CHAPTER 7

AGRICULTURE — LAND USE

arranged by

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"Man has always held the past in high esteem; otherwise his knowledge of his environment would be limited to the experience of his own generation, and each individual would have to start anew his voyage of discovery through the complexities of nature."

The Foundation Years

Agriculture, in its broadest sense, has been practised in Australia from the earliest days of European settlement. The first farm was located where the Royal Botanic Gardens now stand, fronting Farm Cove. What might be called the first crop of wheat (200 bushels) was harvested in the Parramatta district (Rose Hill) in 1789, and in 1790, James Ruse, our first individual farmer, sowed by hoe and brought to harvest one and a half acres of bearded wheat and half an acre of maize at Experiment Farm. His success led to his receiving the first official grant of land (30 acres) to be soon followed by land grants to William Reid (60 acres) and Robert Webb (80 acres) and to more than 20 others. In 1791, William Shaffer grew our first tobacco crop (140 acres) in the neighbourhood of Vineyard and Subiaco Creeks. The same year, the first grapes were harvested on the site of old Government House, Parramatta.

In 1793, Captain John Macarthur, of the New South Wales Corps, was granted 100 acres of land which was to form the nucleus of Elizabeth Farm Estate. The following year he received a second 100 acres as a prize to the first man who should clear and cultivate fifty acres. Four years later, Mrs. Macarthur wrote that she had 120 acres in wheat, extensive plantings of fruit and vegetables and that her husband had set a plough to work, "the first that was used in this country".

Agriculture, horticulture and sheep and cattle breeding gradually expanded along coastal river valleys, particularly along the Hawkesbury and Nepean Rivers, but for almost the first hundred years, pioneer squatter-pastoralists dominated the agricultural scene.

Macarthur stands out as the pioneer of the pastoral industry and, incidentally, of the agricultural and mixed farming industry as well. In 1802 he is recorded as possessing 3,950 acres and owning 2,750 sheep and being "by far the principal land holder and pastoralist in the Colony". By this time, some of his sheep were merinos. The first merino sheep were brought to Australia from Cape Town by Captains Waterhouse and Kent in 1796. While their supply ships were anchored in Table Bay, a small flock of merinos was, by chance, put up for sale. "It seems that the King of Spain had presented a few merinos to the Dutch Government. The climate of Holland was entirely unsuitable, and some of them were sent to South Africa in charge of Colonel Gordon. A short time before the Australian ships arrived at Cape Town, Colonel Gordon died, and his widow decided to sell off and return to Europe." The speculative purchase by the two naval captains was a most fortunate one for Australia's future. Macarthur is reported to have offered £15 per head for the whole consignment of about 30, but Captain Waterhouse kept a few for his own property and sold the remainder to a few individual land holders besides Macarthur. Macarthur obtained three rams and five ewes. It seems that Macarthur was the only one to keep a proportion of his merinos separate from other breeds then in the Colony, and thus to build up a small flock of pure merinos at Elizabeth Farm.

Macarthur was of an energetic but quarrelsome disposition. He had disputes in succession with Governors Phillip, Hunter and King, and following a duel in which he wounded his superior officer, Colonel Paterson, he was sent to England under arrest in 1801 for trial by court martial, and there he remained for four years. He, however, made good use of his time. He promoted Australian wool as "being equal to the very best obtained from Spain" and finally received general and official recognition of his advocacy. He returned in triumph to Sydney in 1805 in the *Argo,* a ship he had chartered, with six pure merino sheep selected from King George's flock at Kew, and a promise of a grant of 5,000 acres in a district of his own choice and the services of thirty convicts as shepherds. Following some debate with Governor King, Macarthur was finally given a grant of 5,000 acres of the "Cowpastures". This was increased to 10,000 acres in that area, and later became known as Camden Park. "From the small consignment from South Africa and the six from King George's flock at Kew, a few imported from England by Rev. Samuel Marsden and one ram presented by the Duke of Northumberland to Major Johnson, the great merino flocks of Australia have been built up, although there were quite a number of importations from time to time in later years."

Exploration and expansion of the pastoral industry was the pattern of land use during the next half century or so. For several generations, life in the Colony revolved around sheep and wool. In May, 1813, a crossing of the western ramparts of the Colony, the Blue Mountains, was effected by Blaxland, Lawson and Wentworth, to be followed in two years by the selection by Governor Macquarie of a site of a future town at Bathurst. The fertile country around Bathurst was quickly taken up by graziers, and following Oxley's explorations of 1817 and 1818, their penetration continued along the valleys of the Lachlan and Macquarie Rivers and soon north into the Liverpool Plains. By the time Governor Macquarie left the Colony in 1822, its population had grown to nearly 39,000 and sheep numbers to 290,000 and cattle, 103,000. A new realm had been opened. It was now certain that for 400-500 miles west from Sydney there were vast areas of well-watered country where great flocks and herds could pasture and large communities of people could thrive. The attitude of the British Government towards free settlement in Australia changed and newspapers began to advertise the attractions of New South Wales as a field for immigration. Exploration continued. Hume and Hovell penetrated into Victoria, and Allan Cunningham into the rich Darling Downs of Queensland. Settlement had commenced on most of the coastal rivers and also in the Southern and Northern Tablelands, and following Sturt's solution of the "problem of the rivers" in 1828-30, the rich country adjacent to the Murrumbidgee and the lower reaches of the Lachlan and parts of the Murray became available.

An event of considerable importance was the formation in London by royal charter, in 1824, of the Australian Agricultural Company. The Company was formed at the instigation of Mr. John Macarthur, son of Captain John Macarthur, and was given a free grant of one million acres of land in New South Wales in any selected area that would not interfere with other settlers. In the following year, two ships were despatched with 700 merino ewes and rams, a party of shepherds, and a number of thoroughbred horses and cattle. The area first selected for settlement was between the Hunter and Manning Rivers. This was found, however, to be more suitable for cattle than sheep, and following negotiations, the British Government agreed to about half a million acres being in the Liverpool Plains and Tamworth districts. The operations of the Australian Agricultural Company are reported to have led to a form of "sheep and cattle mania" in the Colony. People vied with one another to possess some sheep and cattle, "being determined that the Australian Agricultural Company should not be the only reaper of the golden harvest". In the midst of this, a severe drought (1828-1830) struck, and many were ruined. A financial crisis had occurred in 1826 and a prolonged depression from 1828-1830. Crops failed and stock died, but one important outcome of the drought was the emphasis given by Governor Darling to further exploration, seeking better country, and the resulting extensive discoveries by Sturt, Hume and Hovell and the Surveyor-General, Major Thomas Mitchell.

The Land and the Squatters

It was now becoming realized that Australia was equal in fertility to many parts of Europe. It was capable, given favourable economic conditions, of growing every natural product—tropical and temperate—and all kinds of domestic animals would thrive in it. Valuable timber flourished in its forests, and its rocks were veined with minerals.

Because of changing conditions, political and climatic, it was not easy for the United Kingdom Government to define a policy that might be pursued in making this country available to those who could use it. Up till 1831 (Imperial Land Act) the only method of acquiring land was by free grant, although some areas thus acquired were leased or sold by their owners. In that year, free grants were abolished, and all land belonging to the Crown had to be purchased at a flat rate, which was, at first, five shillings per acre and later increased by stages to twelve shillings and, ultimately, to one pound. The Imperial Land Act of 1831 was formulated on Wakefieldian lines and included the appropriation of land revenues to assist emigration, the intention being to pay the passages to Australia of shepherds, stockmen and other labourers. Relatively large revenues resulted from land sales and immigration soon added appreciably to the population of the Colony which, on July 5, 1836, numbered 77,000 persons—27,000 convicts and 50,000 free settlers and their children.

The changeover from grants to sales, however, did not, as was hoped, consolidate the settled districts, but rather caused wider dispersion. Adventurous young men, mostly free immigrants from England, Scotland and Ireland, and sons of earlier settlers, moved out into the practically unknown regions with their flocks and herds, generally following the river valleys marked out by the explorers, and settled down, or squatted, on areas of land which appealed to them. There were, of course, no fences, so that creeks, hills or prominent trees or rocks were used to mark the boundaries between properties. The march of settlement was not only westward, but also north and south into Queensland and Victoria.

Although the squatters acted illegally, their activities can now be assessed as of great benefit to the developing Colony. They were the real discoverers and pioneers of many new areas and suffered many hardships in establishing their "runs" or "stations". Wool exports rose from two million pounds to over ten million pounds between 1830 and 1839. Labour shortage for shepherding, for there were no fences, and for shearing, was a major difficulty, and this was intensified when transportation of convicts ceased in 1840.

