Terra Incognita

Farrer Memorial Oration, 1988

This is a copy of the 1988 Farrer Memorial Oration, presented by Dr Allan N Smith.

The Farrer Memorial Trust was established in 1911 to perpetuate the memory of William James Farrer and to encourage and inspire agricultural scientists. Initially it awarded scholarships for 'study or research in agricultural problems'. Later it included the delivery of an annual oration and the presentation of the Farrer Memorial Medal to a distinguished agricultural scientist for service rendered in the fields of research, education or administration.

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TERRA INCOGNITA

FARRER MEMORIAL ORATION 1988

ALLAN N. SMITH

It is extremely appropriate that this function to honour the memory of the father of Australia's Wheat Industry should be held in Wagga Wagga, a city that recognises the value of wheat to the local economy so much that on its coat of arms are portrayed "...eight stalks of wheat each four in the form of the letter W..."

Wagga does not just have an association with the crop, it has a connection with Farrer himself - he was a frequent visitor to the "Experiment Farm". We find him writing to Max Kahlbaum on 30 September 1900, "Just a hurried line from the Wagga farm - I shall go home by the train which carries this letter, ..."

The New South Wales Department of Agriculture has had a long ownership of that "experiment farm" and has fostered the various institutions which have served the agricultural community over the years; culminating, and now continuing, in the Agricultural Research Institute. This, with its associated station at Temora, is renowned as a wheat breeding centre amongst other things. It has the unique distinction in that working in it, during its short life of only 35 years, have been from time to time four previous Farrer medalists - Pugsley, Single, Martin and Syme.

For me, the choice of Wagga is a welcome one, we lived for 20 years here. Longer than I have lived in any other place. Two of our children were born here and all had education within the city.

It is like coming home.

It is a unique experience for me to be listed as speaker at a function on the program of a plant breeding conference. Farrer was a plant breeder - I certainly am not, although I can claim an indirect association. I had, at one stage, the vicarious charge of the Farrer barn at the Cowra Research Station and I once used "Sunset" in an experiment, looking at the effect of phasic development on phosphorus uptake.

I cannot therefore, pretend that Farrer's insights into the techniques of producing better-adapted, disease-resistant varieties and his ability to identify important characteristics have been or are applicable to my work. However, I like to think that in his basic abilities, in his perception of environment and people, there is something to learn and copy. So I shall not be drawing on the breeding aspects of William James Farrer's work but rather on his other attitudes, opinions and contributions.

There is a considerable body of opinion on Farrer, in published works, in previous orations and in library collections; but also the Institute at Wagga was singularly fortunate that through the generosity of the late Dr. S. L. MacIndoe, it received a collection of letters from and to Farrer, and other memorabilia. It was MacIndoe's intention that the Institute, being at the time, and I can say in this location still a pre-eminent Australian wheat breeding centre, should be the repository for this material. I was fortunate in having access to it but it did not help me much initially since I could only read the correspondence with difficulty. Mrs. Sheree Passlow has, over the years, with assistance from other staff members, translated Farrer's execrable script. It really was bad and Farrer was aware of it. He is quoted by Russell (1949) as writing "I hope you can read my handwriting. Shelton writes to me that only after singing a hymn he succeeded in reading my last."

Farrer had views about agriculture long before he thought about becoming a wheat breeder. Only three years after arriving in Australia he published a pamphlet "Grass and Sheep-Farming. A Paper Speculative and Suggestive" (Farrer 1873). He pointed out that the colony had earned itself a character "of being behind hand in every advance that the world makes..." "America has colleges in about every state in which not only agriculture, chemistry and scientific agriculture are taught but at many of her colleges practical instruction is also given."

For 10 years, from 1876, Farrer was a licensed surveyor with the Lands Department; surveying stock routes in the west of New South Wales, first at Dubbo and then from Nyngan to Cobar - eventually moving to Cooma.

One can readily imagine that in his time spent in the wide open spaces of this State, he had time to observe and reflect on the crops growing in it. It was in 1882 that the idea of making improvements to the wheat plant took hold of him, so he told a meeting of the Australian Association for the Advancement of Science in 1898. In 1886 he resigned from the Lands Department and started wheat breeding at his recently purchased property "Lambrigg". So he continued independently although with a large circle of correspondents - Biffen in England, Vilmorin in France, Saunders in Canada, Moreland in India, Blount and Carleton in America, Kahlbaum in South Australia, Pye in Victoria, Bancroft in Brisbane.

