Effects of Pollutants at the Ecosystem Level
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CHAPTER 1
Introduction

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This report is concerned with changes in ecosystems. It is normal for them to be in a constant state of change but the complex interactions among their many components endow them with a measure of short-term stability so that they can withstand brief disturbances. This homeostasis does not, however, prevent long-term changes of an evolutionary type or in response to a sustained cause of harm. Because of this homeostasis the process of damage may begin slowly and subtly and may not be detected until it is well advanced. Such early changes are difficult to detect among the natural variations displayed by all ecosystems. Thus, in a programme of continuous surveillance there is, in addition to the problem of detection, the difficulty of assessment. Are the observed changes temporary and reversible, as are the 'spontaneous' ones, or are they the early stages of more permanent and important damage? The problem of assessment is rendered more difficult by the fact that not all changes, even permanent ones, are for the worse. Ecosystems, like species (or along with species), are subject to slow evolutionary changes by which they may become equally viable and better adapted to changed conditions.

Opinions on whether a change is for the better or worse will vary with the assessor. For example, chemical and thermal pollution of a body of water often results in an increase in productivity and biomass but not everyone regards the resulting eutrophication as an improvement.

Several properties of ecosystems have been considered as indices of welfare or damage in the hope that they might simplify the problem of assessment by providing quick answers. Some of these properties are listed below.

1. The total biomass of a population, a species, a compartment, or an ecosystem.
2. The number of different species present. Indices of diversity have been devised and recommended for assessment.
3. Trends in reproductive success and populations of various species, especially the most sensitive ('sentinel') species.

4. The metabolic activities of an ecosystem such as photosynthesis or the throughput of energy or chemicals.

All these attributes of ecosystems are useful to know but much effort has been wasted (at least by this writer) in trying to decide which are the most definitive indices of ecosystem welfare. Probably the answer is that no change in these or other attributes can be ignored in making a proper assessment. The most useful diagnostic information should include:

1. The history of changes in a number of similar ecosystems including the one under diagnosis.
2. As many as possible numerical descriptors and their 'normal' variation.
3. Any external or new influences, present and predicted, either injurious or restorative in effect.

At different times and with different ecosystems some signs will assume greater importance but in all cases they must be evaluated as a group. With practice the diagnostician will know what is a normal or self-restorable range of variation and what are the danger signs. The appraisal should result in a summary (quantitative if possible) of the present condition and a prediction of future developments. These are needed to guide the administrator on possible interventions and the kind of quality standards to promulgate. The analysis will also provide guidance on how to monitor the ecosystem.

Many of these aspects of the subject of assessing environments were discussed in SCOPE Publication 5 (1975) which dealt largely with the methodologies of environmental impact assessment including modelling and monitoring.

SCOPE Publication 12, *Principles of Ecotoxicology*, which may be considered the progenitor of the present report, devoted 13 chapters to the quantitative assessment of the effects of pollutants on species, populations and communities. Chapter 15 considered 'Ecosystem response to pollution'. It divided the problem into three parts:

1. How polluted is the ecosystem? This can be measured by monitoring important compartments and, with the aid of models, doses to important receptors may be calculated.
2. What are the effects on ecosystems? These are illustrated by ten examples where a variety of pollutants have been observed to act on different ecosystems.
3. How do you assess these effects in terms of ecosystem characteristics?

SCOPE 12 was prepared and published under the guidance of a preparatory committee and in its final report to the SCOPE Executive this committee concluded that the weakest part of the publication was that dealing with the responses of whole ecosystems and that this subject required further study. The Executive decided subsequently to embark on such a study and the present report is the result.

The objective of the report is to provide information to scientific advisors of decision-makers and to scientists studying effects of environmental pollution in ecosystems.

Since an ecosystem consists of 'communities of living organisms together with their habitat (or abiotic environment) and including the interactions among these components', it is described not only by specifying the living and nonliving things it contains but also by giving an account of what goes on in it, for example, energy and material flows as well as productivity. Characteristics and classifications of ecosystems can be, and have been, discussed at length. They provided an indication of the broad range of systems which it is possible to consider. A more limited range will be included in this report, by reference to concrete examples.

The chapters that follow begin with a survey of established results in the published literature of the subject, looking at, first, the distribution of chemicals in the environment, then the difficulty of detecting the effects of pollutants in the presence of large background variations and, finally, the nature of these effects on populations, communities and whole ecosystems. This survey is followed by a collection of case studies, selected as illustrations of the problems encountered in the diagnosis, assessment and subsequent handling of problems at the ecosystem level. The final chapter presents some of the lessons to be learned from these experiences and attempts to identify some priorities for handling such problems in the future.