

# A CHIP OFF THE OLD BLOCK



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**People have been cloning plants since ancient Roman times, when grafting of fruit trees was developed. In Japan, clonal forestry dates back to the 1400s, when plantations of Japanese cedar were first established from cuttings. Some clones of food and flower crops have been used for 100 years. Golden Delicious apples, Cavendish bananas, Delaware potatoes and rose cultivars are common clonal plants. Now cloning technology is being used to dramatically improve wood production in tree plantations.**

As the world's population grows, the increasing demands for timber and paper pulp cannot be met by sustainable harvesting from native forests, so there is an increasing need to establish new ones. Throughout the world, fast-growing Australian eucalypts such as Tasmanian bluegum have already been established in large plantations. There are 7 million hectares of eucalypt plantations world wide, with 50 000 hectares in Australia. At present, Australian plantations mainly depend on seed collected from native forests, and the best quality seed is in short supply. Seed production in eucalypts peaks every few years and heavy seed production delays the next peak.

To maximise timber production in the plantation, tree breeders need to undertake several cycles of selection to produce the best trees for each area (*LANDSCOPE*, Autumn 1990). Seed is collected from the most promising parent trees from a range of regions where the species occurs naturally, and is planted in trial plots. After several years of growth the best trees from the best seed sources are identified. If shoots from these trees can be grafted or rooted as cuttings, they can be planted in "orchards" where natural intercrossing between superior trees or careful hand pollination will yield a supply of top pedigree seed.

This is a long process; several years elapse before trees flower, and growth rates and wood quality cannot be accurately assessed until trees of each new generation are 7-10 years old.

**Shoot cultures of *Eucalyptus globulus* and trays of micropropagated *E. globulus* cloned from a Western Australian plantation. These plants have been hardened off under mist and are now growing under glasshouse conditions.◄**

**A cutting of a superior tree of *E. globulus* growing under glasshouse conditions to stimulate clean, healthy shoots suitable for tissue culture.▼**

## CLONAL FORESTRY

Considerable gains can be made if, instead of using seed from natural stands or from selected trees in trial plots, clones of the superior plants are grown.

The advantages of clonal forestry are illustrated on page 52, which shows how the growth of trees in a hypothetical plantation resulted in trees with different heights. If the tallest two per cent of trees are selected and intercrossed, we will get a population of trees with a greatly increased average size, and a reduced, but still wide distribution of sizes around that average. Taking the best trees and cloning them gives an even greater increase in average size, and there is less variation around the average.

Selective breeding and selective cloning must be used hand-in-hand: while cloning gives greater gain in the short term, in the long term selective breeding will produce plants superior to those used for the initial cloning. Cloning at various stages of a breeding program will provide maximum gain as early as possible, while cross-breeding will improve lines further.

Clonal forestry has significant advantages over the use of seedlings. Only superior trees are used, so plants can be spaced further apart and need less thinning. Uniform growth and known wood quality makes harvesting and processing easier. Major cost savings can be made if high growth rate results in a shorter rotation time; for example if trees can be harvested after 10 years rather than 15. For species such as bluegum, pulp quality, or pulp yield, is even more important as, due to processing costs, a small improvement in pulp quality is of more value than a similar increase in volume of lower quality pulp.

