

Preface

Succession is the process undergone by natural ecosystems such as lakes, grasslands, and forests as they proceed from early stages of development to maturity, when the community of plants and animals achieves a condition of equilibrium with its physical environment. Ecosystems succeed in response to either natural or man-made disturbances. Therefore it is important to understand how successional behavior arises and how to control it in order to avoid irreversible deterioration of systems that are indispensable for survival in spaceship Earth. At a time when intensive methods of utilizing ecosystem food production are becoming prohibitive due to short supply and soaring costs of fossil fuels, it is critical that man understand how to use succession as a constructive ecological force.

Empirical study of successional behavior has led over the years to several hypotheses to explain this phenomenon. Although long successional time periods make it difficult to compile complete time histories, several investigators have collected data that serve to identify the basic patterns of behavior. In this book we integrate the available empirical evidence on succession into a dynamic model that accounts for successional modes of behavior as they arise from the internal structure of the ecosystem. The numerical quantification of the model approximates the values of biomass and other variables typical of a grassland ecosystem. Our computer simulations with the model confirm that, within the limitations imposed by the physical environment and other open-loop factors, secondary succession is generated by the closed-loop structure of the ecosystem. They also show that successional modes of behavior are relatively insensitive to parametric and exogenous perturbations as long as they are not exceptionally large and that, while climatic factors are certainly influential on range productivity in the short run, the internal feedback structure that is responsible for succession is also responsible for the performance of the range ecosystem in the long run.

The authors are not biologists or ecologists. We are engineers who share the conviction that system dynamics provides a methodology that is particularly applicable to analysis and modeling of large-scale ecosystems for the purpose of designing better ecosystem utilization policies. We have endeavored to review the pertinent ecological literature and several ecologists were consulted while the model was under development. Needless to say, our model is by no means definitive. In this book the model is fully documented so that each assumption and parameter used can be reviewed and criticised by the community of ecologists and land-use managers. It is hoped that the experience of reviewing and using the present model may lead to a better one. After all, science also advances by a succession of sorts; any good model should eventually lead to a better model.

This book is intended primarily for ecologists and land-use managers interested in the quantitative analysis of dynamic ecological processes, succession in particular. The book can be used either as a reference or more appropriately as a case study that can be dissected in courses of quantitative ecology. More generally, it is intended for system dynamics students and practitioners interested in applying this tool to land-use management.

As mentioned before, several ecologists were consulted during model development. In particular, Eugene P. Odum of the University of Georgia provided extremely useful guidance in the early stages of the work. Arthur C. Benke of Georgia Tech and Bernard C. Patten of the University of Georgia also provided valuable advice. Anthony C. Picardi of Development Analysis Associates, Inc., Cambridge, Mass., read the complete manuscript and offered suggestions of substance. George M. Van Dyne of Colorado State University also read and commented on the manuscript and brought to our attention several important references. We are also grateful to William Bossert of Harvard University for bringing to our attention the Drury-Nisbet hypothesis on succession. John Kominski of the Library of Congress was instrumental in making library resources available to the senior author. The time and clerical support provided by IBM and Georgia Tech is gratefully acknowledged. In particular, the excellent editorial assistance of Mr. Robert C. Service at IBM was of great value. Needless to say, responsibility for errors is fully ours.