Ulf Dieckmann

Ecological Change in Space and Time

Ulf Dieckmann, born in 1966, studied physics at the Rheinisch-Westfälische Technische Hochschule in Aachen, Germany. He specialized in statistical physics on cooperative phenomena of self-organization, phase transitions and the origins of complexity, while realizing that the realm of physics is too narrow to encompass the latter. Encouraged by supplementary studies in philosophy (theory of science and knowledge) and in theoretical ecology (where system-theoretical methods are fruitfully applied) he focused attention on the theory of evolution. He is currently working on the mathematical foundations of coevolutionary dynamics, population dynamics and selection in spatially extended systems, the adaptational design of neural networks, and the evolutionary origin of hierarchical organization. Before coming to the Wissenschaftskolleg, Ulf Dieckmann worked at the University of Leiden, the Netherlands (where he obtained his Ph.D. in theoretical biology); at the University of York, U.K.; the Research Center Jülich, Germany; and at Stanford University and the Xerox Palo Alto Research Center, California, USA. In 1996 Ulf Dieckmann joined the International Institute for Applied Systems Analysis in Laxenburg, Austria, to become project coordinator of the Adaptive Dynamics Network, an international research initiative that fosters the development of new mathematical and conceptual techniques for understanding the evolution of complex adaptive systems. — Address: International Institute for Applied Systems Analysis, Schlossplatz 1, A-2361 Laxenburg.

When I first came to the Wissenschaftskolleg in October, I was enchanted by the special atmosphere I encountered. As a gesture of hospitality from Wolf Lepenies, I discovered a bottle of St. Emilion 1985 sitting on my desk: a wine (although, it must be admitted, not a year) that would kindly accompany us through the ups and downs of the months to come. On the first evening, like many times later on, I sat down and quietly listened to the pleasant tunes of Berlin's Klassik Radio. On the next morning I was awaken by sparks of pure yellow light shining

through my window and originating from the old chestnut tree in Wallotstrasse which was set on golden fire by the autumn sun.

Soon after this serene and inspiring start, our little focal group in ecology, comprising Richard Law, Tomas Herben and me, convened for the first time. With Richard Law I had already the pleasure to cooperate, TomAg Herben I first got to know on this occasion. Together we had formulated an ambitious and exciting research program for our seven months in Berlin.

Ecological systems evolve in space and time. Unfortunately, however, research in ecology over the past five decades has confined attention either to the temporal or the spatial aspects of ecological structures. The integration of pattern (spatial structure) and process (structure in time) in the study of ecosystems, although frequently called for, in particular in plant ecology, remained pending. Too difficult seemed the open problems in both domains; synthesizing them in the analysis of spatio-temporal processes hence appeared daunting. Nevertheless, with the rise of modern computer technology, this barrier could be challenged. Several investigations clearly demonstrated that studying ecological change separately either in space or in time can lead to entirely misleading predictions — predictions of high relevance for questions of ecosystem management and for measures aimed at conserving biodiversity. Simulation studies succeeded in preparing the ground for an increased awareness of the spatio-temporal dynamics in ecological systems; some of the most important questions in this field, however, cannot be answered by mere computer analyses:

(1) What are the most appropriate and efficient mathematical paradigms for modeling space and time in ecology? How are these models formally related?
(2) What methods can be employed to ensure that a natural ecosystem and its simplified representation in a simulation model are as closely akin as possible?
(3) Can we devise techniques to analyze and predict long-term ecological change without having to run expensive computer simulations for each individual question under consideration?

In view of the past decades of research, seven months of joint work is not a particularly long period. Nevertheless, owing to the fruitful cooperation and the wide spectrum of backgrounds within our little group, we managed to tackle the questions outlined with some success and, as we hope, with some fresh input of ideas into the field. First, we have studied in parallel different paradigms for spatio-temporal modeling in

ecology. The sometimes strikingly different predictions resulting from such models could be interpreted.

First steps towards establishing an encompassing network of formally-linked classes of models have been taken. Second, the method of pattern-deviation functions has been devised and tested. With this method a stochastic ecological model can be calibrated to match the actual spatio-temporal data observed in the field. The new technique provides a necessary and natural extension of least-square estimators to the realm of spatio-temporal processes. Third, moment equations and related formal tools have been constructed to overcome the necessity of excessive simulation runs. Eventually it should be possible to provide ecologists with guidelines on how to reduce the full spatio-temporal dynamics of ecosystems to manageable low-dimensional representations. These describe the dynamics of summary statistics appropriate for a given ecosystem and would help to understand some of the complex interactions between the spatial and temporal domain that shape ecological change. A more detailed account of our results can be found in the report "Spatio-temporal processes in plant communities" later in this volume. In collaboration with the International Institute for Applied Systems Analysis, we are preparing a volume that will review the state of the art in this rapidly developing field of spatio-temporal processes in ecology.

Time at the Wissenschaftskolleg is special indeed. The vibrant pace of the initial months occasionally slowed to a crawl when we encountered major hurdles or dead ends in our research. With a setting of splendid isolation cultivated by the Kolleg, it was not always easy to become sufficiently disentangled again from the predicaments of our particular scientific endeavour. In spite of the attractively stimulating and diverse colloquia presented by all the Fellows, and although I tried to follow up on two smaller research topics (the coevolutionary origin of symbiotic interactions, and the relation between the notion of emergence and processes of evolution), I recall my time in Berlin as very tightly focused. A well-tempered mixture of unconditional involvement and disinterested retreat might be most conducive to fruitful work. The Kolleg allows for the former, but it is up to the individual Fellow to ensure the latter. With the end of our term approaching — and charged with nostalgia as well as with a pleasant amount of St. Emilion — we thus dreamt up the ideal scenario: two months at the Wissenschaftskolleg in every year to come.