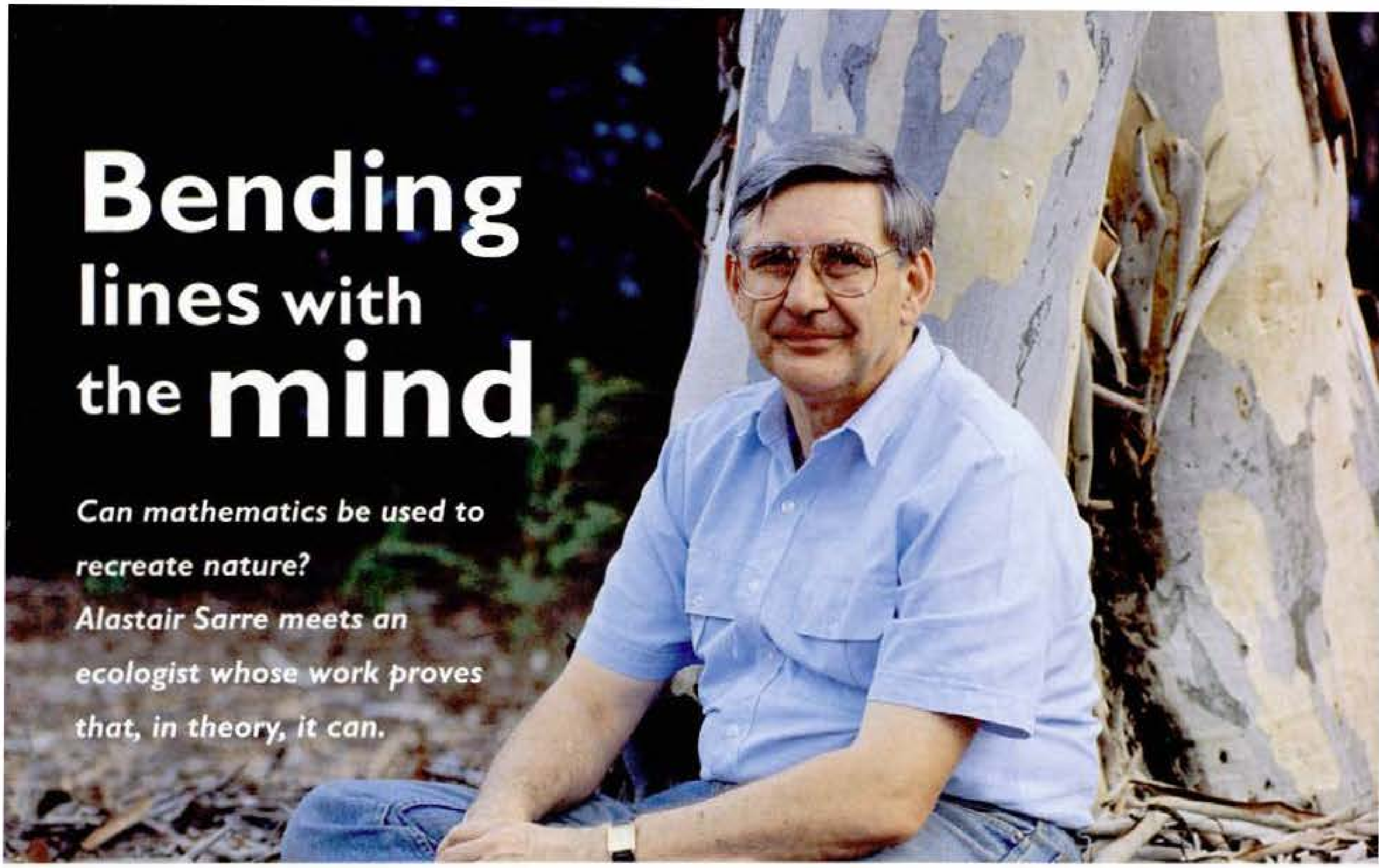
Bending lines with the mind

Can mathematics be used to recreate nature? Alastair Sarre meets an ecologist whose work proves that, in theory, it can.



Mike Austin: no 'armchair' ecologist.

Mike Austin is a thinker. He's a cruncher of numbers, a bender of lines and a fitter of curves. He's one of those most enigmatic of creatures, a theoretical ecologist, and he's spent much of his career preoccupied with the intricacies of statistical modelling and concepts such as niche, continuum and skewness.

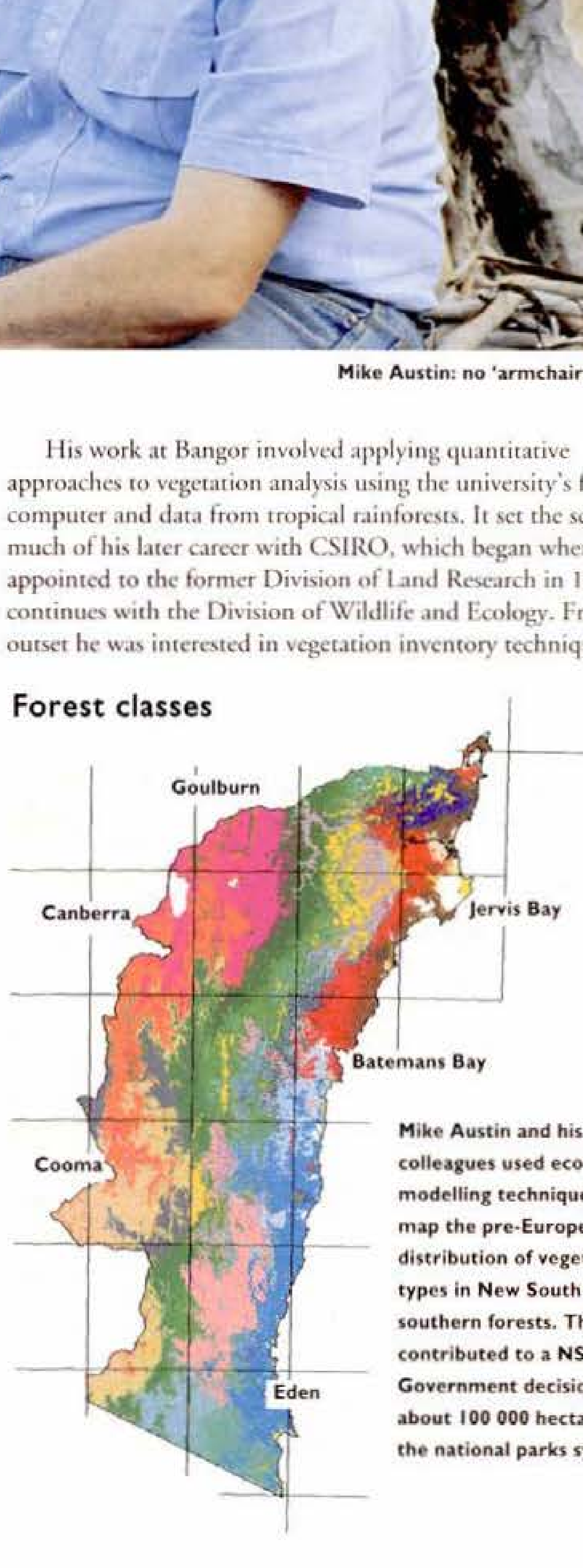
But he also has the botanist's trademark: dirty knees, from endlessly kneeling in bush dirt identifying seedlings, grasses and mosses that most of us would trample without thought. According to Austin, that's the role of any self-respecting ecologist, theoretical or otherwise. 'Many armchair ecologists work with data in the office, but you also need to get out and see what the problems are in the real world,' he says.

In fact, Austin's fieldwork ethic is legendary among his colleagues. One particularly cold day in the forests of south-east New South Wales, Austin was working an annual vegetation survey of about 180 small plots as part of an experiment on forest fragmentation. It's painstaking work at the best of times, but on this rainy day the temperature was near freezing. For some, a late-afternoon hailstorm that covered the ground in ice might have spelled the end of the day, but for Austin, the thought of a cup of hot cocoa back at the fieldstation held no temptation. He and his colleague, Nick Nicholls, merely swept the hail from the plots with their hands and carried on. That's dedication.

Austin's career began with a degree at the University of London and continued with a part-time PhD in a department specialising in mycology (the study of fungi). Then he got what he calls his 'lucky break': a post-doctoral position in the Department of Botany at the University of North Wales at Bangor. It was there that he had his first real opportunity to mix with ecologists on a daily basis, and he was fascinated by what was then an emerging science.

His work at Bangor involved applying quantitative approaches to vegetation analysis using the university's first computer and data from tropical rainforests. It set the scene for much of his later career with CSIRO, which began when he was appointed to the former Division of Land Research in 1967 and continues with the Division of Wildlife and Ecology. From the outset he was interested in vegetation inventory techniques and

Forest classes



Mike Austin and his colleagues used ecological modelling techniques to map the pre-European distribution of vegetation types in New South Wales' southern forests. The map contributed to a NSW Government decision to add about 100 000 hectares to the national parks system.

the use of natural resource information in regional planning, but always with an eye to what such work says about theory, and vice-versa: 'There is a constant tension in my research between trying to make practical use of information and making sure that the ecological theory supports that use,' he says.

Entering the forest debate

The way Austin has combined theory and practice is illustrated by his work in the south-east forests of NSW, forests subject to three decades of dispute between conservationists and the timber industry. These are also among the most studied forests in Australia, although much of the research has been *ad hoc*.

