2 Why do I need a model?

2.1 Reason for use of models

Some of the reasons for using models in scientific research have already been mentioned in the last chapter. The need for simple ways of expressing the relationships between basic entities in the search for a solution to a problem encourages us to use a language capable of making abstractions from the complexity of the world we are trying to understand. Many of these problems are too complex to be solved by commonsense rules of thumb or by intuition, and the use of words by themselves is not usually a satisfactory way of describing relationships. We use models because they reduce ambiguity and because they describe complexity with the maximum parsimony.

Ecological research has a particular need for the use of models because of its concern with the many-sided interactions of a wide variety of organisms. Nearly all of these interactions are dynamic, in the sense that they vary with time and are constantly changing. Furthermore, these interactions frequently possess the characteristics of ‘feedback’, i.e. the carrying back of some of the effects of a process to their source or to a preceding stage so as to strengthen or modify them. This feedback may be positive, in the sense that the effect is increased, or negative in the sense that the effect is decreased. Feedback may itself be complex, involving a series of positive and negative effects, with various results depending on other environmental factors.

The complexity of ecological relationships is not, however, confined to the presence of multiple interactions in the relationships between organisms. Living organisms are themselves variable – indeed, variability is one of their essential attributes. This variability may be expressed in terms of effects on other organisms, for example by competition or by predation, or it may be expressed in the response of the organisms, either collectively or singly, to environmental conditions. Such response will be reflected in variable rates of growth, and reproduction, or even in variable ability to exist under markedly adverse conditions. When this characteristic is added to independent variations in environmental factors such as climate and habitat, ecological processes become difficult to investigate and control.

As a result, the understanding of even relatively unmodified ecological systems is far from easy. The traditional response of the ecologists to the difficulty has been to focus attention on small subsets of a larger problem. Much research has been concentrated on the behaviour of single organisms in simplified habitats, for example on beetles in bags of
flour, or enchytraeid worms on selected media. Alternatively, the competition between two or three species, again in relatively simple habitats, has been studied extensively. In all of these examples, an attempt is made to reduce the level of the complexity studied to a level which is manageable by traditional methods of investigation, by eliminating many of the possible sources of variability. Even when this has been done, however, the inter-relationships remain difficult to understand.

When the effects of deliberate modification of ecological systems are included in the ecological research, a further dimension of variability and interaction is introduced. Both forestry and agriculture are examples of applied ecology, in which some simplification of the ecological system is usually achieved by considering the response of the crop species alone, but such research provides very little information on the response of the system as a whole to modifications introduced by changes in management. In particular, the effects of the crop species on the soil, and on species or organisms associated with the ecosystem on which the crop has been imposed, are seldom studied, mainly because of the difficulty of designing experiments which are capable of testing hypotheses with the necessary degree of complexity. The extension of these ideas to the ecological effects of land use, where several alternative strategies for land use and environmental management are considered, is even more difficult.

For all the above reasons, i.e. the inherent complexity of ecological relationships, the characteristic variability of living organisms, and the apparently unpredictable effects of deliberate modification of ecological systems by man, the ecologist requires an orderly and logical representation of the underlying relationships. There is, however, a further reason for the use of models in ecological research. By its very nature, such research frequently requires long time-scales, measured in years rather than in weeks. It is, therefore, necessary to ensure the greatest possible advance from each stage of experimentation, and models of systems in ecology provide a useful framework for the integration and testing of the compatibility of information which is collected about the system under investigation. Especially where much of the research is undertaken by different groups of people, and in different locations, this integration and testing for compatibility becomes an important task for which the model acts as a means of communication between different research workers. This particular use of models will be discussed further later in this chapter.

A rather similar context of the use of models lies in the use of simulation as a synthesis of available information. Again, this application of models in ecological research will be discussed later in the chapter.

2.2 Complexity
As one of the reasons for using models to describe ecological relation-