1998). Some growers are electing to reduce the frequency of cropping to delay the onset on weed resistance to herbicides, as part of a strategy to lessen the costs of managing herbicide-resistant weeds. Pasture phases in a rotation enable weed control to be

\(^3\) This is a region in the south-west where average annual rainfall is 600 to 750mm.
achieved through grazing, mechanical methods and utilizing different herbicide groups.

Thirdly, although not captured by the farm models, wool and sheep production are means of spreading price and production risks associated with farming. Wool and sheep enterprises tend to be low input systems with price and production outcomes that are not strongly correlated to those of the cropping enterprises. Accordingly, for very risk-averse farmers, retaining sheep for wool to diversify farm enterprises can be part of a sensible risk management strategy.

Lastly, some farmers use wool production in their farming system as part of their response to combating the spread of salinity caused by rising water tables. To lower water tables requires increased water use to reduce deep percolation. It is clear that this cannot be achieved through continued reliance on annual crops. Trees and perennial species need to be included in the system and at present the main species of perennials that can be grown profitably in some drier areas are those used for fodder. Utilising this feed source in many cases requires retention of sheep. Also adoption of agro-forestry can involve use of sheep to eat pastures growing between young trees.

4. Implications for Wool Industry R,D&E in Western Australia

The inference from modelling results presented in the preceding section is that the demise of the wool industry in Western Australia is not imminent. Rather it is likely to retain an important, although under some likely scenarios, possibly diminished role in the State’s agricultural region. Assuming this, what are the implications for future R,D&E for the wool industry in the State? Should wool industry R,D&E alter its focus? For example, should it focus more or less on improving farm productivity; or should it switch funds into off-farm areas such as the efficiency of processing, marketing and promotion? This last question is particularly pertinent in Western Australia in light of government policy.

The prolonged downturn in the wool industry has prompted a number of responses from the Western Australian government, including the formation of a Wool Strategy Group. This group has sought to identify ways to improve industry viability and to advise on the allocation of research funding to projects within the wool program of Agriculture WA, the main provider of R,D&E services to the wool industry in Western Australia. Since the inception of the Wool Strategy Group resources have been directed increasingly to off-farm research and marketing, and away from on-farm research in the wool program of Agriculture WA. This is consistent with government policy that seeks to enhance the market focus of agriculture.

The aim of redirecting funds has been to improve the demand for Western Australian wool in various ways, such as providing services to processors and promoting the distinct characteristics of wool from Western Australia. In part the justification for redirecting funds towards enhancing market opportunities has been because of the perceived limited improvement in the farm productivity of wool production during the 1980s and early 1990s, despite many years of R,D&E investment. Hence the issue of whether further redirection of R,D&E resources is warranted is an important
investment question. Before addressing this question the productivity performance of
the wool industry is discussed.

The Productivity Performance of the Wool Industry: on-farm
Agriculture in Western Australia has changed markedly since the early 1980’s. Farmers
have proved to be amongst the most progressive in Australia, as indicated by the
change in productivity during this period. Coelli and Kingwell (1991, 1992) have
estimated the improvement in total factor productivity (TFP) for the State’s wheat-
sheep industry to be 2.7 per cent per annum from 1952/3 to 1987/8. A later analysis
of the TFP of the State’s wheat-sheep industry (AgWA, 1998) shows an annual
improvement of 4.1 per cent for the period 1987/8 to 1996/7 compared to the
Australian average of 3 per cent per annum. Much of the productivity improvement
in the wheat-sheep industry, however, appears due to greater improvement in
cropping enterprises rather than from sheep and wool production because crop
dominant farms tend to display greater rates of productivity improvement than sheep
dominant farms. Certainly the findings of Knopke et al (1995) identify that for the
period 1977/78 to 1993/4, TFP growth was much faster in Australia’s broadacre
cropping industries compared to the livestock industries. They found, for example,
that the TFP growth was 4.6 per cent per annum in the crops industry compared to 1
per cent for the sheep industry and 2.1 per cent for the sheep-beef industry.

An earlier study by Lawrence and McKay (1980) estimated productivity improvement
in the Australian sheep industry to be 2.9 per cent per annum over the period 1952/53
to 1976/77. For a later period, 1977/78 to 1988/89, Males et al (1990) estimated the
total factor productivity of the Australian sheep industry to be only 0.2 per cent per
annum. An unpublished study of the TFP growth for sheep farming in Western
Australia (Layman, pers. comm.) had findings consistent with those of Males et al.
Layman found that during much of the 1970s and 1980s, the TFP growth of sheep
farming was not significantly different form zero and the average growth in TFP was
only 1.9% since 1977/78 until the mid-1990s.

