WHAT IS THE ROLE OF SCIENCE IN THE DIALOGUE PROPOSED BY WILLIAM KLINK?

by Thomas L. Gilbert

Abstract. Klink rejects the use of ecological models in environmental decision making because their predictions cannot be tested by rigorous scientific methods. I argue that models that cannot be tested according to the rigorous standards of the physical sciences can still be considered "scientific"; they are useful (and, in practice, used) for assessing the impacts of human actions on the environment and choosing between alternative courses of action. It is, however, important to be aware of the uncertainties and to make corrections as new data and insights become available. The interplay between (1) model-based decisions and action and (2) their consequences and subsequent corrections can be regarded as a dialogue between humans and nature (or God) in the sense proposed by Klink. Klink also claims that future actions should be informed by the larger vision of theology and should not be based on science. I suggest that science has an indispensible role. The larger vision *is* needed to respond to the fundamental religious question: How should I live—and why? But this question cannot be answered without first addressing the fundamental scientific question: How does the world work? I suggest that responses to the first question can be formulated as visions of a future state of existence that we feel compelled to strive to realize, and that science is necessary to provide "maps of reality" needed to realize visions. I also suggest that Christian traditions can probably provide adequate visions; the crucial need is for improving our "maps of reality."

Keywords: ecology; environment; environmental impacts; map of reality; religion; science; scientific models; uncertainty; vision.

William Klink's central proposal is that a "dialogue" between humans and Nature is needed and that technology should be regarded as the medium of communication, "listening to and talking with nature via the medium of technology" (Klink 1992, 207), and "listening,

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responding, and listening again" (Klink 1992, 208). He gives a theological interpretation to this process as a dialogue with God and suggests that our technical incursions into the environment can be regarded as a " 'speaking back' to God in which we expect, and listen for, responses from the environment and recognize them as God's responses". This theological interpretation enables our response—our subsequent actions—to be informed by the larger vision of theology, which attempts to fathom "God's larger plan for the universe" (Klink 1992, 209). Klink summarizes the purpose of his article in the closing sentence: "The hope is that this might be the beginning of a genuine dialogue between human beings and Nature, and from the Judeo-Christian perspective, a new dialogue between human beings and God" (Klink 1992, 210).

At the first reading, Klink's interesting and worthwhile proposal appeared to be quite in line with current thinking on the need to draw on both scientific and religious knowledge in coping with the problem of the increasingly destructive impact of humans on their environment. But, when I reread his essay, the following statement stood out: "I have just argued that *future actions cannot be based on science*, but need to be informed by a larger vision. The role of theology is to provide that larger vision" (209; my italics). He did not say "should not be based *solely* on science." The phrase "informed by a larger vision" suggests that his proposed approach might still allow science a significant role in the decision-making process (distinct from the role of a communications medium he assigns to technology). A different conclusion is suggested, however, by an earlier statement:

> I want first to close off . . . the possibility of using ecology as a tool for guiding our actions toward the environment. My claim is that there can be no science of ecology (I am using the term *science* in a narrow, but precise way) and therefore the possibility of using the science of ecology as a guide for our actions toward the environment cannot succeed. If this claim is correct, then other means for guiding our actions toward the environment must be found. (Klink 1992, 204–5)

I concluded that he might be proposing to substitute theology for science as the *sole basis* for decisions pertaining to the future of the environment. This is a radical proposal.

Whether or not it is Klink's intent to propose substituting theology for science in this manner, his statement raises two issues on which I would like to comment. One concerns his use of a narrow interpretation of science. I will argue that a broader interpretation, reflecting the actual practices of the sciences, allows an extended reading of his proposal that makes it more useful. The other concerns

the roles for which religion and science are needed and suited in addressing the problem. I will present a rationale for delineating these roles in order to justify the claim that science is an essential part of the basis for environmental decision making and should have a major role, which Klink appears unwilling to grant.

A broader definition of science is the following: a process of theory-construction and theory-testing and the body of knowledge resulting from the application of this process. Differences within the scientific community arise in interpreting what constitutes an adequate "test" of a theory, which raises questions of the extent to which science is an objective/subjective enterprise and how to deal with the problem of uncertainty. The narrow interpretation used by Klink focuses on the scientific ideal of striving for objectivity and certainty. Most of the practice of science takes place in a broader arena where we must continually grapple with subjectivity and uncertainty. It is difficult to make this clear because we lack even an adequate terminology for describing it. A terminology I have found useful for addressing this problem, and which will be adopted for this commentary, uses the terms *speculation, conjecture, hypothesis, theory,* and *principle* to characterize a scale of increasing certainty and objectivity.

