PART I

INNOVATION SYSTEM ACTIVITY PRIOR TO 1930

INTRODUCTION TO PART I

> *There was no direct association between economic development and the systematic application of scientific knowledge. Nevertheless there were a number of instances of invention and technological adaptation in the nineteenth century.*[1]

With the move into the Australian hinterland of sheep farming in the first half of the nineteenth century woolgrowing soon became the leading land-based economic activity. The dominance of the grazing activity on colonial economic life continued into the second half of the nineteenth century where, in partnership with gold mining, wool exports generated much of the foreign exchange earnings on which a large part of Australia's economic development (and private import consumption) depended. These growth pressures and rapid economic utilization of the land mass created distinctly new patterns of land utilization as well as systems of animal husbandry from those used in England or Europe at the time. In particular, environmental and social conditions encouraged the development of "settler capitalism" and underpinning these adapted forms of social organisation was new technology.

Driving this explosion of woolgrowing activity across the continent was the frenetic growth of the Bradford textile mills in England and the decline of the German Saxon and Spanish Merino wool industry. Wool demand in Europe and supply from Australia expanded commensurately, producing sustained periods of profitability. Confidence was high even during downturns in the British textile industry, British industrialists and local financiers continued to invest in industry expansion. As a consequence, the demand for breeding stock, combined with the urban population requirements for mutton, kept stock prices high, providing a good secondary income and boosting the overall return for grazing enterprises in times of low wool prices. Minimal land costs (via leasehold land tenure arrangements) and high rates of return provided woolgrowers with considerable financial capacity to undertake capital improvements and progressively secure tenure or stock more land.

Thus by the close of the nineteenth century, Australian woolgrowers had substantially altered European methods for grazing livestock and harvesting wool, and successfully adapted them to Australian colonial and environmental conditions. This in itself represented an enormous technological achievement, although it did come at some cost to environmental and productive capacity at the turn of the century and afterwards. The transplanted European farming model was not adjusted to local conditions overnight and in many localities early graziers soon found out to their considerable cost, the limitations of soil and grass species. The precariousness of

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[1] Schedvin, C.B., *Shaping Science and Industry - a History of Australia's CSIRO 1926-1949,* Allen & Unwin, Sydney, 1987, p2.

the land's capacity to sustain productivity was most clearly demonstrated during the late 1890s drought when overgrazing exposed large areas to erosion and the destruction of grass species. When combined with low wool prices, the disruption to the flow of investment money from Britain, and a slow-down in the rate of land-alienation, many woolgrowers (as well as the land) were ruined. In this way, the recession of the 1890s loosened the stranglehold of many grazing "barons" on land and encouraged the intensification and diversification of land usage in areas suitable for this purpose. This saw many large holdings divided (especially on inside country) and used for wheat farming, growing cattle for the frozen meat trade, dairying or other forms of intensive agriculture such as fruit growing in high rainfall areas or where irrigation was possible.

The main production difficulties experienced by woolgrowers at this stage were those associated with the variability of the climatic conditions, contending with low levels of soil fertility in large parts of the continent, and developing animal husbandry practices which minimised losses. Others key factors which influenced the development and uptake of innovation in the nineteenth century were labour costs and availability, as well as the need for transport systems. Despite the successful transfer of woolgrowing to Australian conditions, and the highly inventive and adaptive industry that developed as the industry was established, there was a growing realisation that many of the more difficult problems confronting the industry would require the application of much more science before they would be really resolved or ameliorated. Individual inventiveness and the establishment of industry practices and structures were the distinguishing feature of the industry technological change during the nineteenth century, but to further adjust the operation of all these enterprises to the physical and social conditions in Australia required extensive infrastructure investment as well as research and scientific discovery.

The research agenda did not really get under way until after the establishment of CSIR in 1926 and other research agencies such as the Waite Institute, CSL, CSIR and WIRA and mainly during the interwar period of the twentieth century. Moreover, before growers would accept the imposition of an export levy on wool production and even the setting up of a statutory body to manage wool R&D allocations, they needed more convincing of the merits of such investment. Although there was already much inventiveness and adaptiveness, whether the prognostications of scientists had something to contribute (or that woolgrowers should contribute towards the cost) was something yet to be widely understood or conclusively appreciated. It was the achievements of scientists and the promise of the work in-hand in the years up to 1936 that made the case compelling and in large part encouraged growers to support the establishment of a dedicated research programme funded by industry.

Chapter 2

PRE-INSTITUTIONAL RESEARCH ERA

1. NINETEENTH CENTURY PASTORAL TECHNOLOGY

European land use in nineteenth century Australia was dominated by the production of exportable products of sufficient value to warrant the cartage costs to overseas destinations. Until the advent of refrigeration and speedier shipping, the product which best fitted this economic prerequisite was Merino wool. In the first half of the nineteenth century, the techniques for growing wool involved the transplanting the European model of shepherding sheep on open land with only very minimal structures or development. The sheep were folded at night because of the depredations from dingoes. Each shepherd had around 300-350 sheep, and was supported by a cook and a person to move the structures for folding each night. As a consequence of these high labour requirements innovation focussed on ways of reducing labour requirements (100-200 sheep per person), developing basic farm infrastructure quickly and minimising stock losses. Prior to the 1870s, land was occupied inexpensively and was plentiful, capital improvement funds were limited, and labour was in very short supply. After the 1870s, increasing competition for land, and severe degradation on stock routes adjacent to water courses, accelerated proprietorial partitioning of land, and investment into basic infrastructure such as fencing, water conservation, shearing sheds and homes. The situation became critical after the middle of the century when farm and shearing labour became extremely difficult to procure either because of events such as gold rushes, or the labour requirements from rapid urban development in the main capital cities of Sydney and Melbourne. In addition, the larger population after the gold rushes created a demand for land, and further depleted the available labour for shepherding.

During prolonged downturns and drought the boiling down of sheep to export tallow to the United Kingdom was a financial salvation for many. This was done on a large scale during the 1840s and 1890s, when the demand for breeding stock or for food was not sufficient to cope with the stock available for slaughter and the value of sheep dropped to very low levels.

It was during the phase of rapid spread and setting up of basic economic infrastructure from the 1840s to the 1890s that individual farmer inventiveness was needed to overcome the severe constraints of labour and capital as well as the difficulties of the environment. The initial woolgrower reaction to labour shortages was to increase the number of sheep to each shepherd and adopt a procedure whereby permanent yards were built in a central position to which sheep were brought. However, this proved unsatisfactory because the yards filled up with manure sometimes feet high, and became a haven for disease. Constant travel over one portion of ground caused compaction and destroyed all the grass surrounding the yard area. The permanent solution was to build fences around the perimeter of the area to be grazed and for the sheep to range freely without needing to be tended. Free ranging sheep became a even more practical option when to eliminate the depredation from dingoes, strychnine was introduced. The struggle began between those seeking small acre settlement and the established grazing industry heightened the imperative to enclose land. Paddocking was also found to be beneficial in other ways, and with the advent of fencing-wire landholders were encouraged by the Stock Inspectors of the time to fully enclose and divide with fences the land under their control. What was achieved was the constraint on expansion requiring labour to tend sheep in exchange for boundary riders to check fences. Flocks of 20,000 could be managed by a dozen or so stockmen and boundary riders. As a result, 'paddocking' became the dominant form of animal management, and shepherding activity was soon confined to ewes at lambing time. These techniques for occupying land and managing grazing enterprises in the years to the turn of the century facilitated the rapid utilisation of the hinterland. Driven also by speculative property development, Australia became the most partitioned and fenced country in the world.[2]

With the 1890s depression and the long drought at the turn of the century, many of the huge pastoral runs were broken up. This process was accentuated by government action with many leaseholds purchased or reclaimed for soldier-settler schemes at the point of lease renewal. This was often disastrous for the land, as the undercapitalised soldiers attempted to generate an income out of an area that was not sufficient to sustain them, giving rise to an extended period of personal tragedy and land degradation. It often lead to the re-establishment of large grazing estates through aggregations.

In general terms, the period of rapid spatial expansion of farming/grazing activity and expansion in production reached its limits around the first world war. Thereafter increases in production would be from more intensive development based on more detailed information and understanding of Australian conditions. In altering the natural environment for commercial exploitation, finding the balance between looking after the land and responding to economic pressures to produce more were often not reconcilable.[3] In an unavoidably "hit-and-miss" fashion, the Australian farming community and government learnt how to better match the

[2] Winslade, S.L., *The Australian Wire-Fencing Boom 1874 - 1914*, Honours Thesis, University of New England, 1990.

[3] Farming zones in Australia are for dairying and crossbred lamb production to take place on the coastal high rainfall areas, beef and sheep on the slopes, ranges and tablelands (the clover belts), and cropping (mainly grain or in more recent times, cotton) in the favoured western slopes of the great divided and the inland fringe of south-west Western Australian. Woolgrowing is best suited to temperate and dry regions, not coastal or tropical areas.

economic demands of farming enterprises to the environmental capacities of particular regions. However, this was a crude approach and it needed a research effort to build a better information and regulatory framework for land management. Ensuring responsible use and ongoing productivity for Australia's land resources was treated as the responsibility of government because much of the grazing lands were leaseholds. Expanding output, minimising losses and cutting costs in a way that did not destroy the land and impoverish the farmer required the assistance of good agricultural research, effective extension and the inter-generational practical knowledge of farmers. Some of the main innovations during this period are given in Table 2.1.

TABLE 2.1 Innovations Pre 1929:

Type of innovation	Provider	Research phase or introduction	Main adoption period	Est. Time taken to full usage
Ryegrass	Private	N/A	1820s+	N/A
Lucerne	Private	1803	1830s+	N/A
Other grasses	Private	N/A	1850-1910	N/A
Aust. Phalaris	Private	N/A	1905+	N/A
Early Pedological	CSIR	1914+	1930+	25-30 Years
Mount Barker	Howard	1907+	1930-40+	25-30 Years
Cactoblastis	CSIR	1925	1930-1940	10 Years
Super research	State/CSIR	1880s+	Ongoing	N/A
Permanent Yards	Private	1830s+	1830-1850	5 Years
Stock routes	Public	1930s+	1930-1950	5 Years
Botany Bales	Private	1840s	1850s+	5-10 Years
Fencing/Paddock	Private	1850s+	1870-1890	20-30 Years
Railway	States	1860s+	1870-1890	5-10 Years
Sheep washing	Private	1860s	1870s+	N/A
Mechanical Shear	Private	1868-1893	1895-1930	20 Years
Sheds	Private	1870s+	1870-1930	10-15 Years
Water bores	Private/Public	1870s+	1870-1890	10-15 Years
Modern Shearing	Private	1909-1935	1920-1940	20 Years
Merino Breeding	Private	1840s+	1870-1900	20 Years
Wool Auctions	Private	1843	1860-1890	20-25 Years
Wool Class	Private	1850s+	1870-1900	N/A
Bradford System	Private O/S	1850	1850s-1900	N/A
Continental System	Private O/S	1870	1870s	N/A

Source: This table is based on information and calculations collected during the course of the research for this thesis.

