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About ISEM

The International Society for Ecological Modelling (ISEM) promotes the international exchange of ideas, scientific results, and general knowledge in the area of the application of systems analysis and simulation in ecology and natural resource management. The Society was formed in Denmark in 1975, and today has chapters in Europe, Asia, and North- and South-America. ISEM sponsors conferences, symposia, and workshops that promote the systems philosophy in ecological research and teaching, and in the management of natural resources. The Society publishes the newsletter ECOMOD, and its members frequently contribute articles to the official scientific journal of the Society, *Ecological Modelling*.

Perspectives

Howard T. Odum

Environmental Engineering Sciences

University of Florida, Gainesville, Florida, USA

Suggestion for a Project for The International Society of Ecological Modelling:

Representing Simulation Models With Energy Systems

Abstract: This is a proposal for an ISEM project to represent the full detail of published simulation models in a form readily understood from inspection of network diagrams on paper. In a project supervised by committee and with the participation and approval of the authors of each model, an atlas of diagrams of simulation models can be prepared. Each diagram should be accompanied by the difference and logic equations extracted from the computer codes and also represented by the symbol network. Making models visible and more easily understood will encourage use by more people, more discussion of the structure and functions in previous models, and more building of one effort on another. People can trust a model better if they understand what is in it. Then they can suggest the changes they require for additional used in other situations.

Energy Systems Language

In wide usage since 1966, the symbols and diagramming rules of the energy systems language are used to represent a model in Figure 1. The language contains mathematical equivalents, energy constraints, and means of representing information as summarized in the Appendix from a recent book [1]. When symbols are placed on the page from left to right in order of their energy transformity, a model drawn by one person is congruent with those of another. Whereas the language is also used qualitatively in a soft way as a first step in converting verbal, mental models to network form, this project might rigorously represent already published, simulated models. Detailed explanations of the language's use and mathematical definitions are already available in many books and papers [2], but a committee of the society could choose to modify or elaborate symbols and rules for these purposes.

Example

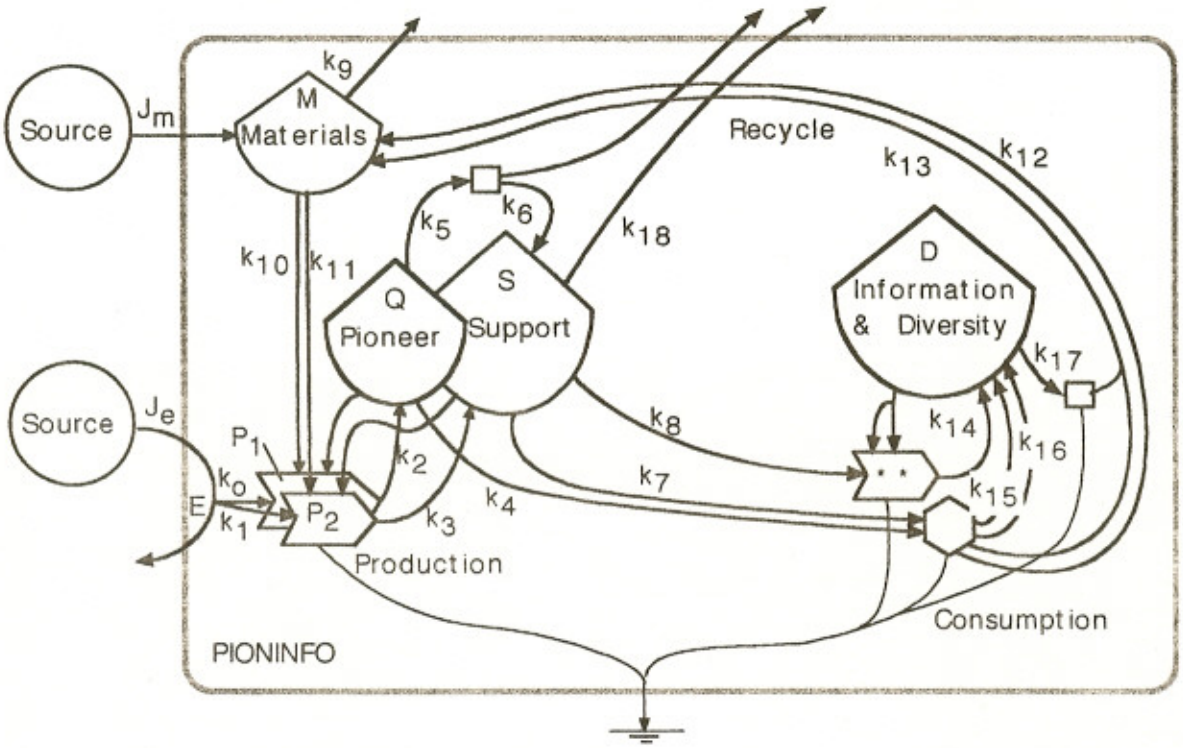
The simulation model diagrammed with energy systems symbols in Figure 1 has the equations that are implied [3]. More complex models require several pages. It may be desirable to include at least one simulation run (example: Figure 2) so that readers can better understand what is involved. Authors, graduate students, or secretaries can generate figures from pencil drawings with little training. With the symbols in memory as "macros", Figure 1 was drawn with CANVAS in 1-2 hours. After being checked by authors, figures are easily edited and printed out.