I suggest that science starts with speculation. A speculation is any idea, however subjective, uncertain, and wild, proposed to explain a phenomenon. It is intended to loosen the grip of established notions on our thinking and chart new paths from the scientific frontier into the unknown. A conjecture is a speculation that shows enough promise to justify testing. The tests (public falsification tests, see Popper 1972 and Lakatos 1978) can involve carefully designed laboratory or field experiments or searching for elusive data (as in paleontology, anthropology, and astronomy). After a conjecture has been formulated in a testable form it becomes a hypothesis. A theory is a hypothesis that has passed at least one falsification test but not a sufficient number to shift the burden of testing from those who advocate the theory to those who question it. At some point in the testing process this shift occurs and the theory may be called a principle. There are very few principles in science. Examples are the principles of thermodynamics and the principles of quantum mechanics. The testing never ends, and it can lead to extension and revision of the principles, as occurred when classical mechanics was superseded by quantum mechanics.

In discussing the level of uncertainty/certainty and subjectivity/objectivity of predictive models used in decision making, it is often helpful to locate them on a scale of speculation to principle. In using this scale, we need to bear in mind that coherence (the relatedness of

different concepts involved in theories) and correspondence (agreement between a theory and data) are both essential for validating a scientific concept or model.

Most systems involved in decision making involve stochastic elements. If one adheres to strict criteria for validating predictive models of such systems, then repeated measurements on the same system (if the measurements are nondestructive) or identical systems are necessary. This is not possible if there is only one system and the final state of interest is one in which the system is irreversibly changed. Klink adopts strict criteria, which lead him to the conclusions, "the outcome of our actions on the environment cannot be predicted on the basis of ecological models—we cannot predict with *any* confidence what the outcomes of our actions might be" (Klink 1992, 206; my italics), and "the possibility of using the science of ecology as a guide for our actions toward the environment cannot succeed" (Klink 1992, 205).

I do not fault Klink's reasoning, given the premises and presuppositions from which he starts, although I believe that the qualifier *any* is stronger than can be justified by his arguments. It is true, for example, that even though the measured increase in the concentration of CO_2 (and other "greenhouse gases") in the atmosphere supports a belief that a global warming trend will occur, and it is reasonable to believe that the concentration increase is primarily due to the burning of fossil fuels, current ecological models are unable to predict, with scientific certainty, that a global warming trend is actually occurring (it could be a natural fluctuation in temperature, such as has occurred in the past) and, if so, what the cause and remedy might be. But it is too soon to claim that we will not be able to make such predictions with scientific certainty as better models are developed and tested and more data are accumulated.

Further, I suggest that the rigorous criteria used for awarding the scientific seal of approval to a model for constructing the scientific edifice *are not, cannot,* and *should not* be used in environmental impact assessment. I use "should not" in the sense that one should not impose unattainable standards for validating a model. One should, of course, set standards that are as high as resources for testing permit. The logic outlined above demonstrates the "cannot." The following discussion, drawn from several years of personal experience in environmental impact assessment and environmental risk analysis, is in support of the claim "are not."

Environmental models used for environmental impact assessment are constructed on the basis of expert judgment (see Cantor 1977; Erickson 1979; Rau and Wooten 1980). The models are cus-

tomarily constructed from models of subsystems (e.g., the transport of pollutants through various pathways in a subsystem) that can be tested and validated. The model for the complete system cannot be tested but is subjected to a careful review by experts with different backgrounds and perspectives for logical flaws and omitted causative factors or effects. An adequate review includes an uncertainty and sensitivity analysis. Because it is rarely possible to test the model for the entire system (I am not aware of any environmental impact assessment for which this has been feasible), the environmental models used should properly be classified as conjectures or hypotheses rather than theories.

One can adopt a hard-nosed scientific stance and argue that, because the models have not been tested according to strict standards for validating scientific hypotheses and theories, the models cannot give reliable predictions of the consequences of our actions and, therefore, should not be used as a basis for decision making. Whether or not the confidence placed in such models is justified, government officials have sufficient confidence to use them as a basis for decisions on major federal actions, including the promulgation of environmental regulations, and the public has sufficient confidence in them to accept their use. The predictions are usually comparative—they compare the impacts of alternative courses of action—and are more credible than absolute predictions. An element of faith is, of course, involved—as in all science.

A purist might object to use of the word *scientific* for a process involving the use of environmental models that cannot be rigorously validated. But the models are made up of parts that have been constructed using scientific methods. One must either develop a new terminology to describe such models or broaden the category *scientific* to include them. Along with most scientists who have been involved in preparing environmental impact statements, I have adopted the latter course. The important point is that environmental models have proved to be indispensable in environmental decision making in spite of their limitations and lack of scientific rigor.

