NOTES ON AGATHIS AUSTRALIS.

By C. T. SANDO.

Introduction.—Much has been published about our kauri (*Agathis australis*) and it is now generally recognised as one of the finest coniferous trees of the world. The New Zealand species is one of a genus of ten—the most important being—

A. Palmerstoni	...	(Queensland)
A. microstachya	...	(Queensland)
A. robusta	...	(Queensland and Philippine Islands)
A. vitiensis	...	(Fiji)
A. alba	...	(Malaya, Sumatra, Java, Celebes, Borneo, and Philippine Islands)
A. lanceolata	...	(New Caledonia)
A. macrophylla	...	(Solomon Islands)

The value of *Agathis australis* was first recognised before 1800 by which time a considerable trade in kauri spars had sprung up between Australia and New Zealand. Later, naval-store ships were sent out from England for cargoes and from that time on kauri has increased in value. Up till a short time ago it was used for building and interior furnishing, but now the limited supplies demand a price far too high for these purposes so that its present uses have been confined to carriage building, cabinet-making, and general joinery, vats, tubs, and other special purposes.

Wanton waste has so depleted out kauri areas that now, more than ever it is forced upon us, the necessity of making very serious attempts at conservation of the remaining supplies and propagation of this tree for scenic purposes, and, if economic conditions warrant it, for timber production.

Geographical, Climatic, and Edaphic Range.—Kauri occurs in the northern parts of the North Island except in the extreme northern peninsula. It is found from Ahipara and Mangonui in the north as far south as the Bay of Plenty on the East Coast and Kawhia Harbour on the west, i.e. between latitudes 35° and 38° S. from sea level to approximately 2,650 feet.*.

The temperature in these parts ranges from 50° F. to over 100° F., with a mean of 60°—70°F. while the average annual rainfall varies from 50 inches to 90 inches distributed fairly evenly throughout the year, often with heavy midsummer falls sometimes amounting to over 15 inches a month. Only light frosts are experienced in most of this area and the weather generally is very mild.

*Cranwell and Moore recently recorded kauri at this elevation on the Coromandel Peninsular. (*N.Z. Journal of Science and Technology.* Nov., 1936. p.532).

The species was apparently never a tree of the alluvial flats to any extent but was usually confined to the heavy residual clay soils largely from basalts, rhyolites, and other igneous rocks but also from the sedimentary rocks of the district.

Vegetational Status.—In the past kauri occurred at much lower elevations than are the majority of the existing stands but in conjunction with other factors the gradual encroachment of taraire (*Beilschmiedia taraire*) and kohekohe (*Dysoxylon spectabile*) has caused it to recede.

Whenever a gap was caused by millers, fire, or natural causes there occurred a dense growth of either mamaku (*Cythea medullaris*) and ponga (*C. dealbata*) on shady faces, or broadleaf species which prevented the germination of kauri seed. When these species grew larger and let in the light, the source of kauri seed had often been destroyed so only those species with bird distributed seed became established. Thus the kauri areas receded to the spurs where the less luxuriant growth of other species allowed germination and subsequent development. Now, *A. australis* is found mostly in dense pure clumps mainly on ridges and spurs and the remainder of the forest consists of either broadleaf or podocarp species. In the kauri forest proper there is often a dense ground cover of kauri grass (*Astelia trinerva* and *Gahnia xanthocarpa*) and very little other growth, but on some of the spurs where kauri grass is sparse there is a ground cover of *Blechnum Frazeri, Lycopodium densum, Gleichenia circinata,* and *G. Cunninghamii* and a few small shrubs, such as—*Corokia buddleoides, Senecio Kirkii, Dracophyllum latifolium, Phebalium nudum, Alseuosmia spp., Hedycarya arborea, Olea lanceolata, O. montana,* and on the higher levels *Quintinia serrata,* and *Weinmannia sylvicola.* In all kauri stands there are a few tanekaha, (*Phyllocladus trichomanoides*) and on higher levels toatoa (*Phyllocladus glaucus*) and miro (*Podocarpus ferrugineus*).

In the broadleaf association the composition varies considerably. Where taraire is dense there may only be an undergrowth of nikau (*Rhopalostylis sapida*) but in other parts there is an upper story of taraire, kohekohe, puriri (*Vitex lucens*) and rewarewa (*Knightia excelsa*) and on the higher levels towai (*Weinmannia sylvicola*) tawa (*Beilschmiedia tawa*) and tawheowheo (*Quintinia serrata*) with a thick tangle of shrubs beneath. The podocarp species occur on the richer soils the main species being rimu (*Dacrydium cupressinum*) associated with totara and Hall's totara (*Podocarpus totara* and *P. Hallii*), matai (*P. spicatus*), miro (*P. ferrugineus*) and kahikatea (*P. dacrydioides*). Once again the undergrowth is usually dense. All types merge into one another but wherever kauri occurs it is the dominant tree.