Participation of Authors

Whereas the translation of an energy systems diagram to equations is rigorous and unambiguous, the reverse translation of equations to systems diagrams has more than one solution. For example, a systems design on paper that translates to logistic differential equation is clear, but for mathematical equations that reduce to the logistic, we know of 18 different network designs, each with different mechanistic rationale. Thus, the participation of the authors of a model is needed to make sure that the network mechanisms are the ones originally intended. Also, the diagramming requires the energy processing to be shown, another aspect that may require the author to indicate what was in mind. For example, an algorithm used by Richard Wiegert to model consumer animal populations, when diagrammed with aid of one of his former students, was different and clearer than one done without participation of the modeller (although both were mathematically correct).

An Aid to Comparative Ecology

So called "canned" models developed for one area are being systematically applied in other areas and ecosystems by integrative organizations such as the network of Long Term Ecological Research sites (LTER'S) of the National Science Foundation. The participants in these group projects have no easy way to know the details of the models. Even the authors of models using them later do not remember all the details. Even when code print-outs are available, it is not easy to see what is being represented, what should be



$$E = J_e - k_0 * E * M * Q - k_1 * E * M * S \quad \text{Therefore } E = J_e / (1 + k_0 * M * Q + k_1 * M * S)$$

$$P = P_1 + P_2 \quad \text{where} \quad P_1 = k_2 * E * M * Q \quad \text{and } P_2 = k_3 * E * M * S$$

$$C = k_4 * Q + k_7 * S + k_8 * S * D * D \qquad P_{net} = P - C$$

$$dQ = P_1 - k_4 * Q - k_5 * Q$$

$$dS = P_2 + k_6 * Q - k_7 * S - k_8 * S * D * D - k_{18} * S$$

$$dM = J_m + k_{12} * Q + k_{13} * S - k_9 * M - k_{10} * E * M * Q - k_{11} * E * M * S$$

$$dD = k_{14} * S * D * D + k_{15} * S + k_{16} * Q - k_{17} * D$$

Figure 1. A simulation model relating productivity, competitive dominance of successional weeds and diversity [2].

