# DEVELOPMENT OF A FOREST NURSERY ON PEAT LAND

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*SYNOPSIS*

*Investigation into a suitable nursery site to supply tree stocks (mainly radiata pine) for Aupouri Forest, Northland, began in 1963. In 1966, 29.5 ha of peat land was acquired, some 6.5 km south of the Forest headquarters. Development of this site was virtually complete in 1973, much of the work having been of an experimental nature because of lack of local experience in using peat soils for a tree nursery. The various measures taken, and their results, are described.*

## INTRODUCTION

Sweetwater Nursery, established in 1967 by the New Zealand Forest Service, lies some 11 km north of Kaitaia and about 3 km inland from Ninety Mile Beach. It is divided into a west block of 8.1 ha and an east block of 21.4 ha (see Fig. 1).

### *Climate*

Rainfall is 1000 mm/year, with dry periods more common from January to March, and occasionally in early spring. Only two or three frosts occur each year and they seldom exceed — 2° C. Mean maximum temperature is 19° and mean minimum 12° C.

### *Site and Vegetation*

Terrain is flat to gently undulating, with the west block falling slightly towards the east and the east block slightly to the south-east and west. Vegetation on the west block before development was principally scattered gorse *(Ulex europaeus)*, kanuka *(Leptospermum ericoides)*, manuka *(L. scoparium)*, black wattle *(Acacia decurrens)*, with some tree lupin *(Lupinus arboreus)*, woolly nightshade *(Solanum mauritianum)*, rushes *(Juncus* spp.) and swamp umbrella fern *(Gleichenia circinata)*. The east block had a more homogeneous cover of manuka, kanuka, swamp umbrella fern, rushes, and scattered pampas grass *(Cortaderia selloana)*.

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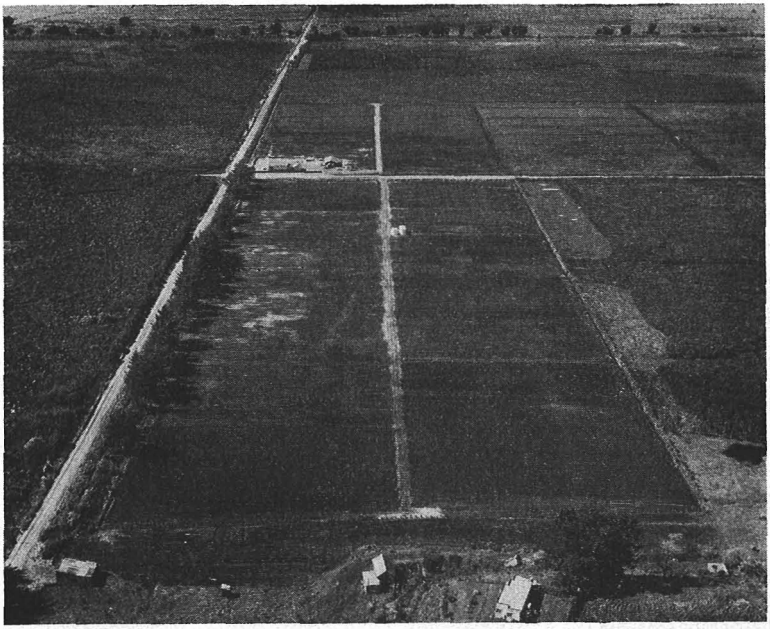

FIG. 1: *Sweetwater Nursery in 1969 — an aerial view showing the stage of development.*
N.Z. Forest Service photograph by J. H. Johns, A.R.P.S.

In both blocks there were numerous holes up to one metre deep and one to two metres in diameter (the results of kauri gum digging around the turn of the century) and also occasional buried or partly buried kauri logs and stumps (see Fig. 2).