An important feature of an environmental impact statement (EIS) is that the potential impacts are examined before the action is taken. Serious impacts can thereby often be recognized and averted before the damage is done, a great gain over becoming aware of the impacts only after an action is taken—when it may be too late for remedial action.

There are, however, two serious drawbacks to the NEPA (National Environmental Policy Act) process (so called because the requirement that EISs be prepared for all "major federal actions"

was mandated by the National Environmental Policy Act of 1969). One is that the uncertainties in model predictions are usually quite large, and there is no provision in NEPA for monitoring the consequences of the action undertaken in order to compare consequences with predictions and improve the models for future use. The other applies primarily to environmental regulations that require an EIS, but also to a lesser extent to the regulatory precedents set by the acceptance of an EIS for a particular federal action. Once a regulation or a regulatory precedent has been established, it tends to become "cast in concrete," and to resist change, even if later evidence shows it to be inadequate—either not restrictive enough, or too restrictive and therefore wasteful of precious resources.

One can formulate these two problems as a lack of dialogue. The predictions of the models used, the regulations promulgated, and the actions actually taken constitute the first part of the dialogue, that of humans talking to nature. Nature then responds by revealing the initial consequent impacts of our actions. If we do not measure and analyze these impacts, and take the analysis and data into account in future applications of our models, we are terminating the dialogue. We can express this either as not listening to what nature is telling us, or, more prosaically, as not acquiring the data we need to improve the models and reduce the uncertainty before we use them again. Klink's metaphor of a dialogue between humans and nature or humans and God can be regarded as a potentially powerful tool for motivating an effort to enter into a dialogue or, equivalently, to collect and use the data needed to improve the environmental models that are the basis of our decisions to take action.

Even when the uncertainties in global environmental models are too great to enable useful predictions, the insight these models provide gives important guidance for making decisions. For example, on the basis of models of very simple nonlinear systems, we have reason to suspect that the biosphere may be a nonlinear system in a particular self-sustaining state—in technical language, a state corresponding to a particular "strange attractor." We may reasonably infer from these models that the earth might tolerate impacts only up to a certain point and then suddenly shift to a different state—a different strange attractor—and create a new environment in which life as we know it today might not be able to survive. We need to carry out a dialogue with nature, using models and extrapolating from measurements of impacts that are too small to cause a drastic transformation of the state of the biosphere, in order to find out what nature has to say about this. It is, meanwhile, necessary to proceed on faith that a radical shift will not happen before we know enough

to prevent it from happening. But we will not find out unless we use the models we construct in order to engage in a dialogue with nature (or God). It could be regarded as a theological dialogue, but the concepts involved are scientific, and quite different from those of any traditional theology.

Whether one approaches the problems of the impact of human activities on the environment from the perspective of a dialogue or the more prosaic and limited perspective of improving the models used to guide environmental decision making, progress toward a solution depends on the willingness of people to enter into a dialogue, or, equivalently, to make the effort to acquire the data needed to improve the models (and listen to nature). The overwhelming complexity of the problems and the prospect of a lower standard of living and loss of material amenities lead many to refuse to participate. Some take a fatalistic attitude. This may take the form of a passive acceptance of "God's will" in the belief that God will take care of global problems as long as we are faithful to the Scriptures and attend to local problems that are our immediate responsibility. Continuing to strive to live according to ideals that evolved in the environment of the past is a part of this response. An escape hatch used by some Christians is that the suffering in this life does not matter; we should concentrate on preparing ourselves for a life hereafter. In other religions the escape hatch may be to cultivate a detached state of mind that immunizes a person against suffering. Many less religious individuals adopt the attitude "Eat, drink, and be merry, for tomorrow we die." Many avoid a dialogue by claiming that there is no serious problem, so that no dialogue is needed.

What can we do to bring these people into the dialogue? If our concerns turn out to be justified, the pain from the consequences of the environmental impacts will eventually cause them to join in. But it may then be too late to prevent suffering on an unprecedented scale.

This brings me to the second issue: the roles of theology and science in addressing the problem of human impacts on the environment. Because we are dealing with global impacts that involve people from many different religions, and dimensions of religion other than theology may be involved, I will discuss this issue in the context of the roles of religion and science rather than theology and science.

We first need a clear idea of what religion and science are and their respective roles in human affairs. This is still an open question on which a consensus has not emerged. Let me briefly summarize a perspective that I have found to be especially helpful.