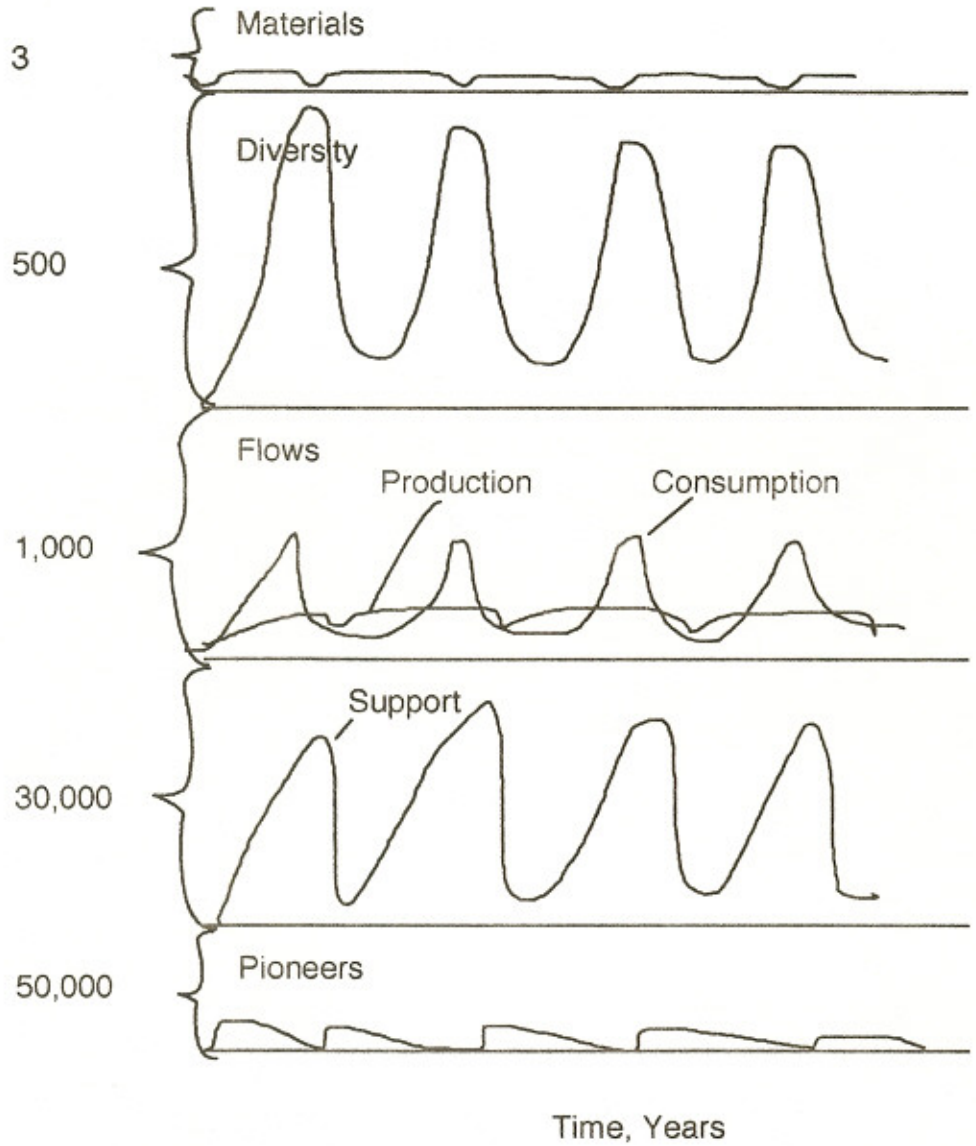