Water conservation and transportation networks.

In the latter part of the century, the sinking of bores and use of windmills to provide water in the semi-arid regions opened up vast areas of inland country to grazing. Artesian water was first discovered in 1878 at Kallara station, near Bourke, NSW and the first successful free-flowing bore was put down in 1879. Development of groundwater and particularly the Great Artesian Basin by government bores and channels was enormously important for the spread inland of sheep.[4] Groundwater was found to be widespread in Australia underlying around 60% of the continent. State governments assisted the spread inland with infrastructural projects such as government bores on the Great Artesian Basin. Around 4,700 flowing artesian wells had been drilled by the 1980s.[5] The quality of artesian water varies according to the level of mineral content or dissolved solids. For many, bore water from surficial aquifers provided more suitable and cheaper supplies of stock and farm water than building dams or carting water. The States also provided the investment into transportation networks such as the provision of road and rail links, port facilities and handling infrastructure for shipping services such as the inland paddlesteamers wool trade on up the Darling and Murray Rivers. Before more efficient transportation networks were provided, sheep washing prior to shearing was practised in order to reduce transport costs.[6] Perhaps the largest impact on productivity was that from land clearing and pasture development and Merino sheep breeding both of which were undertaken by farmers.

Clearing land and pasture innovations.

Land and water improvements were aimed at either increasing output or reducing the level of labour required to run the rural enterprise. Land clearing was nearly always the first option and in some areas (such as the Mallee in Victoria) techniques were specifically designed for uprooting the local vegetation. For example, mullenising using a heavy roller pulled by horses or oxen would knock down the scrub and small trees ready for burning at the end of summer. In 1876 the stump-jump plough was invented so that on meeting an obstruction a hinged plough would rise out of the ground and return just past the troublesome tree root. This permitted the farming of the country immediately after clearing and before all the roots had been grubbed.

> *...he is a benefactor to his country who makes two blades of grass grow where only one grew before."*[7]

This dictum was first advocated in conjunction with the earliest form of pasture improvement in Australia: the practice of ringbarking.[8] Thought to 'sweeten the ground', ringing was

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[4] The Great Artesian Basin is up to 3000 metres thick in places and extends over 1.7 million square kilometres.

[5] Pigram, J.J., *Issues in the Management of Australia's Water Resources,* Longman Cheshire, Melbourne, 1986, pp. 24-25.

[6] Graziers also washed sheep prior to shearing to save weight in ships *en route* to sales in Britain because lowering total shipping-weights supposedly minimised the risk of ships overturning during gales. Alistair Mackenzie, Personal Communication, 28th September, 1993.

[7] Gordon, P.R., *Fencing as a Means of Improving our Pasture Lands, and its Advantages to the Stockowners and the Colony with Suggestions for a Fencing Bill and the Improvement of Pasture by Means of Sapping*, William Maddock, Sydney, 1867.

[8] Known also as "ringing", "rung country" or "sapping". Ringbarking requires removal of the fibrous bark outer layer nine to twelve inches high; sapping/ringing involves a V-cut around the tree about one inch or so deep.

vigorously supported in the 1860s by P R Gordon, and later 'scientifically justified' by William Farrer, both of whom thought Australian trees were mostly valueless. Only a few tree species such as Apple, Box, Kurrajong and Stringybark were kept for drought feed or fencing needs. Better understood and appreciated were the native grasses and saltbushes. Many soft and palatable perennial grasses such as the Mitchell grass (Queensland), wallaby grass (southern Australia) and inland shrubs such as salt-bush, blue-bush and mulga trees were able to sustain sheep and enabled them to grow good quality wool. However, many of the better native grasses were not resilient to the heavy grazing pressures of sheep or cattle which caused the more useful grass species to be quickly eaten out. This encouraged, even at a very early stage of European agriculture in Australia, the selection and importation of hardier and more resilient grass species for introduction into the high rainfall areas.

Even as early as 1820, English grasses and clovers had been tried, and by mid-century, perennial and Italian ryegrass, cocksfoot, Timothy grass, red and white clover, cowgrass, alsike clover, lucerne, trefoil and parsley were being successfully grown at the Experimental Farm in Melbourne. Lucerne was supplied by Sir Joseph Banks to Governor King in 1803 but over the next century it was shown to only prove effective in well-structured soils with good water availability either from irrigation or via a readily available water table.[9] Prairie Grass was introduced from South America by Josiah Mitchell in 1853, and *Paspalam dilatatum* by Baron von Mueller in 1881, together with a number of other summer grasses. For northern high rainfall pastures best suited to cattle and dairy production, Rhodes grass and Kikuyu, were introduced in 1900 and 1909 respectively.

All these imported grasses had to undergo a period of selection through adaptation and hybridisation before they achieved a full suitability to the new environment. After years of trial and error, many cultivars were developed and later, new strains protected by seed-certification schemes. The choice of a cultivar was important because it could extend the growing season, be more persistent (especially after cropping), or be selected for suitability to waterlogged environments. A good example of long-term research with grasses was the development of lucerne in which distinctive regional strains were developed and phalaris. Phalaris was first brought from Italy in 1905, and the strain developed became known as Australian phalaris. Although it was hardy in most seasons, it developed toxic periods, and was notoriously difficult to harvest seed, which limited its spread. Early research also looked to inform farmers about whether the native grasses they had on their properties were in any way toxic and the effects on grazing animals with the purpose of understanding how to counteract the effect.

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[9] Davidson, B.R., and Davidson, H.F., *Legumes: The Australian Experience - The Botany, Ecology and Agriculture of Indigenous and Immigrant Legume*, John Wiley & Sons Inc., England, 1993, pp. 213-4.

The first use of clover occurred at the turn of the century in South Australia, after the infiltration into isolated pastures of the Mediterranean weed subterranean clover was noticed in 1906, by A.W. Howard, a nurseryman and small farmer. He observed and then publicised the usefulness of subclover as a legume base for pasture improvement programmes and advocated the topdressing with superphosphate to establish the plant.[10] When techniques were developed after 1920 to make seed harvesting more efficient (using a sheepskin roller harvesting technique developed by the Western Australian P.D. Forrest), the pasture improvement package using clover became more readily available. By 1925, its use had spread into the high rainfall areas of Victoria, South Australia, and Tasmania and it was proving to be highly productive and profitable. The use of subterranean clover in pasture continued to expand in the period 1930-40, but even in the case of selected exotic grasses a more careful matching of differing species to climatic conditions was needed to maximise the benefit and extend the regions able to improve their pastures.

The other area of innovation which encouraged further scientific research investment was pasture improvement. Before the turn of the century, fertiliser usage was mostly from commercial 'blood and bone crushing' or by 'on-the-property crushing', and many machines were sold for the purpose. There was also other material such as imported 'guano' available. Generally, such fertilisers were used by wheat growers or horticulturalists and there use for pasture was limited and little understood. Matching fertilisers to soil requirements and understanding those needs in the first place was to become a large part of the research agenda.

Fertilisers first became available in the second half of the nineteenth century, but they were not extensively used, and hardly at all for pastures on extensive grazing enterprises. They took the form of 'blood and bone', for which meat/bone crushing machines were designed and manufactured for use on farms, or guano. Superphosphate was first tried in the 1880s, and in 1892 the NSW DA recommended the use of 2cwt of superphosphate per acre to assist in the establishment of pasture legumes.[11] A.E.V. Richardson (1914) observed the effects of spreading superphosphate at 125kg per hectare and recorded significant improvements in liveweight gains.[12] Phosphate applications provided the essential ingredient for establishing legumes which fixed nitrogen in the soil and improved the growth of nearby grasses. This rejuvenated rundown or struggling pasture and over years of continuous application the grasses would gradually compete with the clover and balance the sward providing a much more

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[10] ibid., pp. 219-21, Baron von Muellor described the presence of subterranean clover in 1888 and it was probably introduced into Western Australia between 1829 and 1842.

[11] Superphosphate is made from a rock phosphate (which is insoluble in water), and sulphuric acid. The chemical reaction which takes place when these are mixed makes the greater part of the phosphorous soluble in water and, when applied to soil, available to plants.

[12] Davidson, B.R., and Davidson, H.F., op.cit., pp. 226-7.

productive and resilient pasture. Phosphate also assisted grass root development, causing deeper penetration into the soil profile which made pastures more tolerant to dry spells and extended the growing season.

Most of the phosphate used in Australia this century was calcium phosphate from Ocean Island, Nauru and Christmas Island, and imported by the British Phosphate Commissioners. Phosphate was a bulky item which required extensive shipping, so Australia was fortunate to have reserves on nearby Islands to last until the end of the century.[13] Nearly all of the 'super' used before 1900 was imported in processed form, and the beginnings of the superphosphate industry in Australia came at the turn of the century. During 1901/02, 40,000 tons of super (as distinct from raw phosphate rock) was sold throughout Australia most of which was imported. By 1905, of the 87,000 tons sold that year 64,000 had been imported. Such was the increased usage after the island groups were mined by the British and manufacturing capacity in Australia had been developed, that sales during 1910/11 reached 220,000 tons, all manufactured in Australia. By 1920, sales had grown to 332,779 tons and by 1929/30, 909,030 tons. Imports were drastically reduced during the early depression years, yet even by the start of the second world war sales had returned to one million tons. When the Japanese occupied the Islands during the war, the supply and quality dropped to very low levels. Existing stocks were put under the control of the Superphosphate Industry Committee, and sales fell to around half that sold prior to the war. Yet by the end of the war, sales went again back to one million tons, and within five years, had risen to over one and a half million tons. All states had manufacturing facilities to produce their own 'super' requirements, although Queensland's needs were met from NSW until 1946.[14] This level of super use was sufficient to fertilise the area utilised for intensive agricultural and dairying activities, but to fertilise grazing country would require a significant increase.

The pattern of demand for superphosphate was rapid in all states, although in terms of distribution NSW lagged behind other states. In 1934-35 improved pastures in NSW were only around 10,000 acres; it was 1955 before NSW was using as much phosphate fertiliser as Victoria had by 1930.[15]

Sheep breeding.

The main technical achievement and one that had the greatest impact on productivity in the nineteenth century was the evolution of Merino types which suited the harsher western regions

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[13] The rock was of a high quality and prior to the war 'super' had been consistently 22% grade.

[14] Cabinet Document on fertiliser usage, John Crawford Collection MS 4514 Box 41, Australian National Library.

[15] Bishop, H., *Agricultural Science,* Vol.5 , No.1, 1992, p.18.

and grew substantially more wool. It was largely the development of the Australian Merino which formed the basis for Australia's comparative advantage in woolgrowing and industry prosperity.[16] Descending from the original Spanish flocks, the precursors to the main bloodlines of Merinos in Australia were derived from mixtures of Spanish, Saxon (German), South African, English, Rambouillet (French) and Vermont (USA) bloodlines. The broader Merino types were the outcome of crossing with the Vermont or Rambouillet types. The resulting larger-framed, heavier-cutting Merinos were found to be well suited to native pasture and dry climate.[17] For example, through the 1860s, the Peppin brothers selected between many thousands of animals, and with careful cross-breeding developed the superior Merino which came to dominate the drier pastoral regions.[18] For the higher rainfall zones, Saxons were crossed to produce a larger animal ideally suited to the tablelands conditions of NSW, Tasmania and parts of Victoria.

