Agathis australis: A New Era for Kauri Propagation

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INTRODUCTION

Less than 200 years ago there were 1.2 million ha of kauri forests in New Zealand, but today there are only about 4,000 ha left. Kauri forests were extensively clearfelled and cutovers burned by the early settlers until the 1950s. Since then they were selectively logged for approximately 20 years. Today all the larger remaining kauri forests are protected as reserves (Halkett, 1991).

Kauri timber is a superb textbook-grade softwood, highly esteemed by all craftsmen who have ever converted this fine wood into boats, buildings, furniture, musical instruments, etc. Kauri has also been the subject of research and observation since 1885 and there have been over 600 articles written (Ecroyd, 1991 unpublished bibliography). The efforts of the New Zealand Forest Service, the indigenous forestry group at the Forest Research Institute, the Department of Conservation, various New Zealand Universities, and the general public are acknowledged.

A cursory review of past efforts to propagate and grow kauri has revealed that the work to recreate a national resource from this magnificent species has been disappointing, to say the least. Numerous trees have been planted in forests, parks, gardens and on farms—many of which are but a poor reflection of the species. A seed orchard was also established in Waipoua Forest in the 1950s by the New Zealand Forest Service. Of the hundreds of thousands of trees planted over the last one hundred years throughout the country, only two or three small groves appear to be doing well, and a few individual trees could be described as excellent. These few are of good form and growing at a satisfactory rate.

Kauri is a large tree. Kairaru, a tree in Tutamoe Forest, contained 735 cubic metres of millable timber, before being destroyed by fire. Tane Mahuta in Waipoua Forest, and Hokianga and Rakaunui in Omahuta Forest, all exceed 50 m in height. Today there are only three remaining trees containing over 200 m^3 of timber in their straight trunks—Tane Mahuta which equals 224.5 m^3, the Phantom which equals approximately 210 m^3, and Te Matua Ngahere which equals 208.1 m^3. These three trees are estimated to be more than 1,000 years old. Fourteen known trees contain over 100 cubic metres of merchantable timber. More could remain unbeknown in Warawara Forest—a forest sufficiently remote and in such wild country that, for the most part, it is unexplored.

Kauri is neither a primary colonising species nor a climax forest tree. It occupies Stages Four and Five in a Six-Stage order of forest succession (Platt, 1987). It is further subject to an order of development: this is the relationship kauri has with other trees of its own species, which draws them up into the magnificent straight trees they are capable of growing into. Kauri is dictated in every aspect of its growth and development by these two natural orders within the forest structure.

We now know that each of the tree's complex needs must be met before successful forest growth and development is possible. The needs of kauri are:

- Good genetic stock
- Adequate light
- Adequate nutrition
- Correct temperatures
- Correct water availability
- Correct spacing
- Correct thinning during growth of the forest

We believe all the needs of *Agathis australis* have now been identified, allowing us to proceed with trials to ensure that each of these needs is met.

HELICOPTER COLLECTION

Collecting seed and scion wood off giant and remote trees has been so daunting as to be beyond consideration. The simple fact is that if you can climb up a kauri tree, the tree is often inferior as to not warrant further consideration. The idea of using a helicopter to aid in seed and scion wood collection was conceived and debated. Jenny Aitken-Christie, John de Ridder of Marine Helicopters, Keith his assistant, and Graeme Platt commenced a programme to develop the concept of picking kauri material from a helicopter. Flying a Bell Jet Ranger, we visited various forests for collection of material. Suspended in a harness on a long strop under the machine, Graeme was flown to the crowns of many trees, where he was to collect both scion wood and immature cones for propagation by grafting and micropropagation.

As the pilot was unable to see the collector under the machine, a system of hand signals was employed, so that the observer could pass on instructions to the pilot. The concept of using a radio for this work was rejected, on the grounds that the collector was unable to see the helicopter and did not know which way it was facing. Good team work allowed for the pilot to place the collector anywhere within the crown of the tree.

These flights were probably the most important breakthroughs in this project. It established for the first time that quality scion wood and seed could be collected off mature kauri trees, regardless of height or remoteness of location. As a result of these flights, scion wood grafted from several selected mature trees has successfully taken, proving that gene stock can be successfully brought into cultivation from the most elite trees of a thousand years old or more.

TRADITIONAL PROPAGATION

Kauri is traditionally grown from fresh seed, which must be planted out within three months of picking. Poor germination or no germination will result from seed that is old. Seedlings will reach 0.75 to 1.2 m in 3 years. To facilitate calculations on kauri growth and performance, we have given all kauris a birthday on March 1st. This date was arrived at because seed is ripe in the last week of February and the first week of March, and as it must be sown fresh that date is very relevant in the life of kauri. Furthermore, most growth for the year will have been completed by March 1st—therefore any measurements will not change until the following

September. This arrangement has proved to be very satisfactory. The fastest proven growth rate for kauri is 2.9 m in 3 years, from a young tree growing at Driving Creek, Coromandel; and the slowest is 1 m in 30 years for a tree in Tairua.

