Capítulo Introductorio del libro: ECOLOGY From Individuals to Ecosystems

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Definition and scope of ecology

The word 'ecology' was first used by Ernest Haeckel in 1869. Paraphrasing Haeckel we can describe ecology as the scientific study of the interactions between organisms and their environment. The word is derived from the Greek oikos, meaning 'home'. Ecology might therefore be thought of as the study of the 'home life' of living organisms. A less vague definition was suggested by Krebs (1972): 'Ecology is the scientific study of the interactions that determine the distribution and abundance of organisms'. Notice that Krebs' definition does not use the word 'environment'; to see why, it is necessary to define the word. The environment of an organism consists of all those factors and phenomena outside the organism that influence it, whether these are physical and chemical (abiotic) or other organisms (biotic). The 'interactions' in Krebs' definition are, of course, interactions with these very factors. The environment therefore retains the central position that Haeckel gave it. Krebs' definition has the merit of pinpointing the ultimate subject matter of ecology: the distribution and abundance of organisms – where organisms occur, how many occur there, and why. This being so, it might be better still to define ecology as:

The scientific study of the distribution and abundance of organisms and the interactions that determine distribution and abundance.

As far as the subject matter of ecology is concerned, 'the distribution and abundance of organisms' is pleasantly succinct. But we need to expand it. The living world can be viewed as a biological hierarchy that starts with subcellular particles, and continues up through cells, tissues and organs. Ecology deals with the next three levels: the individual organism, the population (consisting of individuals of the same species) and the community (consisting of a greater or lesser number of species populations). At the level of the organism, ecology deals with how individuals are affected by (and how they affect) their environment. At the level of the population, ecology is concerned with the presence or absence of particular species, their abundance or rarity, and with the trends and fluctuations in their numbers. Community ecology then deals with the composition and organization of ecological communities. Ecologists also focus on the pathways followed by energy and matter as these move among living and nonliving elements of a further category of organization: the ecosystem, comprising the community together with its physical environment. With this in mind, Likens (1992) would extend our preferred definition of ecology to include 'the interactions between organisms and the transformation and flux of energy and matter'. However, we take energy/matter transformations as being subsumed in the 'interactions' of our definition. There are two broad approaches that ecologists can take at each level of ecological organization. First, much can be gained by building from properties at the level below: physiology when studying organismal ecology; individual clutch size and survival probabilities when investigating the dynamics of individual species populations; food consumption rates when dealing with interactions between predator and prey populations; limits to the similarity of coexisting species when researching communities, and so on. An alternative approach deals directly with properties of the level of interest – for example, niche breadth at the organismal level; relative importance of density-dependent processes at the population level; species diversity at the level of community; rate of biomass production at the ecosystem level – and tries to relate these to abiotic or biotic aspects of the environment. Both approaches have their uses, and both will be used in each of the three parts of this book: Organisms; Species Interactions; and Communities and Ecosystems.

Explanation, description, prediction and control

At all levels of ecological organization we can try to do a number of different things. In the first place we can try to explain or understand. This is a search for knowledge in the pure scientific tradition. In order to do this, however, it is necessary first to describe. This, too, adds to our knowledge of the living world. Obviously, in order to understand something, we must first have a description of whatever it is that we wish to understand. Equally, but less obviously, the most valuable descriptions are those carried out with a particular problem or 'need for understanding' in mind. All descriptions are selective: but undirected description, carried out for its own sake, is often found afterwards to have selected the wrong things. Ecologists also often try to predict what will happen to an organism, a population, a community or an ecosystem under a particular set of circumstances: and on the basis of these predictions we try to control the situation. We try to minimize the effects of locust plagues by predicting when they are likely to occur and taking appropriate action. We try to protect crops by predicting when conditions will be favorable to the crop and unfavorable to its enemies. We try to maintain endangered species by predicting the conservation policy that will enable them to persist. We try to conserve biodiversity to maintain ecosystem 'services' such as the protection of chemical quality of natural waters. Some prediction and control can be carried out without explanation or understanding. But confident predictions, precise predictions and predictions of what will happen in unusual circumstances can be made only when we can explain what is going on. Mathematical modeling has played, and will continue to play, a crucial role in the development of ecology, particularly in our ability to predict outcomes. But it is the real world we are interested in, and the worth of models must always be judged in terms of the light they shed on the working of natural systems. It is important to realize that there are two different classes of explanation in biology: proximal and ultimate explanations. For example, the present distribution and abundance of a particular species of bird may be 'explained' in terms of the physical environment that the bird tolerates, the food that it eats and the parasites and predators that attack it. This is a proximal explanation. However, we may also ask how this species of bird comes to have these properties that now appear to govern its life. This question has to be answered by an explanation in evolutionary terms. The ultimate explanation of the present distribution and abundance of this bird lies in the ecological experiences of its ancestors. There are many problems in ecology that demand evolutionary, ultimate explanations: 'How have organisms come to possess particular combinations of size, developmental rate, reproductive output and so on?' (Chapter 4), 'What causes predators to adopt particular patterns of foraging behavior?' (Chapter 9) and 'How does it come about that coexisting species are often similar but rarely the same?' (Chapter 19). These problems are as much part of modern ecology as are the prevention of plagues, the protection of crops and the preservation of rare species. Our ability to control and exploit ecosystems cannot fail to be improved by an ability to explain and understand. And in the search for understanding, we must combine both proximal and ultimate explanations.

Pure and applied ecology

Ecologists are concerned not only with communities, populations and organisms in nature, but also with manmade or environments (plantation forests, wheat fields, grain stores, nature reserves and so on), and with the consequences of human influence on nature (pollution, overharvesting, global climate change). In fact, our influence is so pervasive that we would be hard pressed to find an environment that was totally unaffected by human activity. Environmental problems are now high on the political agenda and ecologists clearly have a central role to play: a sustainable future depends fundamentally on ecological understanding and our ability to predict or produce outcomes under different scenarios. When the first edition of this text was published in 1986, the majority of ecologists would have classed themselves as pure scientists, defending their right to pursue ecology for its own sake and not wishing to be deflected into narrowly applied projects. The situation has changed dramatically in 20 years, partly because governments have shifted the focus of grant-awarding bodies towards ecological applications, but also, and more fundamentally, because ecologists have themselves responded to the need to direct much of their research to the many environmental problems that have become ever more pressing. This is recognized in this new edition by a systematic treatment of ecological applications – each of the three sections of the book concludes with an applied chapter. We believe strongly that the application of ecological theory must be based on a sophisticated understanding of the pure science. Thus, our ecological application chapters are organized around the ecological understanding presented in the earlier chapters of each section.