That completes our description of the persistent pollution sector equations. The next section presents analyses of the sector's behavior under a variety of assumptions.

## 6.6   SIMULATION RUNS

The persistent pollution sector of the world model serves to convert information on resource use in industry and agriculture into a long-term projection of persistent pollution levels in the global ecosystem. In this section we examine the general behavioral characteristics of this conversion.

The following series of simulation runs illustrates the general dynamic behavior modes of the persistent pollution sector when it is driven by exogenous inputs affecting the generation of persistent pollution. These inputs are time-dependent functions of arable land AL, agricultural inputs per hectare AIPH, population POP, and the per capita resource usage multiplier PCRUM. First, we examine the behavior of the sector in response to pulse and step inputs to pollution generation. Next we show the behavior of the persistent pollution sector when driven by the historical values of the four inputs. The following three parts explore the behavior of the sector when past growth trends are assumed to continue through the year 2100. The last part examines the behavior of the sector if pollution generation stops growing and becomes constant at various points in the future. A complete DYNAMO program listing of the persistent pollution sector with exogenous inputs and a list of parameter changes for each of the following runs are included in Appendix A to this chapter.

### Behavior in Response to Pulse and Step Inputs

Runs 6-1 and 6-2 (Figures 6-26 and 6-27) illustrate the behavior of the persistent pollution sector in response to pulse and step inputs in pollution generation. They indicate the roles played by the persistent pollution transmission delay PPTD and the persistent pollution assimilation rate PPASR in moderating the response of the persistent pollution level PPOL to changes in pollution generation PPGR. As will be shown later in this section, the transmission delay and the assimilation rate are of particular concern to policy makers, for both factors help determine the effectiveness of pollution control policies that act to reduce the generation of pollution.

Run 6-1 (Figure 6-26) shows the behavior of the sector in response to a hypothetical pulse input in pollution generation 20 years after the initiation of the run. This pulse represents the effect on the pollution sector of a pulse increase in any of the determinants of the persistent pollution generation rate PPGR (for example, in the agricultural inputs per hectare AIPH or in the toxicity of industrial materials IMTI). Before 1920 no pollution is generated in Run 6-1; initially, both the level of persistent pollution PPOL and the index of persistent pollution PPOLX are zero. In 1920 the persistent pollution generation rate PPGR rises to 10 billion units per year, remains there for one year, and then promptly falls to zero. Because of the assumed delay between the time a pollutant is first generated and the time it has had its full impact on the biosphere, the persistent pollution appearance rate PPAPR does not immediately respond to the sudden rise in PPGR. Instead, PPAPR rises gradually to
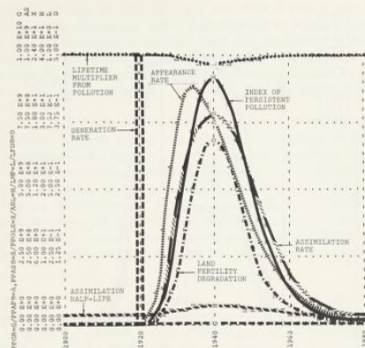
**Figure 6-26**   Run 6-1: behavior of the pollution sector in response to a pulse input in persistent pollution generation in 1920

a peak of 0.9 billion units per year 15 years after the occurrence of the pulse in pollution generation. Notice that the scales for PPGR and PPAPR in Run 6-1 differ by a factor of 10. If the scales were equal, the area under the PPGR and PPAPR curves would be equal, since no pollution is lost from the transmission delay.

The pollution assimilation process also introduces a delay whose magnitude is governed by the assimilation half-life. The half-life AHL varies between 1.5 years and 3 years in Run 6-1. The time of maximum persistent pollution assimilation occurs in 1940, 5 years after the peak in PPAPR. Because of the lag between appearance and assimilation, pollution tends to accumulate, and PPOLX rises. These two runs are synthetic and designed to display the behavioral properties of the pollution sector, not to forecast real-world behavior. Thus PPOLX has a slightly different meaning in Runs 6-1 and 6-2 than it does in the later runs of Chapter 6 and in simulations of the full World3 model. Here it is an index of the level of pollution relative to the PPOL value at 1970 in the standard run of World3. We did not adjust the value of PPOL70 in Runs 6-1 and 6-2 to equal the values of PPOL in 1970 for those two runs.

In 1940 the appearance rate drops below the assimilation rate, and both persistent pollution PPOL and the index of persistent pollution PPOLX begin to fall. PPOLX reaches its peak value 20 years after the occurrence of the PPGR pulse. It