KYBYBOLITE EXPERIMENT FARM – A HISTORY

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1906–1920: EARLY FARMING PHASE

In 1903 the Principal of Roseworthy Agricultural College, Professor A.J. Perkins, in his annual report stated that the college was a teaching institution and concluded by suggesting 'It will be necessary to call into existence what for want of a better name, we may term an experiment station, in no way hampered with direct teaching operations'.

Two years later the Minister of Agriculture, Laurence O'Loughlin, stated that the Council of Agriculture was pleased that the government had set aside land for an experimental farm at Kybybolite.

In 1905 the Director of Agriculture, Professor William Angus, in emphasizing the need for experimentation stated 'Such subjects as nitrification (one of the most important natural processes affecting agriculture), the assimilation of food by the plant, the effect of heavy dressings of any artificial manure on the availability of plant food, the effect of rains on the fertility of the soils in certain localities, the best stage at which to cut wheat or oats for hay, the economic feeding of farm animals, a comparison of different crosses for lamb production, the best methods of working certain types of land, etc., afford ample scope for the experimentalist; and the fact that most of these have not been satisfactorily solved justifies the existence of such stations'. He was certainly looking well ahead at some of the research projects that would be carried out at Kybybolite.

Indeed in an attempt to summarise 100 years of work at Kybybolite it will be this author's aim to describe the work done as providing answers initially for those properties immediately surrounding 'the Farm' (as it was and still is referred to by locals), then over time to investigate the management of soils, plants and animals over the large area of meadow podsol soils of Southern Australia. Ultimately the research facilities at Kybybolite enabled wide ranging studies to be undertaken, the results of which have been applicable over a much larger area, indeed wherever pastures and livestock are part of Australia's agricultural scene.

The first manager of the Experimental Farm at Kybybolite, S.H. (Simeon) Schinckel reported in July 1906 that the 1060 acres of the Homestead block was typical of a large area in the district. The soil was largely sand over tight clay with an iron pan subsoil layer that, he suggested, needed to be broken to promote better drainage as the area was subject to flooding. The soil was low in fertility, it was felt that heavy rain over the years had carried away essential plant foods and the property had been overstocked. He stated that there was considerable doubt as to its suitability for arable farming.

Action in the first year of occupation showed he aimed to meet one of the foreseen difficulties. A system of surface drains was ploughed leading to the blowhole immediately south of the two-storied homestead building. Over the years more work on these drains proved effective and heavy rains in later years saw much surface water diverted to the blowhole. The first move to improve soil fertility saw sheep manure from beneath the woolshed spread on an area being prepared for root crops. In 1906 some 220 acres was sown to cereals, which included 21 wheat varieties, 13 oat and 7 barley cultivars. Just west of the homestead some 25 acres were cleared, trees roots were grubbed out and the area, planned as an orchard, was subsoil ploughed to a depth of 18". In addition, sties and yards for 20 pigs were erected.

It is apparent that the planners were out to demonstrate that the new farming community could better use the well-watered area than had been possible by the earlier grazing pioneers. The title of ‘Experiment Farm’ suggests that the farm itself was an experiment though no doubt the originators intended the name to also imply that the area would be used to carry out such experiments as might be needed to benefit the local community.

A new manager, Mr H. Wilson who came from Murray Bridge, reported on excessive rain in July of 1906. Indeed, rainfall for May, June and July was recorded as 4", 5.35" and 9.35". That three-month total of 18.7" has never been exceeded! A subsequent report stated, ‘their efforts to grow cereals under such conditions can be better imagined than described’! Wilson noted that all cereals were cut for hay and subsequently threshed, that crops had responded to superphosphate and to spring application of nitrate of soda. By July 1907 the farm carried 700 sheep and lambs, 18 horses, 18 cattle, 75 pigs and 20 poultry and 2.5 miles of sheep proof fencing had been erected.

For the first time the annual report showed total expenditure and receipts for the year. Figures of £1257.15.2 and £361.10.3 would not have been unexpected with so much early development required but the continued publication of such figures may have been judged unwise by a government department, subject to close scrutiny and possible local criticism, for after this they were seldom published.

The total rainfall of 36.07" for 1906 may well have discouraged cereal production in the Kybybolite area but further north in the Pinnaroo district on better drained soils wheat yields were so good that large areas of Mallee scrubland were rapidly developed. Three years later W.J. Colebatch, the Superintendent of Agriculture in the South East, commented that ‘due to the wetness of 1909 and in the absence of an efficient draining system, cereal yields were light’. To improve drainage an area was ploughed with a mole-plough to a depth of 22". With only horses for traction this was slow and very heavy work and the ‘mole drains’ so formed led water to a lower site but not necessarily out of the soil profile. The need to improve drainage was ever present: wheat yields over a small area were said to be improved by ploughing to a depth of 9" in 1917.

Cook (1922) published an article on depth and clay – see the *Journal of Agriculture* (SA).

In 1908 the manager suggested there was ‘a need for the conservation of dry fodder and growing of green crops (rape, sorghum etc.) and it seems desirable that a small dairy be established’. Early days, but livestock rather than crops must have seemed more logical in wet seasons. A further two blocks of land (Section 499 of 504 acres and Section 511 of 748 acres) located 4 miles north of the homestead were added to the farm but that new area totalling 1252 acres could not carry 800 ewes – hence the need for conserved fodder. That land was used for grazing until 1923 when the permit was cancelled and the blocks allotted to local producers.

The Merino ewes on the farm were considered small bodied and English Leicester rams were introduced to produce a half-bred ewe more suitable for the production of meat lambs. Colebatch in 1910 suggested that ‘the establishment of permanent experimental flocks, as at Rothamstead, is most necessary’. In due course the Kybybolite farm ran small studs of Clydesdale horses and Ayrshire cows. Curly-coated Lincolnshire pigs were introduced from England, not maintained initially as stud animals but when subsequently bred up to Middle Berkshires and later still bred up to Middle Whites the herd was registered in 1921. In 1910 a report on the Department of Agriculture’s Egg laying competition showed 21 pens of various breeds tested and the breeding stock maintained to ‘provide chickens for farmers’.

Adjacent to the homestead in 1908 the first plantings in the orchard included 1152 export apples (equal numbers of the varieties Jonathan and Cleopatra); 86 fruit varieties (plums, nectarines, orange, quince, pears and almonds) and 86 grape vines. In 1911 a fruit room was built adjacent to the homestead building, a room so well built and so useful it still is in existence. Fertilisers and lime were applied to the orchard along portions of rows and yields were determined annually. Responses to both phosphate and lime were obtained (lime reduced the growth of the weed Sorrel) and the heaviest yield came from the Cleopatra variety. Quality fruit was produced over many years with 600 cases being sent to cold store in 1918 and local people enjoying an annual purchase. The orchard was maintained until 1930 when a collapse in fruit prices led to its closure. When the apple trees were grubbed it was found that the roots of the trees had not penetrated the clay sub-soil and the trees had existed on the nutrients in the shallow surface soil. This was reflected in the ‘dwarf’ appearance of the mature trees. Cook stated in 1957, ‘if it were possible to break through the 24" to 36" of sub-soil to reach the marl below, no doubt the growth of trees and their production would have been much greater’. It is therefore of interest to note these features in the apple trees established in the district on the property of ? in the 1990s where modification of the soil profile by extreme ridging has been most beneficial.

During 1910–11 a cottage for a married couple and a substantial building providing accommodation for the farm staff were erected near the homestead building and these were all maintained until the late 1960s. For many years the farm staff included a number of single men and the relatively low rates of pay offered by the government ensured that the farm supplied the district and township with some ‘interesting’ characters. When the ‘single mens quarters’ were closed as such in 1955 they were converted to offices and laboratory accommodation until the Minister of Agriculture, Ross Story, opened a fine new office and laboratory complex in May 1969.