As the industry was expanding rapidly both geographically and in absolute production terms, many important studs were formed, including Bungaree (1841), Wanganella (1861), Mumblebone (1879), Haddon Rig (1882), Collinsville (1895), Bundemar (1901), and Egelabra (1906). This stud activity helped create the four main Australian Merino types; with the breeding strains established, it remained to improve the flocks through type-culling and ram-selection. Although Merino types fall into a range of fibre-diameter categories, they are commonly described by their general styles: superfine, fine, medium (Peppin and non-Peppin), and strong (South Australian). The hierarchal structure of the breeding industry and the dominance of the large studs ensured the progress in genetic improvements was quickly disseminated and accessible to other woolgrowers.

However in this period, not every breeding innovation represented progress. For example, experimentation in the 1880s and 1890s led to the introduction of a new Vermont type from America. These wrinkly versions of the sheep the Peppins had used for crossing, were popular because it was thought wrinkles provided more skin area and therefore a larger cut of wool. However, they were found to be more susceptible to flystrike, constitutionally weak, produced little or no extra wool, and the wrinkles made them difficult to shear. Despite this, the advocacy of influential woolgrowers meant it took many years to eliminate what had become a breeding fad.

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16 Massey, C., *The Australian Merino,* Viking O'Neil, 1990, Ringwood, Australia, for full details.

17 Strains were which suited differing to geographic areas were the Saxon types in the higher rainfall zone, Peppins in the better pastoral areas, and South Australian medium types in the more arid areas, which required sheep with strong constitutions as well as long legs to walk to water.

18 The Peppins used German and Rambouillet rams as well as two Vermont rams. These Vermonts were distinctly different from the wrinkly Vermonts imported some twenty years later.

Shearing machines.

Another example of farmer inventiveness leading to industry wide innovation was the development of mechanical shearing. Although invented in the 1870s, it was not until the early 1890s that machine-shearing was extensively introduced to reduce the skill required and the amount of seasonal labour needed. J.A.B. Higham patented the first machine for shearing sheep in 1868, but it was the hand-pieces and driving gear for mechanised shearing developed by Frederick Wolseley that brought the innovation to the industry. An Irishman, Wolseley arrived in Australia in 1854 and worked on sheep stations until 1859 when he acquired a station in the Murrumbidgee District Wolseley started his own experiments on shearing machines in 1868, and later with R.P. Park his engineer partner, over the next twenty years tried a number of designs and driving mechanisms. By 1872 Wolseley had a working model and after he bought "Euroka Station" near Walgett in 1876, he experimented with a number of prototypes. Wolseley displayed the shearing machine at shows for two years, before the first full installation was achieved at Sir Samuel McCaughey's shed at "Dunlop Station" in 1888. Eighteen other sheds installed the machines in the first year, and Wolseley set up manufacturing works in Birmingham and Melbourne, employing Herbert Austin as foreman in the latter. Austin, an engineer, improved the overhead gear, and in 1893, went to Birmingham as Wolseley's production manager.[19]

The Wolseley handpiece sold very well through the agents Dangar Gedye & Co., but when the agency was lost to another firm in 1909, Dangar Gedye started negotiations with the English firm R.A. Lister & Co. to design and set up the tooling for an improved handpiece and they sent the second-in-charge of the Sydney workshop to manage the development.[20] This was Jim Davidson, who had shorn sheep at "Dunlop Station" in that first year of Wolseley's installation, and went on to work for him demonstrating and selling machines around NSW on a pushbike, which doubled as the power source. With plans in his head, he stayed at the Lister machine works in Dursley for the next nine months to develop a prototype. The handpiece incorporated the hinge design for converting curvilinear motion into a more efficient straight-line horizontal movement (first patented by David Unaipon in 1907).[21] The design also incorporated American engineering and mass production principles of fine tolerances and interchangeability of parts. In the years to 1935, Jim Davidson obtained over 26 patents for modifications to

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[19] Wolseley resigned from the manager-directorship in 1894, and in the next year Austin designed and made the first Wolseley motor car. Wolseley died in 1899, and in 1905 Austin started the Austin Motor Co.

[20] Details on Jim Davidson: Smyth, J.G., 'The Man - and the Industry: Mr Jim Davidson - The "G.O.M." of the Shearing Machine World', (no publisher) 1936.

[21] Unaipon found problems with obtaining development finance. Once the patent application had lapsed the idea was incorporated and widely used without credit or money coming his way. Article by Margaret Simons, *Canberra Times*, May 7, 1994, p.C6.

shearing handpieces which covered most of the features still contained within handpieces currently used in Australia and elsewhere.[22] Davidson was the inventive master who added the technical sophistication to what Wolseley and Austin had begun. Other companies such as Coopers (Sunbeam), and Moffit Virtue emulated Davidson's basic design and these became the main companies to sell handpieces after the second world war, with fewer sales to those committed to Wolseley equipment or firms such as Ronaldson Tippet based in Ballarat, Victoria. In fact, specialisation or companies going out of business meant that it was common for properties to have a mixture of brands in overhead gear and handpieces. Eventually Sunbeam came to dominate the market for handpieces and overhead gear as well as a significant share of the comb-and-cutter market. The adoption of the new handpieces and shearing machines was rapid and by 1946-7 some 93,000 shearing machines existed. As a comment on the spread of technology when circumstances allow, and on the expanding level of output during the 1950s, some eleven years later (1957-8) there were 165,500 shearing machines.[23]

Wool bales and shearing sheds.

Efficiency was also improved on an industry wide basis. The 'Botany Bale' was developed in the 1840s, as were the first baling presses. The dimensions chosen for the original wool bale were, fortunately, well suited to subsequent transportation systems and are still being used. Many shearing sheds were also built in this period, some of which were enormous complexes demonstrating the faith those at the time had in the future. Even though the design of these is by today's standards far from efficient, for the technology of the time they were impressive and efficient. There are many examples of sheds built in this early period since modified still in use.

Woolclassing, appraisement and selling procedures.

Greasy wool is a variable product largely because of subtle changes in breed, differences in sex and age of sheep, as well as those environmental factors of season, type of soil, and vegetation. These affect the colour, alter the character, and determine the level of contaminants such as dust, grit, and vegetable matter. Even the pasture type or weather conditions can modify the feel or strength of the fibre, especially where trace elements are lacking. Changes in animal husbandry or grazing management can also impact on the evenness of growth along the shaft. Classifying the natural complexity was the grading work of the wool classer at shearing time, or

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[22] Components from handpieces made today operate handpieces that are thirty or forty years old. The bodies for handpieces are still imported from the same iron works in England.

[23] Barnard, A., *The Simple Fleece: Studies in the Australian Wool Industry*, Melbourne University Press, Melbourne, 1962, p.617.

that of the sheep classer who looked to improve the flock by selecting sheep which were visually similar to the style wanted. However, the skill-levels and experience of both of these could vary considerably.

The wool appraisal system was non-existent in the early nineteenth century. At this time, farm woolclassing was not performed and a shorn fleece was just bundled together, tied with string or by the leg-portions of the wool, put into 'socks' or, later on, 'Botany Bales', and sold in auction-rooms overseas where it was often classed just prior to sale.[24] In the 1830s and 1840s wool came to the ports loosely packed and only then was it sorted and more tightly packed. Wool was distinguished either by geographic region, by whether it was fine or coarse, or given general gradings such as first, second or third combing/clothing wools.[25] Once purchased and delivered to the processing mill, 'sorters' would open the bundled wool and break it into many 'lines' for various uses. After a few years sorters of mixed ability also became available in Australia; these presorted greasy wools assisted the processor enough to attract a premium at auctions. This woolclassing and skirting at shearing time became more widely adopted after the 1850s, but while it became more exacting, it did not replace the more definitive sorting that was done at the mills.

The classing procedure that developed in the shearing shed over time was for the shorn fleece to be thrown onto a 'wooltable' of slatted timber and then 'skirted'. This involved removing inferior parts such as the fribby, very short, tender, stained, coloured, or portions of wool with high vegetable matter (VM) content. The fleece was then 'rolled' and presented with the shoulder-part of the fleece uppermost for the woolclasser to assess. The routine of the classer after a fleece was handed over by the woolroller involved the visual/hand assessment of 'count', tensile strength, length, and colour and the general condition or style of the fleece, paying special attention to any faults. Communication of a processor's wants was never clear because buyers would amalgamate lines to arrive at a processing package. The grower would never know what part he might play in this, and it would vary from year to year, making the market-signals inconsistent. It was a woolclasser's job to put like with like and divide the clip into lines, with the aim of making the wool uniform to facilitate type/quality number and yield assessments. Once assessed, the wool was placed in a 'woolbin'. Large sheds also had "piecepickers" and "bellypickers", and so created even more lines. As the woolbins filled up, 'pressers' collected the classed wool, pressed it into bales, and labelled them according to the designated type, bale number, property name, and agent details, in readiness for transportation and selling.

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[24] Barnard, A., *The Australian Wool Market 1840-1900*, MUP, 1958, p.77.
[25] ibid., p.79.

Despite all the effort to divide wool at shearing time, it was actually the sheep selection of the farmer or sheep classer which did most to determine the quality of a fleece line - woolclassing was little more than be a quality control procedure to eliminate inferior wool from fleece lines or differentiate worsted types from those to be used in the continental or woollen systems. On mixed enterprise properties where sheep could vary considerably classing could separate fleeces on an effective basis but in these cases it was more likely that wool within a bale was mixed and thrown together more. Although some basic quality control was desirable, attempts to replicate the precision achieved at the mill created diminishing returns and only fragmented clips beyond what the processors required.

For those growers who could not procure a classer, or in cases where the quantity of wool did not warrant the expense of shed classing, 'bulk classing', 'storeclassing', 'pooling', and 'blending' were performed by wool brokers. These were often an attractive alternative for small woolgrowers because combined wools often received a better price than 'star lots' (sale lots of four bales or less). The price differential between large lots of shed-classed and store bulk-classed was small, but shed classing remained a cheaper option for most woolgrowers.[26] The broker could also combine small lots into larger lines without breaking open the bales (known as 'interlotting'). Buyers preferred interlotting to bulkclassing because the wool was not such a mixture and yield could be more accurately appraised.

The fifty years from the middle of the century saw a number systems of classing develop that were complex and often irratically subjective. Whether it be in the shed, wool store, or processing mill, what the classer was doing in this process was based on years of experience, and the principles the classer worked by were matters of individual experience, which meant some methods were idiosyncratic. Not only did skill levels vary considerably, but bad classing was often undetected because growers generally knew very little about the craft.[27] The traditional methods could be extremely accurate when the classer was very experienced. However, even when wool was classed according to accepted practice (as assessed by woolclassers), it was not always rewarded in the market because woolbuyers might make different judgments about the same wool. It was also very difficult to receive accurate market signals because the practice of blending wools from different clips to create a mill lot meant that the place of a particular clip in the mixture could vary from season to season.

