the model is the starting point. Superior data based on local knowledge plays an important role in improving the accuracy of model applications.

From any one run of the model up to 40 reports can be produced. These include reports on market share, trade and investment, consumption and demand, income and employment multipliers, value added multipliers, and a variety of impact reports.

IMPLAN uses input-output transaction tables which show the interdependence of all industry categories in terms of how much every industry buys from and sells to every other industry. Because the NZ version of IMPLAN is being regionalised it will be of particular value for analysing changes in the forestry sector. This is because regions such as the Bay of Plenty, which have a strongly integrated forestry based economy, can be used as a basis for estimating the development requirements of the "new" forestry regions. For example, firms not yet present in Northland or Otago can use IMPLAN to assist them in identifying opportunities in these regions once the wood supply increases.

The modification programme is being developed by Dr Patrick Aldwell at FRI and Dr Jeff Weber of the Agricultural Economics and Business Department at Massey University. IMPLAN's value is that it will greatly reduce the time needed to conduct impact analyses and it will facilitate responses to "what if" questions associated with industrial activity.

Advances in forest biotechnology – an update

Colin O'Loughlin,[1] Peter Carter[2] and Michael Menzies[3]

Modern biotechnology research is increasingly opening doors of understanding to a vast array of complex biological problems. The application of new technologies such as micropropagation, cryogenic storage, protoplast fusion, gene mapping and establishment of gene libraries, gene transfer and DNA manipulation, are unfolding opportunities to understand the genetic structure of forest trees and populations, identify the key factors in responses of forest trees to environmental stress and define linkages between genetic markers and important traits allowing accelerated selection and breeding. Furthermore, these technologies make possible the use of genetic material not currently in the natural breeding population of forest species, including genetic material from other plants, bacteria, viruses and animals, to confer increased resistance to diseases, pests and toxic chemicals as well as the ability to detoxify pollutants and respond to environmental stresses.

Recent visits to a range of Canadian and USA biotechnology laboratories and one private biotechnology company (Promega) provided an improved appreciation of the range of opportunities that biotechnology offers, particularly for application to conifers such as radiata pine in New Zealand. It also provided information about where biotechnology could play a role in the future development of the wood processing industry.

Based on what was learnt during these visits to biotechnology laboratories and knowledge of forest biotechnology progress in New Zealand, the following conclusions are drawn about the potential opportunities that biotechnology developments provide, especially for New Zealand's forest industry.

1. Molecular biology programmes involving gene mapping and genetic engineering are now important forestry research programmes in Canada and USA. However, this work is very costly, requires highly skilled biologists, biochemists and other technical people, is usually long-term and is high risk from the viewpoint of providing early applicable results. Nevertheless, there have been a number of successes.
2. To be successful, a molecular biology research programme must be integrated with a sound forest genetics programme. In this respect New Zealand's long-established radiata pine forest genetics programme at the Forest Research Institute (FRI) provides a sound basis for a radiata pine molecular biology programme.
3. The requirements for forest genetic engineering are:
   - a micropropagation system to regenerate plants
   - a gene(s) of interest
   - a gene transfer system, e.g. using bacteria, microinjection or ballistic gun or other techniques
   - gene control mechanisms or promoters.

   Many laboratories are only working on one or two of these aspects. Gene transfer technology is developing rapidly. For conifers, it appears that ballistic guns or other bombardment techniques which transfer DNA material into target tissues or individual cells of meristematic tissue, embryonic tissue or cotyledons, offer the greatest promise for engineering transgenic or transformed plant material. Generally, the lack of effective micropropagation methods has restricted work with conifers but it is in this area that New Zealand is strong. However, the most significant obstacle to advancing the application of molecular biology/genetic engineering in forestry is the lack of understanding about the basis of gene expression. Gene mapping and the isolation of genes controlling selected traits is complex and expensive.
4. In forest genetic engineering research the most economically useful developments to date involve genes that impart increased resistance to herbicides and insect damage. Over the next decade we expect that most progress in molecular biology studies with radiata pine will be made in increasing herbicide tolerance and raising resistance to *Dothistroma pini*. A joint DSIR-FRI molecular biology programme aimed at increasing radiata pine resistance to *Dothistroma pini* has already been initiated. Increasing wood production in radiata pine through gene manipulation is probably many years away but is certainly not beyond the realms of possibility within the next two decades. Male sterility is another useful target, both for increasing productivity and also preventing pollen flow from genetically modified trees.
5. The application of biotechnology in the wood processing industry holds great potential. For instance, in the USA biotechnology research is expected to provide a cost-effective treatment process for effluents from kraft-process pulp mills using fungal pellets, a treatment for reducing levels of pentachlorophenol in landfills using woodchips inoculated with bio-organisms, a bio-pulping technique based on lignin-degrading fungi and an improved pulp bleaching process using bio-organisms. The application of such developments in New Zealand is probably several years away.
6. One of the problems hindering the commercial development and use of genetically-engineered forest and agricultural plants in the USA and Canada is the lack of comprehensive rules or legislation for marketing and testing genetically modified organisms. This has led to limited testing of genetically-altered plants outside

(Continued on page 28)

1. Ministry of Forestry, Wellington.
2. NZFP Forests Ltd, Tokoroa.
3. Forest Research Institute, Rotorua.