# MULTIPLE LAND USE OF OPEN FOREST IN SOUTH-EASTERN QUEENSLAND FOR TIMBER AND IMPROVED PASTURE: ESTABLISHMENT AND EARLY GROWTH

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## ABSTRACT

*The establishment phase of a multiple land use experiment near Gympie in S.E. Queensland is discussed. Seed of six grasses and six legumes was aerially broadcast onto an ash burn under a thinned open Eucalypt forest. After* 18 *months, total yields from the resultant legume-dominant pasture compared favourably with published yields from improved pastures on conventionally cleared land.* Macrotyloma axillare *cv. Archer established uniformly throughout the area, but* Desmodium intortum *cv. Greenleaf was more frequent in moister gully situations. There were very low correlations between pasture and forest variables, and possible reasons for this are presented.*

## INTRODUCTION

The traditional approach to pasture development in forest areas has been through the total clearing of standing timber, except perhaps for narrow bands left along waterways and small areas for cattle camps. Although there appear to be no published data concerning feasibility, development of such country may be achieved by establishing pastures under a reduced forest stand with the following possible advantages:—

(a) lower costs;
(b) returns from timber, and
(c) markedly reduced frost damage.

Large tracts of undeveloped open forest still exist in south-eastern Queensland. An experiment has therefore been initiated in the Neerdie State Forest about 20 km north of Gympie to investigate the effects of an introduced pasture understorey on tree growth, and the effects of certain forest characters on pasture production.

## SITE DESCRIPTION

### *Location*

State Forest 904, Parish of Neerdie 26°0'S and 152°44'E.

### *Topography and rainfall*

The 145 ha experimental area has a westerly aspect with broad ridges and gullies running generally east-west. The altitude is 80 m above sea level in the west and rises to 120 m in the east.

The average rainfall at the site over the last eight years has been 1460 mm (see Table 1), although long term data (40 years) from a nearby station suggest an average of around 1200 mm. Over half this rain falls between November and February.

### *Soil types*

The site has two major parent materials. The higher ridges to the east comprise phyllites, and the lower ridges to the west, coarse siliceous sandstones. Isbell *et al.* (1967) have placed the phyllite soils under the map unit (Pc2) and sandstone soils

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TABLE 1

*Site rainfall data (mm)*

| | Jan. | Feb. | Mar. | April | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1974 | | | | | | | | | | | | 45 |
| 1975 | 166 | 159 | 45 | 100 | 2 | 63 | 33 | 65 | 35 | 78 | 68 | 115 |
| 1976 | 293 | 249 | 342 | 174 | 83 | 11 | 59 | 3 | 65 | | | |
| Mean 1968/75 | 348 | 279 | 94 | 69 | 73 | 36 | 89 | 50 | 35 | 115 | 136 | 138 |

under the map unit (Cd7). The inherent soil fertility of both soil groups is low—phyllites 8 ppm available P (B.S.E.S.), 140 ppm replaceable K; sandstone 3 ppm P, 52 ppm K.

### *Vegetation*

The vegetation is a layered open forest (Specht 1970). Eucalyptus are named according to Pryor and Johnson's (1971) classification. The ridges have a higher density of spotted gum (*Eucalyptus maculata*) and broad-leafed red ironbark (*E. fibrosa*) with grey ironbark (*E. siderophloia*), red bloodwood (*E. intermedia*) and forest red gum (*E. tereticornis*) occurring in greater numbers in the gully association. White mahogany (*E. acmenioides*) is evenly distributed throughout both associations. The understorey layer is discontinuous and can develop to 7 m in height with *Acacia aulacocarpa*, *Acacia cunninghamii* and occasional *Casuarina torulosa* in the upper levels. The shrub layer is also variable in height and the major species are *Leucopogon* spp., *Acacia penninervis*, and *Pultenaea cunninghamii*. Grass is found throughout the area but is sparse under heavy tree canopies. Blady grass (*Imperata cylindrica* var. *major*) is found most commonly in the wetter gullies and kangaroo grass (*Themeda australis*) on the ridges.