The farm office erected in 1910 also stood for many years immediately adjacent to the homestead and was not replaced until 1969.

A very dry season in 1911 saw wheat yielding only 5.3 bushels/acre and Colebatch emphasised that early seeding was essential, 1 cwt of superphosphate/acre was adequate, and there was a need for additions of lime. A very dry season in 1914 saw wheat all cut for hay yielding only 16 cwt/acre but needed to provide fodder for the horses that were the sole source of power for the next 30 years.

In 1915 a new manager, L.S. Davie, was appointed. For five years he carried on the program in which emphasis was given to the potential for dairy production.

In the absence of conserved fodder the growth of young animals was restricted and in 1917 the young horses were agisted at the Department’s farm at Veitch in the Murray Mallee and the Shorthorn cows went to the Returned Soldiers Farm at Mount Remarkable in the Upper North. The Shorthorn dairy cows did not return from Mount Remarkable and were replaced by Ayrshires. Over many years the Ayrshire herd was part of the State Herd Testing Association. On occasions, individual cows were adjudged best producers of their breed in the State and sires and surplus heifers were readily sold to local and Victorian dairy farmers.

Reflecting on the agistment of the weaner sheep away from the farm, the Manager later said: ‘rearing of young sheep on limestone country is making a marked improvement in our flock’. Forty years later the farm and the locals were still concerned about the growth of weaner sheep in the area.

In 1917 the former Manager of the farm, Simeon Schinckel, presented a paper to the Naracoorte Branch of the Agricultural Bureau in which he recommended the use of superphosphate for pasture lands. He said that extra superphosphate applied to a crop would be a very good investment, not because there would be a direct gain in the crop, but because of the marked improvement in the pasture that would follow.

The annual report of 1918 described 1917 as the worst cereal year the farm had experienced with 4.72" in May, 4.47 in July, which flooded the farm, and above average rainfall in October and November. It is not surprising that next year Davie said ‘the first steps have been taken towards converting the activities of this farm to be mainly livestock’. Nevertheless many different crops were being tried, including tick beans, linseed, millet, mangolds, turnips and Swedes; most being crops widely used in Europe. In 1920 much work was put into drains and subdivisional fencing and Davie was convinced that ‘the time is fast approaching when the farm will be well subdivided and fairly well drained’.

Droughts followed by very wet seasons made farming conditions difficult indeed. Nevertheless on 30-acre fields, the historic Norfolk four-course rotation (first described in 1733 by Jethro Tull in his book *Horse Hoeing Husbandry*) of turnips, oats, peas and wheat was in use.

A five-course course rotation of oats, peas, wheat, ? and kale was also commenced. The growing of peas ahead of wheat, to produce nitrogen and increase grain yield and of fodder crops to provide summer grazing for livestock were both logical developments.

Of particular interest was a six-course rotation pasture – wheat, oats with vetch, turnips, oats with red clover and Italian ryegrass, clover and ryegrass. Importantly, the use of three years of legume-based pasture ahead of wheat and oats foreshadowed the pattern of cropping in the area in the years ahead though the ultimate pasture species were not to be red clover and Italian rye grass but subterranean clover and Wimmera rye grass.

In 1919 the Director of Agriculture, Professor Perkins, initiated a pasture fertiliser experiment that was to continue for more than 60 years, and provided excellent data and was a magnet attracting interest from producers and scientists not only in Australia but also from beyond. Davie set out six plots each of 3.5 acres on virgin soil in the northeast corner of the property that were top dressed with differing amounts and types of fertiliser. These plots were later added to and became historically important as they were maintained for a period of more than 60 years and provided data on medium term sheep carrying capacity and much longer soil chemical changes. In the 1990s when pressure for grazing land increased and the plots were felt to be no longer required a very active local committee fought hard for the retention of certain plots as Vintage or Antique parts of the traditional history of the area and thankfully these plots are still in existence.

In 1920 (see *Journal of Agriculture* [SA] *24*:121) an irrigation well was sunk to a depth of 45 feet and with 12 000 gallons/hour proven, an area of 12 acres of heavy 'crab-hole' soil was graded and plans made to flood irrigate a range of crops. Maize yielded 52 bushels/acre in the first year while other crops tested included sorghum, turnips, mangolds and lucerne. The area produced valuable fodder for many years and after 10 years water quality had not varied and depth to water was not altered. Without a doubt this was a 'demonstration first' for irrigation in the South East. The work was not continued during the 1930s but subsequently stud Strawberry clover seed was produced.

1921–1940: PASTURE DEVELOPMENT PHASE

On 11 October 1921 the Director of Agriculture reported that Davie had resigned his position as Manager of Kybybolite Experimental Farm and L.J. (Len) Cook was transferred from the Eyre Peninsula Experimental Farm to Kybybolite. This was later recognised as a momentous move as the name Cook became synonymous with the new phase which was to follow the early development and farming stage. Three years after his appointment Cook addressed a distinguished gathering – the Australian Association for the Advancement of Science. His words summarise the first phase of work at the Experimental Farm: 'During the past 15 to 18 years a large variety of crops, manurings, methods and cultivations have been tried, and except where correction of soil by liming, combined with surface drainage, has been attempted, very little consistent results from crop growing has been secured. An exception of recent years has been the growing of subterranean clover with the aid of phosphatic manures'.

A.W. Howard had identified subterranean clover (*Trifolium subterranean*) near Mount Barker in the Adelaide Hills as early as 1889. He fertilised the legume, promoted its use, multiplied seed and helped develop harvest equipment to produce the first seed for sale in 1917. S.S. (Syd) Shepherd and E.C.H. (Ted) Schinckel, two local graziers who were strong supporters of the farm over many years, first sowed subterranean clover in the Kybybolite area in 1918.

In 1919 in the northeast corner of the property on natural pastures with no previous cultivation several plots of 3.5 acres each were fenced. These were added to in 1924 and 1926 to provide 13 plots that were maintained for 60 years and became well known as the permanent fertiliser plots. An energetic local group has retained some of these plots as 'Historic Plots' largely as a consequence of some very commendable and determined work. (See a section written by one of them in Judy Murdoch's book.)

Along the eastern boundary a further 15 plots of 5 acres each were sown to subterrranean clover in 1924: Wimmera rye grass was also established. These plots were treated annually with variable rates of different phosphatic fertilisers with some having additional lime, gypsum or ground limestone at intervals. Control plots, which were not fertilised, were also maintained. All plots were grazed intermittently with sheep that were removed at a time that left an even residue on all plots. Sheep-carrying capacity (calculated from sheep grazing days) was the measure of pasture production. Soils were sampled and analysed at the start of the trials, again in 1938 and finally in 1962.

Though long term in nature, after five years Cook reported that on the natural pasture area the no manure plots carried only 0.91, those receiving phosphatic fertiliser carried 1.45 and those with phosphate and lime 2.13 sheep per acre respectively. Subsequently he was able to report increased carrying capacity in sheep per acre over a 10-year period (1928–1938) as follows:

	Natural pasture	Sown pasture
No Manure	1.00	1.16
Calcium Rock phosphate	2.43	3.11
WSP Superphosphate	3.41	4.38
Lime + Super	3.46	5.16
Gypsum + Super	3.22	4.73

From these figures four basic findings can be drawn. Firstly, without fertiliser both natural and sown pastures had low carrying capacity. Secondly, water-soluble phosphate increased carrying three to four fold; thirdly, the addition of lime marginally increased sheep carried while in general terms sown pastures that were fertilised carried some 38% more sheep than pastures that did not include subterranean clover.

