INTERNAL REPORT 106

DEVELOPMENT OF PROTOTYPE PRODUCER-CONSUMER INTERACTION MODELS

M. A. Strand

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Investigator: M. A. Strand
Dept. of Forest Management
Oregon State University

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ABSTRACT

Three modeling approaches were taken in 1972. These were: compartment modeling, fine level process modeling, and coarse level process modeling. The compartment model is of a litter layer arthropod community. It has been formulated and parameterized, but a computer program for simulation has not been written. The fine level process model is a generalized model of a consumer population. This model couples population dynamics and energetics in its representation of eight basic consumer processes. Submodels of several processes have been tested for different consumer types, but two processes have not been adequately formulated yet. The total model has not been tested. The coarse level process model investigates the influence of the structure of food chains on the rate of secondary production and of passage of materials through the food chain. Two food chains have been examined and several more will be simulated prior to production of a formal report.

The purpose of this project was to develop and investigate models that relate to the mutual influence of the animal and plant communities. This influence is exhibited in so many facets of ecosystem operation that it was

necessary to formulate a few modeling tasks from the general purpose. Three approaches were investigated and three models resulted from these investigations. Each approach and resulting model are discussed in the succeeding sections of this report. More complete discussions will be available as biome internal reports.

Compartment modeling:

Simple compartment models of animal communities were investigated. Generally in this form of modeling, the transfer from one compartment to another is a function of the state of the donor or receiver compartment, environmental variables, or time or any combination of these factors. The state of a compartment is often expressed as the simulated biomass, caloric, or mineral content of the biological component being modeled.

After reading many compartment models, a model of a litter layer arthropod community was developed. This model was formulated as a practice exercise. It had a two-fold objective: to explore the uses of the FLEX computer program and to discover mathematical expressions useful in modeling. The components were chosen not by factual considerations of the arthropods of the litter layer but rather to represent a variety of modeling problems.

The model is basically a non-linear compartment model that follows the flow of energy through eight compartments (Fig. 1). The time resolution is daily. Environmental effects are included as time dependent influences on death and emergence rates. Two energy sources are included in the modeled system: annual litterfall from the canopy trees and growth of small forest floor plants. There is an interesting competition between detritivores and saprophytes that is influenced by fungal feeding arthropods and the predators which feed on both the detrivores and the fungal feeders.

The parameters for this model were estimated from published literature. Currently the model is in line to be implemented on FLEX.

Process modeling (fine level of resolution):

Many models have been reported in the literature concerning the processes involved in the dynamics of population numbers. Fewer models have been developed to investigate the processes of animal energetics and fewer yet have attempted to interrelate the dynamics of energy and numbers.

The investigation of these reported models has laid the foundation for the formulation of a canonical consumer model, that is, a general scheme that represents a model of a single population of any type of consumer. This model couples population dynamics and energetics in its representation of eight basic consumer processes (Fig. 2). The processes are described by sets of equations that are used to convert one set of variables into another set, for example, the equations for growth and development convert consumed food into consumer biomass.

The canonical consumer model is still in the embryonic stage. Some processes have been formulated completely. The processes of consumption and growth have been formulated, parameters for two populations were estimated, and computer simulations have been made. The process of vulnerability and death has not yet been adequately conceptualized. The other processes are midway in development. As yet, the complete model has not been tested for any population.

The canonical model may be used to demonstrate the influence of the food source with regard to both availability and quality on the consumer population. It also shows the influence of the qualities of the consumer population (e.g. age-size distribution) on the food requirements of the population. This model is being developed to investigate the properties of a population at a fine level of resolution.

Process modeling (coarse level of resolution):

In this approach, an attempt is being made to investigate the structure of an entire food chain as it influences the rate of secondary production and the rate of passage of materials through the chain. The structure of the chain is defined by the degree of interconnectedness between its members. For food chains using detritus or microbes as a basic food source, the rate of material passage may be critical to mineral cycling in the entire ecosystem.

