ESTABLISHING KAURI IN A PINE STAND AND IN SCRUB

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ABSTRACT

Growth and survival of kauri (**Agathis australis** (D. Don) Lindl.) planted within a young **Pinus elliottii** Engelm. stand on an exposed site on the Coromandel Peninsula were significantly better than that of kauri planted within adjacent low (1 m high) and tall (3-4 m high) scrub. However, on a sheltered site no significant improvement occurred. Fertiliser application to kauri at planting within pines was not worthwhile but in tall scrub was beneficial. This indicates that pines not only provide shelter but may also induce beneficial soil changes.

Keywords: nurse crop; fertiliser; scrub; **Agathis australis**; **Pinus elliottii**.

INTRODUCTION

Considerable areas of secondary forest and scrub in northern New Zealand result from an earlier period of kauri logging and forest clearance. Natural regeneration of kauri in scrub is often scarce or patchy due to lack of a local seed source. To supplement natural regeneration, large numbers of kauri seedlings were planted by the New Zealand Forest Service in the late 1970s and early 1980s on a variety of scrub sites in State forests within the natural range of the species. However, growth of planted kauri has been variable. Better results have been obtained by planting in vegetation over 3 m high where this is available. High mortality often occurs in early years on more exposed sites.

Work in Queensland, Australia, has indicated a nurse crop of *Pinus* is beneficial to the growth of *Araucaria cunninghamii* Ait., a species in the same family as kauri (Bevege & Richards 1970). It was found that *A. cunninghamii* could be grown without fertilisers by underplanting in established pine stands on sites which would not support open planting without fertiliser.

In New Zealand self-sown pines are scattered throughout many scrub areas. The ability of pines to provide quick shelter for underplanting native species has been recognised for some years; however it has not been tested experimentally. Early small-scale underplanting of kauri within pines indicated good survival and growth (Morrison & Lloyd 1972), but a major problem in older stands was the removal of larger exotic trees without damaging the natives once the nurse role had been completed.

Although kauri seedlings can tolerate soils with low nitrogen and phosphorus status (Peterson 1962), it is not known if the application of fertilisers at planting will boost growth. There are also problems with choosing a suitable fertiliser and method of application (Ecroyd 1982). In addition, the effect of applying fertiliser to kauri planted in a pine stand is not known.

A trial was established on the Coromandel Peninsula to compare the growth of kauri planted within tall scrub, younger low scrub, and a young pine stand. The effects of different fertiliser regimes were also compared.

TRIAL AREA

The trial was located in the Whenuakite Block of Coromandel Forest Park 5 km north of Tairua (lat. 36° 58′ S, long. 175° 50′ E), 300 m above sea level. Covering an area of some 5 ha, the trial was sited on a flat ridge which gave way to a moderately steep north-west facing slope.

The soils in this region are mapped as the Mangonui hill soils. On slopes, brown granular clays have developed from weathered andesite. On ridge tops, yellow brown loams (Whangamata sandy loam), which are more fertile, have developed from mixed andesite and volcanic ash (McCraw & Bell 1975).

The gradient in soil fertility is reflected in the vigour of fire-induced regrowth that covers most of the Whenuakite Block. Vegetation on the broad ridge within the trial area consists predominantly of karamu (*Coprosma robusta* Raoul), five finger (*Pseudopanax arboreus* (Murr.) Philipson), and hangehange (*Geniostoma ligustrifolium* A. Cunn.) up to 4 m high with scattered mapau (*Myrsine australis* A. Rich.) and tree ferns (mainly *Cyathea dealbata* (Forst. f.) Swartz) with patches of gorse (*Ulex europaeus* L.). On the slopes scrub is shorter and less vigorous than on the ridge. Manuka (*Leptospermum scoparium* J.R. et. G. Forst) becomes more dominant with locally abundant tanekaha (*Phyllocladus trichomanoides* D. Don) seedlings and saplings. Low scrub on recently disturbed sites is dominated by gorse and bracken (*Pteridium esculentum* Cockayne) on the ridge with manuka, Spanish heath (*Erica lusitanica* Rud.), and occasional *Pomaderris rugosa* Cheesem, and *Gahnia pauciflora* Kirk. on the slope. Scattered emergent self-sown pines occur in the scrub throughout the block.

