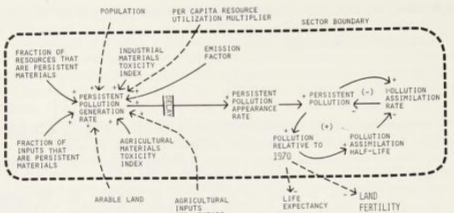

Figure 6-10 Causal-loop structure of the pollution sector

used, and the fraction of resources used in industry and agriculture that is emitted into the environment.

The effects of persistent pollution on the biosphere are not immediately influenced by the persistent pollution generation rate. As explained earlier, the physical and biological properties of material transportation and concentration introduce a delay between the time a pollutant is released and the time it is located and concentrated in ways that decrease human life or soil fertility. The transmission delay incorporates in World3 the lagged effects of both concentration and transmission.

The total level of persistent materials in the environment is the sum of the pollution level and the contents of the transmission delay. The pollution level is simply the integration of all past differences between the appearance and the assimilation of persistent materials. The behavior of pollution assimilation is determined by the two feedback loops shown in Figure 6-10. Consider first the negative feedback loop. If pollution rises and the assimilation half-life remains constant, the rate of pollution assimilation will also rise; as the rate of pollution assimilation rises, pollution will tend to decrease. This negative feedback loop constitutes a control mechanism that acts to decrease the level of persistent pollution to zero. It is dynamically analogous to the population–death rate loop in the population sector and to the depreciation relationships influencing industrial and service capital.

The second feedback loop has no analogue elsewhere in the model. Since this loop is positive, it tends to amplify any rise in pollution. Rising pollution lengthens the assimilation half-life by interfering with natural degradative processes; the increase in the half-life depresses the pollution assimilation rate and reinforces the rise in pollution. Since the negative loop will always dominate the positive loop, the endogenous behavior of the pollution sector is exponential decay in the level of pollution. The positive loop simply determines the time constant of that decay. The relationships enclosed within the dashed line of Figure 6-10 are defined in section 6.5. The effects of pollution on life expectancy and land fertility are described in

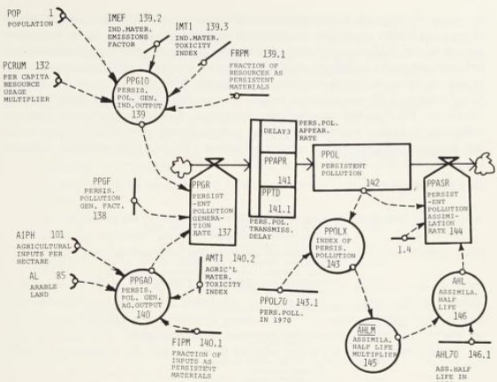

Figure 6-11 DYNAMO flow diagram of the pollution sector

Chapters 2 and 4, respectively. The full DYNAMO flow diagram of the relationships in the pollution sector is shown in Figure 6-11.

6.5 DESCRIPTION OF EQUATIONS

In this section the DYNAMO equations for the persistent pollution sector are explained in detail. In the discussion we shall employ data from case studies presented in the literature, a theoretical model of pollution assimilation, and two of our pollution substudies (Randers 1973, Anderson et al. 1973). These substudies illustrate in more detail the dynamic behavior of two materials, DDT and mercury, representing general classes of persistent pollutants, pesticides, and heavy metals.

Persistent Pollution Generation Rate PPGR Although persistent pollutants may sometimes be chemically similar, there is a fundamental dynamic difference between those resulting from industrial activity and those released in the production of food. The first are inadvertent wastes that are released into the environment by accident or because no one is willing to pay the cost of abatement. Industrial emissions are often