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Further Development of a Stream Ecosystem Model

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FURTHER DEVELOPMENT OF A STREAM ECOSYSTEM MODEL

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ABSTRACT

This report describes accomplishments involving the General Stream Ecosystem Model from June of 1974 to November of 1975. These accomplishments include an exploratory sensitivity analysis of the model and model structure changes based on that analysis. Additional model output, which allows for the study of the function as well as structure of stream ecosystems, is described. Also included are a "User's Guide for Exploratory Sensitivity and Statistical Analysis," proposed research including model validation, and an overview of the General Stream Ecosystem Model.

INTRODUCTION

This report describes accomplishments involving the General Stream Ecosystem Model from June of 1974 (report by Wlosinski et al. 1974) to November 1975. Work on the model during that time progressed as a cooperative venture between members from two separate projects; the Aquatic Section of the Desert Biome, US/IBP, and members of the Utah Cooperative Fishery Unit with funding from the Central Utah Project, Bureau of Reclamation.

In July of 1974 an exploratory sensitivity analysis of the model was made to qualitatively test the response of the model over a range of driving variables, and to make recommendations for model structure changes based on the results. This analysis was completed in November of 1974 and was followed by a joint meeting of the modeling personnel from the Aquatic Section of the Desert Biome and those from the Utah Cooperative Fishery Unit. At that meeting several recommendations were made concerning the stream ecosystem model. First and foremost, it was decided that it would be necessary to have additional information available concerning the structure and function of each simulation in order to gain a better understanding of the model and the stream ecosystems mimicked by the model. Second, recommendations concerning model structure (Wlosinski 1975a) were to be implemented. Third, work was to continue on a literature search to aid in setting parameters of the present model as well as uncovering areas of concern in real world situations which are presently not incorporated into the model. Fourth, the members from the Desert Biome group were to prepare data decks of stream sections which were to be used for validation studies in conjunction with a planned manipulation of light in Deep Creek, Curlew Valley (on the Utah-Idaho border) during the summer of 1975. Fifth, the modeling group would search for new uses for the model, offering it at its present level of development in exchange for expertise in different fields of aquatic systems to be used to further aid in development of the model.

In addition to further explanation of the work cited above, this report includes a "Users Guide for Exploratory Sensitivity and Statistical Analysis," and proposed research for 1976. An overview of the General Stream Ecosystem Model will first be given.

OVERVIEW OF THE GENERAL STREAM ECOSYSTEM MODEL

The General Stream Ecosystem Model is an abstract, dynamic, nonlinear, simulation model, in which the ecosystem is envisaged as a horizontally homogeneous stretch of water. It is not general in the sense of Levins (1966) who proposed sacrificing realism or precision as a strategy to gain generality. However, the model is general in the sense that specific components of the ecosystem modeled are not specified by the model, but are left to be specified by the user at execution time, along with a series of switches and parameters that control those components. With this control it becomes unnecessary to describe separately the process in which each state variable is involved. Instead, switches and parameters are set in a manner that allows only processes relevant to a particular state variable to occur.

At the present time the main state variables modeled are the quantities of the different organic constituents which make up the plants, animals, heterotrophic microorganisms, detritus and the dissolved component of water, the inorganic constituents (either dissolved or in a particulate state) and certain physical characteristics, such as depth and velocity. Exogenous variables include materials entering the ecosystem from upstream drift, tributaries, overland flow, and from the atmosphere. Materials may exit from the system through downstream flow, by way of withdrawals for irrigation, or in the case of water, by evaporation. Those variables that represent materials which leave the system as downstream flow may be saved and used as input for a downstream section when more than one stretch of stream is to be simulated.

The processes modeled which may affect the plants are photosynthesis, plant respiration, consumption by animals, mortality, leakage, scouring and colonization. The animals may be affected by ingestion, respiration, assimilation, egestion, predation, transfer from one size class to another (including reproduction), nonpredatory mortality, scouring, colonization and behavioral drift. Decomposition, respiration, lysing, assimilation, consumption by animals, scouring and deposition affect the heterotrophic microorganisms. Organic detritus may be consumed, and along with inorganic detritus may be scoured or deposited.

The computer representation of the model is written in FORTRAN IV, using difference equations over a time step of one day. If the approximation by difference equations over this time step leads to negative values of an essentially nonnegative variable, the program reduces the time unit as required. Output can be in graphical or tabular form. Tabulated reports on any day specified may include the weights of any components of the system, all allochthonous materials entering the system as well as components leaving by way of the downstream vector, and productivity of the components of the system. Certain physical characteristics may also be included as output. Most of these same variables may be graphed against time through the course of simulation. Output units may be in grams per square meter, grams per cubic meter or grams per ecosystem where ecosystem is a variable, being defined as the volume of water contained in the stretch of stream being modeled.

A much more detailed explanation of the model can be found in reports by Wlosinski et al. (1974) and Stalnaker et al. (1975).

EXPLORATORY SENSITIVITY ANALYSIS

Exploratory sensitivity analysis was accomplished by qualitatively comparing outputs of a series of simulations in which a different level of a driving variable was used in each simulation. Although exploratory sensitivity analysis (term from Noy-Meir and Goodall 1973) has not been found in the literature as such, a few works have been found where driving variables have been changed and their effect on the state variables noted. Much of this work has been done on terrestrial models in connection with the IBP Tundra Biome (Miller and Tieszen 1972, Miller et al. 1973, Miller 1974). Although the purpose may not have been to look for peculiarities in the model, Miller (1974) mentions that several changes have been made to the model after the sensitivity analysis. Brylinsky (1972) studied model sensitivity to photosynthesis, which was a forcing function in his model. Rykiel and Kuenzel (1971) manipulated forcing functions to measure steady state in their model of the wolves of Isle Royale. Terrestrial models from five different biomes (IBP) were tested with parameterized climatic changes by Cooper et al. (1974). Cooper used "models [that] have been extensively validated" and drew several major conclusions from the study. Fowler (1973) studied the effect of altered stream flow and suggested that the "determination of the effect of different climatological conditions on the overall behavior of the system" be studied. It was Fowler's approach that was taken for the exploratory sensitivity analysis on the General Stream Ecosystem Model.

Exploratory sensitivity analysis on the General Stream Ecosystem Model employed two different data sets. One data set was collected on Deep Creek, a cool-desert stream, and the other simulated a generalized mountain stream. The latter data set was furnished by C. W. Fowler of the Cooperative Fisheries Unit of Utah State University as part of a grant to study the effects of reducing flow volume in a stream.

Although both studies were conducted at the ecosystem level, many of the components of the ecosystems were purposely deleted from the data sets. In the case of the Deep Creek study, more data were available than were actually used in the simulations, with the limitation being set by core storage in the computer. The mountain stream data were limited by the fact that the users wished to study interactions built into the model, so the number of components was kept at a minimum and the parameters used were for generalized groups rather than for specific species. All simulations spanned a period of one year.

Most of the Deep Creek data used for simulation were based on actual field measurements as collected by Desert Biome personnel (Aquatic Section) as part of the International Biological Program. A detailed description of Deep Creek is given in Minshall et al. (1973).

According to Minshall et al. (1973), Deep Creek drains a substantial portion of Curlew Valley, which lies at the Utah-Idaho border north of the Great Salt Lake. The climate of the area is semiarid, with total annual precipitation from 15 cm at the southern end of the valley to 41 cm at the northern end. There are four sampling stations on Deep Creek, with Station 2 being the collection point for most of the data used in simulations for sensitivity analysis. Discharge at Station 2 is regulated by Holbrook Springs, which provides a constant discharge of 17 C water at the rate of .46 cubic meters per second. The flow of the spring is supplemented and the temperature significantly reduced during periods of heavy snowmelt runoff. During the summer the volume of flow is reduced in areas where water is diverted for irrigation.

For the drift of materials entering the system through upstream flow, four sets of data were used, being collected in January, June and August of 1971 and April of 1972. Interpolation was used for all periods between collection times. Appendix K of the report by Wlosinski et al. (1974) contains a complete listing of all input data used for simulations for Deep Creek. Appendix L of that report is a listing of initial conditions used for the Deep Creek simulations. The values for initial state variables were supplied by G. Wayne Minshall, Idaho State University, who coordinated the aquatic studies project.

There are five species or groups of plants, eight animal species (of which seven are invertebrates and one a fish), two groups of heterotrophic microorganisms and two size classes of organic detritus. In addition, the eight animal groups are subdivided into three to eight size classes for each group.

The mountain stream simulation had as the main state variables three taxa of plants, six taxa of animals, one heterotrophic microorganism and one detrital category. According to Fowler (pers. comm.) this is a gross simplification but represents what are viewed to be representative of the major groups or "para-species" within the system. The animals play the roles of detritivores, carnivores and herbivores, and they can be looked at as representatives of larger taxonomic groups. The six animal groups are two species of fish and four species of invertebrates. As in the Deep Creek data deck, each taxon is further broken down into size categories.

Information concrning constituents from upstream were contained in monthly data sets, with interpolation used between each data set. Appendix C of the report by

Wlosinski (1975a) contains listing for the data deck of the mountain stream. Appendix A of that report contains initial state variables for the mountain stream.

The parameters used in the simulations were set in several ways. Some of the parameter values were taken directly from the literature, as listed in Minshall et al. (1974), with others being set by solving equations in the model to produce solutions to correspond with values found in previously published work or actual field or laboratory study. Most of the parameters, though, were unknown, and had been set either as a "best guess," or by trial-and-error fitting. It is my opinion that the parameter sets used do not in all cases reflect the best information available at the present time and that further upgrading is needed.

The Sperry Rand Univac 1108 computer was used for all exploratory sensitivity analysis. A simulation would be run during which time values representing state or other variables of interest were collected and stored on an external data file. This step would be repeated once or twice, with different levels of a driving variable or exogenous input being used for each simulation. The model used was as described in the report by Wlosinski et al. (1974) except for a slight revision of the main program which allowed for the collection and storage on an external file of state variable values. After a set of runs were made with different levels for a particular exogenous variable, another program would bring together the set of external data files, and simultaneously graph the variables of interest. The sets of driving variables changed are listed in Table 1, while Table 2 lists the variables graphed. To make sure the proper external data files were used in the graphing routine, all control cards used were printed at the start of each graphing series. The following conclusions and recommendations were made based on exploratory sensitivity analysis (Wlosinski 1975a):

1. The model has the potential of being a theoretical as well as a managerial tool. Its theoretical value is its use in studying the dynamics of the total ecosystem through time. This is possible because the model tracks through time all exchanges of constituents between the ecosystem and the surrounding biosphere, the mass of all components of the system, and the productivity of trophic levels, either in daily increments or total productivity for the entire simulation period. In addition, all the fluxes for particular levels may be followed through time. As a managerial tool it could be used to study the change of the ecosystem given certain perturbations.

2. Exploratory sensitivity analysis is a valid means of examining the response of the model over a range of driving variables. The graphs from the analysis show how the model has been analyzed in this manner with the results aiding in suggesting revisions for parts of the structure of the model. In addition, exploratory sensitivity analysis helps by showing faulty parameters used for the simulations.

3. A better means of modeling changes that occur as the discharge changes should be sought. Increased discharge causes the size of the ecosystem to expand, covering greater areas of the stream bottom. The opposite occurs as the discharge decreases. When the size of the ecosystem increases or deceases, state variables (e.g., plants and detritus) may be covered or uncovered by water, a process which is not now modeled. Since the area of a stream which may be wetted or dried is in itself a complex ecosystem and its modeling not within present objectives, I recommend simply adding or subtracting a value equal to the average value for nonmotile constituents occurring in the ecosystem as depth increases or decreases.

4. Work should be undertaken to model the heterogeneity found in a stream ecosystem. In the model a plant is conceptualized as a solid sheet across the stream, absorbing radiation and thus shading all plants beneath it. In many instances in a stream system this is not the case, as pointed out by Hynes (1970). In these instances, problems arise in the model because plants occurring below other plants may be shaded to a much greater or lesser extent than is found in the stream being modeled.

5. It has been pointed out in many studies and reviewed by Hynes (1970) that the velocity of water and the type of substratum are important factors regulating the occurrence and distribution of much of the biota in streams. At present these are not treated in the model and steps should be taken to model these phenomena.

6. A better means of providing more continuous temperature input should be incorporated into the model. It has been pointed out that the ecosystem is affected more by a change in temperature than by other driving variable changes and that, at present, only a few measured temperature values are read as data. By tracking temperature more closely, the model should have more predictive value. I recommend reading daily value for temperature.

Table 1. The levels of exogenous variables used for exploratory analysis of the General Stream Ecosystem Model

Variable(s) changed	Deep Creek	Mountain stream
Discharge -- multipled by	.5	.5, .25
Temperature -- multiplied by		1.1, .9
Temperature -- plus and minus	5C	
Solar radiation -- multiplied by	.75, 1.25	.75, 1.25
Inflowing dissolved inorganic constituents -- multiplied by	.5, 2.	.5, 2.
Inflowing detritus -- multiplied by	.5, 2.	.5, 2.
Discharge -- multiplied by*	.5	
All inflowing constituents -- multiplied by	2.	

*The last two variables were changes and simulated as a single perturbation.

7. Any animal in the system may ingest any food within or passing through the ecosystem. Foods may be any animal, plant, decomposer or detritus category, with ingestion being controlled by a preference-availability factor and the amount of the foods available. I believe the total amount of food passing through the ecosystem should not regulate the amount of food ingested by a consumer. Given otherwise identical streams, a consumer (in the model) in a larger stream would be allowed to ingest more than a similar consumer in a smaller stream. Although food passing in the immediate vicinity of an invertebrate may affect the amount ingested, I do not believe food meters away from an invertebrate affects its ingestion, a problem that should be corrected. By dividing the foods entering the ecosystem by the cross-sectional area of the stream, this problem should be alleviated.

Table 2. Variables graphed for exploratory sensitivity analysis of the General Stream Ecosystem Model

1. Biomass for each species or group of plants.
2. Total net productivity from the beginning of the simulation for each species or group of plants.
3. Daily net productivity for each species or group of plants.
4. Biomass for each species or group of animals.
5. Total growth (listed as productivity) from the beginning of the simulation for each species or group of animals.
6. Daily growth for each species or group of animals.
7. Biomass for each group of heterotrophic microorganisms.
8. Total growth from the beginning of the simulation for each goup of heterotrophic microorganisms.
9. Daily growth for each group of heterotrophic microorganisms.
10. Total biomass for all plants.
11. Total net productivity from the beginning of the simulation for all plants.
12. Daily total net productivity for all plants.
13. Total biomass for all animals.
14. Total growth from the beginning of the simulation for all animals.
15. Daily total growth for all animals.
16. Total biomass for all heterotrophic microorganisms.
17. Total growth from the beginning of the simulation of all heterotrophic microorganisms.
18. Daily total growth for all heterotrophic microorganisms.
19. Mass for each size class of organic detritus.
20. Total mass for all organic detritus.
21. Net gain or loss of organic carbon to the ecosystem.
22. Photoperiod.
23. Radiation.
24. Discharge.
25. Temperature.
26. Depth of water.
27. Amount of water in the ecosystem.
28. Water velocity.

8. The processes modeled involving animal growth should be examined for their realism. Although the problem may be attributable to a faulty parameter set, it was pointed out that growth of the western speckled dace was thought to be abnormally fast, a problem also occuring with other animal representatives of both Deep Creek and the mountain stream.

9. Discontinuous functions should be examined for their realism. This recommendation is based on the fact that a temperature change caused egg deposition to be completely halted.

Additional Model Output

Since the November meeting work was undertaken to make additional information available to the user of the computer program, as output. This output is of three main types, corresponding to needs generated by much of the present ecological theory and work and allows for the inspection and comparison of internal dynamics of ecosystems.

First, numerical output concerning community metabolism is now available. This includes gross productivity of plants and respiration of plants, animals and microorganisms. Units for this ouput are in kilocalories for either an ecosystem or a square meter and for each time unit of simulation or accumulated throughout the simulation. Also available is the ratio of productivity to respiration (P:R) within the community.

Second, much of the present ecological theory is based on the structure and function of trophic levels. Output of this nature was previously unavailable because values representing this information were calculated at the level of taxonomic groups. To make bioenergetics of animals available, the model was altered to internally compute the fraction of the diets for all groups of animals coming from different food sources. The model first computes and has available for output the proportion of the total ingestion for each species of animal (and the total for all animals) coming from plants, animals, detritus and microorganisms. Since ingestion depends, in part, upon the amounts of different food sources available and since the relative amounts of these sources change through time, a graph showing the changes of intake from different food sources becomes quite useful. The actual amounts of food ingested are also calculated on the basis of a trophic level, partitioning the food eaten by each species according to the proportions calculated above. Animal respiration is calculated in the same manner, as is net production (growth). The latter three outputs are given in kilocalories per ecosystem for the period of simulation.

Third, exchanges of energy within the simulated ecosystem and between the ecosystem and the surrounding biosphere through time are followed now. Figure 1 is a simplified diagram of the energy flow (arrows) and levels (boxes) within the model. Each of the variables (boxes) shown in the figure may be represented in the model as a series of variables broken down by taxonomic categories or size classes, each with as many flows as represented in the figure. Each of the groups is also broken down to elemental constituents, each with a flow similar to Figure 1. Previously, only the amounts of the state variables at different points through time (structure) were reported to the user. The user had no idea of the function of the system. As an example, plant biomass on two different days may have been the same, which could mistakenly lead to the assumption that nothing was happening to the plants. But actually, flows of energy (or constituents) away from the plants by way of mortality, herbivory, respiration or outgoing drift may have been balanced by incoming drift or photosynthesis. These flows or rates describe the function of the system, and are just as important in describing an ecosystem as is the structure. Knowing the rates of different processes (arrows in Figure 1) is helpful in the study of a system for, although the biomass of a particular component is proportionally small, the turnover rate may be much faster than other components. Such situations may be very sensitive to perturbation. All of the rates of all processes shown in Figure 1 are now available as output in graphical or tabular form. Units are given in kilocalories per ecosystem for the simulation period, and as an average per ecosystem or per square meter per day.

The three major additions described (community metabolism, animal bioenergetics at the trophic level and the rates for all processes) have all been extensively tested in coded form and are now incorporated as part of the model. An example of the output of these three areas is given in Appendix A. A listing of the subroutine RPORT2 which handles this output can be found in Appendix B.

Additional model output is available as exploratory sensitivity and statistical analysis. For further explanation refer to the section of this report entitled "User's Guide for Exploratory Sensitivity and Statistical Analysis."

Model Structure Changes

Three of the five recommendations concerning changes of model structure, and covered under the section entitled "Exploratory Sensitivity Analysis," have now been implemented. First, exploratory sensitivity analysis of the model showed that the ecosystem is affected more by a change in temperature than by other driving variable changes, and that originally, only a few measured temperature values were read as data. By tracking temperature more closely the model should have better predictive power. The model has now been changed so that daily temperature values are read as data, which is one value for each simulated time step.

Second, any animal in the system may ingest any food within or passing through the ecosystem. Foods may be any animal, plant, decomposer or detritus category, with ingestion being controlled by a preference-availability factor and the amount of the foods available. Feeding in the model is based in part on the components of predation (prey and predator density) as set out by Leopold (1933) and elaborated by Holling (1959). In calculating the amount of food available to a consumer, the model does not necessarily take into account the density of the food source. Instead the total amount of the food available in a period of time is used in the calculations. The total amount of food passing through the ecosystem should not regulate the amount of food ingested by a consumer. Given otherwise identical streams, a consumer (in the model) in a larger stream would be allowed to ingest more than a similar consumer in a smaller stream. Although food passing in the immediate

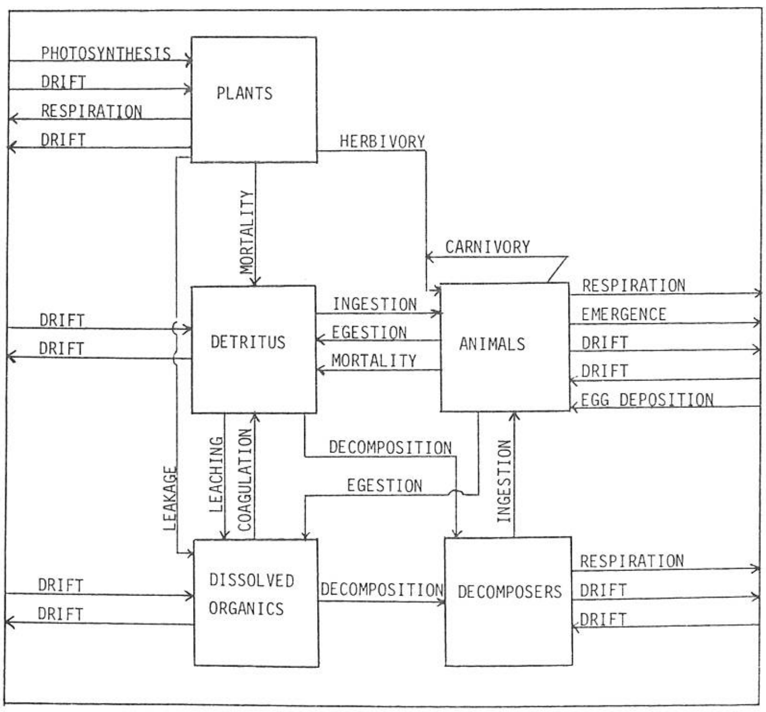

Figure 1. An energy flow diagram representing the General Stream Ecosystem Model.

vicinity of an invertebrate may affect the amount ingested, food meters away from an invertebrate should not affect its ingestion. This problem was solved by dividing the foods entering the ecosystem by the cross-sectional area of the stream. Thus the amount of food passing near an animal can affect ingestion rates, as is the case of filter feeders and the net-spinning caddisflies, but the size of the stream will not affect ingestion.

Third, increased discharge causes the size of the ecosystem to change, covering greater areas of the stream bottom. The opposite occurs as the discharge decreases. When the size of the ecosystem increases or decreases, state variables (e.g., plants and detritus) may be covered or uncovered by water, a process which was not modeled as of the November meeting. Therefore, the density of all constituents within the system changes with a change of stream ecosystem size. Since all animals within the system are considered motile, no change to the model for this trophic level was made. In the case of detritus it was decided that, as the water covered or uncovered land, a value equal to the average value for detritus contained within the ecosystem would be added in the case of increased area covered, or subtracted in the case of decreased area covered. In the case of plants and microorganisms during a decrease in area, biomass is considered lost, but since neither is considered motile, the density changes during an increase in stream ecosystem area.

The two recommendations which have yet to be incorporated into the model are more major in scope and a better understanding of the ecosystem, as well as modeling, must be acquired before they are attempted. One deals with regulating the occurrence and distribution of much of the biota in streams as it relates to the velocity of water and type of substratum, and the other deals with modeling the spatial heterogeneity found in an ecosystem.

Two areas were also to be studied for their realism, one being processes modeled by discontinuous functions, and the other concerning processes involving animal growth. Both of these areas are being studied continually as more information becomes available.

Literature Search

In May of 1973 the members of the Aquatic Section of the Desert Biome at Idaho State University started a literature search for values to be used as parameters for the model (Minshall et al. 1974, Perry and Minshall 1975). Results from this study are currently being used to update the parameter sets used in the model.

Model Validation

Work has started on a model validation by members of the Desert Biome using data collected on Deep Creek, Curlew Valley, Utah-Idaho, since 1969. Although methodology for validating large-scale models is still in its infancy, the modeling group is currently using data from 1971 for "working" or "massaging" the model. Validation or a comparison of key variables will then be made using data collected at a site where light was manipulated in 1975. During the summer of 1975, two 100-m sections of Deep Creek were covered with a plastic cloth which cut down light reaching the stream by about 70 and 100%, respectively. Field measurements of key variables are being made and will then be compared to model output. More information concerning model validation can be found in the section of this report entitled "Proposed Research."

New Model Uses

The members of the modeling group have met with one other group (in March of 1975) who were interested in the possible use of the model. Their project was "A Technique for Predicting Aquatic Ecosystem Responses to Weather Modification -- Phase I" with project members being part of the Utah Water Reserach Laboratory, College of Engineering, Utah Center for Water Resources Research. Because that project was started in 1973 and had June of 1975 as a completion date, it was decided by all concerned that time was too limiting and members from that project would not use the model.

Two papers were presented concerning the model, one at the Fort Union Coal Field Symposium at Billings, Montana, April 1975 (Wlosinski and Stalnaker 1975), and the other during the meeting of the AIBS at Corvallis, Oregon, August 1975 (Wlosinski 1975b).

USER'S GUIDE FOR EXPLORATORY SENSITIVITY AND STATISTICAL ANALYSIS

Introduction

As an aid for further development and validation of the General Stream Ecosystem Model, a program package of exploratory sensitivity and statistical analysis has been constructed. Both types of analysis are conducted apart from the simulation model, using values for variables of interest that were stored in an external file during the simulation.

Exploratory sensitivity analysis allows the user to view simultaneously the results of the behavior of variables of interest that are created by changes to initial conditions of state variables, driving or exogenous variables, parameters or model structure. According to Noy-Meir and Goodall (1973):

> "The purpose [of exploratory sensitivity analysis] is to test the response of a model over a wide range of conditions, in order to get some feeling for its general behavior and to see whether this behavior is at least qualitative over this range . . . Even if the parameter values used are not accurate values for any particular species or site, the trends in the model responses should indicate at least any peculiarities in the behavior of the model, which might lead to revision of its structure."

This type of analysis may also be used as a managerial tool for evaluating perturbations on a stream ecosystem. To do this, a stream ecosystem is simulated using the model and the best information available for a particular section of stream, with output variables being saved on an external tape. Changes are then made to the data deck simulating a perturbation and again the program is executed with the same set of output variables being saved. This step may be performed as often as necessary until all perturbations are simulated. The program for exploratory sensitivity then brings together all external tapes, simultaneously graphing for all variables of interest, the standard run and all perturbed simulations.

For statistical analysis the values for the predicted as well as observed values are graphed. In addition, six statistical tests are available to the user:

1. The difference squared between each observed value and its predicted counterpart for the same time period is summed for each variable. The mean of the squared differences is also given. Summations for the same two figures are also calculated for all variables of interest. This statistic may be calculated if only one observed value for a variable is available for a particular time period. The result is invariant against additive variation. This indicates that the calculation for a predicted (P) value and a corresponding observed (A) value would be the same as that for P' and A' where $P' = P + C$ and $A' = A + C$ where C is a constant.

2. Theil's (1961) inequality coefficient is calculated for each variable as well as all variables of interest. The coefficient is confined to the closed interval between zero and one except for the trivial case where all predicted and observed values are zero. With perfect prediction the inequality coefficient is zero. The coefficient is not invariant against additive variations.

3. Kapoor's (1968) inequality coefficient is calculated for each variable as well as all variables of interest. For this statistic at least two observed values are needed for each validation time. The measure is scale invariant and is equal to zero if each prediction falls at or between the maximum or minimum values for each validation time. There is no upper limit for the coefficient.