In 1898 he was induced to join the Department of Agriculture. In his letter of acceptance (quoted in Russell, 1949) he wrote, "In addition to improvements in the wheat plant itself, it is, I consider, <u>of even greater importance</u> (my emphasis) that I should conduct experiments for the purpose of ascertaining the methods of soil management which are the most suitable for our climate..." "It has long been my conviction that the system of alternate cropping and fallowing... is a mistaken one; and the present impoverished condition of the once famous wheat lands of South Australia, where the system originated and has been in operation for so long, supports this opinion."

If Farrer had not been side-tracked into wheat breeding, who knows what he might have accomplished!

This then will be my theme - **the methods of soil management which are suitable for our climate and conditions.**

Farrer was not the only Australian of his time to be concerned at the impoverishment of agricultural soils but before we turn to them a comment from another great Australian.

1983 marked the hundredth year of Roseworthy Agricultural College and to mark the occasion there was a centenary symposium entitled "Agriculture, Exploitive or Permanent?" It was opened by Sir Mark Oliphant with the following words:

> "This harsh continent, so different in climate, vegetation and soils from the Europe where our early white settlers originated, proved so hostile to their techniques of farming and animal husbandry, that it became for them an enemy which must be subdued. European experience, over almost 300 years, was that existing inhabitants of a new land must be conquered in battle before occupation and utilization became possible. In Australia, resistance by its stone-age Aborigines was minimal, and the enemy became the land itself. Probably, it was for this reason that the land was treated so brutally, its strange trees and other alien vegetation

> cleared away so completely. A relatively few occupiers of land were able, in less than 200 years, to rape its surface more thoroughly, and with more disastrous consequences, than white occupation of any other new country of large area."

We did not know then, and I suggest that we do not really know now, the full consequences of our treatment of the land, hence the title of my talk, not an unknown land but one in which the proper treatment of the land is yet to be fully discovered and practised.

It was certainly recognised by many thinking people that knowledge was lacking, and that what information there was was not being passed on to others. As an example we have Farrer in 1873 questioning how long it would be before technical education became properly appreciated in the colony of New South Wales and then, 25 years later, commenting on the decline of the once famous wheat lands of South Australia.

He was not the only migrant to these shores to come to the same conclusion. J. D. Custance, who arrived in South Australia in 1881 as the Government Professor in Agriculture, quickly realised that what was needed was an agricultural college and experiment farm. He was not isolated in this opinion. There had been, from the 1870's, a movement for agricultural education. It was recognised that whilst education and science were being applied to all other industries, there should come a time when farmers would apply scientific knowledge and skill to their work. As a direct outcome, the Hon. F. Basedow succeeded in inducing Parliament to sanction the establishment of an experiment farm and agricultural college (Anon 1907). It opened its doors two years after Custance's arrival. In the intervening period he had not been idle. In his first year he established one hundred plots with a wide range of plants, such as mustard and furze, rice and earth nut, a number of grasses and clovers and even including a plant called "hemp" (Williams 1976).

It is important to understand the environment in which Custance was working. It goes back to the earliest years of settlement in Australia - and to sheep. Captain Macarthur brought the first sheep to Australia in 1797 and established his farm at Camden in 1805; but because of his well known differences with the Colonial administration, his wife did most of the subsequent work. By the year 1860 there were 20 million sheep in Australia and 31 years later the total had exploded to 106.5 million.

Such changes were mirrored in the increases in South Australia. Only five years after first settlement in 1836 there were a quarter of a million sheep and 20,000 cattle. Ten years later, the sheep and cattle numbers had increased fivefold. In 1891 the livestock populations reached 7.5 million sheep and 400,000 cattle. Not until forty years later were these sheep numbers exceeded. Up to the time of the 1891 peak, land use had been essentially exploitative (Pearson 1968), sheep and cattle were moved into and grazed widely in the pastoral country. The bush was plentiful and short-lived grasses and plants grew freely after rain. In 1891 a major drought began. There were 2 million sheep and 200,000 cattle in this low rainfall region. In the early years of this century, when the drought had run its course, stock numbers were down to a quarter of what they had been and such damage had been done to the stands of perennial bush and herbage that at no time since has this peak been equalled.

It was quite clear that the native plants were unable to survive heavy and continuous grazing. Partly because of this, but largely because of the tremendous increase in pasture development in the higher rainfall and cereal growing districts of the State, the proportion of South Australian livestock carried in the pastoral region, which at one time had been as high as 25 per cent, dropped to 10 per cent. In other words, the overwhelming proportion of that State's livestock has, since the turn of the century, been carried on pastures in the agricultural areas.