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[26] Gruen, F.H., and White, J.O., 'Shed Classing Versus Store Classing', *Australian Journal of Agricultural Economics,* Vol. 4, No. 2, December 1960, pp. 115-120.

[27] Barnard, loc.cit., quotes Shaw, T., *The Australian Merino*, p.6, on colonial wool-sorters as "old fellmongers, weavers, hatters and porters to cloth warehouses who were simply imposters".

These irregularities created much uncertainty and encouraged the buying of certain clips from certain regions year after year which also encouraged growers to retain the same classer year after year. Classers were employed directly by the grower (often accommodated in the homestead), and their specialist knowledge was respected. The end effect of this was that practices and understandings were perpetuated which formed a network of resistance to any changes that would subsequently be mooted by scientists. Another consequence of the system was that wool classed on one property could bear no relation to similarly described wool classed on a different property. The descriptions branded onto the wool bale were not consistent, which meant it was absolutely crucial that the buyer inspect the wool before purchase.

This is not to say that attempts at descriptive standardization were not made many years before. The earliest woolclassing course was offered in NSW in 1891 and around 1900, a system of quality numbers was devised and introduced in Yorkshire. Its transfer to Australia provided a more unified basis on which to categorize wool. It was especially useful to small woolgrowers, who were becoming more numerous and did not have sufficient wool to make a large number of lines.[28] The Yorkshire system focussed on the wool's crimp definition, on the basis that this was paramount to spinning performance and value. However, these terms were not widely used for many years, and because they lacked precision, were open to interpretation. It was actually not until the postwar period or into the 1960s that standardized teaching, and an accreditation system for woolclassers, provided a set of minimum standards.

By this time, subjective methods of wool appraisal were proven by research to be erratic and to assess processing values inaccurately even when performed well. Despite the fact that wool would often be incorrectly described, the woolbuying fraternity resisted the introduction of any new system of wool description and measurement and the auction system perpetuated an adherence to traditional methods. Woolbuyers served an important brokerage function which insulated the grower from claims from the processor. Woolbuyers avoided purchasing single lines of wool to minimise mistakes and used an averaging technique to combine a number of grower lines into a mill lot.[29] The downside of this procedure for growers was that it disguised what part their wool played in the formulation of a mill lot, and gave them confused information with which to evaluate the effectiveness of breeding, animal husbandry or the work of their classer.

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[28] Quality numbers refer to the number of hanks of wool 560 yards long that are able to be spun out of a pound of wool. Thus increasing numbers represent increasing fineness, and therefore, increasing numbers of fibres and yarn length.

[29] Although many of the appraisers were reasonably accurate, it remained a deliberate strategy to buy wool from a number of clips to make up a consignment and even out mistakes. Processing prediction is more accurate from this procedure than buying all the wool from one property or line. This is why the buyer resistance to large lots at auction has remained.

Table of Limits/Type Lists.

As already noted, the nomenclature of describing wool was often confusing. The descriptive mixture of weights, volume, measures of yield and designations of wool type were steadily more incoherent and unworkable for modern industrial purposes. Despite the attempts at standardization, wool buyers/exporters had their own classificatory systems (some still do) to form wool packages for individual processor needs. Given this background, it is little wonder a universal system of description was feared because it threatened to undermine or replace the wool exporter's "expertise". The first universal grading system was actually devised during World War One, at a time when the shipping lanes were disrupted and when the auction system was suspended because of the British purchase of the entire clip. The body set up to administer the sale of wool to Britain, the Central Wool Committee, devised a table of wool types covering 848 categories. It was used to appraise wool prior to transport or stockpiling, and to provide the basis for differentiating payments to growers. Known as the 'Higgins' Table of Limits', its use lapsed after the war, after all stockpiled wool was sold. However, its influence lingered and another list was quickly constructed during World War Two, when wool brokers and exporters were again asked to come together and thrash out an updated classificatory code for wartime purchases. During a special meeting in the Paddington Town Hall, classifications and general types were nominated in a trial-and-error fashion, based on a show of hands. This second list was known for many years as the 'Australian Wool Realisation Commission Table of Limits', which, with slight modifications, became what is known today as the AWC Type List. Based on variations in crimp frequency, staple length, quality and fault content, the list encompassed 650 basic types, 1,295 sub-types, including crossbred wools, as well as scoured wools which added another 513 types creating a schedule of well over three thousand types.[30] Although this list is now in a number of respects an anachronistic amalgam of processing terminology and wool style descriptions, at the time, the creation of a type-list marked an important turning point for the revolution that was to occur after World War Two. This was because it became the first wedge in breaking up the old ways, and formed a basis upon which comparisons on the worth of particular wool attributes could be made.

Open-market wool-selling arrangements

An important element in the innovative history of the wool industry is the structure and reforms associated with the selling of wool internationally. The system of selling wool in Australia is the result of 150 years or more of continuous development. The first recorded sales of imported Australian wool in Britain was of Macarthur wool (between 1800 and 1821) and it was sold by

[30] Report of the Wool Marketing Committee of Inquiry, Commonwealth of Australia, February, 1962, Appendix 10.

'private treaty' in Garraway's Coffee House, Change Alley, Cornhill, London.[31] The growing volume of Australian wool exports developed the London market to the point where, on the 17th August, 1821, the first public auction of wool took place again in Garraway's.[32] Wool transported to the London market in the 1830s came via local merchants, who bought wool from pastoral stations on a speculative basis and resold in London or Europe at their own risk. By the 1840s this was changing, because increasingly wool was forwarded directly to London and Liverpool on consignment by woolgrowers on their own account, with only a small portion forwarded by the merchants. The reason for the change was that the size of individual clips was often too large for the financial resources of the local merchants to purchase outright and carry the considerable financial risk. Consignment became the dominant form of wool-selling after 1840 through to the end of the century by which time local auctions on a commission basis had become the dominant form. In the meantime, many of the merchants became consignment agents, representing the woolgrower to London buyers on a commission basis. An alternative selling method was to forward-sell part or all of the clip and receive an advance payment direct from London. The price in these cases was less and it was in the merchants favour because the risk margin needed to be sizeable to contend with possible rapid market fluctuations.

The dominance of Britain in the textile trade, on the shipping trade during the nineteenth century, and the strong commercial links with the London capital market, ensured the London wool market received nearly all of the colonial wool exports, and buyers from all over Europe re-export from the London or Liverpool markets. Being the financial and transport centre of world trade at the time it gave the London market significant economic control, and woolgrowers had little choice if they wanted to maximise buyer interest, but to consign wool there. For the colonial woolgrower prices received were variable because of the transport risk, sudden downturns in the wool price, delays in payment, and the distance provided ample opportunity for profiteering by dealers. These circumstances encouraged the introduction of auctions in Australia in an attempt to smooth the market risk and speed up payment after shearing.

Australian auctions

Selling a major portion of the clip at auctions in Australia took some time to develop. Although the first public auction in Australia was in Adelaide on March 3rd, 1840, regular auctions were

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[31] Macarthur's first sale achieved a price of 48d. per lb. for ewe's wool and 60d. per lb. for ram's wool. The average weight per fleece was 3lbs. Background History issued by the AWB in February, 1970, which itself was based on the work of Guthrie, J.F., 'A World History of Sheep and Wool", McCarron Bird, Melbourne, 1957, and Barnard, A., *The Australian Wool Market 1840-1900*, MUP, 1958.

[32] The prices at the first auction ranged from 29d. to a top price of 124d. per lb. - a price which stood as a record for the next one hundred years.

not held in Australia until 1867. The first Sydney auction was conducted by Thomas Sutcliffe Mort on the 17th September, 1843. In 1888 Mort joined with Richard Goldsborough, and concentrated the operations in Melbourne after it became the centre of finance during the gold rushes. With others like Strachan, Dalgety and Dennys, a numbers of wool stores were constructed to store wool prior to shipment. The first recorded public sale in Victoria was held on January 8th, 1856, when Olgilvie and Robinson offered a few bales in Geelong.[33] By 1867, Victorian catalogues could contain 4000 to 5000 bales. This was still a relatively small level of activity, and was restricted to those specialty lines which could attract good competition. The bulk of wool was still sent to London, where prices remained much higher, but so did the costs of transport and the commissions imposed by London agents.

The volumes sold at auction in Australia remained comparatively small for some time because of the undeveloped nature of the financial markets, the logistical constraint of not having representative agents of processors located in Australia, and because buyers, many of whom were small-scale operators, on the other side of the globe preferred to have the wool available for inspection prior to purchase. Consignment and importing agencies were also providers of credit and wool advances to growers. This had the effect of tying the grower to particular merchants, leaving them little capacity to decide how or through whom they would sell their wool. Moreover, banks in England clearly valued the flow and exchange of funds and were reluctant to see the business move to the colonies.

To achieve large sales in Australia first required a relocation of financial flows through Australian pastoral houses. As these gained more economic strength they found they could handle and compete effectively for the wool auction business.[34] With Australian woolselling brokers incorporating in England to draw on the English capital market, English finance houses then moved to Australia to maintain market share. In 1867, three firms began selling wool on a regular basis by auction in Australia: Elder Smith & Co., Luxmore & Co., and Priestly & Co. The main advantage for growers was the quick financial return from local sales. Permanent selling centres were soon created as the growth volume of locally sold wool required.[35] The

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[33] Private auctions were held in Melbourne on a periodic basis during the 1840s by Isaac Hinds, and the Bakewells and Bear & Son. Barnard, A., op.cit., p.52.

[34] The finance actually came from similar sources, but once the channelling of British capital through Australian financial houses occurred, this freed the grower from selling in London, if desired.

[35] Auctions began at the following centres under the direction of the early agents:

Adelaide	1840	Solomon
Sydney	1843	Thomas Mort
Melbourne	1848	Goldsbrough Mort
Geelong	1856	Olgilvie & Robinson
Ballarat	1869	Strickland & Sons
Albury	1895	Younghusband Ltd.
Brisbane	1898	Dalgety & Co. Ltd.; Messrs. B.P. Morehead and Co.; Fenwick and Co.
Hobart	1902	Webster & Sons Ltd

relocation of buyer-representatives in Australia to act on account of processing firms was facilitated by the installation of telegraphic links between Australia and England in 1872, and the ever-faster forms of ocean transport which made the move to Australia increasingly feasible. In addition, profiteering and escalating prices in the London market meant buyers found a commercial advantage in buying wool direct from Australia. The prospect of Australian competition also had the effect of improving these aspects in the operation of the London market. Local auctions grew rapidly, and by the end of the nineteenth century, around half the clip was auctioned in Australia. By the end of World War One, this had increased to nearly 70 per cent and to an estimated 92 per cent by 1970.