4. The percentage difference for each pair of predicted and observed values is calculated and summed within user-specified ranges. This is reported for each variable as well as all variables.

5. The parameters for the linear equation:

$$P = mA + b$$

are calculated using conventional regression techniques (Sokal and Rohlf 1969). The intersection of this equation with the equation for perfect prediction:

$$P = A$$

is also calculated. This information can be used to analyze whether the predicted data are systematically different than observed data.

6. For each time period when validation data were collected, the variance for these data is calculated (Sokal and Rohlf 1969) and a comparison made to see if the predicted value lies within the 95 or 50% confidence intervals of the observed data. The percentage of the time this occurs for each variable as well as all variables is reported.

The exploratory sensitivity and statistical analysis package consists of three programs written in FORTRAN IV. The first is a MAIN program which handles all input data including the collection of data from external files, sets up the specifications and switches and prepares arrays for graphing. Subroutine GRAF actually prints the graph and subroutine STATS computes and reports all statistical analysis. A listing of definitions for all variables in COMMON storage, variables read in as data, dimensioned and other variables can be found in Appendix C. Appendix D contains a listing of the source decks for the three programs which contain minimal comments. Appendix E contains examples of input data decks used for the output found in Appendix F.

For the examples given, 6588 words were used for code and 57,509 words for data. All work was done on the Sperry Rand Univac 1108 located at the University of Utah.

Input Organization

The successive cards required for input, many of which are optional and are determined by the special requirements of the model in question, are detailed below. Constraints are placed on these input data by the array sizes of this report.

The FORTRAN name of the variables is included in parentheses.

Comments

Any comments to be associated with the output may be printed out before the output proper by inserting cards bearing the comment information at the beginning of the input deck. These cards should finish with a blank, or be replaced by a blank if no comments are needed (STATE).

Instruction Cards

Card 1—Contains the following information in successive fields of five columns, right justified (16I5 format).

1. The month in which the simulation started (KMONTH)
2. The day of the month on which the simulation started (KDAY)
3. The year in which the simulation started (KYEAR)
4. The number of simulation days (should be at least 120) (KDAYRN)
5. A switch which should be set to 0 (zero) if no validation data are to be read or 1 (one) if validation data are to be read (NUMCRD)
6. The number of graphs to be printed (NXPLOR)
7. The number of curves for each graph (IGPP)

Card 2—

1. In columns 1 through 5, right justified, the number of levels to be used showing how many predicted points lie between specified percentage levels (JVALU)
2. From column 6, in F5.0 format, the A'th value (in percent) to be used showing how many predicted points lie between the values specified (VALU(A))

If this statistic will not be used or if the run is for exploratory sensitivity analysis, this card should be blank.

Names for Graphical Output

Card 1—Contains in columns 1 through 40 any title the user wishes printed with every graph (TITLE2).

For each of the graphs in succession the following two cards are needed:

1. A title card for each particular graph, from columns 1 through 40 (TITLES)
2. A title for the Y-axis of the graph (the X-axis always being in days). This titie may occupy columns 1-40 of the card. If the work "ZERO" is punched in columns 41-44, the Y-axis of the graph will include zero; otherwise it will extend from the minimum to the maximum value of the variables graphed (YAXISS, ORIGIN)

The number of cards in (1) and (2) above should equal two times the value of NXPLOR (from (6) under Instruction Cards). Then a number of cards equal to IGPP (item (7) under Instruction Cards) with a title for each curve per graph printed in columns 1 through 20 must be included (EXPLAN).

If the purpose of the run is for exploratory sensitivity analysis, the data deck is complete. For validation the cards described below are also needed.

Validation Data

For each validation value the following information is needed in successive fields of five columns, right justified (4I5 format). All data must be in order based on graph number (1 below) and date for each graph.

1. The numerical designation of the variable to which the validation value is to be compared. This designation is the same as the graph number (NUMDAT).
2. The month in which the data were collected (KM)
3. The day on which the data were collected (KD)
4. The year in which the data were collected (KY)
5. The value of the data point in columns 21 through 30 (F10.4 format) (VAL)

In addition to the above, the first card for each variable (each time a new number appears in columns 1 through 5) should contain the following switches. A 1 (one) punched in the appropriate column indicates a particular statistic will be used in analyzing the variable of interest (KS).

Column

(35) The difference squared between observed and predicted data
(40) Theil's inequality coefficient
(45) Kapoor's inequality coefficient
(50) Model output lies between certain specified percentage levels
(55) Parameters calculated for the regression equation: predicted value equals m observed value + b
(60) Model output passes through confidence intervals a certain percentage of time.

For a 1 to be in columns 45 or 60, at least two values must be specified for each date for each variable of interest.

ARRAY DIMENSIONS

The use of the programs is limited by the dimensions allotted to the arrays, and these limitations need discussion so that the user may be in a position to modify them as his particular requirements indicate. Below is a list of arrays included in the programs in which the dimensions which may appropriately be varied are indicated by letters. Dimensions of other arrays, and dimensions indicated by numbers, are subject to other constraints, and changes in them could call for other changes in the program.

ALGRAF (5, a, 120)	NFIGDA (a, b)
AMAXI (a)	NREPER (a, c)
AMINI (a)	NREPNO (a)
ANUM (10)	NSTAT (a, 6)
EXPLAN (5, 5)	ORIGIN (a)
FIG (5, 120)	STATE (20)
FIGVAL (a, b)	SYMBOL (5)
FMT1 (7)	TITLE (10)
GRAPH (51, 121)	TITLE2 (10)
IDAYS (13)	TITLES (a, 10)
IYEARS (13)	VALU (d)
KS (6)	XLINE (31)
KVALU (e)	YAXIS (6)
KVALUT (e)	YAXISS (a, 10)
MDAT (a)	YTITLE (10)
NDATAS (a)	

The dimensions indicated by letters define the maximum values possible for the following quantities (the FORTRAN name is in parentheses):

a. Number of variables to be graphed (NXPLOR)
b. Number of validation points per variable
c. Number of different collection days for validation points for a particular variable
d. Number of levels for percentage differences for validation (JVALU)
e. JVALU + 1

INTEGRATION WITH THE GENERAL STREAM ECOSYSTEM MODEL

Both exploratory sensitivity and statistical analysis are run apart from the General Stream Ecosystem Model -- that is, in a separate runstream. The only connection between the two is an external data file, created during the simulation, which contains values of variables of interest. For statistical analysis only one external data file is created and used. For exploratory sensitivity analysis as many as five external data files may be created and later used simultaneously. For either type of analysis the switch, NXPLOR, in the simulation model should be set to the number of variables to be graphed. This value is constrained by certain dimensioned variables, and the reader is cautioned to read the section elsewhere in the user's guide entitled "Array Dimensions." The simulation model is executed as many times as there will be curves per graph (up to a maximum of five) with appropriate changes made to the data deck for each simulation. The same variables in the same order must be saved for each simulation. The numerical designation of the variables of interest must also be included, and they should be placed into the data deck after the parameter list and specifications for graphical output. This information is in successive fields of 6 columns, right justified, 12 values per card (12I6 format). These values are expressed as addresses in the state variables array (common block/STAT/); the addresses in the sums array for state variables (common block/TOTALS/) increased by 10,000; the addresses in the array which tracks the accumulated exchanges of constituents with the area outside the ecosystem (common block/ACC/) increased by 20,000; the addresses in the sums array for productivity (common block/PROSUM/) increased by 30,000; the addresses in the array dealing with incremental changes of productivity (common block/PRODCH/) increased by 40,000; the addresses of the array dealing with accumulated changes of productivity (common block/PRODUC/) increased by 50,000; the addresses in the array of additional accessible variables (common block/OTHER/) increased by 60,000; the addresses in the sums array for tracking accumulated changes with the area outside the ecosystem (common block/EVERY1/) increased by 70,000; the addresses in the array tracking accumulated changes of flows (common block/RRATE/) increased by 80,000; the addresses in the sums array tracking flows (common block/RRATOT/) increased by 90,000; the addresses in the array dealing with trophic levels (common block/TROFIC/) increased by 100,000; the addresses in the array which tracks the incremental exchanges of constituents with the area outside the ecosystem (common block/ACCINC/) increased by 110,000; and the array which tracks the incremental exchanges of flows (common block/RRATEQ/) increased by 120,000.

The reader is cautioned to prepare an external file for the data which are to be saved. Internally, it is designated as logical unit 12. Also, the dimensions of variable EXSAVE are (a, 120), where a equals the maximum number of variables to be graphed.

For the execution of the runstream for exploratory sensitivity analysis as many as five external files are used, and are designated internally as logical units 12, 13, 14, 15 and 16. The number that is actually used for a particular run is the same as the value for variable IGPP, which is the number of curves per graph. When the graphs are printed the curves are labeled A, B, C, D and E and represent, in the same order, the data stored on logical units 12, 13, 14, 15 and 16. Only one external file is needed for validation, internally designated as logical unit 12.

Mathematical Description of Statistical Analysis

Six different statistics are available to the user for each variable of interest, with control for each variable being set by a series of switches on the first data card for that variable. Use of these switches is further explained in the section titled "Validation Data" under "Input Organization."

Let A_{itn} equal the value for the n'th replicate for the t'th time for the i'th observed variable of interest and let P_{it} equal the value for the corresponding t'th time for the i'th predicted variable of interest where:

$i \quad = 1, \ldots, I$

$t \quad = 1, \ldots, T_i$

$n \quad = 1, \ldots, N_{it_i}$

If the value for switch KS(1) is positive, the deviations squared between predicted and observed data are calculated according to:

$$D_i = \sum_t \sum_n (P_{it} - A_{itn})^2$$

$$\bar{D}_i = \frac{\sum_t \sum_n (P_{it} - A_{itn})^2}{\sum_t N_{it_i}}$$

$$D = \sum_i \sum_t \sum_n (P_{it} - A_{itn})^2$$

$$\bar{D} = \frac{\sum_i \sum_t \sum_n (P_{it} - A_{itn})^2}{\sum_i \sum_t N_{it_i}}$$

where:

D_i = the deviations squared between the predicted and observed values for the i'th variable

$\bar{D}_i$ = the average deviation squared between the predicted and observed values for the i'th variable

D = the deviations squared between the predicted and observed values for all variables with a positive KS(1) value

$\bar{D}$ = the average deviation squared between the predicted and observed values for all variables with a positive KS(1) value

If the value for switch KS(2) is positive, Theil's (1961) inequality coefficient is calculated according to:

$$U_i = \frac{\sqrt{\frac{1}{\sum_t N_{it_i}} \sum_t \sum_n (P_{it} - A_{itn})^2}}{\sqrt{\frac{1}{\sum_t N_{it_i}} \sum_t \sum_n P_{it}^2} + \sqrt{\frac{1}{\sum_t N_{it_i}} \sum_t \sum_n A_{itn}^2}}$$

$$U = \frac{\sqrt{\frac{1}{\sum_i \sum_t N_{it_i}} \sum_i \sum_t \sum_n (P_{it} - A_{itn})^2}}{\sqrt{\frac{1}{\sum_i \sum_t N_{it_i}} \sum_i \sum_t \sum_n P_{it}^2} + \sqrt{\frac{1}{\sum_i \sum_t N_{it_i}} \sum_i \sum_t \sum_n A_{itn}^2}}$$

where

U_i = Theil's inequality coefficient for the i'th variable of interest

U = Theil's inequality coefficient for all variables with a positive KS(2) value

According to Theil, the coefficient U is confined to the closed interval between zero and one, except for the trivial case where all P_{it} and A_{itn} are zero. Also, the coefficient is not invariant against additive variations.

If the value for switch KS(3) is positive, Kapoor's (1968) V inequality coefficient is calculated. For Kapoor's coefficient each N_{it_i} must be at least two. For each of the t times we define A'_{it} to be the maximum response of the N_{it_i} replicates and A''_{it} to be the minimum response.

For each of the t_i times we define:

$$\ell_{it} = \begin{cases} P_{it} - A'_{it} & \text{if } P_{it} > A'_{it} \\ 0 & \text{if } A''_{it} \le P_{it} \le A'_{it} \\ A'_{it} - P_{it} & \text{if } P_{it} < A''_{it} \end{cases}$$

The V inequality coefficient is

$$V_i = \frac{\sqrt{\frac{1}{T_i} \sum_t \ell_{it}^2}}{\sqrt{\frac{1}{T_i} \sum_t (A'_{it} - A''_{it})^2}}$$

$$V = \frac{\sqrt{\frac{1}{\sum_i T_i} \sum_i \sum_t \ell_{it}^2}}{\sqrt{\frac{1}{\sum_i T_i} \sum_i \sum_t (A'_{it} - A''_{it})^2}}$$

where

V_i = Kapoor's V inequality coefficient for the i'th variable of interest

V = Kapoor's V inequality coefficient for all variables with a positive KS(3) value

V is equal to zero if all predictions at each of the T_i times fall between the minimum and maximum observed values for those particular times. The coefficient is scale invariant.

If the value for switch KS(4) is positive, the percentage difference between the average observed values and predicted values for each t times is calculated. The number of comparisons falling within JVALU levels is then summed.

For $P_{it} > \frac{\sum_n A_{itn}}{N_{it_i}}$

$$V_{it} = \frac{100\left(P_{it} - \frac{\sum_n A_{itn}}{N_{it_i}}\right)}{\sum_n A_{itn}}$$

For $P_{it} < \frac{\sum_n A_{itn}}{N_{it_i}}$

$$V_{it} = \frac{100\left(\frac{\sum_n A_{itn}}{N_{it_i}} - P_{it}\right)}{P_{it}}$$

$$S_{di} = \sum_{t_i} j_{ti} \qquad \text{where } j_{ti} = \begin{cases} 1 & \text{if } V_{it} \le \text{VALU(d)} \\ 0 & \text{if } V_{it} > \text{VALU(d)} \end{cases}$$

$$S_d = \sum_i S_{di}$$

where

V_{it} = the percentage difference between average observed and predicted data for the i'th variable at the t'th time

S_{di} = the total number of V_{it} less than or equal to VALU(d) for the i'th variable

S_d = the total number of V_{it} less than or equal to VALU(d) for all variables with a positive value for KS(4)

If the value for switch KS(5) is positive, the coefficients for the equation:

$$P_{it} = m_i A_{itn} + b_i$$

are calculated using conventional regression techniques (Sokol and Rohlf 1969).

Given:

$$C_i = \sum_t N_{it_i}$$

$$\Sigma X_i = \sum_t \sum_n A_{itn}$$

$$\Sigma Y_i = \sum_t N_{it_i} P_{it}$$

$$\Sigma X_i^2 = \sum_t \sum_n A_{itn}^2$$

$$\Sigma X_i Y_i = \sum_t \sum_n P_{it} A_{itn}$$

the regression coefficient (m_i) equals:

$$m_i = \frac{\Sigma X_i Y_i - \frac{(\Sigma X_i)(\Sigma Y_i)}{C_i}}{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{C_i}}$$

and the Y intercept (b_i) equals:

$$b_i = \frac{\Sigma Y_i}{C_i} - m_i \frac{\Sigma X_i}{C_i}$$

The intersection of the predicted line with the line of perfect prediction ($P_{it} = A_{itn}$) equals:

$$\frac{b_i}{1 - m_i}$$

If the value for switch KS(6) is positive the standard deviation is calculated for all observations at the t'th time (Sokol and Rohlf 1969). Those predictions falling within the 95 and 50 percent confidence intervals are then summed.

Given:

$$C_i = N_{it_i} \quad \text{with all } N_{it_i} \geq 2$$

$$\Sigma X_i = \sum_t \sum_n A_{itn}$$

$$\Sigma X_i^2 = \sum_t \sum_n A_{itn}^2$$

The standard deviation for the i'th variable at the t'th time equals:

$$S_{it} = \sqrt{\frac{\Sigma X_i^2 - \frac{(\Sigma X_i)^2}{C_i}}{C_i - 1}}$$

$$S_{95i} = \sum_t j_{it} \qquad S_{95} = \sum_i S_{95i} \qquad \text{Where: } \begin{cases} j_{it} = 1 \text{ if } P_{it} > \frac{\Sigma X_i}{C_i} - 1.96 S_{it} \text{ and } P_{it} < \frac{\Sigma X_i}{C_i} + 1.96 S_{it} \\ j_{it} = 0 \text{ otherwise} \end{cases}$$

$$S_{50i} = \sum_t j_{it} \qquad S_{50} = \sum_i S_{50i} \qquad \text{Where: } \begin{cases} j_{it} = 1 \text{ if } P_{it} > \frac{\Sigma X_i}{C_i} - .674 S_{it} \text{ and } P_{it} < \frac{\Sigma X_i}{C_i} + .674 S_{it} \\ j_{it} = 0 \text{ otherwise} \end{cases}$$

where

S_{95i} = the number of t_i times (for the i'th variable) the predicted value was within the 95% confidence intervals of observed data

S_{95} = the number of times the predicted value was within the 95% confidence intervals for all variables with a positive value for KS(6)

S_{50i} = the number of t_i times (for the i'th variable) the predicted value was within the 50% confidence interval of observed data

S_{50} = the number of times the predicted value was within the 50% confidence intervals for all variables with a positive value for KS(6)

PROPOSED RESEARCH

One of the objectives of the International Biological Program and the Analysis of Ecosystems Program as listed in the 1970 Desert Biome Research Design (Goodall 1970) is "To synthesize the results of this and previous studies into predictive models of temporal and spatial variation . . ." The studies referred to in this quotation included the structure and function of desert aquatic ecosystems. To accomplish this end, a goal was set out and elucidated at an aquatic specialists meeting in 1970. It stated "Very simply, we have set out to construct a predictive model of a series of rather common desert aquatic ecosystems."

Although much of the field work and validation studies were started much earlier (Minshall et al. 1971, 1972), work on constructing the model did not begin until the spring of 1972. At that time, the objective was to create a general model to cover permanent springs and streams and temporary waters represented by a playa and intermittent streams (Aquatic Specialists Meeting, 1970). In July of 1973 a cooperative use and development of the model was undertaken between the Desert Biome personnel and those of the Cooperative Fisheries Unit of Utah State University who were interested in predicting effects of reduced water flows on stream ecosystems. It was felt at that time that the model should be developed to be general enough to cover only streams located in different biomes and modeling efforts were to be centered on moving water. This generality was accomplished not by building an all-inclusive ecological model of a specific ecosystem, but by building a model framework. This framework explicitly contains the types of components found within a stream ecosystem as well as functions describing the major fluxes between these components. The actual components used for a particular ecosystem, as well as parameters for the functions, are left to be specified by the user at execution time. Because of common usage, the word "model" in this proposal will be used in place of "model framework."

We now have a model which has proven itself on the basis of qualitative evaluations to be worthy of more consideration, study and use. The range of output of the model is such that its representation of ecosystem function as well as structure can be analyzed. Besides producing output in the form of values for state variables, all exchanges of energy between major components of the ecosystem and along the ecosystem boundary are tracked, all exogenous variables may be followed, and other values for variables of interest are available. In addition, most variables are available in both tabular and graphical form, and cross classification of many variables allows us to study the ecosystem structure at different levels of resolution.

Based on the number of biological components included in the stream ecosystem model, it is of high resolution when compared to other aquatic ecosystem models. In a survey of aquatic ecosystem models compiled by Parker (1974), 162 models were listed, although the meaning of the term ecosystem may be questioned in many of the models. According to Odum (1971), it is the living organisms and their abiotic environment in a given area with the exchange of materials between these two parts that make up the ecosystem. In the survey by Parker describing such models, nine biological components were listed with respondents checking those components included in a particular model. These biological components were: bacteria, fungi, algae, aquatic macrophytes, zooplankton, bottom fauna, other invertebrates, fish and other vertebrates. Goodall (1973) mentions that the tendency in ecosystem modeling has been to combine large numbers of biological elements, and he gives reasons for these tendencies as well as the shortcomings of such work. The argument that models should not be called ecosystem models unless they are an isomorphism of the real world is not being made here but, nevertheless, of the 162 "ecosystem" models listed by Parker, over 75% have three or less of the biological components listed, with approximately 40 models having no organisms! No other stream model listed had as many or more components as the General Stream Ecosystem Model.

The stream ecosystem model is now at a point where we wish to increase our confidence in it by analyzing and evaluating it. However, the fact that it is of high resolution, with discontinuous and nonlinear functions, makes it nearly impossible to analyze with current analytical techniques. However, according to Valentine (1975):

> ". . . if we sacrifice complexity and realism in a model for a structure which is amenable to a variety of analytical techniques we may end up analyzing something that is of little or no ecological interest. We should seek to create realistic models and recognize that we will likely have to analyze them with simulation techniques rather than analytical techniques."

It is just such a study that we propose to undertake.

We propose to study different functions for selected individual processes and gain a measure of the worth of each function by comparing predicted model output generated through the use of each function on an ecosystem level with observed values. This is model validation, or what Schrank and Holt (1967) said is done to "prevent the construction of models from being exercises in science fiction." Each of the functions then is a hypothesis of the workings of the process, with model validation acting as the critical experiment.

Parameter estimation, in place of its direct measurement, may appear to negate this study since there is no feasible way to adequately estimate all values for such an extensive parameter list. Thus it may appear that model A has better predictability than model B, but by tinkering with the parameter list we may reverse this decision. With a model of the complexity of the General Stream Ecosystem Model, this will remain a problem until mathematical or statistical techniques are further developed, and at present parameter estimation is a variable in the modeling process. So as not to bias the results of the proposed study, two data decks representing two different stations on Deep Creek with an initialization time in 1971 will be used for initial parameter estimation. For the actual validation, data from a perturbation study in 1975 involving light inhibition will be used. The validation, however, will not tell us if the model is valid or invalid. According to Goodall (1971), validation tells us how good the predictions of the model are under certain sets of circumstances, or which of two models fits more closely to reality. Even the latter use may not have an unambiguous answer given the many factors in the objective function.

For validation, the values for the predicted as well as observed values are graphed. In addition, six statistical tests will be used. These statistical tests are explained elsewhere in this report under the section entitled "User's Guide for Exploratory Sensitivity and Statistical Analysis."

Another purpose of the study is to try to correlate model complexity with predictability. O'Neill (1971) has shown that model inaccuracy may initially drop with increased model complexity, but past a certain point, which is model specific, may increase. O'Neill bases his results not on comparing predicted versus observed data, but by equating error with an increased standard deviation. Also, his most complex model contained only nine parameters, whereas this proposed study model may contain up to approximately 4000 parameters. Model complexity can be increased in three ways (Goodall 1971): 1) by subdividing the state variables, 2) by including more processes or 3) by taking into account more influencing variables for a given process. The present model structure is built in such a way that all three of these changes can be incorporated with a minimum of changes to the model. An example of subdividing state variables would be to handle many size classes for a species instead of only one single component for the species. Using maximum and minimum temperatures instead of average temperatures is an example of taking into account more influencing variables for a given process. Growth could be handled as a single process or it could be broken down to the difference of ingestion minus egestion and respiration. All three methods will be used for this proposed study, although at present, all the exact mechanisms which may be changed are not known. There will be lumping and separating of state variables, some function of behavior will be added, and functions involving light and temperature as driving variables will be changed.