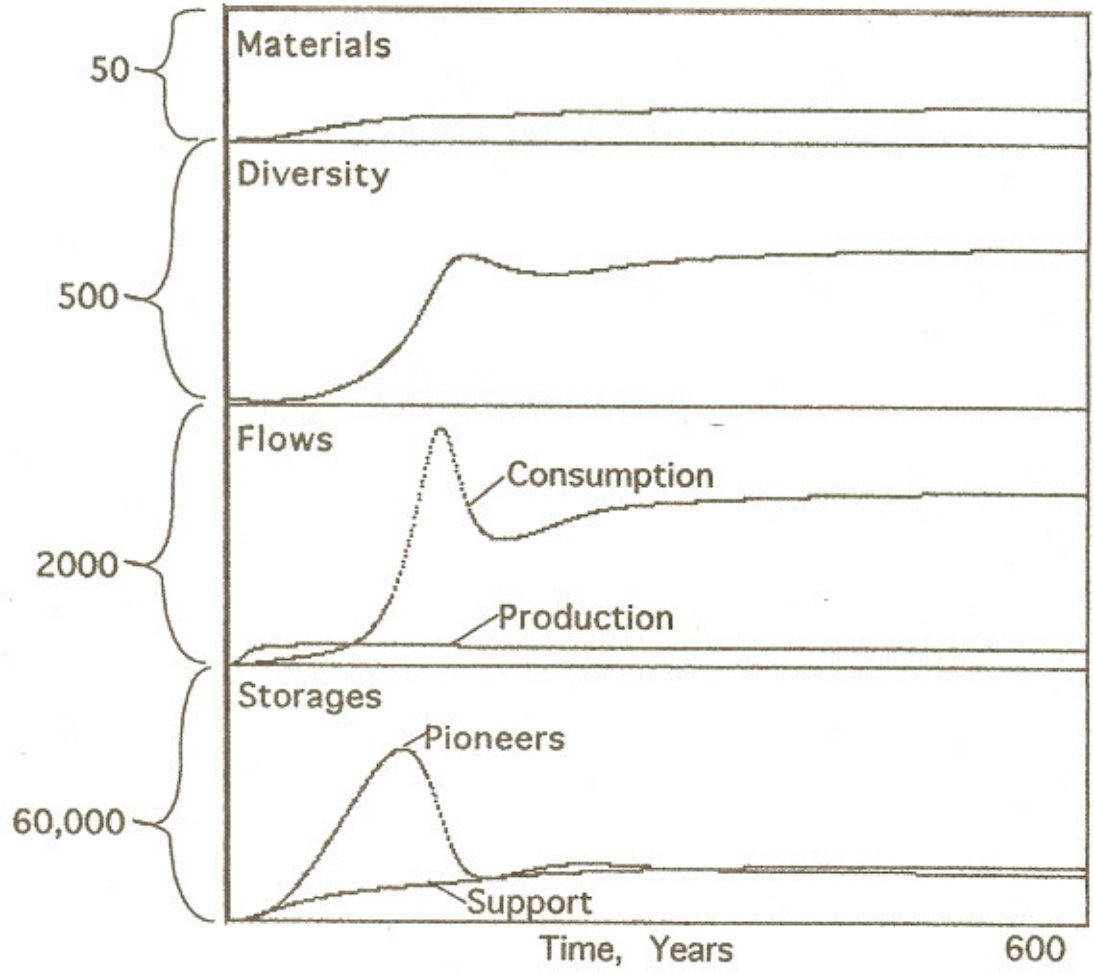


