## MANAGING SOILS FOR BETTER

# THIRTY YEARS OF PHOSPHATE FERTILISER APPLICATION ON A NEW ENGLAND TABLELANDS GRAZING PROPERTY

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***Abstract:*** *Fertilisers containing phosphorus and sulphur have been applied annually to a New England mixed cattle and sheep grazing property from 1961 to 1992, mostly at a rate of round 10.7 kg P/ha per annum. These fertiliser applications have maintained available soil phosphorus (Bray No. 1 test) at 15 to 20 ppm. Estimates of phosphorus removal in animal products indicate that there has been a continual accumulation of total soil phosphorus. Soil pH and electrolytic conductivity during the last eleven years show no increase or decrease. There has been a change from a native pasture dominated by summer perennials to a natural pasture dominated by year-long green perennials with a white clover understorey under this fertiliser regime. The carrying capacity has increased from 2-3 to 10-15 dry sheep equivalent per hectare. Eight years of transect data indicate that the species composition of this natural pasture has now reached a dynamic equilibrium.*

## INTRODUCTION

Karuah is a mixed cattle and sheep grazing property in the high rainfall zone of the eastern fall of the New England Tablelands (Table 1). In terms of both dry sheep equivalents [DSE] and income, the ratio of cattle to sheep is about 2:1.

## FERTILISER HISTORY

Before 1961, some phosphate fertiliser was spread on a limited area. From 1961 to 1979, superphosphate was applied annually by air over the whole property at a rate of 125 kg/ha (Table 2).

Since 1981, with regular annual soil tests and the availability of a greater range of phosphate-based products, a more flexible fertiliser program has been followed. The years 1979-81 were drier than average and soil tests in the early 80's indicated soil phosphorus above 15 ppm (Bray No. 1 test) (Figure 1), so phosphorus applications were reduced. Higher rainfall occurred in most years after 1981 and decisions on phosphorus applications each year have been based on the results of soil tests and estimated taxable income. For example, if soil tests indicate available phosphorus >15 ppm and estimated taxable income is low, phosphate applications are reduced (1986 and 1987); but if estimated taxable income is high, normal phosphorus applications (125 kg/ha) are maintained.

**Table 1: Descriptive statistics for "Karuah".**

| Parameter | Descriptive statistic |
|---|---|
| Location | 53km NE Armidale, in the Wongwibinda district |
| Latitude | 30°19'S |
| Longitude | 152°19'E |
| Altitude | 1240m |
| Rainfall | 907mm/yr, summer and winter distribution |
| Size | 607ha |
| Soil types | Granitic podzols, black basaltic soils |
| Pasture type | Natural pastures, Microlaena dominant and a white clover understorey |
| Enterprises | Yearling steers<br>First cross trade lambs<br>Medium micron merino wool |
| Stocking Rate | 10 to 15 DSE/ha |

The fertiliser product used in recent years has been determined by the least cost per unit of applied phosphorus. High analysis phosphorus fertilisers have consistently been cheaper per unit phosphorus than single superphosphate. The two products used (Pasture $P^{(R)}$ or Goldphos $10^{(R)}$) have differed little in cost per unit phosphorus but cost per unit of P has varied from year to year.

## SOIL REQUIREMENT AND RESPONSES

Soil samples have been taken annually with a 2.5 inch soil auger at fixed sites, starting with four sites in 1980 and increasing to thirteen sites by 1991. Samples have been analysed by the Department of Agriculture, Rydalmere, until 1987 and by Soil-Tec, Bonville, after 1987.