The wool selling system

The selling system consisted of wool auctions which brought together the grower's wool, the grower's brokers, and wool buyers who could be either overseas processors or more often their appointed agents/brokers/merchants. Only a few overseas mills had their own buying representatives and they generally relied on the local knowledge of wool-buying companies to guarantee the quantity and quality of the greasy wool supplied. The advantage was that if the wool purchased failed to meet specification, claims were made against the wool buyer generally at the end of the season. Woolbuyers (now called wool exporters) made purchases either to fulfil firm orders or to prepare for anticipated orders. This often amounted to speculative buying, and could be very lucrative especially if the market was rising. Manufacturers regularly made more out of astute changes in stocking levels than from processing wool. For their part the mills were reluctant to change woolbuyers, because once a working combination was established they would not risk moving. Even so, the number of claims for incorrect supply at the end of the season could be considerable (especially in dry seasons when a more tender wool was available).

The traditional auction procedure required buyers to visually assess the wool bales (identified by a lot and bale number) displayed for inspection on the 'show floor', nominate the lines they might buy, and set a valuation ready for bidding. Under agreed rules, a proportion of bales from each lot were displayed and a prescribed number of fully-opened and half-opened bales were made available for inspection.[36] The remainder were held in stacks ready for post-sale

Launceston	1911	A. Stewart Pty.Ltd. (amongst others)
Perth	1913	Dalgety & Co. and C.H. Fielding & Co.
Newcastle	1929	New England, North and North West Producers Co.Ltd.
Goulburn	1931	R.D. Gray & Sons
Albury	1963	Various existing brokers
Portland	1963	Ditto

[36] There was a set scale of 'showings' where small lots were fully displayed falling to 8 per cent of bales for lots greater than 100 bales. This required buyers to be even more careful and a system developed of taking samples from other bales to

examination by the purchaser to check the similarity of type to that displayed on the auction room floor. This inspection procedure prior to selling made it necessary for the entire clip to pass through the point of sale. At the end of the sale, wool was returned to the bale (fadging), re-weighed, and the bale caps resewn in readiness for shipment. With ownership transferred, the grower's broker would forward proceeds to the grower, after selling charges (and any lines of credit) had been deducted.

After purchasing, the woolbuyer then had to ensure the correct weight of wool was within the bale and estimate the yield of the wool. This was important because the woolbuyer was guaranteeing the processing outcome of the batch consigned to meet an order within a certain range and it was well known that the moisture levels in the wool could vary considerably. This was a larger problem for reclassed wools, so correcting and adjusting for weight-changes was constantly requiring 'in store' and 'out-of-store' weighings (the store facility bore the cost of any losses from the original weight). This was the reasoning behind the imposition, until World War Two, of the custom of 'draftage', whereby one pound per hundredweight (112 pounds) was allowed to the buyer to cover for possible weighing discrepancies.[37] All these selling foibles meant the grower was apt to lose a small fraction at every stage. The advent of wool testing established the real wool content which eliminated the risk of such losses, and removed the guesswork involved with estimating yield.

Resistance to improving the selling and description systems was encountered because accurate information about the wool offered for sale threatened to disturb their commercial advantage or even replace the need for intermediaries. It was feared that once processors were able to understand what sort of wool they required they would buy without woolbuyer assistance. Woolbuyers, therefore, became strong defenders of the craft approach to wool assessment, and the operation of the selling system basically reflected their preferences. They argued that as many bales would not be consistent or true to their labels some level of visual assessment would always be required, because commercially important attributes were not able to be objectively measured. Their position was understandable from a commercial point of view because once wool was bought, no line of compensation from the grower was available- *caveat emptor* applied.

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confirm evenness of the lot. Even though brokers tried to reduce the showing whenever possible, in 1947/48, 62.3 per cent of all bales sold in NSW were shown on saleroom floors.

[37] In the 1920s and 1930s, 'draftage' represented around 18-24,000 bales of wool annually.

Wartime wool-selling arrangements and Table of Limits

Two consequences of wartime exigencies were the development of the Table of Limits and the experience of controlled marketing of wool after World War One. Although the auction system continued in much the same vein until the late 1960s, important exceptions for what was to occur during the 1970s and 1980s were the selling systems created during both world wars and the post-war arrangements for selling the stockpiles that had accumulated. The purchase of the entire clip by the British government occurred part way through the first world war, and again negotiated prior to the commencement of the second world war. At the conclusion of both wars, arrangements were made for the disposal of the accumulated wool stocks in an orderly manner. During both wars, wool was 'appraised' on receipt to a central depot (see Section Two), and payment was made immediately. This was advantageous to many woolgrowers, especially small enterprises or sheep/wheat growers with broader wool, because it stabilised returns, but full-time woolgrowers felt it had held prices below what they might have otherwise received. As a consequence, there was significant debate as to whether controlled marketing would become a permanent arrangement, yet at every vote on the issue the proposals were defeated.

The Central Wool Committee and BAWRA.

After the outbreak of World War One, wool auctions continued as before and the price of wool rose to very high (and profitable) levels. In the early stages of the war, it became necessary to place an embargo on wool being sold to those countries suspected of trans-shipping wool to enemy countries, but the embargo proved difficult to police. With the Americans buying one-third of the clip (much more than normal), it was presumed some American firms could be diverting wool to the Germans. There was a suggestion to limit sales to American buyers, but asking growers to limit sales when demand elsewhere was falling would only have depressed the market, so this was not a popular option. British wool supplies were also becoming short, and having witnessed the French and Italians commandeering their own clips, they also moved to compulsorily acquire the entire British wool clip (at 35% above pre-war prices). However, when the leakages to Germany from the Australian market started to be substantial, the British moved to control supplies from the Dominions.[38] In October, 1916, Prime Minister William Hughes received a cable offering to purchase for three clear years (with an option for a fourth), the entire clip at a fixed price 55% above pre-war prices, a flat-rate of 15.5d per lb. Australia's rationale for acceptance was the:

[38] Dyason, E.C., 'BAWRA', *The Economic Record,* Vol. IV, February, 1928, pp. 51-67. The British increased the price to their wool growers, taking the price to 50% higher than pre-war levels in 1917, then 60% the next year.

... patriotic desire to fall in with the Imperial Government's war measures and the very natural preference for a guarantied profitable price, payable in cash as the wool arrived in port, rather than a problematical higher price dependent upon freight being available.[39]

Organising this purchase was an enormous logistical undertaking involving transactions to the value of £211,000,000. The Central Wool Committee (CWC) was created to coordinate the British government purchase. Headed by Sir John Higgins, it operated from 1916 to 1921. The purchase agreement stipulated that any profits from the sale of all wool sold during peacetime which exceeded the agreed price would be shared equally. The British processor could draw any amount of wool for military purposes at the wartime price. They determined who would be given wool, and insufficient allocations to the United States forced them to buy all the North and South American wool at twice or three times the Imperial wool prices. Similarly, European processors were forced to pay high prices, which helped maintain the competitiveness of British textiles. Moreover, by extending the clip-purchase beyond the period of the war, the British effectively controlled world trade during peace time.

Small-scale wool growers wanted the continuation of wartime marketing arrangements, but large-scale woolgrowers were against enforced marketing, as they looked forward to the prospect of higher prices when the free market opened again. Unhappily for all growers, higher prices did not eventuate. It was not until June 30, 1920 that the deal expired with the British, and despite world shortages, the postwar period experienced little movement of the stocks stored in Australia. Combining overseas production with the Australian clip, and including bales stockpiled, over five million bales were available in 1920 to a market that had only purchased 260,000 bales in the previous six months. By the end of 1920, demand and price levels moved sharply downwards, and much politicking between grower organisations took place during the second half of 1920, with a view to re-introducing a marketing scheme. The situation needed to be managed, and the British-Australian Wool Realisation Association (BAWRA) was established in January, 1921, again under the direction of Sir John Higgins. This organisation was entrusted with purchasing wool that could not be sold from the current season's clip, and to sell the British stockpiled wools when it was possible. This meant keeping accounts for around 149,000 growers.[40] Controls were put in place for the coordination of auction sales in London and Australia, and for price-fixation. The main proviso within the arrangement was that the quantity of wool put on offer in Australia must always exceed that of the London market. After some anxious moments in the early stages, within eighteen months the stockpile of wool was gone and in one year alone, three million bales of stocks were sold. The three seasons in

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[39] ibid., p.52.

[40] Sims,H., *A Message from BAWRA*, Endeavour Press, Sydney, 1933.

which BAWRA operated, prices rose to generate a surplus of some £32,000,000, half of which was distributed to Australian growers. After profits were distributed, the grower gained a good average price of 17.43 pence per lb or £24.14.0 per bale.[41] However, any profits made on wool surplus to British requirements (a small proportion of the whole) were relatively insignificant, given the reduced profitability from the controls during the postwar period.

During the operation of BAWRA, Sir John Higgins analysed the operation of the wool market and sought to introduce efficiencies related to shipping, appraisement methods, and reconditioning of the clip. As a consequence of his experience and knowledge, he became the best known advocate of an ongoing system of market stabilisation, and in 1922 he argued that agricultural returns would be higher should controlled marketing be continued.[42] He estimated the handling and appraisement efficiency that could be made from continuing such a scheme and proposed using BAWRA's unissued capital of £6,000,000 to fund the scheme. However, in what was one of the largest company meetings seen in Melbourne to that time, before the plan could be seconded by the meeting an amendment was moved to dissolve BAWRA because the stockpile had been liquidated. Brokers together with proxies meant the vote was carried six hundred votes to twenty, thereby ensuring the proposal was without a forum. Many growers subsequently regretted the lost opportunity, and doubted the circumstances would ever arise again to allow the creation of such a structure.

Having experienced BAWRA, small growers and sheep/wheat farmers continued to agitate for controlled marketing mechanisms during the interwar period at forums such as the 1930 Imperial Wool Research Conference held in England, and the 1931 Wool Inquiry Committee. Three proposals for orderly marketing were brought forward at the Empire Wool Conference in Melbourne in 1931 (one from Sir John Higgins) but they were all rejected. To appease the concerns of small growers, a Committee of Inquiry was set up by the Conference to investigate other options. In 1932, the Gunn Committee recommended that exports of wool be prohibited on wool which failed to reach a specified minimum price, or that sudden falls in the market be supported. It was suggested a Commonwealth Wool Executive be established to implement these options. Again, large grazier opposition prevented this from going ahead, and the Central Wool Committee was wound up in March, 1932, which removed the remaining organisational element through which controlled marketing could be operated.[43]

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[41] Longworth, S., 'The Australian Woolgrowers in Reverse', 29/12/45, ANU Archives of Business and Labour, E256/709.
[42] Sims, *loc.cit.*
[43] White, L.,*Wool in Wartime: A Study in Colonialism,* Alternative Publishing Cooperative, 1981, p.45.