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APPENDIX A

Example of Additional Model Output

DEEP CREEK STATION 2 CURLEW VALLEY UTAH

REPORT NO. 1 ON AUG 2 1971 (I.E., AFTER 121 DAYS OF SIMULATION)

****** THE FOLLOWING FIGURES ARE FOR METABOLISM. ALL FIGURES ARE BASED ON ENERGY MEASURED IN KILOCALORIES ******

	FOR THE CURRENT TIME UNIT		ACCUMULATED FOR THE ENTIRE SIMULATION	
	AVE. PER SQ. METER	PER ECOSYSTEM	AVE. PER SQ. METER	PER ECOSYSTEM
PLANT GROSS PRODUCTIVITY	.0244	4.696	2399.04	462415.5
PLANT RESPIRATION	.0059	1.145	1819.98	350802.2
ANIMAL RESPIRATION	4.5689	880.652	306.13	59006.0
MICROBAL RESPIRATION	.1974	38.045	150.27	28963.9
TOTAL RESPIRATION	154.8415	919.842	2276.38	438772.2
P/R RATIO (DIMENSIONLESS)	.01		1.05	

****** ANIMAL BIOENERGETICS AT THE TROPHIC LEVELS BASED ON INGESTION FOR 121 DAYS PER ECOSYSTEM ******

PROPORTION OF INGESTION FROM TROPHIC LEVELS (CALCULATED FOR AN ENTIRE SPECIES OR GROUP)

SPECIES NAME	FROM PLANTS	FROM ANIMALS	FROM DETRITUS	FROM MICROOGANISMS
RHINICHTHYS OSCULUS	.000000000	.100000000+01	.000000000	.000000000
HYALLELA AZTECA	.991186490-01	.149044733+00	.749574848+00	.226178180-02
BAETIS TRICAUDATUS	.412152179+00	.350601770+00	.236362023+00	.884034780-03
OPTIOSERVUS DIVERGENS	.220982233+00	.468584769-01	.729313403+00	.284589941-02
TRICORYTHODES MINUTUS	.222284392+00	.238484418+00	.537943728+00	.128746100-02
HYDROPSYCHE OCCIDENTALIS	.228824360+00	.187129168+00	.584046468+00	.000000000
SIMULIUM ARGUS	.000000000	.318438459-03	.164424279-01	.983239137+00
ARGIA VIVIDA	.000000000	.100000000+01	.000000000	.000000000
TOTAL	.154525910+00	.187111747+00	.643380076+00	.149822810-01

AMOUNT OF INGESTION FOR ANIMAL TROPHIC LEVELS (BASED ON PROPORTION OF INGESTION). KIOCALORIES PER ECOSYSTEM PER 121 DAYS

SPECIES NAME	HERBIVORES	CARNIVORES	DETRITIVORES	MICROVORES
RHINICHTHYS OSCULUS	.000000000	.429612015+03	.000000000	.000000000
HYALLELA AZTECA	.173476680+05	.260856921+05	.131190000+06	.395855274+03
BAETIS TRICAUDATUS	.327151334+04	.278294870+04	.187615535+04	.701714498+01
OPTIOSERVUS DIVERGENS	.278606709+03	.590775375+02	.919492966+03	.358801097+01
TRICORYTHODES MINUTUS	.244781362+05	.262620962+05	.592387964+05	.141776241+03
HYDROPSYCHE OCCIDENTALIS	.271055090+04	.221664832+04	.691835291+04	.000000000
SIMULIUM ARGUS	.000000000	.133240595+01	.687981873+02	.411405609+04
ARGIA VIVIDA	.000000000	.389367847+03	.000000000	.000000000
TOTAL	.480864746+05	.582267734+05	.200211590+06	.466229272+04

AMOUNT OF RESPIRATION FOR ANIMAL TROPHIC LEVELS (BASED ON PROPORTION OF INGESTION). KIOCALORIES PER ECOSYSTEM PER 121 DAYS

SPECIES NAME	HERBIVORES	CARNIVORES	DETRITIVORES	MICROVORES
RHINICHTHYS OSCULUS	.000000000	-.103071370+03	.000000000	.000000000
HYALLELA AZTECA	-.265128415+04	-.398673654+04	-.200500706+05	-.604994750+02
BAETIS TRICAUDATUS	-.579181623+02	-.492687201+02	-.332150469+02	-.124230012+00
OPTIOSERVUS DIVERGENS	-.691113758+02	-.146548154+02	-.228090071+03	-.890044518+00
TRICORYTHODES MINUTUS	-.619604395+04	-.664760992+04	-.149948584+05	-.358872023+02
HYDROPSYCHE OCCIDENTALIS	-.864311852+03	-.706821411+03	-.220605133+04	.000000000
SIMULIUM ARGUS	.000000000	-.557827894-03	-.288031949-01	-.172239943+01
ARGIA VIVIDA	.000000000	-.477632132+02	.000000000	.000000000
TOTAL	-.983866931+04	-.115559264+05	-.375123130+05	-.991233501+02

AMOUNT OF NET PRODUCTION(GROWTH) FOR ANIMAL TROPHIC LEVELS (BASED ON PROPORTION OF INGESTION). KILOCALORIES PER ECOSYSTEM PER 121 DAYS

RHINICHTHYS OSCULUS	.000000000	.297576527+03	.000000000	.000000000
HYALLELA AZTECA	.626404901+04	.941925183+04	.473712427+05	.142938913+03
BAETIS TRICAUDATUS	.138586758+04	.117890346+04	.794770676+03	.297257957+01
OPTIOSERVUS DIVERGENS	.192431614+03	.408044219+02	.635087051+03	.247821286+01
TRICORYTHODES MINUTUS	.883130884+04	.947493225+04	.213723833+05	.511505361+02
HYDROPSYCHE OCCIDENTALIS	.626001816+03	.511934998+03	.159779382+04	.000000000
SIMULIUM ARGUS	.000000000	.104586507+01	.540027771+02	.322930679+04
ARGIA VIVIDA	.000000000	.342919041+03	.000000000	.000000000
TOTAL	.172996587+05	.212673677+05	.718252783+05	.342884702+04

****** EXCHANGES OF ENERGY BETWEEN THE ECOSYSTEM AND THE SURROUNDING BIOSPHERE ******

PLANTS

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
BENTHIC DIATOMS	OUTSIDE THE SYSTEM	DRIFT	-.862330547+05	-.712669868+03
CLADOPHORA	OUTSIDE THE SYSTEM	DRIFT	-.211727184+06	-.174981143+04
SPIROGYRA	OUTSIDE THE SYSTEM	DRIFT	-.211735838+06	-.174988295+04
CHARA	OUTSIDE THE SYSTEM	DRIFT	-.196672053+06	-.162538885+04
POTOMOGETON	OUTSIDE THE SYSTEM	DRIFT	-.187013582+06	-.154556679+04
PLANTS	OUTSIDE THE SYSTEM	DRIFT	-.893381703+06	-.738331982+04

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
BENTHIC DIATOMS	OUTSIDE THE SYSTEM	RESPIRATION	-.772694492+05	-.246276949+03
CLADOPHORA	OUTSIDE THE SYSTEM	RESPIRATION	-.629852485+05	-.200749649+03
SPIROGYRA	OUTSIDE THE SYSTEM	RESPIRATION	-.665201006+05	-.212016102+03
CHARA	OUTSIDE THE SYSTEM	RESPIRATION	-.367362920+05	-.117087697+03
POTOMOGETON	OUTSIDE THE SYSTEM	RESPIRATION	-.107291106+06	-.341963436+03
PLANTS	OUTSIDE THE SYSTEM	RESPIRATION	-.350802191+06	-.289919165+04

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
OUTSIDE THE SYSTEM	BENTHIC DIATOMS	DRIFT	.860526680+05	.711179070+03
OUTSIDE THE SYSTEM	CLADOPHORA	DRIFT	.211853480+06	.175085521+04
OUTSIDE THE SYSTEM	SPIROGYRA	DRIFT	.211853480+06	.175085521+04
OUTSIDE THE SYSTEM	CHARA	DRIFT	.196609857+06	.162487485+04
OUTSIDE THE SYSTEM	POTOMOGETON	DRIFT	.186775273+06	.154359729+04
OUTSIDE THE SYSTEM	PLANTS	DRIFT	.893144758+06	.738136163+04

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
OUTSIDE THE SYSTEM	BENTHIC DIATOMS	PHOTOSYNTHESIS	.931291660+05	.296825809+03
OUTSIDE THE SYSTEM	CLADOPHORA	PHOTOSYNTHESIS	.782684209+05	.249460920+03
OUTSIDE THE SYSTEM	SPIROGYRA	PHOTOSYNTHESIS	.775752451+05	.247251596+03
OUTSIDE THE SYSTEM	CHARA	PHOTOSYNTHESIS	.700131768+05	.223149405+03
OUTSIDE THE SYSTEM	POTOMOGETON	PHOTOSYNTHESIS	.143429475+06	.457145401+03
OUTSIDE THE SYSTEM	PLANTS	PHOTOSYNTHESIS	.462415477+06	.382161548+04

ANIMALS

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
OUTSIDE THE SYSTEM	BAETIS TRICAUDATUS	EGG DEPOSITION	.531739929+03	.439454484+01
OUTSIDE THE SYSTEM	TRICORYTHODES MINUTUS	EGG DEPOSITION	.869531265+03	.718620878+01
OUTSIDE THE SYSTEM	HYDROPSYCHE OCCIDENTALIS	EGG DEPOSITION	.870655884+03	.719550312+01
OUTSIDE THE SYSTEM	SIMULIUM ARGUS	EGG DEPOSITION	.181804979+03	.150252049+01
OUTSIDE THE SYSTEM	ARGIA VIVIDA	EGG DEPOSITION	.443116603+02	.366212066+00
OUTSIDE THE SYSTEM	ANIMALS	EGG DEPOSITION	.249804367+04	.206449890+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
OUTSIDE THE SYSTEM	HYALLELA AZTECA	DRIFT	.425961187+05	.352034035+03
OUTSIDE THE SYSTEM	BAETIS TRICAUDATUS	DRIFT	.517837280+05	.427964691+03
OUTSIDE THE SYSTEM	OPTIOSERVUS DIVERGENS	DRIFT	.612921528+05	.506546715+03
OUTSIDE THE SYSTEM	TRICORYTHODES MINUTUS	DRIFT	.242234496+06	.200193797+04
OUTSIDE THE SYSTEM	HYDROPSYCHE OCCIDENTALIS	DRIFT	.120337613+06	.994525726+03
OUTSIDE THE SYSTEM	SIMULIUM ARGUS	DRIFT	.428646992+05	.354253712+03
OUTSIDE THE SYSTEM	ARGIA VIVIDA	DRIFT	.530495557+05	.438426079+03
OUTSIDE THE SYSTEM	ANIMALS	DRIFT	.614158359+06	.507568890+04

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
HYALLELA AZTECA	OUTSIDE THE SYSTEM	DRIFT	-.450148286+05	-.372023376+03
BAETIS TRICAUDATUS	OUTSIDE THE SYSTEM	DRIFT	-.519381147+05	-.429240616+03
OPTIOSERVUS DIVERGENS	OUTSIDE THE SYSTEM	DRIFT	-.613913115+05	-.507366211+03
TRICORYTHODES MINUTUS	OUTSIDE THE SYSTEM	DRIFT	-.244539957+06	-.202099138+04
HYDROPSYCHE OCCIDENTALIS	OUTSIDE THE SYSTEM	DRIFT	-.120762442+06	-.998036713+03
SIMULIUM ARGUS	OUTSIDE THE SYSTEM	DRIFT	-.430122051+05	-.355472767+03
ARGIA VIVIDA	OUTSIDE THE SYSTEM	DRIFT	-.531014507+05	-.438854961+03
ANIMALS	OUTSIDE THE SYSTEM	DRIFT	-.619760297+06	-.619760297+06

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
BAETIS TRICAUDATUS	OUTSIDE THE SYSTEM	EMERGENCE	-.573524575+02	-.584601075-01
TRICORYTHODES MINUTUS	OUTSIDE THE SYSTEM	EMERGENCE	-.317904102+03	-.584601075-01
HYDROPSYCHE OCCIDENTALIS	OUTSIDE THE SYSTEM	EMERGENCE	-.246464159+02	-.584601075-01
SIMULIUM ARGUS	OUTSIDE THE SYSTEM	EMERGENCE	-.259725916+02	-.584601075-01
ARGIA VIVIDA	OUTSIDE THE SYSTEM	EMERGENCE	-.183418722+02	-.584601075-01
ANIMALS	OUTSIDE THE SYSTEM	EMERGENCE	-.444217434+03	-.367121845+01

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
RHINICHTHYS OSCULUS	OUTSIDE THE SYSTEM	RESPIRATION	-.103071370+03	-.328514084+00
HYALLELA AZTECA	OUTSIDE THE SYSTEM	RESPIRATION	-.267485906+05	-.852544088+02
BAETIS TRICAUDATUS	OUTSIDE THE SYSTEM	RESPIRATION	-.140526159+03	-.447891813+00
OPTIOSERVUS DIVERGENS	OUTSIDE THE SYSTEM	RESPIRATION	-.312746304+03	-.996800236+00
TRICORYTHODES MINUTUS	OUTSIDE THE SYSTEM	RESPIRATION	-.278743997+05	-.888426428+02
HYDROPSYCHE OCCIDENTALIS	OUTSIDE THE SYSTEM	RESPIRATION	-.377718463+04	-.120388266+02
SIMULIUM ARGUS	OUTSIDE THE SYSTEM	RESPIRATION	-.175176045+01	-.558329612-02
ARGIA VIVIDA	OUTSIDE THE SYSTEM	RESPIRATION	-.477632132+02	-.152233237+00
ANIMALS	OUTSIDE THE SYSTEM	RESPIRATION	-.590060327+05	-.487653160+03

DECOMPOSERS

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
DRIFTING MICROBES	OUTSIDE THE SYSTEM	RESPIRATION	-.300429486+04	-.248288829+02
BENTHIC MICROBES	OUTSIDE THE SYSTEM	RESPIRATION	-.259596443+05	-.214542513+03
DECOMPOSERS	OUTSIDE THE SYSTEM	RESPIRATION	-.289639390+05	-.239371395+03

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
OUTSIDE THE SYSTEM	DRIFTING MICROBES	DRIFT	.167605027+07	.138516550+05
OUTSIDE THE SYSTEM	BENTHIC·MICROBES	DRIFT	.280145176+06	.231524936+04
OUTSIDE THE SYSTEM	DECOMPOSERS	DRIFT	.195619544+07	.161669044+05

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
DRIFTING MICROBES	OUTSIDE THE SYSTEM	DRIFT	-.167202981+07	-.138184281+05
BENTHIC MICROBES	OUTSIDE THE SYSTEM	DRIFT	-.280126895+06	-.231509830+04
DECOMPOSERS	OUTSIDE THE SYSTEM	DRIFT	-.195215670+07	-.161335264+05

DETRITUS

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
FINE PARTICLES	OUTSIDE THE SYSTEM	DRIFT	-.280323100+09	-.231671981+07
COARSE PARTICLES	OUTSIDE THE SYSTEM	DRIFT	-.247185802+09	-.204285786+07
DETRITUS	OUTSIDE THE SYSTEM	DRIFT	-.527508900+09	-.435957762+07

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
OUTSIDE THE SYSTEM	FINE PARTICLES	INCOMING TRANSPORT	.280281120+09	.231637287+07
OUTSIDE THE SYSTEM	COARSE PARTICLES	INCOMING TRANSPORT	.247275298+09	.204359750+07
OUTSIDE THE SYSTEM	DETRITUS	INCOMING TRANSPORT	.527556416+09	.435997037+07

DISSOLVED ORGANICS

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
DISSOLVED ORGANICS	OUTSIDE THE SYSTEM	DRIFT	-.649234144+10	-.536557140+08

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER ECSYS.PER DAY
OUTSIDE THE SYSTEM	DISSOLVED ORGANICS	DRIFT	.649213446+10	.536540035+08

****** EXCHANGE OF ENERGY WITHIN THE ECOSYSTEM ******

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
BENTHIC DIATOMS	HYALLELA AZTECA	HERBIVORY	.421619743+03	.134380695+01
CLADOPHORA	HYALLELA AZTECA	HERBIVORY	.248045471+04	.790582597+01
CHARA	HYALLELA AZTECA	HERBIVORY	.945342542+04	.301304176+02
POTOMOGETON	HYALLELA AZTECA	HERBIVORY	.499216858+04	.159112827+02
BENTHIC DIATOMS	BAETIS TRICAUDATUS	HERBIVORY	.452237278+03	.144139266+01
CLADOPHORA	BAETIS TRICAUDATUS	HERBIVORY	.669323486+03	.213330036+01
SPIROGYRA	BAETIS TRICAUDATUS	HERBIVORY	.139167997+03	.443563014+00
CHARA	BAETIS TRICAUDATUS	HERBIVORY	.688797310+03	.219536829+01
POTOMOGETON	BAETIS TRICAUDATUS	HERBIVORY	.132198732+04	.421350229+01
BENTHIC DIATOMS	OPTIOSERVUS DIVERGENS	HERBIVORY	.303842752+02	.968422405-01
CLADOPHORA	OPTIOSERVUS DIVERGENS	HERBIVORY	.117185120+03	.373498116+00
SPIROGYRA	OPTIOSERVUS DIVERGENS	HERBIVORY	.247784855+02	.789751951-01
CHARA	OPTIOSERVUS DIVERGENS	HERBIVORY	.175547907+02	.559514831-01
POTOMOGETON	OPTIOSERVUS DIVERGENS	HERBIVORY	.887040443+02	.282721847+00
BENTHIC DIATOMS	TRICORYTHODES MINUTUS	HERBIVORY	.261365915+04	.833038163+01
CLADOPHORA	TRICORYTHODES MINUTUS	HERBIVORY	.252978165+04	.806304312+01
SPIROGYRA	TRICORYTHODES MINUTUS	HERBIVORY	.227013150+04	.723547357+01
CHARA	TRICORYTHODES MINUTUS	HERBIVORY	.849949133+04	.270899923+02
POTOMOGETON	TRICORYTHODES MINUTUS	HERBIVORY	.856507288+04	.272990170+02
BENTHIC DIATOMS	HYDROPSYCHE OCCIDENTALIS	HERBIVORY	.205653058+04	.655467433+01
CLADOPHORA	HYDROPSYCHE OCCIDENTALIS	HERBIVORY	.108971991+03	.347320829+00
SPIROGYRA	HYDROPSYCHE OCCIDENTALIS	HERBIVORY	.193795353+03	.617673978+00
CHARA	HYDROPSYCHE OCCIDENTALIS	HERBIVORY	.150245417+03	.478869502+00
POTOMOGETON	HYDROPSYCHE OCCIDENTALIS	HERBIVORY	.201007643+03	.640661336+00
PLANTS	RHINICHTHYS OSCULUS	HERBIVORY	.000000000	.000000000
PLANTS	HYALLELA AZTECA	HERBIVORY	.173476682+05	.552913322+02
PLANTS	BAETIS TRICAUDATUS	HERBIVORY	.327151337+04	.104271265+02
PLANTS	OPTIOSERVUS DIVERGENS	HERBIVORY	.278606712+03	.887988873+00
PLANTS	TRICORYTHODES MINUTUS	HERBIVORY	.244781365+05	.780179071+02
PLANTS	HYDROPSYCHE OCCIDENTALIS	HERBIVORY	.271055093+04	.863919985+01
PLANTS	SIMULIUM ARGUS	HERBIVORY	.000000000	.000000000
PLANTS	ARGIA VIVIDA	HERBIVORY	.000000000	.000000000
BENTHIC DIATOMS	ANIMALS	HERBIVORY	.557443097+04	.177670975+02
CLADOPHORA	ANIMALS	HERBIVORY	.590571692+04	.188229883+02
SPIROGYRA	ANIMALS	HERBIVORY	.262787332+04	.837568569+01
CHARA	ANIMALS	HERBIVORY	.188095139+05	.599505978+02
POTOMOGETON	ANIMALS	HERBIVORY	.151689403+05	.483471847+02
PLANTS	ANIMALS	HERBIVORY	.480864722+05	.153263544+03

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
RHINICHTHYS OSCULUS	RHINICHTHYS OSCULUS	CARNIVORY	.705004993-06	.224702620-08
HYALLELA AZTECA	RHINICHTHYS OSCULUS	CARNIVORY	.116956156+02	.372768352-01
HYALLELA AZTECA	HYALLELA AZTECA	CARNIVORY	.198052654+05	.631243057+02
HYALLELA AZTECA	BAETIS TRICAUDATUS	CARNIVORY	.860573326+03	.274286118+01
HYALLELA AZTECA	OPTIOSERVUS DIVERGENS	CARNIVORY	.252628269+02	.805189107-01
HYALLELA AZTECA	TRICORYTHODES MINUTUS	CARNIVORY	.116554363+05	.371487737+02
HYALLELA AZTECA	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.219891443+04	.700848705+01
HYALLELA AZTECA	SIMULIUM ARGUS	CARNIVORY	.564460158+00	.179907489-02
HYALLELA AZTECA	ARGIA VIVIDA	CARNIVORY	.260614323+03	.830642648+00
BAETIS TRICAUDATUS	RHINICHTHYS OSCULUS	CARNIVORY	.499052739+02	.159060517+00
BAETIS TRICAUDATUS	HYALLELA AZTECA	CARNIVORY	.253791544+04	.808896756+01
BAETIS TRICAUDATUS	BAETIS TRICAUDATUS	CARNIVORY	.744862566-01	.237406221-03
BAETIS TRICAUDATUS	OPTIOSERVUS DIVERGENS	CARNIVORY	.123968788-01	.395119350-04
BAETIS TRICAUDATUS	TRICORYTHODES MINUTUS	CARNIVORY	.167045605+01	.532415882-02
BAETIS TRICAUDATUS	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.957990043+00	.305335247-02
BAETIS TRICAUDATUS	SIMULIUM ARGUS	CARNIVORY	.560660765+00	.178696527-02
BAETIS TRICAUDATUS	ARGIA VIVIDA	CARNIVORY	.655378133+00	.208885307-02
OPTIOSERVUS DIVERGENS	RHINICHTHYS OSCULUS	CARNIVORY	.283480862+01	.903523993-02
OPTIOSERVUS DIVERGENS	HYALLELA AZTECA	CARNIVORY	.372699828+02	.118788702+00
OPTIOSERVUS DIVERGENS	BAETIS TRICAUDATUS	CARNIVORY	.148500274+01	.473307300-02
OPTIOSERVUS DIVERGENS	OPTIOSERVUS DIVERGENS	CARNIVORY	.259883471+00	.828313241-03
OPTIOSERVUS DIVERGENS	TRICORYTHODES MINUTUS	CARNIVORY	.267494285+02	.852570804-01
OPTIOSERVUS DIVERGENS	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.167360249+01	.533418730-02
OPTIOSERVUS DIVERGENS	SIMULIUM ARGUS	CARNIVORY	.600360177-02	.191349716-04
OPTIOSERVUS DIVERGENS	ARGIA VIVIDA	CARNIVORY	.106788300+02	.340360864-01
TRICORYTHODES MINUTUS	RHINICHTHYS OSCULUS	CARNIVORY	.339718822+03	.108276835+01
TRICORYTHODES MINUTUS	HYALLELA AZTECA	CARNIVORY	.401925610+03	.128103685+01
TRICORYTHODES MINUTUS	BAETIS TRICAUDATUS	CARNIVORY	.191980025+04	.611888075+01
TRICORYTHODES MINUTUS	OPTIOSERVUS DIVERGENS	CARNIVORY	.333655806+02	.106344402+00
TRICORYTHODES MINUTUS	TRICORYTHODES MINUTUS	CARNIVORY	.145508954+05	.463773217+02
TRICORYTHODES MINUTUS	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.137220554+02	.437356029-01
TRICORYTHODES MINUTUS	SIMULIUM ARGUS	CARNIVORY	.197819449+00	.630499773-03
TRICORYTHODES MINUTUS	ARGIA VIVIDA	CARNIVORY	.107386728+03	.342268206+00
HYDROPSYCHE OCCIDENTALIS	RHINICHTHYS OSCULUS	CARNIVORY	.254038951+02	.809685308-01
HYDROPSYCHE OCCIDENTALIS	HYALLELA AZTECA	CARNIVORY	.123612589+04	.393984056+01
HYDROPSYCHE OCCIDENTALIS	BAETIS TRICAUDATUS	CARNIVORY	.804328360+00	.256359449-02
HYDROPSYCHE OCCIDENTALIS	OPTIOSERVUS DIVERGENS	CARNIVORY	.139647298+00	.445090660-03
HYDROPSYCHE OCCIDENTALIS	TRICORYTHODES MINUTUS	CARNIVORY	.215588484+02	.687134108-01
HYDROPSYCHE OCCIDENTALIS	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.109218228+01	.348105651-02
HYDROPSYCHE OCCIDENTALIS	SIMULIUM ARGUS	CARNIVORY	.272999867-02	.870118458-05
HYDROPSYCHE OCCIDENTALIS	ARGIA VIVIDA	CARNIVORY	.795763290+01	.253629547-01
SIMULIUM ARGUS	RHINICHTHYS OSCULUS	CARNIVORY	.536079174-01	.170861762-03
SIMULIUM ARGUS	HYALLELA AZTECA	CARNIVORY	.206214395+04	.657256556+01
SIMULIUM ARGUS	BAETIS TRICAUDATUS	CARNIVORY	.171436112+00	.546409516-03
SIMULIUM ARGUS	OPTIOSERVUS DIVERGENS	CARNIVORY	.302429663-01	.963918537-04
SIMULIUM ARGUS	TRICORYTHODES MINUTUS	CARNIVORY	.472791547+01	.150690422-01
SIMULIUM ARGUS	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.234002048+00	.745822712-03
SIMULIUM ARCUS	SIMULIUM ARGUS	CARNIVORY	.597958926-03	.190584379-05
SIMULIUM ARGUS	ARGIA VIVIDA	CARNIVORY	.167813410+01	.534863066-02

ARGIA VIVIDA	HYALLELA AZTECA	CARNIVORY	.504701728+01	.160860990-01
ARGIA VIVIDA	BAETIS TRICAUDATUS	CARNIVORY	.399725726-01	.127402527-03
ARGIA VIVIDA	OPTIOSERVUS DIVERGENS	CARNIVORY	.696065603-02	.221853415-04
ARGIA VIVIDA	TRICORYTHODES MINUTUS	CARNIVORY	.105836201+01	.337326288-02
ARGIA VIVIDA	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.541788549-01	.172681483-03
ARGIA VIVIDA	SIMULIUM ARGUS	CARNIVORY	.134074689-03	.427329375-06
ARGIA VIVIDA	ARGIA VIVIDA	CARNIVORY	.396831788+00	.126480158-02
ANIMALS	RHINICHTHYS OSCULUS	CARNIVORY	.429612015+03	.136928031+01
ANIMALS	HYALLELA AZTECA	CARNIVORY	.260856924+05	.831415882+02
ANIMALS	BAETIS TRICAUDATUS	CARNIVORY	.278294873+04	.886994958+01
ANIMALS	OPTIOSERVUS DIVERGENS	CARNIVORY	.590775380+02	.188294804+00
ANIMALS	TRICORYTHODES MINUTUS	CARNIVORY	.262620964+05	.837038317+02
ANIMALS	HYDROPSYCHE OCCIDENTALIS	CARNIVORY	.221664835+04	.706500947+01
ANIMALS	SIMULIUM ARGUS	CARNIVORY	.133240597+01	.424670911-02
ANIMALS	ARGIA VIVIDA	CARNIVORY	.389367847+03	.124101214+01
RHINICHTHYS OSCULUS	ANIMALS	CARNIVORY	.705004993-06	.224702620-08
HYALLELA AZTECA	ANIMALS	CARNIVORY	.348183262+05	.110974664+03
BAETIS TRICAUDATUS	ANIMALS	CARNIVORY	.259175198+04	.826055801+01
OPTIOSERVUS DIVERGENS	ANIMALS	CARNIVORY	.809575396+02	.258031808+00
TRICORYTHODES MINUTUS	ANIMALS	CARNIVORY	.173670120+05	.553529854+02
HYDROPSYCHE OCCIDENTALIS	ANIMALS	CARNIVORY	.129308508+04	.412138367+01
SIMULIUM ARGUS	ANIMALS	CARNIVORY	.206903979+04	.659454429+01
ARGIA VIVIDA	ANIMALS	CARNIVORY	.660345709+01	.210468597-01
ANIMALS	ANIMALS	CARNIVORY	.582267646+05	.185583178+03

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
FINE PARTICLES	HYALLELA AZTECA	DETRITIVORY	.229761829+05	.732308083+02
COARSE PARTICLES	HYALLELA AZTECA	DETRITIVORY	.108213820+06	.344904354+03
FINE PARTICLES	BAETIS TRICAUDATUS	DETRITIVORY	.161824032+03	.515773423+00
COARSE PARTICLES	BAETIS TRICAUDATUS	DETRITIVORY	.171433134+04	.546400028+01
FINE PARTICLES	OPTIOSERVUS DIVERGENS	DETRITIVORY	.962506752+02	.306774836+00
COARSE PARTICLES	OPTIOSERVUS DIVERGENS	DETRITIVORY	.823242302+03	.262387791+01
FINE PARTICLES	TRICORYTHODES MINUTUS	DETRITIVORY	.865335925+04	.275804076+02
COARSE PARTICLES	TRICORYTHODES MINUTUS	DETRITIVORY	.505854385+05	.161228371+03
FINE PARTICLES	HYDROPSYCHE OCCIDENTALIS	DETRITIVORY	.773736618+03	.246609101+01
COARSE PARTICLES	HYDROPSYCHE OCCIDENTALIS	DETRITIVORY	.614461646+04	.195844204+02
FINE PARTICLES	SIMULIUM ARGUS	DETRITIVORY	.687981882+02	.219276933+00
DETRITUS	RHINICHTHYS OSCULUS	DETRITIVORY	.000000000	.000000000
DETRITUS	HYALLELA AZTECA	DETRITIVORY	.131190002+06	.418135159+03
DETRITUS	BAETIS TRICAUDATUS	DETRITIVORY	.187615536+04	.597977364+01
DETRITUS	OPTIOSERVUS DIVERGENS	DETRITIVORY	.919492973+03	.293065274+01
DETRITUS	TRICORYTHODES MINUTUS	DETRITIVORY	.592387974+05	.188808777+03
DETRITUS	HYDROPSYCHE OCCIDENTALIS	DETRITIVORY	.691835303+04	.220505114+02
DETRITUS	SIMULIUM ARGUS	DETRITIVORY	.687981882+02	.219276933+00
DETRITUS	ARGIA VIVIDA	DETRITIVORY	.000000000	.000000000
FINE PARTICLES	ANIMALS	DETRITIVORY	.327301511+05	.104319130+03
COARSE PARTICLES	ANIMALS	DETRITIVORY	.167481447+06	.533805016+03
DETRITUS	ANIMALS	DETRITIVORY	.200211590+06	.638124123+03

