

food chain and animal populations change because of this introduction? Answers to many questions such as these will become available in direct proportion to the degree to which ecology is given a strong theoretical, analytical base.

People trained in theoretical ecology would receive strong mathematical training, considerable background in physics and chemistry, and in computer science. In addition they would receive thorough training in ecology and considerable amounts of biological science with less of some courses from the more traditional biology curriculum. Rather than spending much time in the field the theoretical ecologist would spend his time working out models and fitting observational data (much of it already in the literature) into a coherent framework according to models which he formulates. Precisely the same relationship exists between the theoretical physicist and the experimental physicists, the theoretical and laboratory chemists, and the theoretical and observational astronomers as I suggest is needed for the ecologists. Weather forecasting is now being placed on a substantial numerical basis and much of atmospheric science is being given a strong framework in the theoretical physics of fluid motion, atomic collisions, thermodynamics, etc.

Q. 4. With regard to the systematic collections which you have indicated are too few and too poorly supported, what magnitude of assistance—either Federal or private—is needed in your judgment to rectify this problem?

A. 4. The situation relative to the major systematic collections of this nation is as follows: I did not imply there were too few of these systematics collections; however, I did say that they were very poorly supported. Most of these large collections (Smithsonian, New York Botanical Garden, Missouri Botanical Garden, Field Museum, The Gray Herbarium at Harvard, Philadelphia Academy of Sciences, Field Museum, Bishop Museum, and many others) were started and supported entirely by private funds. Today every single major collection is operating on a marginal or submarginal budget and nearly every collection is poorly or desperately housed. Some collections have been lost to fire because of inadequate housing. For many of these institutions it is a desperate task to hold body and soul together until some sort of direct aid becomes available. Each of these large collections is a critical national asset for reasons I spelled out in my testimony.

I give here some very off-the-cuff estimates of the magnitude of financial aid these institutions require in the immediate future.

1. For new buildings—\$50 million.
2. For annual operating costs to defray only a fraction of the maintenance of the collections—\$3 million per year.
3. For additional expenditures to collect and record the unknown flora and fauna of the world before it is too late—\$500,000 to \$750,000 a year.

These great, unique collections are every bit as tangible and as much in demand as any telescope, oceanographic ship, radio telescope, or nuclear accelerator. Mr. Chairman, please compare these costs with the cost of building and operating a single large nuclear accelerator. The costs listed above are far all of the great systematic collections in America.

Q. 5. If a National Ecological Institute were to be established as another of NSF's national centers, what initial cost do you believe would be necessary to get the institute functioning? In your judgment what locale or locales might best be the site of such an institute?

A. 5. The cost for establishing a National Ecological Institute would be comparable to the cost involved in establishing the National Center for Atmospheric Research. A National Ecology Institute probably would cost substantially less than NCAR in absolute amount. If NCAR cost \$40 M then NEI might cost \$25 M. The reason for this is that the NEI would not involve some of the enormously expensive physical facilities that NCAR required—such as a National Balloon Launching Facility and a Flight Aircraft Facility for atmospheric research. Clearly I cannot give you a good estimate of cost—except to compare with the NCAR experience.

The cost of a National Ecological Institute. Initial cost outlay for buildings, equipment, and staff—\$20 million.

Annual Operating Costs—\$2.5 million.

First few years probably considerably less than this because of the necessity to build staff. The costs for establishing the National Center for Atmospheric Research might be used as a guide here.