Rural development in Australia has been recognised (Callaghan 1951) as falling into three phases; wool to 1890, followed by wheat to 1930 and then pasture (Fig.1). Wheat was, of course, grown in 1789 - 16 years before Camden Park was established but it did not become the dominant agricultural activity until after the first 100 years of Australian settlement. Nevertheless, the growth of wheat expanded rapidly in the last 25 years of the 19th century. In 1860 South Australia planted 274,000 acres but 20 years later this area had increased to 2 million. The expansion in New South Wales was somewhat later; there was a fivefold increase from 320,000 acres between 1890 and 1904 (Dunsdorfs 1956). Much of this increase had been achieved through rapid expansion into lower rainfall areas.

Plantings in South Australia fell by 300,000 acres during the next 10 years. In 1891 the situation was (Reimers 1983) that "Yields were rapidly declining because of poor farming practices and much of the earlier settled land had been withdrawn from cultivation. ...Farming systems were exploitive because of continuous cropping without the addition of fertilisers. Pastures were only grown in areas unsuited to cultivation, and were unimproved."

Such was the situation to which Custance came and in which the new agricultural college began its work.

In addition to his plots with the wide range of plants, he established 46 plots of "Purple Straw" to test the response of wheat to various manures and fertilisers. These included mineral amendments such as salt, gypsum, ashes, lime and potash; organics such as sheep and farmyard manure; Peruvian guano and bone dust; and the manufactured fertilisers, sulphate of ammonia and superphosphate - there were five control plots (Custance 1883).

The year was exceptionally dry but he was able to conclude that there was a beneficial effect from bone dust and guano. Five hundredweight of each produced a yield of 26 bushels, superphosphate on its own gave 21 bushels.

In 1885 it was an even drier growing season, rainfall measuring only 8.17 inches. He reported "some important facts will be noticed, notwithstanding the unfavourable season, such as the yield of 22 bushels per acre from 3 cwts superphosphate, while 4 cwts superphosphate with 2 cwts sulphate of ammonia yielded less by 4 bushels per acre."

"The quantity of superphosphate used, namely 3 cwts costing 4 shillings per cwt, only 12 shillings per acre, should induce farmers to give this manure a fair trial....After numerous experiments carefully conducted during the last four years, I can strongly recommend superphosphate as the cheapest and best manure for the wheat crop. The quantity used per acre, if properly distributed and well mixed with the soil, should not exceed 3 cwts per acre."

This was his legacy - superphosphate. He also left advice. "It is certain that farmers cannot continue to grow wheat profitably without paying attention to the condition of the land, ...the requisite food supply for the wheat plant must, in some way or other, be available. The cheapest way undoubtedly being the growth of cruciferous and leguminous crops fed off by sheep, combined with good cultivation of the land as a preparation for the wheat crop." The same identification of need as that of Farrer some 15 years later.

Custance was a man who was "misunderstood" by the farming community. He resigned his position in 1886 and returned to England. His place was taken, after a year, by W. Lowrie. He had a much better relationship with farmers. He made a point of visiting the Agricultural Bureaux and attending their conferences. With evangelistic fervour he preached the gospel of superphosphate. "On this farm, year after year phosphates alone have given good results and often better than phosphates with nitrogenous manures added. Of the phosphates, the more soluble such as superphosphates are much to be preferred but each man will do well to conduct a few careful comparative tests." (Lowrie 1898)

"These results confirm the opinions once more, which have been so often urged from this Institution: (1) that for our conditions, superphosphate of one kind or another is the most profitable, artificial manure; (2) that 2 cwts per acre is to be recommended in preference to 1 cwt for the first few years at least of its use."

His views on fertilisers were being generally accepted (Anon 1901). Farmers were getting results from following his advice. Reports and opinions on the subject of superphosphates were received with enthusiasm; at one Agricultural Bureau conference even with cheers! (Anon 1902). Superphosphate worked, it gave economic results. The practice became more and more accepted and at the close of the century, 27 per cent of South Australian wheat was "supered" (Callaghan and Millington 1956). The pattern was followed in other Australian States and superphosphate became and has remained the fertiliser to use with cereal crops, to the exclusion of virtually all others. The situation in the southern New South Wales wheat belt in 1967 was stated to be as follows:- "Up to a few years ago it could be said that there was only one fertiliser being used by the Australian wheat farmer, namely, single superphosphate. At the present time this fertiliser is still commonly used but its supremacy is being challenged by other products such as concentrated superphosphate and by mixed fertilisers." (Smith 1967) During the past 15 years, nitrogen applications have become increasingly more common (Fig.2).

The decline in yield which occurred in the latter part of the 19th century was arrested by the use of phosphatic fertilisers but the farming pattern was still essentially exploitative, one of cropping and fallow. So, whilst superphosphate corrected the decline it was not the full answer to the total maintenance of fertility in a system of non-exploitative agriculture.