The nearest weather station was 31 km south of the trial area at Tairua Forest. Daily mean temperature was 14.5°C with an average daily minimum of 10°C and maximum of 19°C. Average annual rainfall was 1850 mm, with about 30 ground frosts recorded each year (New Zealand Meteorological Service 1983).

METHODS

Site Preparation

In 1972, 4 ha of scrub was crushed and burnt. The following year part of this area was planted in *Pinus elliottii* at 2 × 2 m spacing as a nurse crop for later planting of kauri. *Pinus elliottii* was chosen as it was expected to show better growth and survival on this site than *P. radiata* D. Don and would not need topdressing with fertiliser at later stages. The pines established quickly and formed a closed canopy within 5 years and in 1980 averaged 6.5 m in height and 12.5 cm in diameter (1.4 m above ground). There was no significant difference between the slope and the ridge in growth of pines.

In 1980 access lines were cut at approximately 10 m spacing from the ridge down the slope in three vegetation types – first within the 5- to 6-m high pines; secondly, in a strip of low scrub (1–2 m high) which had regenerated since clearing; and thirdly, in an adjacent area of tall scrub (3–4 m high) typical of much of the Whenuakite Block. Five treatments were applied in the pines. Canopy gaps of 4, 8, or 16 m^2 were made at 10-m intervals by removing one, two, or four pines respectively. Another treatment consisted of removing four pines so that planted kauri could be mulched with pine needle litter. The other treatment involved pruning groups of four pines to a height of 2 m. Gaps of approximately 9 m^2 were cut within the low scrub and of 16 m^2 within the tall scrub. Single treatments were located along a randomly selected pair of lines with a total of 40 gaps per treatment. Composite soil samples were taken by core sampler from the 0- to 10-cm layer under each of the three vegetation types. This involved collecting 30 samples from throughout each vegetation type for both ridge and slope sites. These were analysed for pH, total-nitrogen, and Bray-2 phosphorus using the methods described by Nicholson (1984).

Kauri Planting and Fertiliser Treatment

In June 1980 groups of three kauri seedlings were planted in gap centres usually in a triangular formation with seedlings spaced up to 1.5 m apart. Kauri were 2- to 3-year-old potted seedlings raised at the Forest Service nursery at Sweetwater, near Kaitaia. Average height at planting was 56 cm. In the mulching treatment each kauri had two 10-*l* buckets of pine needle litter spread around its base to discourage weed growth and to maintain higher soil moisture content during dry periods.

One of four fertiliser treatments was randomly applied to each kauri group: (1) control (no fertiliser), (2) 56 g of a slow-release fertiliser ('Magamp' coarse granules – N7 : P17 : K5 : Mg12) applied at planting, (3) 113 g Magamp applied at planting, and (4) 56 g Magamp applied 12 months after planting. Fertiliser application at planting involved thoroughly mixing fertiliser with soil in the planting pit before kauri were planted. Fertiliser applications 12 months later involved scratching fertiliser into the upper soil surface about each planted kauri. Annual releasing of kauri seedlings from regrowth of ferns and hardwoods was necessary on some sites.

Measurement and Analysis

Survival and height of planted kauri were recorded annually for 5 years after planting. Root collar diameters were recorded for the first 4 years.

Over-all height and diameter increments and percentage survival were analysed by use of a four-factor analysis of variance. The factors were the seven main treatments (consisting of low and high scrub and five treatments in pine), the 14 lines with two lines assigned to each treatment, the site effect represented by ridge and slope running at right angles to the rows, and the four fertiliser treatments. The main treatments were tested against the line : treatment effect, the site and site : treatment effects against the treatment : row : site effect, and the fertiliser and fertiliser interaction effects against the treatment : line : site : fertiliser effect. The results of these analyses are presented graphically by plotting means and their standard errors derived from appropriate interactions.

RESULTS

Survivals

On the ridge there was good survival of kauri under pines and tall scrub, but a significant amount of mortality in low scrub. On the slope survival was good under pines but mortality was high in both tall and low scrub (Fig. 1). Gap size and fertiliser treatment had no significant effect. Most mortality occurred within the first 3 years.

Height Growth

On the ridge, height growth of kauri (Fig. 2) was similar under all vegetation types, averaging over 20 cm per year. The lower rate of fertiliser boosted growth significantly.

On the slope height growth was less, averaging 15 cm/year under the pines but only 5 cm/year in the scrub for trees without fertiliser. The lower rate of fertiliser increased kauri height growth in the tall scrub but did not significantly increase height growth under the pines.

In general the higher rate of fertiliser at planting and a delayed application gave inferior results to the lower rate. Gap size within pines had no significant effect on growth of kauri. Over the 5-year period of measurement, height growth remained fairly consistent.

Apart from the first year, 20–40% of kauri had a current annual height increment of less than 2.5 cm (Fig. 3). These stagnant trees did not necessarily remain stagnant in following years but were more common on hard sites and more prone to mortality in the subsequent year.

Diameter Growth

Root collar diameter growth (Fig. 4) showed a somewhat different pattern to height growth. On both the ridge and the slope diameter growth of kauri was significantly better under scrub than under pines. The lower rate of fertiliser significantly improved diameter growth of all kauri except those planted on the slope under pines.

Regrowth

The canopy gaps created by removal of one tree were small and in the treatment where pines were only pruned there was no canopy gap. Hardwood, fern, and weed regrowth was not a problem and a constant leaf fall maintained a deep litter of pine needles. Regrowth in the larger pine gaps was more vigorous, responding to increased light levels; kauri within these gaps required some releasing. A mulch of pine needle litter around the base of newly planted kauri temporarily kept kauri free of weed growth but in general was not worth the effort involved.

The increased light levels in scrub gaps generally favoured vigorous regrowth of hardwoods and ferns. Bracken and coppicing gorse were a major problem, particularly in low-scrub sites.

Soil Analysis

Results of a limited range of soil analyses are given in Table 1. They reflect the greater fertility of the ridge site compared to the slope, but show no consistent differences in nitrogen and phosphorus status under the three vegetation types.

DISCUSSION

This trial demonstrated that kauri seedlings can be very site-specific in their requirements. The trial area consisted of two adjacent sites – one a more fertile ridge-top site with tall, vigorous, mesophytic scrub hardwood regrowth at least 3 m high providing favourable conditions for survival and growth of kauri seedlings, the other an exposed