*Soils*

The soil in the west block is Ruakaka peaty sandy loam and loamy peat grading eastwards to Otonga peaty loam which is found throughout the east block. The soil is black or grey-black, and the surface zones contain a variable but significant proportion of light-coloured sand grains. Some of the sand has arisen from past gum washing activities, but it is believed that most has been derived through podzolization by the original kauri *(Agathis australis)* forest. Particles of kauri gum and fibrous roots and other organic material are liberally scattered throughout the profile. Raw peat occurs at variable depths, from just below the surface to 2.5 m.

Detailed sampling before the land was purchased gave the following average figures:

| | |
|---|---|
| pH .. .... .... .... | 4.35 (3.85 to 5.10) |
| Percentage organic matter | 60 (ash content 38-40%) |
| Percentage nitrogen .... | 0.84 |
| Carbon:nitrogen ratio .... | 71 |

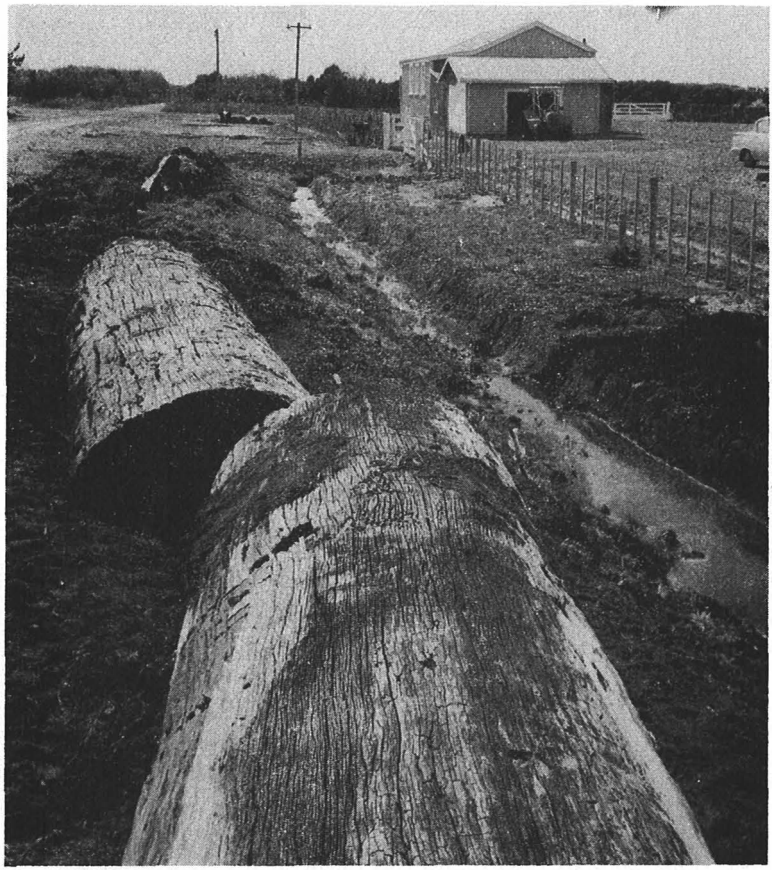

FIG. 2: *An old kauri log encountered during nursery development.*
N.Z. Forest Service photograph by J. H. Johns, A.R.P.S.

## DEVELOPMENT

### *Drainage*

Lowering of the water-table and over-draining of peat soils can lead to rapid shrinkage and subsidence. As a guide, peat soils with an ash content of 10% are likely to subside at a rate of 5 to 7.5 cm/yr, whereas those with 40% ash (as in Sweetwater Nursery) may sink at a rate of only 1.3 cm/yr. Drainage is consequently a long-term project. Disused main county drains on the north side of both blocks, and along the east side of the west block, were re-opened and a new deep drain subsequently dug along the southern boundary of the east block. Poor lateral drainage has been overcome by forming shallow drains, 20 to 40 cm deep, at about 40 to 60 m intervals. These feed into subsidiary boundary drains and thence into

the main county drains. These shallow internal drains were made by a spinning ditch digger mounted to the rear of a wheeled tractor. Their location can be varied from time to time to prevent the ground around them from becoming compacted and thus impeding water movement. They are formed after cultivation and general levelling.