Figure 2. A simulation of the productivity-diversity model in Figure 1 showing initial low diversity of pioneers using excess resources (materials and energy) being replaced by high diversity and recycle processes [2].

[Editor's note: Due to a software incompatibility, Figure 2 is not an exact reproduction of the material submitted by Dr. H. T. Odum] Original is included.

modified, or how an investigator dealing with a particular part can relate.

For example, the Century model is being used in a general way in more than one biome of the NSF Long Term Ecological Research groups. A first draft of a diagram of that model showed it to be a soil organic matter



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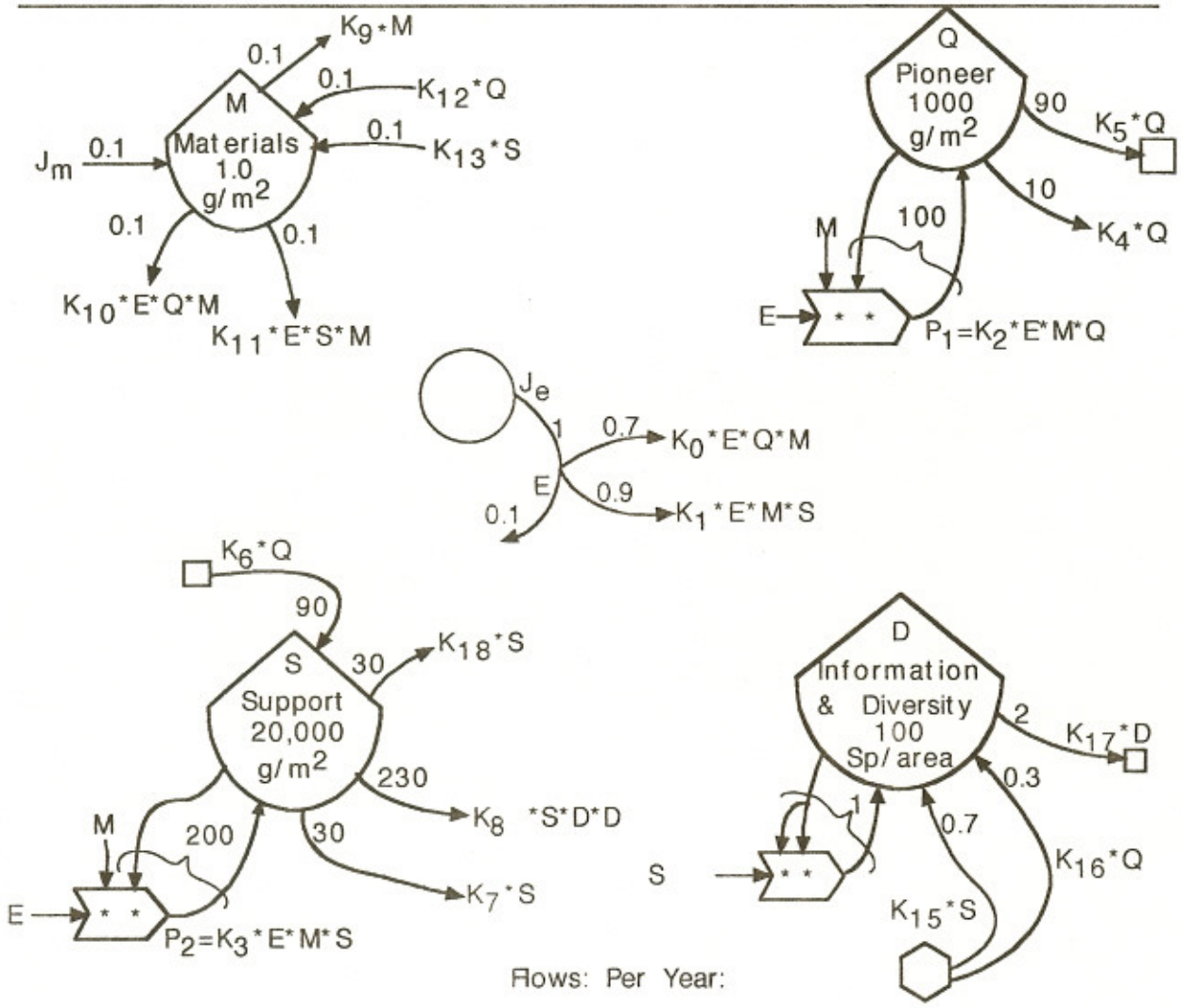


Figure 3. Symbols of the model PIONINFO in Figure 1 isolated to document calibration.

model with storages and pathways of organic matter on several scales with other aspects of ecosystems de-emphasized. Robert Waide, coordinating exchange between LTER programs, recently endorsed the intent of this proposal.

References

[1] Odum, H.T. 1996. Environmental Accounting, Emergy and Decision Making. J. Wiley, NY, 370 pp.

[2] Odum, H.T. 1983, 1993. Systems Ecology (reprinted as Ecological and General Systems). Univ. Press of Colorado, Niwot, CO, 644 pp.