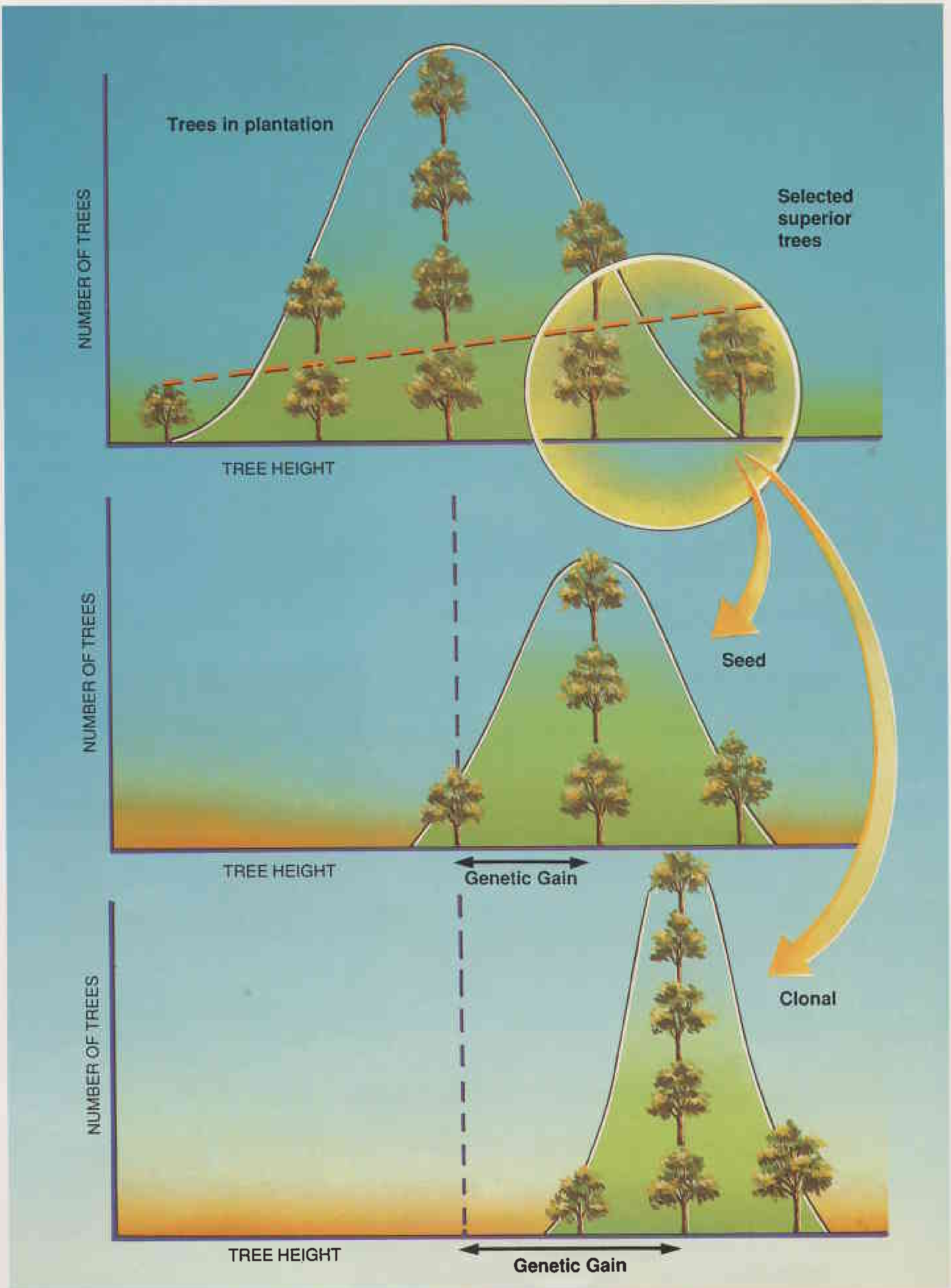
When cloning trees for plantations, care must be taken to have a range of parent trees in the population, not just one or two superior ones. Without this genetic diversity there is a danger that a new pest or disease, or a mutant of an existing one, might damage much of the crop before harvest.

Cloning employs the fact that trees pass through a distinct juvenile phase - seen as an abrupt change in leaf shape and colour in bluegums. In animals, body cells grow continuously and age uniformly, but in plants only the tips of the shoots and roots grow. At the base of each leaf, each shoot has a reservoir of small shoot buds which grow if the main shoot is damaged. The buds that form when the plant is a seedling or a sapling will, if they grow, produce juvenile shoots. Even if a tree is over 100 years old, juvenile shoots will sprout from the base of its trunk if the crown is damaged by fire, or from the cut stump if it is felled.

Juvenile shoots can form roots as cuttings, but cuttings from mature shoots will not root. So the first stage in cloning is to induce sprouting of the juvenile buds at the base of a tree. This can be done by felling the tree or, if the crown is needed for collecting seed, by wounding its base.