To check the rate of subsidence, survey marks were established, and cross-section profiles of both blocks are measured annually. There has been no significant change in seven years of operations.

*Internal Clearing and Cultivation*

Initial development was undertaken in the west block in 1965. Kauri stumps and logs were either dragged out by tractor or, if beyond the capacity of the machine, blasted. The land was then roughly levelled by crawler tractor and blade, holes were filled, and the site cultivated with giant discs. Areas covered with gorse were disced twice. Rubbish was heaped and burnt. Early the next year further levelling was undertaken using a wheeled tractor and blade. This form of levelling has been carried out throughout the nursery, since the ground is too soft after the initial discing to sustain large levelling machines such as graders, and has been restricted to blocks of 0.8 to 1.2 ha. After two years' operations a relatively flat surface is obtained.

This general sequence was followed in due course over the whole nursery. Small debris such as sticks were progressively collected by hand and taken away and burnt. This was particularly necessary during the first two years on all areas, but is still necessary since cultivation brings into the surface layers more debris which can hinder root pruning and wrenching. A tiller with 30 to 38 cm tines at 23 to 30 cm spacing assists the collection of smaller debris, and has been found more useful than potato harvesters, which tend to get clogged with lumps of peat and fibrous clods.

Development of the east block began in October 1967, and at the end of 1972 almost two-thirds of the block was under nursery crops, or was in a condition suitable for sowing, while the rest had been cleared, disced and roughly cultivated.

Since 1968 a single-furrow disc plough has been used for cultivation after stick removal, rough levelling and discing. This is followed by rotary hoeing and tilling prior to seed sowing. The single-furrow disc allows greater depth of cultivation than previous methods and brings to the surface more peat for mixing with the friable sandy upper layers. It also prevents the formation of a compacted layer of peat near the surface and thus improves drainage. All areas that have carried a nursery crop are now ploughed with this equipment.

## NURSERY SHELTER

The need for shelterbelts within the nursery was not fully appreciated until 1968. Light westerly breezes are common, but winds occasionally reach moderate or strong intensity,

leading to considerable movement of sand grains. When this coincides with the first two months following germination, the tender stems of seedlings can be abraded, sometimes resulting in significant mortality. To overcome this problem where existing shelter is inadequate, temporary fences of polypropylene mesh are erected at suitable intervals and these have been quite effective.

The west block was divided, for management purposes, into eight units, and single-row shelterbelts were established along the boundaries of these in 1968. Slash pine *(Pinus elliottii)* was used because it is tolerant of the acid soils, has a relatively dense crown, and grows quickly during early years; its ultimate height is less than that of radiata pine. Attempts to interplant the pine with pampas grass were unsuccessful, and to give quick interim shelter a band of brush wattle *(Albizzia lophantha)* was broadcast sown along most unit boundaries. This grew to about two metres high in two years, but after three years the slash pine was the same height and the brush wattle was removed by rotary slashing.

Perimeter shelter with slash pine has also been established in the east block, and inter-unit shelterbelts have been extended as development of each block has proceeded.

## NURSERY PRACTICE

### *Soil Management, Fertility and Mycorrhizae*

Soil analysis carried out by the Forest Research Institute showed that calcium and magnesium levels were medium to good while potassium and phosphorus levels were low or very low. The main emphasis in fertilization has been to correct this, particularly the shortage of phosphorus. Before forming nursery beds, blood and bone (6:7:0) is broadcast at 630 kg/ha with the object of assisting early seedling growth. An alternative (due to shortages of blood and bone), diammonium phosphate (18:20:0), was substituted in 1973 at the roughly equivalent rate of 250 kg/ha.

