Biodiversity, conservation and sustainability

Earth is the only planet in the entire universe where we know for certain that life exists. On this remarkable planet, approximately1.7million species of organisms have been described by biologists, but current work suggests that the true number of living species may be much higher than this — of the order of10million, possibly more. The key challenges in biodiversity research are not only to catalogue life on Earth, but also to understand how this diversity evolved, how it is maintained, and how we might hope to conserve it in the face of massive, and growing, human impacts.

The main focus of my own research spanning more than thirty years has been to try and understand 'nature's rules' underpinning this diversity, and what the rules tell us about attempts to conserve it. I have not been alone in these endeavours and the lecture will explore what ecologists have learned collectively about patterns and processes in biodiversity. It will, however, concentrate on the systems I have studied personally, using insects on bracken (a globally common fern, *Pteridium aquilinum*), controlled environment facilities, mathematical models, and analyses of very large datasets assembled by others. The core of my work has been in community ecology, that branch of environmental science concerned with how many species co-inhabit a bit of 'real-estate' on planet Earth, and why this number, and not an order of magnitude more, or less?

By way of example, we now know that there are more species in large patches of habitat than small patches — the 'species-area relationship'. This is hardly remarkable, but what is remarkable is its regularity. We also know that on average, species with large geographic ranges (widespread species) are more abundant where they occur than species with restricted geographic ranges - the 'range-abundance correlation'. This is less intuitive, and less well understood than the species-area relationship, but both have major consequences for conservation as human beings fragment habitats (creating smaller patches) and artificially restrict the ranges of most species (leading to declines in population density even where species still survive). I will illustrate both ideas with data and experiments.

These relationships set the big picture. What happens at more local scales, say within a small patch of bracken? Ecologist have for many years concentrated their attempts to understand local biodiversity on what I have called the 'local rules of engagement between species' — particularly interspecific competition, predation and parasitism. I have done this myself, in seeking to understand how food-webs work using mathematical models of species interactions for example. But because bracken occurs naturally on every continent in the world (except Antarctica), and because it has a different, and largely independently evolved, herbivorous insect fauna associated with it on each continent, I was able to show that the major determinants of local species richness in these assemblages of insect herbivores operate at large, biogeographic scales. The 'local rules of engagement' are very much second-order phenomena. There is every reason to believe that these same rules apply to many, possibly most other animal and plant communities, shifting the emphasis of community ecology from local processes to biogeographic scales.

Ecology in general is a big and diverse subject, with surprisingly little contact between its various sub-disciplines. I have never found this satisfactory, and have particularly striven to reunite two of its major sub-disciplines, namely community ecology and ecosystem ecology. Indeed, I have argued that neither can seriously advance without them coming together. Two examples illustrate the problem. One is a growing body of data and theory showing that loss of species from local assemblages (local extinctions) can progressively impairkey ecosystem processes such as net primary production and nutrient cycling. My own work in the Ecotron controlled environment facility was the first to show this experimentally, and I and colleagues subsequently extended this work into a pan-European field experiment, confirming the results across a wide range of soil-types and climates.

The second example concerns the role of organisms as 'ecosystem engineers' — species that create and maintain habitats for many other species. Community ecologists have essentially ignored the general rules that underpin the roles of species (like beavers) that create and maintain habitats for myriads of others by ecosystem engineering. The phenomenon is quite general, with simple rules and generalisations, and deserves much more attention from ecologists.

I will also touch on arguably the greatest contemporary challenge of all for ecologists, which is the likely impacts of human-induced climate change on communities of plants and animals, driven by rising atmospheric carbon-dioxide concentrations. Again, to predict and deal with the likely consequences, we have to adopt an ecosystem perspective, and I will illustrate emerging insights derived from the Ecotron and other experiments, not least the unexpected effects of rising carbon-dioxide concentrations themselves on soil processes and soil organisms.

Finally, despite a huge growth in understanding the underpinning processes that determine the diversity of life on Earth from local to global scales, we are also losing species at an accelerating rate: Earth faces another mass extinction, this one driven entirely by the activities of one species — us. Climate change is partly responsible, and its impacts will grow. But the main drivers are habitat destruction, pollution, direct hunting and harvesting of species, and the shear scale of the human enterprise. I will close by considering the sombre statistics, and point out how they pose questions about the sustainability of modern societies unless we adopt hugely different and cleverer ways of doing things. Then, and only then, can we hope to use our knowledge about life on Earth to deliver a sustainable future for all the species with which we share this remarkable planet.