At the farm cereal yields were poor in 1922 and the yields in the year following were below the 10-year mean due to a spring plague of caterpillars! Cook stated briefly in 1923 that rainfall was 2" below average and therefore cereal crops yielded above average though average wheat yield was only 14 bushels/acre. The movement towards pasture development is revealed in his statement, 'the five course rotation (mentioned above) has now been changed to Wheat, Oats and three years of Subterranean clover, and in view of the great promise of this clover, this course should, during the next few years provide some interesting results'. He also calculated the mean yield of oats over the period from 1910 to 1923 to be 16 bushel/acre with a range from 6.19 to 33.2. While the 14-year average of 16 bushel/acre was reasonable it does not compare well with 100 bushel/acre from a crossbred oats in 1958 being sown on a well-drained field that had been under legume pasture for some 30 years.

Besides the crop rotation experiments, trials were conducted with low-grade rock phosphate (calcium and aluminium) in a wheat-peas rotation. It was important to see if cheaper, less concentrated fertilisers could be substituted for the more expensive, more concentrated 45% water-soluble form. Indeed, this was only the first of many investigations over the years that aimed to determine the optimum fertiliser treatment to correct possible deficiencies of both major and minor plant nutrients.

Phosphorus fertiliser had been shown, by Professor Custance at Roseworthy College in 1885 to markedly increase wheat yields and recognition that the plant nutrient phosphorus was deficient in most Australian soils soon followed. In retrospect the combination of subterranean clover and superphosphate resulted in greatly increased production on huge areas of well-watered land over much of Australia. Of the 'naturalised' species, Cluster clover (*Trifolium glomeratum*) responded well to fertiliser but it was not recommended in view of the productivity of the introduced subterrranean clover (*Trifolium subterranean*).

In 1924 Cook published average yields from fertiliser trials on 2-acre plots of wheaten hay from 1919 to 1923 (see table). Super doubled the hay yield and lime added a further 25% but the cost of £3/acre for lime on land valued at that time at £6–£8/acre could not be justified.

Treatment	Yield

	(Ton–Cwt–Qtr)
No manure	0–10–85
1 cwt super	0–19–08
1 cwt super + 5 cwt lime	1–4–100

The 1925 report again highlighted the impact of seasonal conditions on cereal yields. Good rains in January, February and March allowed early soil preparation. Winter rains were half normal and good spring rains gave yields well above average.

Yields (bushels/acre)	1925–26	1926–27
Wheat	13.62	13.85
Barley	14.60	31.94
Oats	17.18	21.0

Although above average, these yields were relatively low and the big seasonal variations that had been experienced suggested that cropping of cereals would always be risky and a more productive crop of pasture would well suit the animal industries which were to be tested in the years ahead.

Cook reported in 1927 that 'the establishment of subterranean clover with the liberal use of super phosphate fertilizers and lime and the utilization of summer irrigated crops are having the anticipated effect and altering the character of feed and conditions, making them quite suitable for dairying'. Pasture was proving adequate for the spring months of August to November, lucerne with irrigation was sufficient for December to March while surplus pasture conserved as ensilage in the spring maintained milk production from April to July. While the dairy herd was restricted to 36 milking cows their production was at a very good level and many local properties were also running dairy herds. Indeed, the district level of milk production was such that a dairy factory was established at Kybybolite in 19??. The Ayrshire herd was maintained until 1950, was regularly tested and produced Best Milk producers for J3, J4 and Mature cows in 1946 while in 1948 a senior 4-year-old called Kybybolite Herophile set a State record as the Best Ayrshire Butterfat producer!

In 1930 Director A.J. Perkins said:

> There is no single factor better calculated to lead to expansion and prosperity in our livestock industries, especially sheep and dairy cattle, than the comparatively recent practice of top dressing with phosphates the pastures of our better rainfall districts. It is no exaggeration to say this process could double or even treble livestock carrying capacity.

1924–25	67 000 acres
1925–26	123 000 acres
1926–27	162 000 acres
1927–28	210 000 acres
1928–29	250 000 acres
1929–30	302 000 acres

Figures for the area top dressed with phosphates in South Australia suggest that results from the long-term plots at the Experimental Farm were being repeated elsewhere.

The worldwide financial depression of the 1930s was reflected in the 1931 annual report which stated 'the difficulties of the financial position have led to the closing of the Booberowie and Veitch Farms whilst the Minnipa Farm has been let on a share farming agreement until such time as conditions improve. Hence Departmentally we are now responsible for one farm only, situated at Kybybolite'. Late in the 1920s there was a move to close all Government Experimental Farms and leave research to the CSIRO and the Waite Agricultural Research Institute but fortunately Kybybolite remained open.

Despite the difficult times of the 1930s the farm continued with its developmental work with the area to sown pastures increasing and the emphasis on livestock showing in the projects initiated. At the request of the local branch of the Agricultural Bureau in 1933 a small experiment looked at the production of export type fat lambs bred from English Leicester cross Merino comeback ewes mated to four sire breeds. Overall the 184 ewes dropped 245 lambs of which 187 reached market, dressed out a 32 lb carcase with 95% graded first or second quality. There were minor differences between lambs from the different sires: the Suffolks grew faster and gave the heaviest carcasses, but with a lower price per lamb; the Southdowns graded much better; and the Dorset Horn progeny achieved heavier carcase weights which did not grade as well. Lambs were consigned by rail to Adelaide and shrinkage was suspected. The suitability of the first cross ewe as a producer of lambs for the meat trade was well demonstrated and they were used in many subsequent trials at the farm.

A subsequent experiment looked at the shrinkage (loss in weight recorded during movement of lambs) from farm to abattoir at Portland, Victoria and Gepps Cross, Adelaide. Within truckloads sent by rail to Mt Gambier and then trucked to Portland with 46.5 hours from despatch to slaughter in both November and December or sent to Adelaide by rail with trans-shipping at Wolseley in November, groups were compared with control groups of similar lambs slaughtered at the farm when the other groups were despatched.

Controls at the farm	November	49.8 %
Controls at the farm	December	51.8 %
Portland	November	52.8 %
Portland	December	–
Gepps Cross	November	53.8 %

The percentage of weight lost by the various groups.

They indicated that weight loss in the first draft lambs in November was 2% more at Portland and 3% more at Gepps Cross than at the point of origin. Later in the season with older, woollier, heavier lambs and probably warmer weather the shrinkage from farm to Portland was 4% higher. These losses were regarded as acceptable but in due course many lambs were trucked in semi-trailers, the entire distance from properties to the abattoirs. With grain prices depressed (the return in 1929 for a bushel of wheat was ?? and had only increased to 1 s 7.5 d in August 1938) the number of sheep in South Australia rose from 5.89 million in 1930 to 8.9 million in 1937 – an increase of 50%. The associated increase in lambs produced for export is shown in the following figures:

1932–33	53 000
1933–34	206 000
1934–35	273 000
1935–36	345 000
1936–37	420 000
1937–38	376 000

Export carcase numbers.

Many of these were running on the subterranean clover pastures of the South East as about 100 000 lambs a year were being sent from SA for slaughter at Portland.

In an effort to assess the residual value of superphosphate after 10 years of use on subterranean clover pasture and the possibility of reducing the quantity applied a series of four plots (with no replicates) to receive 0, 45, 90 or 180 lb/acre of 45% WSP annually were set out in 1935 on land which had received 10 cwt over 11 seasons. After 5 years the average carrying capacity was 2.76 for the nil plot and 3.77 for the fertilised plot. When the experiment ended in 1952 the mean carrying capacity for the four levels of phosphate applied were 2.0, 3.4, 3.7 and 3.6 respectively. Without phosphate, carrying capacity fell by 1 sheep/acre in the first year but showed little further decrease. The similarity between 45 and 90 lb/acre suggested that the annual maintenance level might be near the 0.5 cwt and the immediate question was would it be adequate to apply twice the requirement every second year.