### pH and conductivity

Soil pH ($CaCl_2$) from 1981 to 1991 averaged 4.7. This has varied little from year to year, and has not decreased or increased (regression of pH against time, slope = -0.002). While the soils are acid, there are no indications that the low pH is reducing pasture production. Trials on a neighbouring

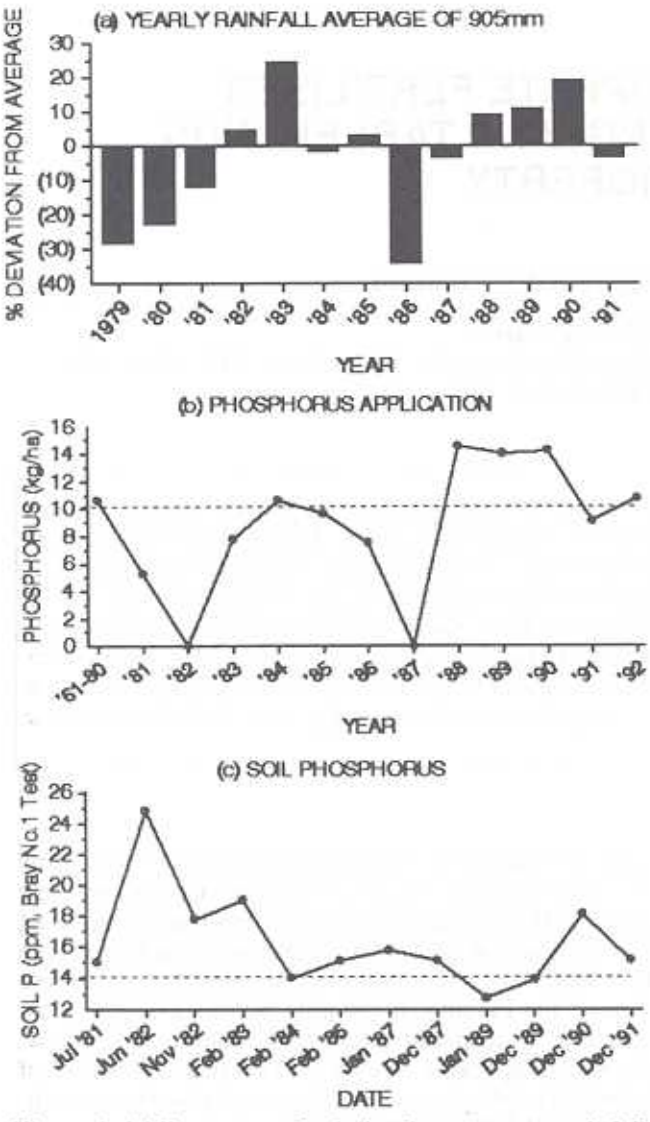


**Figure 1: (a) Percentage deviation from average rainfall, 1979-1991; (b) Phosphorus applications (kg/ha), 1961-1992; and (c) Available soil phosphorus (Bray No. 1 test, ppm), in soil samples, average of all sites, 1980-1991.**

**Table 2: Fertiliser applications on "Karuah", 1962 - 1992.**

| Year(s) | Product | Rate | Rate of nutrient | | |
|---|---|---|---|---|---|
| | | | P | S | Mo |
| | | (kg/ha) | (kg/ha) | | (g/ha) |
| 1961-80 | AFL single superphosphate[A] | 125 | 10.7 | 14.4 | [B] |
| 1981 | AFL single superphosphate | 61 | 5.2 | 7.0 | 0 |
| 1982 | None | | | | |
| 1983 | AFL single superphosphate | 90 | 7.8 | 10.4 | 18.1 |
| 1984 | AFL single superphosphate | 123 | 10.6 | 14.2 | 0 |
| 1985 | AFL single superphosphate | 112 | 9.6 | 12.9 | 0 |
| 1986 | AFL single superphosphate | 87 | 7.5 | 10.0 | 0 |
| 1987 | None | | | | |
| 1988 | AFL Pasture P$^{(R)}$ | 112 | 14.6 | 7.8 | 0 |
| 1989 | AFL Pasture P$^{(R)}$ | 111 | 14.0 | 7.8 | 0 |
| 1990 | Hi-Fert Goldphos 20$^{(R)}$ | 89 | 14.2 | 17.8 | 71.2 |
| 1991 | Hi-Fert Goldphos 20$^{(R)}$ | 57 | 9.1 | 11.4 | 0 |
| 1992 | Incitec Pasture P$^{(R)}$ | 64 | 10.8 | 6.1 | 0 |

[A]Sulphur fortified superphosphate sometimes applied to the basalt country:
[B]see text.

property indicate there are no benefits from the application of lime (M. Chapman, *pers. comm.*).

Soil conductivity from 1981 to 1991 averaged 0.16 dS/M and has not decreased or increased (regression of conductivity against time, slope = 0.023), indicating that salinity levels are stable.

## Macro-nutrients: phosphorus and sulphur

Available soil phosphorus from 1981 to 1991 averaged 18.4 ppm and has not increased or decreased as indicated by a slope of -0.033 of regression of P against time.

From 1961 to 1992, phosphorus applications have averaged 12.2 kg/ha/yr, but the phosphorus removed in animal products in 1988, 1989 and 1990 averaged only 1.2 kg/ha (calculated from AFRC Technical Committee on Responses to Nutrients 1991, equations on p. 581). Assuming the same rates of removal in earlier years, phosphorus application has exceeded removal by 10.9 kg/ha/yr, or a total of 339 kg/ha over thirty-one years. Some losses would have occurred from runoff, soil erosion, and to the deep sediments, but even after allowance for these, there must be a considerable phosphorus "bank" in the soil.

From a management perspective, these calculations suggest that if finances became tight I could stop phosphorus applications for a few years and maintain productivity by drawing on the soil "bank".

In recent years, because high analysis phosphorus fertilisers have been used, the amount of sulphur applied per hectare has declined (Table 2). Given the long history of single super applications, sufficient sulphur should have accumulated in organic matter to provide sulphur requirements (M.Duncan, *pers. comm.*; P.G.Sale, *pers. comm.*). In 1990 to 1991, the high analysis sulphur fertiliser Goldphos 20$^{(R)}$ was used.

## Trace elements: molybdenum and selenium

There were two applications of 0.02% molybdenum (24.7 gm Mo/ha) between 1961 and 1980 and 0.02% molybdenum was applied again in 1983. In 1990, nodules on clover roots were sparse and lacking in pink colouration, suggesting a molybdenum deficiency. M.Duncan (*pers. comm.*) recommended molybdenum applications considerably higher than those used in the past so I applied molybdenum at 0.08%. Since that molybdenum application, clover roots have been well nodulated.

Selenium has not been applied to pasture because it is unlikely there would be an economic response in cattle, the main enterprise. Although cattle in the Wongwibinda district have low blood selenium (Langlands *et al.*, 1981) and sheep on the New England Tablelands respond to selenium supplementation (Wilkins and Markwick, 1982), responses by cattle to selenium supplementation are variable and often do not occur (Langlands *et al.*, 1989).

Cattle on "Karuah" do not show symptoms of selenium deficiency (scouring and ill-thrift, Langlands *et al.* 1989), have satisfactory growth rates and high fertility. In the summer of 1987/88 fourteen calves on Karuah were orally dosed at

six weekly intervals with 0.1 mg Se/kg. Liveweight gain of these calves did not differ significantly from that of fifteen untreated calves. A similar trial on a neighbouring property also failed to show a response by cattle to selenium supplementation (Q. Wright, *pers. comm.*).

## PASTURES

Pastures on "Karuah" in 1961 were dominated by the cool season perennial snow grass (*Poa sieberiana*), summer perennials including kangaroo grass (*Themeda australis*), red grass (*Bothriochloa macra*)and wild sorghum (*Sorghum leiocladum*), and annual rat's-tail fescues (*Vulpia* spp.).

Aerial seeding with white clover (*Trifolium repens,*) cocksfoot (*Dactylus glomerata*) and rye grass (*Lolium perenne*)commenced in the 1960's, as did regular superphosphate applications and increased stocking rates. The natural pastures are now dominated by microlaena (*Microlaena stipoides*) and, when soil moisture is favourable, an understorey of white clover. In addition, there are some twenty native, naturalised and introduced grasses, *eg.* Kentucky blue grass (*Poa pratense*), paspalum (*Paspalum dilatatum*), Parramatta grass (*Sporolobus elongatus*), goose grass (*Eleusine tristachya*), bromes (*Bromus* spp.), cocksfoot and ryegrass. The original perennials have almost disappeared and the rat-tail fescues have reduced in abundance.