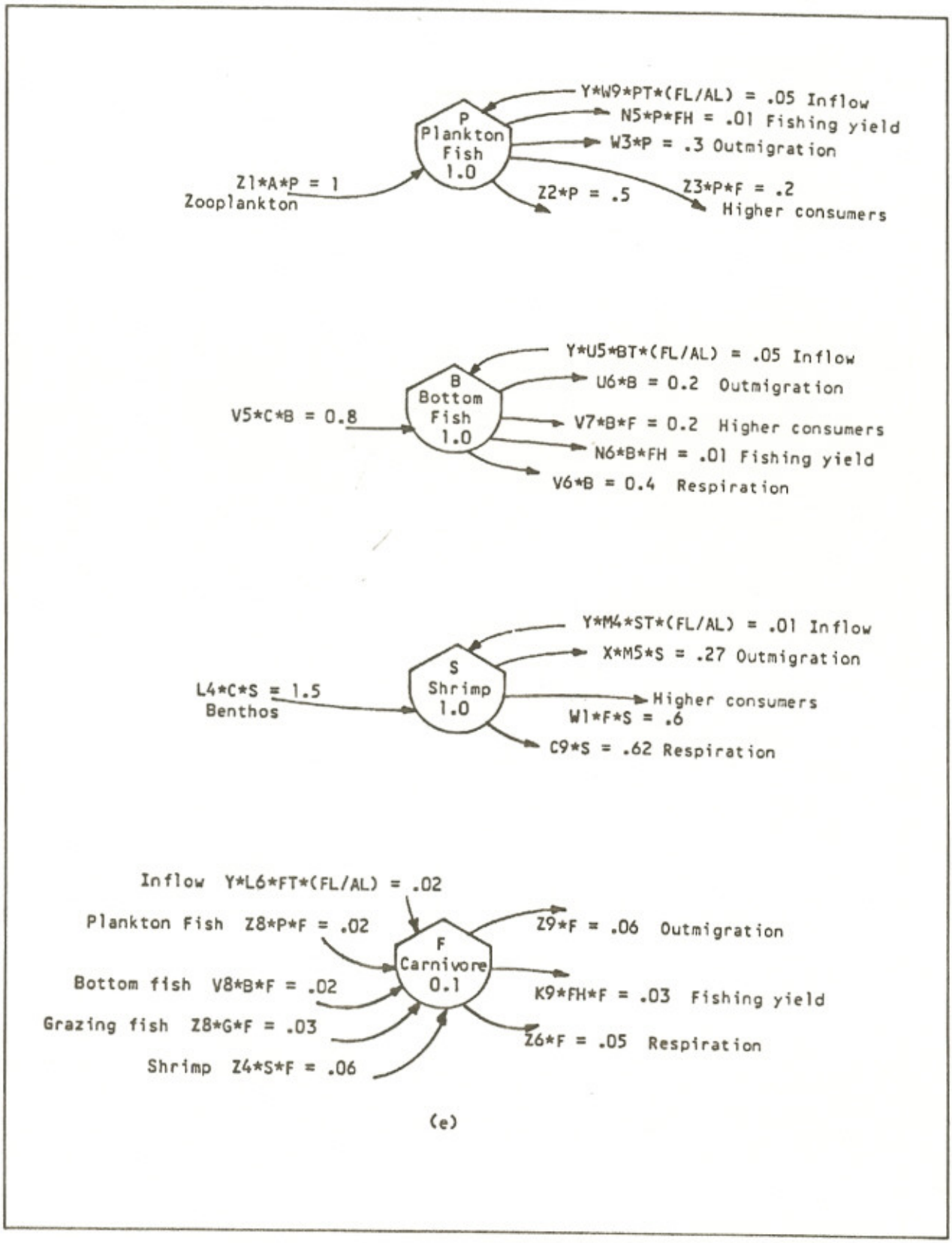
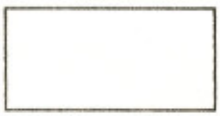


Figure 4. One of the several pages of detail showing mathematical terms and calibration for the model in Figure 3.

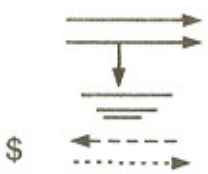
Appendix
Use of Energy Systems Symbols

SYSTEM FRAME-- A rectangular box is drawn to represent the boundaries that are selected. Boundaries selected must include three dimensions. For example, the analysis of a city would probably
include its political boundaries, a plane below the ground surface (example, 10 m), and a plane above the city (example, 100 m).



SOURCE-- Any input that crosses the boundary is a source, including pure energy flows, materials, information, genes, services, and inputs that are destructive. All of these inputs are given a circular symbol. Sources are arranged around the outside border from left to right in order of their solar transformity starting with sunlight on the left and information and human services on the right. No source inflows are drawn in to the bottom.

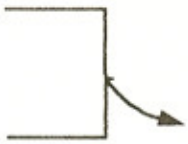
PATHWAY LINES-- Any flow is represented by a line, including pure energy, materials, and information. Money is shown with dashed lines. Where material flows of one kind are to be emphasized, dotted lines are suggested (or color). Barbs (arrowheads) on the pathways mean that the flow is driven from behind the flow (donor driven) without appreciable backforce from the next entity. Lines without barbs flow in proportion to the difference between two forces; they may flow in either direction.