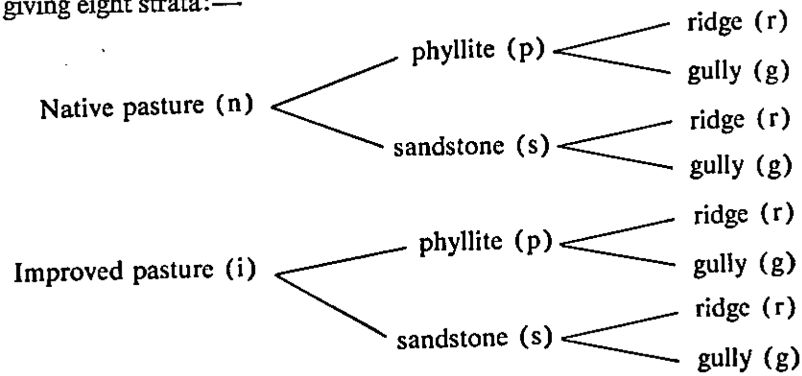
## METHODS

### *Stand treatments*

The experimental site was logged through all strata removing trees that had reached maturity or had unacceptable crowns or trunks. Following logging, it was silviculturally treated removing unwanted trees by stem injection of a chemical compound containing 5% w/v picloram (4-amino—3,5,6—trichloropicolinic acid) and 20% w/v 2,4,5-T (2,4,5—trichlorophenoxyacetic acid). The technique is similar to that in general use on Queensland State Forests. Stems retained were those of desirable species with an acceptable crown and a 6 m log or potential log. No two stems were closer than 8 m.

### *Sampling design*

The experiment is being conducted on two adjacent areas, a native pasture block (68 ha) and an improved pasture block (77 ha) of which only the latter is considered in this paper. The design is a stratified random sample of three factors each at two levels, giving eight strata:—



Each stratum has 20 randomly located 0.1 ha plots distributed over a range of tree densities, basal areas and crown shadings as illustrated in Table 2.

TABLE 2

*Range and mean value of stems per hectare, spacing, basal area per hectare, and projected crown cover for the four improved pasture strata at the establishment, 1975.*

| Strata | Stems $ha^{-1}$ | Spacing (m) | Basal Area† $ha^{-1}$ ($m^2$) | Projected Crown Cover (%) |
|---|---|---|---|---|
| ipr | 40–150 (96)* a | 16–8 (10) | 1.8–9.8 (5.2) c | 8–55 (28) e |
| ipg | 20–130 (80) a | 22–9 (11) | 1.9–8.9 (5.3) c | 8–44 (27) e |
| isr | 40–160 (93) a | 16–8 (10) | 1.9–8.0 (5.3) c | 10–43 (25) e |
| isg | 20–100 (48) b | 22–10 (14) | 0.8–8.7 (3.4) d | 3–41 (17) f |
| L.S.D. ($P < 0.05$) | 19 | | 1.3 | 6 |
| Mean Pasture Block | 79 | 11 | 4.8 | 24 |

*( ) Mean.
†Cross sectional area of a tree at 1.3 m from ground level.
Parameter means suffixed by the same letters are not significantly different ($P < 0.05$).

*Establishment technique of improved pasture block*

Logging and silvicultural treatment were completed by August, 1974, and the improved pasture block was burnt in December, 1974. The following mixture of pasture seed was aerially sown in December, 1974.

| Grasses | | Rate kg $ha^{-1}$ |
|---|---|---|
| *Melinis minutiflora* | | 0.07 |
| *Panicum maximum* var. *trichoglume* cv. Petrie | | 1.12 |
| *Chloris gayana* cv. Katambora | | 0.28 |
| *Pennisetum clandestinum* cv. Whittet | | 0.21 |
| *Panicum maximum* cv. Hamil | | 0.37 |
| *Setaria anceps* cv. Narok | | 0.56 |
| | TOTAL | 2.60 |
| **Legumes** | | |
| *Desmodium intortum* cv. Greenleaf | | 0.85 |
| *Macrotyloma axillare* cv. Archer | | 1.12 |
| *Glycine wightii* cv. Cooper | | 1.12 |
| *Macroptilium atropurpureum* cv. Siratro | | 0.56 |
| *Stylosanthes guianensis* cv. Cook | | 0.28 |
| *Trifolium repens* cv. Grasslands Huia | | 0.56 |
| | TOTAL | 4.50 |