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
DRIFTING MICROBES	SIMULIUM ARGUS	MICROBIVORY	.411405615+04	.131125200+02
BENTHIC MICROBES	HYALLELA AZTECA	MICROBIVORY	.395855278+03	.126168920+01
BENTHIC MICROBES	BAETIS TRICAUDATUS	MICROBIVORY	.701714504+01	.223653861-01
BENTHIC MICROBES	OPTIOSERVUS DIVERGENS	MICROBIVORY	.358801100+01	.114358832-01
BENTHIC MICROBES	TRICORYTHODES MINUTUS	MICROBIVORY	.141776243+03	.451876141+00
DECOMPOSERS	RHINICHTHYS OSCULUS	MICROBIVORY	.000000000	.000000000
DECOMPOSERS	HYALLELA AZTECA	MICROBIVORY	.395855278+03	.126168920+01
DECOMPOSERS	BAETIS TRICAUDATUS	MICROBIVORY	.701714504+01	.223653861-01
DECOMPOSERS	OPTIOSERVUS DIVERGENS	MICROBIVORY	.358801100+01	.114358832-01
DECOMPOSERS	TRICORYTHODES MINUTUS	MICROBIVORY	.141776243+03	.451876141+00
DECOMPOSERS	HYDROPSYCHE OCCIDENTALIS	MICROBIVORY	.000000000	.000000000
DECOMPOSERS	SIMULIUM ARGUS	MICROBIVORY	.411405615+04	.131125200+02
DECOMPOSERS	ARGIA VIVIDA	MICROBIVORY	.000000000	.000000000
DRIFTING MICROBES	ANIMALS	MICROBIVORY	.411405615+04	.131125200+02
BENTHIC MICROBES	ANIMALS	MICROBIVORY	.548236671+03	.174736659+01
DECOMPOSERS	ANIMALS	MICROBIVORY	.466229279+04	.148598864+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
RHINICHTHYS OSCULUS	COARSE PARTICLES	EGESTION	.243649395+02	.776571203-01
HYALLELA AZTECA	COARSE PARTICLES	EGESTION	.368802266+05	.117546453+03
BAETIS TRICAUDATUS	COARSE PARTICLES	EGESTION	.190610135+04	.607521898+01
OPTIOSERVUS DIVERGENS	COARSE PARTICLES	EGESTION	.651204319+02	.207555009+00
TRICORYTHODES MINUTUS	COARSE PARTICLES	EGESTION	.187746511+05	.598394818+02
HYDROPSYCHE OCCIDENTALIS	COARSE PARTICLES	EGESTION	.222579828+04	.709417260+01
SIMULIUM ARGUS	COARSE PARTICLES	EGESTION	.502102398+03	.160032520+01
ARGIA VIVIDA	COARSE PARTICLES	EGESTION	.133114437+02	.424268809-01
RHINICHTHYS OSCULUS	DETRITUS	EGESTION	.243649395+02	.776571203-01
HYALLELA AZTECA	DETRITUS	EGESTION	.368802266+05	.117546453+03
BAETIS TRICAUDATUS	DETRITUS	EGESTION	.190610135+04	.607521898+01
OPTIOSERVUS DIVERGENS	DETRITUS	EGESTION	.651204319+02	.207555009+00
TRICORYTHODES MINUTUS	DETRITUS	EGESTION	.187746511+05	.598394818+02
HYDROPSYCHE OCCIDENTALIS	DETRITUS	EGESTION	.222579828+04	.709417260+01
SIMULIUM ARGUS	DETRITUS	EGESTION	.502102398+03	.160032520+01
ARGIA VIVIDA	DETRITUS	EGESTION	.133114437+02	.424268809-01
ANIMALS	FINE PARTICLES	EGESTION	.000000000	.000000000
ANIMALS	COARSE PARTICLES	EGESTION	.603916743+05	.192483282+03
ANIMALS	DETRITUS	EGESTION	.603916743+05	.192483282+03

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
RHINICHTHYS OSCULUS	DISSOLVED ORGANICS	EGESTION	.365474091+02	.116485680+00
HYALLELA AZTECA	DISSOLVED ORGANICS	EGESTION	.553203394+05	.176319677+03
BAETIS TRICAUDATUS	DISSOLVED ORGANICS	EGESTION	.285915170+04	.911282742+01
OPTIOSERVUS DIVERGENS	DISSOLVED ORGANICS	EGESTION	.976806459+02	.311332509+00
TRICORYTHODES MINUTUS	DISSOLVED ORGANICS	EGESTION	.281619775+05	.897592249+02
HYDROPSYCHE OCCIDENTALIS	DISSOLVED ORGANICS	EGESTION	.333869736+04	.106412586+02
SIMULIUM ARGUS	DISSOLVED ORGANICS	EGESTION	.753153542+03	.240048760+01
ARGIA VIVIDA	DISSOLVED ORGANICS	EGESTION	.199671657+02	.636403216-01
ANIMALS	DISSOLVED ORGANICS	EGESTION	.905875127+05	.288724926+03

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
BENTHIC DIATOMS	COARSE PARTICLES	MORTALITY	.677840698+04	.216044686+02
CLADOPHORA	COARSE PARTICLES	MORTALITY	.342067099+04	.109025290+02
SPIROGYRA	COARSE PARTICLES	MORTALITY	.312621155+04	.996401358+01

CHARA	COARSE PARTICLES	MORTALITY	.561678015+04	.179020751+02
POTOMOGETON	COARSE PARTICLES	MORTALITY	.840045508+04	.267743392+02
PLANTS	FINE PARTICLES	MORTALITY	.000000000	.000000000
PLANTS	COARSE PARTICLES	MORTALITY	.273425247+05	.871474247+02
BENTHIC DIATOMS	DETRITUS	MORTALITY	.677840698+04	.216044686+02
CLADOPHORA	DETRITUS	MORTALITY	.342067099+04	.109025290+02
SPIROGYRA	DETRITUS	MORTALITY	.312621155+04	.996401358+01
CHARA	DETRITUS	MORTALITY	.561678015+04	.179020751+02
POTOMOGETON	DETRITUS	MORTALITY	.840045508+04	.267743392+02
PLANTS	DETRITUS	MORTALITY	.273425247+05	.871474247+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
RHINICHTHYS OSCULUS	COARSE PARTICLES	MORTALITY	.372819309-01	.118826784-03
HYALLELA AZTECA	COARSE PARTICLES	MORTALITY	.815102075+04	.259793298+02
BAETIS TRICAUDATUS	COARSE PARTICLES	MORTALITY	.118797307+03	.378636558+00
OPTIOSERVUS DIVERGENS	COARSE PARTICLES	MORTALITY	.168521738+02	.537120681-01
TRICORYTHODES MINUTUS	COARSE PARTICLES	MORTALITY	.262941776+04	.838060820+01
HYDROPSYCHE OCCIDENTALIS	COARSE PARTICLES	MORTALITY	.171683622+03	.547198392+00
SIMULIUM ARGUS	COARSE PARTICLES	MORTALITY	.646792936+02	.206148991+00
ARGIA VIVIDA	COARSE PARTICLES	MORTALITY	.271402237+02	.865026414-01
RHINICHTHYS OSCULUS	DETRITUS	MORTALITY	.372819309-01	.118826784-03
HYALLELA AZTECA	DETRITUS	MORTALITY	.815102075+04	.259793298+02
BAETIS TRICAUDATUS	DETRITUS	MORTALITY	.118797307+03	.378636558+00
OPTIOSERVUS DIVERGENS	DETRITUS	MORTALITY	.168521738+02	.537120681-01
TRICORYTHODES MINUTUS	DETRITUS	MORTALITY	.262941776+04	.838060820+01
HYDROPSYCHE OCCIDENTALIS	DETRITUS	MORTALITY	.171683622+03	.547198392+00
SIMULIUM ARGUS	DETRITUS	MORTALITY	.646792936+02	.206148991+00
ARGIA VIVIDA	DETRITUS	MORTALITY	.271402237+02	.865026414-01
ANIMALS	FINE PARTICLES	MORTALITY	.000000000	.000000000
ANIMALS	COARSE PARTICLES	MORTALITY	.111796281+05	.356322546+02
ANIMALS	DETRITUS	MORTALITY	.111796281+05	.356322546+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
BENTHIC DIATOMS	DISSOLVED ORGANICS	LEAKAGE	.480345966+04	.153098203+02
CLADOPHORA	DISSOLVED ORGANICS	LEAKAGE	.341163626+04	.108737330+02
SPIROGYRA	DISSOLVED ORGANICS	LEAKAGE	.311755753+04	.993643105+01
CHARA	DISSOLVED ORGANICS	LEAKAGE	.555618243+04	.177089350+02
POTOMOGETON	DISSOLVED ORGANICS	LEAKAGE	.803566052+04	.256116481+02
PLANTS	DISSOLVED ORGANICS	LEAKAGE	.249244961+05	.794405670+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
FINE PARTICLES	DISSOLVED ORGANICS	LEAKAGE	.826999304+04	.263585243+02
COARSE PARTICLES	DISSOLVED ORGANICS	LEAKAGE	.228009128+05	.726721783+02
DETRITUS	DISSOLVED ORGANICS	LEAKAGE	.310709058+05	.990307026+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
DISSOLVED ORGANICS	FINE PARTICLES	COAGULATION	.835236846+05	.266210751+03
DISSOLVED ORGANICS	DETRITUS	COAGULATION	.835236846+05	.266210751+03

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
FINE PARTICLES	BENTHIC MICROBES	DECOMPOSITION	.461628632+04	.147132523+02
COARSE PARTICLES	BENTHIC MICROBES	DECOMPOSITION	.221593892+05	.706274834+02
DETRITUS	DRIFTING MICROBES	DECOMPOSITION	.000000000	.000000000
DETRITUS	BENTHIC MICROBES	DECOMPOSITION	.267756753+05	.853407354+02
FINE PARTICLES	DECOMPOSERS	DECOMPOSITION	.461628632+04	.147132523+02
COARSE PARTICLES	DECOMPOSERS	DECOMPOSITION	.221593892+05	.706274834+02
DETRITUS	DECOMPOSERS	DECOMPOSITION	.267756753+05	.853407354+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
DISSOLVED ORGANICS	DRIFTING MICROBES	DECOMPOSITION	.375536890+04	.119692944+02
DISSOLVED ORGANICS	BENTHIC MICROBES	DECOMPOSITION	.567388043+04	.180840678+02
DISSOLVED ORGANICS	DECOMPOSERS	DECOMPOSITION	.942924927+04	.300533621+02

FROM	TO	BY WAY OF	KCAL.PER ECSYS. FOR121 DAYS	AVE KCAL.PER SQ.M..PER DAY
DRIFTING MICROBES	DISSOLVED ORGANICS	LEAKAGE	.694743256+03	.221431950+01
BENTHIC MICROBES	DISSOLVED ORGANICS	LEAKAGE	.600316846+04	.191335905+02
DECOMPOSERS	DISSOLVED ORGANICS	LEAKAGE	.669791168+04	.213479099+02

APPENDIX B

Listing of Subroutine RPORT2

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      SUBROUTINE RPORT2
C-----------------------------------------------------------------------
C     COMMON BLOCKS/PROSUM/,/PRODUC/,/PRODCH/ DEAL WITH PRODUCTIVITY
C     IN THE SYSTEM.
C-----------------------------------------------------------------------
      COMMON/PROSUM/PVTOT(4),PRTOT(4),PATOTS(15,4),PATOTA(4),PVSUM(4),
     1PBSUM(4),PASUMS(15,4),PASUMA(4)
      COMMON/PRODUC/PCVEG( 8,1,4),PCBIOM(40,4),PCBACT(3,4)
      COMMON/PRODCH/CVEGP( 8,1,4), CBIOMP(40,4),CBACTP(3,4)
      COMMON/OTHER/AVFIND(40),XGRA(20),PRRASO,PRRTOT
C-----------------------------------------------------------------------
C     COMMON BLOCK /TOTALS/ CONTAINS SUMS OF THE STATE VARIABLES,
C     TOGETHER WITH CERTAIN OTHER VARIABLES REQUIRING INITIALIZATION
C     BUT NOT INCREMENTATION AT EACH TIME UNIT.
C-----------------------------------------------------------------------
      COMMON/TOTALS/CVEGV(1,4),CVEGO( 8,4),CVEGVO(4),BPINRT( 6),
     1WPINRT( 6),PINRTT( 6),AQUATT(4),WDINRT( 6),
     2                    CBIOMA(4),CLITT(4),CORGT(4),
     3TOT(4), POPSP(15),ANIM(15,4),CBACTT(4),TOTAL(4)
      COMMON/EVERY1/AGAINT(4),H2OTOT,CGAINT( 6),DGAINT( 6)
C-----------------------------------------------------------------------
C     THE COMMON BLOCK /NAMES/ CONTAINS THE NAMES REQUIRED FOR
C     TABULATED OUTPUT
C-----------------------------------------------------------------------
      COMMON/NAMES/COHNAM(26,4),BACNAM(3,5),VSPNAM( 8,7),ASPNAM(15,7),
     1ORGNAM(1,6),FRANAM( 4,3),ALINAM(5,4),DINAM( 6,3),PINAM( 6,3)
     2,STRNAM(5,3),RATEN(5,20),SRANAM(5,7),SOURCE(5,13)
C-----------------------------------------------------------------------
C     COMMON BLOCK /ACC/ CONTAINS ACCUMULATED CHANGES, WHICH MAY BE
C     NEGATIVE.  COMMON BLOCK /ACCINC/ CONTAINS THE INCREMENTS TO THE
C     ARRAYS IN /ACC/ FOR A SINGLE TIME UNIT.
C-----------------------------------------------------------------------
      COMMON/ACC/AGAIN(13,4),H2O(13),CGAIN(13, 6),DGAIN(13, 6)
      COMMON/ACCINC/AGAINQ(13,4),H2OQQ(13),CGAINQ(13, 6),DGAINQ(13, 6)
C-----------------------------------------------------------------------
C     COMMON BLOCK /SPEC/ CONTAINS SPECIFICATIONS AND OTHER INFORMATION
C     COMMON TO THE WHOLE SET OF PROGRAMS, BUT EXCLUDING STATE AND
C     EXOGENOUS VARIABLES.
C-----------------------------------------------------------------------
      COMMON/SPEC/       NCHAN,                 WATER,NSPECV,NSPECA,NORGAN,
     1  PHW,PHB,     NCLIT ,NCHECK,IDAY, ATOT, ATOTO,IYRDAY,NREPET(20)
     2,NCOH(15),LISCOH(40),NCOHCU(15),NCOHOR              ,NSPCOH,NDEBUG
     3,FLOUT,MICROB   ,              KMONTH ,       NSTRCH,JSAVE
     4,NSUBST,CYCLE,               NOLIT1
     5,IDAYPR,WATTOT,NPRT(30) ,REACH,NPOPT,FLOWS
     6,NFRELM,ISTRTM,INORGP,INORGD
     7,KORGSW(2,4),KINRGP(1, 6),KINRGD(1, 6)
     8,NDRIFM(3),NDRIFA(40),NDRIFV( 8)
     9,NTRIB ,NPORTI,TEMPW,TEMPB,NPASS,NRATE,ILIT,KDAY,KYEAR,IMIN
C-----------------------------------------------------------------------
C     COMMON BLOCK /STAT/ CONTAINS THE STATE VARIABLES, AND /CHANGE/
C     THEIR INCREMENTS OR DECREMENTS FOR THE CURRENT TIME UNIT.
C-----------------------------------------------------------------------
      COMMON/STAT/CVEG( 8,1,4),CORG(5,4),POP(40),CBIOM(40,4),AQUA(4),
     1CLIT(5,4),CBACT(3,4),AQUAB(4),WDINR( 6),WPINR(5, 6),BDINR( 6)
     2,BPINR(5, 6)
      COMMON/CHANGE/CVEGQQ( 8,1,4),CORGQQ(5,4),POPQQQ(40),CBIOMQ(40,4)
     1,AQUAQQ(4),CLITQQ(5,4),CBACTQ(3,4),AQUABQ(4),
     2WDINRQ( 6),WPINRQ(5, 6),BDINRQ( 6),BPINRQ(5, 6)
C-----------------------------------------------------------------------
C     COMMON BLOCK /DIAGR/ CONTAINS INFORMATION REQUIRED FOR GRAPHS.
C-----------------------------------------------------------------------
      COMMON/DIAGR/FIG(8,70),EXPLA(5,8),TITLE(20),YTITLE(10),
     1 XDOT(71), XMAX, XMIN, YMAX, YMIN, NOSYM, INITYR
      COMMON/PHYS/FLOW,PERIM,DEPTH,WATSYS,VELOCT,AREA,WIDTH
C-----------------------------------------------------------------------
C    COMMON BLOCKKS/RRATE/IS THE RATE OF FLOW FOR PROCESSES FOR THE
C     ECOSYSTEM  AND /RRATEQ/ IS THEIR  INCREMENTS OR DECREMENTS FOR
C     THE CURRENT TIME UNIT./RRATOT/CONTAINS TOTALS FOR THESE PROCESSES
C-----------------------------------------------------------------------
      COMMON/RRATE /RPLDR (8),RPLRE (8),RDRPL (8),RPHPL (8),RDETD (5),
     1RALDE (5),RDIDR ,RDRDI ,RDERE (3),RDRDE (3),RDEDR (3),REDAN (15),
     2RDRAN (15),RANDR (15),RANEM (15),RARES (15),RACAR (15,15),
     3RFLEO (8),RPMOD (8,5),RPHEA (8,15),RDEIA (5,15),RAEGD (15,5),
     4RAMOD (15,5),RDDED (5,3),RANED (15),RDLED (5),RDIDD (3),RDLEO (3),
     5RDINA (3,15),RDCOD (5)
      COMMON/RRATEQ/RPLDRQ(8),RPLREQ(8),RDRPLQ(8),RPHPLQ(8),RDETDQ(5),
     1RALDEQ(5),RDIDRQ,RDRDIQ,RDEREQ(3),RDRDEQ(3),RDEDRQ(3),REDANQ(15),
     2RDRANQ(15),RANDRQ(15),RANEMQ(15),RARESQ(15),RACARQ(15,15),
     3RFLEOQ(8),RPMODQ(8,5),RPHEAQ(8,15),RDEIAQ(5,15),RAEGDQ(15,5),
     4RAMODQ(15,5),RDDEDQ(5,3),RANEDQ(15),RDLEDQ(5),RDIDDQ(3),RDLEOQ(3),
     5RDINAQ(3,15),RDCODQ(5)
      COMMON/RRATOT/REDANT,RDRANT,RANDRT,RANEMT,RAREST,RANEDT,
     1RACART(15),RACARS(15),RACARL,RPHEAT(15),RPHEAS(8),RPHEAL,
     2RDEIAT(15),RDEIAS(5),RDEIAL,RAEGDT(15),RAEGDS(5),RAEGDL,
     3RAMODT(15),RAMODS(5),RAMODL,RDINAT(15),RDINAL,RDEDRT,
     4RDRDET,RDERET,RDLEOT,RDIDOT,RDDEDT(3),RDDEDS(5),RDDEDL,RDETDT,
     5RALDET,RDLEDT,RDCODT,RPMODT(8),RPMODS(8),RPMODL,RPLDRT,RPLRET,
     6RDRPLT,RPHPLT,RFLEOT,RARESD,RDERED,RPLRED,RPHPLD
C-----------------------------------------------------------------------
C     COMMON/TROFIC/CONTAINS VALUES OF ANIMAL BIOENERGETICS BASED ON
C     TROPHIC LEVELS.
C-----------------------------------------------------------------------
      COMMON/TROFIC/ETCENT(15,4),EATAL(4),RESTRO(15,4),RESALL(4),
     1GROTRO(15,4),GROALL(4),EATTRO(15,4),ALLEAT(4),ANGRO(15)
C-----------------------------------------------------------------------
C     COMMON BLOCK /METEOR/ CONTAINS THE VALUES OF EXOGENOUS VARIABLES
C     FOR THE CURRENT TIME UNIT.
C-----------------------------------------------------------------------
      COMMON/METEOR/WIRRIG,     RUNSOL(4),RUNDEB(5,4),DARAIN,DAYRUN,
     1RUNPNR(5, 6),RUNDNR( 6),DUSTIP(5, 6),
     2TRFLOW,TCOMPN(4),TDETIN(5,4),TDRIFV( 8,1,4),TDRIFO(40),
     3TDRIFA(40,4),TDRIFM(3,4),TPNORG(5, 6),TDNORG( 6),
     4EVAP,RAINDI( 6),DAPHOT, DAYRAD,DADUST(5,4), EXOG(40),RAINCO(4),
     5FLOSEC,COMPIN(4),DETIN(5,4),DRIFTV( 8,1,4),DRIFPO(40),
     6DRIFTA(40,4),DRIFTM(3,4)   ,PH,PNORG(5, 6),DNORG( 6),WTEMP,
     7FLOWIN,XCOMPN(4),XDETIN(5,4),XDRIFV( 8,1,4),XDRIFO(40),
     8XDRIFA(40,4),XDRIFM(3,4)   ,XPH,XPNORG(5, 6),XDNORG( 6),XWTEMP
C-----------------------------------------------------------------------
C     VALUES FOR COMMUNITY METABOLISM ARE PRINTED.
C-----------------------------------------------------------------------
      IF(NPRT(27).EQ.0)GO TO 50
      WRITE(6,5)
    5 FORMAT(1H0,8X,'****** THE FOLLOWING FIGURES ARE FOR METABOLISM.
     1ALL FIGURES ARE BASED ON ENERGY MEASURED IN KILOCALORIES ******')
      WRITE (6,10)
   10 FORMAT (1H0,35X,'FOR THE CURRENT TIME UNIT',25X,
     1'ACCUMULATED FOR THE ENTIRE SIMULATION')
      WRITE (6,15)
   15 FORMAT (1H0,23X,'AVE. PER SQ. METER',5X,'PER ECOSYSTEM',
     120X,'AVE. PER SQ. METER',5X,'PER ECOSYSTEM')
      PA1=RPHPLD/AREA
      PA2=-RPLRED/AREA
      PA3=-RARESD/AREA
      PA4=-RDERED/AREA
      PA5=-(RPLRED+RARESD+RDERED)/AREA
      PB1=RPHPLT/AREA
      PB2=-RPLRET/AREA
      PB3=-RAREST/AREA
      PB4=-RDERET/AREA
      PB5=-(RPLRET+RAREST+RDERET)/AREA
      PA6=-(RPLRED+RARESD+RDERED)
      PB6=-(RPLRET+RAREST+RDERET)
      WRITE(6,20)PA1,RPHPLD,PB1,RPHPLT
      F1=-RPLRED
      F2=-RPLRET
      F3=-RARESD
      F4=-RAREST
      F5=-RDERED
      F6=-RDERET
      WRITE(6,25)PA2,F1,PB2,F2
      WRITE(6,30)PA3,F3,PB3,F4
      WRITE(6,35)PA4,F5,PB4,F6
      WRITE(6,40) PA5,PA6,PB5,PB6
   20 FORMAT(1H0,'PLANT GROSS PRODUCTIVITY',9X,F10.4,10X,F10.3,26X,
     1F10.2,10X,F10.1)
   25 FORMAT(1X,'PLANT RESPIRATION',16X,F10.4,10X,F10.3,26X,
     1F10.2,10X,F10.1)
   30 FORMAT(1X,'ANIMAL RESPIRATION',15X,F10.4,10X,F10.3,26X,
     1F10.2,10X,F10.1)
   35 FORMAT(1X,'MICROBAL RESPIRATION',13X,F10.4,10X,F10.3,26X,
     1F10.2,10X,F10.1)
   40 FORMAT(1X,'TOTAL RESPIRATION',16X,F10.4,10X,F10.3,26X,
     1F10.2,10X,F10.1)
      WRITE(6,45)PRRASO,PRRTOT
   45 FORMAT(1X,'P/R RATIO (DIMENSIONLESS)',20X,F5.2,51X,F5.2)
   50 CONTINUE
C-----------------------------------------------------------------------
C     VALUES OF ANIMAL BIOENERGETICS AT THE TROPHIC LEVEL ARE PRINTED.
C-----------------------------------------------------------------------
      IF (NPRT(28).EQ.0)GO TO 495
      WRITE(6,55)IDAY
   55 FORMAT(1X,/,17X,'****** ANIMAL BIOENERGETICS AT THE TROPHIC LEVELS
     1 BASED ON INGESTION FOR ',I3,' DAYS PER ECOSYSTEM ******',/)

C...........PROPORTION OF INGESTION FROM TROPHIC LEVELS.
      WRITE(6,60)
   60 FORMAT(1X,/,23X,'PROPORTION OF INGESTION FROM TROPHIC LEVELS (CALC
     1ULATED FOR AN ENTIRE SPECIES OR GROUP)',/)

      WRITE(6,65)
   65 FORMAT(5X,'SPECIES NAME',24X,'FROM PLANTS',13X,'FROM ANIMALS',12X,
     1'FROM DETRITUS',8X,'FROM MICROOGANISMS')
      DO 75 I=1,NSPECA
      WRITE(6,70)(ASPNAM(I,J),J=1,7),(ETCENT(I,J),J=1,4)
   70 FORMAT(1X,7A4,8X,E16.9,8X,E16.9,8X,E16.9,8X,E16.9)
   75 CONTINUE
      WRITE(6,95)(EATAL(J),J=1,4)

C...........AMOUNTS OF INGESTION FOR TROPHIC LEVELS.
      WRITE(6,80)IDAY
   80 FORMAT(1X,/,6X,'AMOUNT OF INGESTION FOR ANIMAL TROPHIC LEVELS (BAS
     1ED ON PROPORTION OF INGESTION). KIOCALORIES PER ECOSYSTEM PER ',I3
     2,' DAYS',/)
      WRITE(6,85)
   85 FORMAT(5X,'SPECIES NAME',24X,'HERBIVORES',14X,'CARNIVORES',13X,'DE
     1TRITIVORES',13X,'MICROVORES')
      DO 90 I=1,NSPECA
      WRITE(6,70)(ASPNAM(I,J),J=1,7),(EATTRO(I,J),J=1,4)
   90 CONTINUE
      WRITE(6,95)(ALLEAT(J),J=1,4)
   95 FORMAT(9X,'TOTAL',15X, 8X,E16.9,8X,E16.9,8X,E16.9,8X,E16.9)