A severe drought occurred in 1838, the price of wool fell, and an unprecedented commercial crisis set in which reached its maximum intensity in 1842 and 1843. For years there had been much speculation—with land, town allotments, and sheep and cattle selling far beyond their real value. Finally, the bubble burst. Several banks failed, values of all commodities fell, and sheep sold for as low as sixpence per head. Bankruptcy became widespread.

In the depth of this depression in June, 1843, the writs were issued for the first election of twenty-four members to the Legislative Council of New South Wales. Within six months, the Legislative Council was plunged into uproar by the publication of new squatting regulations by Governor Gipps. To increase revenue which had fallen because of the depression and decreased land sales, Gipps proposed that the squatters should pay a separate annual licence of ten pounds per run, which were not to exceed twenty square miles in area or to cover an area capable of depasturing more than five hundred head of cattle or seven thousand sheep. Pandemonium broke loose among the squatters, with W. C. Wentworth being perhaps the most vocal. He, for instance, had fifteen stations, of which he was absentee landlord, and Benjamin Boyd held fourteen.

After much debate, it was decided in 1847 to grant the squatters leases to their properties, and district commissioners of Crown land were appointed "to tidy up boundary questions and to see that no man got too large an area". The Order in Council gave security of tenure to the squatters but it had almost the opposite effect from that which was intended. As a result of the leases, the great bulk of the good pastoral and much that was suitable for agriculture became locked up in the hands of relatively few. "By 1850, the pastoralists held undisputed sway. Their estates stretched across the occupied portions of the continent broken here and there by embryo townships, with farming an insignificant occupation."

With security of tenure, squatters began to improve their runs by fencing their paddocks, thus reducing the need for shepherds, and putting up homesteads in brick or stone. The new idea of ring-barking trees to remove them from competition with natural grasses became generally accepted and the problem of disposing of surplus stock was being met by boiling down. The sheep were skinned, cut up and boiled in huge cauldrons with water till the fat separated. After cooling, the fat was exported as tallow to London, where it was in firm demand. The return from the skin and tallow from a fat sheep was about six shillings, compared with about a shilling or so on the hoof during the depression.

The practice of boiling down started at Yass in 1843. Within a year, there were fifty-six boiling-down works and two hundred thousand sheep were treated; by 1850, the figure was 2·5 million. Cattle were treated in similar fashion after removing the hide "and 260,000 were prepared for the cauldron in 1850". Boiling down was practised for many years, until the process of commercial refrigeration was developed about 1880.

Gold was discovered in 1851 by Edward Hargraves, who had a sheep station on the Bathurst Plains, and this was soon followed by reports of fabulous nuggets being found at Ballarat and Bendigo. The news flew round the globe and immigrants poured in. The hectic but formative days of the fifties had arrived. Full self government was granted to both New South Wales and Victoria, a national system of education was established, the first university was founded, and railway construction increased.

The immediate effect of this upsurge on the land industries was disastrous, as indispensable labour was attracted away. Sheep were unshorn, agriculture could not cope with the increased demand for food, and imports of grain had to take place on a large scale. In the long run, however, the rural industries benefited. The demand and high prices for food led many disappointed miners to take up farming. Between 1856 and 1860, the area under crop in New South Wales increased from 186,000 to 260,000 acres. By 1860, the total population of Australia had grown to over a million, cattle had increased to four million, and sheep to twenty million.

Nevertheless, the problem of the country was that the bulk of the desirable land in New South Wales was still the monopoly of large graziers and squatters, and there was an increasing demand for small properties. In 1861, Sir John Robertson introduced and had passed by Parliament two Land Laws (Crown Lands Alienation Act and Crown Lands Occupation Act) which it was thought would meet the situation. Under the first Act, the "Free Selection before Survey" Bill, the right was given to any person to select land, excepting town, suburban and reserved lands. It was provided that the selected area must be not less than 40 acres and not more than 320 acres; the selector must reside on the property and make certain specified improvements. The price of land was fixed at £1 per acre.

Conflict developed between the "selectors" and the squatters, and there was much underhand work on both sides with "dummying" and "peacocking", but the Robertson Acts eventually did some good. Between 1861 and 1880, revenue from the sale of Crown land increased tenfold, and the wheat acreage increased from 128,829 acres in 1860 to 253,138 in 1880-1881. But it was largely the squatters buying agricultural land under the Selection Acts, rather than selectors, who boosted government revenue and doubled the area under wheat.

Wheat-Growing

The conquest of Australia has been accomplished by very hard work, aided by ingenuity and, later, applied science. It soon became evident that wheat-growing in Australia had to be carried out on an extensive scale, profits depending on the cultivation of a large acreage rather than on high average yields. The year 1843 is noteworthy for a discovery that altered the entire outlook of wheat-growing in Australia. Yields were generally small and the limiting factor was the labour of harvesting by scythe, or even sickle.

The squatters had locked up much of the agricultural land of New South Wales, but wheat-growing was beginning to expand in South Australia and Victoria. John Ridley, a miller, farmer, and an ingenious mechanic, of Adelaide, early conceived the idea of a machine that would reap, and when a prize of £40 was offered in 1842 by the self-appointed Corn Exchange Committee for an improved type of harvester, Ridley's ideas were revealed. Ridley soon constructed a machine in which he may or may not have incorporated some ideas of John Wrathall Bull, which enabled "four men to do in a single day what it took the equivalent of two men the whole harvesting season to do before". The machine became known as "the stripper", and comprised a horizontal projecting comb and revolving wooden beaters driven by belts connected with the carriage wheel axles. Horses were attached to a pole at the rear of the stripper, and as they pushed it through the crop, the comb gathered the wheat heads only. The beaters knocked the heads into a box-like structure. Later, they were threshed and winnowed. Ridley's stripper with some modifications became the universally used harvesting-machine for the next fifty years, when it was superseded by the combined harvester-thresher invented by Hugh Victor McKay (an 18-year-old farm lad) in 1884. The McKay harvester stripped, threshed, cleaned and bagged the wheat ready for market.

From South Australia came another invention which greatly assisted wheat-growing, namely, the stump-jump plough. This is a multiple-furrow plough with the shares spring-loaded so that when any share strikes an obstruction in imperfectly cleared land it rises, passes over it, and re-enters the ground. But perhaps more important than the implements was the establishment in 1880 in South Australia of the Roseworthy Agricultural College, and the experiments of Professor Custance and Professor Lowrie, which demonstrated the great value of superphosphate and the cultivated fallow in increasing the yield of wheat.

Wheat harvesting showing in background an auto-header, driven and operated by its own engine, an innovation of 1924, and in the foreground a power take-off header driven through couplings by the tractor engine which first appeared in 1928.

Photograph: Massey-Ferguson (Aust.) Ltd.

In New South Wales, the Robertson Acts had been only partially effective, and in 1884, a land Act was introduced which, in effect, marked the beginnings of resumption of leasehold station properties for closer settlement; although closer settlement, as we know it today, was not fully implemented until 1905. Large numbers of wheat farmers were attracted by the greatly improved facilities provided for land settlement under this Act, and later under the Carruthers' Crown Land Act of 1895. Few of the new farmers were now squatters turned wheat farmers—most came from other Colonies, notably Victoria and South Australia, and brought experience with them. Some purchased land, but others farmed on the share system with large land holders. The

Auto-header in a rice crop in the Murrumbidgee Irrigation Areas. Commencing about 1928, rice-growing has become a most successful industry with average yields per acre being consistently amongst the world's best. A total of 212,000 tons of rice were harvested in New South Wales in the 1966-1967 season.

Photograph: N.S.W. Department of Agriculture.

State acreage under wheat expanded rapidly. Between 1880 and 1890, the area more than doubled, in spite of heavy losses from rust and a severe drought in 1888. In the 1893-1894 season, the area sown for grain in New South Wales exceeded a million acres for the first time, and the State found itself independent of outside sources for its wheat. By the 1900-1901 season, the area had expanded to more than 1·5 million acres.