However, just as there was a solution to the immediate soil fertility problem awaiting in the wings from the new patent manure superphosphate, so there was a corrective to the wheat/fallow system already present in South Australia.

Various clovers and medics had come into South Australia some time before 1880 (Pearson 1968). They did not do particularly well on the soils which were at that time deficient in phosphorus; but as the use of superphosphate began to increase, these colonising legumes responded with better growth and, of course, there was more fixed nitrogen. It was fortunate that after the superphosphate evangelist there was another perceptive mind to spread the word on legumes. I refer, of course, to Amos Howard, whose attention had been attracted in 1889 to "a weed, which I believe will go far to solve the problem of introducing nitrogen to the soil", (quoted in Hill 1937). He was, of course, talking about subterranean clover, the first commercial sale of which took place on the 18th January 1906 - 30 pounds at 2/6 per pound.

The ingredients were in place then at the turn of the century for a suitable method of soil management and, certainly, the practice of ley farming was taken up by wheat farmers in southern Australia but it took a long time to become the dominant practice. The third of Callaghan's (1951) phases of rural development - "permanent" agriculture by means of the use of sown pastures and livestock on wheat farms - was not identified by him as having begun until 1930. In 1946 it was remarked (Breakwell 1946) that "the most significant trend is the increasing popularity of clover ley farming. It will be difficult for the majority of wheat growers to visualise a system of farming which does not include a period of fallow. The fact remains, however, that the fallow had disappeared from many farms and wheat crops of up to 40 bushels an acre had been grown on unfallowed land."

Research in the 1930's and 40's had shown the value of subterranean clover in maintaining soil fertility in rotations (Bath 1949). A Wimmera ryegrass and subterranean clover ley was more efficient than a volunteer ley. Carrying capacity was raised from 4 to 5.5 dry sheep equivalent and yields of subsequent wheat crops were 2.1 compared to 1.86 tonnes per hectare. This research and that of other States confirmed the view that was held by leading agriculturalists. The Rural Reconstruction Commission (1945) said in its sixth report "As far as crop farming is concerned, probably the most important change in southern Australia, whenever the rainfall between March and September or October is reliable enough for the introduction of subterranean clover, has been the introduction of "ley" farming. Under this system the old rotation of fallow-wheat-oats or fallow-wheat-pasture, has been amended to include several years of subterranean clover with the omission of fallow. The results have seen a marked increase in the yield of wheat per acre and in the capacity to produce fat lambs, while the clover has improved the soil texture (sic)." Nevertheless, the pattern of wheat farming on the red-brown earths in 1950 was still of a system dominated by the wheat-fallow rotation: with bad effects on soil structure and increased susceptibility to erosion, with skeleton weed as a major component of most paddocks, with phosphate being replaced regularly by superphosphate applications with the seed at sowing, with the nitrogen supply coming mainly from the breakdown of soil organic matter; but with the knowledge available to change the domination of the wheat-fallow rotation systems for the better and with improved practices being adopted (Smith 1981).

It was certainly some time after the war that the fallow-wheat rotation became the exception rather than the rule. I certainly remarked on the isolated presence of long fallows when I was introduced to farming practices in this wheat-sheep zone some 27 years ago. There were still farmers who complained that they could not fill their dams as easily as in the past, since run-off from the clover ley was so much reduced.

Certainly, however, by the 1970's the clover ley farming system was established - a permanent agriculture. Organic matter built up under the clover was broken down in the cereal phase, but it was stable over the long term. We had finally got away from the mistaken system of alternate cropping and fallowing so perceptively identified by Farrer, and we had finally followed Custance's advice; we were paying attention to the condition of the land and we were growing a leguminous crop and feeding it to sheep.

Some 90 years after being told what we should be doing we had reached the happy situation of long-term, non-exploitative stability. We had discovered how to treat the land and we were practising in the light of that knowledge.

Then it all went awry!

It is not an overstatement to say that disaster struck. The greatest tragedy, in my opinion, that Australian agriculture has suffered - the build up of soil acidity, so much so that wheat yields were reduced to barely economic levels and farmers were forced to grow other crops, or other cereals such as oats.