Before pasture improvement was commenced, microlaena was a minor component of New England pastures (Roe, 1947) and restricted to areas of high fertility, such as sheep camps (Viera, 1980). High soil fertility and heavy grazing intensity appear to have given microlaena a competitive edge and on "Karuah" it has become dominant over the majority of the property. Microlaena is a year-long green perennial (Robinson, 1979) and has annual dry matter production and digestibility comparable to that of phalaris (*Phalaris aquatica*) and fescue *Festuca arundinacea* (Robinson and Archer, 1988; Archer and Robinson, 1988).

Eight permanent transects were set up in 1982, in association with R. Whalley, to monitor trends in the species composition in selected paddocks. These transects indicate that pastures appear to be at a dynamic equilibrium. Between seasons, and even between years, there are changes in the species assemblages and relative frequencies (density) of the species, but there are no obvious trends of increasing dominance or subordination of the major pasture components. In particular, the amount of white clover waxes and wanes between wet and dry seasons but there is no indication that the frequency of white clover has declined during the eight years.

## CONCLUSIONS

The carrying capacity of "Karuah" has been lifted from 2-3 to 10-15 dry sheep equivalents per hectare under the fertiliser regime described. Traditionally, it is recommended that fertiliser programs be accompanied by the establishment of pastures comprising white clover and introduced grasses such as cocksfoot, rye or fescue. Introduced grasses comprise but a minor component of natural pastures on "Karuah" and I propose that it is primarily soil fertility and the clover component, not the grass species composition, that determines the productivity of these pastures. A similar conclusion was reached by Robinson and Dowling (1985) when they compared the productivity of pastures composed of varying amounts of native and introduced grasses.

## ACKNOWLEDGMENTS

I thank K. Hutchinson, M. Duncan and R.B. Whalley for their assistance with aspects of this paper, and M. Chapman and Q. Wright for permission to cite their unpublished trials.

## REFERENCES

Archer, K.A. and G.G.Robinson (1988). Agronomic potential of native grass species on the Northern Tablelands of New South Wales. II. Nutritive value. *Australian Journal of Agricultural Research*, **39:** 425-36.

ARFC Technical Committee on Responses to Nutrients (1991). Report 6. A reappraisal of the calcium and phosphorus requirements of sheep and cattle. *Nutrition Abstracts and Reviews (Series B)* **61:** 573-612.

Langlands, J.P., Wilkins, J.F., Bowles, J.E., Smith, A.J. and R.F.Webb (1981). Selenium concentration in the blood of ruminants grazing in northern New South Wales. I. Analysis of samples collected in the national brucellosis eradication scheme. *Australian Journal of Agricultural Research*, **32:** 511-521.

Langlands, J.P., G.E.Donald, J.E.Bowles and A.J.Smith (1989). Selenium concentration in the blood of ruminants grazing in northern New South Wales. III. Relationships between blood concentration and the response in liveweight of grazing cattle given a selenium supplement. *Australian Journal of Agricultural Research*, **40:** 1075-1083.

Robinson, G.G. (1979). Natural pastures of the Northern Tablelands. *NSW Agriculture, Division of Plant Industries Bulletin P2.3.1.*

Robinson, G.G. and K.A.Archer (1988). Agronomic potential of native grass species on the Northern Tablelands of New South Wales. I. Growth and herbage production. *Australian Journal of Agricultural Research*, **39:** 415-23.

Robinson, G.G. and P.M.Dowling (1985). The effect of proportion of sown grasses on pasture and animal production from fertilised pastures on the Northern Tablelands of New South Wales. *Australian Rangeland Journal*, **7:** 88-92.

Roe, R. (1947). Preliminary survey of the natural pastures of the New England district of New South Wales and a general discussion of their problems. *CSIR Bulletin No. 210.*

Wilkins, J.F. and Markwick, G.J. (1982). Selenium responsive production in northern New South Wales. *Wool Research Trust Fund Final Report Project K/1/1083.* NSW Department of Agriculture.

Viera, A. (1980). Grazing value of *Microlaena stipoides* (Labill.) R. Br. on sheep camps on the Northern Tablelands of NSW and its response to fertiliser when growing in a glasshouse. *Diploma of Agricultural Science Thesis, University of New England*, Armidale, NSW.