

areas, in areas close to highways, in the surface waters of the oceans, apparently even in the bodies of men. Some insecticides, such as DDT, have been found (usually in very small amounts) in fishes far at sea, in penguins and seals in the Antarctic, in snow and rain, and in the atmosphere. Some of these compounds, in relatively small amounts, are toxic to some forms of life—for example, to shrimp at less than 1 part in a billion parts of water. (Considering that shrimp, and crabs and lobsters too, are biologically much closer to the insects than to the vertebrates, it is not surprising that they are especially sensitive to chemicals designed to kill insects.) For the most part, we have not seen obvious ill effects from the quantities present in our environment. But our ability to detect change is not good, our experience has not been long, and effects there may well be.

Living systems pass on these materials from one level of life to another, often concentrating them at each successive stage. Oysters for example are able to extract DDT from water containing less than 1 part in 10,000,000,000 and concentrate it to 0.8 part in 1,000,000 in their bodies in 15 days. At slightly higher environmental levels, the concentration factor may reach 70,000 times. Even though apparently not harmed themselves, they can pass on these substances to other organisms that feed on them, which in turn accumulate still more.

The best documented case of the effects of such accumulation was at Clear Lake, California, where lake waters containing 1 part of DDD in 50,000,000 parts of water produced plankton containing 5 parts per million. Fish feeding on the plankton contained fat with hundreds of parts per million; grebes that fed on the fish died. Similar concentration phenomena have been observed in terrestrial environments.

Waste generation will continue and despite greater attention to recycling and reduction in waste production, there will continue to be a need to dispose of wastes.

To dispose of wastes in the "best" manner requires that we learn, and use, the capacity of the environment to assimilate wastes. Thus, we need to learn enough about the physical structure and processes within our environment—air, land and water—to make suitable judgments as to rates and methods of movement, capability to retain wastes segregated from the rest of the environment, effects of wastes on physical and chemical characteristics.

We also need to learn enough about the biosphere to both utilize its capabilities and protect it from damage.

Today our knowledge is not complete for any single ecosystem, though we know much more about some than about others.

There is need for a great deal of hard, grubby work—an extension of the natural history of the last century, using present-day techniques, to provide us with knowledge of just what species are where—and beyond this a refinement that quantifies their relationship; that elucidates the dynamics of the population. Such knowledge, for at least representative ecosystems, would provide us with ecological baselines against which change can be measured.

Most studies to date have dealt with effects of single pollutants, yet pollutants occur in innumerable combinations and concentrations in nature, some of which react synergistically. Most studies have dealt with short periods of time, yet some of these are nearly constant low-level presences; most studies have dealt with healthy organisms, yet wild populations are made up of young and old, healthy and ill, and almost always they are under some stress or another which may make them more susceptible to pollutants.

Waste disposal, and control of other pollutants too, must eventually be based on a knowledge of what happens with what concentration of what pollution where, a judgment of what we can accept in environmental damage, and information on the costs of control. Eventually "on-line" computers programmed with suitable models and fed with appropriate environmental data, perhaps gathered by remote sensing techniques, may well direct our actions. In the meantime, construction of models will help us select proper priorities for our research efforts.

A number of Bureaus in the Department of the Interior are conducting research and acquiring data, and developing methods, including simulation and modeling, that will provide necessary information for sound environmental management. The appended statement of the Geological Survey illustrates such activities related to the physical environment.

Both Bureaus of the Fish and Wildlife Service, as well as the Federal Water Pollution Control Administration have research underway on the biological effects of pollutants. Some of the problems they face are severe: