

ON THE USEFULNESS OF SIMULATION MODELS OF ECOLOGICAL SYSTEMS

(Some thoughts for further discussion)

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1. Maintaining the integrity and options for development of ecosystems like arable fields, forests, sea-arms and the human society in its entirety is a fundamental social problem. Is it also a fundamental scientific problem? Yes, if it can be established that the problem has not yet been solved and if it can be made plausible on theoretical grounds that a solution to the problem exists.
2. It is sure that the above mentioned problems have not been solved yet. The existence of a solution to these problems is viewed by some in a more optimistic way than in the past, because the knowledge of the relevant processes seem to be large and because techniques have been developed to summarise this knowledge in an operational way into simulation models.
3. However only those problems, for which the conditions are known under which the solution can be refuted, can be considered to be solvable; or stating this in a more positive sense in connection with models: models can only be considered to be representations of systems if they are verifiable or at least can be tested as to usability.
4. We can distinguish verifiable and speculative models.
5. Verifiable models can only be constructed of (a) systems that are repeatable or of (b) systems that (re-)occur in nature and that present themselves to us in their different stadia.

Examples of a (repeatable systems):

- flow-cultures (e.g. bacteria, algae)
- agricultural systems (e.g. cultivation of maize)
- industrial systems (e.g. oil refining processes)

Examples of b (reoccurring systems):

- weather systems (short term)
- specimens of a well defined species
- ecological systems of which the development in time is controlled by a negative feedback

6. Experiments can be carried out with repeatable systems. Reoccurring systems are not or less amenable to experimentation. In ecology more and more experiments are being used for research on reoccurring systems. The probability of permanent disturbance of the system by these experiments is small because mostly the influence of negative feedback is predominant on one hand and on the other hand the risks are acceptable because generally more systems of the same kind exist.

7. In ecology system-analytical research mostly is limited to the study of repeatable and reoccurring systems. And with justice, because it appears that the knowledge of the processes that are involved is so limited that one cannot do without strict validation of the resulting models.

8. Models of unique systems are speculative models. These models cannot be tested as to their validity and usability, because analysis and validation has to refer to systems that operate independently of each other, for the result of the validation to be able to have refutation of the model as a consequence.

9. Examples of unique systems are:

- climatologic systems (long term)
- ecosystems of which the development is only controlled by negative feedbacks within a small interval. The development of these systems is uncertain, and initially identical systems diverge in behaviour in time and space.
- ecosystems determined by geographical circumstances: like river estuaries, sea-arms, the world itself and human society.

Unique systems in general do have certain reoccurring aspects.

10. Unique systems can be analysed and in some cases experimented with. The importance of the measurements and of the experiments has to be weighted against the risk of disturbing the system. Abstinence is mandatory in case of doubt.

11. Speculative models or models of unique systems can be frusted more or less. Confidence in the model grows if analogous methods of analysis of repeatable or reoccurring systems have led to veryfiable models with usable results.

12. The confidence in models of systems of which the behaviour is controlled by physical phenomena (and their respective laws) can be quite large. Nobody has serious doubts about the results of computations by the department of Public Works on the relation between height of dykes and the probability of inundations. A trip to the moon has not necessary the validity of the model of the relevant space vehicle.

13. In ecology it has only been possible, until now, to obtain useful results with models of relatively simple systems and, according to some, only of systems that could also have been understood without making use of advanced methods of system-analysis and model-building. The confidence in speculative models of unique ecosystems therefore is justifiable slight.

14. "Worldmodels" with any perspective of usefulness are more complicated than the models of those ecosystems of which usefulness has been proven. This is so, because in these models knowledge from a great many scientific disciplines has to be assimilated, and this knowledge is much smaller, in some significant disciplines, than the knowledge of physical, chemical and biological processes that play a role in simple ecosystems.

15. Because the basis for confidence is missing, and in many cases is not created, "worldmodels" remain unusable for the preparation of policy decisions. Therefore it is an open question if - in view of the whole effort spent in research - the analysis of "world"systems that leads to speculative, interdisciplinary models, has to be carried on.

16. The answer is affirmative. By comparative research of verifiable and speculative models, the basis for confidence can be built up in the course of time. System-analysis and modelbuilding is moreover the only interdisciplinary field of science in development with which it is possible, starting from available imperfect knowledge, to oversee a complete system and, moreover, it makes no sense to throw away half-finished shoes before new ones have been designed.

17. Long before speculative, interdisciplinary, models will be usable for assisting in making policy decisions on social matters, these kind of models will be useful as an instrument for research policy in evaluating priorities of research between the disciplines.

18. It is also possible to formulate criteria that have to be fulfilled by speculative, interdisciplinary models and considerations, in order to have them contribute to the advancement of science. These can then lead to recommendations for research that will gradually grow in importance when more models will have been evaluated in a mutually comparable way. There is a need for a body which will fulfil this role, because individuals can hardly form an opinion on the quality of these models and mutual assessment of the merits by "competing teams of modelbuilders" easily degenerates into unessential disputes.

19. Possible criteria are the following:

- The model has to be "transparent" and usable by others than the authors
- The objectives of the model have to be well defined and documented
- Based on the description of the objectives of the model, a reasoning should be provided on basis of which the choice of participating disciplines and their contribution to the model is outlined. This outline should also provide the necessary information for defining the amount of detail to be provided in any model subset contributed by any participating disciplinary group.
- The contributions by the groups from different disciplines should all be scientifically sound.
- The verifiable parts of the model should all have been thoroughly validated.
- The claims as to usefulness should all have been evaluated.

- The model should be incorruptable. This means that it must be clear which assumptions have been built into the model, and the conclusion of such assumptions should have been handled in such a way that the consequences of alternative assumptions can be established within the framework of the objectives of the model.
- The model should have been used in a way warranting integrity. This means that the authors of the model have investigated the consequences of a reasonable amount of alternative assumptions and have documented the results obtained, and have not only used assumptions that fit their views about the results that the model should provide.