

damage. Most materials are ultimately assimilated by the environment, that is, they are converted chemically or stored so that they cause no further harm. If the assimilation of these materials took place instantaneously, significant ambient levels would never be observed. One of the defining characteristics of persistent pollutants is that their assimilation proceeds relatively slowly. In the next section we discuss the important dynamic determinants of this assimilative process.

6.3 BASIC CONCEPTS

Fundamental Postulates of the Sector

The concept of pollution is intimately related to entropy and energy flows. One may usefully define a pollutant as a displaced natural resource whose entropy is so great that it can no longer be reclaimed economically. The entropy of a closed system will inevitably increase. We believe that the earth may be considered to be a closed system insofar as pollution is concerned. Thus we assumed in the persistent pollution sector that:

1. Materials will inevitably be released to the environment through man's industrial and agricultural activities; and the generation of pollution will tend to increase with growth in the physical scale of man's activities.
2. The global biosphere has only a finite capacity to degrade, that is, to assimilate, persistent materials.

Other considerations led us to postulate that:

3. There is a delay between the time a persistent material is first released into the environment and the time its full effects are felt in the biosphere.
4. The rate of assimilation of persistent materials is proportional to the quantity of such materials present in the environment.

Definition of Persistent Pollution

The term "pollution" is commonly used to denote any material or energy stream that either disrupts the natural processes of the ecosystem or impairs the aesthetic qualities of the environment. Thus DDT, particulate matter in the air, discarded aluminum beer cans, noise, and thermal emissions have all been identified as pollutants. Indices of the level of pollution are correspondingly diverse. Parts per million, particles per cubic meter, cans per acre, decibels, and British thermal units, respectively, might be used to measure these pollutants. In the world model our objectives required a much more restrictive definition of pollution and a more general measure of pollution quantities.

In the persistent pollution sector we focused on materials that may have a significant negative impact on the global biosphere, that is, on animal and plant life in all regions of the world, within the next hundred years. Thus we included only materials that cause damage to some form of life, are released through many different forms of industrial and agricultural activity, and are sufficiently long-lived that they may be transported through the global environment by the planet's air or water

streams. We use the phrase "persistent pollutants" to denote this general class of materials. Our focus is similar to that adopted by the 1970 Study of Critical Environmental Problems (SCEP 1970), but our attention was directed to the implications of these materials for human health and soil fertility.

Because of the long time perspective of the model, we did not focus on a set of specific materials. Some of the current global persistent pollutants will be eliminated over the next hundred years. For example, there is already strong pressure to replace DDT with other, less stable chemical compounds, and new materials will also be added to the list of global hazards. Man creates many new materials every year and often discovers that substances already in wide use have harmful effects. Thus we formulated the persistent pollution sector to represent the generation, transmission, concentration, and assimilation of materials with common dynamic attributes rather than with specific chemical identities. Six families of materials that exemplify the general class of materials represented in the pollution sector are radioactive wastes; heavy metals; suspended particulates and aerosols, including asbestos; fertilizers; pesticides; and other persistent synthetic chemicals.

Our definition of pollution permits only an imprecise specification of the units by which to measure persistent pollution levels and flows. The absolute level of persistent pollution in the model and the flows of pollutants are measured in units derived from nonrenewable resource units and agricultural input units and are weighted according to their toxicity. The index used to relate the level of pollution to life expectancy, soil fertility, and the pollution assimilation half-life is not an absolute measure. It is, instead, expressed in relative terms, or "index units." One index unit is any quantity and mix of persistent materials equivalent in biological impact to the total of all persistent materials present in the environment in 1970. Thus the index of pollution in any year equals the level of persistent pollution in that year, a variable, divided by the level of persistent pollution in 1970, a constant. Obviously, any variable related to persistent pollution will also be related to the persistent pollution index.

Pollution levels of many different magnitudes and compositions can have the same biological impact and thus be equal when measured in index units. Because of our definition, changing the chemical mix of one index unit of pollution may alter the dynamic behavior of the pollution's transmission and degradation, but its eventual biological impact would, by definition, remain the same. Since an index unit of pollution can have different transmission delays and different assimilation rates at different times, conclusions derived from World3 had to be valid for a wide range of values for these two parameters.

Assimilative Capacity of the Global Environment

The level of pollution in World3 represents the accumulation of all persistent materials in areas where they can cause damage to human health, food-producing species, or the soil. Thus materials in the air, in water, in topsoil, and in living tissues are all represented by this level. Once they appear in the environment, materials remain in the persistent pollution level until they are assimilated, that is, altered