After germination a composite pelleted fertilizer (15:7:5) is applied at rates of 125 to 250 kg/ha. Usually two applications are required up to the time of first wrenching, and the second dressing may be reduced to 63 kg/ha where excessive height growth is expected.

The need to raise the pH should not be overstressed, but the intention is to raise it to about 5.0. Lime is applied at 5 tonnes/ha before sowing the first crop on each area and this is followed by an annual maintenance dressing of 2.5 to 5.0 tonnes/ha according to results of pH tests. Trial applications of lime have shown that the following increases in pH can be obtained:

| *tonnes/ha* | *Average increase in pH* |
|---|---|
| 5 | 0.40 |
| 10 | 0.65 |
| 15 | 0.85 |
| 20 | 1.00 |
| 25 | 1.10 |

Increases of this magnitude have not been obtained in practice because continuing cultivation and disc ploughing bring up peat from lower levels and mix it with the topsoil.

Signs of copper deficiency recently appeared in radiata pine seedlings growing in the east block but this was remedied by the application of copper sprays to which seedlings responded rapidly.

An existing shelterbelt of old radiata pine along the northern boundary of the west block (subsequently removed) was believed to have given some degree of mycorrhizal inoculation to the soil, and in all new areas the first crop of pine seedlings has been regarded as the best means of establishing mycorrhizae. Spot sowings of radiata pine were made throughout the west block in spring 1965, half the area sown being inoculated with pine duff. No growth differences between treated and untreated areas were apparent, and foliage analyses indicated that the main deficiency was phosphorus. However, in the first year of cropping there are small patches of yellow stunted trees found irregularly distributed, the disorder being most apparent midway through the life of the crop. Mycorrhizae are not completely absent from trees in these patches and it is possible that other factors are responsible — *e.g.*, depth of the peat layer below the surface and its restricting effect on drainage. Trials with various fertilizers, with and without pine duff, in subsequent years, have not corrected the disorder and, since the affected trees often improve in growth towards lifting, a proportion can be used for planting. In any case, over 85% of the crop from an initial sowing is usable, and the variation in growth is much reduced in second and third crops.

The very nature of peat, being an organic soil, precludes the need for green cropping to maintain soil structure and to build up the organic status — at least for a long period of time. The major interest in using green crops is as a soil covering for fallow areas to prevent windblow of the surface sand and finer peat particles, and for easier maintenance of fallow land. Experimental crops of blue lupin *(Lupinus angustifolius)*, maize *(Zea mays)* and Algerian oats *(Avena byzantina* var. *algerians)* were tested. Maize failed completely, while blue lupin showed partial failure or variable growth. Algerian oats gave the best results and responded positively to applications of phosphate and a complete NPK fertilizer.

*Seedling Crops*

The principal species grown is radiata pine. About three million 1½/0 (autumn sown) seedlings are grown, mainly for planting on sand dunes in Aupouri Forest, and some two million 1/0 (spring sown) are produced for other State forests in the Northland region.

Eucalypts *(Eucalyptus saligna, E. pilularis)*, slash pine and loblolly pine *(Pinus taeda)* are also raised from time to time, but in far smaller quantities. Macrocarpa *(Cupressus macrocarpa)* is also grown for planting as a protective coastal belt at Aupouri Forest. In addition, some 77 species of ornamental trees are raised for amenity planting.

For the principal species the aim is to grow 1½/0 stock with stem length of 40 to 50 cm and 1/0 stock from 25 to 35 cm. A height:root collar ratio of 60 or less is prescribed for all radiata pine stocks. The general pattern of growth is shown in Fig. 3.

