Rainforest more or less?

Steve Davidson considers how tropical forests might shape up in a warmer world.

How do scientists predict the effects of future climate change on ecosystems as complex as tropical forests? After all, each species in the forest might respond to climate change differently. But the exceptionally rich biodiversity of these forests makes it impossible to take a species-centred approach.

To tackle this conundrum, scientists at the CSIRO Tropical Forest Research Centre and Cooperative Research Centre for Tropical Rainforest Ecology and Management have turned to a class of computer models designed to mimic the human brain. These models, known as artificial neural networks, have proved useful in environmental and other sciences (see story on page 33).

Dr David Hilbert, Dr Bertram Ostendorf and Dr Mike Hopkins have investigated the effects of climate change on tropical forests by developing a model named FANN (Forest Artificial Neural Network) that uses a classification system based on existing information about environmental conditions and how they are linked to forest-structure type.

'The model has the capacity to learn the relationships between environmental conditions and the pattern of forests,' Hilbert says.

Hilbert and his colleagues focused on a strip of north-eastern Queensland between Cooktown and Townsville that supports forest types ranging from dry, open woodlands to humid lowland rainforests. Their aim was to predict how the distribution of the forest types would be affected by climate changes expected in the next 50–100 years.

The 'brainy' model calculated how environmental conditions – climate, geology and terrain – would change under 10 scenarios of future climate, and predicted the resulting distribution of 15 forest types. The scenarios incorporated a warming of up to 1°C, combined with changes in rainfall ranging from a 10% drop to a 20% rise (1°C is the extent of warming conservatively predicted to occur in the region before the middle of the century; rainfall change is less predictable).

Ecological ramifications

'Overall, the analysis suggests that the tropical forests of north Queensland are extremely sensitive to the small amounts of climate change likely to occur in the near future,' Hilbert says.

'The areas and distribution pattern of all 15 forest types will eventually change under the climates likely to be experienced. Some forests will expand their ranges, but, on average, it looks as if forests will experience less suitable climates.'

The model predicts that some rainforest types would be favoured by increased rainfall, but that decreased rainfall would favour forests dominated by eucalypts and similar sclerophyllous (hard-leaved) groups. For example, a 10% decrease in rainfall would reduce the total areas suitable for rainforest from 56% to 44%.

While most rainforest environments are relatively immune to a slight rise in temperature, highland rainforest was predicted to shrink by 50% with a mere 1°C of warming, even if rainfall remained the same.

This is bad news for many of the region's vertebrates. The area supports 566 species of land vertebrates, 12% of which occur nowhere else. Most tree-dwelling possums and most of the region's endemic vertebrates occur in the highlands or wet uplands, both of which are likely to recede as temperatures rise. Cloud forests are thought to be especially sensitive to global warming because the cloud base is expected to increase in altitude, reducing mist. Vertebrate animals in high elevation forests could be at significant risk.

High vertebrate biodiversity occurs in the tall open forest found between woodlands and rainforest, a vegetation type already declining for other reasons, including less frequent fires. Animals here face the prospect of further habitat loss if warming or increased rainfall eventuates.

The region also supports many primitive flowering plants and has the most diverse bird fauna in Australia.

Shifting boundaries

The sensitivity of forest ecosystems to rapid but quite minor alterations in climate, suggested by FANN, means that most forest types will experience climates that are more appropriate to some other type of forest, putting them under some degree of stress.

The researchers believe that the more immediate consequence will be change in the ecology of the forests, while actual shifts in the distribution of forest types across the landscape will take longer due to inertia. It will take time for vegetation to track environmental change.

The model indicates that most of the change in the distribution of forests across the landscape is likely to occur at the boundaries between forest types and in the transitional area between rainforest and open woodland.

This shift in forest boundaries may initially prove imperceptible to a casual observer, but it is inevitable that the distribution of various kinds of forest will gradually adjust to reflect changes in temperature and rainfall regimes. As the mosaic of tropical environments alters, so surely will the pattern of forests.

Hilbert and his colleagues say that because their modelling identifies the forest types and locations likely to be most affected by climate change, it provides information helpful to conservationists and land managers.

It should guide the formulation of strategies to cope with ecological changes wrought by rapid modifications in climate of the kind predicted to occur in the not-so-distant future.

The most recent consensus among climate modellers predicts much greater warming in this century than the previous estimates. A worse case scenario for north-eastern Queensland is a warming of more than 4.5°C by 2100. So warming, even in the tropics, may be much greater than the 1°C warming used in this research.

More about tropical forests

Hilbert DW Ostendorf B and Hopkins MS (2001) Sensitivity of tropical forests to climate change in the humid tropics of north Queensland. *Austral Ecology*, 26: 590–603.

Multi-talented **models**

ARTIFICIAL neural networks were developed in 1958 to model the working of connected nerve cells (neurones) in the brain. The original version was known as The Perceptron.

The general usefulness of this type of model was recognised in the 1970s with the development of a mathematical improvement called backpropagation which allows the model to be ‘trained’ to associate inputs and outputs. Basically, this involves running the model repeatedly until statistical error between the model and a set of known outputs is minimised. It is then ready to tackle more difficult problems where the answers aren’t known!

There are now many types of artificial neural networks and they are remarkably versatile. They have been successfully applied in many fields including prediction of financial markets, speech recognition and synthesis, handwriting recognition and medical diagnosis.

In the environmental sciences, they have been used widely on projects as diverse as classifying satellite imagery, weather forecasting, aspects of weed invasion, forecasting fish stocks, and predicting the occurrence of wildfire.

FANN, the model used to compute the sensitivity of Queensland’s tropical forests to climate change, was developed in the late 1990s by Dr David Hilbert and Jeroen van den Muyzenberg. It recently helped to delineate the distribution of tall open forests in the humid tropics, as they were 18 000 years ago.