Grafting a kauri from ancient trees has proved to be a rather frustrating operation. It is fair to say that all the collections have been done at the most unsatisfactory time of the year, and that grafting should be carried out during early to mid-September as reported earlier (Thulin, 1957). However, flights into the forest have always been organised during the spring (November) and the first week of March, to collect both seed and scion wood for the laboratory. Therefore, to date grafting has only been done as a secondary operation.

Successful grafting of giant trees is a major breakthrough in conservation. It means that our superior gene stock can now be brought into cultivation and preserved in perpetuity in gene banks and seed orchards. It is known that *A. australis* can be cutting propagated from young trees, and it is eventually hoped that grafted scions will provide quality material for cutting production.

MICROPROPAGATION

Micropropagation and somatic embryogenesis methods are currently being developed using a variety of selected juvenile and mature explants by Keiko Gough, Helen Davies, Lyn Holland, Susan van der Maas, and Jenny Aitken-Christie of the New Zealand Forest Research Institute.

Micropropagation of Selected Juvenile Trees. Seven 3-year-old kauri trees were selected on the basis of form, growth rate, leaf shape and size, and apical dominance from thousands of seedlings. For the micropropagation of these juvenile select trees a reliable method for sterilisation of shoots has been developed. Preliminary success with shoot growth and multiplication has been obtained but it is by no means optimal. There are currently more than 600 shoots from seven clones, either in culture or in soil, and rooting experiments are underway. Some plantlets have been produced and are growing in the glasshouse. Methods need to be optimised further to increase multiplication rates and to obtain reliable rooting. Growing-on plantlets for field and clonal testing will take several years. New selections will be incorporated into the programme to increase the number of clones when they become available. Similar results have been obtained in the micropropagation of other Araucariaceae species (Burrows et al., 1988; Sehgal et al., 1991).

Micropropagation of Selected Mature Trees. Mature kauri shoots were collected by helicopter, as described, or by using long-reach pruning shears and subsequently placed into culture. The overall success rate was less than 10%. Contamination, poor nutritional status, and age of the material were the main reasons for losses. Despite high losses, healthy growing shoot cultures from mature kauri more than 500 years old have been established for some collected clones.

Shoots from grafted mature select trees have recently provided better material for micropropagation. Grafted kauris were placed in the glasshouse, where fertiliser, fungicide, and insecticide were applied. New shoots were collected, sterilised, and placed into culture. Approximately 80% of these shoots survived and grew on. The growth of mature shoots in culture is much slower than juvenile shoots. No shoots have been rooted yet.