In broadacre farming, particularly in the crop industries, adoption of new technology
and cultural practices has been widespread. The profitability of these changes largely
has compensated for a declining terms of trade. However, this has not been true for
the wool industry where a significant decline in real farm income has occurred in the
1990s. Further, relative to the productivity gains observed in industries competing for
wool’s share in fibre markets (eg cotton) and in industries competing for its land and
labour resources (eg crop and forestry industries), only mediocre change has occurred
in the productivity of wool production since the early 1980s. Despite large amounts
spent on on-farm R,D&E, few innovative profitable changes have been developed and
adopted in wool production.

During the 1990s the incomes of woolgrowers in the major wool growing region of
Western Australia have lagged behind the high incomes generated by crop-dominant
enterprises in the same region (Martin, 1998). Wool prices have followed the price of
other fibres downwards; yet cotton has remained much more profitable due in part to
its higher rate of productivity improvement.

During the 1980s there were concerns raised within the then Department of
Agriculture regarding the effectiveness of wool research in influencing farmer
practices. There was a perception that wool producers were generally poor adopters of new innovations, and extension programs seemed ineffective in accelerating adoption of these improvements.

It is possible that the incentives to change were inadequate. The period of high interest rates in the early 1980s, coupled with some unfavourable weather years, led to widespread financial difficulties for farmers who made major investment shifts away from wool production into cropping (Kingwell, 1985). This period of widespread financial trauma in broadacre agriculture possibly reinforced cautious and conservative management by woolgrowers. High real interest rates discouraged adoption of innovations financed through borrowings. A further disincentive for change was that improvements in profitability often required large shifts in production methods and increases in effort. Yet it is observed that often farmers only make such changes to management when there are sizeable profit incentives (Just et al., 1990). In this period when the reserve price scheme seemed an effective price risk management tool wool producers also had no need to consider production and marketing innovations that dealt with price variance.

Earlier during the 1960’s and 1970’s much extension effort for wool production was carried out by wool researchers rather than extension specialists. Understandably these researchers tended to emphasise aspects of wool production and overlooked occasionally important whole farm implications of management changes (K. Croker, pers. comm.). This was due, at least in part, to the difficulty and cost of considering such changes within experimental programs. Trials with livestock were inherently costly, and variability between plots and paddocks made prohibitive the costs of large-scale experiments that captured interactions within a whole farm.

Even extension messages that seemed initially successful sometimes did not result in a long term change in farmer practice because problems encountered by farmers during initial adoption were not quickly resolved. An example was the development and extension of spring lambing in the late 1960s. Whilst it was heavily promoted as a means of improving profit, its implementation was not straightforward. Although many farmers are now adopting spring lambing, its uptake has been slow and in many cases it is still the single change that could most easily boost profit from wool production.

The slow adoption of innovations in the period up until the early 1990s has led to a questioning of whether less R,D&E funds to on-farm improvements is justifiable. Whether such a reduction is defensible requires knowledge of a range of matters including: the current factors that influence adoption; what innovations are emerging that could boost the productivity of wool production, and what are the foreseeable important problems that could profitably be addressed through R,D&E.

There is now increased recognition by researchers of the need to take a whole-farm approach to wool production, and more use is being made of models that enable researchers to gain a better appreciation of the whole-farm system. Wool extension specialists are now employed to facilitate adoption of the outcomes of wool research and more effort is being made to ensure that producers are assisted to obtain first hand experience in new management strategies.
Recent R&D by the wool program indicates good potential for improvement in wool productivity with rates of return on research funds competitive with those for crop research, even at low rates of adoption. Recent releases of pasture varieties that exploit niches within farming systems have been shown to improve pasture production by over 100% in some cases (Revell et al, 1998). Yellow serradella is particularly suited to the Wodgil sandplain soils of the eastern wheatbelt, where subclover does not persist. In high rainfall regions, a new pasture cultivar, Cadiz serradella, is likely to lead to profit increases of around $15/ha in the high rainfall region of the State (Geisbertz and Bathgate, pers.comm.). Also in high rainfall regions introduction of balansa clover on waterlogging-prone soils could result in profit increases of between $50 to $80 per hectare (Geisbertz and Bathgate, 1998).