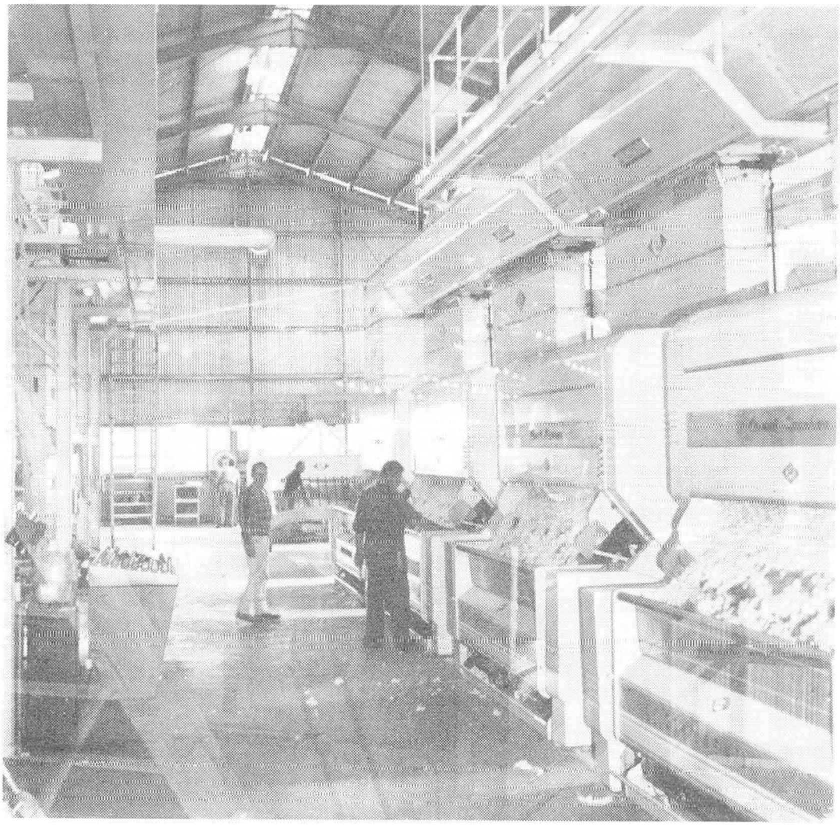
During this period of expansion, much guidance came from the New South Wales Department of Agriculture, which was established in 1890. Wagga Experiment Farm (now Wagga Agricultural Research Station) became our first centre for wheat research.

Wheat varieties available to the early settlers were unadapted types of overseas origin. Most of these did not yield well in dry seasons. They

Harvesting cotton at Narrabri. Cotton-growing under irrigation in New South Wales is a development of the last seven years. Last season, 60,000 bales of cotton were harvested—an average yield of more than two bales per acre.

Photograph: The North Western Courier Pty. Ltd.

were often so late in maturity that the hot dry winds of late spring and early summer caused them to wilt before the grain had filled out, and most of them were very susceptible to rust. "A realization of this brought to light perhaps the greatest of all benefactors to the wheat-growers of Australia—William Farrer. He was the son of a small landed proprietor in the north of England and had a distinguished career



A cotton gin, Narrabri, N.S.W. After harvest the seed cotton must be ginned to separate the cotton fibre from the cotton seed.

Photograph: The North Western Courier Pty. Ltd.

at Cambridge University. Fortunately for Australia, he came here in 1870 for health reasons, meaning, ultimately, to go on the land. He first took the position of tutor to the family of George Campbell, of Duntroon Station, near Canberra, partly with the idea of getting to know something of local conditions. After spending five years at this and other stations, he qualified as a surveyor, and was employed by the Lands Department to do survey work in a number of districts, some of which were in the wheat belt. During this period, he became intimately acquainted with many of the problems of the man on the land, being particularly impressed by the damage caused by rust. In 1896, he retired and settled down on a small property at Lambrigg in what is now Australian Capital Territory. Although it was not a typical wheat-growing district he immediately undertook the self-appointed task of trying to produce improved varieties. In a little three-acre paddock he sowed small plots of different varieties of wheat which he had collected from all the Australian Colonies, and from Canada, the United States and India, paying particular attention to those which had a reputation for rust-resistance. For the first three years, he confined himself to close observation of the varieties and did a certain amount of selection work. He soon came to the conclusion that some new method was necessary if he were to reach his objective of producing varieties more suitable to Australia's soil and climatic conditions. He decided on cross-breeding followed by selection so that he might combine the good qualities of two or more varieties in one variety and fix these desirable qualities so that the new varieties would always breed true to them. Farrer was the first wheat breeder in Australia, and almost the first in the world, to adopt this method which has since given such fruitful results in every progressive wheat-growing country. He actually made his first cross at Lambrigg in 1889, but he was so careful in his subsequent selection work that it was not till 1900 that his first new cross-bred variety, Bobs, was released for use by the farmers of Australia. In the meantime, his work had attracted the attention of the recently formed Department of Agriculture in New South Wales. In 1898, he was appointed wheat experimentalist to the Department at the modest salary of £350 per annum. What induced Farrer to accept the position was the much wider opportunity it gave him to develop his work in typical wheat-growing districts like Cowra and Wagga Wagga, and the use of a much greater area of land in which to test the yielding capacity of his new cross-breds. For nine years at Lambrigg and eight years with the Department, he pursued his breeding programme with enthusiasm and success. From the beginning of the century till the time of his death in 1906, he released for extended trial a number of new varieties each year, whilst others which were not properly fixed at the time of his death were made available later.

As already indicated, Farrer was first attracted to wheat breeding by the desire to produce varieties resistant to rust, a fungous disease which almost threatened the continuance of the wheat-growing industry in the 1890's. He did produce a number of varieties which were more rust-resistant and rust-escaping than any of the older varieties. More important than that, he gave to Australian farmers varieties which were higher yielding, earlier in maturing, more drought-resistant, more bunt-resistant, stronger in the straw, easier to harvest and of better milling and baking quality. In increased yield alone, his varieties added millions of pounds annually to the value of the Australian wheat harvest. His work meant even more than that. He prolonged the sowing season, made possible the extension of wheat growing into drier districts, made the work of harvesting easier, and appreciably improved the average quality of the grain for bread-making. He thus raised the whole wheat-growing industry to a higher plane.

His most popular variety was Federation, which, as the name suggests, was released for general cultivation in 1901. By 1910, more than half of the wheat area in New South Wales was sown with this variety, and it was widely grown in all the other States. It remained the most popular variety in New South Wales till about 1930, after which it gradually declined in favour. Although the quality of the grain was not much above the ordinary and it had little resistance to rust, it was drought-resistant, had a high ratio of grain to straw, and was easy to harvest. Above all, it filled the bags more quickly than any other variety as the harvester went round the paddocks, the quality which chiefly accounted for its popularity with the growers. It is not given to many men to alter the appearance of a whole landscape as Farrer did with this variety, the dark-brown heads of Federation replacing the pale golden colour of most of the varieties which it supplanted.

The breeding of Federation illustrates the general methods pursued by Farrer, as well as throwing light on the way in which he searched the world for his parent material. He first of all crossed improved Fife, a variety imported from Canada, and noted for the quality of its grain, with an Indian variety called Etawah, which was early in maturing, short in the straw and had a reputation for drought resistance. The result of this cross was the variety Yandilla, which proved a rather indifferent yielder although it had other good qualities. Farrer crossed it with the best yielding of the local purple-straw varieties he could find and after fixing one strain of the variable progeny of this second cross, got the variety Federation. It might be represented diagrammatically thus:

Improved Fife × Etawah

Purple-straw Tuscan × Yandilla

Federation

Two other wheat breeders, contemporaries of Farrer and in close touch with him, who produced a number of varieties formerly widely grown, should be mentioned—Marshall of South Australia, and Hugh Pye, a former principal of Dookie Agricultural College in Victoria.

Very few Farrer varieties are grown today, and none of them extensively. Why? Because they have been displaced by still better varieties, most of which have Farrer wheats in their parentage. They have been bred by men, most of them, fortunately, still with us, who learned some of their technique and received a great deal of their inspiration from the pioneer wheat breeder of Australia; so that Farrer's work still lives on."

Another benefactor was Dr. Nathan A. Cobb, the Government Plant Pathologist of the day, who directed the wheat experimental work between 1892-1898. Cobb and the manager of Wagga Experiment Farm first took up resolving the confused varietal nomenclature and the production and release of pure seed wheat to growers. Cobb also interested himself until his departure from New South Wales, in 1905, in disease control problems, grading of wheat seed, varietal identification on grain and ear characters, and, in 1895, advocated for the first time the bulk handling of harvests. He also initiated the first detailed wheat fertilizer experiments in this State. These experiments demonstrated the low phosphate status of the soils of the southern wheat belt and led, in 1898, to the first published statement recommending the use in New South Wales of superphosphate on wheat.