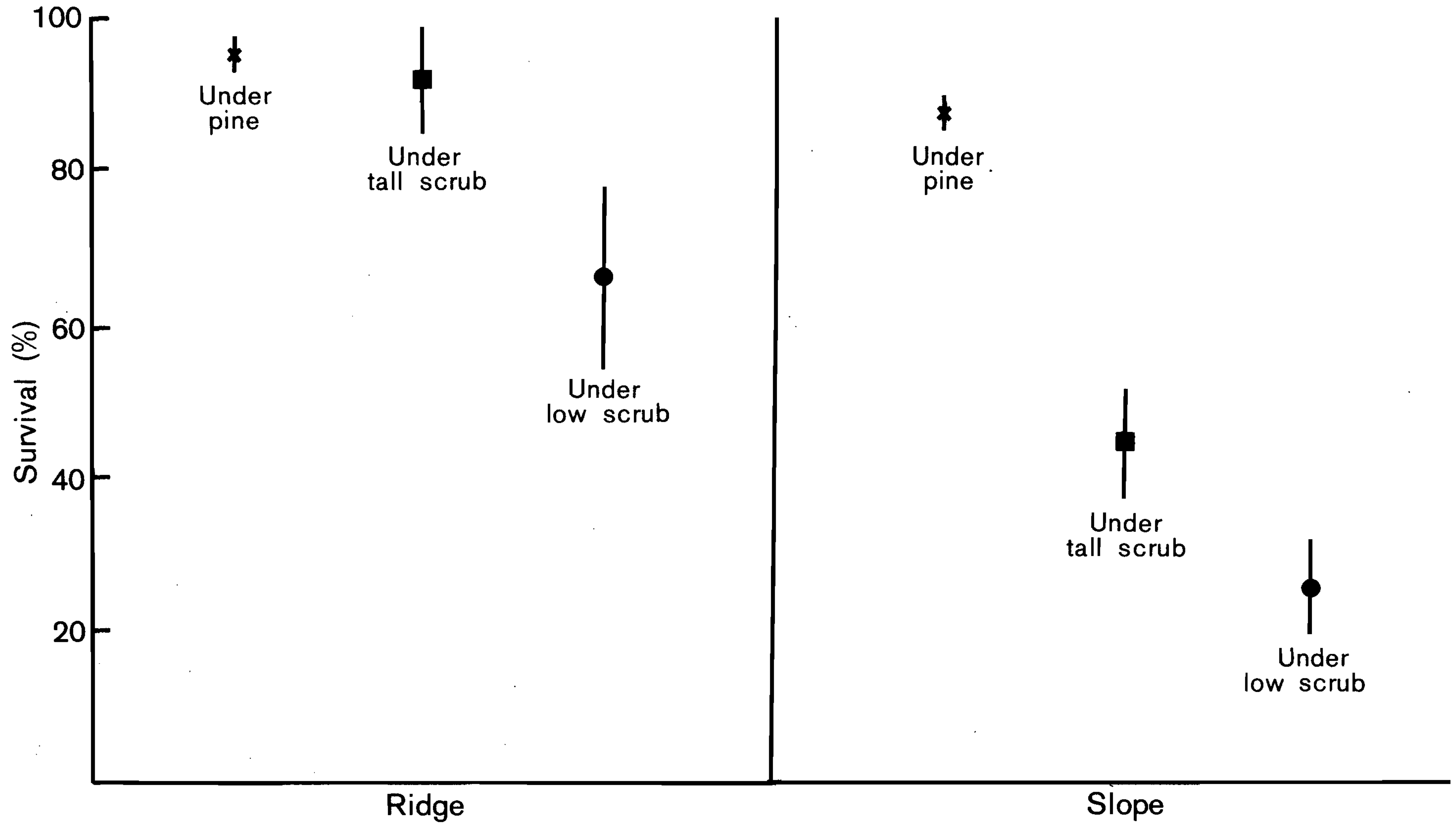

FIG. 1—Survival of underplanted kauri after 5 years. The five pine treatments are combined. Vertical lines indicate standard errors.

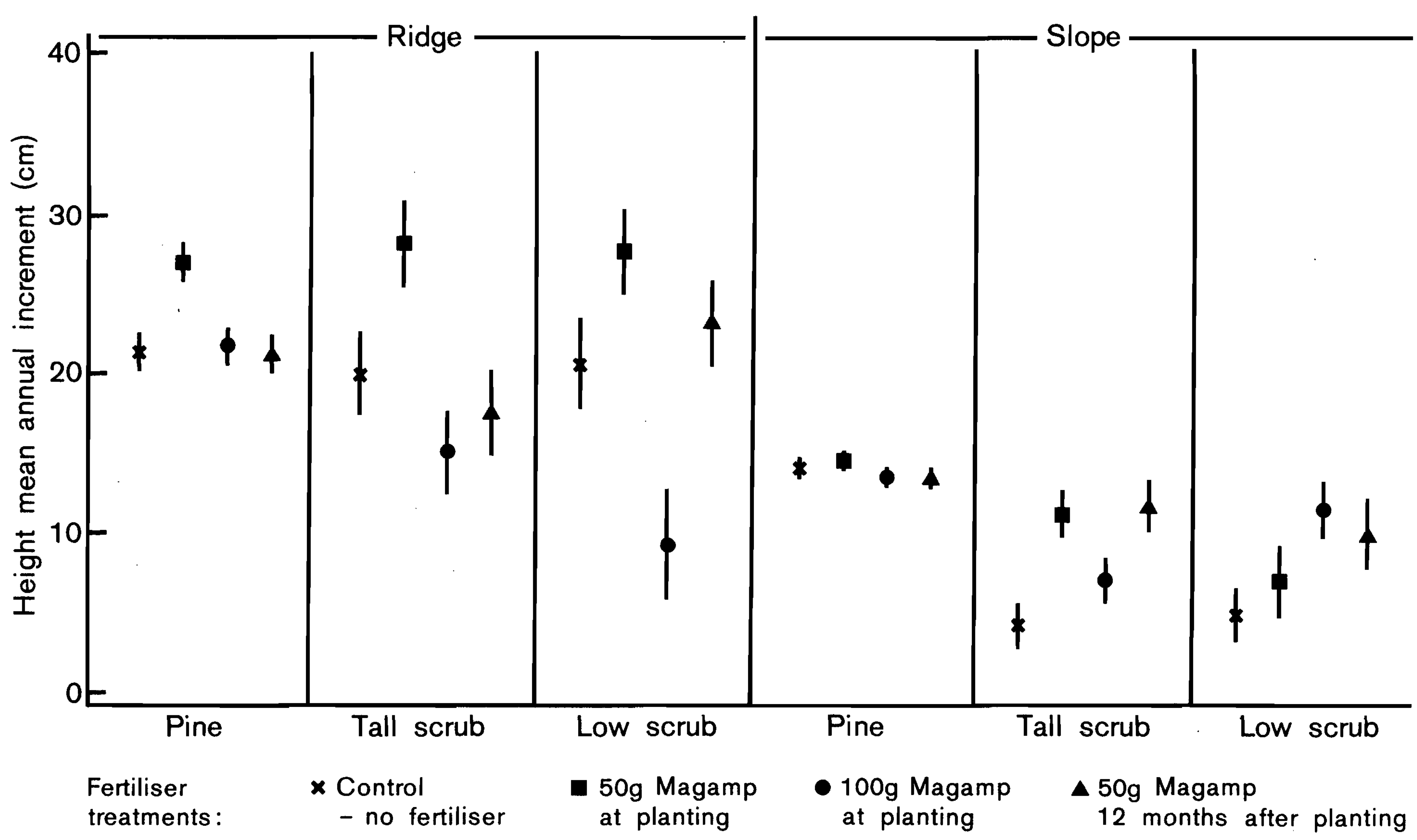

FIG. 2—Mean annual height increment of underplanted kauri. The five pine treatments are combined. Vertical lines indicate standard errors.

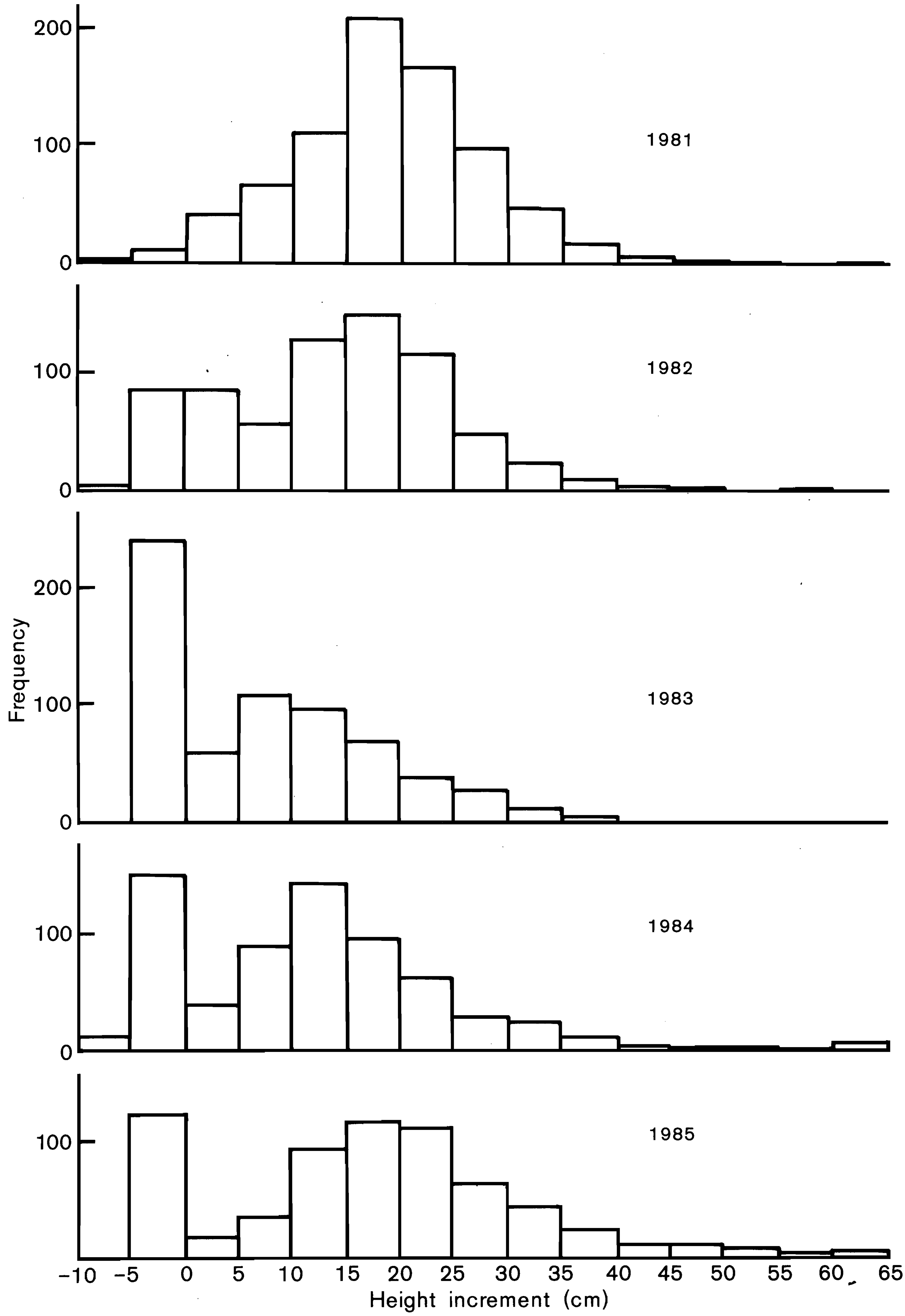

FIG. 3—Yearly distributions of height increment. All treatments are combined.

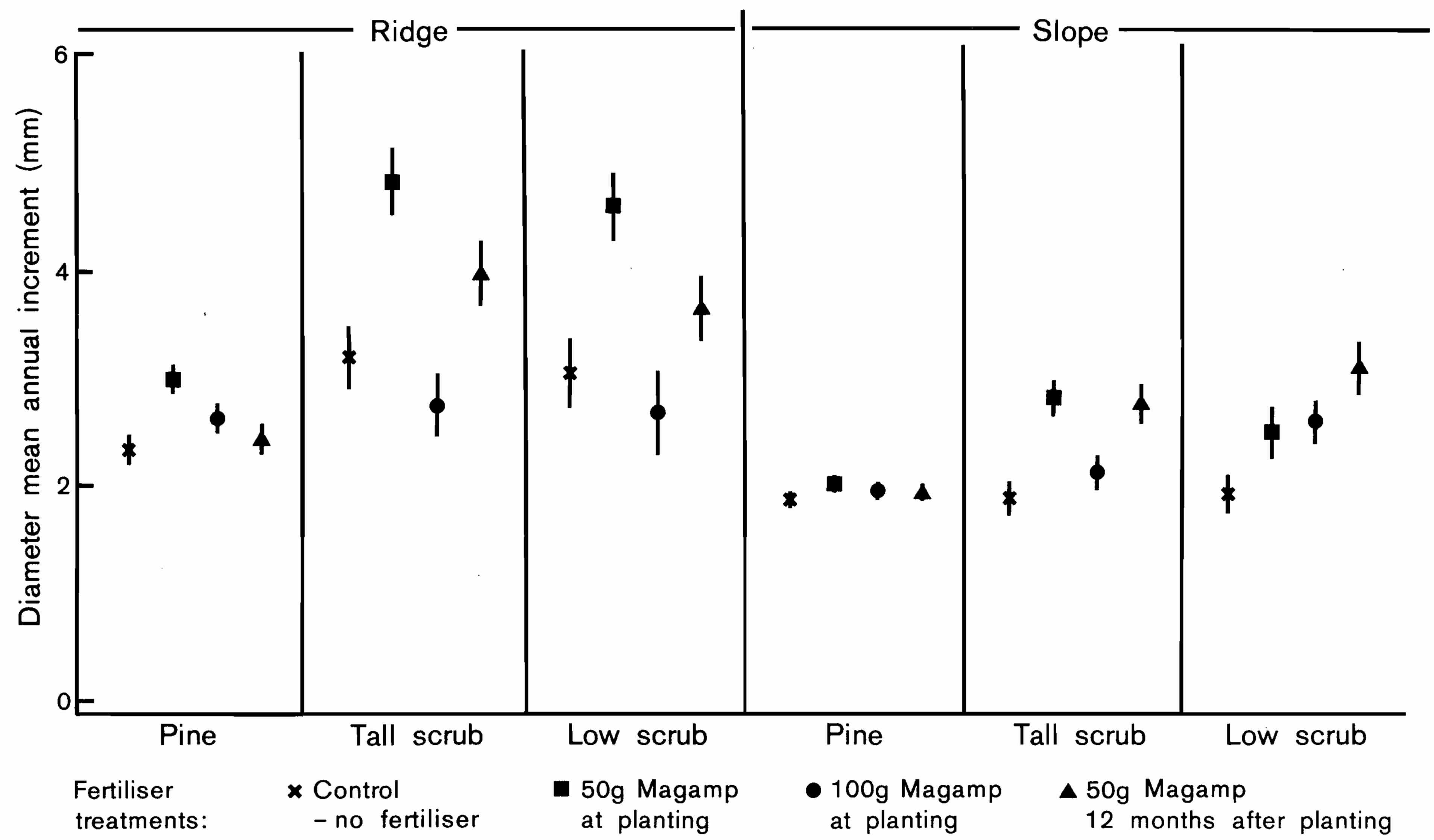

FIG. 4—Mean annual diameter increment of underplanted kauri. The five pine treatments are combined. Vertical lines indicate standard errors.

TABLE 1—Soil analyses*

Vegetation type	pH		Total-N (%)		Bray-2 P (ppm)	
	Ridge	Slope	Ridge	Slope	Ridge	Slope
Pines	5.7	5.5	0.56	0.22	7.2	4.7
Tall scrub	5.9	5.5	0.76	0.24	8.4	3.0
Low scrub	5.7	5.4	0.54	0.26	3.3	3.0

* Composite 0- to 10-cm soil samples taken by core sampler.

slope with skeletal hill soils and less vigorous regrowth producing very poor survival and growth of kauri. Several factors may contribute to these differences. Good shelter is clearly crucial to seedling survival, with quite high mortality in seedlings in the shorter regenerating scrub even on the fertile site (Fig. 1). The very poor shelter provided by regenerating scrub on the exposed site led to very high mortality. Growth rate may be affected by shelter but soil nutrient status may also be important, as demonstrated by the considerable fertiliser response in seedlings planted in the tall scrub on the slope (Fig. 2).

Pine, as a nurse crop, had no effect on seedling survival and height growth on the more fertile ridge site compared to the slope. On the exposed slope the shelter provided by the pines markedly improved seedling survival (Fig. 1) and may also have helped to improve height growth (Fig. 2). However, the improved growth may not be due to shelter alone. Of particular interest is the negligible response to fertiliser of kauri planted in the pines and the significant response in scrub. In Australia, Bevege & Richards (1970) found a similar improvement in growth of *A. cunninghamii* planted under a pine stand and only a slight response to added nitrogen compared to open planting. They suggested a multiplicity of factors concerning the nitrogen cycle of the ecosystem and nitrogen metabolism of *A. cunninghamii* were involved. In the United States Fisher & Stone (1969) found that herbaceous plants growing beneath or near conifers had significantly higher nitrogen and phosphorus concentrations and greater dry weight. In addition, higher percentages of organic nitrogen could be extracted with hydrofluoric acid from soil beneath young conifer plantations (10–14 years) than in adjacent, open, abandoned fields. They hypothesised that the conifer rhizosphere mineralised or otherwise extracted soil nitrogen that had been resistant to microbial action under previous vegetation. Although the limited range of soil analyses conducted on the Whenuakite samples failed to show clear differences in fertility between vegetation types, the lack of response of kauri to fertiliser under pines might indicate some improvement in soil conditions. Factors other than improved nutrient status that could be involved are a deeper litter layer under the pines and associated better moisture retention. Alternatively, the lack of response of kauri could be due to pines successfully competing for the fertiliser.

As gap size within the pines had no significant effect on growth or survival of kauri, smaller gaps with their less vigorous regrowth requiring less releasing are preferable. Compared to the pines, the higher light level in scrub gaps was reflected in both greater regrowth and increased diameter growth of kauri. However, it is more desirable that kauri gain height as quickly as possible in early years to avoid being smothered and diameter growth is less critical. The need for regular releasing in the scrub gaps suggests that smaller gaps would have been more suitable.

Although application of fertiliser at planting helped with faster early growth under scrub, the higher rates generally gave a poor response. MagAmp is not readily soluble but warm temperatures and high rainfall could have caused burning of roots where fertiliser was in higher concentrations.

CONCLUSIONS

Although a nurse crop of pines improves survival of kauri on hard sites, the temporary conversion of large areas to an exotic nurse crop for extending kauri planting is expensive, involves high levels of disturbance, and is probably unacceptable to an increasingly conservation-minded public. A major problem is removal of the pines once they have completed their nurse role, without damaging kauri. Early kauri underplanting trials have resulted in major disturbance to kauri when exotics were extracted.

The use of other exotic species as nurses has not been investigated widely. *Eucalyptus* species may establish quickly but removal of large trees again becomes a problem. Interplanting shorter-lived nitrogen-fixing species such as tree lucerne (*Chamaecytisus palmensis* (Christ) Hutch.) on less frosty sites may be worth trying. Some *Acacia* species could also be considered.

The wide-scale planting of kauri on a range of scrub sites may not continue in future, with such areas being left to regenerate naturally. Where planting is to continue, resources are likely to be limited. In areas such as the Whenuakite Block, any further kauri planting should therefore concentrate on better sites along flat ridges where soils are moderately fertile and well-drained, and tall scrub gives adequate side shelter. Using small gaps to reduce regrowth and applying a small amount of slow-release fertiliser to kauri at planting on such sites is likely to be of some benefit.

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