Ecosystem Theory and Application

Edited by Nicholas Polunin

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NICHOLAS POLUNIN

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Ecosystem Theory and Application

ENVIRONMENTAL MONOGRAPHS & SYMPOSIA

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Edited by
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In affectionate memory of
Sir Arthur George Tansley
(1871–1955)
Pioneer Ecologist
who identified the concept and originated the term
'Ecosystem'

This Book is Dedicated
with Deep Appreciation

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Series Preface

For civilization to survive in anything like its present form, the world's human population will need continuingly to increase and widen its knowledge of the ever-changing environment. Moreover, this knowledge will need to be closely followed by concomitant action to safeguard The Biosphere and so maintain the framework and chief structures of our life-support system. The *increase* in knowledge and awareness must come through observation, research, and applicational testing, its *widening* through environmental education, and the necessary concerted *action* through duly-organized application of the knowledge that has been thus acquired and disseminated.

The environmental movement has long been an undefined but widely effective vehicle for increasing appreciation of the vital reality and fundamental importance of Man's and Nature's environment. It is hoped that the World Campaign for The Biosphere, 1982–, and its adopting World Council For The Biosphere (WCB)–International Society For Environmental Education (ISEE), will focus attention on the vulnerability and frequent fragility of that 'peripheral envelope of Earth together with its surrounding atmosphere in which living things exist naturally'. At the same time it should point out our utter dependence on The Biosphere's health—as it constitutes our only life-support system—and inculcate the necessity to foster it in every possible way, as is emphasized chronically in the allied quarterly journal *Environmental Conservation.*

To help to encourage such ideals and guide appropriate actions which in many cases are imperatives for Man and Nature, as well as to distil and widen knowledge in component fields of scientific and allied environmental endeavour, we founded and are now fostering an open-ended series of *Environmental Monographs & Symposia.* This emanated from an invitation by the international publishers John Wiley & Sons, and consists of authoritative volumes of two main kinds: monographs in the full sense of being detailed treatments of particular subjects by from one to three leading specialists, and symposia by more than three specialist Authors covering a particular subject between them under the guidance and editorship of a suitable specialist or up to three specialists (whether such a volume results in part or wholly from an actual 'live' symposium or consists partly or entirely of 'contributed' papers conforming to an agreed plan).

There seems to be virtually no end to the possibilities for this series; we are constantly getting or being given new ideas, and now have very many to think about and, in chosen cases, to work on. At the same time we hope to complement the existing SCOPE Reports, emanating from what in a sense is the world's environmental 'summit'. In addition to the present work and the already published *Modernization of Agriculture in Developing Countries:*

Resources, Potentials, and Problems, by Professor I. Arnon, *Stress Effects on Natural Ecosystems*, edited by Professor Gary W. Barrett & Dr Rutger Rosenberg, *Air Pollution and Plant Life*, edited by Professor Michael Treshow, and *Impounded Rivers: Perspectives for Ecological Management*, by Dr Geoffrey E. Petts, many others are in various stages or being contemplated.

Whether or not we shall in time come to cover, in however general a manner, the entire vast realm of environmental scientific endeavour, must remain to be seen, though this was the gist of the distinguished publishers' original invitation and poses a challenge that we can scarcely forget. Meanwhile we believe we have decided on a constructive compromise with this most timely, open-ended series, in which we look forward to effective participation of more and more of the world's leading environmentalists.

NICHOLAS POLUNIN
(Convener & General Editor of the Series)
Geneva, Switzerland

Preface

Although this book originated as an opportunity to publish our choice of the invited papers presented to the plenary sessions of the Second International Congress of Ecology (after excluding our own!), it has emerged as a series of essays mainly on aspects or ancillaries of the theme indicated by its title. This necessitated the omission of some worthy candidates as being incongruous or otherwise unsuitable, allowed inclusion of a few having primarily different thrusts, and engendered the addition of several chapters for which their specialist Authors deserve our appreciative thanks—not least for helping to make the result a reasonably coherent, though by no means all-inclusive, treatment of its vast topic.

With the emergence of the concept and term of 'ecosystem' as one of the most valuable to use in ecology, and its advance of late to occupy what is probably the foremost position of all in that subject, it has long seemed to us that such a book as the present, dealing *inter alia* with various aspects of its holistic realism of the whole forming commonly much more than the sum of the parts, would be very valuable—hence our treatment of it as the main recurrent theme in this symposium volume.

As indicated in our dedication, the concept and term 'ecosystem' originated with A.G. Tansley, who first advanced it in print in 1935 (when the undersigned was fortunate enough to be his sole Advanced Student at Oxford). Tansley deliberated long on the theme of vegetation as a 'quasi-organism', but concluded that more should be considered together with it, and so came out with what he was apt to write on the blackboard in two words as 'eco system'. This was composed of both the inorganic and dead parts of the system and the various organisms which live together in it as a social unit and comprise the *biota*, or in some cases (such as large shading plants or predatory animals) may affect it from outside.