2. EARLY RESEARCH INFRASTRUCTURE AND ASSOCIATED INNOVATION OUTCOMES: 1900-1930

As the nineteenth century concluded woolgrowers continued to be plagued by a number of production problems such as scab, flystrike, diseases, cactus, or dingoes. While a number of inventive devices and homebrew solutions were developed to tackle many of these problems, most met with limited success. For example, scab control was partly achieved with tobacco and sulphur infusions or lime-sulphur concoctions, but both methods were laborious and difficult to execute properly. The most successful among the early remedies for sheep ailments was the use of arsenic. First introduced in the 1840s, it was used for the next 130 or so years for various animal health treatments. The main emphasis was on expansion, capital development on farms and sheep husbandry operated at a very rudimentary level and stock management was basically reactive in response to observable problems The exceptions in respect to Merino breeding, land occupation, shearing and wool handling where the industry capacity for innovation was much more impressive.

Until the early 1930s increasing levels of production levels were almost entirely the consequence of geographic expansion, extensive land clearing activity, or the product of greater fleece weights from each sheep from breeding improvements. Although the 1900-1930 period saw the continuation of land occupation and clearing activity, it was essentially a transitional phase before the large-scale intensive development of high rainfall pastoral land became the main contributor to increases in output especially after the Second World War. The intensive development phase was delayed to the 1950 onwards because of low prices during the depression, the labour and capital constraints of the war, the expansion in the number of small-scale woolgrowers, and the inadequate level of scientific understanding to draw upon.

This was particularly evident as mentioned above once the drought of the 1890s had concluded. the environmental impact from the experience of pastoral settlement was costly and inevitable. For most areas, the clearing of land, grazing intensity, fencing, and water conservation activities quickly changed the natural habitat beyond recognition and infested it with wildlife and weeds unknown to Australia previously. Useful trees species, shrubs (mulga) and native grasses were removed almost entirely and the pressure on the remaining pockets of native vegetation became intense. With regeneration restricted, large areas suffered dieback either from beetle attack or old age. Pastoralists not appreciating the effects on grass species and grasslands of overgrazing, also precipitated a lowering of the long-term carrying capacity of many areas. It would take many years of research to more adequately tailor and adapt wool growing to the new ecological environment.

When it came to controlling rabbits, the solutions tried during this period were costly and the effectiveness was only partial. The problems of soil degradation and declining soil fertility surfaced early, although the effect was camouflaged to a large extent by the continually rising levels of total production and the aggregation of farms into very large holdings. Thus, the combined effects from land degradation, drought, overgrazing or rabbits on the productivity gains from the innovations of the period were counterbalanced. Thus in the pre-World War I period, the wool industry was mainly achieving absolute increases in production through the continued expansion into unoccupied land with only productivity increases largely flowing from Merino breeding improvements.

Early institutional activity

The earliest bodies within the colonies to foster better knowledge and improved farming techniques were the Inspector's of Stock or the agricultural societies and bureaux. The societies and bureaux principally assisted small farmers and intensive agriculture, and they received some financial assistance from state governments. With a growing enthusiasm for the 'advancement of science' a department of agriculture was established in Victoria in 1872. Support from the Victorian government was variable in the early years, yet it became an initiative soon replicated in other colonies or states.[44] The departments of agriculture supplemented and then gradually replaced the activities of the agricultural societies, although the agricultural bureaux continued to play a role in disseminating information to farmers, especially those involved with cropping, dairying and small scale horticulture.[45] The last quarter of the century also saw, agricultural colleges were established to train people to serve in various state bureaucracies, as well as extension officers in the departments of agriculture. A close relationship developed between agricultural colleges and the departments as a consequence.[46]

Until CSIR was established, government funding of rural research was confined to CSL and by state governments and undertaken by their respective Departments of Agriculture. The rationale for their involvement at the conclusion of the last century, was to by ameliorate the problems encountered by farmers and thereby stem the decline in land sales (and hence

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[44] Departments of agriculture were established in 1887 in Queensland, 1890 in New South Wales, 1897 in Tasmania, Western Australia in 1898 and 1902 in South Australia.

[45] Tribe, D.E., and Peel, L.J., 'Innovation, Science and the Farmer', in Technology *in Australia 1788-1988,* Australian Academy of Technological Sciences and Engineering, Canberra, 1988, pp. 17-19.

[46] The first college was Roseworthy in South Australia, begun in 1885 under the Professorship of J.D. Custance. This was followed by Victoria, in 1886, with the establishment of Dookie in north-eastern Victoria and a second Victorian College at Longerenong was founded in 1889.; Hawkesbury in New South Wales was set up in 1891; Gatton College in Queensland opened its doors in 1897; in Tasmania a college, which did not survive for very long, was created in 1915; the Muresk Agricultural College was founded in Western Australia 1926. After the war colleges were created at: Wagga, NSW 1949, Marcus Oldham, Victoria, 1962, Yanco, NSW, 1963, C.B. Alexander, (Tocal) NSW, 1965, Longreach, Queensland, 1967, Emerald, Queensland ,1971, Glenormiston, Victoria, 1971, Orange, NSW, 1973.

revenue), and prevent 'out-migration'. The focus was on intensive rural industries, even though it was the larger export industries based on extensive agricultural systems would, by the very nature of its size, provide significantly greater community benefit.

Early research work specifically for the pastoral industry was undertaken by the state departments. This work was mostly confined to supporting the regulatory functions of the departments such as animal health inspection, control of stock movements to limit the spread of disease, or enforcing the control of noxious weeds. The departments of agriculture (Inspectors of Stock and Stock agencies) helped in regulating stock movements, monitoring the spread of diseases, and providing husbandry advice. Diseases and sheep ailments often caused havoc in some areas. In the interwar period, some of these activities were formed into specialized offshoots such as Pasture Protection Boards, Noxious Weeds Boards, Soil and Water Conservation bodies and so on.[47]

Prior to 1929, an important exception to the general focus on small landholder was the New South Wales Department of Agriculture (NSWDA). The NSWDA established an experimental farm and Merino stud for research in Trangie in 1914 after negotiations and representations from the local community and the State Ministers.[48] The initial objectives for the experimental farm were:

> * *to establish a Merino sheep stud;*
> * *to provide training facilities for those interested in Merino breeding; and*
> * *to conduct experiments and demonstrations to determine wheat growing methods most suited to the district.*[49]

This was to be the vanguard facility for breeding research and, in the same leadership vein, the main centre for wool textile research was the Wool Industries Research Association (WIRA). WIRA was first conceived during World War One, as a way of closing the technological gap that had opened up in textile production between Germany and England.[50] It was established in 1918 as the British Research Association for the Woollen and Worsted Industry, and in 1930 changed its name to Wool Industries Research Association. Initially funded on a voluntary

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47 In NSW the Pasture Protection Boards handled stock routes, drought declarations, weed declarations, and stock movements and the NSW Soil Conservation Service deals with management of soil degradation, dryland salinity and the maintenance of soil fertility. Similarly in other states, DA's regulated land usage to protect and maximise the productive capacity of agricultural industries within each state.

48 On the 2nd of November, 1914, Mr A.E. Shirlaw, Sheep and Wool Expert, took control of the Mullah Scrub Lease for the proposed experimental farm. The amount of land from the Scrub Lease was extended: a total of 4091 ha (9000 acres) was taken up, and a total price of £7214 paid. The first move to start what is now know as the Agricultural Research Centre Trangie was the reservation on September 1st 1909, from Mullah Scrub Lease 162, comprising an area of 1318 Ha (2900 acres) for the purpose of an establishing an experimental farm, which was then held by the Executors of the late A.S.C. Beveridge. Trangie *1987 Research Report*.

49 ibid., p.1.

50 'Wira - Past, Present and Future', in *The Journal of the Bradford Textile Society*, 1977/78, pp.40-9.

basis by the textile industry in England and Scotland, it had an annual income of around £12,000. WIRA also had a number of financially supportive member organisations in Australia, such as the AWGC (and the WRTF later on) so even at this stage woolgrower funds were directed to sustaining a textile research programme.

Early institutional research activity

Before the first world war, only a couple of universities had any involvement with research relevant to the wool industry. Funds were always in short supply, and staff could not devote much time because teaching commitments took precedence.[51] University training places were limited and confined to undergraduate studies. With the demand for rural research scientists or extension officers running well ahead of supply, many of the research and teaching appointments were filled by overseas postgraduates or by Australians who had studied abroad. In the 1920s only one student, Ian Clunies Ross, was in final year of veterinary science at Sydney in 1921 and in 1927, the Veterinary School of Melbourne was closed for lack of students. [52] Then between the world wars, the already inadequate level of funding for university research was exacerbated by falling benefactor contributions. This further curtailed any capacity for the universities to provide the basic research base for wool industry innovation or to produce the requisite numbers of research scholars. As a result, university departments remained undergraduate teaching establishments until well after 1949, by which time the Commonwealth funding of universities was providing the opportunity for them to engage in research.

In the case of the state departments of agriculture, by the first world war these had grown into much larger and well organised bureaucracies, with numerous experimental farms to help promote extension work for small acre agriculture. Unfortunately, basic research and applied research related to the many problems confronting the pastoral sector were inadequately funded or staffed because the demand for extension required all the available resources. This was largely the product of both a lingering (and widely held) perception that the future lay with farming and small-scale enterprises. The partial exception was the NSW Department of Agriculture in NSW where the size of the sheep flock meant they had considerable opportunity to benefit from any outcomes.

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[51] A Faculty of Agriculture was created in Melbourne in 1905. An agricultural faculty began in 1927 in Queensland University, whereas the University of New South Wales established its faculty in 1949. Tasmania followed in 1962, and LaTrobe University in 1967. The University of Adelaide had a useful programme of research before 1950; Sydney and Melbourne were doing small amounts of veterinary work; and the University of Western Australia was working on clover varieties; feed rations and lupins trails.

[52] Schedvin, C.B., *Science and Industry* , Allen & Unwin, Sydney, 1987, p.10.

Taken together, these early research arrangements were inadequate for addressing wool industry needs and except perhaps for Commonwealth Serum Laboratories (see below) they lacked a national or pastoral sector focus. They did not constitute a stable structure for long-term research programmes and there were almost no specialist wool-research scientists to do the work. Thus before CSIR entered the scene in 1926, the research efforts were small, underfunded, uncoordinated, unrelated to each other and unable to create or sustain an adequate scientific elite for the benefit of the wool industry. Combining scientific excellence with better funding, the CSIR filled this role in the research area as well as with extension until such time as the Departments of Agriculture were better funded and staffed in terms of wool research.[53] In this general milieu of struggle and underfunding, the outposts in the early research industry in Australia, were the Commonwealth Serum Laboratories (CSL), the Commonwealth Science and Industrial Research (CSIR) body, and the Waite Institute.

Disease control in sheep: private sector and Commonwealth Serum Laboratories est. 1916.