Cones and Seed.—Kauri fruits annually in crops of varying extent but there is no known periodicity of good crops although every season a plentiful supply is produced.

The species is monoecious, each tree bearing two types of cones.

(i) **Male Catkins.**—The buds of the male catkins first appear in late summer, *i.e.*, February and March. They are lateral or axillary and occur at the same time as the buds of new shoots and female cones. In one month they are $\frac{1}{4}$ inch in length and are fully developed, 1-1$\frac{1}{2}$ inches long, cylindrical in shape by the following spring (September and October) a period of 7 to 8 months. The yellow pollen dust is plentiful for a short time.

(ii) **Female cones.**—The buds of the female cones appear in late summer, obovoid in shape but apparently remain dormant till the following spring. By December the young cones are $\frac{1}{2}$ inch in diameter and by March 1 inch and over, attaining a size of some 2 inches to 3 inches in diameter, spherical in shape with flattened ends, when mature about March or April of the following year, a period of some 24 months since the buds first appeared. The ripe cones weigh on an average about 1$\frac{3}{4}$ ozs. In the cone a single, light, winged seed is attached to each scale but those in the apical and basal scales do not develop and only the rudiment of a wing is apparent. In the terminal scales even this is absent. The number of scales varies from 130-160 but only 65-75% of these contain seed and of this number 55-65% are sound, *i.e.*, 50-70 sound seed per cone. The wing is not detachable without injury to the seed. The cone disintegrates on the tree at maturity but often a large number of cones fall prematurely to the ground. This is caused either by heavy winds or the depredations of the kaka (*Nestor occidentalis*). Owing to this premature falling of the cones the radius of dispersal of most of the seed is confined to the crownspread and only a small percentage find a suitable germination bed at any distance from the parent tree.

The fallen immature or unopened cones are frequently associated with *Pestalozzia funerea* ; this fungus has also been found to infest living cones on the trees, probably following a very wet summer.

The viability of stored seed is evanescent. In a few weeks it has diminished considerably and has lost all viability 18 months after collection.

The Seedling.—For germination, light, a certain amount of moisture and warmth, and shelter from the drying winds are essential. If the weather is suitable, germination may take place within a very short time but may be prolonged for several months. Seed sown in April has germinated right through the winter and early spring. The wing and testa often remain attached to the cotyledons for as long as 2 months after germination but when shed, the seedling is from 1-1$\frac{1}{2}$ inches high with two lanceolate or slightly falcate cotyledons at the end of the stem and at right angles to it. The single, long, fleshy taproot is nearly 2$\frac{1}{2}$ inches in length. Four to five months after germination the seedling may be 2-3 inches high with a deep reaching taproot and a few fibrous laterals. For this reason transplanting is most successful if carried out within 6-7 months after germination.

Photo: C. T. Sando

A small group of kauri (*Agathis australis*) **'rickers.'**

In dense bush the foliage is light green or yellowish green in colour but growing in the open it varies considerably from green to a reddish or light chocolate brown. The new shoots are noticeable by their paler tints. The seedling growing naturally in dense forest may be completely suppressed for very long periods without producing fresh shoots but it survives this domination in early life and when a breach occurs in the canopy it will continue its delayed development. The seedlings apparently have strong recuperative powers. If they are damaged externally gum immediately forms a protective covering over the wound.

The Sapling.—This is a long pyramidal or conical tree with small persistent branches almost right to the ground when growing in the open. The foliage is dark green in colour but the young shoots are prominent, being a glaucous bluish-green. In the later stages the branches are ejected from the stems without leaving a scar. A knob forms at the base of each branch and consists almost entirely of bark with a very thin strip of extremely tough wood attached to the tree. Later this wood is pinched off and the knob consists of bark only. This is evidently just prior to shedding.

Many saplings only 20 feet high and 4-6 inches in diameter bear a good crop of cones.

The Immature Tree or "Ricker."—When the sapling reaches its maximum height growth the side branches have been shed leaving a long clean barrel and a small crown, rapidly developing from a pyramidal to a cylindrical head : This immature tree is devoid of large branches. The time taken to reach this stage is, as yet, unknown. Ring counts in a fairly dense stand gave over 150 rings at stump height but some of these may not have been annual rings due to the double and even treble growths in some years.

When the faces of these trees are exposed to wind and sun, as on some of the more prominent ridges, there appears a considerable number of adventitious shoots. They are cast off later in the same manner as the branches without leaving a scar. These trees all bear crops of cones containing fertile seed.

The Mature Tree.—The mature kauri is a massive tree with a comparatively short, large, cylindrical bole with very little taper. Owing to its habit of shedding the bark in large flakes, the trunk is usually clean. The widespreading crown, often longer than the bole and usually 60-100 feet in diameter, is a mass of large heavy branches. The branch wood, heavily impregnated with gum, is very durable.