C...........AMOUNTS OF RESPIRATION FOR TROPHIC LEVELS.
      WRITE(6,100)IDAY
  100 FORMAT(1X,/,6X,'AMOUNT OF RESPIRATION FOR ANIMAL TROPHIC LEVELS (B
     1ASED ON PROPORTION OF INGESTION). KIOCALORIES PER ECOSYSTEM PER ',
     2I3,' DAYS',/)
      WRITE(6,85)
      DO 105 I =1,NSPECA
      WRITE(6,70)(ASPNAM(I,J),J=1,7),(RESTRO(I,J),J=1,4)
  105 CONTINUE
      WRITE(6,95)(RESALL(J),J=1,4)

C...........AMOUNTS OF NET PRODUCTION FOR TROPHIC LEVELS.
      WRITE(6,110)IDAY
  110 FORMAT(1X,/,32X,'AMOUNT OF NET PRODUCTION(GROWTH) FOR ANIMAL TROPH
     1IC LEVELS (BASED ON PROPORTION OF INGESTION).',/,46X,'KILOCALORIES
     2 PER ECOSYSTEM PER ',I3,' DAYS',/)
      DO 115 I=1,NSPECA
      WRITE(6,70)(ASPNAM(I,J),J=1,7),(GROTRO(I,J),J=1,4)
  115 CONTINUE
      WRITE(6,95)(GROALL(J),J=1,4)
C-----------------------------------------------------------------------
C     RATE VALUES FOR ENERGY FLUX ALONG ECOSYSTEM BOUNDARIES
C     ARE PRINTED.
C-----------------------------------------------------------------------
      IF (NPRT(29).EQ.0)GO TO 495
  120 FORMAT(1X,/,/,/,24X,'****** EXCHANGES OF ENERGY BETWEEN THE ECOSYS
     1TEM AND THE SURROUNDING BIOSPHERE ******',/)
  125 FORMAT(1X,/,/,/,40X,' ****** EXCHANGE OF ENERGY WITHIN THE ECOSYST
     1EM ******',/)
  130 FORMAT(1X,/,61X,'PLANTS',/)
      WRITE(6,120)
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      WRITE(6,130)
      WRITE(6,400)IDAY
C..........DRIFT OF PLANTS OUT OF THE ECOSYSTEM.
      DO 140 I=1,NSPECV
      RPLDRA=RPLDR(I)/IDAY
      IF (RPLDR(I).EQ.0)GO TO 140
      WRITE(6,135)(VSPNAM(I,J),J=1,7),(SRANAM(J,6),J=1,5),(RATEN(J,1)
     1,J=1,5),RPLDR(I),RPLDRA
  135 FORMAT(1X,7A4,1X,5A4,9X,5A4,4X,E16.9,12X,E16.9)
  140 CONTINUE
      RPLDRB=RPLDRT/IDAY
      WRITE(6,250)(SRANAM(J,1),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,1),
     1J=1,5),RPLDRT,RPLDRB
      WRITE(6,265)IDAY

C..........PLANT RESPIRATION.
      DO 145 I=1,NSPECV
      RPLREA=RPLRE(I)/(IDAY+AREA)
      IF(RPLRE(I).EQ.0)GO TO 145
      WRITE(6,385)(VSPNAM(I,J),J=1,7),(SRANAM(J,6),J=1,5),(RATEN(J,2),
     1J=1,5),RPLRE(I),RPLREA
  145 CONTINUE
      RPLREB=RPLRET/IDAY
      WRITE(6,250)(SRANAM(J,1),J=1,5),(SRANAM (J,6),J=1,5),(RATEN(J,2),
     1J=1,5),RPLRET,RPLREB
      WRITE(6,400)IDAY

C..........DRIFT OF PLANTS INTO THE ECOSYSTEM.
      DO 155 I=1,NSPECV
      RDRPLA=RDRPL(I)/IDAY
      IF (RDRPL(I).EQ.0)GO TO 155
      WRITE(6,150)(SRANAM(J,6),J=1,5),(VSPNAM(I,J),J=1,7),(RATEN(J,1),J=
     11,5),RDRPL(I),RDRPLA
  150 FORMAT(1X,5A4,9X,7A4,1X,5A4,4X,E16.9,12X,E16.9)
  155 CONTINUE
      RDRPLB=RDRPLT/IDAY
      WRITE(6,250 )(SRANAM(J,6),J=1,5),(SRANAM(J,1),J=1,5),(RATEN(J,1),
     1J=1,5),RDRPLT,RDRPLB
      WRITE(6,265)IDAY

C..........GROSS PHOTOSYNTHESIS.
      DO 160 I=1,NSPECV
      RPHPLA=RPHPL(I)/(IDAY+AREA)
      IF(RPHPL(I).EQ.0)GO TO 160
      WRITE(6,150)(SRANAM(J,6),J=1,5),(VSPNAM(I,J),J=1,7),(RATEN(J,3),
     1J=1,5),RPHPL(I),RPHPLA
  160 CONTINUE
      RPHPLB=RPHPLT/IDAY
      WRITE(6,250)(SRANAM(J,6),J=1,5),(SRANAM(J,1),J=1,5),(RATEN(J,3),
     1J=1,5),RPHPLT,RPHPLB
      WRITE(6,165)
  165 FORMAT(1X,/,61X,'ANIMALS',/)
      WRITE (6,400) IDAY

C..........AERIAL EGG DEPOSITION OF INVERTEBRATES.
      DO 170 K=1,NSPECA
      REDANA=REDAN(K)/IDAY
      IF(REDAN(K).EQ.0)GO TO 170
      WRITE(6,150)(SRANAM(J,6),J=1,5),(ASPNAM(K,J),J=1,7),(RATEN(J,5),
     1J=1,5),REDAN(K),REDANA
  170 CONTINUE
      REDANB=REDANT/IDAY
      WRITE(6,250)(SRANAM(J,6),J=1,5),(SRANAM(J,5),J=1,5),(RATEN(J,5),
     1J=1,5),REDANT,REDANB
      WRITE(6,400)IDAY

C..........ANIMAL DRIFT INTO THE ECOSYSTEM.
      DO 175 K=1,NSPECA
      RDRANA=RDRAN(K)/IDAY
      IF(RDRAN(K).EQ.0)GO TO 175
      WRITE(6,150)(SRANAM(J,6),J=1,5),(ASPNAM(K,I),I=1,7),(RATEN(I,1),
     1I=1,5),RDRAN(K),RDRANA
  175 CONTINUE
      RDRANB=RDRANT/IDAY
      WRITE(6,250)(SRANAM(J,6),J=1,5),(SRANAM(J,5),J=1,5),(RATEN(J,1),
     1J=1,5),RDRANT,RDRANB
      WRITE(6,400)IDAY

C..........ANIMAL DRIFT OUT OF THE ECOSYSTEM.
      DO 180 K=1,NSPECA
      RANDRA=RANDR(K)/IDAY
      IF(RANDR(K).EQ.0)GO TO 180
      WRITE(6,135)(ASPNAM(K,J),J=1,7),(SRANAM(J,6),J=1,5),(RATEN(J,1),
     1J=1,5),RANDR(K),RANDRA
  180 CONTINUE
      RANDRB=RANDRT/IDAY
      WRITE(6,250)(SRANAM(J,5),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,1),J
     1=1,5),RANDRT,RANDRT
      WRITE(6,265)IDAY
      RANEMA=RANEM(K)/(IDAY+AREA)

C..........INVERTEBRATE AERIAL EMERGENCE.
      DO 185 K=1,NSPECA
      IF (RANEM(K).EQ.0)GO TO 185
      WRITE(6,385)(ASPNAM(K,J),J=1,7),(SRANAM(J,6),J=1,5),(RATEN(J,6),
     1J=1,5),RANEM(K),RANEMA
  185 CONTINUE
      RANEMB=RANEMT/IDAY
      WRITE(6,250)(SRANAM(J,5),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,6),
     1J=1,5),RANEMT,RANEMB
      WRITE(6,265)IDAY

C..........ANIMAL RESPIRATION.
      DO 190 K=1,NSPECA
      RARESA=RARES(K)/(IDAY+AREA)
      IF(RARES(K).EQ.0)GO TO 190
      WRITE(6,135)(ASPNAM(K,J),J=1,7),(SRANAM(J,6),J=1,5),(RATEN(J,2),
     1J=1,5),RARES(K),RARESA
  190 CONTINUE
      RARESB=RAREST/IDAY
      WRITE(6,250)(SRANAM(J,5),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,2),
     1J=1,5),RAREST,RARESB
      WRITE(6,195)
  195 FORMAT(1X,/,61X,'DECOMPOSERS',/)

C..........MICROBIAL RESPIRATION.
      WRITE(6,400)IDAY
      DO 200 I=1,MICROB
      RDEREA=RDERE(I)/IDAY
      IF(RDERE(I).EQ.0)GO TO 200
      WRITE(6,250)(BACNAM(I,J),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,2),J
     1=1,5),RDERE(I),RDEREA
  200 CONTINUE
      RDEREB=RDERET/IDAY
      WRITE(6,250)(SRANAM(J,4),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,2),
     1J=1,5),RDERET,RDEREB
      WRITE(6,400)IDAY

C..........MICROBIAL DRIFT INTO THE ECOSYSTEM.
      DO 210 I=1,MICROB
      IF(RDRDE(I).EQ.0)GO TO 210
      RDRDEA=RDRDE(I)/IDAY
      WRITE(6,250)(SRANAM(J,6),J=1,5),(BACNAM(I,J),J=1,5),(RATEN(J,1),
     1J=1,5),RDRDE(I),RDRDEA
  205 FORMAT(1X,5A4,9X,4A4,13X,5A4,4X,E16.9,12X,E16.9)
  210 CONTINUE
      RDRDEB=RDRDET/IDAY
      WRITE(6,250)(SRANAM(J,6),J=1,5),(SRANAM(J,4),J=1,5),(RATEN(J,1),
     1J=1,5),RDRDET,RDRDEB
      WRITE(6,400)IDAY

C..........MICROBIAL DRIFT OUT OF THE ECOSYSTEM.
      DO 220 I=1,MICROB
      IF(RDEDR(I).EQ.0)GO TO 220
      RDEDRA=RDEDR(I)/IDAY
      WRITE(6,250)(BACNAM(I,J),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,1),
     1J=1,5),RDEDR(I),RDEDRA
  215 FORMAT(1X,4A4,13X,5A4,9X,5A4,4X,E16.9,12X,E16.9)
  220 CONTINUE
      RDEDRB=RDEDRT/IDAY
      WRITE(6,250)(SRANAM(J,4),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,1),J
     1=1,5),RDEDRT,RDEDRB
  225 FORMAT(1X,/,61X,'DETRITUS',/)
      WRITE(6,225)
      WRITE(6,400)IDAY

C..........DETRITAL DRIFT OUT OF THE ECOSYSTEM.
      DO 230 M=1,NOLIT
      RDETDA=RDETD(M)/IDAY
      IF(RDETD(M).EQ.0)GO TO 230
      WRITE(6,215)(ALINAM(M,I),I=1,4),(SRANAM(I,6),I=1,5),(RATEN(I,1),
     1I=1,5),RDETD(M),RDETDA
  230 CONTINUE
      RDETDB=RDETDT/IDAY
      WRITE(6,250)(SRANAM(J,2),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,1),
     1J=1,5),RDETDT,RDETDB
      WRITE(6,400)IDAY

C..........DETRITAL DRIFT INTO THE ECOSYSTEM.
      DO 240 M=1,NOLIT
      RALDEA=RALDE(M)/IDAY
      IF(RALDE(M).EQ.0)GO TO 240
      WRITE(6,235)(SRANAM(J,6),J=1,5),(ALINAM(M,J),J=1,4),(RATEN(J,4),

     1J=1,5),RALDE(M),RALDEA
  235 FORMAT(1X,5A4,9X,4A4,13X,5A4,4X,E16.9,12X,E16.9)
  240 CONTINUE
      RALDEB=RALDET/IDAY
      WRITE(6,250)(SRANAM(J,6),J=1,5),(SRANAM(J,2),J=1,5),(RATEN(J,4),
     1J=1,5),RALDET,RALDEB
      WRITE(6,245)
  245 FORMAT(1X,/,61  X,'DISSOLVED ORGANICS',/)

C..........DISSOLVED ORGANICS LEAVING THE ECOSYSTEM.
      WRITE(6,400) IDAY
      RDIDRA=RDIDR/IDAY
      IF(RDIDR.EQ.0)GO TO 255
      WRITE(6,250)(SRANAM(J,3),J=1,5),(SRANAM(J,6),J=1,5),(RATEN(J,1),
     1J=1,5),RDIDR,RDIDRA
  250 FORMAT(1X,5A4,9X,5A4,9X,5A4,4X,E16.9,12X,E16.9)
  255 CONTINUE
      WRITE(6,400)IDAY
      IF(RDRDI.EQ.0)GO TO 260

C..........DISSOLVED ORGANICS ENTERING THE ECOSYSTEM.
      RDRDIA=RDRDI/IDAY
      WRITE(6,250)(SRANAM(J,6),J=1,5),(SRANAM(J,3),J=1,5),(RATEN(J,1),
     1J=1,5),RDRDI,RDRDIA
  260 CONTINUE
C-----------------------------------------------------------------------
C     RATE VALUES FOR ENERGY FLUX WITHIN THE ECOSYSTEM ARE PRINTED.
C-----------------------------------------------------------------------
      WRITE(6,125)
  265 FORMAT(1X,/,11X,'FROM',24X,'TO',18X,'BY WAY OF',6X,'KCAL.PER ECSYS
     1. FOR',I3,' DAYS',3X,'AVE KCAL.PER SQ.M..PER DAY',/)
      WRITE(6,265)IDAY

C..........INGESTION OF PLANTS BY ANIMALS.
      DO 280 J=1,NSPECA
      DO 275 I=1,NSPECV
      RPHEAA=RPHEA(I,J)/(IDAY+AREA)
      IF(RPHEA(I,J).EQ.0)GO TO 275
      WRITE(6,270)(VSPNAM(I,K),K=1,7),(ASPNAM(J,K),K=1,7),(RATEN(K,10),
     1K=1,5),RPHEA(I,J),RPHEAA
  270 FORMAT(1X,7A4,1X,7A4,1X,5A4,4X,E16.9,12X,E16.9)
  275 CONTINUE
  280 CONTINUE
      DO 285 I=1,NSPECA
      RPHEAC=RPHEAT(I)/(IDAY+AREA)
      WRITE(6,150)(SRANAM(J,1),J=1,5),(ASPNAM(I,J),J=1,7),(RATEN(J,10),
     1J=1,5),RPHEAT(I),RPHEAC
  285 CONTINUE
      DO 290 I=1,NSPECV
      RPHEAD=RPHEAS(I)/(IDAY+AREA)
      WRITE(6,135)(VSPNAM(I,J),J=1,7),(SRANAM(J,5),J=1,5),(RATEN(J,10),
     1J=1,5),RPHEAS(I),RPHEAD
  290 CONTINUE
      RPHEAB=RPHEAL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,1),J=1,5),(SPANAM(J,5),J=1,5),(RATEN(J,10),
     1J=1,5),RPHEAL,RPHEAB
      WRITE(6,265)IDAY

C..........INGESTION OF ANIMALS BY ANIMALS.
      DO 300 K=1,NSPECA
      DO 295 KK=1,NSPECA
      RACARA=RACAR(K,KK)/(IDAY+AREA)
      IF(RACAR(K,KK).EQ.0)GO TO 295
      WRITE(6,270)(ASPNAM(K,I),I=1,7),(ASPNAM(KK,I),I=1,7),(RATEN(I,7),
     1I=1,5),RACAR(K,KK),RACARA
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  295 CONTINUE
  300 CONTINUE
      DO 305 I=1,NSPECA
      RACARC=RACART(I)/(IDAY+AREA)
      WRITE(6,150)(SRANAM(J,5),J=1,5),(ASPNAM(I,J),J=1,7),(RATEN(J,7),
     1J=1,5),RACART(I),RACARC
  305 CONTINUE
      DO 310 I=1,NSPECA
      RACARD=RACARS(I)/(IDAY+AREA)
      WRITE(6,135)(ASPNAM(I,J),J=1,7),(SRANAM(J,5),J=1,5),(RATEN(J,7),J
     1=1,5),RACARS(I),RACARD
  310 CONTINUE
      RACARB=RACARL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,5),J=1,5),(SRANAM(J,5),J=1,5),(RATEN(J,7),
     1J=1,5),RACARL,RACARB
      WRITE(6,265)IDAY

C..........INGESTION OF DETRITUS BY ANIMALS.
      DO 325 K=1,NSPECA
      DO 320 M=1,NOLIT
      RDEIAA=RDEIA(M,K)/(IDAY+AREA)
      IF(RDEIA(M,K).EQ.0)GO TO 320
      WRITE(6,315)(ALINAM(M,I),I=1,4),(ASPNAM(K,I),I=1,7),(RATEN(I,11),
     1I=1,5),RDEIA(M,K),RDEIAA
  315 FORMAT(1X,4A4,13X,7A4,1X,5A4,4X,E16.9,12X,E16.9)
  320 CONTINUE
  325 CONTINUE
      DO 330 I=1,NSPECA
      RDEIAC=RDEIAT(I)/(IDAY+AREA)
      WRITE(6,150)(SRANAM(J,2),J=1,5),(ASPNAM(I,J),J=1,7),(RATEN(J,11),
     1J=1,5),RDEIAT(I),RDEIAC
  330 CONTINUE
      DO 335 I=1,NOLIT
      RDEIAD=RDEIAS(I)/(IDAY+AREA)
      WRITE(6,215)(ALINAM(I,J),J=1,4),(SRANAM(J,5),J=1,5),(RATEN(J,11),
     1J=1,5),RDEIAS(I),RDEIAD
  335 CONTINUE
      RDEIAB=RDEIAL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,2),J=1,5),(SRANAM(J,5),J=1,5),(RATEN(J,11),
     1J=1,5),RDEIAL,RDEIAB
        WRITE(6,265)IDAY

C..........INGESTION OF MICROPS BY ANIMALS.
      DO 350 I=1,MICROB
      DO 345 K=1,NSPECA
      RDINAA=RDINA(I,K)/(IDAY+AREA)
      IF(RDINA(I,K).EQ.0)GO TO 345
      WRITE(6,150)(BACNAM(I,J),J=1,5),(ASPNAM(K,J),J=1,7),(RATEN(J,15),
     1J=1,5),RDINA(I,K),RDINAA
  340 FORMAT(1X,4A4,13X,7A4,1X,5A4,4X,E16.9,12X,E16.9)
  345 CONTINUE
  350 CONTINUE
      DO 355 I=1,NSPECA
      RDINAC=RDINAT(I)/(IDAY+AREA)
      WRITE(6,150)(SRANAM(J,4),J=1,5),(ASPNAM(I,J),J=1,7),(RATEN(J,15),
     1J=1,5),RDINAT(I),RDINAC
  355 CONTINUE
      DO 360 I=1,MICROB
      RDINAD=RDINAS(I)/(IDAY+AREA)
      WRITE(6,250)(BACNAM(I,J),J=1,5),(SRANAM(J,5),J=1,5),(RATEN(J,15),
     1J=1,5),RDINAS(I),RDINAD
  360 CONTINUE
      RDINAB=RDINAL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,4),J=1,5),(SRANAM(J,5),J=1,5),(RATEN(J,15),
     1J=1,5),RDINAL,RDINAB
        WRITE(6,265)IDAY

C..........EGESTION FROM ANIMALS TO DETRITUS.
      DO 370 K=1,NSPECA
      DO 365 M=1,NOLIT
      RAEGDA=RAEGD(K,M)/(IDAY+AREA)
      IF(RAEGD(K,M).EQ.0)GO TO 365
      WRITE(6,420)(ASPNAM(K,J),J=1,7),(ALINAM(M,J),J=1,4),(RATEN(J,12),
     1J=1,5),RAEGD(K,M),RAEGDA
  365 CONTINUE
  370 CONTINUE
      DO 375 I=1,NSPECA
      RAEGDC=RAEGDT(I)/(IDAY+AREA)
      WRITE(6,135)(ASPNAM(I,J),J=1,7),(SRANAM(J,2),J=1,5),(RATEN(J,12),
     1J=1,5),RAEGDT(I),RAEGDC
  375 CONTINUE
      DO 380 I=1,NOLIT
      RAEGDD=RAEGDS(I)/(IDAY+AREA)
      WRITE(6,235)(SRANAM(J,5),J=1,5),(ALINAM(I,J),J=1,4),(RATEN(J,12),
     1J=1,5),RAEGDS(I),RAEGDD
  380 CONTINUE
      RAEGDB=RAEGDL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,5),J=1,5),(SRANAM(J,2),J=1,5),(RATEN(J,12),
     1J=1,5),RAEGDL,RAEGDB
        WRITE(6,265)IDAY

C..........EGESTION FROM ANIMALS TO DISSOLVED ORGANICS.
      DO 390 K=1,NSPECA
      IF(RANED(K).EQ.0)GO TO 390
      RANEDA=RANED(K)/(IDAY+AREA)
      WRITE(6,385)(ASPNAM(K,J),J=1,7),(SRANAM(J,3),J=1,5),(RATEN(J,12),
     1J=1,5),RANED(K),RANEDA
  385 FORMAT(1X,7A4,1X,5A4,9X,5A4,4X,E16.9,12X,E16.9)
  390 CONTINUE
      RANEDB=RANEDT/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,5),J=1,5),(SRANAM(J,3),J=1,5),(RATEN(J,12),
     1J=1,5),RANEDT,RANEDB
        WRITE(6,265)IDAY

C..........MORTALITY FROM PLANTS TO DETRITUS.
      DO 405 I=1,NSPECV
      DO 395 M=1,NOLIT
      RPMODA=RPMOD(I,M)/(IDAY+AREA)
      IF(RPMOD(I,M).EQ.0)GO TO 395
      WRITE(6,420)(VSPNAM(I,J),J=1,7),(ALINAM(M,J),J=1,4),(RATEN(J,9),J
     1=1,5),RPMOD(I,M),RPMODA
  395 CONTINUE
  400 FORMAT(1X,/,11X,'FROM',24X,'TO',18X,'BY WAY OF',6X,'KCAL.PER ECSYS
     1. FOR',I3,' DAYS',3X,'AVE KCAL.PER ECSYS.PER DAY',/)
  405 CONTINUE
      DO 410 I=1,NOLIT
      RPMODC=RPMODT(I)/(IDAY+AREA)
      WRITE(6,235)(SRANAM(J,1),J=1,5),(ALINAM(I,J),J=1,4),(RATEN(J,9),
     1J=1,5),RPMODT(I),RPMODC
  410 CONTINUE
      DO 415 I=1,NSPECV
      RPMODD=RPMODS(I)/(IDAY+AREA)
      WRITE(6,135)(VSPNAM(I,J),J=1,7),(SRANAM(J,2),J=1,5),(RATEN(J,9),
     1J=1,5),RPMODS(I),RPMODD
  415 CONTINUE
      RPMODB=RPMODL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,1),J=1,5),(SRANAM(J,2),J=1,5),(RATEN(J,9),
     1J=1,5),RPMODL,RPMODB
        WRITE(6,265)IDAY

C..........MORTALITY FROM ANIMALS TO DETRITUS.
      DO 430 K = 1,NSPECA
      DO 425 M = 1,NOLIT
      RAMODA = RAMOD(K,M)/(IDAY+AREA)
      IF(RAMOD(K,M).EQ.0.)GO TO 425
      WRITE(6,420)(ASPNAM(K,I),I=1,7),(ALINAM(M,I),I=1,4),(RATEN(I,9),I
     1=1,5),RAMOD(K,M),RAMODA
  420 FORMAT(1X,7A4,1X,4A4,13X,5A4,4X,E16.9,12X,E16.9)
  425 CONTINUE
  430 CONTINUE
      DO 435 I=1,NSPECA
      RAMODC=RAMODT(I)/(IDAY+AREA)
      WRITE(6,135)(ASPNAM(I,J),J=1,7),(SRANAM(J,2),J=1,5),(RATEN(J,9),
     1J=1,5),RAMODT(I),RAMODC
  435 CONTINUE
      DO 440 I=1,NOLIT
      RAMODD=RAMODS(I)/(IDAY+AREA)
      WRITE(6,235)(SRANAM(J,5),J=1,5),(ALINAM(I,J),J=1,4),(RATEN(J,9),
     1J=1,5),RAMODS(I),RAMODD
  440 CONTINUE
      RAMODB=RAMODL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,5),J=1,5),(SRANAM(J,2),J=1,5),(RATEN(J,9),
     1J=1,5),RAMODL,RAMODB
        WRITE(6,265)IDAY

C..........LEAKAGE FROM PLANTS TO DISSOLVED ORGANICS.
      DO 445 I=1,NSPECV
      RFLEOA=RFLEO(I)/(IDAY+AREA)
      IF(RFLEO(I).EQ.0)GO TO 445
      WRITE(6,385)(VSPNAM(I,J),J=1,7),(SRANAM(J,3),J=1,5),(RATEN(J,8),
     1J=1,5),RFLEO(I),RFLEOA
  445 CONTINUE
      RFLEOB=RFLEOT/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,1),J=1,5),(SRANAM(J,3),J=1,5),(RATEN(J,8),
     1J=1,5),RFLEOT,RFLEOB
        WRITE(6,265)IDAY

C..........LEACHING FROM DETRITUS TO DISSOLVED ORGANICS.
      DO 450 M=1,NOLIT
      RDLEDA=RDLED(M)/(IDAY +AREA)
      IF(RDLED(M).EQ.0)GO TO 450
      WRITE(6,215)(ALINAM(M,J),J=1,4),(SRANAM(J,3),J=1,5),(RATEN(J,8),
     1J=1,5),RDLED(M),RDLEDA
  450 CONTINUE
      RDLEDB=RDLEDT/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,2),J=1,5),(SRANAM(J,3),J=1,5),(RATEN(J,8),
     1J=1,5),RDLEDT,RDLEDB
        WRITE(6,265)IDAY

C..........COAGULATION FROM DISSOLVED ORGANICS TO DETRITUS.
      DO 455 M=1,NOLIT
      RDCODA=RDCOD(M)/(IDAY+AREA)
      IF(RDCOD(M).EQ.0)GO TO 455
      WRITE(6,235)(SRANAM(J,3),J=1,5),(ALINAM(M,J),J=1,4),(RATEN(J,16),
     1J=1,5),RDCOD(M),RDCODA
  455 CONTINUE
      RDCODB=RDCODT/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,3),J=1,5),(SRANAM(J,2),J=1,5),(RATEN(J,16),
     1J=1,5),RDCODT,RDCODB
        WRITE(6,265)IDAY