In 1937 the Director of Agriculture, W.J. Spafford, reported that L.J. Cook RDA, the Manager of the Kybybolite Experiment Farm, had been appointed Experimentalist at Head Office on 5 October 1936. His replacement, Worsley Clifton Johnston RDA, Agricultural Adviser, was appointed Manager on 10 November 1936.

The 1937 Report was presented by Cook (and this was, in effect, a summary of work in progress at the time of his departure):

> At this station the pasture and livestock tests are being continued as follows: -
> 1. Grazing tests of various pasture mixtures.
> 2. Manurial tests with phosphate and lime on natural and sown Subterranean Clover pastures
> 3. Rotational grazing of (a) natural (b) subterranean and WRG and (c) subterranean and Phalaris pastures.
> 4. The replacement of such naturalised grasses as Brome, Barley and Silver grass with better grasses such as WRG.
> 5. Pasture seed and plant trials in collaboration with the Australian Dairy Council.
> 6. Sheep and wool development and production from pasture mixtures in conjunction with the Waite Research Institute.
> 7. Export lamb production.

Late in the Depression years, funds were short and the farm could not be as well staffed as perhaps the facilities justified. However, those same facilities were ideal for field research and the initiation of work by the Waite Institute, the Australian Dairy Council and later by workers from the CSIR commenced a long period of co-operation. For many years to come much work was also initiated by officers of the State Department located in Adelaide but carried out by the station staff. Within two years of Johnston’s appointment, World War II imposed even greater restrictions on staff and funds and the 1937 program could not be expanded.

Soon after he left the farm Cook had soil samples from both the natural and the sown pasture plots analysed and he published his extensive findings in 1939. The sheep-carrying capacity per acre for the 10 years from 1928 to 1938 was:

	Natural Pasture	Sown Pasture
No manure	1.00	1.16
Rock phosphate	2.43	3.11
Base phosphate	2.43	4.09
Superphosphate	3.41	4.38
Super + lime	3.46	5.16
Super + gypsum	3.22	4.73

These figures indicated the benefit of water-soluble phosphate, the superior carrying capacity of sown pastures and a mixed response to additional calcium. Phosphates slightly increased soil acidity in the surface few inches but had little effect on the top foot of soil while lime definitely reduced acidity. Most of the residual phosphate was in the top 4". Soil nitrogen levels reflected increased pasture growth. The only legume to persist was subterranean clover, annual grasses increased with time and lime promoted the growth of thistles.

Over the 10-year period the carrying capacity of plots receiving 45, 90 or 180 lb/acre were 3.29, 4.54 and 5.26 sheep/acre. These figures suggested that the pastures and livestock would still respond to an annual dressing of 180 lb/acre. The question of how much phosphate was required to maintain productivity could not as yet be answered. Indeed it would be another 15 years before this question was seriously asked in a field trial.

How to most efficiently use the grass-legume pastures was another frequently asked question. Research elsewhere, with pastures being cut at intervals, suggested that intermittent grazing might give maximum yields. Indeed, the question of grazing methods and pasture 'management' to give maximum output was to be investigated in many trials, with different animals, for the next seventy years both at Kybybolite and elsewhere.

With surplus pasture available late in the spring and the development of mowers, hay rakes and balers, many were asking 'what is the most economic method of conserving this material?'. In 1939 a trial compared pasture mowed and left in the swathe with material left in the windrow and that mown, windrowed and pushed into cocks. Half of each treatment was baled either 7 or 14 days after cutting. This design was good and hay was sampled and analysed but a total of 158 points of rain falling on 11 of 22 days of hay making, low sunshine and high humidity spoiled much of the material and the results were inconclusive. This type of investigation was repeated in the 1960s but while wethers grazing at 6 per acre showed body weight benefits from the hay wind rowed or baled and fed back, wool production did not differ.

Despite staff shortages Johnston prepared for two grazing management trials to be run in co-operation with Cedric Neale-Smith of the Waite Institute. In the first, three groups each of 30 ewes grazed either natural, subterranean Wimmera rye grass or subterrranean Phalaris pasture, with four plots of each grazed one week on and three weeks off, with additional sheep when required including rams at mating time. Over four years the sown pastures carried significantly more sheep (3.76 for annual and 3.89 for perennial) than did natural pasture which averaged 3.18 ewes/acre. The mean yield of herbage cut at the end of the season varied, with Wimmera rye grass significantly higher than natural in four of five years and Phalaris being higher than natural in 2 of 5. As noted in other trials an increase in annual grasses led to a decrease in clover. These measured differences confirmed the observations of many local producers and the decline in the annual Wimmera rye grass suggested that the perennial grass Phalaris might be a better species for permanent pasture areas. This grass grew well on the areas of black self-mulching soil, the 'crab-hole country' but with undergrazing tended to become dominant, reduced the legume and after summer rains produced a green pick which in some areas in the South East caused a 'staggers disease' in sheep.

Ewes developed more quickly on sown pasture, had a higher lambing percentage and more wool than those on the natural swards. The mean weight and value of wool/ewe was higher on sown pastures during the first three years but not significantly higher over the whole term of the experiment. Over that period sown pastures produced 8 lb more wool/acre/annum than the natural pasture. Neale-Smith pointed out 'the possibility of more effective utilization of the sown grasses by cutting for silage or hay and by adopting a longer interval between grazings'.

With the belief that export lamb production would be superior if pastures were grazed for a period and then 'spelled' a trial was started in 1940 at the farm with a 2, 4, or 8-paddock grazing system. Unfortunately, results from this experiment which was terminated early were not ever published. An early reference suggested that lambs were heavier at market when moved frequently but when in a subsequent year the reverse result appeared, it was suggested that the 'grazing management' was not sound! The exact criteria for the shifting of sheep from a short closely grazed pasture to a leafier 'spelled' sward had perhaps been not clearly defined. Should there be a fixed time interval between grazings? Could one estimate the pasture still available before shifting the sheep? Should sheep weight, live weight change or body condition be the major criteria? And, if so, could these measures be made quickly, accurately and economically?

Many farmers did not have their properties sub-divided as fencing was never a cheap addition so many lamb flocks were raised where the lambs were born. Others lambed the flock in small paddocks under supervision and 'marked' the lambs into a 'clean' paddock where they remained until ready for market. Factors such as grass seed at the end of the pasture-growing season led to selection of paddocks for finishing the lambs. Despite many trials it would be safe to suggest that most flocks were not involved in a regular rotational grazing system. Observations led some to suggest that in rotational systems the ewes seemed to benefit from a paddock shift while the lambs often appeared to suffer. Possibly the change from a short bite to a longer bite was a disadvantage to the young animals digestive system. In later trials the impact of grazing management on the intestinal parasites of the sheep were investigated.

In 1940 Neale-Smith commenced a trial comparing continuous with rotational grazing, with and without cutting hay in the Spring and feeding same back in Summer and Autumn to Merino or crossbred wethers. The effect was evaluated by comparison of live weight gains and wool production, the productivity and botanical composition of the pasture under the two management systems over a period of five years. It was planned to maintain 4 sheep/acre but 1940 and 1944 were two of the most severe droughts since 1924 and the stocking rate averaged 3.31.