We had been warned. Back in 1954 Donald and Williams (1954) had found that in a podzolic soil of the southern tablelands of New South Wales, the pH fell by 0.06 units per 125 kg superphosphate applied to each hectare. The change was thought to be due to an increase in the exchange capacity of the soil due to increased organic matter, increased capacity that was filled by protons. In addition to this mechanism, as every text book tells us, added nitrogen results in bases being displaced, for example for every 100 kg of ammonium sulphate added to soil, 45 kg of calcium is lost. Helyar (1976) has pointed out that acidification will ensue when nitrogen fixed by symbiotic rhizobia is mineralised and leached. There were other demonstrated increases in acidity under irrigation (Rixon 1970), under wheat (Lipsett and Simpson 1965), where the pH after clover was 6.4 as against 6.7 in the wheat; and when we looked we found in Kohn's long-term rotation plots here at Wagga Institute that the magnitude of the decrease in pH was directly proportional to the duration of pasture to crop in the rotation (Table 1).

Table 1

Changes in pH (1:5; soil:0.01 M $CaCl_2$)

Rotation		ΔpH (12 years)
WWWWSS		-0.44
WWWSSS		-0.49
WWSSSS		-0.56
	S.E.	0.08

W=Wheat S=Subterranean clover pasture

(K.M.Furniss, unpublished data)

The seriousness of the problem has been recognised in that a task force has been set up with some co-ordination of research at the national level. The situation can be avoided by growing different species or by selecting more acid tolerant cultivars and, of course, by modifying the agricultural system - but the same inexorable biological laws still apply. The only long-term solution is replacement of that which is lost and, in many States, where supplies of limestone are few and far between, that is expensive and, economically, sometimes impossible.

Economics is crucial, farmers must make a living or they cannot stay in business, but some practices forced on our agriculturalists by circumstances are more dangerous than others. The sustainable agricultural systems in Europe, in India, and in China which have maintained large populations over thousands of years are based on replacing what is taken off. Leave the land better than you find it! In the New Worlds of America and Australia there was a different attitude. In America farmers, starting with the Pilgrims, would cultivate land, wear it out and blithely move west five miles (Peters 1988). In Australia, as I have quoted, it was an enemy to be subdued and there was an underlying thought always of lands still to be tamed out on the margin. Up to a few years ago, land in Western Australia was still being released for "development".

We have oxidised organic matter; we have lost millions of tonnes of top soil; "many eco-systems have been changed to the point of instability during the past 200 years"; and restitution may involve "processes operating on a geological rather than a human time scale" (Walker 1986). We have, and this takes on the elements of a Greek tragedy, in attempting a noble ideal of a permanent cropping system, induced massive increases in soil acidity with concomitant aluminium and manganese toxicities.

How have we fared with replacement of the nutrients that we have taken out?

If we can take phosphorus as an example. It has been calculated (Smith 1983) that assuming each tonne of grain contains 3 kg of phosphorus and with average production of 1.3 tonnes per hectare, there is a removal of about 4 kg of phosphorus for each hectare of grain produced. This, of course, is not the only phosphorus removed in plant parts, but that in the chaff, straw, leaves and roots eventually becomes part of the source of inorganic phosphorus in the soil through the biological processes of decay. Average application rates are in excess of 6 kg of phosphorus per hectare, so we are replacing the direct loss of phosphorus in cereal grain. Of course, cereals are not the only plants grown in the cropping rotation. Much more phosphorus is applied to pastures than is applied to crops. These pastures are grown to feed livestock and the amount of phosphorus lost depends on the animals and their products. The total livestock losses may be in excess of 415,000 tonnes of superphosphate from Australia each year. This, together with losses in grain, amounts to about 1 million tonnes of single superphosphate equivalent. The total phosphorus applied as superphosphate to pastures and cereals has varied over the past 10 years from just over 2 million to just over 2,750,000 tonnes (Fig.3). We are quite clearly replacing what we take off the farm.

So how far have we come in discovering and putting in place the answers to the important questions that Farrer would, himself, have liked to introduce - the methods of soil management that are most suitable for our climate.

We know what we should be doing. There is no lack of information from overseas examples or from experiments here, as to what practice we should follow to maintain the land "in good heart". The problem is to be able to afford to do it, given economic circumstances.

Government involvement in the price mechanism in the United Kingdom and Western Europe is having a baneful effect on soil conditions and on the environment in general. Nitrogen fertiliser consumption has increased four-fold over the past 25 years in U.K. (Gasser 1988) because of the lucrative subsidies given (Fig.4). It is no accident that over the same period of time, nitrogen concentration in English rivers has steadily increased (Fig.5). In some it is approaching the World Health Organisation limit. In China, with the "responsibility system" (more private plots, more free markets, more enterprises with their own responsibility for profit and loss and quotas fixed on a household basis - Liu Shao-Qi), the Chinese leaders are walking a tight-rope, balancing the needs of the people now against the ability to provide for those needs in the future. In encouraging greater production, the dangers are that with increasing use of nitrogenous and other artificial fertilisers and with less inclination to apply organic manures, the total fertility of the Chinese soils will rapidly decline (Smith et al. 1985).