Undeterred by the disastrous drought of 1902 which resulted in the all-time low average wheat yield for the State of 1·2 bushels per acre and enormous stock losses—17 million sheep and half a million head of cattle perished—farmers continued to grow wheat on a more and more extensive scale. In 1910-1911, the State acreage had reached the 2 million mark. Three seasons later, over 3 million acres were harvested for grain in New South Wales, and in the 1915-1916 season, under the impetus of the First World War, the area harvested exceeded 4 million acres for the first time.

Factors which favoured expansion were improved varieties, gradual extension of the country railway system, the availability of improved sowing and harvesting implements and the gradual acceptance by farmers of the value of superphosphate. After the World War, a new aid crept into the industry, as in other progressive countries, namely, the use of the tractor, and gradually supplanted horses on the majority of wheat farms. Tractors enabled still larger areas to be worked by one man with still larger implements. A further advantage over horse teams was that the tractor could be worked at a faster rate, night and day if necessary, so that the different operations of cultivation, sowing and harvesting could be carried out at the best time for each. Early in the century, seed was sown by hand on ploughed land and then covered with the harrow. An Australian invention of the simultaneous seed and fertilizer drill came into use, and this was superseded by another Australian invention, the combine. This implement gives the final cultivation to the land as well as sowing the seed and fertilizer in the same rows in one operation. The McKay type of harvester, which was a favourite for many years, had been gradually displaced by the "header" or reaper thresher invented by Headlie Shipard Taylor of Henty, New South Wales, which snips off the heads instead of beating them off, thus preventing loss by shattering, and because of its combing action, can harvest crops that have been badly lodged by wind or rain. Then, in 1924, came the auto-header, in which the header part is integral with the tractor and which, in a good crop, can head, thresh and bag at the rate of a bag a minute. By 1928, with the fast-spreading use of tractors, the power take-off header was introduced. The majority of headers today are of this type.

In 1920, with memories still fresh of the enormous losses during the war in bag-stacked wheat caused by weather, weevils and mice, a system of bulk handling was inaugurated in New South Wales. This not only saves the use of bags, but greatly simplifies the loading of railway trucks and ships. In the first season of operation (1920-1921), 28 silos, with a total capacity of 12 million bushels, handled 2 million bushels, being 3·5 per cent. of the total harvest. By 1924-1925, almost 30% of the State harvest was bulk-handled by 61 silos. Today, almost all of the harvest is handled by the grain elevator system, which has a total storage at bulk handling depots of about 80 million bushels.

In the period after the First World War, the value of sheep in conjunction with wheat was becoming to be appreciated, and a few progressives began to think in terms of pasture improvement. Wimmera ryegrass was introduced from Victoria about 1920, and subterranean clover received pioneer treatment by C. E. Prell in the Crookwell district. Wheaten and oaten hay and oaten grain previously grown for the working horses were being conserved to tide sheep and cattle over drought periods. Returns were now found to be greatest when mixed farming of sheep and wheat was practised, and the subdivision of properties for sale or for letting of portion to share-farmers increased.

Federation, which had long reigned as the premier variety, was superseded by Waratah, Marshall No. 3, Canberra, Turvey and Yandilla King. These, in turn, were replaced by Nabawa, which achieved prominence by reason of its resistance to flag smut, the most serious disease of the 1920's, and later by Dundee and Ford and, to a lesser degree, by Bobin. Later came Bencubbin and Glenwari. Another smut disease—bunt, or stinking smut—had been a source of loss to wheat growers from the earliest times, but about 1915, Dr. Darnell Smith devised the dry copper carbonate dust treatment which has since almost eliminated the disease.

The financial depression of the 1930's caused a sharp reaction in the price of wheat. Wheat-growing came to be regarded as unprofitable, even in the most efficiently managed farms, and the acreage was greatly reduced. As time went on, growers turned more and more to a sheep-and-wheat system of farm management, and in the southern portion of the wheat belt, this was promoted by the alarming spread of skeleton weed (*Chondrilla juncea* L.). Infested areas no longer suitable for wheat-growing were increasingly utilized for grazing purposes.

Recovery from the depression slowly took place. In 1938-1939, the State acreage for grain reached 4,653,000 acres, the highest figure since the 1932-1933 season, but the recovery was short-lived. Shortage of labour and superphosphate during the early war years caused a marked decline—to 2·7 million acres, the lowest since 1919-1920. In the post-war years, the average climbed again—over five million acres being sown in New South Wales in 1947-1948.

Attention now was being given to wheat quality as distinct from high yielding ability of varieties. In spite of the high yields, drought- and frost-resistance of such varieties as Bencubbin and Glenwari, their bread-making properties were unsatisfactory. The new wheats released by Farrer's successors, now formally known as plant breeders—Eureka, Gabo, Festival, Gamenya, Mengavi, Mendos, Festiguay, Gamut—sought to combine high milling and bread-making qualities with high yield, and drought- and rust-resistance. Wheat growers and the community owe our plant breeders a deep debt of gratitude. Average yields per acre are now 19·1 bushels, compared with 9·82 in the decade 1901-1910, and 13·84 in 1941-1950. Total annual yields still fluctuate widely, drought being the main factor responsible. Thus, 151,483,000 bushels were harvested in New South Wales in 1964-1965, 39,000,000 bushels in 1965-1966, and nearly 200,000,000 bushels in 1966-1967.

Progress of the Pastoral Industry

Whilst sheep and wool took pride of place, cattle-breeding also played a prominent part in land utilization; many of the settlers combining the two industries. From the earliest days, bullock teams were the chief means of transport, and when ploughs and harrows gradually displaced spades and hoes, bullocks became the main source of power. Horses were scarcer and bullocks were also cheaper to feed.

Most of the early cattle, which were introduced from South Africa and India, were humped cattle of the zebu type, but in addition to these draught animals, many of the cows that had been used for the supply of milk on ship board were left behind, and these formed the nucleus of the first dairy herds. Quite early, pure-bred Ayrshires were introduced by settlers in the Illawarra and Nepean districts, and provided much of the milk and butter of the Colony. By degrees, nearly all the prominent British breeds of both beef and dairy cattle were introduced, and at first were used mainly for crossing with the early cattle, but later, small herds of pure-breds were built up. Pure-bred Shorthorns were established in the Hunter River district by the Australian Agricultural Company, and because of their excellent all-round qualities, they were soon to be the leading breed of Australia. Herefords were first imported into Tasmania, but before long appeared also in the Hunter Valley.

In the early days of the Colony, cattle raising was combined with shepherding, and as stock numbers increased, the demand for meat and working bullocks and dairy products was over-supplied. As in the case of wool, prices fell, and during the commercial crisis of 1842-1843, the whole of the pastoral industry was in dire trouble. Boiling down brought some relief, but the final solution did not come until the introduction of refrigeration.

The gold rush and the related population growth by immigration in the fifties increased the demand for food and other products and assisted the pastoral industries, but shortage of labour for shepherding and shearing remained. Australia's population by 1860 exceeded a million, but stock numbers had grown to 20 million sheep and four million cattle, and the problem of rural labour was taxing the minds of all connected with the pastoral industry.

Then another problem emerged—the devastation of pastures by rabbits and the need for more labour to control them. In 1859, a small number of wild rabbits (24) were imported from England for sporting purposes by a Victorian farmer living near Geelong. Within two years, the rabbits, multiplying without restriction by any of their natural enemies and with unlimited supplies of food, had overrun the farmer's property and the neighbouring countryside. In less than twenty years, they had reached and crossed the Murray River and continued their migration into New South Wales and South Australia. By 1886, it is reported that they had infested most of the plain and partially cleared country in western New South Wales and had penetrated into Queensland. Much effort was made to control the rabbits by hunting, trapping, digging out the burrows, poisoning, hunting with dogs and ferrets, wire netting fences, etc., all of which called for labour. Until recently, however, the rabbit has won the contest, but his rule is now challenged by myxomatosis, a form of biological control which will be referred to later.

In spite of the rabbit infestation, occasional setbacks because of dry seasons, and fluctuating prices, the pastoral industry continued to progress. Homesteads and living conditions gradually improved, holdings were being fenced, and more roads and railways were being built. Two developments of the greatest significance occurred before the end of the century that changed the future of Australia's land industries, namely, the discovery of commercial refrigeration, and the invention of an efficient sheep-shearing machine.