HEAT SINK-- The heat sink symbol represents the dispersal of available energy (potential energy) into a degraded, used state, not capable of further work. Representing the second energy law, heat sink pathways are required from every transformation symbol and every tank. At the start, one heat sink may be placed at

the center bottom of the system frame. Then two lines at about 45 degrees to the bottom frame border are drawn to collect heat sink pathways. Using finer lines or yellow lines for heat sinks, keeps these from dominating the diagram. No material, available energy, or usable information ever goes through heat sinks, only degraded energy.

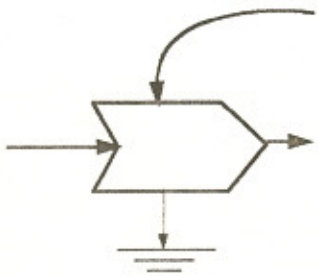
OUTFLOWS-- Any outflow which still has available potential, materials more concentrated than the environment, or usable information, is shown as a pathway from either of the three upper system borders, but not out the bottom.



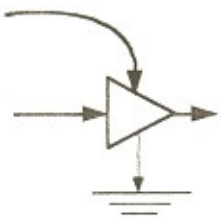
STORAGE TANK-- Any quantity stored within the system is given a tank symbol, including materials, pure energy (energy without accompanying material), money, assets, information, image, and quantities that are harmful to others. Every flow in or out of a tank must be the same type of flow and measured in the same units. Sometimes a tank is shown overlapped by a symbol of which it is part. For example: wood storage, a part of Radiata Pine population in Figure 13.1a.

ADDING PATHWAYS-- Pathways add their flows when they join or when they go into the same tank. No pathways should join or enter a common tank if they are of different type, transformity or measured in different units. A pathway that branches represents a split of flow into two of the same type (Figure 2.6).

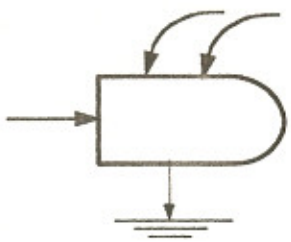
INTERACTION-- Two or more flows that are different and both required for a process are connected to an interaction symbol. The flows to an interaction are drawn to the symbol from left to right in order of their transformity, the lowest quality one connecting to the notched left margin. The output of an interaction is an output of a production process, a flow of product. These should usually go to the right, since production is a quality-increasing transformation.



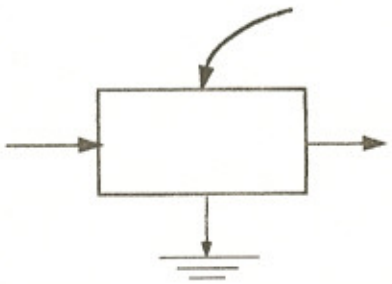
CONSTANT GAIN AMPLIFIER-- A special interaction symbol is used if the output is controlled by one input (entering symbol from left), but most of the energy is drawn from the other (entering from the top).



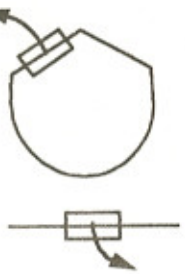
PRODUCERS-- Producer symbols are used for units on the left side of the systems diagram that receive commodities and other inputs of different types interacting to generate products. The producer symbol implies that there are intersections and storages within. Sometimes it may be desirable to diagram the details of interactions and processes inside. Producers include biological producers such as plants and industrial production.



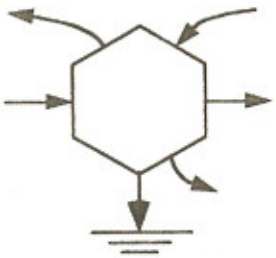
MISCELLANEOUS BOX-- The rectangular box is used for any subsystem structure and/or function. Often these are appropriate for representing economic sectors such as mining, power plants, commerce, etc. The box can include interactions and storages with products emerging to the right. Details of what goes on in within the consumer is not specified unless more details are described or diagrammed inside.



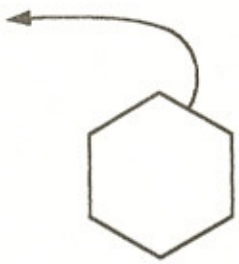
SMALL BOX-- A very small box on a pathway or on the side of a storage tank is used to initiate another circuit which is driven by "force" in proportion to the pathway or storage. This is sometimes called a "sensor" when it delivers its action without draining much energy from the original pathway or tank.