Measurements of our larger kauri have often been published but, although the large sizes are frequently seen, the average of our present virgin stands has a bole of under 40 feet in length and a G.B.H. from 18-20 feet. In the spring, the forest from above is a white or bluish

colour but the glaucous colouring disappears within a few weeks although the new shoots remain a lighter colour than the rest of the forest for a very long time. This same "whiteish" tinge may also be observed later when a double growth occurs in the one season.

Round the base of the kauri is a high mound of decaying bark and other vegetable matter ("pukahukahu"), covering the large lateral roots which spread for a long distance underground. On steep country these roots may be visible for a short distance and are easily injured by stock, bleeding freely. Whenever an external injury occurs on kauri a large quantity of gum is exuded and acts as a protective covering for the damaged part until healing is complete. It is a characteristic of kauri that, unless the injury is too large, the new bark grows across the green wood excluding any gum and dead bark or wood. Where large cuts have healed there often remains a solid gum streak or bark pocket in the timber. The piece of gum exuded quickly hardens on the outside but it may keep flowing inside until the damage is almost repaired. In the later stages it will be found that a new bark has formed completely across the injury and a piece of this bark will possibly be adhering to the back of the gum. The gum is finally shed when the bark flakes off. The majority of small blazes will heal within 2 years and in 3 years a solid lump of hardgum could be removed without further injury to the tree.

Natural Regeneration.—It is often suggested that the growth of kauri impoverishes the soil but it is most likely that this impression has largely arisen from observation of the poor quality of the gumfields where removal of the forest cover, repeated burning, and digging have caused the barren conditions. In countries with heavy rainfalls it is known that podsolization occurs when cover is removed but whether this takes place in virgin forest has yet to be determined. Apparently iron is essential to the growth of kauri and on flat country where the drainage is vertical, the iron leaches through to form a solid hard-pan that is detrimental to the growth of the species. This must be another factor causing the gradual withdrawal of the species to higher sloping country where there is no noticeable hard-pan and possibly accounts for the large number of gumfields occupying swampy land. Investigation of this geological change should be of great assistance in determining the value of our northern lands for the reproduction of this species.

The ability of *A. australis* to regenerate itself naturally is limited by a number of other factors, the main ones being :—

(i) Limited dispersal of seed owing to the premature falling of unopened cones.

(ii) The small number of fertile seed in each cone and its fleeting viability.

(iii) Fungous infestation of cones.

(iv) Excessive leaf-litter and dense floor covering of kauri grass.

(v) Dense shade produced by taraire—kohekohe association and also the dense growth of mamaku and ponga on shady faces in old workings preventing germination.

(vi) Attacks on young shoots by insects, *e.g. Tortrix sp.* and a leaf-mining larva.

That kauri will regenerate under favourable conditions, is observed everywhere in the forests. On spurs where the growth is sparse but there is sufficient shelter kauri regenerates prolifically. As many as 1,300 seedlings, all well established, have been counted on 1-10th acre plots in similar situations and it is hoped that by assisting the development of these conditions in future we will be able to reproduce kauri sufficiently, at least to maintain the present area and possibly to extend it.

Methods that can be adopted are :

(a) Silvicultural treatment that will prevent complete removal of the ground cover and also provide for sufficient trees to be left to distribute seed all over the area. Care will be necessary to prevent removal of all the surrounding shelter from these trees on exposed sites, as sudden isolation of the trunk may cause death within a very few years.

(b) The use of nurse trees (e.g. manuka) to assist in suppression of mamaku, ponga, and broadleaf species and in providing the required conditions for germination.

(c) Liberation cuttings round seedlings after germination. The seedling develops best under light shade but once established, the more full light the better, so long as drying winds are kept out.

Planting.—Many specimens have been successfully raised in gardens but no large scale planting scheme is sufficiently far advanced for any comments to be made on the degree of success. Germination in the seedbeds has so far been quite satisfactory, as many as 4,000 seedlings per pound being obtained.

Rate of Growth.—Isolated specimens have been measured and rate of growth calculated but nothing of real value has yet been obtained. The fact that kauri may shoot twice or even three times in one year makes stem analysis somewhat less reliable than in the case of ordinary conifers. It might be possible to segregate the rings into their respective years but the results would only be approximate. For example a section of a "ricker" taken at ground level was recently counted and showed 46 complete rings. By grouping, the age was estimated at just over 30 years and it was afterwards ascertained from the owner that it was 34 years since transplanting from the bush when the seedling was only 6 inches high.

Owing to this uncertainty, periodical remeasurement of trees of varying sizes is our only reliable method of ascertaining the rate of growth, and as yet this work is only in its infancy.