Such has always been our interpretation, and is adhered to in this book. Thus an ecosystem is as extensive as, but no more so than, its characteristic dominance (in terrestrial instances usually by plants) or influence-sphere, which we believe should exclude any wider eca that collectively comprise ecobiomes—or, in the case of the world as a whole, The Biosphere. This policy has been endorsed by leaders whom we have consulted—including

Tansley's early collaborator and my doctoral examiner, the late Sir Harry Godwin, who, however, commented (*in litt.* 18 May 1983) that he rarely used the *term* ecosystem as: 'I very early decided that people were going to misuse [it and so] have stood off its employment as much as possible.'

In conclusion it is a pleasure to thank my Personal Assistant, Mrs Lynn Curme, for compiling the Indexes, and my long-time friend Monsieur Gilbert Huguet, of Atar Arts Graphiques, Geneva, without whose enthusiastic support and executive verve this book would not have been printed in time for the 'Fourth' International Congress of Ecology.

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NICHOLAS POLUNIN
Environmental Conservation

ECOSYSTEM THEORY AND APPLICATION

(Edited by Nicholas Polunin)

Dedicated to Sir Arthur George Tansley

CONTENTS

Ecosystem Theory and Application,
Edited by Nicholas Polunin for Environmental Monographs and Symposia.

Introductory Review: Perspective of Ecosystem Theory and Application

by

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'Ecosystem' is widely accepted as an important concept in theory but, until recently, not in practice. By and large, attempts to deal with environmental problems have involved piecemeal approaches. Attempts to control agricultural insect pests offer a good example. Until recently the chief approach has been to apply massive sprayings of very toxic insecticides, with little regard for the long-term effect of those poisons on other components, and with no understanding of the agro-ecosystem as a whole or appreciation of the tremendous complexity and resilience of ecological systems. Exclusive dependence on chemical controls in agriculture has often resulted in a temporary increase in yield which, as viewed in the short term, is a successful solution of a pest problem. However, all too often the pests themselves become resistant, other than target species become pests, and natural control mechanisms become so disrupted that the whole agro-ecosystem becomes increasingly disorderly.

Experience with insect control in cotton is a good example of this, as was recently documented by Adkisson *et al.* (1982). Massive aerial spraying of insecticides in Texas resulted in increased yields for a number of years; but in the early 1960s an almost complete failure of the crop occurred, as the pest species had become resistant and other species of insects moved in to become new pests. Yields in this area were restored only after a more holistic approach, which entomologists term 'integrated pest-control,' was adopted. Experiences such as those are rapidly making it evident that complex situations and problems cannot be successfully dealt with in the long-term by focusing on only some component or components of the system. Accordingly, there is renewed interest in determining in detail how ecosystem

theory can help Mankind to learn to coexist in proper harmony with the biospheral life-support system on which we ultimately depend.

Reasons for Slowness in Application

Before we review an updated theory of ecosystems, let us inquire into the reasons why 'applied' scientists have been so slow to apply ecosystem theories to practical problems. The first and most obvious reason is that the 'quick-fix' so often works very well in the short-run of political and economic worlds, as in the cotton example. But when numbers of small 'quick-fixes' are made independently, the central problem is not properly addressed; decisions at a higher hierarchical level, that would benefit the whole, are accordingly not made. Economist Alfred Kahn has termed this situation the 'tyranny of small decisions' (Kahn, 1966; cf. W.E. Odum, 1982).

A second reason, I believe, for delay in the widespread application of ecosystem theory, is the fact that science has become so strongly reductionist that we are victimized by 'a tyranny of small technologies'. Although the philosophy of science has always been holistic, in the sense of attempting to understand the whole of the situation, the actual trend of science in the past few decades has become more and more reductionist—with increasing specialization, emphasis on smaller and smaller units down to the molecular and beyond, and a preoccupation with laboratory study. Much good, of course, has come from the reductionist approach. Mankind, in general, has benefited from advances in medicine, engineering, and agriculture, that have come from narrowly-defined laboratory, greenhouse, and experiment station, research. The real world, however, consists of open, far-from-equilibrium, thermodynamic systems that cannot be enclosed in glass test-tubes or within laboratory walls. Such open systems must have a strong input-flow of high-quality energy to enable them to survive, let alone evolve and improve. They are also very much influenced by economic and political considerations that are rarely included in the scientists' models. For these reasons, real-world systems cannot be dealt with one piece at a time, or in isolation from economic and political co-acting systems.

A third reason why applied scientists have been slow to apply an ecosystem concept to practical problems lies, I believe, in the mistaken notion that 'the whole' is nothing more than the sum of its parts; according to this widely-held philosophy, the whole can be understood on the basis of detailed study of major components. In a book on experimental biology, Norman (1963) expresses this viewpoint as follows: 'The whole living organism is nothing more than the sum of its parts. There is nothing more about the life of the whole organism that cannot be explained by the physics and chemistry of the individual activities.' Then Norman attempts to justify the experiments on parts of organisms rather than the whole organisms by claiming: