14. Three Interconnections of Ecology

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INTRODUCTION

Higashi and Burns (1990) argued that three perspectives are currently of great importance to ecological study, particularly on the ecosystem-community level of organization. Those are the network perspective (Higashi and Burns 1990), hierarchical perspective (O'Neill et al. 1986) and evolutionary perspective (Burns, Patten and Higashi 1990). Among these three, the network perspective is the most fundamental, providing the basic modelling framework. The other two perspectives supplement the first by increasing the efficiency and effectiveness of modelling; specifically, the hierarchical perspective distinguishes multiple scales, whereas the evolutionary perspective introduces the powerful dimension of time into the whole picture. The network perspective utilizes the interconnections existing among objects of concern as the main ingredients to discover "structure", the context in which ultimate factors can be better perceived and their significance understood.

We observe that many, and virtually all, of the papers presented in the symposium are concerned with interconnections of some sort. We may conveniently distinguish the following three categories of interconnections. The first category is for interconnections among the components that constitute an ecological system of concern. The second category of interconnections are methodological ones; namely, the interconnections among different but related approaches in ecology, which are desirable but in practice very weak in current ecology, and those that ecology should make with other related fields of science. The third category is for the interconnections that ecology should have with the resolution of practical problems of social interest, particularly the environmental problems that threaten in various ways and scales all of the life on earth including Homo sapiens.
INTERCONNECTIONS AMONG
COMPONENTS OF AN ECOLOGICAL SYSTEM

Ecology is the biology of interdependence. A pair of action and reaction between two objects makes up a feedback loop, which provides a novel mechanism for generating self-regulatory or self-amplifying behavior, of the objects involved in the loop, depending on whether the loop represents a negative or positive feedback (DeAngelis, Post and Tribus 1986). A classic example of this is Clements' (1936) idea of succession. As Burns (this volume) pointed out, it was unfortunate for Clements to use the term "super-organism" for his conception of communities as a system. This is not only because the terminology misleads those who, forgetting the fact that "an analogy is an analogy", tend to rely too much on analogies, but also because the justifiable negative reaction to his idea obscures an important point in his original thoughts: the explicit recognition of the action-reaction pair, which makes up a feedback cycle, and its role and significance as a driving force for the succession of an ecological system.

The "Gaia", which was proposed by Lovelock (1979) and presented in the paper by Hinkle and Margulis (this volume), is a modern version of Clement's super-organism. This notion represents a perception of the global geosphere-biosphere complex as a cybernetic system incorporating stabilizing negative feedbacks. Although it is thus an application of the general notion of ecosystems (Higashi and Burns 1990), the extremely global scale to which it is applied generates a fresh image. But, one must be careful in further investigations of the Gaia, not to rely too much on the analogy between the Gaia and an organism or a cell, avoiding the repetition of the mistake that Clements made by overextending the notion of super-organism.

When we obtain a means to detect chemical signals that cannot usually be sensed, the world must appear to be filled with a much denser network of ecological interactions. Yamaoka (this volume) shows that chemical media are available for complex networks of information transmission among individual organisms in the same and different species. Because information affects the behavior of organisms, it alters the manner in which organisms or species interact with each other, resulting in an increase in the complexity of interaction networks.

The network of interactions among species, which may contain feedback loops, has more recently found its relevance to, and even its important role in, biological evolution (Burns, Patten and Higashi 1990). Endler (this volume) emphasizes that the interactive connections, in the context of which each biological species is placed, are crucial when one studies the evolution and natural selection that a species experiences in the wild.
Species-population approach and ecosystem-process approach

Ecology has been the study of biological species, their life histories, population dynamics and social structures, on the one hand, and the study of ecosystems, their energy and matter processing and sustainability, on the other. Also, it has pursued the origin and evolution of species in diverse environments. But, a review of recent studies on communities, the intermediate levels between the population and ecosystem levels, reveals a discrepancy or gap between these two research foci, population and ecosystem ecologies, or more specifically, species-population approach and process-functioning approach (O'Neill et al. 1986). This gap or separation has resulted in several shortcomings, which in turn suggest important research areas and themes that new research should address.

Among those the most important in our view is the deficiency in understanding the relationship between the macroscopic functioning of an ecosystem, in terms of energy and nutrients processes, and the spatiotemporal dynamics and fate of species-populations, as well as their biotic interactions (predation, competition and mutualism etc.) within the ecosystem. The importance of understanding the interplay between these two subjects is increasing in the context of the potentially great contributions of ecology to several global environmental problems, i.e., globally distributed problems, such as greenhouse effects, acid rain, and globally shared problems, such as the drastic reduction of biodiversity.

The separation of research efforts has caused, on the part of population/community theory, the neglect or underestimate of the decomposer and detritus components and also the nutrient and energy cycling processes in communities and food webs. The explicit addition of these missing ingredients to the population/community interaction model may make a quantitatively and quantitatively significant difference in the theoretical conclusions on community stability, food web structure and development, and species coexistence and diversity.