Economic analysis of genetic lines of sheep has indicated potential for substantial increases in profit. Trials conducted at various locations throughout the State have shown marked differences in wool cut and fibre diameter between flocks. Sheep from different flocks were run together on selected farms and production characteristics were measured and compared. The trial data were used to determine the difference in profitability of flocks when run on a typical farm in the major wool growing region of the State. There was over $80,000 difference in profit between the best and worst genetic lines in the trials (Windsor, 1999).

There are also the foreseeable problems of herbicide-resistant weeds, waterlogged soils unsuited to cropping, increasing concerns about animal welfare and salinity abatement; all of which are R,D&E opportunities from which woolgrowers could benefit. There are also consumer demands for sustainable, low-input, chemical-free farming systems that encompass humane treatment of animals. Delivering such systems for wool production will require R,D&E expenditure.

Whether the on-farm R,D&E as outlined above, including the opportunities for further R,D&E, justifies continued investment in the on-farm area is both an empirical issue and a matter of judgement. The other area directly competing for wool R,D&E funds involves off-farm R&D and promotion.

**Off-farm research**
There are two broad aims of off-farm R&D undertaken by the wool program of Agriculture WA. They are to improve the efficiency of processors (spinning and top making) and to increase the price received by growers through promotion (branding) and direct marketing. It is widely acknowledged that off-farm research can result in benefits to growers through an increased or maintained demand for greasy wool. This occurs by maintaining or increasing demand for wool apparel through promotion or by reducing processing costs and hence improving the competitiveness of wool compared to other fibres. In the absence of wool promotion, and given advertising of other fibres, some consumers could switch away from wool.

Freebairn et al (1982) showed that funding for R&D off-farm provided benefits to primary producers that were as great as those provided by on-farm research. In some cases the benefits were even greater. They found the distribution of benefits was unchanged by the stage of the production process at which technological change occurred. The results were dependent on a number of key assumptions, one of which
was that the elasticities of substitution between farm and non-farm inputs in the processing stages of the marketing chain were zero.

Scobie *et al* (1991) showed that these results were very dependent on this assumption. Mullen *et al* (1988) undertook an empirical study which showed that in the case of beef production a very low elasticity of substitution between farm and non-farm inputs had a marked impact on the proportion of research benefits accruing to primary producers. Holloway (1989) determined the distribution of benefits from processing research in the hog industry in the United States. He concluded that the assumptions regarding the elasticity of substitution between farm and non-farm inputs was crucial in determining distribution of benefits in the marketing chain. Furthermore the point in the chain at which the technological improvement was made influenced the distribution of benefits throughout the chain.

Mullen *et al* (1989) examined the impact of farm and processing research on the Australian wool industry and found that the wool industry was likely to gain more from farm production research than from research at other stages of the wool chain. Their findings were consistent with more recent work involving the development of a partial equilibrium model for the wool industry in Western Australia (Layman, 1999). Preliminary results of Layman indicate that the benefits to WA growers of a 1 per cent cost saving at different stages of the market chain are greatest when made at the farm level. For example, a 1 per cent cost-saving at the farm level generates benefits to farmers 10 times greater than those received by farmers from a 1 per cent cost saving at the spinning and weaving stages of processing.

Although studies such as Mullen *et al* (1989) and Layman (1999) point to farmers benefiting more from on-farm research, nonetheless these studies and others identify farmers as beneficiaries of off-farm research. Some off-farm projects offer substantial benefits to farmers. For example, ABARE assessed the benefits accruing to growers from the development of new spinning technology by CSIRO. The new technology, known as Sirospun, decreased the unit cost of producing pure wool yarns by 25%. The benefits of the technology were spectacular generating an investment benefit cost ratio of 123:1 (Johnston *et al*, 1992) with growers share of the benefits depending largely on the elasticity of supply of greasy wool.

Another example is wool promotion. ABARE (1987) quantified the net benefits of wool promotion by the Australian Wool Corporation in the United States. The results of the study showed the demand for Australian wool increased in the United States as a direct result of the expenditure on promotion. The benefit cost ratio of promotion was shown to be 2:1, and the general conclusion regarding the cost effectiveness of promotion held for a range of assumptions. However, a number of other evaluations have examined the success of promotion and advertising of commodities in Australia and overseas (eg Kinnucan *et al*, 1994; Ward, 1997). Many of these programs have been successful at increasing the demand for the commodity, and this has resulted in benefits to growers. However, over the range of these evaluations of commodity promotions, wool has perhaps been one of the least successful (Ward, 1997).