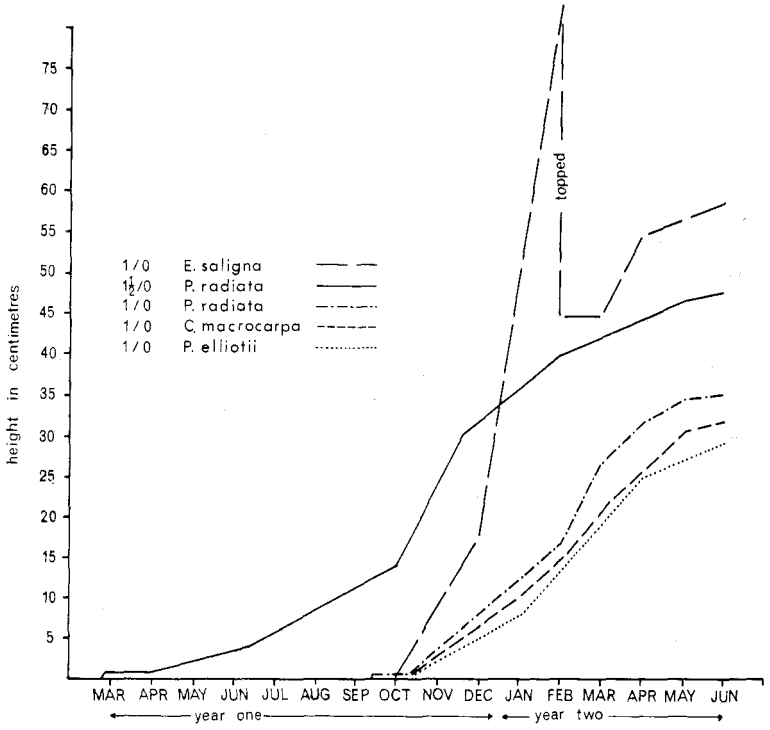


FIG. 3: *Generalized growth pattern of conditioned nursery stock, Sweetwater Nursery.*

## *Seed Sowing*

Seedbeds are raised by moulding and rolling to attain a height of 7 to 10 cm so as to avoid ponding, thus helping to reduce problems of root rot and damping-off. The pathways between beds act as shallow lateral drains during heavy rain. Bed width is sufficient to permit the sowing of six drills, with 15 cm between each. Further rolling after sowing, combined with the earlier disturbance by the seed-sowing machine, provides sufficient covering material for the seed.

Autumn sowing usually takes place in February to allow seedlings to gain sufficient height before winter to withstand soil splash and soil coning — the latter causing growth retardation, and both tending to increase damping-off. Spring sowing is undertaken from mid-September to mid-October —

the earlier date on the better blocks where 1/0 stock usually grows to a similar size to 1½/0 stock. This allows any shortages in autumn-sown seedlings to be made good if necessary.

*Irrigation*

On occasions water may be needed for spring-sown stock after germination (October) when drought conditions can occur. At this time wind may also lead to stem blasting of small seedlings. Irrigation may also be required to permit undercutting and wrenching during dry conditions. The nursery is supplied from an artesian source which is pumped to feed oscillating sprinkler lines.

*Weeds*

In general the weedicide regime adopted for pines gives good control. It consists of:

— propazine at 1 kg/ha a.i. at the time of sowing with additional applications as required during the season.

— paraquat at 2 litres/ha just before tree seedling emergence.

— aromatic oil (18% aromatics) at 400 litres/ha applied over tree seedlings once the primary needles have formed to kill emerging weeds. Two to four applications may be necessary, and propazine is applied simultaneously.

Propazine is favoured at Sweetwater Nursery rather than simazine, since the latter was found to cause some seedling damage and growth depression when heavy rain followed application, while some surface ponding occurred with consequent local concentrations of simazine. No such effect has been observed with propazine, which has been applied to pine crops at rates of up to 3 kg/ha a.i. without apparent damage.

Any difficult weeds such as establised sheep's sorrel *(Rumex acetosella)* or Kikuyu grass *(Pennisetum clandestinum)* are adequately dealt with by chemicals applied during fallow periods.