Molybdenum trioxide was incorporated into the legume pelleting material at the rate of 210 g $ha^{-1}$. The initial application of 500 kg $ha^{-1}$ of superphosphate was aerially applied in March, 1975. The pasture was not stocked between planting and assessment.

*Pasture measurement*

Dry matter yields and botanical composition of the improved pasture area were measured between March 30, 1976 and April 2, 1976. Dry matter yields were determined using the "type 3" procedure for comparative yield estimation described by

Haydock and Shaw (1975). The dry-weight-rank method ('t Mannetje and Haydock 1963) was used for assessing botanical composition on a dry weight basis and also species frequency.

Three observers were used in each plot. Each observer moved in a predetermined direction (60°, 180° and 300°) from the centre point of the plot, taking ten observation points along each transect. At each observation point, a 0.25 $m^2$ quadrat was placed, and yield and botanical composition observations made.

Data from assessed and harvested standard quadrats were used (program LINREG) to provide the constants for conversion of yield ratings to estimates of actual yield.

Using a second program, BOTANAL, total plot yields, species dry weight percentages, individual species yields and species quadrat frequency percentages were estimated.

## RESULTS

Since the intention of the paper is to view establishment and early growth of the improved pasture, growth figures relating to the native pasture block will be considered in a later publication.

### *Improved pasture-strata*

Table 3 presents the mean dry matter yields as related to soil and topography. The phyllite ridge stratum yielded significantly less than the other three strata.

TABLE 3

*Total dry matter yields (tonnes $ha^{-1}$) by strata.*

| | phyllite | sandstone | mean |
|---|---|---|---|
| ridge | 5.4 a | 6.2 b | 5.8 x |
| gully | 6.4 b | 6.7 b | 6.6 y |
| Mean | 5.9 m | 6.4 n | |

Individual strata and overall means suffixed by the same letters are not significantly different ($P < 0.01$).

### *Improved pasture-forest*

Correlation coefficients between total pasture yields and forest variables are presented in Table 4. Significant negative but low order correlations were obtained between pasture yield and all forest variables except diameter breast height. Percentage crown cover is the only forest variable showing a reasonably high correlation with pasture yield, but only in the phyllite ridge (pr) stratum.

TABLE 4

*Correlation coefficients between total pasture yields and forest variables overall and by strata.*

| Forest Variables | Overall | Stratum | | | |
|---|---|---|---|---|---|
| | | pr | pg | sr | sg |
| stems $ha^{-1}$ | –0.24* | –0.12 | –0.38 | –0.38 | –0.07 |
| % crown cover | –0.45** | –0.71** | –0.38 | –0.27 | –0.22 |
| average basal area $m^2$ $ha^{-1}$ | –0.41** | –0.57** | –0.35 | –0.30 | –0.30 |
| basal area increment $m^2$ $ha^{-1}$ | –0.30* | –0.42 | –0.25 | –0.31 | –0.32 |
| diameter breast height increment (cm) | –0.03 | 0.02 | 0.06 | –0.10 | –0.15 |

*significant at $P < 0.05$.
**significant at $P < 0.01$.

*Species composition*

Pasture yields and quadrat frequencies of the major pasture components as related to the various strata are summarized in Tables 5 and 6. The balance of the species in the mixture contributed in total only four to eight per cent to pasture yield and are therefore not considered.