The success of promotional programs tends to be proportional to their budgets. However, given current farm profits of specialist woolgrowers in Western Australia, it is unlikely that these farmers could be convinced to contribute sufficient funds to
form an effective promotion budget for WA wool. Further, because WA wools go to various markets and due to ease of substituting other Australian wools for WA wools, it is unlikely that promotion of WA wools alone would evince demand responses in these markets sufficient to make the investment in promotion highly profitable.

**R,D&E directions**

In forming a portfolio of R,D&E projects, against the backdrop of low farm incomes from wool production, the historical tendency for R,D&E activity has been to look off-farm. As Walsh (1968) observed over 30 years ago:

‘Australian farmers who, when caught in the cost-return squeeze, habitually grasp for off-farm solutions to their problems and neglect on-farm remedies.’ (p. 25).

In spite of the understandable tendency to look off-farm, the preceding discussion has identified profitable on-farm R,D&E opportunities from which farmers can benefit. However, off-farm areas can also be profitable from the farmer’s perspective although, regarding innovation in processing, the benefits to a farmer are often dissipated by the stage of processing at which innovation occurs. Thus, if all wool industry R,D&E activity in Western Australia was solely funded by its woolgrowers then the allocation of resources to on-farm and off-farm activity would in many cases tend to favour on-farm R,D&E and early-stage processing.

The need to invest in on-farm R,D&E is consistent with the need to respond to the likely long run decline in real prices for wool. In the cotton industry that directly competes with wool, increases in cotton yields through biological and technical innovation have prevented a major loss in cotton’s market share to man-made fibres (Foster, 1995). Similarly, wool’s small share of the fibre market would be further eroded unless on-farm productivity improves. Such improvement enables growers to reduce the impact of declining real prices on profit. A study of marketing options, admittedly for crop producers rather than woolgrowers (Zulauf andIrwin, 1998), concluded that producers “will increase their probability of long-term survival by using their scarce resources to first maximize their production efficiency before chasing the allure of marketing profits. In other words, a good marketing program starts with a good program for managing and controlling the cost of production.” (p.327,328).

In some circumstances woolgrower investment in later stages of processing may prove profitable to Western Australian farmers. Such profitability would depend on the uniqueness of WA wool and the quality and reliability of its supply chain. If Western Australian wools and their supply chain have no unique characteristics for which buyers or millers are prepared to pay premiums, then promotion of WA wools is unlikely to be a profitable long-term investment for Western Australian farmers. If wools from other regions are close substitutes for the Western Australian wools, or if supply chains elsewhere are more efficient or of better quality, then sustained price premia for Western Australian wools are unlikely to be offered.

Although it may seem likely that there could be a high degree of substitution among wools, studies by Dewbre et al (1983) and Simmons and Ridley (1987) conclude that
the elasticity of substitution\(^4\) between Australian wool and wool from other countries is surprisingly low. However it is likely that wool from other Australian States could readily substitute for wool from Western Australia. Hence the benefits from advertising and promoting Western Australian wool may be limited by the ease of substituting wool from other sources in Australia.

In practice, farmers are not the sole funders of wool industry R,D&E. Woolgrowers contribute monies for R,D&E through their research levies and as taxpayers. However, in Western Australia the bulk of funds for wool industry R,D&E comes from other taxpayers and graingrowers.\(^5\) Reliance on taxpayers funds means that the focus of R,D&E cannot solely be the degree to which farmers or others in the marketing chain will benefit. For example, taxpayers would see little merit in supporting innovation that increased the economic surplus of firms and consumers overseas, unless there were subsequent trade benefits. Further, taxpayers would see little justification in activity that only benefitted farmers.

The common view, as expressed by Hussey (1996), is that public funds should only be used to fund R,D&E that is of a public good nature. Even this view requires qualification because some public goods (eg agronomic knowledge) have clearly defined end-users or beneficiaries (farmers) who can contribute to the provision of these goods by existing mechanisms such as R,D&E product levies. In short, public goods need not be funded solely from the public purse.

Similarly, Caswell (1997) argues that the well–being of consumers (taxpayers) should be the primary focus of government policy with market participants being of secondary concern. She argues that farmers are not different to other small businesses, and as such should be treated like those in other sectors of the economy. Her view is that Government should not be involved in promotion and advertising but should ‘authorise and facilitate cooperatives and bargaining associations.’