We may start from one of the most fundamental questions a human can ask: How should I live—and why? Every human being must address this question—at least the first part and at least implicitly—in order to live. I suggest that this question serves to define what religion is. By introducing the presupposition (which could also be regarded as a conjecture) that whatever religion is, whatever attributes it may have, or whatever functions it may serve, these all emerge from attempts to answer this fundamental question, one may define religion by a question rather than by a statement. I suggest that this definition is consistent with definitions in terms of symbol systems, myths, rituals, personal experience, concepts, doctrines, institutions, etc., that have been given by scholars of religion (Bishop and Darton 1987; Smart 1969; Geertz 1968).

We find that we cannot address this first question without at least a provisional answer to a second fundamental question: How does the world work? I suggest that this question can be used to define what science is, and that such a definition is consistent with the definition given earlier, which is widely accepted within the scientific community.

In the following discussion, I will refer to the foregoing two questions as the first and the second questions, respectively.

In order to gain a more precise understanding of the religion–science relationship, it is helpful to formulate a framework for responding to the first question. I suggest that our response can be, and often is, expressed as a vision of a future state of existence that we seek to realize (and justify). Regardless of the actual form in which the religious imperatives that guide our lives are given—as commandments or principles of conduct that must be obeyed, as rituals that must be followed, in the form of parables or metaphors that must be interpreted, or explicitly in the form of a vision, such as the Kingdom of God (a world in which love, justice, and stewardship prevail)—our response to the first question is motivated and shaped by our vision of a future state of existence to which we aspire, either for ourselves or for our progeny. Even if there is no consciously or explicitly formulated vision, visions are still the implicit shaping force behind the commandments, parables, myths, rituals, or doctrines that guide our actions. These visions are what give meaning and purpose to our lives. We may infer from the foregoing that the primary function of religion is to provide us with a vision.

If we had no vision, or if there were no connection between the consequences of our actions and the visions that guide us, then it would not matter what course of action we chose; i.e., it would not

matter how we lived. The first question would then be irrelevant. Hence, we may conclude that, as a part of our response to the first question, we must be able to predict the consequences of our actions with at least some probability that the predictions will be realized. Thus, we are forced to respond to the second question.

It is a function of science to provide us with the answers to the second question, which we may describe metaphorically as "maps of reality" by means of which we predict the consequences of our actions. As with all maps, we need measurements and standards to determine how reliable they are. But even if the measurements for the territory into which our journey will take us are sparse, so that we must fill in blank areas by inference and, consequently, the uncertainty in the predictions of the consequences of our actions (i.e., where the path we choose will take us) is high, we cannot do without a map of reality.

It is on the basis of arguments such as the foregoing that I believe we must continue to use ecological models as a basis for environmental decision making even though they do not meet the rigorous scientific standards of predictive power to which we hold models used solely for building a solid scientific base for explaining natural phenomena. I can support Klink's "dialogue" proposal as a way of continually reviewing ecological models as we use them. It is a way of describing the testing process that links the theory-construction and theory-testing processes of science with the Christian religious heritage that has molded the visions of Christians. But I believe that the dialogue metaphor should be applied in a way that gives science a major role in the dialogue and the decision-making process, a greater role than Klink proposes.

There are so many harmful things that can be done to the environment and so few right ways to treat the environment in order to realize a sustainable world that it does not appear to me to be reasonable to forego use of ecological models because they "can never make deterministic predictions in the way that physics or biology or even occasionally psychology can" (Klink 1992, 206). If ecological models have no predictive value, what basis is there for expecting that a human/nature or human/God dialogue that does not make use of them will provide better predictions? If we conclude that *no* useful predictions are possible, what basis do we have for expecting that a Christian vision can be realized? Is Klink proposing that we return to a blind trust in nature/God and hope that the responses of nature or God to our errors will somehow be sufficient to guide us to make the right choices—before we destroy the environment? I do not believe that this is Klink's intent. I suspect that he would agree that

ecological models should be used to the utmost, recognizing their limitations and correcting and improving them as we proceed. But his key arguments and statements appear to me to imply otherwise.

My summary assessment of Klink's proposal is that his idea of a dialogue is a valuable one, but possibly not in the context he intended. His points regarding the limited predictive power of ecological models are well taken, but I would interpret them as arguments for improving the predictive power of the models rather than for discontinuing their use in technical decisions, even though we should be aware that their predictive power will always be limited and it will be necessary to take frequent compass readings and make frequent course changes as we proceed with our journey into an unknowable future. I suggest that the dialogue with nature/God that he proposes should have two parts: one to gain the data and insight we need to improve the models we use to predict the consequences of our actions in the process of making decisions to accomplish our objectives; the other to continually review and revise our objectives (i.e., the visions by which we set our course). The first part is a scientific dialogue; the second part is a religious dialogue.

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