There were no differences in herbage yield between rotational or continuous grazing either with or without hay feeding and the live weight of sheep responded only slightly to different treatments. Subterrranean clover yield increased under continuous grazing with grass dominance after rotational grazing. In four of five years the cost of cutting and conserving was not met by additional returns but drought in 1944 converted a debit balance for the practice to a highly profitable one for the full period of five years! Most local producers did not hold the concept of a drought reserve for a severe drought was not common in this well-watered part of South Australia.

In 1948 Professor Trumble of the Waite Institute published an analysis of rainfall, evaporation and drought year frequency for many recording stations in South Australia. Over 37 years the Kybybolite Experiment Station recorded 20.78", had a mean rainfall season of 8.1 months, a drought year frequency of 7% and a mean air temperature for July of 48ºF. With a drought expected on average only once in 14 years, a relatively long growing season and no period of extreme cold in the winter to inhibit pasture growth even the local landholders had to see the region as a 'safe' area despite the problems of the first 40 years!

While the dairy herd had been a fine method of converting good pastures into a saleable product it had introduced a worrying weed problem. The broad-leaved plant, Echium plantagineum, known in South Australia as Salvation Jane though called Pattersons Curse in the eastern States became well established over many parts of the farm and while its attractive purple flowers in the Spring put colour into the landscape the weed was dry and unpalatable in late Spring, made poor quality dry feed and left the soil bare in the Autumn months. Johnston commenced trials that examined the effect on this and other broad-leaved weeds of newly developed herbicides.

With the dairy a feature a small pig unit was always run on the farm. The Tamworth breed was introduced in 1937 and litter testing recorded in 1942. Some sires were sold locally but when the dairy herd was reduced to a few cows in 1950 pig production ceased.

1944 saw extreme drought conditions over the whole of South Australia with a State wheat average of 5.7 bushels/acre and the lowest total production of that cereal since 1897–98, i.e. a period of 46 years. In addition, severe rationing of superphosphate throughout the war years made this a difficult time for many local producers and the farm also had to reduce fertiliser use on all but essential experiments. One important change occurred in 1944 when the horse team was phased out and the farm acquired its first tractor.

Despite these problems, work commenced with the nutrition branch of the CSIRO to investigate the effect of the trace elements copper and cobalt on the development of Merino sheep and the quality of their wool production. While shortage of these elements posed problems elsewhere in the South East, the annual report in June 1947 was able to state categorically that ‘trace element work shows no deficiency of the elements cobalt and copper at Kybybolite’. Work over 6 years with 60 Merino ewes and their progeny concluded in 1952 with the finding that no deficiency in copper could be shown in sheep bred and grazed wholly on subterrranean clover/grass pasture growing on the meadow podsol soils of the South East that had been well fertilised with superphosphate.

Such a statement was reassuring to many flock owners but few would appreciate the hours of work involved in managing the sheep, dosing, injecting, blood and wool sampling, weighing, and the complex laboratory analysis of blood and wool fibres for elements whose presence could often be expressed only in terms of ‘parts per million’. This work and much that was to follow involved detailed and precise field and laboratory work associated with sound experimental design, including the replication of treatments, allowing results to be statistically analysed.

In 1946 Johnston was transferred to a position as Agricultural Adviser at Port Lincoln and J.D. (Jack) McAuliffe was appointed Manager. In his first report McAuliffe had the unenviable task of stating that while the permanent pasture investigations had continued ‘on account of an unfortunate grass fire on portion of the farm, a break in the sequence of grazing events will unavoidably occur’.

Fencing material was almost impossible to obtain and only by very skilful manipulation of flocks were the long-term plots given the grazing they required. Understandably the grazing data for some years may have been affected but the fertiliser applications were maintained and transfer of nutrients through the sheep was minimized. Isolated small stunted subterrranean clover plants could be found on the non-manured natural pasture plots indicating their arrival as seed in the droppings of sheep.

The 1940s were quiet times and the Department's annual reports for 1941 and 1942 had only four lines referring to work at Kybybolite. In 1948 the oil crops of safflower and sunflower were sown, but the weed control work still ranked high in importance.

Post-war shortages checked development in some areas but the world demand for wool is seen in the following figures:

Wool Value (pence/pound)

5 years to 1938–39	10.83
1946–47	22.05
1948–49	35.88
1948–49	44.14
1949–50	57.77
1950-51	129.16

The outbreak of war in Korea saw wool price rise dramatically to the astonishing figure of £1 (240 d.)/lb and sheep values moved accordingly. The increased return from wool gave many producers an opportunity to correct shortages of fertiliser and even restore and replace fencing. Jack McAuliffe listed the relative costs of essentials in 1951:

Item	**1947**	**1951**	**Increase (%)**
Superphosphate/ton	£5-£6	£14	164
Plain wire/ton	£24	£38	58
Water piping	£2.1.8	£5.4.2	150
Station hands (with keep)	£4.14.6	£9.6.8	98

Undoubtedly the most important work carried out by Jack McAuliffe was the field treatment of Salvation Jane. A range of herbicides was tested with Atlacide(?) and 2-4-D being the most effective. Rates and time of application had to be determined. Rapid cell division in the sprayed plants promoted sugar production, increased palatability and heavy grazing by crossbred ewes which had the capacity to eat the central tap root of the Salvation Jane to below ground level (a feat the larger mouthed dairy cow could not achieve) helped control seeding of the weed. Making of silage to reduce flowering, cultivation to kill seedlings and the sowing of Phalaris, which provided good competition, were all successful tools in the attack on the problem.

So successful was this work that in January 1953 he published his account with two very contrasting plans showing the extent of the weed in 1946 and again in 1953. (See *Journal of Agriculture* (SA) *56*: Jan. 1953 p. 279)

Immediately after World War II land development in the South East was stimulated by government action to acquire and develop properties for ex-servicemen. The Agriculture Department was committed to plan for a fuller use of Kybybolite. The pastures were there, how could they best be converted into saleable animal products? In 1948 L.J. Cook reported on his visit to New Zealand 'to investigate the organisation of animal research work in that country'. Soon after D.B. (Dennis) Muirhead, a Sheep and Wool Officer, spent three months in New Zealand 'to investigate the sheep industry with particular attention to lamb raising'. Matters being queried included: where should resources be directed; research was required on the rendzina soils; a new station was needed; and should Kybybolite be closed. From New Zealand came Dr C.P. McMeekan, a highly qualified scientist and Director of the long-established Animal Research Centre at Rua Kura. He agreed that a new station would be needed to answer the problems of the black soil plains, but he stated very strongly that Kybybolite should be retained. He believed that the research had been excellent, that the soils and their fertiliser history were well documented, that the general resources could not be transferred and needed little to make them adequate for the sheep husbandry work which was logical on the excellent pastures of the region.

1950–1995: A NEW RESEARCH CENTRE

In May 1949 Dr A.R. (Allan) Callaghan, who had been Principal of Roseworthy Agricultural College, and as Chairman of the Land Development Executive was responsible for much of the post -war property development, was appointed Director of Agriculture. The black soil plains were a logical area for further research as little work had been done on an extensive area that had been subject to annual flooding. Land was obtained at Struan, designated an outstation of Kybybolite and became the responsibility of Jack McAuliffe in 1951. In addition, the Kybybolite Farm was reduced in size when approximately 250 acres on the southern portion was ceded to the Lands Department for a soldier settlers block.

In 1953 McCauliffe was transferred to Jamestown, the Experimental Farm was renamed the Kybybolite Research Centre, and W.G. (Bill) Allden was appointed Officer in Charge. The upgrading in status signalled a plan for increased funding and more trained staff. Allden was a graduate from Cambridge University and had knowledge of the climatic variations of the country over which he had piloted aircraft in World War II. When first appointed to the Department he had worked with beef cattle on the property of Mr H.L. Miles of Hynam. Initially he was to have two research officers on site though it was to be some years before that staffing level was realised. Appointment of an office secretary freed Allden from much of the time-consuming paper work done by his predecessors. Eight new cottages to house research and farm staff were erected and a 240-volt electricity generator was installed. This allowed for use of a herbage-drying oven so pasture samples could be handled on site. Many farm buildings were repaired and painted and beef cattle yards and scales were installed.