The crucial issue involving use of taxpayers funds is: what R,D&E areas will farmers or others in the supply chain under-invest in regarding the level of public benefits. For example, the land management practices of farmers may provide an inadequate level of environmental amenity to society. Publicly-funded R,D&E activity might aim to maintain the profitability of farmers’ land management whilst increasing its environmental amenity. Practical examples for the wool industry might be:

(i) Better adapted summer fodder crops and new more productive pastures that increase water use;

(ii) Biological innovation that reduces the need for mulesing and which improves animal welfare;

(iii) Biological innovation that reduces methane production from sheep without affecting feed conversion efficiency for wool production;

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\(^4\) The elasticity of substitution is a measure of the ease and degree to which one input (eg Australian wool) can replace another input (eg wool from another country).

\(^5\) The Grains Research and Development Corporation (GRDC) contributes a sizeable portion of funds to pasture research from which woolgrowers benefit.
(iv) Development of low-cost reliable establishment methods for more productive salt-tolerant fodder species that improve the visual amenity of salt-affected areas.

Note that public funds would not be required to fully fund such R,D&E, as most of the projects would have a private benefit component. Woolgrowers, through their product levies, would be expected to contribute to such projects.

5. Conclusions

This paper presents the findings of a scenario analysis for the wool industry in Western Australia. Mathematical programming models of farming systems in the State’s wheat-sheep zone are used to examine the place and profitability of wool production under a range of price and productivity changes. The various scenarios are projections of conditions in the year 2010.

The more likely scenarios suggest that wool production will remain an important part of the farming system in the wheat-sheep zone of WA. The wool industry is likely to remain the second largest agricultural industry in terms of area. The area of pasture that supports wool production is forecast for the year 2010 to either increase slightly from the current area of 5.87 million hectares or to reduce by almost 30 per cent to be around 4.2 million hectares, depending largely on future wool prices.

Given these findings about the wool industry remaining important, this paper explores the ramifications for R,D&E expenditure in Western Australia, particularly by Agriculture WA, the main funder of wool industry R,D&E in the State. Returns to investment on and off farm are discussed.

This paper argues that, while woolgrowers do benefit from off-farm research and promotion, the ability of WA producers to uniquely capture these benefits is limited. Given the high elasticity of substitution of WA wool, significant leakage of R,D&E benefits is likely. In addition it is argued that because most R,D&E activity is publicly-funded it is appropriate that R,D&E activity should generate public benefits that otherwise would not be provided.

7. References


Appendix One

Data Sources and Key Assumptions for Scenarios

Availability of land
The total area of land in the wheatbelt in the 1996 Australian Bureau of Statistics (ABS) census was 13.1 million hectares. This includes crop and livestock areas, revegetated land and that lost to secondary salinity. In the case of wheatbelt shires that extend into the pastoral zone, areas were adjusted to exclude land devoted to pastoralism. It was assumed that no extra land would become available for production in the wheatbelt region between now and 2010. Furthermore, it was assumed that land would continue to be lost to secondary salinity and that by 2010 an additional 5% of the landscape would be lost. This amounts to 650,000 hectares of secondary salinity by 2010.

Estimates of the area of secondary salinity from ABS give much lower estimates than other measurement methods. Generally they account for bare salt land only. The ABS figures are used because they assume all but bare salt land will have some other productive use (albeit poor) and also because they are the most comprehensive source of shire level data.

Crop Yields
Since 1950 average wheat yields in Western Australia have doubled. Similar increases in production have occurred for other crops. The rate of increase in average yields has been particularly high since the early 1980’s. In 1980 the five year average wheat yield for WA was 0.93 t/ha. By 1997 this had increased to 1.73 t/ha. Recent yield increases are attributed to a combination of factors including earlier sowing, new varieties, improved weed and insect control and increased fertiliser use (Anderson, pers comm). The trends in wheat yields since the early 1980s for nearly all Shires are linear and range from a low of 11 kg/ha/year for Westonia to a high of 117 kg/ha/year for Boddington (Stephens 1998, unpublished).

Generally average shire yields for most crops were estimated to be around 30% above current levels, by the year 2010. A notable exception to this is lupins in the medium and low rainfall zones, where average shire yields are expected to be only 15-20% higher.