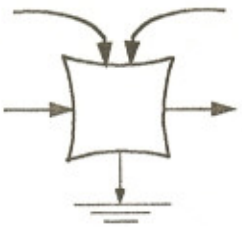
CONSUMERS-- Consumer symbols are used for units on the right side of the systems diagram that receive products and feedback services and materials. Consumers may be animal populations or sectors of society, such as the urban consumers. A consumer symbol usually implies autocatalytic interactions and storages within (Figure 2.7a). However, the consumer symbol is a class symbol (refers to many similar but different units), and details of what goes on within the consumer are not specified exactly unless more details are diagrammed inside.



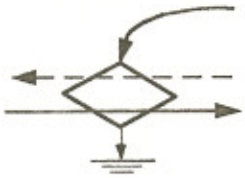
COUNTER-CLOCKWISE FEEDBACKS-- High quality outputs from consumers, such as information, controls, and scarce materials, are fed back from right to left in the diagram. Feedbacks from right to left represent a diverging loss of concentration, the service usually being spread out to a larger area. These flows should be drawn with a counterclockwise pathway (up, around, and above the originating symbol--not under the symbol). These drawing procedures are not only conventions that prevent excess line crossing and make one person's diagrams the same as another's, but they make the diagrams a way of representing energy hierarchies.



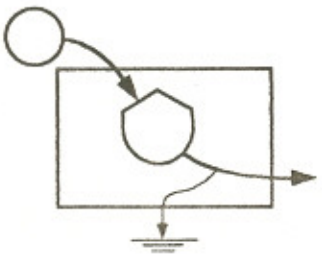
SWITCH-- The concave sided box represents switching processes, those that turn on and off. The flows that are controlled enter and leave from the sides. The pathways that control the switches are drawn to the top. This includes thresholds and other information. Switching occurs in natural processes as well as with human controls. Examples are earthquakes, reproductive actions, and water overflows of a river bank.



EXCHANGE TRANSACTION-- Where quantities in one flow are exchanged for those of another, the transaction symbol is used. Most often the exchange is a flow of commodities, goods, or services exchanged for money (drawn with dashed lines). Often the price that relates one flow to the other is an outside source of action representing world markets; it is shown with a pathway to the top of the symbol.



MATERIAL BALANCES-- Since all inflowing materials either accumulate in system storages or flow out, each inflowing material, such as water or money, needs to have outflows drawn.



Appendix A in Environmental Accounting (Odum 1996) [1]
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President's Address

This is my first message as President of ISEM. Let me begin by first thanking all who supported me in the 1998 election. I pledge to do the utmost during my tenure to prove that vote of confidence is well founded. Secondly, and more importantly, I want to thank our outgoing President, Bill Grant and Secretary-General, Ed Rykiel for their outstanding and invaluable service to ISEM. Bill, Ed, from myself and on behalf of ISEM---Thank you. You've left some big shoes to fill. It is now up to the new Executive Officers, myself, Secretary-General Wolfgang Pittroff, and Treasurer Dave Mauriello, to pick up the ball (to mix metaphors!) and continue the job of carrying ISEM into the future.

Now, to business. ISEM is still in the process of internal reorganization and transition to our new relationship with Elsevier Science BV. Former President Bill Grant outlined the main points of the ISEM reorganization in his President's Address in the September 1998 issue of ECOMOD. (That issue also contains the letter of Incorporation of ISEM and the Bylaws of ISEM. Inc.) We have made much progress in the reorganization, but work remains. Implementation of our new policy with Elsevier wherein Elsevier invoices and collects membership and subscription fees directly from members, and mails journal issues directly, has been ... bumpy. Things are improving, but are certainly not yet satisfactory (as many of you have experienced).

Be assured that we, capably led by Secretary-General Wolfgang Pittroff, are aggressively pursuing the resolution of remaining issues, "bugs" if you will, in this procedure. We ask your patience in this matter. But we also encourage you to report, to myself (awk@ornl.gov) or Wolfgang (wolfgang@stat.tamu.edu), any and all problems or concerns you encounter with billing from Elsevier, journal delivery, etc. Your feedback will help us "fix what needs fixin'".

As part of the reorganization of ISEM,