

I am sure we will be calling on you as these hearings continue for additional advice. I appreciate the fact that you were here and it has been an exciting morning and if we did have a lot of young people listening to you I am sure you would already have gotten some recruits.

Dr. GATES. Thank you very much. I appreciate being asked.

(The questions and answers requested are as follows:)

*Q. 1. With reference to the erosion of land, which is an irreversible process, do you believe that the evolution of a theoretical ecology could slow this process significantly?*

A. 1. The development of a strong theoretical ecology would aid significantly with most applied ecology problems, such as erosion. Actually the problems of erosion can be dealt with in an immediate practical manner by direct application of classical ecological knowledge, although a thorough theoretical analysis will strengthen the decision making and improve our judgment concerning land management.

*Q. 2. We are told the world's greatest reservoir of fresh water, the Great Lakes system, is already seriously polluted in part and may become so entirely. Testimony suggests that both Lake Erie and Lake Michigan are in a serious condition and that, in the case of Lake Michigan at least, it may be impossible to repair the damage. How might the application of ecological understanding help alleviate this problem?*

A. 2. There is absolutely no doubt that ecological understanding has been and will need to continue to be applied to the disasters threatening the Great Lakes. The cost to the inhabitants of the shores of the Great Lakes has been enormous. The correction of the lamprey problem some years ago in the Great Lakes was a direct consequence of careful ecological studies applied to the fish of the lakes. The Great Lakes are a clear example of the need for ecological management. Man has blundered into near disaster with regard to the pollution of the lakes. In order to correct this problem it is necessary to consult the aquatic ecologists for careful advice with regard to the chemistry of the lakes and the delicate balance of organisms. The Great Lakes Research Institute at the University of Michigan is the best source for advice on this matter. Here is an excellent example of the importance in having an institute established to deal with a major ecological situation—the Great Lakes. If this institute had not been established 10 or more years ago we would have been in a much worse position today for an advisory group concerning the pollution of the Great Lakes.

*Q. 3. You have testified that the nation seriously needs a new science discipline of theoretical ecology. Could you describe the composition of such a discipline in more detail? What sub-disciplines might it include?*

A. 3. Theoretical ecology is that branch of ecology which primarily uses mathematical models to describe ecosystems and to describe processes and events within ecosystems. There exists today a very large body of observational data concerning ecosystems and great amounts of information about the physiology, anatomy, genetics, etc. of individual organisms. The time is now at hand to put much of this information into a framework which will tie all the bits and pieces together into a coherent system. This can be done only with the use of large computers. By means of mathematical analysis and the computerized management of large amounts of information it is possible for the first time to give theoretical ecology a strong analytical foundation.

The establishment of theoretical ecology does not imply that all biological phenomena or events can be reduced to the "cold" analytical treatment of mathematics. It simply says that mathematics and physical theory offer a strong basis for objectively analyzing complex ecosystems. I can guarantee, that when a substantial number of first rate theoretical ecologists begin to work with the study of ecosystems that there will be great advances in our level of understanding of some of these ecosystems. It is absolutely essential that this be brought about.

From theoretical models of ecosystems, or of components of ecosystems, many direct predictions of the end results of events set in motion within an ecosystem are possible. If the vegetation of a hillside is modified from grass to trees what will be the change in water usage and runoff? Modify the climate of a crop, a grassland or a forest and how will this change its productivity? Introduce a new animal into a community and how and to what degree will the entire