The estimated yields were compared to figures for potential yield using the French and Shultz equation:

\[ \text{PY} = (\text{GSR-Ev}) \times \text{WUE} \]

Where  
\( \text{PY} = \) potential yield (kg/ha)  
\( \text{GSR} = \) growing season rainfall (mm)  
\( \text{Ev} = \) soil evaporation (mm)  
\( \text{WUE} = \) water use efficiency (kg/ha/mm)

In the case of wheat, and assuming soil evaporation of 80 mm and water use efficiency of 20 kg/ha/year estimates for yields in 2010 were consistently below potential yields. The shire closest to its potential yield was Tammin at 86% of potential, while 35% of shires were still below 50% of potential yield.

In addition to these “best bet” estimates of 2010 yields, a range of extremes was included in sensitivity analysis. The worst case scenario assumed no improvements in current average yields. The best case assumed yield improvements of 50% above current yields.

Grain Prices
Estimates of grain prices in 2010 are shown in Table 1 (Wilkinson, pers. comm.). These prices were subject to sensitivity analysis of $40/tonne above and below the stated levels.
Table 1. Estimates of grain prices in 2010 used in the analyses.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Estimated Price (nominal S/t)</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASW Wheat</td>
<td>$200</td>
<td>Net Pool Return</td>
</tr>
<tr>
<td>Malting Barley</td>
<td>$205</td>
<td>Net Pool Return</td>
</tr>
<tr>
<td>Feed Barley</td>
<td>$175</td>
<td>Net Pool Return</td>
</tr>
<tr>
<td>Oats (milling)</td>
<td>$145</td>
<td>Delivered Perth</td>
</tr>
<tr>
<td>Triticale</td>
<td>$160</td>
<td>Delivered Perth</td>
</tr>
<tr>
<td>Canola</td>
<td>$365</td>
<td>Net Pool Return</td>
</tr>
<tr>
<td>Lupins</td>
<td>$190</td>
<td>Net Pool Return</td>
</tr>
<tr>
<td>Field Peas</td>
<td>$230</td>
<td>Delivered Perth</td>
</tr>
<tr>
<td>Faba Beans</td>
<td>$230</td>
<td>Delivered Perth</td>
</tr>
<tr>
<td>Chick Peas</td>
<td>$320</td>
<td>Delivered Perth</td>
</tr>
</tbody>
</table>

Costs of production
A review of the index of prices paid by farmers showed that over the last 20 years costs of inputs have increased linearly (Annan, pers comm). By projecting this trend to 2010, it was estimated that costs of chemicals and fertilisers would be approximately 35% higher, while other farm inputs would cost 40% more than current levels.

A large range of prices was used in the sensitivity analysis, the lowest level was an 8.75% increase in the cost of chemicals and fertilisers, and a 10% increase in other farm inputs, while the highest cost increases assumed were 52.5% and 60% respectively.

Wool production and price
Woolcuts per sheep in 2010 were estimated to be 10% higher than current levels. This is much lower than the target of a 30% increase in sheep productivity stated in the strategic plan of the wool program of Agriculture WA. However, pasture productivity is described in MIDAS separately to woolcut. Therefore total productivity growth for woolgrowers will result from a combination of both factors. In addition to this best bet estimate, sensitivity analysis of woolcut was included. The lowest level assumed was for no improvement on current levels, while the highest level used was a 30% increase by 2010.

In forming the various scenarios three different price forecasts were used for wool. Firstly, a slightly optimistic Western Market Indicator price of 850 c/kg for the year 2010 was used. In early 1999 the Western Market Indicator price was around 470 c/kg. To achieve a price of 850 c/kg by 2010 assumes cessation of depressed wool prices. Hence, economic recovery in Asia and a significant run-down in wool stocks are assumed to have occurred. A lower and slightly pessimistic wool price of 650 c/kg is also considered. Such a price assumes that productivity improvement in competitive fibres (cotton and polyester) limits the extent of price recovery in wool to be only 650 c/kg. Lastly, a very optimistic wool price of 1050 c/kg is considered. Such a price is possible, although unlikely.

Pasture Productivity
The “best bet” level of pasture production in 2010 was 20% higher than current levels. This is a modest increase given the performance of recently introduced pastures species, the potential of new species being developed, and the scope for improved management. Sensitivity analysis was included ranging from no increase in pasture production on current levels through to a 30% increase.

Estimated total productivity for woolgrowers is slightly below the wool program target of 30% when pasture and woolcut productivity are combined. This is because an increase in pasture growth is not linearly related to stocking rate. Assumed productivity growth is around 20-25% in total.