Prior to 1880, Australian meat, surplus to local requirements, was very difficult to dispose of. Although, by 1867, considerable quantities were being processed by canning, the bulk of the surplus was still boiled down for tallow and fertilizer. The story of refrigeration commences with James Harrison, printer and publisher of the Geelong *Advertiser* newspaper. He produced the world's first commercially successful mechanical refrigerator compressor, for which he obtained a British patent, and in 1851, he set up on the banks of the Barwon River, Geelong, the world's first ice factory operated by mechanical refrigeration.

He was successful in keeping local meat fresh, but sought to develop suitable refrigerated chambers in which meat could be exported to British seaports. At great cost, Harrison persisted in his experiments, until, in 1873, he felt sufficiently confident to embark on an experimental shipment to England of 25 tons of beef and mutton in a specially-fitted hold of the ship *Norfolk*. Unfortunately, the refrigeration machinery broke down during the voyage to London, and the meat was thrown overboard. Harrison was, by now, in difficult financial circumstances, and he dropped out of the quest.

About the same time, another remarkable man, Thomas Sutcliff Mort, whose statue stands in Macquarie Place, Sydney, had similar vision on the future need of Australia's meat industry as Harrison, and the same enterprise in risking his capital. Mort was a man of many parts. In the height of the financial crisis of 1843, he set up business as an auctioneer, and was actually the first man to sell wool by auction in Australia. This activity gradually evolved into the well-known firm of Goldsbrough Mort and Company Limited. He was one of the promoters of the company that commenced railway construction in Australia (Sydney to Parramatta) and founded the first heavy engineering works for locomotives and ships and the first dry dock. He was also a leader in the dairy industry at his estate at Bodalla. His burning ambition was, however, in his own words, to find out "how safely, simply and economically to carry animal food in a perfectly natural condition from one country to another".

In 1867, Mort, now a man of considerable capital, became associated with a skilful engineer, E. D. Nicolle, who had similar ambitions, and who, in 1863, had secured a patent for an ice-manufacturing process dependent on the evaporation of ammonia. The process proved very successful, and for several years, Nicolle supplied Sydney with ice, and even exported it to Brisbane. Mort and Nicolle commenced experiments on freezing carcases in a small factory in Darlinghurst. The problem was to get a continuous temperature below freezing-point for an indefinite period, and they finally solved it by a system which enabled the evaporating ammonia to be used over and over again.

A large freezing works was established at Darling Harbour and slaughterhouses were erected at Lithgow in preparation for the despatch of a cargo of frozen beef to England. The ship *Northam* was chartered in 1878 to take to Britain a refrigerated cargo valued at £100,000. Unfortunately, there was delay in fitting up the machinery and the ship had to leave without its cargo. Mort died at Bodalla the same year, a disappointed man.

Mort's refrigeration plant at Darling Harbour was purchased by the Fresh Food and Ice Company, who continued to use the ammonia process. The first successful experimental shipment was made in 1879 and is credited to a Sydney syndicate headed by Andrew McIlwraith. The ship chosen for this historic voyage, the s.s. *Strathleven,* was loaded with 40 tons of beef and mutton, and the consignment was frozen on board in Sydney Harbour. The *Strathleven* sailed for London on November 29, 1879, and arrived on February 2, 1880. The frozen meat was discharged in excellent condition, and thus, the world's first successful international trade in frozen meat began. Today, produce frozen or chilled by refrigeration ranks amongst Australia's most important exports. These exports have helped to stabilize many rural industries. In 1964-1965, more than 266,000 tons of meats preserved by the cold process were sent overseas, as well as many thousands of tons of butter, cheese and fruit.

A patent for the world's first sheep-shearing machine was filed by James Higham of Victoria in the Patents Office of New South Wales in 1868, but historical records do not reveal to what extent, if at all, he developed his ideas. Up till this time, sheep were shorn by blade shears and in Britain, Australia and America, a variety of mechanisms was under trial to enable the wool to be removed by mechanical means. In Britain, horses were being clipped by a type of hand-operated mechanism. A machine was patented in 1877 by Robert Savage and Frederick Wolseley, of Victoria, and to them and several associates is credited the world's first commercially successful sheep-shearing machine.

Wolseley emigrated to Australia in 1854 and served as a jackeroo for five years on his brother-in-law's property near Deniliquin, New South Wales. He later bought a property of his own and began experiments with the idea of lessening the strain and speeding up the operation of shearing. By 1872, he and the Melbourne engineer, Robert Savage, had a working model by which they removed at least part of the fleece from a sheep. Shortly afterwards, however, Wolseley went to England for a period of two years seeking new ideas. On his return, he purchased the sheep station Euroka, near Walgett, New South Wales, partly with a view to trying out his ideas under practical woolshed conditions. The Savage-Wolseley machine was not a success, mainly because of the problem of transmitting power from the old-fashioned horse-gin that was being used. In 1877, he engaged another Melbourne engineer, Robert Park, and by 1884 they featured together in a patent for a cog-gear universal joint. Experimental work continued at Euroka station. In 1885, Wolseley engaged a skilled mechanic, John Howard, who had arrived two years previously from England, where he had had some experience with a horse-clipping machinery firm. Progress then became more rapid as the skilful Howard overcame, one by one, the mechanical difficulties. The first public demonstration of the improved machine took place at Goldsbrough & Company's wool store in Melbourne the same year. The machine used friction power to drive the hand-piece—friction from a large wheel on a rotating overhead shaft caused a small cone to rotate on the upper end of a flexible core and drive the hand-piece. The demonstration took the form of a competition and was not without drama—three sheep being shorn by the new machine at the same time as an expert shearer, Dave Brown, attended to three others with hand-shears or blades. The hand-shearer won by a narrow margin, and things looked grim until someone suggested that the new mechanical shears should be run over the three hand-shorn sheep. The result was that an additional three-quarters of a pound of wool was taken off. The trial had succeeded and the business-minded Wolseley immediately placed orders for the manufacture of several machines by R. P. Park in Melbourne.

Several more public demonstrations were held in Sydney and in Brisbane, but adoption by graziers was slow. A notable improvement was made by William Ryley in the functioning of the hand-piece, which was incorporated in a patent in 1887, but there was still reluctance by graziers to install the machines. Many consider that it was the demonstration carried out in 1888 on Sir Samuel McCaughey's Dunlop station, west of Bourke, that turned the scales. This station carried a flock of 184,000 sheep and the trial again had an element of drama about it. "Before the forty shearers arrived, the machines were duly installed in the commodious shearing shed. When informed of the position, however, the shearers refused to sign the contract, as they wanted nothing to do with the new-fangled machinery. They retired to a camp some distance away, and it took Howard and his associates nearly three weeks of almost daily demonstrations of the advantages of the machine before they reluctantly agreed to make a start. At first, their performance was very poor—an average of about 43 sheep per stand per day, partly because of unfamiliarity with the machine method and partly because the majority of the shearers did not wish to make a success of it. The rate of remuneration was a pound per hundred, and gradually some of the keener and more expert men got up to the rate of a hundred a day, which was not bad going. The others, by degrees, became really interested, and began to study closely the technique of the most successful, with the result that the average for all hands gradually mounted to 120 per day. The shearing was completed in a little over two months and Dunlop's was the first large flock in any part of the world to be entirely shorn by machinery. More important, a large proportion of the 31 shearers who stuck it out to the end became converts to the new idea."

Eighteen other sheds were fitted with Wolseley machines during 1888 and orders were taken for many more for delivery the following year. Before long, several other makes of shearing machines appeared on the market, and by the time of Federation, when Australia's flocks numbered about 70 million, it was the exception rather than the rule to find hand-shearing in progress on any large station.

The greatest factor in progress since the beginning of the century has been the advancement of science and its application to the problems of the primary producer. In spite of rapid advances in wheat-growing, horticulture and dairying, the wool industry, after Federation, continued to be the mainstay of Australia's economy. The numbers of sheep had already dropped from 106 million to 70 million during the dry seasons preceding Federation, and in 1902, when the drought reached its maximum intensity, there was a further fall to 56 million. As indicative of the recuperative power of the pastoral country, and also because of improved husbandry which had become necessary to cope with sheep blowfly and other pests, sheep numbers had again reached the 100 million mark by 1911. The maximum number recorded in any one year was 125 million in 1941-1942. More creditable than sheep numbers is the record of continued improvement in the yield of wool per sheep. This has been largely due to the work of our stud breeders, whose high-producing rams have gradually spread their influence through the majority of our flocks and the advocacy and instruction disseminated by Departments of Agriculture, C.S.I.R.O. and Universities. For the five years up to and including 1901, the average weight of fleece was 6·29 pounds, whereas the average for the five seasons 1962-1966 was 8·70 pounds. Another achievement of the stud breeders and their followers was to breed out the wrinkly-bodied sheep of Vermont ancestry that early in the century were mistakenly believed, because of their wrinkled skin, to carry more wool. The modern merino, as typified by the Peppin or Wanganella strain, is a large-framed sheep with prominent neck-folds, but free from body-wrinkles.