## TISSUE CULTURE

Micropropagation, or plant tissue culture, has made it possible to produce large numbers of clones from selected trees. Tissue culture is done in a nutrient medium in which bacteria and fungi can grow prolifically, so plant tissue must be surface sterilised before it is placed in


Trees in plantation
Selected superior trees
NUMBER OF TREES
TREE HEIGHT
Seed
NUMBER OF TREES
TREE HEIGHT
Genetic Gain
Clonal
NUMBER OF TREES
TREE HEIGHT
Genetic Gain

Plants must be transferred to fresh medium every four weeks. This is carried out in a clean-air station.▸

Racks of tissue-cultured plants at a commercial laboratory.▾

culture. If possible, shoots are grafted or rooted as cuttings so that they may be kept under glasshouse conditions where fungi and insects can be controlled.

After they are sterilised, small pieces of stem are placed in culture, and the buds induced to grow by adjusting the supply of nutrients and plant growth regulators in the medium. In established cultures, the number of shoots that can be generated exceeds the growth achieved by using conventional cuttings and, unlike cuttings, the supply of shoots does not depend on the season. The cultured shoots are eventually used as 'microcuttings', and roots are induced on them by a medium containing the plant growth regulator auxin. Finally, the cultured plantlets are transferred to soil and acclimatised to normal levels of humidity and light.

Researchers at Murdoch University have been cloning bluegums for about four years. Material from superior trees has been made available from leading pulp producers in Tasmania and WA. The research is part of a program, funded by the federal Government and industry, on forest tree biotechnology involving both salt-tolerant and pulpwood species. It includes input from the University of Western Australia, CSIRO Division of Forestry and Forest Products, Plantex, and Alcoa.

## FIELD TRIALS

Field trials using clonal trees are an essential part of the program. They will answer questions about:

- The quality of the initial 'superior' tree. Was its superiority inherited, or due to chance, such as a favourable spot in the plantation? How will it perform when surrounded by other superior clones?
- The root development of clonal trees. Does the shape of the root system differ from that of seedlings, and do clonal trees have enough anchorage to resist toppling in strong winds?
- The wood quality. How much does wood quality vary when the same clone is grown in different environments? How much careful selection will be necessary to adjust clonal types to different sites?

## NEW TECHNIQUES

Biotechnology opens other possible ways to improve the quality of forest trees. Developing these processes is costly, so it is not surprising that they have first been applied to agricultural crops such as wheat, maize and vegetables which mature quickly. However, it is now appropriate to apply these techniques to forest species. For example, DNA fingerprinting will help to identify clones, and show how plants in breeding programs are genetically related. DNA is the main constituent of the chromosomes of most organisms and is responsible for the transmission of hereditary characteristics from parents to offspring. The recent invention of a DNA gun which shoots minute pellets coated with DNA deep into cells offers a way of manipulating genetic material in woody species.

The development of these techniques will allow scientists to incorporate genes from eucalypt species that can tolerate environmental extremes into high-yielding timber trees. It may also be possible to incorporate genes from unrelated organisms, such as bacteria, that can break down herbicides or produce toxins to prevent insect damage to leaves.

Technology is also being developed to 'switch off' undesirable genes. These may include genes that increase the cost of pulping by affecting the chemical properties of the wood, or genes that regulate the plant's normal reproductive processes through production of pollen, ovules and eventually seeds. Some research aims to produce sterile eucalypts through polyploidy (altering the number of sets of chromosomes), which may offer a technique to prevent foreign genes from genetically-engineered plants flowing into adjacent native forests.

Eucalypts have already made a significant worldwide contribution to forestry. In Australia we must continue to develop new eucalypt forests if we are to meet the demand for timber and paper pulp. Biotechnology will help to maximise timber production in the plantations.◘

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# LANDSCOPE

VOLUME FIVE No. 4 - WINTER EDITION 1990

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*A very different landscape replaces what was once a thriving timber industry. Rediscover Cannington in the 1850s. See page 42.*

*Seaweed! Delicate and beautiful, or slimy and smelly? Decide for yourself on page 20.*

*How do birds fly? How do some reach speeds of over 80 kilometres per hour? Learn about avian aerodynamics on page 28.*

*Western Australia grows some rare and stunning native spider orchids. Their alluring nature will delight the reader on page 34.*

## FEATURES



## REGULARS



## COVER

*Back in the early 1970s, Western Australia proclaimed the numbat (Myrmecobius fasciatus) as its State emblem which may have saved its life. With the help of scientists and new techniques, these delightful creatures are now fighting back against extinction. See page 15.*

*Illustrated by Martin Thompson.*

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