*Conditioning Regime*

The normal regime is horizontal undercutting/wrenching at fortnightly intervals and lateral (vertical) side cutting at three- to four-weekly intervals, commencing in late November or early December for autumn-sown radiata pine, and in late February or early March for spring-sown crops.

Lateral root development is vigorous, and trimming of this growth between drills is done with discs adapted for this purpose. But because of favourable climatic conditions and the inability to sever lateral roots which grow along the rows, height growth continues at a rate of some 2.5 cm per four weeks despite wrenching. The within-row lateral roots are trimmed by hand before packing trees for despatch.

Topping is used to control height growth of 1½/0 stock if excessive growth appears likely. This is completed during

December and January to allow sufficient new growth to occur and become hardened in time for lifting.

Results from a small-scale trial carried out at the Department of Scientific and Industrial Research Controlled Climate Laboratory in Palmerston North, on behalf of the Forest Research Institute, indicate the relative hardness of tree stocks. Seedlings were exposed to white frosts of —3°, —6°, and —10° C. for four hours. Sweetwater stock was unaffected at —3° but all were killed at —10°, whereas only 50% of Forest Research Institute nursery seedlings and 15% of Kaingaroa nursery seedlings were killed at —10° C.

*Insects and Fungi*

Damping-off and grey mould *(Botrytis cinerea)* are usually found on all crops, but reasonable control is obtained with thiram (50%) applied at 2 kg/ha.

A small outbreak of terminal crook disease *(Colletotrichum acutatum)* occurred in 1971 in the west block and, as a precautionary measure, all pine sowings are sprayed with 2 kg 50% captan plus 1 kg phenyl mercuric chloride (2.5%) per hectare at weekly intervals until the crop reaches 15 cm in height, and thence fortnightly until 23 cm is attained. After this, spraying is discontinued.

Root rot has also been a minor problem, occurring sporadically in spring-sown radiata pine in the west block, where many areas have not been out of cultivation and have thus not received the deep disc ploughing. Such areas will be disc ploughed and put under autumn-sown stocks, which are less prone to root rot attack.

The main insects affecting nursery crops are greasy cutworm *(Agrotus ypsilon)*, black beetle *(Heteronychus arator)*, black field cricket *(Teleogryllus commodus)* and army worm *(Heliocoverpa armigera conferta)*. These mainly attack the roots of young seedlings or the stems just above ground level. Dieldrin (15%) at 11 litres/ha applied annually gives reasonable control of black beetle and cutworm, while malathion (50%) at 1.7 litres/ha is used against army worm and crickets, with a bait being included for the latter.

## RETROSPECT AND PROSPECT

The original site of the nursery would have brought feelings of despair to many a nurseryman. The main factors leading to its selection were its proximity to Aupouri Forest, the positive features of a peat soil for horticultural use, cheap land price, and the lack of suitable alternative sites with more conventional nursery soils. The rather unpromising form of the original vegetation, the unknowns of drainage and/or a high water-table, the encounters with kauri logs and stumps, and the lack of indigenous experience with the development of peat for tree nurseries, all led to considerable scepticism amongst Forest Service personnel.

The challenge was faced and, with time, confidence and considerable optimism have replaced earlier misgivings. The

requirements of drainage and levelling originally limited the length of nursery beds to 80 to 135 m, but it is hoped to amalgamate units to allow bed lengths to be increased to about 160 to 220 m; this is believed to be about the maximum length possible under the prevailing conditions.

The lack of frosts prevents tree stocks from being hardened off to the extent of those in more southerly nurseries, yet conditioning treatments are sufficient to permit satisfactory transfer and subsequent survival of nursery stock under Northland conditions. Lateral root pruning on four sides of a tree would be the only improvement desirable and this must await the design and development of suitable equipment (in conjunction with precision sowing) at some future date.

Today Sweetwater Nursery has a promising potential. Development problems are a thing of the past. Tree stock now being raised are excellent and have a sound reputation amongst Forest Service personnel and private individuals in Northland.