Another contribution of science during the past half century or so that has been of immense value to the pastoral industry has been the series of discoveries made in relation to pasture improvement. By the use of new species of pasture plants, the use of superphosphate, and, where necessary, very small quantities of "trace" elements like copper, zinc and molybdenum, or a combination of one or more of them with superphosphate, large areas of practically useless land have been transformed into highly productive pastures carrying healthy stock. In the more reliable rainfall districts, pasture improvement has doubled or trebled carrying capacity, increased wool production several times, and controlled soil erosion.

The Era of Pasture Improvement

It was once supposed that the high quality of Australian wool was a direct result of the unique suitability of the native pastures from which it was grown, and for the first hundred years, little or no attempt was made to supplement them. The dairying industry had benefited greatly by displacing native grasses with other grasses such as paspalum and kikuyu. True, phalaris was being sown by pastoralists in the northern and, later, southern tablelands, and Wimmera rye grass had many advocates in the Victorian and southern portion of the New South Wales wheat belt. It was not, however, until the special virtues of subterranean clover became widely appreciated that the era of pasture improvement commenced. It is doubtful if any single pasture plant has created such a revolutionary change in the agriculture of any country as this clover.

Leguminous plants, like clovers, trefoils and lucerne, are richer in protein than the grasses, and, as a result, are more nutritious to animals producing wool, mutton, beef or milk. Furthermore, unlike grasses, leguminous plants do not deplete the soil of nitrogen, but, by virtue of the little nodules which grow on their roots, they "fix" nitrogen from the atmosphere. Instead of depleting the soil, they enrich it in that important element when the roots and leaves decay, or the excreta of grazing animals become incorporated with the soil.

The introduction of subterranean clover to Australia was accidental, and no one at first took much notice of it. It was first recorded in Victoria in 1887, in South Australia in 1889, and in New South Wales in 1896. The person who is given credit for recognizing its value was A. W. Howard, a farmer of Mount Barker, South Australia. He was the first to apply superphosphate to pastures of which subterranean clover was a part, and to observe the remarkable improvement in growth and development. Thus was initiated the combination "sub" and "super", which has contributed so phenomenally to the increase in stock-carrying capacity and soil fertility of a vast region of southern Australia.

In spite of early recognition of the great advantages of sub and super, economic and other factors retarded development of sown pastures until after the Second World War. Between 1946-1947 and 1956-1957, the New South Wales total of sown pastures increased from

Aerial agriculture. An increasing number of agricultural operations are now carried out by the use of aircraft. This plane is spreading superphosphate on hill country. Fixed wing aircraft and helicopters are employed also in pest and weed control in both pastures and crops, and in the application of hormones to increase fruit set, or to defoliate plants to expedite harvest.

Photograph: N.S.W. Department of Agriculture.

2,672,000 acres to 9,040,000. In 1950-1951, the acreage sown to pastures exceeded that devoted to wheat for grain, and three seasons later, exceeded also the area devoted to all sown crops. It is well over 12 million acres today, and for Australia, 51 million acres.

Other leguminous plants and grasses have played a part in pasture improvement—red clover, white clover, lucerne, and a variety of medics, and in higher rainfall areas, rye grass and phalaris and other grasses. C.S.I.R.O. and State Departments of Agriculture are still introducing for trial pasture plants from all parts of the world in the hope that better or more adaptable species will be found. The desire is for a legume as suitable for the summer rainfall and sub-tropical areas as sub has been for the winter-rainfall areas of southern Australia. Selection of strains of sub clover is still in progress, seeking wider adaptability to variations and extremes of climate, and in searching for the ideal leguminous plant for the tropics and sub-tropics, plant breeders are producing many interesting hybrids.

While leguminous plants and introduced grasses are the basis of pasture improvement, without superphosphate, which supplies phosphorus, sulphur, calcium and certain trace elements, little would have been accomplished. Even then, in some soils it has been necessary to make special applications to the soil of very small quantities per acre of molybdenum, zinc or copper.

Battles against Diseases, Pests and Weeds

Australia has been fortunate in that the indigenous fauna were not ruminants, such as sheep, cattle, deer, etc., capable of serving as reservoirs and transmitters of serious infectious diseases. The marsupial fauna are relatively insusceptible to many of the serious animal plagues that have proved a constant drain on the livestock industries of some other countries. Nevertheless, the remarkable development of the sheep and cattle industries over wide territory and in such numbers has been associated with many problems of diseases, pests and weeds.

It is supposed that in the early days, diseased cattle and sheep died on the arduous voyage to Australia, and most of the early flocks and herds were relatively healthy. One malady, however, gave trouble quite early, and great credit is due to the graziers and their advisers for the success in eliminating it from Australia. To do this, legislation was involved and a strict campaign was waged. From this action, perhaps, can be traced the lively interest Australians have in quarantine and in confining diseases and pests by legislation and similar measures. An Act was passed in 1832 to deal with sheep scab, an irritating trouble caused by a tiny mite that had gained entry to Australia and was rapidly spreading. The Act sought to control the movement of affected sheep, but evidently the measures taken to enforce it were not very satisfactory. The Act was amended in 1863, setting up district boards to enforce the regulations rigidly, and no sheep was allowed to travel without a certificate of freedom from scab. Many specifics were used to treat the disease, but the ultimate cure came in the compulsory dipping of all affected or suspected sheep with a mixture of tobacco extract and sulphur or with lime-sulphur solution. The treatment was repeated after an interval of ten to twenty days, and in bad cases, a third treatment was given later. Within three years, New South Wales, Queensland and South Australia were declared to be entirely free from scab, but it was several years before Victoria, Tasmania and Western Australia received a clean bill of health. Strict quarantine has been successful in preventing the disease becoming established again in Australia. But, as indicative of early forthrightness in dealing with exotic diseases and pests which has persisted to the present day, should be mentioned the outbreak of scab in 1884 in a consignment of stud sheep from U.S.A. that escaped the vigilance of quarantine officers. The owner of the station near Carcoar, New South Wales, to which they were consigned, recognized the disease and informed the authorities. Prompt action was taken; the station was quarantined, the American sheep and the local sheep they had contacted were slaughtered and burned, as well as the wool-shed in which they had been housed. For good measure, two miles of fencing and 2,000 acres of grass were also burned. Needless to say, the outbreak was stamped out.

Eradicative measures have been practised in dealing with several other exotic animal diseases such as anthrax, pleuropneumonia, swine fever, black disease, etc., using protective vaccination or slaughter to control outbreaks, and the campaigns have been strikingly successful. Two of the most dreaded exotic diseases—rinderpest and foot-and-mouth disease—each on one occasion gained entrance, but early recognition and the adoption of radical measures effected their eradication. Anthrax appeared in the County of Cumberland, in 1847, where many cattle, as well as sheep and a few horses, died suddenly from a then-unknown cause. A commission set up by the New South Wales Government in 1851 reported that the symptoms were analogous to those of a disease known in France as *Maladie de Sang,* and recommended the burning of affected carcases and restriction on stock movements. In spite of this, the disease continued to spread extensively in New South Wales and into Victoria and, to a lesser extent, into Queensland, taking a heavy toll of sheep and cattle. A successful method of vaccination against anthrax was discovered at the Pasteur Institute in Paris, and was further developed in Australia by Gunn and McGarvie Smith, and this, together with quarantine measures and strict hygiene with carcases, has gradually reduced the disease to a relatively rare one. Pleuropneumonia is believed to have been introduced by a cow imported into Victoria. The cow died several weeks later, but in the meantime infected other cattle, including a team of working bullocks, which is thought to have disseminated the disease very widely. Pleuro became very serious throughout Victoria, New South Wales and Queensland. A fall in cattle numbers in New South Wales from 2·6 million in 1862 to 2 million in 1864 is attributed largely to this disease. The disease persisted, and in the 1920's, was still regarded as endemic in the eastern States. Today, these States are free from the disease, and occasional outbreaks are seen only in cattle introduced from the Northern Territory.