Three major projects with an emphasis on fitting sheep production to the seasonal supply of pasture to produce economic levels of production in both cross-bred and Merino sheep flocks were begun.

The first was initiated by Muirhead in 1950, commenced by McAuliffe in 1951 and written up by Allden in 1956. Three groups of 100 Border Leicester cross Merino ewes each with four paddocks totalling some 30 acres, which they grazed in a flexible rotation, had similar treatments except for the time at which the ewes were mated. Early, mid and late season mated flocks were joined with rams for 6-weekly intervals from 15 December, 25 January or 7 March. The outcome of these different mating times was dramatic with fertility and fecundity increasing markedly as ewes were mated later in their breeding season. Over the 6 years life of the original ewe flocks the percentage of dry ewes was 12, 6 and 1 and the percentage of lambs marked increased from 103 through 129 to 149. The greater productivity through later mating led many to delay mating though in some years the August drop lambs could not be finished on green feed and grass seeds became a problem. Market prices also determined for many producers the best time to have their lamb drops ready for sale.

The second trial starting in 1955 was a detailed study comparing the production from Corriedale ewes with that of first-cross Romney cross Merinos and Border Leicester cross Merino flocks. These were mated to three ram breeds, viz. Southdown, Dorset Horn and Suffolk. With young ewes added in the second and third years a total of 780 ewes were involved. Both wool and meat production were measured. Little difference was measured between breeds for quantity or return per head for wool over the period of the late 1950s. The first-cross Border Leicester ewes proved equal to or superior to the other two breeds. They had fewer dry ewes and those which lambed had a higher percentage of twins. Lamb survival was better, growth was faster and meat production higher.

The impact of the sire varied with better grading of the Southdown progeny and heaviest Suffolk carcases. It is of interest that the Dorset Horn (and the Polled Dorset) remained the choice of most lamb breeders. The black fibres of the Suffolk posed problems to the wool industry while the smaller Southdown carcase, once believed to be the requirement in the UK market, did not command a financial advantage in Australia where the larger lamb sold well.

Soon after this trial was completed the industry moved to eliminate the term 'fat' lamb as dieticians suggested lean meat was better for health. The term 'prime' was used for some years, but later the term 'meat lamb' became acceptable. Later work at the centre aimed to determine the influence of the sire on the production of a heavy weight lamb with limited fat.

In the 1910s and 1920s the dry summer pastures seemed inadequate and young Merino sheep were sent from the farm to the Mallee and Mid North. In the 1950s a series of studies, commencing with Allden's appointment, looked at the nutrition of young Merino sheep. On the maturing pastures in the South East the growth of lambs at or near weaning was often checked. Through the summer months most lost weight, a 'tail' of poor lambs developed, many had tender wool and in some flocks mortalities were high. Weaner 'ill-thrift' was a recognised problem over a large part of the Western District of Victoria on soil types and with pastures akin to those at the farm.

In Allden's early trials self-fed silage proved inadequate, quality meadow hay only provided maintenance and trace elements and Vitamins C and D gave no improvement. A green fodder crop, especially Chou Mollier, when available gave excellent growth rates but of most benefit was the locally grown oaten grain. As little as ½ lb (227 g) of grain/day maintained body weight but of greater interest was the fact that when weaners were offered oats *ad libitum*, in a self feeder, they only consumed 1⅓ lb of oats/day (605 g) and gained 0.75 to 1.5 lb (340 to 680 g)/day. Over many years the legume pastures had lifted the nitrogen levels in the soil to permit good grain yields of oats that then could be used to help weaners through their first summer. A weaner-feeding program was demonstrated at a field day in April 1958 that spelled out rations for the 'tail' of the flock, the future breeders and the dry animals. Subsequent studies looked at the use of pelleted rations and commercially prepared 'sheep nuts' but over many years the value and economics of the 'home-grown' oats became the basis of most supplementary feeding programs.

In 1955 four replicates of 10 pasture types were sown and maintained for 8 years. Species included the perennials Phalaris tuberosa, Cocksfoot, Prairie grass, perennial rye grass, H1 rye grass, Timothy and the annual Wimmera rye plus two mixed species. In 1963 the only species still established was *Phalaris*. The other long-term grasses had not survived the summer temperatures and the short-term annual and biennial species had not re-seeded satisfactorily. The search for better pasture grasses continued.

At the end of 1955 Allden moved from the Department of Agriculture to the Waite Institute where he continued studies into the under nutrition of Merino sheep. P.E. (Peter) Geytenbeek took up the position in May 1956. Geytenbeek's background was in the Murray Mallee and Yorke Peninsula and he had experience in the Soil Conservation Branch. As Officer-in-Charge, Geytenbeek ran the centre and Struan for the next 8 years with the benefit of both senior and then younger research staff.

The year 1956 was extremely wet and an outbreak of infectious footrot in some of the sheep flocks led to an extensive, time-consuming, control and elimination program with the assistance of the District Stock Inspectors. Within 18 months the property was declared free of footrot and the research projects had not been seriously affected. While the program was not given a great deal of local publicity, the State Department was able to emphasise the value of the techniques used as they sought to have the disease declared notifiable and the subsequent movement of certified livestock prohibited.

Initial work by Allden into the supplementary feeding of beef cattle commenced at the centre following his earlier work at Hynam with Mr Miles. Results suggested that high protein grain such as peas produced satisfactory gains but that self-fed ensilage was little better than dry pasture residues.

Hereford cattle were bred to calve at the centre in 1956 and 1957. A study looked at the effect of age at first mating on growth and production of heifers. In the first year a high percentage of heifers calving at 2 years had difficult births and required assistance. However, in the following season this problem did not occur. It was concluded that heifers could be safely mated during their second year providing care was taken to avoid having them over-fat at calving. The use of an Aberdeen Angus bull to produce a 'smaller' calf was shown not to be effective. While the cattle performed well in the dry season of 1957 they did not fare well in the very wet season of 1958 and all were transferred to Struan in the following year.

The first examination of the residual effect of superphosphate commenced in 1935 but the results were somewhat inconclusive and difficult to analyse as there was only one plot per treatment. Without phosphate, carrying capacity fell by 1 sheep/acre in the first year but showed little further decrease and the results over the period 1935–1952 for 0, 45, 90 and 180 lb/acre/annum of superphosphate were 2.0, 3.4, 3.7 and 3.6 sheep/acre respectively.

In 1958 with fertiliser a major farm cost, the question of what level of phosphate was required each year to maintain production on the subterrranean clover pastures still needed an answer. Accordingly, a new project was designed on a site that had received 3500 lb/acre of fertiliser over a period of 44 years. The area was ploughed and re-sown with subterrranean clover and Wimmera rye grass. The trial examined the effect of nil, 28 lb/acre annually, 56 every second year, 56 annually, 112 every second year, 168 every third year or 112 annually. The one-acre plots carried 16 wethers rotated weekly through the four replicates, and pasture measurements made from protected areas at the end of August and at the end of the season. After the 1959 drought all sheep were removed from January to May inclusive and hand fed off the plots. P.S. Cocks presented the results from 1958 to 1963 in his Masters thesis to the University of Adelaide.