C..........DECOMPOSITION FROM DETRITUS TO DECOMPOSERS.
      DO 470 M=1,NOLIT
      DO 465 I=1,MICROB
      RDDEDA=RDDED(M,I)/(IDAY+AREA)
      IF(RDDED(M,I).EQ.0)GO TO 465
      WRITE(6,460)(ALINAM(M,J),J=1,4),(BACNAM(I,J),J=1,5),(RATEN(J,13),
     1J=1,5),RDDED(M,I),RDDEDA
  460 FORMAT(1X,4A4,13X,5A4, 9X,5A4,4X,E16.9,12X,E16.9)
  465 CONTINUE
  470 CONTINUE
      DO 475 I=1,MICROB
      RDDEDC=RDDEDT(I)/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,2),J=1,5),(BACNAM(I,J),J=1,5),(RATEN(J,13),
     1J=1,5),RDDEDT(I),RDDEDC
  475 CONTINUE
      DO 480 I=1,NOLIT
      RDDEDD=RDDEDS(I)/(IDAY+AREA)
      WRITE(6,215)(ALINAM(I,J),J=1,4),(SRANAM(J,4),J=1,5),(RATEN(J,13),
     1J=1,5),RDDEDS(I),RDDEDD
  480 CONTINUE
      RDDEDB=RDDEDL/(IDAY+AREA)
      WRITE(6,250)(SRANAM(J,2),J=1,5),(SRANAM(J,4),J=1,5),(RATEN(J,13),
     1J=1,5),RDDEDL,RDDEDB
        WRITE(6,265)IDAY

C..........DECOMPOSITION FROM DISSOLVED ORGANICS TO DECOMPOSERS.
      DO 485 I=1,MICROB
      RDIDDA=RDIDD(I)/(IDAY+AREA)
      IF(RDIDD(I).EQ.0)GO TO 485
      WRITE(6,250)(SRANAM(J,3),J=1,5),(BACNAM(I,J),J=1,5),(RATEN(J,13),
     1J=1,5),RDIDD(I),RDIDDA
  485 CONTINUE
      RDIDDB=RDIDDT/(IDAY   +AREA)
      WRITE(6,250)(SRANAM(J,3),J=1,5),(SRANAM(J,4),J=1,5),(RATEN(J,13),
     1J=1,5),RDIDDT,RDIDDB
        WRITE(6,265)IDAY

C..........LEAKAGE FROM DECOMPOSERS TO DISSOLVED ORGANICS.
      DO 490 I=1,MICROB
      RDLEOA=RDLEO(I)/(IDAY+AREA)
      IF(RDLEO(I).EQ.0)GO TO 490
      WRITE(6,250)(BACNAM(I,J),J=1,5),(SRANAM(J,3),J=1,5),(RATEN(J,8),
     1J=1,5),(RDLEO(I)),RDLEOA
  490 CONTINUE
      RDLEOB=RDLEOT/(IDAY   +AREA)
      WRITE(6,250)(SRANAM(J,4),J=1,5),(SRANAM(J,3),J=1,5),(RATEN(J, 8),
     1J=1,5),RDLEOT,RDLEOB
  495 RETURN
      END
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APPENDIX C
Definitions List

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C-----------------------------------------------------------------------
C   DEFINITIONS LIST FOR EXPLORATORY SENSITIVITY AND
C         STATISTICAL ANALYSIS.
C   DIMENSIONED VALUES REPRESENTED BY A OR AA MAY BE CHANGED
C         BY CHANGING APPROPRIATE DIMENSION STATEMENT.
C   DIMENSIONED VALUES REPRESENTED BY B REQUIRE OTHER PROGRAM
C         CHANGES.
C-----------------------------------------------------------------------
C AINTR              THE INTERCEPT OF TWO LINEAR EQUATIONS.
C ALGRAF(A, AA, B)    THE PREDICTED VALUE FOR THE
C                    A'TH CURVE OF THE AA'TH GRAPH.
C AMINI(A)           THE MINIMUM VALUE FOR THE A'TH GRAPH.
C AMAXI(A)           THE MAXIMUM VALUE FOR THE A'TH GRAPH.
C ANUM(B)            THE B'TH NUMERICAL SYMBOL USED FOR GRAPHING.
C AVSUM              THE AVERAGE DIFFERENCE SQUARED BETWEEN PREDICTED AND
C                    OBSERVED DATA FOR A PARTICULAR VARIABLE.
C BLANK              STORED BLANK FOR HEADINGS.
C BONE               THE COEFFICIENT FOR SLOPE IN THE LINEAR EQUATION.
C BZERO              THE VALUE FOR THE Y INTERCEPT IN THE LINEAR
C                    EQUATION.
C DIFER              THE PERCENTAGE DIFFERENCE BETWEEN PREDICTED AND
C                    OBSERVED DATA.
C EXPLAN(B, A)       A TITLE FOR THE A'TH CURVE ON A GRAPH.
C FIG(A, B)          THE VALUE FOR THE B'TH TIME AND THE A'TH CURVE FOR
C                    THE GRAPH BEING PRINTED.
C FIGVAL(A, AA)      THE VALUE OF THE AA'TH SET OF VALIDATION DATA FOR
C                    THF A'TH GRAPH.
C FMT1(B)            FORMAT USED FOR THE Y-AXIS.
C GRAPH(B,BB)        THE ACTUAL GRAPH TO BE PRINTED.
C IDAYS(B)           VALUES IN DAYS FOR THE X-AXIS.
C IGPP               THE NUMBER OF CURVES PER GRAPH.
C INITYR             THE YEAR IN WHICH THE SIMULATION STARTED.
C IYEARS(B)          VALUES IN YEARS FOR THE X-AXIS.
C JVALU              THE NUMBER OF DIFFERENT LEVELS TO BE USED IN THE
C                    STATISTIC THAT CALCULATES THE PERCENTAGE DIFFERENCE
C                    BETWEEN OBSERVED AND PREDICTED DATA.
C KD                 THE DAY NUMBER ON WHICH A PARTICULAR VALIDATION
C                    VALUE WAS COLLECTED.
C KDAY               THE DAY NUMBER ON WHICH THE SIMULATION STARTED.
C KGO                A SWITCH WHICH IS SET POSITIVE IF THE GRAPH BEING
C                    PRINTED INCLUDES VALIDATION DATA.
C KM                 THE NUMBER OF THE MONTH IN WHICH A PARTICULAR
C                    VALIDATION VALUE WAS COLLECTED.
C KMONTH             THE NUMBER OF THE MONTH IN WHICH THE SIMULATION STARTFD.
C KS(A)              A SWITCH WHICH ALLOWS THE A'TH TYPE OF STATISTIC TO
C                    BE PERFORMED ON A VARIABLE OF INTEREST.
C KTIME              THE TIME OF VALIDATION COLLECTION USED FOR GRAPHING.
C KVALU(A)           THE NUMBER OF VALIDATION POINTS WITHIN THE A'TH
C                    PERCENTAGE LEVEL FOR A PARTICULAR VARIABLE.
C KVALUT(A)          THE NUMBER OF VALIDATION POINTS WITHIN THE A'TH
C                    PERCENTAGE LEVEL FOR ALL VARIABLES.
C KY                 THE YEAR IN WHICH A PARTICULAR VALIDATION VALUE WAS
C                    COLLECTED.
C KYEAR              THE YEAR IN WHICH THE SIMULATION STARTED.
C MDAT(A)            THE NUMERICAL DESIGNATION OF THE GRAPH NUMBER FOR
C                    THE A'TH SET OF VALIDATION DATA.
C N50                THE NUMBER OF PREDICTED DATA POINTS FALLING WITHIN
C                    THE 50 PERCENT CONFIDENCE INTERVALS FOR OBSERVED
C                    DATA FOR A PARTICULAR VARIABLE.
C N50T               THE NUMBER OF PREDICTED DATA POINTS FALLING WITHIN
C                    THE 50 PERCENT CONFIDENCE INTERVALS FOP OBSERVED
C                    DATA FOR ALL VARIABLES.
C N95                THE NUMBER OF PREDICTED DATA POINTS FALLING WITHIN
C                    THE 95 PERCENT CONFIDENCE INTERVALS FOR OBSERVED
C                    DATA FOR A PARTICULAR VARIABLE.
C N95T               THE NUMBER OF PREDICTED DATA POINTS FALLING WITHIN
C                    THE 95 PERCENT CONFIDENCE INTERVALS FOR OBSERVED
C                    DATA FOR ALL VARIABLE.
C NDATAS(A)          THE NUMBER OF VALIDATION DATA POINTS FOR THE A'TH
C                    GRAPH.
C NFIGDA(A, AA)      THE STORAGE LOCATION FOR THE TIME FOR THE AA'TH SET
C                    OF VALIDATION DATA FOR THE A'TH GRAPH.
C NREPER(A, AA)      THE NUMBER OF SAMPLES FOR THE AA'TH VALIDATION
C                    COLLECTION TIME FOR THE A'TH GRAPH.
C NREPNO(A)          THE NUMBER OF VALIDATION DAYS FOR THE A'TH GRAPH.
C NSTAT(A, AA)       THE LOCATION OF SWITCHES WHICH ALLOWS THE AA'TH
C                    STATISTIC TO BE PERFORMED ON THE A'TH VARIABLE OF
C                    INTEREST.
C NUMCRD             A SWITCH WHICH SHOULD BE SET TO (1) ONE IF
C                    VALIDATION DATA IS TO BE READ.
C NUMDAT             THE NUMBER OF THE GRAPH TO WHICH A VALIDATION VALUE
C                    CORRESPONDS.
C NXPLOR             THE NUMBER OF GRAPHS TO BE PRINTED.
C NYRDAY             NUMBER OF TIME UNITS IN A YEAR.
C ORIGIN(A)          IF THF WORD 'ZERO' IS PUNCHED IN THIS LOCATION, THE
C                    A'TH GRAPH WILL HAVE ZERO INCLUDED IN THE Y AXIS.
C P50                THE PERCENTAGE OF TIME THAT PREDICTED OUTPUT FALLS
C                    WITHIN THE 50 PERCENT CONFIDENCE INTERVALS FOR
C                    OBSERVED DATA.
C P95                THE PERCENTAGE OF TIME THAT PREDICTED OUTPUT FALLS
C                    WITHIN THE 95 PERCENT CONFIDENCE INTERVALS FOR
C                    OBSERVED DATA.
C SDEV               THE STANDARD DEVIATION FOR A DATA SET.
C SDEV50             50 PERCENT CONFIDENCE INTERVALS FOR COMPARING
C                    PREDICTED TO OBSERVED DATA.
C SDEV95             95 PERCENT CONFIDENCE INTERVALS FOR COMPARING
C                    PREDICTED TO OBSERVED DATA.
C STATE(B)           TEMPORARY STORAGE FOR PRINTING COMMENTS BEFORE THE
C                    OUTPUT PROPER.
C SUMSQ              THE DIFFERENCE SQUARED BETWEEN PREDICTED AND
C                    OBSERVED DATA FOR A PARTICULAR VARIABLE.
C SYMBOL(A)          THE ALPHABETIC SYMBOL USED FOR THE A'TH
C                    CURVE PER GRAPH.
C TAVSUM             THE DIFFERENCE SQUARED BETWEEN OBSERVED AND
C                    PREDICTED DATA FOR ALL VARIABLES.
C THIEL              THIELS INEQUALITY COEFFICIENT.
C TITLE(B)           A TITLE FOR THE GRAPH BEING PRINTED
C                    (UP TO 40 CHARACTERS).
C TITLE2(B)          A TITLE, UP TO 40 CHARACTERS, WHICH WILL BE PRINTED
C                    WITH EACH GRAPH.
C TITLES(A, B)       A TITLE FOR THE A'TH GRAPH, UP TO 40 CHARACTERS.
C TSUMSQ             THE DIFFERENCE SQUARED BETWEEN PREDICTED AND
C                    OBSERVED DATA FOR ALL VARIABLES.
C VAL                THE VALUE OF A PARTICULAR VALIDATION POINT.
C VALU(A)            THE PERCENTAGE VALUE FOR THE A'TH LEVEL FOR THE
C                    STATISTIC THAT CALCULATES THE PERCENTAGE DIFFERENCE
C                    BETWEEN OBSERVED AND PREDICTED DATA.
C VKAPR              KAPOORS INEQUALITY COEFFICIENT.
C XLINE(B)           SYMBOLS USED FOR THE X-AXIS.
C XMIN               THE FIRST SIMULATION DAY CONVERTED TO JULIAN DAYS.
C XMAX               XMIN PLUS KDAYRN. USED FOR THE X AXIS OF THE GRAPH.
C XUNIT              SCALING FACTOR FOR THE X-AXIS.
C YAXIS(B)           THE B'TH VALUE FOR THE Y-AXIS.
C YAXISS(A, B)       A TITLE FOR THE Y AXIS OF THE A'TH GRAPH, UP TO 40
C                    CHARACTERS.
C YMIN               THE MINIMUM VALUE FOR THE GRAPH BEING PRINTED.
C YMAX               THE MAXIMUM VALUE FOR THE GRAPH BEING PRINTED.
C YTITLE(B)          A TITLF FOR THE Y AXIS OF THE GRAPH BEING PRINTED.
C YUNIT              SCALING FACTOR FOR THE Y-AXIS.
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APPENDIX D1
MAIN Program

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C-----------------------------------------------------------------------
C     MAIN PROGRAM FOR EXPLORATORY SENSITIVITY AND STATISTICAL ANALYSIS
C-----------------------------------------------------------------------
      DIMENSION STATE(20),KS(6)
      COMMON/GRAXPL/KDAYRN,MDAT(70),FIGVAL(70,20),NDATAS(70),
     1NFIGDA(70,20),KGO,ALGRAF(5,70,120),NSTAT(70,6),NXPLOR,
     2NREPNO(70),NREPER(70,10),VALU(8),JVALU,
     3TITLES(70,10),YAXISS(70,10),ORIGIN(70),AMAXI(70),AMINI(70),
     4FIG(5,120),EXPLAN(5,5),TITLE(10),YTITLE(10),
     5XMAX,XMIN,YMAX,YMIN,INITYR,IGPP,TITLE2(10)
      DATA BLANK/' '/,HIGH/1.E20/
      WRITE(6,10)
   10 FORMAT(1H1)
C-----------------------------------------------------------------------
C     INSTRUCTIONS ARE READ IN FROM THE CARD DECK
C-----------------------------------------------------------------------
   20 READ(5,40)(STATE(I),I=1,20)
      WRITE(6,50)(STATE(I),I=1,20)
      DO 30 I=1,20
   30 IF (STATE(I).NE.BLANK) GO TO 20
   40 FORMAT(20A4)
   50 FORMAT(1X,20A4)

C..........SPECIFICATIONS AND SWITCHES
      READ(5,70)KMONTH,KDAY,KYEAR,KDAYRN,NUMCRD,NXPLOR,IGPP
      READ(5,60) JVALU,(VALU(J),J=1,8)
   60 FORMAT(I5,8F5.0)
   70 FORMAT(16I5)
      INITYR=KYEAR

C..........TITLES FOR GRAPHS
      READ(5,40)(TITLE2(I),I=1,10)
      DO 80 I=1,NXPLOR
      READ(5,40)(TITLES(I,J),J=1,10)
      READ(5,40)(YAXISS(I,J),J=1,10),ORIGIN(I)
   80 CONTINUE
      DO 90 J=1,IGPP
   90 READ(5,40)(EXPLAN(L,J),L=1,5)
      DO 100 I=1,NXPLOR
      AMINI(I)=HIGH
  100 AMAXI(I)=-HIGH
      XMIN=KDAY+(30*(KMONTH-1))
      XMAX=KDAY+(30*(KMONTH-1))+KDAYRN
      DO 170 I=1,IGPP
C-----------------------------------------------------------------------
C     PREDICTED DATA ARE READ IN FROM AN EXTERNAL FILE
C-----------------------------------------------------------------------
      GO TO (110,120,130,140,150),I
  110 READ(12)((ALGRAF(I,J,K),J=1,NXPLOR),K=1,120)
      GO TO 160
  120 READ(13)((ALGRAF(I,J,K),J=1,NXPLOR),K=1,120)
      GO TO 160
  130 READ(14)((ALGRAF(I,J,K),J=1,NXPLOR),K=1,120)
      GO TO 160
  140 READ(15)((ALGRAF(I,J,K),J=1,NXPLOR),K=1,120)
      GO TO 160
  150 READ(16)((ALGRAF(I,J,K),J=1,NXPLOR),K=1,120)
  160 CONTINUE
  170 CONTINUE
C-----------------------------------------------------------------------
C     OBSERVED DATA ARE READ IN FROM THE CARD DECK AND STORAGE
C     ALLOCATIONS SET
C-----------------------------------------------------------------------
      IF(NUMCRD.EQ.0) GO TO 220
  180 READ(5,190,END=220)NUMDAT,KM,KD,KY,VAL,(KS(I),I=1,6)
  190 FORMAT(4I5,F10.4,6I5)
      IF(JCHEK .EQ.0) KCHEK=NUMDAT
      IF(KCHEK.NE.NUMDAT) JJ=0
      IF(JJ.NE.0) GO TO 210
      DO 200 K=1,6
  200 NSTAT(NUMDAT,K)=KS(K)
  210 KTIME=(360*(KY-KYEAR))+(30*(KM-KMONTH))+(KD-KDAY)
      IF(JJ.EQ.0) JK=JK+1
      IF(JJ.EQ.0) JY=0
      MDAT(JK)=NUMDAT
      JJ=JJ+1
      NFIGDA(NUMDAT,JJ)=KTIME
      NDATAS(NUMDAT)=JJ
      FIGVAL(NUMDAT,JJ)=VAL
      IF((JJ.EQ.1).OR.(KTIME.NE.KKTIME)) JZ=0
      IF(JZ.EQ.0) JY=JY+1
      JZ=JZ+1
      NREPER(NUMDAT,JY)=JZ
      KKTIME=KTIME
      NREPNO(NUMDAT)=JY
      JCHEK=1
      JDATA=JDATA+1
      KCHEK=NUMDAT
      GO TO 180
C-----------------------------------------------------------------------
C     SET MAXIMUM AND MINIMUM VALUES FOR GRAPHS
C-----------------------------------------------------------------------

C..........FROM PREDICTED VALUES
  220 DO 230 I=1,IGPP
      DO 230 J=1, NXPLOR
      DO 230 K=1, 120
      AMINI(J)=AMIN1(AMINI(J),ALGRAF(I,J,K))
  230 AMAXI(J)=AMAX1(AMAXI(J),ALGRAF(I,J,K))

C..........FROM OBSERVED VALUES
      IF(NUMCRD.EQ.0) GO TO 250
      JN=1
      MN=MDAT(1)
      DO 240 I=1,JDATA
      JM=JM+1
      AMINI(MN)=AMIN1(AMINI(MN),FIGVAL(MN,JM))
      AMAXI(MN)=AMAX1(AMAXI(MN),FIGVAL(MN,JM))
      IF(JM.NE.NDATAS(MN)) GO TO 240
      JN=JN+1
      MN=MDAT(JN)
      JM=0
  240 CONTINUE

C-----------------------------------------------------------------------
C     TRANSFER INFORMATION FOR PRINTING LINE GRAPHS AND
C     CALL SUBROUTINES GRAF AND STATS
C-----------------------------------------------------------------------
  250 NT=1
      DO 320 I = 1, NXPLOR
      I2 = IGPP
      DO 290 K =  1, I2
      YMAX = AMAXI(I)
      YMIN = AMINI(I)
      IF((ORIGIN(I).NE.ZERO).OR.((YMAX.GT.0.).AND.(YMIN.LT.0.)))GO TO
     1 280
      IF (YMAX) 260,280,270
  260 YMAX = 0.
      GO TO 280
  270 YMIN = 0.
  280 DO 290 J = 1, 120
  290 FIG( K,J) = ALGRAF(K,I,J)
      DO 300 J = 1, 10
  300 TITLE(J) = TITLES(I,J)
      DO 310 J = 1, 10
  310 YTITLE(J) = YAXISS(I,J)
      IF(I.EQ.MDAT(NT)) KGO=I
      IF(I.EQ.MDAT(NT)) NT=NT+1
      CALL GRAF
      KGO=0
  320 CONTINUE
      IF(NUMCRD.GT.0) CALL STATS
      STOP
      END
```

APPENDIX D2
Subroutine GRAF

```
      SUBROUTINE GRAF
C-----------------------------------------------------------------------
C     FOR EXPLORATORY SENSITIVITY AND STATISTICAL ANALYSIS
C-----------------------------------------------------------------------
      DIMENSION FMT1(7),SYMBOL(5),GRAPH(51,121), ANUM(10)
     1 ,YAXIS(6), XLINE(31), IDAYS(13), IYEARS(13)
      COMMON/GRAXPL/KDAYRN,MDAT(70),FIGVAL(70,20),NDATAS(70),
     1NFIGDA(70,20),KGO,ALGRAF(5,70,120),NSTAT(70,6),NXPLOR,
     2NREPNO(70),NREPER(70,10),VALU(8),JVALU,
     3TITLES(70,10),YAXISS(70,10),ORIGIN(70),AMAXI(70),AMINI(70),
     4FIG(5,120),EXPLAN(5,5),TITLE(10),YTITLE(10),
     5XMAX,XMIN,YMAX,YMIN,INITYR,IGPP,TITLE2(10)
      DATA XLINE/'+---','----','--+-',2*'----','+---','----','--+-',
     1 2*'----','+---','----','--+-',2*'----','+---','----','--+-',
     22*'----','+---','----','--+-',2*'----','+---','----','--+-',
     32*'----','+   '/
      DATA ANUM /'0','1','2','3','4','5','6','7','8','9'/
      DATA FMT1/'(1H+',',',' ',' ','PF7.','4,12','1A1)'/
      DATA BLANK /' '/ STAR /'*'/  SMALL/1.E-8/
      DATA APOS/'I' /  PLUS/'+'/ HYPHEN /'-'/
      DATA SYMBOL/'A','B','C','D','E'/
      DATA /INTERV/1/,ISTART/1/,IEND/121/
      DATA X/'X'/
   10 FMT1(4) = BLANK
      FMT1(3) = BLANK
C-----------------------------------------------------------------------
C     IF THE LIMITS OF THE X AXIS ARE EQUAL, AN ERROR MESSAGE RESULTS.
C     IF THE LIMITS OF THE Y AXIS ARE BOTH ZERO, THEY ARE SEPARATED.
C-----------------------------------------------------------------------
      IF (XMAX.GT.XMIN) GO TO 30
      WRITE (6,20)
      RETURN
   20 FORMAT ('1NO GRAPH POSSIBLE BECAUSE NO TIME SIMULATED')
   30 IF (YMAX.NE.YMIN) GO TO 50
      IF (YMAX.NE.0.) GO TO 40
      YMAX = SMALL
      YMIN = - SMALL
      GO TO 50
   40 YMAX = YMAX * 1.001
      YMIN = YMIN * .999
   50 DO 70 I = 1, 51
      DO 60 J = 1, 121
   60 GRAPH(I,J) = BLANK
   70 CONTINUE
      B = AMAX1(ABS(YMIN), ABS(YMAX))
      I = 0
      A = XMAX - XMIN
      IF ((A.GT.0.).AND.(B.GT.0.).AND.(YMAX.GE.YMIN)) GO TO 90
      WRITE (6,80) XMAX, XMIN, YMAX, YMIN
   80 FORMAT ('0ERROR IN LIMITS:', 4E20.6)
```

```
      RETURN
C-----------------------------------------------------------------------
C     THE Y AXIS IS SCALED.
C-----------------------------------------------------------------------
   90 IF (B.GE.1.) GO TO 100
      B = B * 10.
      I = I - 1
      GO TO 90
  100 IF (B.LT.10.) GO TO 110
      B = B * .1
      I = I + 1
      GO TO 100
  110 I102 = I
      J = IABS(I)
      IF (J.LE.9) GO TO 130
C-----------------------------------------------------------------------
C     IF THE VALUES TO BE GRAPHED EXCEED PERMISSIBLE LIMITS, AN ERROR
C     MESSAGE RESULTS.
C-----------------------------------------------------------------------
      WRITE (6,270) (TITLE(K), K=1,10)
      WRITE (6,120)
  120 FORMAT ('0FACTOR FOR Y AXIS .GT. 10**9 OR .LT. 10**-9')
      RETURN
C-----------------------------------------------------------------------
C     THE APPROPRIATE SCALING FACTOR IS INSERTED IN THE FORMAT FOR
C     THE Y AXIS.
C-----------------------------------------------------------------------
  130 IF (I.LE.0) GO TO 140
      FMT1(3) = HYPHEN
  140 FMT1(4)      = ANUM(J+1)
C-----------------------------------------------------------------------
C     THE Y BOUNDARY OF THE GRAPH IS INSERTED.
C-----------------------------------------------------------------------
      DO 150 I = 1, 51
  150 GRAPH(I,1) = APOS
      DO 160 I = 1,51,10
  160 GRAPH(I,1) = PLUS
      YUNIT = 50./(YMAX-YMIN)
      XUNIT= 120./(XMAX - XMIN)
C-----------------------------------------------------------------------
C     THE LINE GRAPH IS CONSTRUCTED.
C-----------------------------------------------------------------------
  170 DO 190 I = 1, IGPP
      DO 180 J = 1, 120
      K = (FIG(I,J) - YMIN)*YUNIT+ .1
      IF (K.GT.50) GO TO 180
      GRAPH(K+1,J+1)= SYMBOL(I)
  180 CONTINUE
  190 CONTINUE
      IF(KGO.EQ.0) GO TO 210
      KN=NDATAS(KGO)
      DO 200 I=1,KN
      NP=NFIGDA(KGO,I)*120/KDAYRN
      K=(FIGVAL(KGO,I)-YMIN)*YUNIT+.1
      IF(K.GT.50) GO TO 200
      GRAPH(K+1,NP+1)=X
  200 CONTINUE
  210 XUNIT = (XMAX - XMIN)/12.
C-----------------------------------------------------------------------
C     THE X AXIS IS SCALED.
C-----------------------------------------------------------------------
      IDAYS(1) = XMIN
      IYEARS(1) = INITYR
      DO 220 I = 2,13
  220 IDAYS(I) = XMIN + XUNIT * FLOAT(I-1)
      DO 250 I = 2,13
      IYEARS(I) = IYEARS(I-1)
  230 NYRDAY = 360
      IF (IDAYS(I).LE.NYRDAY) GO TO 250
      IYEARS(I) = IYEARS(I) + 1
      DO 240 J=I,13
  240 IDAYS(J) = IDAYS(J) - NYRDAY
      GO TO 230
  250 CONTINUE
      YUNIT = (YMAX - YMIN )/5.
      YAXIS(1) = YMAX
      DO 260 J = 2, 6
  260 YAXIS(J) = YAXIS(J-1) - YUNIT
C-----------------------------------------------------------------------
C     THE GRAPH IS PRINTED.
C-----------------------------------------------------------------------