Swine fever has gained a foothold three times within the last forty years, and has been eradicated only at considerable cost and effort. New South Wales and Victoria were affected in 1927-1928, and Western Australia and New South Wales in 1942-1943. In the latter outbreak, the disease was not eradicated until Western Australia had lost half its pig population. A further outbreak occurred in New South Wales in 1960-1962.

The establishment of the Faculties of Veterinary Science in the Universities of Melbourne and Sydney during the early years of this century has been of great significance in solving disease and other problems of the livestock industries as they have arisen. One by one, important diseases have yielded to investigation and the development of control measures by veterinary graduates who have contributed greatly too in the administration association with complex veterinary problems.

Plant diseases have been a challenge since the earliest days of settlement, particularly the rusts and smuts and root rots of cereals. Until about 1860 onwards, little was known about the causes of plant diseases and the parts played in their etiology by fungi, bacteria and viruses, in association with the environment, and sometimes, in the case of viruses, with an insect vector. When wheat was grown in coastal districts, losses from rust were heavy, particularly in wet seasons. It was rust that drove wheat-growing away from coastal districts to the drier inland, and it was probably the reduced liability of wheat crops in South Australia and Western Victoria to contract rust that tended to favour their development as the pioneer wheat-growing States, even though much of the agricultural land in New South Wales was locked up by the squatters. Losses from rust are still sometimes alarming when warm, moist conditions prevail at a critical stage in the growth of the crop, but plant breeders have made great progress in the production by hybridization of rust-resistant varieties. The problem is that although only a single species of fungus, *Puccinia graminis,* is involved, there are a large number of highly-specialized biologic forms of this fungus. A new wheat variety may be completely resistant to one or several forms, but susceptible to another, and to add to the complexity, there is a changing pattern of distribution in the wheat belts of the different biologic forms of the fungus due to mutation and hybridization. Consequently, plant breeders have to be always prepared to discard former rust-resistant varieties and replace them with varieties having resistance of different genetic or physiological origin.

The smut diseases are characterized by the production of black spores and are of frequent occurrence in cereal crops. Two of these diseases, bunt or stinking smut and flag smut, have caused heavy losses in the past by reducing yields and, in the case of bunt, also rendering bread made from the flour malodorous. Wheat growers throughout the world had pitted their skill against bunt. In the early days, farmers soaked the seed before sowing in sea water, and later, brine, to separate the bunt balls and dislodge the spores which adhere to the grain. Later, a solution of bluestone (copper sulphate) came into use, but dipping and drying were clumsy operations and also frequently affected the germination of the wheat if sowing was delayed by weather. A most valuable contribution was made by Dr. Darnell Smith, of the New South Wales Department of Agriculture, in 1915, in showing that if the grain was thoroughly mixed with a small quantity of dry, powdered copper carbonate, bunt was controlled without any of the disadvantages of the wet treatment. It was the first instance of the successful use of a dry powder as a preventive of bunt, and the new method quickly spread throughout the world. Darnell Smith's experiments had paved the way to the use of other fungicides as seed-disinfectant for wheat and, later, for many other crops. Flag smut, too, had severely reduced wheat yields, particularly in Australia, and in the 1920's was rated as our most destructive wheat disease, exceeding rust in importance. The discovery of high flag smut resistance in the variety Nabawa, and the development by plant breeders of a wide range of flag smut resistant varieties has reduced flag smut to the status of being now a relatively rare disease.

Much could be written of the conquest of many other plant diseases as a result of research and the application of science in the field and orchard. As in the case of control of animal diseases, university graduates were an essential part of the successful investigations and control campaigns. (The first Chair of Agriculture in Australia was established at the University of Sydney in 1910 at the same time as the Faculty of Veterinary Science was set up, but because of the War, it was not till about 1920 that any very marked progress was made.) The investigation and control of one plant disease is worthy of special mention, namely, bunchy top of bananas. The flourishing new industry of banana-growing grew up during and immediately after the 1914-1918 war in northern New South Wales and southern Queensland, and appeared to be one of great promise. Many returned soldiers were attracted to the industry. By 1922, the production of bananas was more than half a million bushels, but a puzzling disease which had been noticed as early as 1913 was widespread and causing concern. Three years later, an officer of the New South Wales Department of Agriculture reported: "Fully ninety per cent. of the area producing bananas in 1922 has gone out of production . . . at least 800 deserted plantations." The culmination of much Press and political activity was the setting up of a Commonwealth and interstate commission to examine the problem. The first step was to appoint a committee of three professors early in 1924 to visit the affected areas and recommend what steps should be taken. By this time, it was known that a similar disease had caused losses in Fiji, Ceylon, the Philippines and Egypt, and investigations had been made without throwing any light on the nature of the disease. Nevertheless, the committee recommended that an "on-the-spot" investigation be made, and after fruitless attempts to obtain an experienced plant pathologist for the job, a recent graduate from Sydney University, in the employ of the Department of Agriculture, was assigned the task. Good progress was made, and it is reported that within a year he had got the whole story, namely, that bunchy top was a virus disease transmitted from plant to plant by the banana aphid. Now it was possible to take action with full knowledge of what was happening. It was decided that it would not be good strategy to attempt to deal with the aphids, but rather to attack the reservoirs of the specific virus—the diseased plants. Legislation was introduced in both New South Wales and Queensland, and an organization was built up to enable plantations to be inspected and for diseased plants to be destroyed. The campaign has been thoroughly successful. It has not only rehabilitated the industry, but has established it as one of the most valuable fruit industries in Australia—an industry worth many millions of dollars a year.

Wild rabbits have been fought with vigour for a very long time because they are competitors of grazing stock and destroyers of pastures, which they nibble down to the roots, causing denudation of the land. By 1866, rabbits were numerous in many parts of Victoria, and twenty years later, had infested most of western New South Wales, and were spreading in Queensland. Ultimately, they penetrated every part of Australia outside the tropics and really desert regions. In spite of the erection of many thousands of miles of costly wire netting fences, shooting, trapping, poisoning, hunting, digging out, etc., the rabbit continued to gain ground. There was something on the credit side—they provided a source of local food and the export of their carcases and skins was worth several million dollars.

The possibility of using a myxoma virus against the rabbit was brought to the attention of the Australian Government by Dr. Aragao of Brazil in 1919. The official response was that "the trade in rabbits, both fresh and frozen, either for local food or for export has grown to be one of great importance, and popular sentiment here is opposed to the extermination of the rabbit by the use of some virulent organism". In 1924, a sample of myxoma virus was imported into New South Wales from Brazil by the Director of Veterinary Research for restricted laboratory experiments. These confirmed the lethality of the virus for rabbits and the difficulty of its transmission by contaminated surroundings. Health authorities, however, opposed release of the virus even after extensive investigations which established its specificity had been carried out here and abroad during the 1930's.

In the good seasons of the late forties, the rabbit population increased to a frightening extent, and in 1949, the newly established Wildlife Survey Section of C.S.I.R.O. took special interest in the problem and were permitted to conduct trials with the myxoma in the Murray Valley. These experiments were disappointing until December, 1950, when a dramatic flare up of myxomatosis took place. It would appear to have started with the release at Balldale of rabbits inoculated with freshly harvested virus from Glenfield Research Station. Within a week, the disease had reached the Murray River ten miles away, and in a matter of months had spread, sometimes by spectacular leaps, over an area nearly 1,000 miles from south to north and 1,100 miles from east to west in the Murray-Murrumbidgee-Darling-Lachlan river system. Soon it was evident that mosquitoes and other insect vectors, aided by prevailing winds and the flood conditions of 1950, had made the epizootic possible. In the 1952-1953 season, myxomatosis caused unprecedented rabbit mortality. The wool clip reached a record figure, and it was estimated that the reduced competition from the rabbit had contributed an extra 48 million dollars' worth of wool, as well as valuable additional sheep and lambs. As an instance, with the aid of myxomatosis, the owner of a 10,000-acre property in eastern central New South Wales succeeded in eradicating rabbits and found that by keeping them out he could safely carry twice as many sheep. It is doubtful if there has ever occurred in any country such a dramatic instance of biological control as the advance of myxomatosis on the Australian wild rabbit. Fears are expressed that the survival and multiplication of immune types of rabbits will eventually cause myxomatosis to become unimportant, but thus far, the rabbit is still well under control.

From 1903 onwards, the sheep blowfly has rated as one of our worst pests. It probably entered Australia in the nineties, but because of a series of dry seasons, did not show up strongly until the breaking of the drought. The primary blowfly (*Lucilia cuprina*) is attracted by wet and stained wool, on which it lays its eggs or the actual young maggots, which develop with amazing rapidity. They burrow through the wool, devouring the skin and flesh, and if not attended to can kill the sheep. After the strike of the primary blowfly, other species of blowflies may carry on the wound. Ever since 1903, pastoralists have conducted a sustained campaign by means of dipping, jetting and swabbing to kill the maggots, crutching, and, more recently, by the mules operation (an operation to remove the wrinkles from the neighbourhood of the crutch to lessen the incidence of fly strike). Losses through deaths, down-grading of wool and the expenses of preventive and remedial measures have cost the sheep and wool industry many millions of dollars each year. In more recent years, a modified mules operation and groups of newer insecticides have reduced losses from both crutch and body strike, but, because of the ability of the *Lucilia cuprina* population to adjust itself to insecticides by evolving resistant strains, the battle against the primary blowfly is still being waged.

The cattle-tick, with its accompanying tick fever, first attracted attention in 1880 in a mob of cattle at Glencoe, about 100 miles south-east of Darwin. By 1895 it had reached Longreach in Queensland. Little was known about the associated fever till an investigation by C. J. Pound revealed that it was caused by a protozoan parasite attacking the red blood corpuscles of the affected cattle—the blood sucking cattle-tick being the only means of transmitting the parasite from one animal to another. It was determined that the disease was identical or very similar to Texas and red-water fevers of other countries, and a heavy infestation of ticks, even in the absence of the protozoan parasite, may prevent cattle from thriving and even cause death.

When the tick reached the coast of Queensland, its advance speeded up, and by the turn of the century, it was well established around Brisbane. In the coastal districts, it found a more congenial habitat, and soon attempts were being made to stem its advance into New South Wales. A somewhat elaborate quarantine fence was erected at the border between Queensland and New South Wales, but in spite of every effort, there have been many inroads of the tick, and millions of dollars have been expended on its control. The idea of eradication was undoubtedly present from the first invasion of the tick into New South Wales. Organized programmes of eradication, however, did not begin until 1932, by which time the pest had penetrated as far south as Coff's Harbour and Urunga. The campaigns in these districts were successful, using an arsenic dip, or spray, and de-stocking the areas for 10 or 15 months. Many other successful district eradication campaigns were conducted during the next twenty years or so, but there were also several district campaigns which were rated as having failed for one reason or another.

The idea of complete eradication from the State was proposed in 1946, and it was planned to undertake it in three overlapping stages, commencing with the areas west of the Richmond Range. However, the appearance of arsenic resistance in Kyogle in 1952 led to that area being given priority, in the hope that the resistant strain of ticks might be eliminated. The major eradication campaign was finally mounted in 1956-1957. It covered 2,090 square miles, of which about 500 square miles (Kyogle) was on the east of the Richmond Range, and about 1,200 square miles on the west of the Range. The area contained 1,750 properties, carrying about 200,000 head of stock, and was provided with 394 2,500-gallon cattle dips so located that no beef cattle had to walk more than three miles for treatment and no dairy cattle more than one and a half miles. A staff of 750 men was employed during the campaign. The campaign consisted of three phases: (1) a dipping period of fifteen months, when all stock were treated at fortnightly intervals in dips containing 0·5% DDT; (2) an inspection period of one year, during which all musterable stock were examined every three weeks and all travelling stock were examined; and (3) a surveillance period of one year. The campaign was successful in the more westerly areas, but it failed in that infestations were subsequently found in three areas west of the Richmond Range. This was a costly failure, and it led to a special committee being set up in 1959 to inquire into the whole question of cattle-tick control. This committee concluded that many aspects of the cattle-tick problem in New South Wales require detailed investigation before future policies of eradication can be considered seriously. A well staffed and equipped Cattle Tick Research Station has been established in the Richmond River district, and progress is being made in unravelling the extraordinary survival devices of the tick and its associated protozoan *Babesia argentina*.

The control of weeds is a normal farming activity, and is either carried out by use of cultivation implements or, more recently, by chemicals, sometimes of the hormone type. A grazier who pastures his livestock over large acreages or even square miles can, however, be confronted with weed problems of considerable magnitude, and much research is in progress and is still required to solve his weed problems.

The prickly pear invasion stands out as the greatest threat from a weed against which Australia has had to battle. One species of prickly pear, *Opuntia monocantha*, was introduced from Rio de Janeiro with the First Fleet, with the object of growing the cochineal insect on it for the production of the most popular dye of the period. There is, however, no evidence that it ever got out of hand and became a pest. As time went on, other species were introduced by settlers probably firstly as ornamentals, but soon they were being grown as hedges or fences around gardens and homesteads in New South Wales and in Queensland, where they flourished very well. Being hardy, drought resistant, and capable of propagation by both seeds and leaf segments, they soon began to spread over adjacent paddocks and form dense clumps. By 1883, the Queensland Government declared all prickly pears noxious weeds and exhorted land holders to eradicate them. This was easier said than done, and the infestation continued to grow. By the time of Federation, it was estimated that about ten million acres were carrying pear. It was 1912 before the Queensland Government really tackled the problem in earnest. An experiment station was set up at Chinchilla to test various poisons and poisoning methods, and two scientists were despatched on a mission to all countries where prickly pears grew, seeking parasitic insects and fungi which might help in controlling the pest pear. The most promising parasite introduced by this mission was a sucking insect related to the commercial cochineal insect. By this time, botanists had classified our range of pest pears. There were at least eleven species, but two of them, *Opuntia inermis* and *O. stricta* were causing most of the trouble because of the speed with which they spread. After testing the wild cochineal insect on economic plants with negative results, it was released. All it did was to cause the extermination of one species, the comparatively harmless *O. monocantha.*

When the Commonwealth Advisory Council of Science and Industry was formed in 1916, the prickly pear menace was listed as one of the most pressing problems for scientific investigation, as by now many millions of acres of good quality grazing land were infested, much of it being impenetrable. Another mission was sent to the American continent, the native habitat of all species of *Opuntia,* in search of promising natural enemies of the two destructive species. Collecting and breeding depots were set up in South America, great care being taken to make certain that none of the proposed introductions would attack economic plants, and were also free from their own parasites and predators, before despatch to a quarantine station which had been established at Sherwood, near Brisbane. At least three of the introductions from the second overseas mission did notable damage to the pear, but their rate of spread was comparatively slow. In 1925, A. P. Dodd took charge of the investigation, and while travelling in northern Argentine, was much impressed by the activity of a leaf-boring moth, particularly in relation to our two pest species of prickly pear. This moth had the name *Cactoblastis cactorum.* Dodd despatched 3,000 eggs of the moth from Buenos Aires, and the consignment reached Sherwood in May, 1925. The eggs hatched and the caterpillars thrived on the *Opuntia inermis* and *O. stricta* supplied to them. After passing through the cocoon stage, the resulting moths deposited in September 100,000 eggs, and in the following March the yield was 2·5 million eggs. The eggs were systematically distributed in the worst infected districts—nine million eggs during the first year.

The eggs are laid by the moth in long chains or sticks of 75 to 80, and are thus very convenient for distribution. The caterpillars hatch in a few weeks and bore into the segments of the pear and eat out the succulent interior, growing in size until they are about an inch long.

The pear segments rot, and before long, large clumps are destroyed. There are normally two generations in a year, the egg-laying seasons being usually September-October and January-February. Plants partially destroyed by one brood may be completely killed by their descendants, the moths laying their eggs on the plants on which they had fed as caterpillars.

From September, 1927 to March, 1929, 300 million eggs were released from Sherwood, being sent to every district affected by the pest species, but natural multiplication in the field and the activity of graziers and the general public in spreading the egg sticks soon completed the distribution. With a practically unlimited food supply, and freedom from the natural enemies that kept it in check in the Argentine, the rate of multiplication of *Cactoblastis* was prodigious. By 1932, just six years after its release, the bulk of the prickly pear lay on the ground, a rotting mess, and by 1936, the two main pest pears had been exterminated.

The control of prickly pear in Australia is generally regarded as the most spectacular instance of biological control of a weed in any part of the world, and if it has a rival it is to be found in the miracle wrought by myxomatosis on the wild rabbit in Australia.