Although there was a large residual effect of superphosphate applied over a 40-year period (70% could be accounted for in the 0–2" horizon) pastures still responded to a current application but this response was only in the winter period. Overall, there appeared to be a standard level of winter production maintained by the residual effect of previous applications of super and a higher level representing an increase of 17% that could only be achieved by an annual application. It was only in late winter, early spring that sheep grazing fertilised plots were heavier than those on unfertilised plots. The difference of 10%, however, had disappeared by the following May. Differences due to fertiliser treatment (amount or frequency of application) were not significant at any period.

It appeared that 56 lb/acre/annum was adequate and that unless winter production was critical the more economic use of 112 lb (1 hundredweight) every second year was a logical use on pasture land that had previously received a total dressing of at least 1 ton/acre. In practice the 1 hundredweight was frequently used on a cereal crop and the land left unfertilised in the following year. At the centre the grazing from a stubble paddock was generally poor and it became standard practice for a period to re-sow a new pasture with clover, Wimmera rye grass and fertiliser. This young pasture was lightly grazed in the winter and then used as a very ‘clean’ pasture for the early weaned young Merino sheep.

A seasonal rhythm of live weight in the sheep was correlated with green pasture availability. There was no increase in annual greasy fleece weight to top dressing with superphosphate. The sown Wimmera rye grass remained a significant part of the pasture for no more than 3 years with barley grass invading the fertilised plots and silver grass the unfertilised plots.

It was concluded that the common farming practice of applying superphosphate at the luxury level of 90 lb/acre might be justified in terms of pasture growth but unless the stocking rate was such that maximum use of that pasture occurred the returns from an annual dressing would be small. Small increases in pasture growth would not be reflected by wool growth unless the stocking rate was increased.

The marked benefit of mating the first-cross ewes late in her breeding season led to a comparable trial with Merino ewes. Flocks lambing in either autumn or winter showed no consistent differences in reproductive performance over a five-year period from 1960 to 1964. The first year showed a substantial benefit to the winter lambing flock but this was not maintained. The percentage of ewes that lambed, the level of twin births and lamb mortalities varied from season to season. Lambs born in the winter had higher birth weights and better early growth rates but live weight during their first summer was generally less than that of autumn born lambs. Survival rates in both groups were similar. The results indicated the need to carry out production studies over a number of years. In the area, local producers tended to lamb early as this gave a longer period of growth for the weaners before spring pastures matured but the trial suggested they had room to vary lambing time according to other factors in their property management.

From several studies it was apparent that weaner ill thrift could be reduced if the young Merino lamb made rapid growth during its early life. Most lambs born in the autumn months ran with the flock until spring shearing when they were weaned at approximately 6 months of age. In many seasons for some time prior to shearing there was competition for feed with the ewes. In better seasons with abundant spring growth of pasture the material was too mature for the young animals and grass seeds became a problem. Geytenbeek, Goode and Schuller looked at the effect of age at weaning on growth and production of the young Merinos over 1958 and 1959. In a season with adequate pasture growth, lambs weaned at 12 weeks of age were heavier at 20, 28 and 45 weeks of age than lambs weaned at 20 weeks or 28 weeks.

Differences were no longer apparent at 70 weeks (hogget shearing). Lamb fleece weights were heavier from the early weaned lambs at their lamb shearing but not subsequently. In a dry season with limited pasture production in late winter, lambs weaned at 12 weeks were heavier up to 72 weeks of age, had higher lamb and hogget fleece weights and mortalities and culling (as hoggets) were lower.

Local landholders questioned the value of early weaning initially, but the results of this work and other studies, gained ready acceptance and across the sheep-raising areas of South Australia early weaning became a standard practice. Research elsewhere had shown that by 12 weeks of age the lamb's rumen was adequately developed to digest the fibrous herbage that all ruminants lived on. Producers found they could reserve young and 'worm-free' pastures for their weaners and by separating ewes and wethers could also apply different feeding schedules if required through their first spring and summer period.

Severe weather conditions caused considerable losses in newly shorn sheep in the South East in September 1960. A survey of 17 properties in the Naracoorte and Kybybolite district was undertaken with a view to determine the extent of losses, contributing factors including time 'off-shears' and the efficacy of preventative methods. The following general conclusions were reached.

1. Sheep with one weeks' wool growth were better able to withstand severe weather conditions than sheep shorn five days or less.
2. Sheep up to five days off shears may suffer heavy losses under such conditions. Locally, it had been thought that two days after shearing sheep was safe, so this information was important.
3. Deaths occurred in all age groups and in sheep of all body conditions.
4. Unless sheep are confined to shelter, severe winds, cold and rain will cause them to leave the shelter.
5. Shedding of sheep overnight after they were shorn prevented losses.
6. The positioning of shelter belts needed critical examination.

This survey gave the first figures in Australia on the impact of severe weather on newly shorn sheep. It lead to specific studies by the CSIRO at Prospect in Sydney, work promoted by Dr Phil Schinckel, son of E.C.H. Schinckel of Kybybolite and one-time lecturer in Animal Science at Roseworthy College. Again, the results of this 'off the Farm' study gave guidance to local producers and sheep husbandry advisers. Geytenbeek stated that this was his only paper to gain overseas recognition. It was known in Scotland where he worked in 1975: they had a common problem with snow at shearing time with the hill farming sheep.

With the completion of the time of lambing and breeds comparative studies the question of rotational grazing of prime lamb flocks was again investigated, from 1960 onwards, with Border Leicester cross Merino ewes run at 2–4/acre. Within each stocking rate ewes and lambs, which were set stocked from lambing in July to market in December, were compared with similar flocks that were rotationally grazed over the same period. The trial ran for six successive years and in all factors measured the set stocked lambs showed production increases over those rotated; from 6% in lambs marked, 11% in mean carcase weight and 17% additional meat per acre. Set stocked ewes even grew an additional 3% of wool although there were 11% fewer dry ewes. These results suggested that the earlier work, not completed in Johnston's period, was measuring the same effect, namely the benefit of not moving lambs from pasture to which they had adapted to new material of differing digestibility. Certainly the results bore out the experience of those local lamb producers who had neither the paddock facilities nor the wish to rotationally graze their flocks but regularly marketed well-grown meat lambs in prime condition.

Increasing the stocking rate from 2/acre to 4/acre decreased the percentage of lambs marked but increased the total number of lambs produced, decreased the carcass weights but increased meat per acre. For five years the 4/acre flocks out produced those at 2/acre and 3/acre but reduced body weight in autumn 1965 caused many of the 8-year-old ewes not to lamb at their sixth lambing. Individual owners were surprised at the lifetime performance of these flocks but many adopted the wise practice of running their meat flocks at 'safer' stocking rates and carrying extra Merino wethers which could be stressed and even sacrificed in drought years.

For two years of this trial regular faecal samples were taken from the ewes and analysed by A.W. (Alan) Banks at the Institute of Medical and Veterinary Science in Adelaide for the presence of intestinal parasites. None of consequence was identified even in the heavily stocked ewes. It was concluded that at the stocking rates used the annual pre-lambing drench was sufficient to control the problem. Later studies at the centre by T.H. (Trevor) Brown and the IMVS found internal parasites to be of much more consequence for Merino weaners, especially at higher stocking rates and planned use of anthelmintics was very beneficial.

Over an 8-year period commencing in 1952, data on lamb mortalities were collected from both cross-bred and Merino flocks. Lambs found dead were examined and a field post-mortem carried out to aid in defining the cause of death. From more than 7000 births and an overall lambing figure of 127% total mortalities up to lamb marking were found to be 11.2%. Approximately 15% of twins and 8.5% of singles did not survive to marking. Cause of death could not be suggested for one-third of the mortalities but three factors seemed to account for another 41%. These were still births (14%), mismothering (15%) and udder abnormalities in the ewe (12%). All of these were expected with twins but the last figure suggested that even amongst well cared for ewes damage at shearing and crutching needed to be reduced. Despite the large work input to obtain this data it is doubtful if the findings had much impact on management of farmer's flocks but the data did give advisory officers answers to some of the frequently asked questions. They also suggest specific areas that could be examined in further research projects.

