CHAPTER 8
Conclusions and Recommendations

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The most obvious conclusion from the survey and case studies is that ecotoxicologists have been slow to apply an ecosystem-level approach to the assessment of the effects of toxic pollutants even though, in some cases, theory and methodologies are sufficiently developed to support such activity. It is hoped that this volume will encourage further long-term research on stressed systems and on the evaluation of techniques for distinguishing and quantifying pollutant-related effects at levels of biological organization above that of individuals and populations.

The first question to be answered in assessing the pollution of an ecosystem is: 'How polluted is it, or might it be in the future?' This has led to concern because of the lack of available data on production and release of chemicals which might achieve levels sufficient to cause a regional or even a global hazard. Only for a few very specific chemicals, in restricted areas, is anything like complete information available. Even an elementary hazard ranking scheme based on production and environmental persistence of a large number of potential environmental contaminants would be useful.

Another basic question that ecotoxicologists must ask is whether or not a change is real and whether it can be attributed to the pollutant. If a quantitative assessment of impact is to be made, far greater care must be taken to define natural variability in population and ecosystem parameters, and to determine the amplitude and patterns of natural fluctuations in structure and function.

Individual and population characteristics (behaviour, biochemistry, physiology, etc.) are quite sensitive to toxic chemicals but the meaning of such adverse responses in relation to the long-term success of the inhabitants or functioning of the ecosystem is not fully understood. In cases such as that of low reproductive success associated with pollutant-induced behavioural abnormalities, the significance of individual response to the well-being of the population is obvious. On the other hand, the implications of the loss of a particular
population in a particular area, as a result of pollution, remain largely unresolved.

Special consideration in the interpretation of the initial community response to pollution must be directed towards such factors as life history stages of the resident species, potential for emigration, selection for tolerance and exposure potential associated with particular habitats, since these can influence the long-term adaptation of populations to pollution stress.

Studies of multispecies systems have been used to verify theories on ecology regarding the importance of competition, predation and other relationships as factors in shaping community response to a perturbation. The application of data on competition, to pollutant impact assessments, has been particularly productive in both aquatic and terrestrial plant studies, and information on predation has been valuable in the interpretation of certain aquatic trophic linkages. However, the influence of population interactions on community response to toxic stress needs further clarification, since this may provide the mechanistic information for predicting changes.

There is an important need to determine key species, in relation to ecosystem function. These may be organisms with unique functional roles, such as pollinators, or those which through competitive or predatory interactions exert a major influence on community composition and on the movement of energy and materials. The dynamics of such species may be the factor that determines the rate of whole system change.

There are a variety of quantitative structural indices describing community organization which provide conflicting appraisals; therefore, a good deal of disagreement exists over their utility in monitoring stress. This is particularly evident for diversity indices with regard to their sensitivity and consistency in measuring structural change. In many instances, simple indices requiring little or no calculation (such as species richness) appear to be more sensitive to the presence of a pollutant than do more complex indices.

The concept of ecosystem stability is basic to any assessment of changes brought about by environmental pollutants. Various measures of the dynamic performance of an ecosystem are available to describe the response to perturbations. There is evidence suggesting that the buffering capacity (homeostatic ability) of a system can be measured and used to predict the amount of pollutant which can be absorbed before unacceptable changes result. Contrary to the prevalent idea that stress increases fluctuations in ecosystem indices, it has been found that gross levels of pollution often suppress both temporal and spatial variability in community composition. Furthermore, recovery of an ecosystem following pollution abatement should not be expected to follow the reverse sequence of degeneration, nor should the new state be expected to match the original configuration.

The implications of long-term structural changes for ecosystem function are not clearly defined. In addition to examining such changes in detail, it is important to examine processes which reflect the functioning of the whole system
(e.g. primary productivity) and to identify key processes which are pivotal to the functioning of particular types of ecosystems. Furthermore, it is necessary to consider the yield of the entire system in economic terms.

The importance of assessing interference with organic decomposition and nutrient recycling processes must be emphasized. In this regard, quantitative data on nutrient pools and fluxes and on the relationship of element 'leakage' to long-term productivity are essential to the refining of interpretations of biogeochemical disruptions.

Enclosure techniques are providing an important experimental link between laboratory and field studies. Such methods should enable researchers to consider environmental and population interactions in their experimental designs. A further refinement of enclosure methodologies is required in order that results adequately forecast ecosystem responses.

Similarities between the results from short-term controlled exposure studies in natural systems and those from chronically contaminated systems suggest that ecosystem experiments (at least in streams) may have predictive value.

The usefulness of examining changes along a pollution gradient has been clearly demonstrated. The problem of locating an appropriate reference is minimized, and experimental difficulties related to temporal changes in system parameters can be partly overcome, through the built-in properties of the gradient approach to monitoring relative changes. These factors enhance the utility of this approach in providing both spatially and temporally comparable data.

In addition to the recommendations implicit in the above conclusions, special attention is directed to the need for developing procedures for making integrated quantitative assessment of the effects of pollutants on ecosystems, including the relative importance of these effects to problems of impact assessment, abatement and control. To permit realistic integration requires that all the most important responses be identified and expressed quantitatively in the most meaningful form. Moreover, the response should be quantitatively related to the causative exposure.

Since many polluted systems are contaminated by several toxic substances, it is essential that techniques be developed to link responses to the combined effects of specific groups of substances as well as to individual substances. Combined effects can also result from the addition of pollutants, at levels not normally injurious, to systems already endangered by a broad spectrum of existing chemical or physical stresses. It is imperative that these types of interactions be recognized and taken into account in ecosystem studies.

It is natural that biologists feel more comfortable studying the effects of single pollutants on individuals and populations of single species. Nevertheless, those with an interest in ecology must move beyond this foundation and address the more complex problems involved in assessing the well-being of whole ecosystems.