C..........HEADINGS
      WRITE (6,270) (TITLE(I), I = 1, 10)
  270 FORMAT (1H1, 10A4)
      WRITE(6,280)SYMBOL(1),(EXPLAN(I,1),I=1,5)
  280 FORMAT (1H+, 44X, 6A4)
      IF(IGPP.GT.1)WRITE(6,290)SYMBOL(2),(EXPLAN(I,2), I=1,5)
  290 FORMAT(1H+,72X,6A4)
      IF(IGPP.GT.2)WRITE(6,300)SYMBOL(3),(EXPLAN(I,3), I=1,5)
  300 FORMAT(1H+,100X,6A4)
      WRITE(6,310)(TITLE2(I),I=1,10)
  310 FORMAT(1X,20A4)
      IF(KGO.GT.0)WRITE(6,320)
  320 FORMAT(1H+,44X,'X   OBSERVED DATA')
      IF( IGPP .GT.3)WRITE(6,290)SYMBOL(4),(EXPLAN(I,4),I=1,5)
      IF( IGPP .GT.4)WRITE(6,290)SYMBOL(5),(EXPLAN(I,5),I=1,5)
      WRITE (6,330) I102, (YTITLE(I), I = 1,10)
  330 FORMAT ('  Y AXIS (*10**',I2,') IS ',10A4)

C..........THE MAIN BODY OF THE GRAPH
  340 J = 1
      I3 = 3
      DO 360 I1= 1, 51
      I3 = I3 + 1
      I = 52 - I1
      WRITE (6,350) (GRAPH(I,K), K = 1, 121)
  350 FORMAT (9X,121A1)
      IF (I-I/10*10.NE.1) GO TO 360
      WRITE (6,FMT1) YAXIS(J)
      J = J + 1
  360 CONTINUE
      WRITE (6,370) (XLINE(I), I = 1,31)
  370 FORMAT( 9X,30A4,A3)
      WRITE (6,380) (IDAYS(I), I = 1,13)
  380 FORMAT (' DAY ' , I5,12(6X, I4))
      WRITE (6,390) (IYEARS(I), I = 1,13)
  390 FORMAT (' YEAR ', I5,12(6X, I4))
      RETURN
      END
```

APPENDIX D3
Subroutine STATS

```
      SUBROUTINE STATS
      DIMENSION KVALU(9),KVALUT(9)
      COMMON/GRAXPL/KDAYRN,MDAT(70),FIGVAL(70,20),NDATAS(70),
     1NFIGDA(70,20),KGO,ALGRAF(5,70,120),NSTAT(70,6),NXPLOR,
     2NREPNO(70),NREPER(70,10),VALU(8),JVALU,
     3TITLES(70,10),YAXISS(70,10),ORIGIN(70),AMAXI(70),AMINI(70),
     4FIG(5,120),EXPLAN(5,5),TITLE(10),YTITLE(10),
     5XMAX,XMIN,YMAX,YMIN,INITYR,IGPP,TITLE2(10)
      DATA VCAP2T/0./,VCAP1T/0./,NCAP/0/
      WRITE(6,10)
   10 FORMAT(1X,/,/)
      NS=1
C-----------------------------------------------------------------------
C     CALCULATE AND REPORT STATISTICS FOR EACH VARIABLE
C-----------------------------------------------------------------------
      DO 400 I=1,NXPLOR
      IF(I.NE.MDAT(NS)) GO TO 400
      WRITE(6,20)(TITLES(I,II),II=1,10)
   20 FORMAT('0',35X,'STATISTICS FOR ',10A4)
      NS=NS+1
      K1=NDATAS(I)
      DO 390 J1=1,6
      IF(NSTAT(I,J1).EQ.0) GO TO 390
      GO TO (30,60,90,130,250,320),J1

C..........DIFFERENCE SQUARED BETWEEN PREDICTED AND OBSERVED DATA
   30 SUMSQ=0
      DO 40 K=1,K1
      K2=NFIGDA(I,K)*120/KDAYRN
      TEMPO=FIGVAL(I,K)-ALGRAF(1,I,K2)
   40 SUMSQ=SUMSQ+(TEMPO*TEMPO)
      TSUMS0=TSUMSQ+SUMSQ
      AVSUM=SUMS0/K1
      NSMS=NSMS+1
      NSUMSQ=NSUMSQ+K1
      KSUMSQ=KSUMSQ+1
      WRITE(6,50) SUMSQ,K1,AVSUM
   50 FORMAT(1X,'TOTAL DEVIATIONS SQUARED = ',E10.5,5X,'AVERAGE ',
     1'DEVIATION SQUARED FOR',I3,' SETS OF POINTS = ',E10.5)
      GO TO 390

C..........THEILS COEFFICIENT
   60 FIR=0.
      SEC=0.
      THIR=0.
      DO 70 K=1,K1
      K2=NFIGDA(I,K)*120/KDAYRN
      FIR=FIR+((ALGRAF(1,I,K2)-FIGVAL(I,K))**2)
      SEC=SEC+(ALGRAF(1,I,K2)**2)
   70 THIR=THIR+(FIGVAL(I,K)**2)
      FIRT=FIRT+FIR
      SECT=SECT+SEC
      THIRT=THIRT+THIF
      FIR1=SQRT(FIR/K1)
      SEC1=SQRT(SEC/K1)
      THIR1=SQRT(THIR/K1)
      THIEL=FIR1/(SEC1+THIR1)
      NTHIEL=NTHIEL+1
      KTHIEL=KTHIEL+K1
      WRITE(6,80)K1,THIEL
   80 FORMAT(1X,'THIELS INEQUALITY COEFFICIENT FOR ',I3,' SETS OF ',
     1'POINTS = ',F5.4)
      GO TO 390

C..........KAPOORS COEFFICIENT
   90 VKAP1=0
      VKAP2=0
      N3=1
      M1=NREPNO(I)
      DO 110 N1=1,M1
      BMIN=FIGVAL(I,N3)
      BMAX=FIGVAL(I,N3)
      M2=NREPER(I,N1)
      DO 100 N2=1,M2
      BMIN=AMIN1(BMIN,FIGVAL(I,N3))
      BMAX=AMAX1(BMAX,FIGVAL(I,N3))
  100 N3=N3+1
      N4=NFIGDA(I,N3-1)*120/KDAYRN
      IF((ALGRAF(1,I,N4).GE.BMIN).AND.(ALGRAF(1,I,N4).LE.BMAX)) E=0.
      IF(ALGRAF(1,I,N4).GT.BMAX) E=ALGRAF(1,I,N4)-BMAX
      IF(ALGRAF(1,I,N4).LT.BMIN) E=BMIN-ALGRAF(1,I,N4)
      VKAP1=VKAP1+(E**2)
  110 VKAP2=VKAP2+((BMAX-BMIN)**2)
      VKAP1T=VKAP1T+VKAP1
      VKAP2T=VKAP2T+VKAP2
      NKAP=NKAP+M1
      MKAP=MKAP+1
      V1=SQRT(VKAP1/M1)
      V2=SQRT(VKAP2/M1)
      VKAPR=V1/V2
      WRITE(6,120) M1,VKAPR
  120 FORMAT(1X,'KAPOORS V INEQUALITY COEFFICIENT OVER ',I2,
```

```
      1' TIMES = ',E10.4)
       GO TO 390

C..........PERCENTAGE DIFFERENCE BETWEEN PREDICTED AND OBSERVED DATA
  130 J3=JVALU+1
      DO 140 J=1,J3
  140 KVALU(J)=0
      N3=1
      M1=NREPNO(I)
      DO 210 N1=1,M1
      MAVER=0
      ALL=0.
      M2=NREPER(I,N1)
      DO 150 N2=1,M2
      MAVER=MAVER+1
      ALL=ALL+FIGVAL(I,N3)
  150 N3=N3+1
      AVER=ALL/MAVER
      N4=NFIGDA(I,N3-1)*120/KDAYRN
      IF(ALGRAF(1,I,N4)-AVER)170,180,160
  160 DIFER=100.*(ALGRAF(1,I,N4)-AVER)/AVER
      GO TO 190
  170 DIFER=100.*(AVER-ALGRAF(1,I,N4))/ALGRAF(1,I,N4)
      GO TO 190
  180 DIFER=0.
  190 DO 200 J=1,JVALU
      IF(DIFER.GT.VALU(J)) GO TO 200
      KVALU(J)=KVALU(J)+1
      KVALUT(J)=KVALUT(J)+1
  200 CONTINUE
      IF(DIFER.LE.VALU(JVALU)) GO TO 210
      KVALU(JVALU+1)=KVALU(JVALU+1)+1
      KVALUT(JVALU+1)=KVALUT(JVALU+1)+1
  210 CONTINUE
      DO 220 J=1,JVALU
  220 WRITE(6,230)VALU(J),KVALU(J)
  230 FORMAT(1X,'NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS ',
     1F5.0,' PERCENT = ',I2)
      WRITE(6,240)VALU(JVALU),KVALU(J3)
  240 FORMAT(1X,'NUMBER OF PREDICTED VALUES GREATER THAN PLUS OR MINUS '
     1,F5.0,' PERCENT = ',I2)
      GO TO 390

C..........CALCULATE COEFFICIENTS FOR THE LINEAR EQUATION
  250 XSUM=0
      YSUM=0
      XSUMS=0
      YSUMS=0
      XYSUM=0
      DO 260 K=1,K1
      K2=NFIGDA(I,K)*120/KDAYRN
      XSUM=XSUM+FIGVAL(I,K)
      YSUM=YSUM+ALGRAF(1,I,K2)
      XSUMS=XSUMS+(FIGVAL(I,K)**2)
      YSUMS=YSUMS+(ALGRAF(1,I,K2)**2)
  260 XYSUM=XYSUM+(FIGVAL(I,K)*ALGRAF(1,I,K2))
      XLIT=XSUMS-((XSUM**2)/K1)
      YLIT=YSUMS-((YSUM**2)/K1)
      XYLIT=XYSUM-((XSUM*YSUM)/K1)
      BONE=XYLIT/XLIT
      BZERO=(YSUM/K1)-(BONE*(XSUM/K1))
      IF(BONE.EQ.1.)GO TO 270
      AINTR= BZERO/(1.-BONE)
      GO TO 290
  270 WRITE(6,280) BZERO,BONE,K1
  280 FORMAT(1X,'PREDICTED VALUE EQUALS ',E10.5,' PLUS ',E10.5,
     1' TIMES THE OBSERVED VALUE FOR ',I3,' SETS OF POINTS.',
     2 'NO INTERSECTION')
      GO TO 310
  290 WRITE(6,300)BZERO,BONE,K1,AINTR
  300 FORMAT(1X,'PREDICTED VALUE EQUALS ',E10.5,' PLUS ',E10.5,
     1' TIMES THE OBSERVED VALUE FOR ',I3,' SETS OF POINTS.',
     2 ' INTERSECTION = ',E10.5)
  310 GO TO 390

C..........CHECK PREDICTED DATA AGAINST CONFIDENCE LIMITS OF
C..........OBSERVED DATA
  320 N50=0
      N95=0
      N3=1
      M1=NREPNO(I)
      DO 360 N1=1,M1
      M2=NREPER(I,N1)
      YALL=0
      YALLSQ=0
      DO 330 N2=1,M2
      YALL=YALL+FIGVAL(I,N3)
      YALLSQ=YALLSQ+(FIGVAL(I,N3)**2)
  330 N3=N3+1
      SDEV=SQRT((YALLSQ-((YALL**2)/M2))/(M2-1))
      SDEV95=SDEV*1.96
      SDEV50=SDEV*.674
      N4=NFIGDA(I,N3-1)*120/KDAYRN
      IF((ALGRAF(1,I,N4).LT.((YALL/M2)-SDEV95)).OR.(ALGRAF(1,I,N4).GT.
     1((YALL/M2)+SDEV95))) GO TO 340
      N95=N95+1
      N95T=N95T+1
  340 IF((ALGRAF(1,I,N4).LT.((YALL/M2)-SDEV50)).OR.(ALGRAF(1,I,N4).GT.
     1((YALL/M2)+SDEV50))) GO TO 350
      N50=N50+1
      N50T=N50T+1
  350 CONTINUE
  360 CONTINUE
      M1T=M1T+M1
      P50=N50*100./M1
      P95=N95*100./M1
      WRITE(6,370)P95
  370 FORMAT(1X,'MODEL OUTPUT PASSES THROUGH THE 95 PERCENT CONFIDENCE
     1INTERVAL ',F5.1,' PERCENT OF THE TIME')
  380 FORMAT(1X,'MODEL OUTPUT PASSES THROUGH THE 50 PERCENT CONFIDENCE
     1INTERVAL ',F5.1,' PERCENT OF THE TIME')
      WRITE(6,380)P50
  390 CONTINUE
  400 CONTINUE
C-----------------------------------------------------------------------
C     CALCULATE AND REPORT STATISTICS FOR ALL VARIABLES COMBINED
C-----------------------------------------------------------------------

C..........DIFFERENCE SQUARED BETWEEN PREDICTED AND OBSERVED DATA
      WRITE(6,410)
  410 FORMAT(1X,/,/,35X,'STATISTICS FOR ALL COMPARISONS',/)
      TAVSUM=TSUMSQ/NSUMSQ
      WRITE(6,420) TSUMSQ,NSUMSQ,NSMS,TAVSUM
  420 FORMAT(1X,'TOTAL DEVIATIONS SQUARED = ',E10.5,5X,'AVERAGE ',
     1'DEVIATION SQUARED FOR',I3,' SETS OF POINTS FROM ',I2,' STATE ',
     2'VARIABLES = ',E10.5)

C..........THEILS COEFFICIENT
      FIRT1=SQRT(FIRT/KTHIEL)
      SECT1=SQRT(SECT/KTHIEL)
      THIRT1=SQRT(THIRT/KTHIEL)
      THIEL=FIRT1/(SECT1+THIRT1)
      WRITE(6,430) KTHIEL,NTHIEL,THIEL
  430 FORMAT(1X,'THIELS INEQUALITY COEFFICIENT FOR ',I3,' SETS OF ',
     1'POINTS FROM ',I2,' STATE VARIABLES = ',F5.4)

C..........KAPOORS COEFFICIENT
      V1=SQRT(VKAP1T/NKAP)
      V2=SQRT(VKAP2T/NKAP)
      VKAPR=V1/V2
      WRITE(6,440) NKAP,MKAP,VKAPR
  440 FORMAT(1X,'KAPOORS INEQUALITY COEFFICIENT FOR ',I3,
     1' SETS OF POINTS FROM ',I2,' STATE VARIABLES = ',E10.4)

C..........PERCENTAGE DIFFERENCE BETWEEN PREDICTED AND OBSERVED DATA
      DO 450 J=1,JVALU
  450 WRITE(6,230)VALU(J),KVALUT(J)
      WRITE(6,240)VALU(JVALU),KVALUT(J3)

C..........CHECK PREDICTED DATA AGAINST CONFIDENCE LIMITS OF
C..........OBSERVED DATA
      P50=N50T*100./M1T
      P95=N95T*100./M1T
      WRITE(6,370)P95
      WRITE(6,380)P50
      RETURN
      END
```

APPENDIX E1

Sample Input Deck for Exploratory Sensitivity Analysis

(The right-hand column is the statement identification number for the program statement that actually calls a particular data card. See Appendix D1.)