On the part of ecosystem theory, the same separation has caused the neglect of the life history, spatial heterogeneity and social structure of biological species when studying ecosystems. The lack of an evolutionary perspective in past ecosystem study seems a natural concomitant of this neglect of species' ecological traits, though community and food web theory from species-population approach has not fully incorporated an evolutionary perspective either. The explicit addition of these missing ingredients to the ecosystem model may reveal the causes and effects of disturbance (particularly biological disturbance due to invasion, introduction, or extinction, and deletion of species), spatial heterogeneity, and dynamic features (such as catastrophic changes, succession and evolution) of ecosystems.

Perhaps a more serious problem from the separation into two approaches is that most of the important theoretical problems have not been considered from both points of view at once or from an integrated view of species-populations
and ecosystem-processes. This is the case even with those problems that by
definition involve these two aspects, such as the relationship of stability (in the
multiple senses of resistance, resilience, persistence etc.) and species-diversity to
the energy and nutrient supply regime (total supply level and patterns of
resource-supply paths, both spatiotemporally variable) of a food web (ecosystem),
and further, the trend in these properties during long-term dynamic processes on
time-scales of ecological succession and evolution. New insights into these
theoretical issues should improve our understanding of the impacts made by
various disturbances upon natural ecosystems, and thus contribute to
environmental management and policy making.

Interface between population ecology and behavioral ecology

The main objective of population ecology is to identify and explain a wide variety
of observed patterns of population fluctuations. In particular, the last three
decades have seen the population regulation by density-dependent feedback
mechanisms be debated. In spite of a number of long-term population studies in
various taxa, no consensus on population regulation has been attained. Rather,
most of these studies have remained at a level of phenomenological descriptions
of temporal population fluctuations. The lack of consensus is largely due to the
method that the conventional population study has adopted, which compares
demographic parameters at the population level among different species. This
comparative approach is less effective for drawing general conclusions from such
complex observations, where the magnitude of population fluctuations,
population densities and degree of density-dependence often differ from one
locality to another even in one species.

An alternative approach should thus emphasize underlying mechanisms
governing essential processes responsible for population fluctuations (Ohgushi
and Sawada 1985, Schoener 1986). When we consider underlying mechanisms of
population dynamics, average parameters of demography will no longer be
appropriate. Instead, we should focus on ecology at the individual level, such as
behavior, physiology, and morphology, associated closely through survival and
reproductive processes with the components of demographic parameters.

Conventional population ecology has ignored, however, population
consequences of the properties of individuals. This comes from the long accepted
assumption that all members within a population are identical in terms of
survival and reproductive processes. Population ecologists, based on this
assumption, have long estimated the average values of demographic parameters,
and tried to relate, using a regression method, these average values to those of
population densities that are often defined ambiguously. However, regression
analysis tells us nothing about the causal mechanisms generating various types
of temporal variation in population density.

Once we look at the behavior or physiology of individual organisms, we must
examine how the properties at the individual level are translated to demographic
parameters at the population level. We thus need to know much about
demographic variation within a single population. Demographic variation
TWO-WAY INTERFACIONS
INTERCONNECTIONS WITH PRACTICAL PROBLEM SOLVING:

Ecology as a synthesis of diverse fields of science

1. THREE CONNECTIONS OF ECOLOGY
Literature Cited

Environmental Problems

"Ecology for Tomorrow" will be more useful in managing many environmental problems than "Ecology for Today." While the latter is a sensible, the former is more useful in the context of the complex ecosystems of today. In this volume, the emphasis is on the understanding of the complex ecosystems of today, which is achieved through a better understanding of the different approaches to the basic study of ecology, which forms a bridge connecting different approaches to the basic study of ecology.

Thus, the integration of ecology with practical problem-solving services is synergistic of these related fields. The problems of each other and with researchers in other fields, promoting the coeducation of each other and with researchers in other fields, promoting the basic study of ecology, but also demanding that ecological problems be studied in a more meaningful and practical way.

For solving environmental problems, demonstrating clear interconnections between ecology and environmental science, providing information on how one can utilize and improve local ecosystems, and providing information on how local ecosystems can be improved by practical problem-solving services, even though it is harder for ecology to contribute to practical problem-solving, its importance to recognizing the role of ecology in practical problem-solving is emphasized. This volume provides examples of the relationships between basic studies in ecology and practical problems directly stated in the preface of this volume.

Several papers in this volume, those in Part III in particular, provide examples of the interactions taking place inside organisms, which studies the complex interactions among organisms of diverse ecological spectra, providing a basis for understanding the fundamental role of the interactions among organisms.


Oikawa, T. 1990. Modelling primary production of plant communities. (this volume)


Yamaoka, R. 1990. Chemical approach for understanding the interactions among organisms. (this volume)