For the most part, Australia has been fortunate in avoiding many of the most virulent exotic diseases, these being kept out by a combination of distance/isolation national quarantine restrictions, state regulatory powers and luck.[54] Until vaccines were developed, even the less virulent livestock diseases imposed considerable costs in Australia. For example, black disease was a serious enzootic disease of sheep with a study in 1930 estimating losses at over £1,000,000, with mortalities of 30, 40 or even 50 per cent of flocks in some areas not uncommon.[55] The first vaccines for sheep diseases were developed and used in the 1920s. In the years that followed, vaccines for anthrax, tetanus, brucellosis, pleuropneumonia, swelled head in rams, pulpy kidney (entero-toxaemia), blackleg, and black disease were created so that by 1950 most losses from disease were preventable. These vaccines came from CSIR/CSL laboratory work, or from Australian drug companies. Thereafter, significant losses resulting from the clostridal bacteria were rarely experienced, and the protection was taken for granted. Only failure to vaccinate, or ineffective vaccination were the cause of sheep losses.

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[53] Currie, G., and Graham, J., *The Origins of CSIRO: Science and the Commonwealth Government 1901-1926,* CSIRO, Melbourne, 1966, Schedvin op.cit., or Rivett, R., *David Rivett: Fighter for Australian Science,* Melbourne, 1972.

[54] Until recently, even specimens for diagnosis were prevented from entering the country for fear of their introducing disease. Suspect samples had to be sent overseas, which restricted the ability to quickly verify outbreaks. To assist in this respect, a Maximum Security Laboratory (Australian Animal Health Laboratory) was established in Geelong during the mid-1980s. The establishment of a quarantine station on Cocos Island has allowed the entry of disease-free new genotypes into the mainland.

[55] Brogan, A.H., *Committed to Saving Lives,* Hyland House, Melbourne, 1990 pp. 49-50.

Born of a wartime need for human vaccines and created through an extension of the quarantine provisions of the Constitution, the CSL began its operations in 1916.[56] Though created to produce vaccines for human consumption, the close connection between animal and human forms of contagion made the move into veterinary matters a natural spinoff. Commercial operations at CSL began in the early 1920s with products for the diagnosis of diseases such as tuberculosis, but this soon expanded into the sale of products for the prevention and treatment of disease. In 1924, CSL's first veterinary price-list was issued and it included two serums, seven vaccines and five tuberculins. The first vaccines were for black disease, blackleg and entero-toxaemia, mainly for use in Western Australia. Diagnostic tests for anthrax were available, providing departments of agriculture and local vets facility for sample-analysis. The facility moved from Parkville to Broadmeadows in the middle 1930s, which allowed the veterinary area to expand further.

The CSL research improved existing vaccines by blending them to make single inoculating operations possible and also engineering them to suit specific geographic needs. Treatments for pulpy kidney, tetanus and blackleg were combined, and later the now familiar five-in-one vaccines were developed. Most recently, vaccines containing selenium for areas where it is required has extended the range of multiple vaccines. Since the Second World War the CSL research work concentrated on the cattle industry, although a vaccine against the very prevalent sheep disease, cheesy gland, was developed, and became the largest selling veterinary product for CSL.

In performing this veterinary and vaccine role, the CSL supplemented the active private sector supply of animal vaccines from firms such as 'Websters' who had begun their operations on the basis of discoveries made by Dr Bennetts. For example, enterotoxemia (as the disease later became known) first appeared in Australia after the turn of the century; between 1915 to 1930 it became a widespread condition, especially in Western Australia, where it was known as 'Beverly disease'. Outstanding research by Dr. H.W. Bennetts showed that enterotoxemia was caused by absorption by the intestines of toxins released during the breakdown of bacterial cell walls. 'Endotoxins' secreted by bacteria were already known about, but Bennetts' discovery of a bacterial 'exotoxin' was a completely new concept of disease which ranked highly among Australia's contributions to world research on diseases. It was later found that diphtheria and the clostidial groups of diseases, including botulism, tetanus and gangrene black disease, were also caused by these bacterial exotoxins. Dr. Bennetts developed a vaccine the derivation of which is still used world-wide against diseases in sheep, cattle and goats. Botulism was another

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[56] In 1918, CSL moved to permanent buildings in Parkville in Melbourne. The laboratory also developed an animal house for production and experimental purposes at Royal Park. Brogan, A.H., *Committed to Saving Lives: A History of the Commonwealth Serum Laboratories*, Hyland House, Melbourne, 1990, pp. 46-56. CSL was privatised in the early 1990s.

disease causing considerable economic loss. For example, during the summer of 1932-33 over 100,000 sheep were thought to have died of the condition. Dr Bennetts outlined how to manage sheep in order to control the disease and developed another vaccination to deal specifically with this condition.[57]

Waite Institute.

Before 1950, the exception to the general position of chronically underfunded wool research capacity in universities was the Waite Institute attached to the University of Adelaide. The Waite became a significant contributor to wool research, with research funds largely obtained via personal benefactions, state government funding and later, direct Commonwealth grants. It was started by an endowment from Peter Waite in 1922.[58] He left an area of almost 300 acres at Urrbrae, and a bequest to support agricultural research and the establishment of an agricultural high school.[59] The Institute was formally opened in 1925, and with further donations from Melrose, Darling and Mortlock, three wings of the building were constructed and named after them.[60] The Waite research facility also provided the early base for fir a number of Divisions of the CSIR. The Soils Investigation Section was formed in 1927 by J.A. Prescott who had come to the Waite in 1924 to become Professor of Agricultural Chemistry. In 1929, after the University and the CSIR received a bequest from the John Darling estate to establish the Division of Soils Research, he became its first Chief.

New South Wales Department of Agriculture and Fisheries.

The NSWDA developed out of the Stock Branch established in the 1860s within the Colonial government of NSW and a liaison between it and the Hawkesbury Agricultural College around the late 1880s. At this time, sixty or so sheep districts were serviced by 48 inspectors with a

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[57] Fels, H.E., and Quinlivan, B.J., 'Value for Money in Rural Research', *West Australian Department of Agriculture*, October 1978, p22.

[58] This period was very much one of philanthropy, but one from which the CSIR did not often benefit. Another university example involved the Berry Estate which provided £5,000 to the University of Sydney to establish a School of Agriculture and Veterinary Science in 1910. Similarly in Western Australia Sir Winthrop Hackett gave £18,000 for the endowment of a Chair of Agriculture in 1913. The University of New England (1954) was initiated by the gift of land and buildings to house the institution. The University of New England research farm, north of the university, was also provided by an endowment from a local grazier.

[59] Even in 1905, the University of Adelaide offered already trained students from the Roseworthy College the opportunity to complete a B.Sc. T he University provided the first and fourth years of training; Roseworthy the second and third. But the form of theoretical and applied training became more active after 1924; when the Waite Institute was founded within the University of Adelaide in 1925, it became much better funded and available to do more research and training of students. Edgeloe, V.A., *The Waite Agricultural Research Institute: The First Fifty Years 1924-1974*, Waite Agricultural Research Institute, 1984, p.5. Until the Melrose Laboratory was completed in 1928 the work was conducted in the stables of Urrbrae House. See also Twidale, C.R., Tyler, M.J., and Davies, M., *Ideas and Endeavours - The Natural Sciences in South Australia,* Royal Society of South Australia, 1986, p.69.

[60] Schedvin, op.cit., p.75-6.

view to stabilizing the spread of diseases and advocate practices (innovative for the time) of fencing and sapping.[61] Although the colony was more-or-less free of scab and catarrh by the 1890s, anthrax, footrot, sheath rot, liver fluke and other parasite interactions such as lice and ked were very common, and all subject to regulatory control. Anthrax was the disease that required the most activity, especially in the 'anthrax belt' on the slopes and plains, and vaccination and quarantine were the main methods of containment. The Stock Branch had a group of veterinary officers who were involved in research and contributing articles to the *Agricultural Gazette,* the journal of the NSW Department. The calibre of these officers was such that one of the early veterinarians, J.D. Stewart, active in the area of controlling cattle tick, became Chief Inspector of Stock (1896-1909), then went on to the University of Sydney to become its first professor of veterinary science. However, in terms of a dedicated research capacity for the wool industry, it was not until after the turn of the century that the NSWDA became an important player.

In this respect the NSWDA developed a significant capacity to undertake entomological, chemical and economic research. In entomology, the work with *Cactoblastis cactorum*, locust control and the blowfly problem were three important areas. In the control of prickly pear, the Department cooperated with the Commonwealth Prickly Pear Board (formed in 1920). With work on the sheep blowfly, it was the NSW department which first tried jetting sheep with an arsenical formula in 1923. They also pioneered much of the applied economic research measuring such things as the comparative costs of new chemicals and rates of application for weed control.

In the first quarter of this century, a number of demonstration farms and agricultural colleges were created. Two of these were important for wool research: namely, the Trangie Research Centre, and, in recent years, the Agricultural Research & Veterinary Centre in Orange. To service these epicentres of activity a veterinary laboratory was essential.[62] The growing number of specimens collected by district stock inspectors for diagnostic tests, and the pathology, bacteriology and parasite work maintained the workload for such a facility. In response, the Glenfield Veterinary Research Station was opened in 1923, and Dr. H.R. Seddon was appointed as its first Director.[63]

It was not until the 1950s that positions of District Agronomists were created to advise on deficiencies, fertiliser, pasture and weed problems, supported by a Plant Pathology Branch.

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[61] The Stock Branch zones were later reformed into Pastures Protection Boards to administer the NSW Pasture Protection Act.

[62] Mylrea, P.J., *In the Service of Agriculture: A Centennial History of the New South Wales Department of Agriculture 1890-1990*, NSW Agriculture & Fisheries, Sydney, 1990, p 157.

[63] In 1936 Dr Seddon went to the University of Queensland to become professor of veterinary science. Mylrea, ibid., p.125.

These were established to link in with the work of CSIR/O and facilitate the directions of government policy in connection with raising the level of agricultural production through pasture improvement. Similarly, research on pasture establishment and related rhizobia work continued, with extensive research into natural and introduced species and cultivars. The first experiments with sown fertilised pastures were in 1940 at Glen Innes, and the effect on nutrition and breeding was observed through the 1940s, around the same time as the CSIRO began similar work in Armidale. The research programme examined numerous grasses species, soil fertility, the nodulation of legumes and explore the methods of pasture establishment, management and maintenance. Given the regional variation, nearly all the research centres needed to be involved with pasture research in some capacity. Soil-sample work and fertility assessment procedures were developed and extended.

Formation of CSIR.

Even though the Commonwealth ultimately set the pace in advancing agricultural research, it was initially reticent about funding scientific research. In the years before the first world war, its financial commitment or organisational zeal did not match its political rhetoric. For example, the attempt to set up a Commonwealth Bureau of Agriculture just before World War One was a complete failure. After more recommendations on possible structures were received and the national benefit from having more trained scientists was highlighted in the British White Paper on research issues tabled in the House of Commons in 1915 (which was widely read in Australia) the push to do something was renewed.[64] The establishment of the Department of Science and Industrial Research (DSIR) in Britain in 1916 provided a model of a fully independent organisation capable of ensuring research freedom for the Australian government to emulate.[65] In particular, this galvanised W.M. Hughes to establish the Advisory Council of Science and Industry late in 1916. The purpose of this transitional body was to call for, consider and fund projects until such time as a full research institute could be created. In 1920/21 the Institute of Science and Industry was set up, with the research budget evenly divided between a Bureau of Agriculture and a Bureau of Secondary Industries. To ensure effective use of facilities and prevent overlapping, the Institute was required to co-operate closely with state research organisations. Unfortunately, the Institute experienced difficulties, and was short lived.

Around the same time, the Imperial Conferences of the early 1920s were actively encouraging collaborative national research efforts across the Empire. As a result, under the auspices of the

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64 Currie and Graham loc.cit.

65 Tribe, D.E., and Peel, L.J., 'Innovation, Science and the Farmer', in *Technology in Australia from 1788-1988,* Australian Academy of Technological Sciences and Engineering, Canberra, 1988, p.24

Empire Marketing Board, substantial funds were made available to member states and colonies for rural research. To take advantage of these funding opportunities, and after advice from those involved at DSIR, the Institute was superseded by the Commonwealth Council for Scientific and Industrial Research (CSIR) in 1926 - the same year as the Empire Marketing Board and the New Zealand Department of Science and Industrial Research were established. The Empire Marketing Board provided important research finance during the early years of the depression, which allowed the organisation to continue. After consultations between scientists and the states on possible formats, as well as advice from the secretary of the British DSIR, Sir Frank Heath, the emphasis was given to organisational flexibility and independence within the new structure. Heath also suggested provision be made for the training the future supply of scientists which led to the CSIR being given the capacity to grant scholarships and studentships, through the establishment of a special trust fund.

Operation of CSIR.

The CSIR's first statutory commitment was to coordinate the entire research effort, and only after this was the organisation permitted to fill any research gaps by conducting its own research. The CSIR was also to allocate research grants to universities when projects suited their own 'national' objectives. In this way it was envisaged CSIR would balance the research and coordination roles, but in a research void and because this was not legislatively stipulated, the CSIR rapidly expanded its own research capacity. The mirage of 'cooperative federalism' allowed the CSIR to develop as it wished and fill the research void rather than follow a coordination role and with implicit government compliance, CSIR became a national research body and attracted the bulk of research funds subsequently available from the Commonwealth. Professor Schedvin highlights this capacity:

> *The outstanding feature of CSIR's constitution was its ability to blend ingeniously the political dictate of co-operative federalism with the seemingly irreconcilable ethos of scientific autonomy." In the second reading speech of the Prime Minister when the bill for establishing the CSIR; "The purpose of the Government is, not to create a great new centralized institute of research, but, for the benefit of both the primary and secondary industries, to bring about co-operation between existing agencies and to enlist the aid of the pure scientist, the universities and every other agency at present handling scientific questions."* [66]

Unlike the DSIR, the CSIR focussed predominantly on agricultural research. This accorded with the existing orientation of the national economy, and the external sources of funding from individual donations, the contributions of banks or pastoral houses, and from bodies such as the Carnegie Foundation. The five original areas of priority for the CSIR were plant pests and diseases, animal pests and diseases, food problems, forest products and fuel problems. In the

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[66] B. Schedvin, op.cit., pp.24-25.

period 1928-30, six divisions were established, of which five were in some way connected with the problems of the wool industry.[67] These were staffed with the best scientists available, many from overseas. The first Chairman of CSIR, A.C.D. Rivett, believed that to establish a reputation for the organisation preference for rural research was essential, and that only over time could the substantial move to more industrial research take place.[68] The longevity of CSIR (and therefore the success of science in Australia), was very much dependent on the outcomes achieved in the partnership with the wool industry. To protect the research results in the early period, the CSIR delivered much of the extension and demonstration work.[69]

Despite the limited level of research activity during the 1900-50 phase, a few spectacular successes enhanced science's credibility and made the prospects for similar successes appear extremely good. The first of these was in the area of disease prevention and treatment because by 1950, a number of sheep diseases were able to be controlled.[70] The next was in controlling the prickly pear infestation.

Prickly pear.

It was the prickly pear success more than any other episode during this period, which confirmed the potential contribution of science. Prickly pear is a cactus from South Africa which had spread and rendered unusable around 10.5 million hectares in South-eastern Queensland and Northern NSW. Altogether, six species of prickly pear were introduced from South Africa, and were estimated to be spreading at a rate of about 0.5 million hectares a year. By the end of the long drought, its spread was unchecked, and by 1920 it covered over 24 million hectares (60 million acres). The main area of infestation was in the pastoral country of Queensland and NSW from Nebo to Maitland and westwards to Charleville. Arsenic was effective, but the cost of the compound and its application were prohibitive. In fact, in all of the known control measures, cost considerations were the biggest barrier to effective eradication, because the value of the land and the level of productive capacity could not fund the expenditure required to control the weed.

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[67] The six divisions were Animal Nutrition, Animal Health, Economic Entomology, Plant Industry, Soil Science, and Forest Products. The most important for the wool industry was the Division of Animal Nutrition, based in Adelaide in the University grounds. One section of the Division operated with the Waite Institute, and liaised with a number of privately owed research stations. Experimental work was established on stations at "Kolendo" (west of Port Augusta, S.A.), "Dismal Swamp" (near Mt.Gambier), "Niawanda" (near Beaufort in Victoria), "Wanganella" (near Deniliquin in NSW), "Wambanumba" (near Young, NSW), "Keytah" (near Moree, NSW), "Meteor Downs" (near Springsure, Queensland), and "Peak Downs" (north of Capella in Central Queensland). The work was conducted in close association with the owners, who provided the animals required for experiments. Each of these had a particularly severe problem to which research could be advantageously directed.

[68] Dr Rivett's speech recorded in *Report from the Imperial Wool Research Conference*, Lister, 1930, p.43.

[69] Rivett, op.cit., pp.155-6, p.190, and p.207.

[70] One of these in the area of animal health was the treatment against anthrax in cattle, a vaccine first developed by a NSW pastoralist in 1894 which, with further research, became widely used in the 1920s.

To coordinate the research into solving the problem, the Commonwealth Prickly Pear Board was established in 1920 to organise and fund investigations into natural enemies of the prickly pear. In the four years, 1920-1924, scientists from Australia went to the United States, Argentina and Mexico to investigate the natural enemies of prickly pear.[71] In what was possibly the first foray of entomology in Australia, the insect selected after much detailed enquiry was a moth called *Cactoblastis cactorum.* The larvae were brought into Australia in 1925 and reared into large numbers, before being released experimentally in 1926. By 1930, more than three thousand million eggs had been distributed. Over the next ten years, the moth had consumed virtually all the prickly pear in Queensland and New South Wales.

Flystrike.

Blowfly strike was the other scourge of the industry that required a scientific response. It has been and remains a large cost factor to the industry and certainly the most costly external parasite problem, followed by lice, and then ked.[72] Flystrike was not reported in Victoria and NSW until 1897, but it spread quickly so that by 1938, the annual loss of income it caused was estimated as this time to be 6 per cent of gross income. At the turn of the century, the main form of control of blowflies was arsenic-based insecticides and the dressings for flystrike were based on a mixture of arsenic, boron, copper and phenols. These gave 3 to 5 week's protection, but they were toxis to handle and therefore dangerous. During this period, the task during the fly season was indeed onerous. The sheep had to be checked at least twice a week, and treatment was time-consuming and unpleasant. Equipped with a pair of shears, 'blowfly oil' (*Coopers Milk Oil Fluid*) and dogs to hold the sheep in a corner of the paddock, the task was laborious and continuous in the blowfly season.

The earliest fundamental research on blowfly was probably that by W.W. Froggatt at the turn of the century.[73] He published a paper on the blowfly in 1904, and some years later was still discovering and naming new species of native flies. Blowfly research was also done at Trangie, Nyngan and Cunnamulla, where problems with strike were severe. Though much is now understood about flystrike, cheap comprehensive solutions have not been found. It was established that the species *Lucilia cuprina* was the main culprit in 90% of first strikes inflicted on sheep. It was also found this fly depended on the sheep remaining alive to complete its life

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[71] There was apparently an earlier Committee which applied for and received funding to import the moth, but all the insects died in transit so, with the money spent, the attempt folded. It was some years before the second committee was formed, after it was realised the first consignment had not been tried. Alistair Mackenzie, Personal Communication, 28/9/1993.

[72] Ked were first recorded in Australia in 1940 by H. Carter.

[73] W.W. Froggatt was working for the NSWDA at the start of the century and appears to be the first entomologist to work on the problem of blowflies.

cycle, and it rarely completed a life cycle on a dead animal, which meant a carcass was generally consumed by other maggots (such as the hairy-maggot blowfly). This established that contrary to popular belief and practice the removal of carcasses from the paddock as soon as possible was of little control benefit. It was also shown that blowflies prefer wet habitats, and although blowflies can travel long distances, most remain close to where they are bred.

The presence of lice in sheep is usually not detected until the some in the flock become sufficiently infested to scratch and rub. This mats and tears the fleece, affecting its processing performance and therefore its value. Treatment practices varied considerably across the industry. Lice were especially common in western or low rainfall areas where "dipping" was not practised as an annual operation. In other areas, even though there was no positive detection of lice, treatment was routinely undertaken. With lice and sheep ticks, most of the early chemicals used in dips did not kill the eggs or pupae, so it was necessary for the active chemical to remain in the wool for some weeks ready to kill the parasites as they hatched. Research established that the lice often remained on the neck, the result of bad dipping-practice. This left a residual population of lice to repopulate during the winter, requiring farmers to dip as a yearly operation.

Worm infestations

The earliest worm-drenches involved the use of bluestone (copper sulphate) and arsenic against Black Scour worms, and were distributed by firms such as William Coopers & Nephews or Wilcox Moflan. This was the treatment used by Ian Clunies Ross at "Frodsley" in Tasmania in 1932, when researching the oesophageal groove reflex.[74] These early drenches were cheap and fairly reliable, although the technique of using copper sulphate to elicit a swallowing reflex failed in 10 to 20 percent of cases because the drench was delivered into the rumen, rendering it ineffective. At this time, drenching routines were more random, and generally administered in response to visual evidence of a problem, which in most cases was too late to prevent production losses. The treatment for liver fluke consisted of using bluestone to kill fresh water snails (the intermediate host for liver fluke). Prevention also involved the drainage of swampy areas or the application of 20lbs of copper sulphate to the acre. In dams, it was recommended to drag bags containing bluestone crystals until water was faintly blue. This was an inexact method because the water snail populations would soon build up again, or be transferred from

[74] The oesophageal groove reflex is stimulated by swabbing the back of the sheep's tongue with copper sulphate and waiting 20 seconds before administering the active ingredient. It was necessary to produce this response so that the drench delivered to the correct area of the sheep's stomach, otherwise it was ineffective. If bluestone was in the drench, then it has to be administered slowly, squirting a little first, waiting for the reflex, then completing the dose and hopefully getting the rest into the fourth stomach.

neighbouring properties after heavy rain. In very troublesome areas woolgrowers resorted to fencing these wet areas and grazing with cattle.