We have a stable rotation in terms of organic matter and nitrogen; we are replacing the phosphorus taken off. The only black spot is the almost head-long descent into conditions of aluminium and manganese toxicity.

Australian agriculture has not benefitted greatly from subsidies in the past. Whilst in overseas countries subsidies have been directly deleterious to soil fertility, an incentive for investment into the continued fertility of Australian soils should not be beyond the bounds of possibility. With an appropriate reduction in the price of limestone spread, the last great problem of sustainable agriculture would start to be overcome.

Then whilst we might not be able to follow Swift exactly, the politicians who did this would have ensured that a blade of grass continued to be grown where one grew before; they would have ensured stability and that in itself is an essential service to the country.

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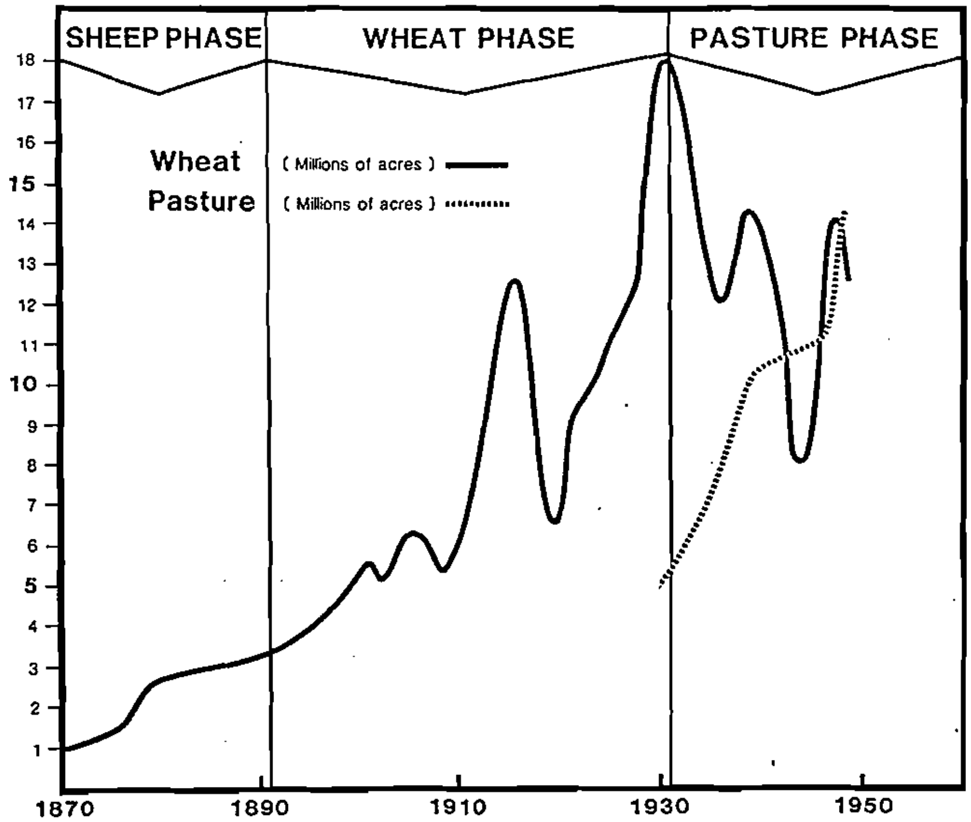