The food chains contain a series of loosely defined functional groups (Fig. 3). For each group, basic life history, growth, and survivorship patterns are described according to the general behavior of species fitting the group description. From these patterns, coarse level models of consumption, growth, elimination and death are formulated. Year simulations of the food chain behavior are made based on these models. Turnover and secondary production rates are calculated for each functional group and for the entire food chain. Comparisons are made between food chains of different structure and between groups of different life history patterns. Only two food chains have been examined so far. Several more patterns will be investigated prior to the formal report.

Expected Publications

Internal reports:

Spruce budworm biomass transfer model. (from work done in 1971)

Litter layer arthropods--a compartment model.

A canonical model of consumer populations.

Food chain turnover rate experiment.

Formal papers:

Spruce budworm biomass transfer model. To be submitted to Annals of American Entomological Association.

Food chains in the coniferous forest--modeling strategies and examples. To be included in the AIBS Coniferous Biome Symposium.

Figure 1. A diagram of the litter layer arthropod system used in formulation of the practice model.

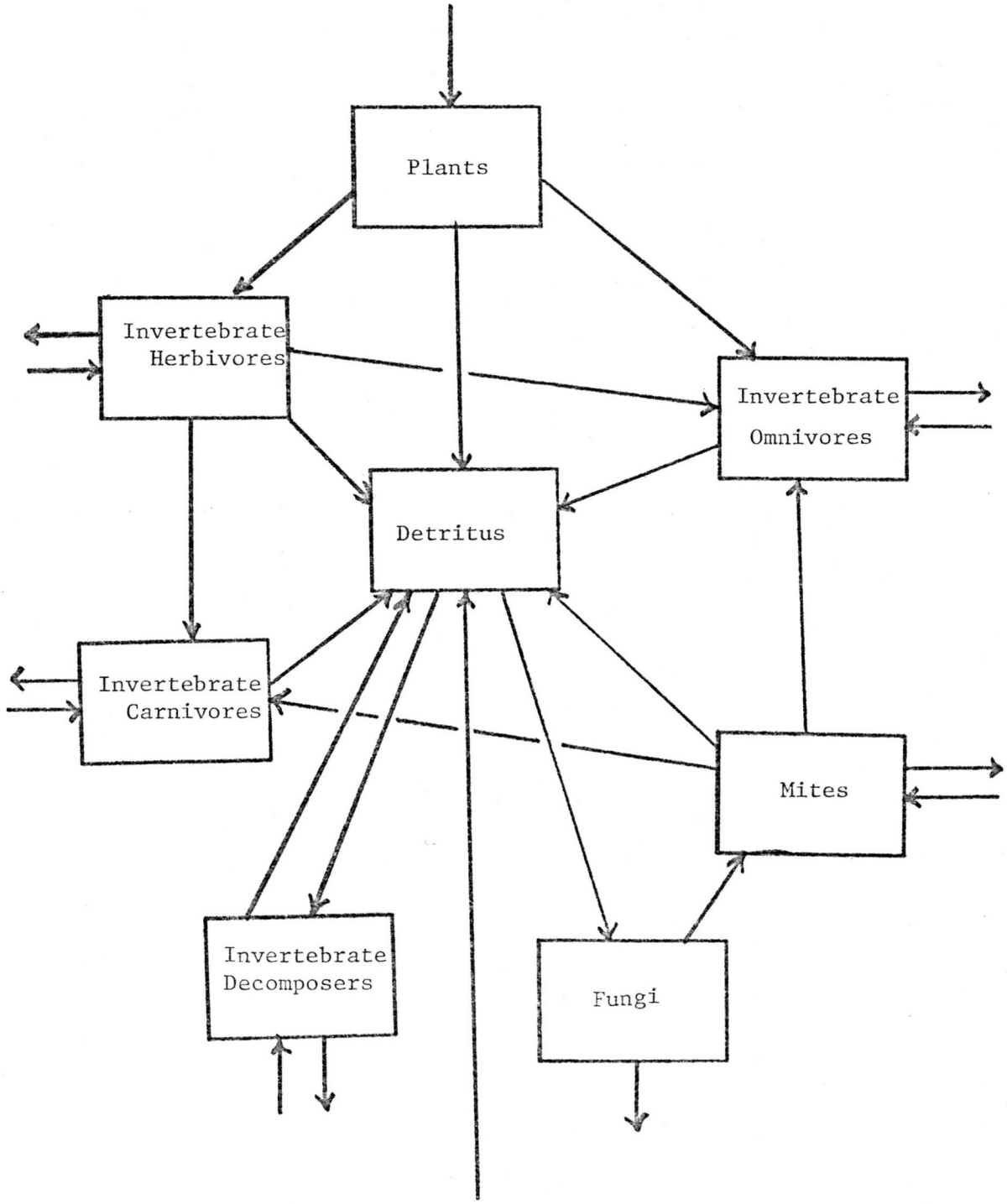
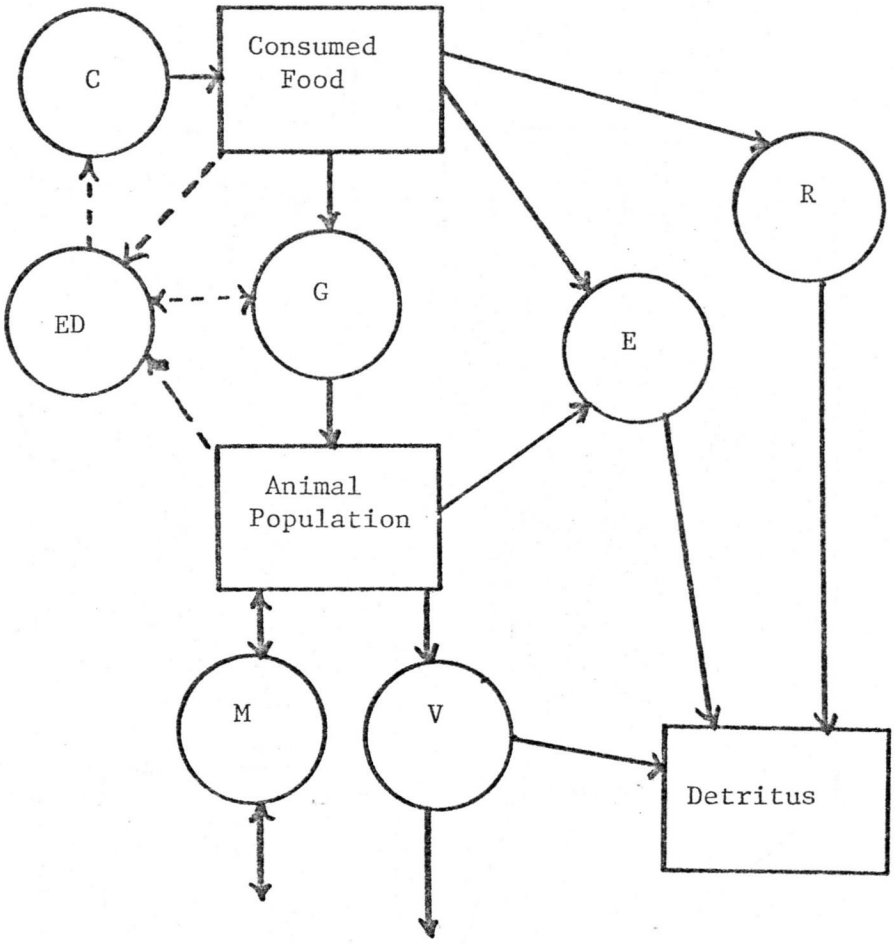


Figure 2. A diagram of a fine resolution model of an animal population showing the relationships between the relevant process submodels. The solid lines indicate material transfer and the dotted lines indicate information transfer.



Processes:

C - Consumption
ED - Energy demand
G - Growth
E - Ejection (elimination)
R - Rejection (waste)
M - Migration
V - Vulnerability (death)

Figure 3. An example of a simplified food chain showing functional groups.