From 1956 onwards several research officers worked at the centre and each contributed to the enlarged research program. A new study on the maintenance level of phosphate was initiated by D.F. (David) Smith who also worked with K.G. (Keith) Bicknell to show the value of lime in the establishment of legumes on the deep acid sandy soils of the Bangham Scrub lying between Frances and Bordertown. Smith left in 1958 to further his career at Dookie Agricultural College, the University of Melbourne and Launceston Teachers College. He spent his later working years in the Victorian Department of Agriculture as Director.

J.M. (Jock) Lobban, a graduate from South Africa, filled his position at Kybybolite. Lobban managed the farm in the wet winter of 1958 and the very dry season of 1959. He highlighted the problem of the crabhole areas covered by the cereal trials, the big variations between years and replicate yields within years and suggested that fewer varieties should be tested and that yield trials should be planted on homogenous areas on farmers' properties. This suggestion was not well received by the plant breeders at the Department of Agriculture and the Waite Institute who liked to test as many new cultivars as possible on a wide range of sites. Lobban left after two years to become a husbandry adviser to the pig industry. He subsequently worked in the pasture utilisation group. The problem of waterlogging recurred in 1963 when a file reported that 'oat plots were washed out in 1963'. A duplicate report in another file had the words 'washed out', crossed out and the word 'drowned' substituted! Despite the conditions a rate of seeding trial in that year with oats suggested that 60 lb/acre was superior to 40, 80 or 160.

J.R. (John) Goode, an Adelaide graduate, came from a United Nation's FAO position in South America to occupy the position of Research Officer Livestock from 1959 to 1961. He contributed to the work on lambing time with Merinos and played a part in extensive tree planting on the centre's extensive roadway system. He left to take up the position of Officer-in-Charge of the Turretfield Research Centre at Sandy Creek near Gawler.

Two significant appointments were made in 1961–62. Both were young graduates and they enrolled to carry out research leading to the Masters degree in Agricultural Science. P.S. (Phil) Cocks worked at the centre to 1965, obtained his Master's degree from work on the residual effect of superphosphate, went to Adelaide and obtained his Doctorate degree and then became a key worker in the field of subterrranean clover and pasture growth doing a deal of his work at the centre. He subsequently supervised from Adelaide a large program of pasture research in South Australia, spent 8 years in the Mediterranean region with ICARDA and was later Professor of Agriculture at the University of Western Australia.

I.C. (Ian) Fletcher came to the centre as a Research Officer in the field of Animal Production. His path was similar to that of his contemporary Phil Cocks. His work on the effect of nutrition on ewe reproduction gained him a Masters degree. At Kybybolite he questioned why had later mating of the Merino ewe not shown the same increases in reproductive rate as it had in the crossbred ewe, why did the Corriedales show low reproductive rates at Kybybolite when they had much higher rates at the Struan outstation, and what effect did differing feed levels, before and during mating, and at different mating times, have on subsequent lambing performance.

Merino and Corriedale ewes ran continuously with raddled teaser rams and oestrus was recorded for a 2-year period. From March to July in 1963 four ewes known to be in oestrus were slaughtered each week, three weeks after service, and ovulation rates and the number of surviving embryos were recorded. The difference between the breeds was apparent in that some Merinos ovulated right through the year while the Corriedales had a marked trough in September–December and a late peak of activity in March–July. Of considerable interest was the high loss (ranging from 30% to 58%) of potential young with many eggs not fertilised or failing to implant.

A second experiment aimed to determine why the Medium Peppin type Merinos at the centre showed similar twinning rates after spring or autumn matings. From November 1963 to March 1965 the ovulation rate at the end of each month was determined by laparotomy on two groups each of 45 ewes. Although there was a marked seasonal variation in the number of ewes ovulating and in their ovulation rate, the level of twin ovulations was remarkably constant. The results suggested that the Merino ewes at the centre showed a constant level of twin ovulations throughout the year and that changes in mating time would not affect the proportion of twin births.

A major study with Border Leicester cross Merino ewes compared the reproductive performance in ewes at two levels of nutrition and at two seasons of mating. Neither the level of nutrition nor the time of mating influenced the number of ewes detected in oestrus. However, the level of twinning was higher in the well-fed ewes and was greater at the later mating time. One important feature of the results was that the effects of nutrition and season on the incidence of dry ewes were independent. Poor nutrition increased the dry ewe proportion at both seasons of mating.

Of equal interest was the effect on twinning rate that increased markedly from December to March at the high level of nutrition, but was little increased at the low level. Overall the experiment showed that at normal field levels of nutrition seasonal effects would have more influence on twinning than on dry ewe numbers but that changes in nutrition from spring to autumn might diminish the effect that later mating could be expected to have on lambing results.

Fletcher went to Sydney University where his finding that reproductive rates in the ewe were a function of both static body weight and of dynamic body weight change gained him a Ph.D. and were well received by his peers in the research field. He worked at Turretfield Research Centre and Roseworthy Agricultural College before moving to Indonesia and China where he occupied a professorial position working with different breeds in the inland regions.

The large-scale sheep lifetime experiments in the 1950s and subsequently led to pressure for more pasture land at the centre. Were the long-term natural pasture plots still needed? Could they not be cultivated, pastured and used for important animal studies? Extensive sampling carried out in 1938 and reported by Cook was repeated in 1958 on the plots laid out from 1919 onwards. The results led to an examination by Dr J.S. (John) Russell of the changes in soil fertility under fertilised pasture. In general terms superphosphate resulted in large increases in sheep-carrying capacity, rock phosphate gave some increase but lime and gypsum did not increase carrying capacity. The build up in organic matter after 40 years of pasture was chiefly in the top 2" and in that layer undergrazing conditions was estimated to be equivalent to 1700 lb/acre of nitrogen or approximately 4 tons of sulphate of ammonia. Soil organic matter level was still increasing in a linear manner in the 2–4" and 4–6"range though there was a slight levelling off at 0-2".

With continuous use of superphosphate the increase in soil acidity was slight and only in the top 2". The alternative fertilisers such as rock phosphate gave increases in soil organic matter but superphosphate was more effective. In general, the use of lime did not lift organic matter, there was a risk of trace element deficiencies and the relatively high cost would inhibit its use.

Russell suggested that when old pasture soils were cultivated the accumulated soil organic matter was rapidly converted into nitrite in greater amounts than the planted cereal could use and was leached from the soil. This was very wasteful. From a theoretical point of view what was needed was a gradual or partial breakdown without the wasteful effect that ploughing and cultivation had on the organic matter store. What the area needed was more productive pasture species, followed by cereal crops and short-term leys. It would be fair to say that in the district the second of these suggestions has been regular practice on areas not subject to flooding. After years of subterranean clover many pastures carried high proportions of barley and brome grass and broad-leaved weed species of which Cape Weed and dock were the most common.

The development of selective herbicides which could be applied after the opening rains to eliminate the broad-leaved weeds, followed by surface seeding of more desirable grass species, was a technique referred to as ‘sod seeding’ or chemical ploughing. Cocks showed Diquat dibromide herbicide to be most effective. The winter yield of Capeweed was equivalent to that of Phalaris and perennial rye grass in a 2-year old stand so the establishment of a suitable productive pasture was essential. Later, the technique of autumn weed control with herbicide followed by seeding of cereals after minimum soil cultivation was made possible by the use of suitable machinery in the South East and in many other regions.