Figure 1 - Three phases in the rural development of southern Australia

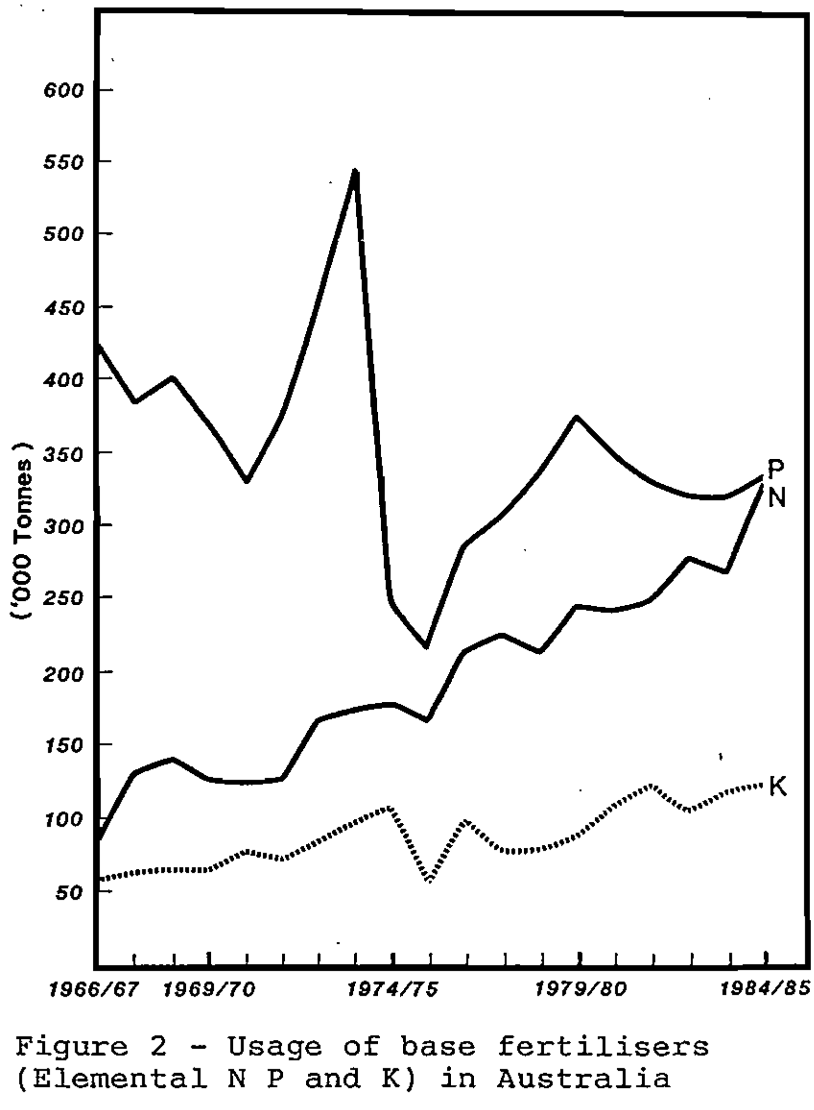

Figure 2 - Usage of base fertilisers (Elemental N P and K) in Australia

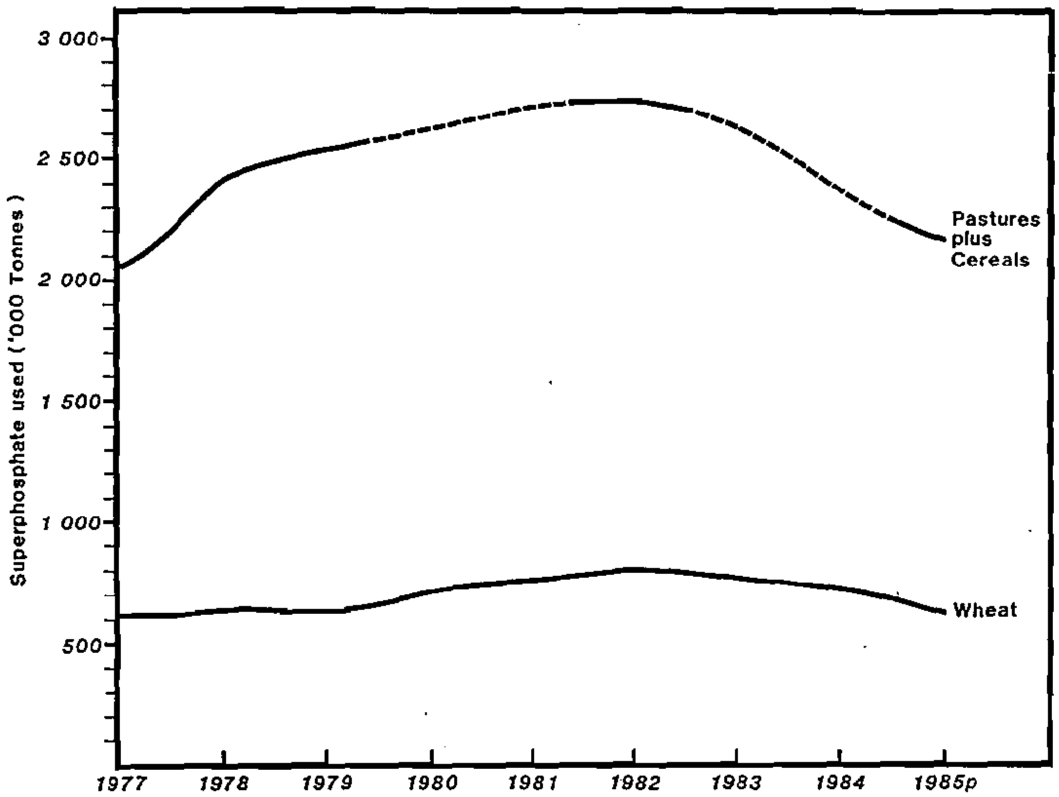

Figure 3 - Consumption of superphosphate in Australia