'People do surveys, use the results for a single purpose, and then forget about it,' Austin says. But such data could be extremely useful at a regional level if someone was willing to put it all together. This is what Austin and colleagues Nick Nicholls, Jacqui Meyers, Margaret Cawsey, Nicholas Coops and others have done, amassing a dataset containing information on canopy tree species from more than 10 000 sample plots.

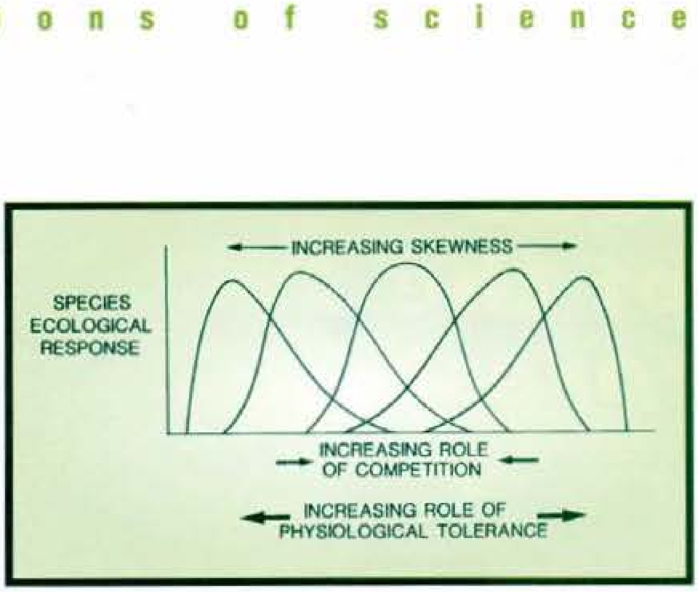
When drawn together in this way, the data can underpin forest management planning. For example, one approach to solving disputes over forest use in the south-east NSW region involves locating habitats not adequately represented in the reserve system. In fact, the recently stated aim of government is to ensure that at least 15% of habitats existing before European settlement should be represented in conservation reserves. Achieving this aim requires a knowledge of habitats existing both before colonisation, and those existing now.

But even a dataset of 10 000 sample plots covers only a minute fraction of the region's forests. And it doesn't show the vegetation history of land now in agricultural or urban use. What Austin and his colleagues had to do was extrapolate from their sample data to predict the vegetation types that occur (or once occurred) in unsampled areas.

To do this they needed a model. In ecology, models generally consist of mathematical formulae that describe the interactions between environmental measures (such as temperature) and species. At their most simple, such interactions could be linear: as temperature increases, the occurrence of a species would also increase (or decrease) at the same rate. But nature is rarely that simple.

The south-east forests model developed by Austin and his colleagues is based on a statistical technique called regression. It relates the presence or absence of 96 eucalypt species to such environmental attributes as lithology, rainfall, temperature and position in the landscape. The resultant mathematical expressions of these relationships can then be combined with a geographic information system to predict the distribution of species over the entire region.

A map showing the pre-European distribution of vegetation types was produced in this way and used during the interim regional forest agreement process. It contributed to the decision by the NSW Government to add about 100 000 hectares to the existing national parks system in the south-east forests region, with another 30 000 ha still to be assessed.



Traditional niche theory suggests that the response of a species to environmental factors can be characterised by a bell-shaped curve (centre). Mike Austin hypothesised that a species' ecological response actually becomes skewed as competition between species increases. This hypothesis has been supported by analysis of the NSW south coast tree database. (Figure courtesy Academic Press).

But how good is the map, and why not just draw one using educated guesses? 'It's not as good as we'd like it to be,' Austin says, 'but it covers the whole area and gives a consistent treatment to it. That's the advantage over subjective approaches: it's explicit, consistent and repeatable. That doesn't mean it's accurate, but you can apply estimates of the confidence that you have in each classification.'

Austin's legacy

Additions to the national parks system are a tangible outcome of Austin's labours, but he has made other significant contributions to the science of ecology. This was recognised in 1995 when he was awarded a Gold Medal for services to ecology and society by the Ecological Society of Australia. Austin himself considers some of his most important work has been to advance niche theory using the south-east forests database.

Niche theory suggests that each species has a distinct niche – or space in the environment – that is related to environmental variables such as soil, rainfall and temperature. Traditionally, species' distributions have been said to peak where such variables are at their most favourable for the particular species and then taper evenly in both directions along environmental gradients as conditions become less suitable. This can be depicted on a graph as a bell-shaped curve.

But Austin's work has brought this traditional view into question. He found that the 'niche curves' of eucalypt species in the south-east are skewed along a temperature gradient, with the long tails of the skews heading in predictable directions. This pattern has not yet been seen in other datasets, but Austin says it suggests regularities in the packing of species along environmental gradients which are more complicated than suggested by original niche theory.

No doubt the debate over lines and curves in ecology will continue for many years. But the work of Mike Austin – and, he is quick to point out, his colleagues – continues to make important contributions. I think we can draw a line under that.