TABLE 5

*Major pasture component yields ($kg\ ha^{-1}$)†*

| Means | *Macrotyloma axillare* | *Desmodium intortum* | *Melinis minutiflora* | *Setaria anceps* | Native†† Species |
|---|---|---|---|---|---|
| phyllite (p) | 1710 | 260 | 110 | 50 | 1220 |
| sandstone (s) | 2520 | 840 | 230 | 160 | 510 |
| sig. diffs. | s > p* | s > p** | N.S. | s > p* | p > s** |
| ridge (r) | 1950 | 200 | 160 | 80 | 710 |
| gully (g) | 2210 | 1080 | 170 | 110 | 890 |
| sig. diffs. | N.S. | g > r** | N.S. | N.S. | N.S. |

†Equivalent means from log (1 + x) transformation.
††Predominantly *Imperata cylindrica, Themeda australis.*

TABLE 6

*Quadrat frequency (%) of the major pasture components.*

| Means | *Macrotyloma axillare* | *Desmodium intortum* | *Melinis minutiflora* | *Setaria anceps* | Native Species |
|---|---|---|---|---|---|
| phyllite (p) | 79 | 43 | 23 | 11 | 69 |
| sandstone (s) | 88 | 57 | 31 | 22 | 49 |
| sig. diffs. | N.S. | s > p* | N.S. | s > p** | p > s** |
| ridge (r) | 81 | 37 | 29 | 18 | 60 |
| gully (g) | 86 | 63 | 25 | 16 | 59 |
| sig. diffs. | N.S. | g > r** | N.S. | N.S. | N.S. |

*Macrotyloma axillare*, the most successful introduced species, yielded significantly more on the sandstone strata, although distributed evenly over all strata. Both distribution and total dry matter of *Desmodium intortum* were superior in the sandstone and gully strata. *Setaria anceps* was more frequently recorded and showed higher dry matter production on the sandstone, but varied little with topography. Native species were more dominant on the phyllite soils.

Correlation coefficients between individual pasture species and forest variables were of the same low order as those in Table 5.

## DISCUSSION

Total improved pasture yields in the early stages of this experiment compare favourably with yields for improved pastures on conventionally cleared land reviewed by Colman (1971). Although yield differences between strata achieved statistical significance, these are of little practical consequence, being at most 25 per cent.

Low correlation coefficients (Table 4) indicate a minor effect of the trees on pasture development. However, maximum projected crown cover on the improved pasture block was 55 per cent (Table 2), and the major tree species present have a mean canopy type factor (i.e., proportion of light intercepted by the canopy) of approximately 50 per cent (J. Walker, personal communication). This indicates a minimum light penetration of 72 per cent which, assuming $10^5$ lux to be full sunlight, is equivalent to approximately $7 \times 10^4$ lux beneath the canopy. Since Ludlow and Wilson (1971) found that net photosynthesis approached light saturation at $10^5$ lux for grass leaves and at $(4–5) \times 10^4$ lux for legume leaves, it is therefore not surprising that there was generally poor correlation between crown cover and pasture variables in this legume-dominant pasture.

Distribution patterns of the various pasture components could have resulted from the early rainfall pattern. During establishment, monthly rainfall totals from December 1974 to March 1975 were well below average, giving rise to extremely dry conditions on ridges. *Macrotyloma axillare*, being highly tolerant of drought (Luck 1975), survived uniformly throughout the area. However, *Desmodium intortum*, being less tolerant of drought (Barnard 1972), was more frequent in moister gully situations.

Studies in moisture relations may hold the key to understanding the pasture-soil-forest relationships in this system. High rainfall between January and March 1976, for example, may also have affected correlations in Table 4 reducing effects of tree density and basal area on pasture yield. Low infiltration rates on phyllite soils (resulting from their surface-sealing nature) could account for phyllite-sandstone differences in both frequency and dry matter yield; lower competition from introduced species may therefore have allowed a higher native species component on phyllite soils.

So far, this experiment has shown that good improved pastures can be established successfully without the need for costly total clearance of existing forest. However, longer term measurements will be necessary to accurately assess the stability, resilience, productivity, and profitability of such a multiple-use system which is more complex ecologically than conventional improved pastures. Such matters will be reported in due course in subsequent papers in this series.

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