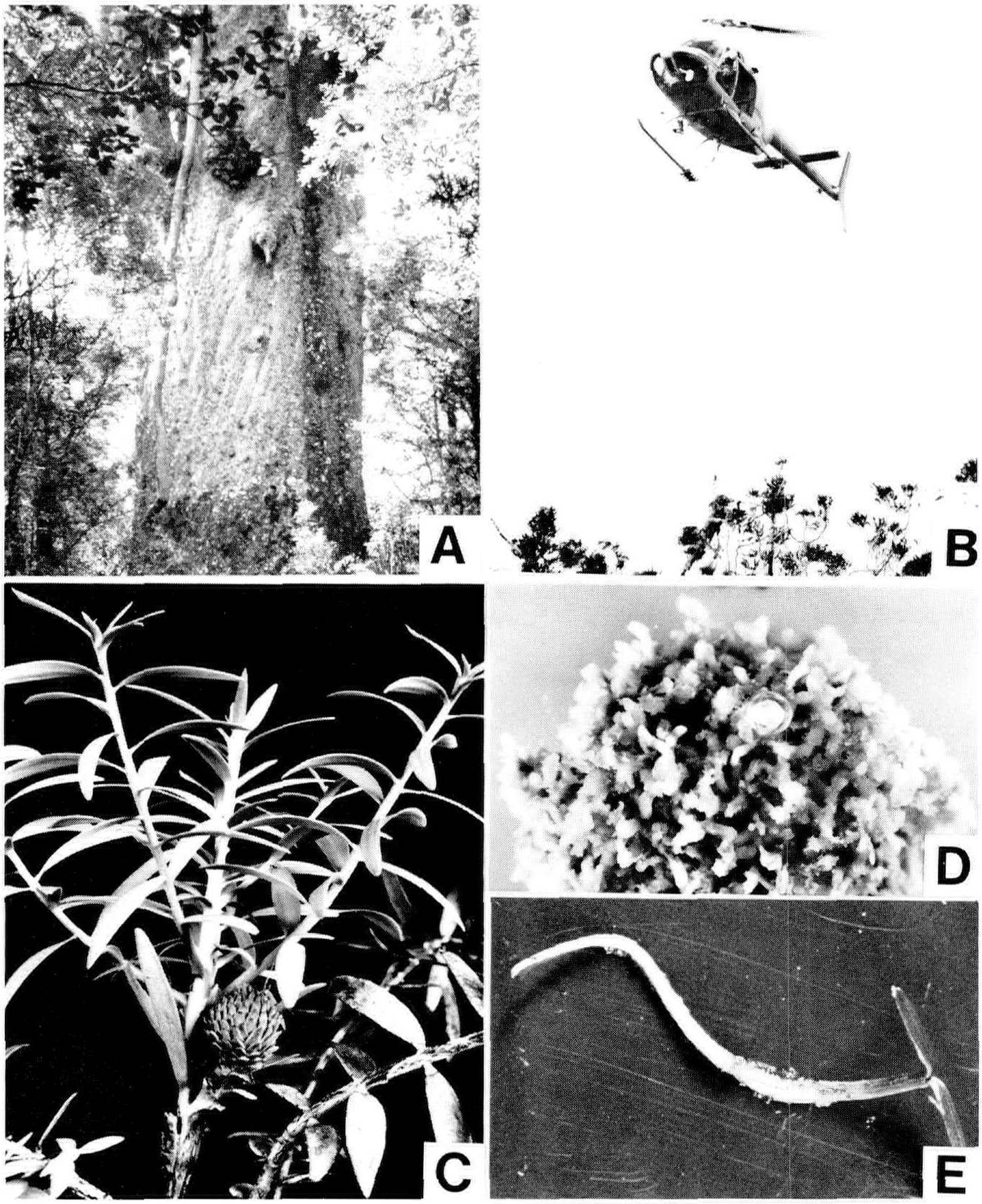

Figure 1. Collection and propagation of *Agathis australis* (kauri): (A) Giant kauri tree more than 1,000 years old; (B) Collection of material from upper crown of tree by helicopter; (C) Grafted kauri plant approximately 1 year after grafting; (D) Embryogenic tissue formed in culture from immature kauri seed; (E) Somatic embryo with well developed cotyledons and root.

Embryogenesis. There has been a very high success rate in the initiation and proliferation of embryogenic tissue of kauri using immature seed tissue from 2-year-old cones collected by helicopter. Somatic embryogenesis in conifers was previously described by Jones (1990). There are 631 embryogenic cell lines (clones) in culture and more than 8,000 embryogenic calli. Each callus can produce approximately 10,000 embryos. Over a thousand mature somatic embryos have developed on media containing abscisic acid (ABA) and embryos with well developed cotyledons, hypocotyl, and radicle have been formed. Further work on embryo germination and transfer to soil needs to be done to complete method development. Preliminary experiments have shown that somatic embryos germinated better on sterile gelled medium than in soil. This is the first report of embryogenesis for any species in the *Araucariaceae* family.

Formation of white, translucent embryogenic-like tissue from 1-year-old unfertilised cone tissue from superior mature trees has also been achieved. This is a major breakthrough in conifer tissue culture and could lead to the production of rejuvenated plantlets that would be genetically identical to the parent tree. DNA/ chromosome analysis and microscopic examination of the origin of the tissue will confirm if rejuvenation has occurred. Collections and culturing of cone tissue during 1991 and 1992 have led to the establishment of 550 clonal cell lines. Further research to prove that these cell lines are embryogenic and that mature embryos can be developed from them is necessary.

Anatomical studies on the origin and development of kauri embryogenic tissue and somatic embryos from both 1- and 2-year-old cones compared with natural embryos are also being carried out in collaboration with Professor John Owens and Glenda Catalano of the University of Victoria, Canada, as is a full study on pollination, fertilisation, cone development, and cytoplasmic inheritance.

When sufficient micropropagules have been produced via either organogenesis or embryogenesis, field trials will be conducted along with seedlings of similar genetic origin.

CONCLUSIONS

Our understanding of the requirements for optimal growth of kauri in the forest has advanced during several years of research. New technology using micropropagation techniques is now being developed for propagating superior trees and preliminary results are encouraging. Consequently, a re-evaluation of kauri forestry is underway, with the objective of producing a crop rotation of 50 to 60 years. Conservation of germplasm of one of New Zealand's most valuable native trees is also an objective.

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