```
                                                                  ME0170
    4    1 1971  121          4    2                              ME0250
                                                                  ME0260
EXPLORATORY SENSITIVITY EXAMPLE                                   ME0320
BENTHIC DIATOM BIOMASS                                            ME0340
GRAMS CARBON PER ECOSYSTEM                                        ME0350
DISCHARGE                                                         ME0340
CUBIC METERS PER SECOND                                           ME0350
HYALLELA POPULATIONS SIZE 4                                       ME0340
NUMBERS PER ECOSYSTEM                                             ME0350
FINE BENTHIC DETRITUS                                             ME0340
GRAMS CARBON PER ECOSYSTEM                                        ME0350
MEASURED DISCHARGE                                                ME0380
DISCHARGE X .5                                                    ME0380
```

APPENDIX E2

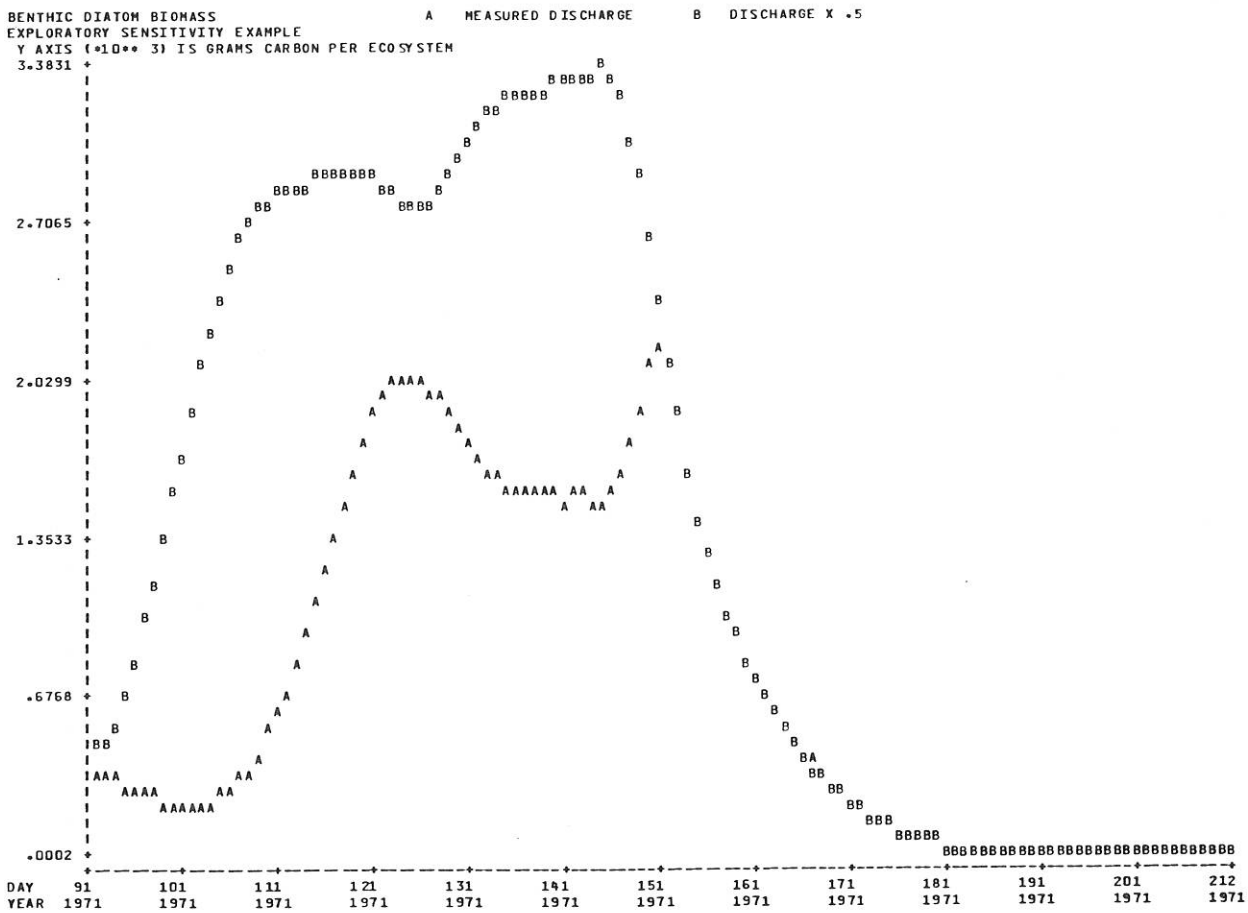
Sample Input Deck for Statistical Analysis

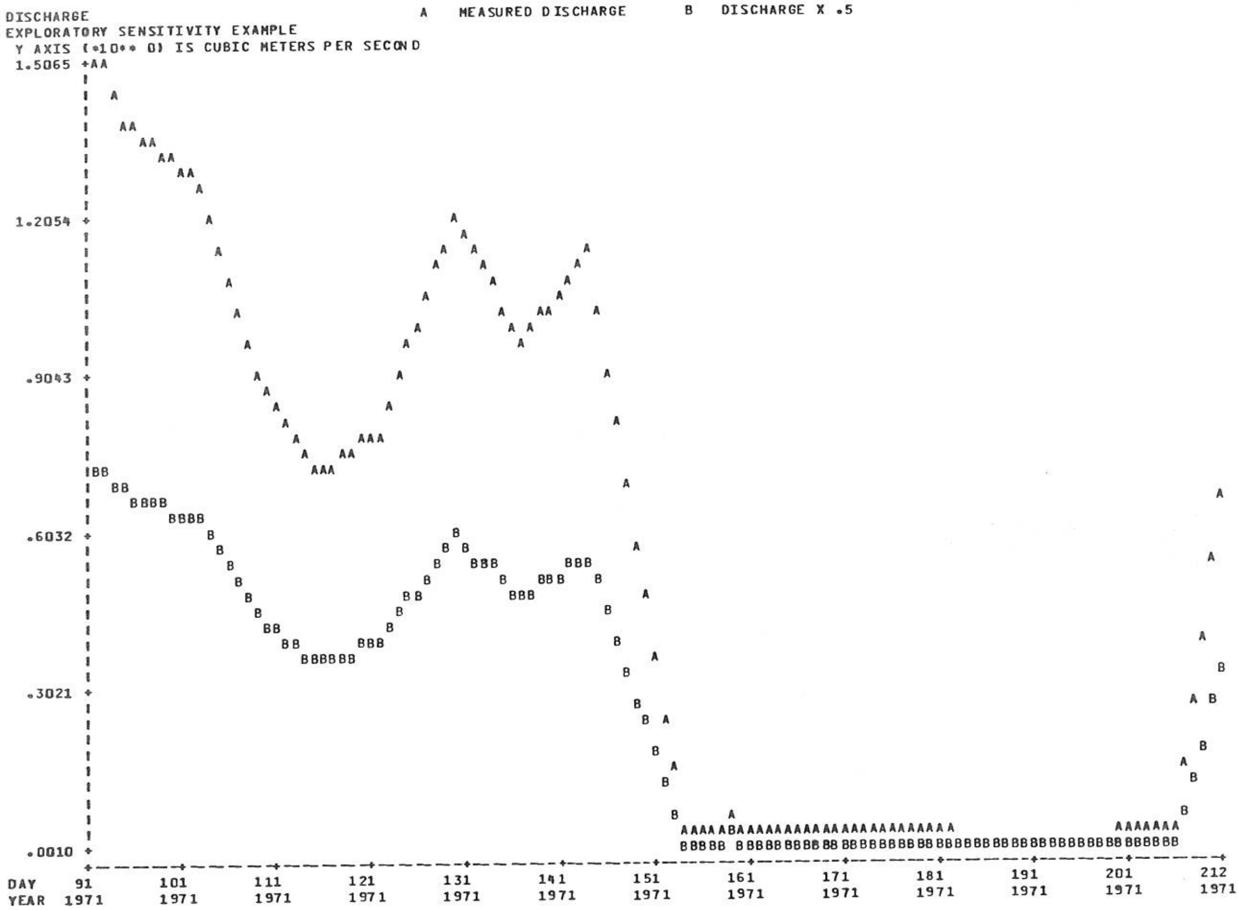
(The right-hand column is the statement identification number for the program statement that actually calls a particular data card. See Appendix D2.)

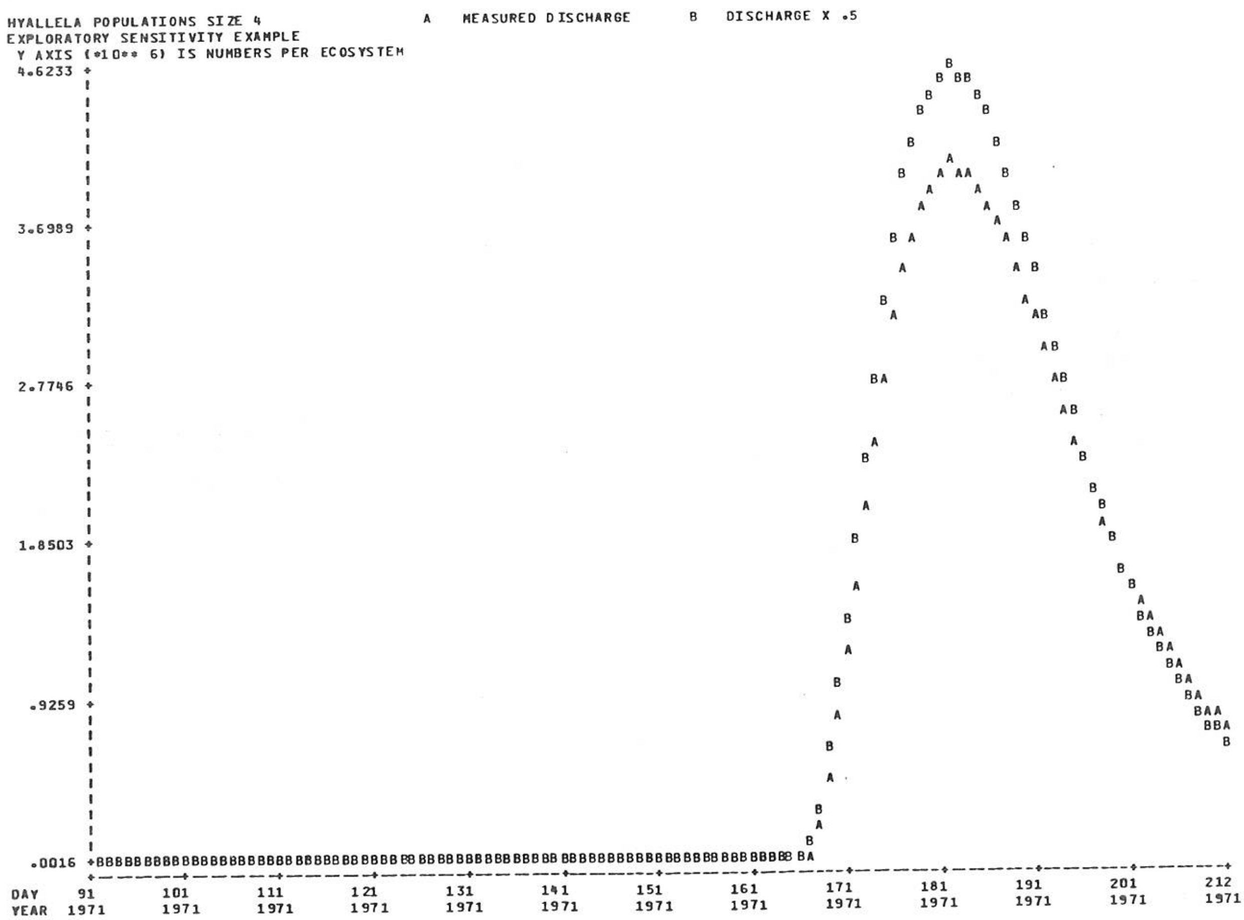
```
                                                                  ME0170
    4    1 1971  121    1    4    1                               ME0250
    5  10.  20.  40.  80. 160.                                    ME0260
VALIDATION EXAMPLE                                                ME0320
BENTHIC DIATOM BIOMASS                                            ME0340
GRAMS CARBON PER ECOSYSTEM                                        ME0350
DISCHARGE                                                         ME0340
CUBIC METERS PER SECOND                                           ME0350
HYALLELA POPULATIONS SIZE 4                                       ME0340
NUMBERS PER ECOSYSTEM                                             ME0350
FINE BENTHIC DETRITUS                                             ME0340
GRAMS CARBON PER ECOSYSTEM                                        ME0350
PREDICTED VALUES                                                  ME0380
    1    4   11 1971       210.   1    1    1    1    1    1      ME0650
    1    4   11 1971       345.                                   ME0650
    1    4   11 1971       375.                                   ME0650
    1    5   11 1971      1200.                                   ME0650
    1    5   11 1971      1350.                                   ME0650
    1    6   11 1971       540.                                   ME0650
    1    6   11 1971       580.                                   ME0650
    1    6   11 1971       630.                                   ME0650
    1    6   11 1971       790.                                   ME0650
    1    6   11 1971       850.                                   ME0650
    1    7    1 1971        50.                                   ME0650
    1    7    1 1971        90.                                   ME0650
    1    7    1 1971       150.                                   ME0650
    1    7   21 1971       180.                                   ME0650
    1    7   21 1971       260.                                   ME0650
    3    4   11 1971    100000.   1    1         1    1           ME0650
    3    4   28 1971    200000.                                   ME0650
    3    5   15 1971    120000.                                   ME0650
    3    6    1 1971    250000.                                   ME0650
    3    6   25 1971    850000.                                   ME0650
    3    7   15 1971   2800000.                                   ME0650
    4    4   11 1971       520.   1    1    1    1    1    1      ME0650
    4    4   11 1971       580.                                   ME0650
    4    4   11 1971       615.                                   ME0650
    4    5   11 1971       280.                                   ME0650
    4    5   11 1971       420.                                   ME0650
    4    6   11 1971       520.                                   ME0650
    4    6   11 1971       550.                                   ME0650
    4    6   11 1971       590.                                   ME0650
    4    7   11 1971       190.                                   ME0650
    4    7   11 1971       280.                                   ME0650
    4    7   11 1971       300.                                   ME0650
```

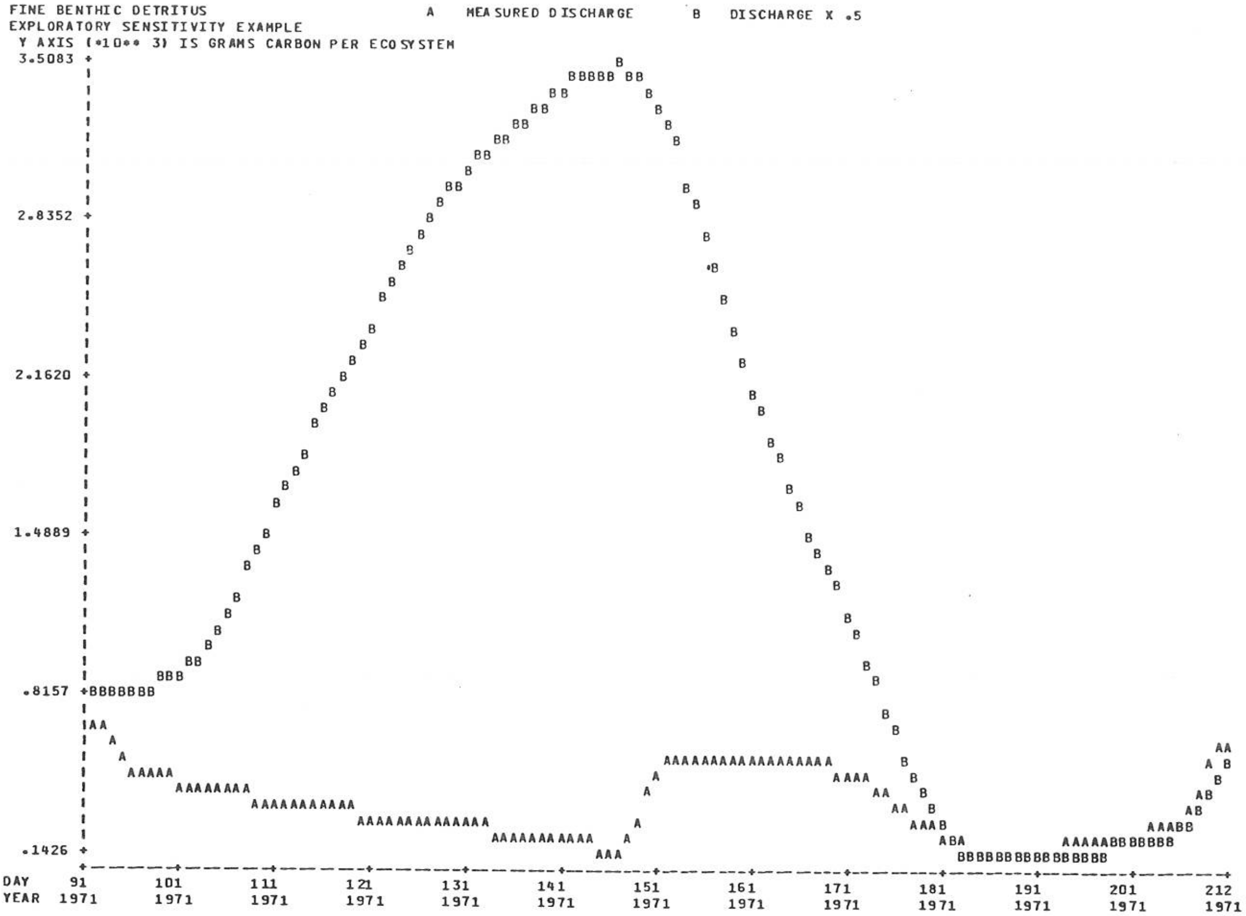
APPENDIX F1

Sample of Output for Exploratory Sensitivity Analysis

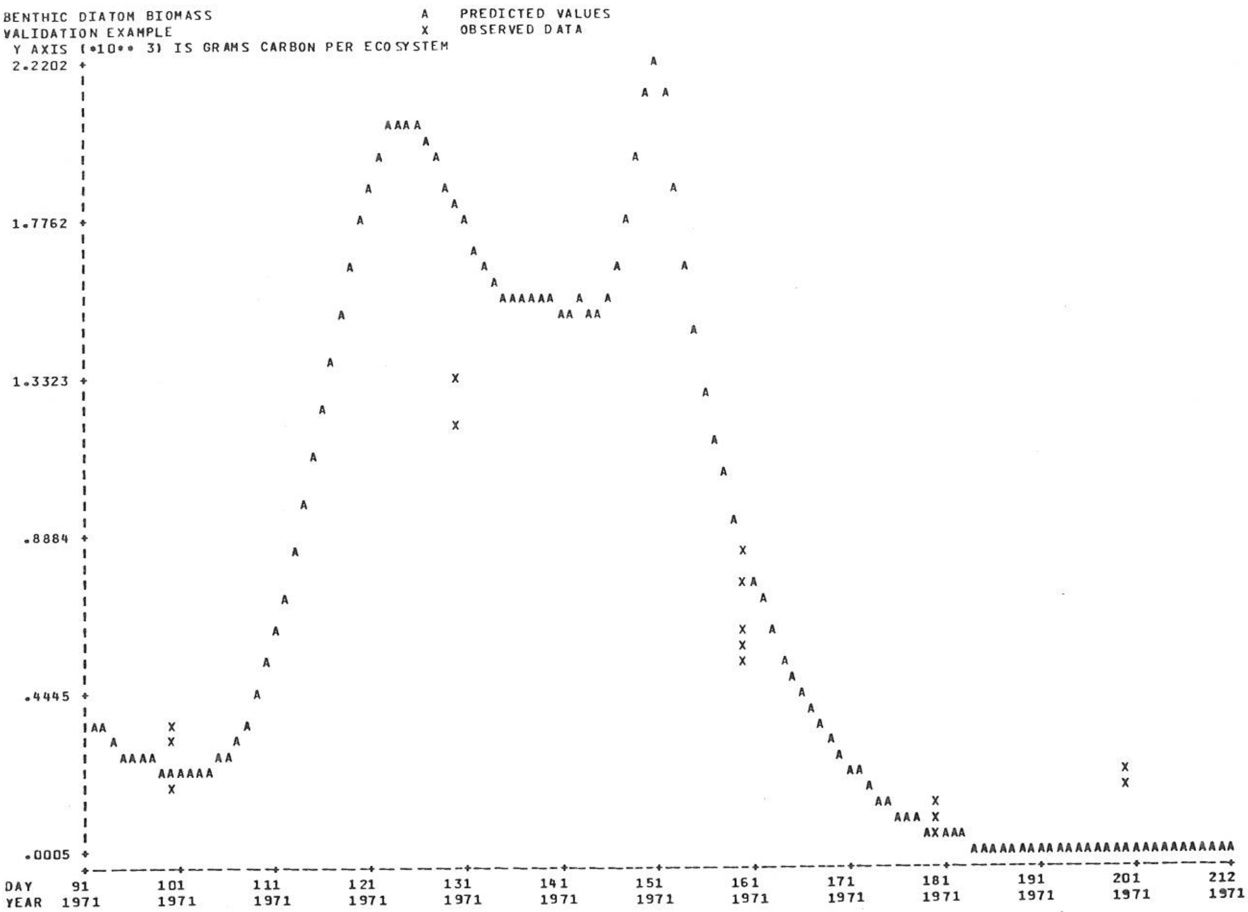


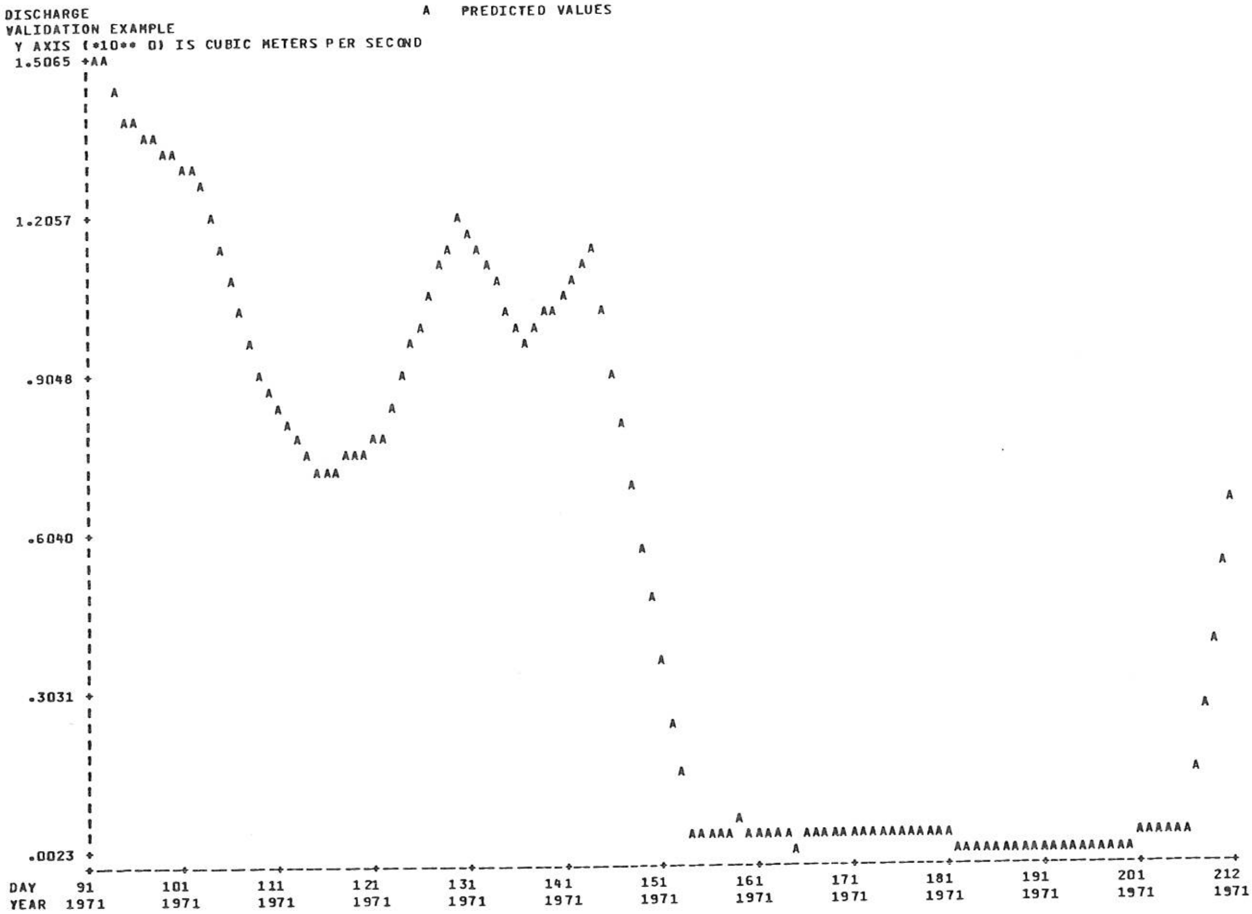

DISCHARGE
EXPLORATORY SENSITIVITY EXAMPLE
Y AXIS (*10** 0) IS CUBIC METERS PER SECOND
A MEASURED DISCHARGE
B DISCHARGE X .5
1.5065
1.2054
.9043
.6032
.3021
.0010
DAY 91 101 111 121 131 141 151 161 171 181 191 201 212
YEAR 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971

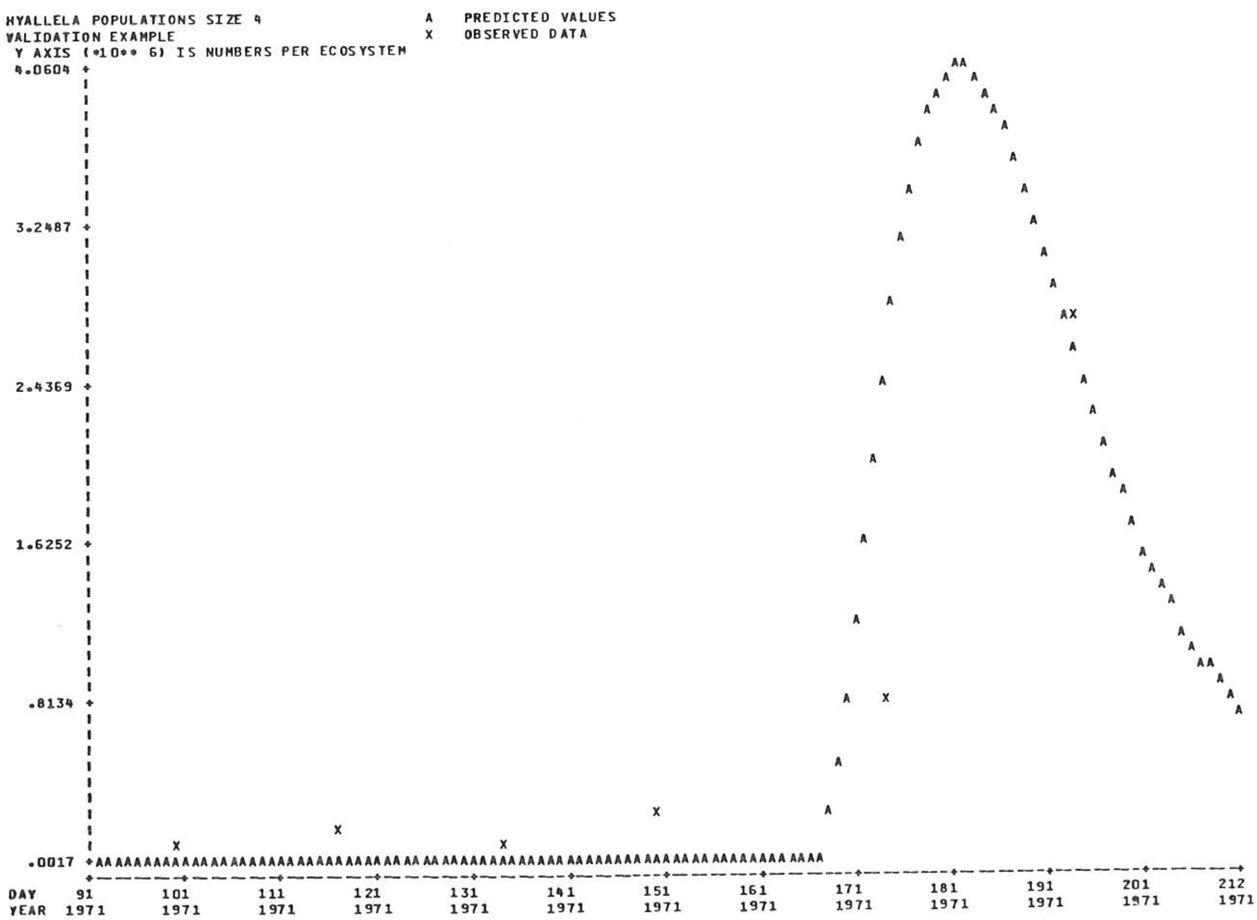

HYALLELA POPULATIONS SIZE 4
EXPLORATORY SENSITIVITY EXAMPLE
Y AXIS (*10** 6) IS NUMBERS PER ECOSYSTEM
A MEASURED DISCHARGE
B DISCHARGE X .5
4.6233
3.6989
2.7746
1.8503
.9259
.0016
DAY 91 101 111 121 131 141 151 161 171 181 191 201 212
YEAR 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971

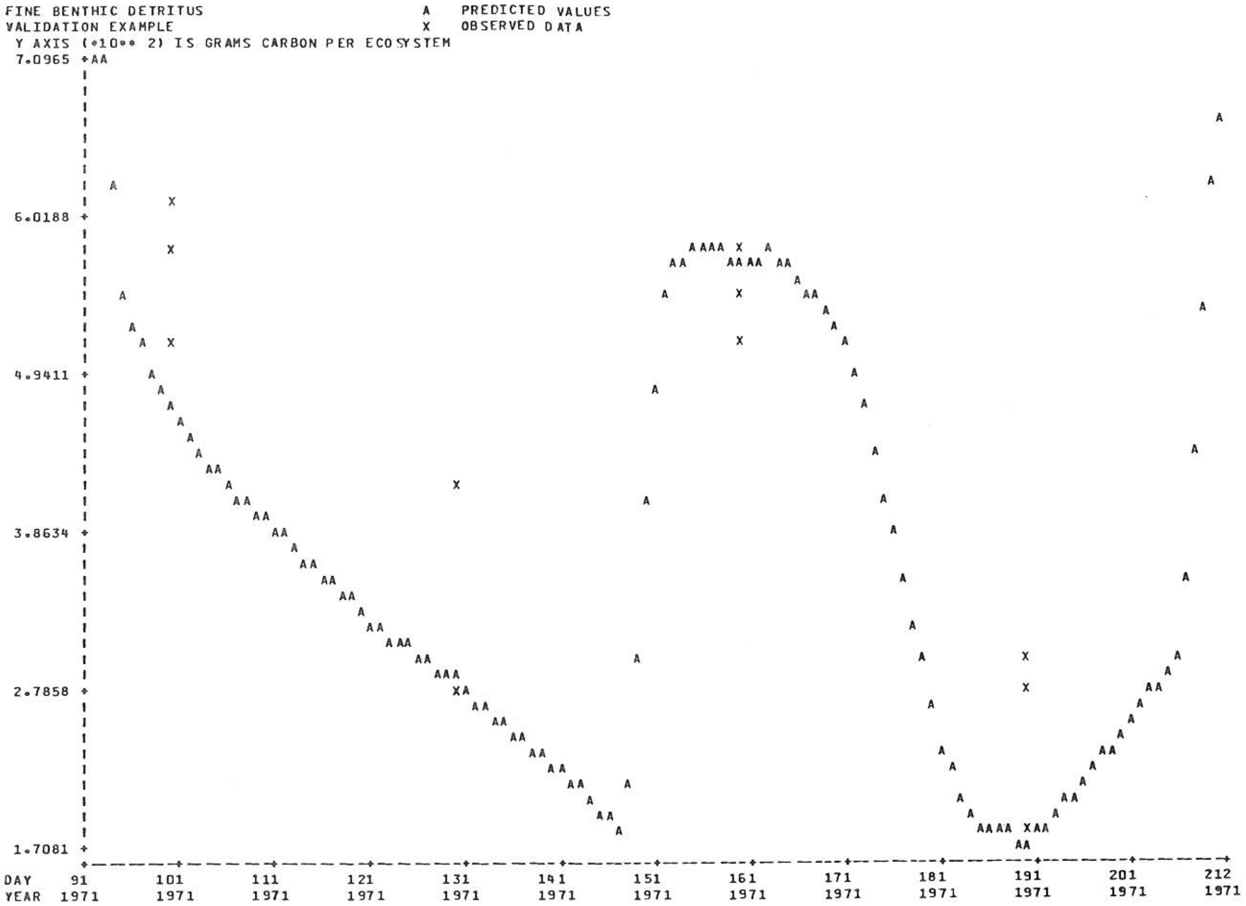

FINE BENTHIC DETRITUS
EXPLORATORY SENSITIVITY EXAMPLE
Y AXIS (*10** 3) IS GRAMS CARBON PER ECOSYSTEM
A MEASURED DISCHARGE
B DISCHARGE X .5
3.5083
2.8352
2.1620
1.4889
.8157
.1426
DAY 91 101 111 121 131 141 151 161 171 181 191 201 212
YEAR 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971

APPENDIX F2
EXAMPLES OF OUTPUT FOR STATISTICAL ANALYSIS




DISCHARGE
VALIDATION EXAMPLE
Y AXIS (*10** 0) IS CUBIC METERS PER SECOND
A PREDICTED VALUES
1.5065
1.2057
.9048
.6040
.3031
.0023
DAY 91 101 111 121 131 141 151 161 171 181 191 201 212
YEAR 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971


HYALLELA POPULATIONS SIZE 4
VALIDATION EXAMPLE
Y AXIS (*10** 6) IS NUMBERS PER ECOSYSTEM
A PREDICTED VALUES
X OBSERVED DATA
4.0604
3.2487
2.4369
1.6252
.8134
.0017
DAY 91 101 111 121 131 141 151 161 171 181 191 201 212
YEAR 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971 1971

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                         STATISTICS FOR BENTHIC DIATOM BIOMASS
TOTAL DEVIATIONS SQUARED =  .10161+07     AVERAGE DEVIATION SQUARED FOR 15 SETS OF POINTS =  .67742+05
THIELS INEQUALITY COEFFICIENT FOR  15 SETS OF POINTS = .1758
KAPOORS V INEQUALITY COEFFICIENT OVER  5 TIMES =    .1273+01
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   10. PERCENT =  0
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   20. PERCENT =  0
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   40. PERCENT =  2
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   80. PERCENT =  4
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS  160. PERCENT =  4
NUMBER OF PREDICTED VALUES GREATER THAN PLUS OR MINUS  160. PERCENT =  1
PREDICTED VALUE EQUALS -.16038+03 PLUS  .14972+01 TIMES THE OBSERVED VALUE FOR  15 SETS OF POINTS. INTERSECTION =  .32257+03
MODEL OUTPUT PASSES THROUGH THE 95 PERCENT CONFIDENCE  INTERVAL  60.0 PERCENT OF THE TIME
MODEL OUTPUT PASSES THROUGH THE 50 PERCENT CONFIDENCE  INTERVAL  40.0 PERCENT OF THE TIME

                         STATISTICS FOR HYALLELA POPULATIONS SIZE 4
TOTAL DEVIATIONS SQUARED =  .27530+13     AVERAGE DEVIATION SQUARED FOR  6 SETS OF POINTS =  .45884+12
THIELS INEQUALITY COEFFICIENT FOR   6 SETS OF POINTS = .2532
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   10. PERCENT =  1
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   20. PERCENT =  1
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   40. PERCENT =  1
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   80. PERCENT =  1
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS  160. PERCENT =  1
NUMBER OF PREDICTED VALUES GREATER THAN PLUS OR MINUS  160. PERCENT =  5
PREDICTED VALUE EQUALS  .10537+06 PLUS  .10370+01 TIMES THE OBSERVED VALUE FOR   6 SETS OF POINTS. INTERSECTION = -.28495+07

                         STATISTICS FOR FINE BENTHIC DETRITUS
TOTAL DEVIATIONS SQUARED =  .79480+05     AVERAGE DEVIATION SQUARED FOR 11 SETS OF POINTS =  .72255+04
THIELS INEQUALITY COEFFICIENT FOR  11 SETS OF POINTS = .0963
KAPOORS V INEQUALITY COEFFICIENT OVER  4 TIMES =    .2156+00
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   10. PERCENT =  1
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   20. PERCENT =  1
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   40. PERCENT =  3
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   80. PERCENT =  4
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS  160. PERCENT =  4
NUMBER OF PREDICTED VALUES GREATER THAN PLUS OR MINUS  160. PERCENT =  0
PREDICTED VALUE EQUALS -.55456+02 PLUS  .10050+01 TIMES THE OBSERVED VALUE FOR  11 SETS OF POINTS. INTERSECTION =  .11080+05
MODEL OUTPUT PASSES THROUGH THE 95 PERCENT CONFIDENCE  INTERVAL  75.0 PERCENT OF THE TIME
MODEL OUTPUT PASSES THROUGH THE 50 PERCENT CONFIDENCE  INTERVAL  50.0 PERCENT OF THE TIME


                        STATISTICS FOR ALL COMPARISONS

TOTAL DEVIATIONS SQUARED =  .27530+13     AVERAGE DEVIATION SQUARED FOR 32 SETS OF POINTS FROM  3 STATE VARIABLES =  .86032+11
THIELS INEQUALITY COEFFICIENT FOR  32 SETS OF POINTS FROM  3 STATE VARIABLES = .2532
KAPOORS INEQUALITY COEFFICIENT FOR   9 SETS OF POINTS FROM  2 STATE VARIABLES =   .1129+01
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   10. PERCENT =  2
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   20. PERCENT =  2
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   40. PERCENT =  6
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS   80. PERCENT =  9
NUMBER OF PREDICTED VALUES WITHIN PLUS OR MINUS  160. PERCENT =  9
NUMBER OF PREDICTED VALUES GREATER THAN PLUS OR MINUS  160. PERCENT =  6
MODEL OUTPUT PASSES THROUGH THE 95 PERCENT CONFIDENCE  INTERVAL  66.7 PERCENT OF THE TIME
MODEL OUTPUT PASSES THROUGH THE 50 PERCENT CONFIDENCE  INTERVAL  44.4 PERCENT OF THE TIME
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