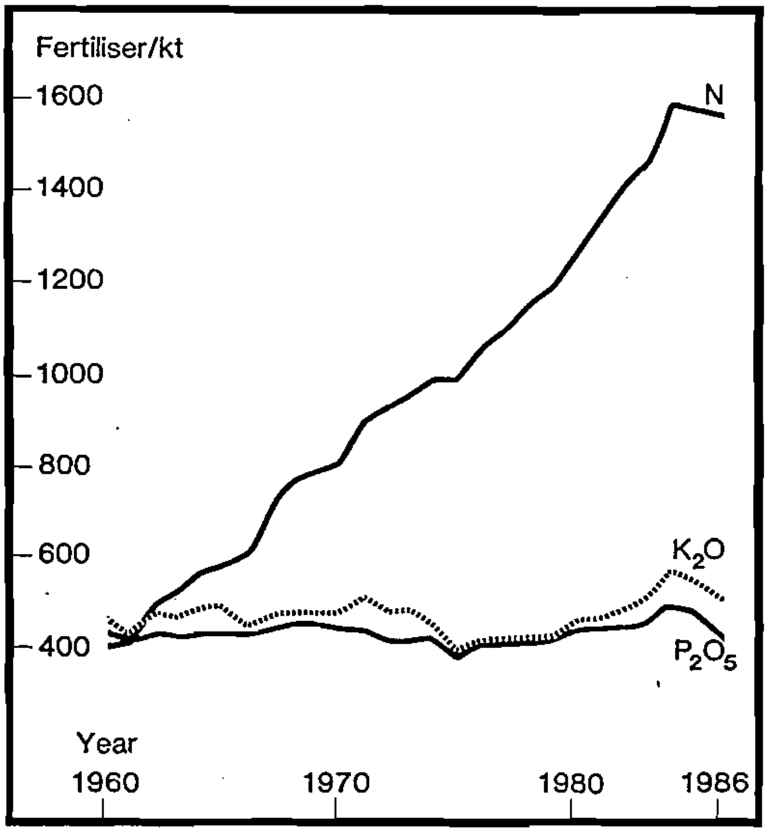

Figure 4 - Fertiliser consumption in U.K. 1960-86

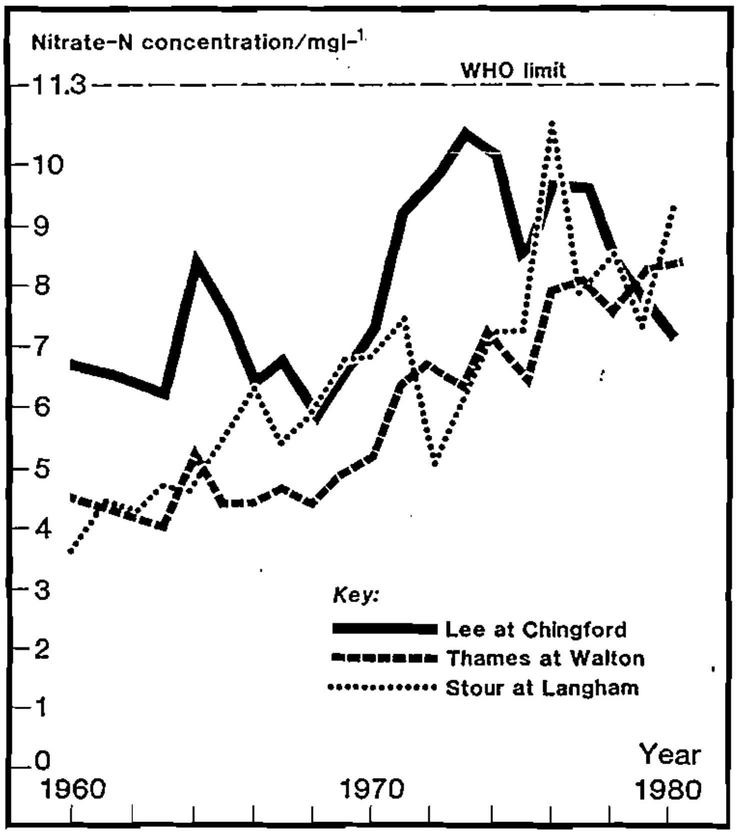

Figure 5 - The mean annual concentrations of nitrate in some English rivers - arable and grassland areas.