



Figure 6-27 Run 6-2: behavior of the pollution sector in response to a step increase and decrease in persistent pollution generation

does not return effectively to zero until approximately 50 years after the last pollution was generated.

Run 6-2 (Figure 6-27) shows the responses of the persistent pollution sector to a step increase and subsequent step decrease in the generation of persistent pollution PPGR. Twenty years after the beginning of the simulation, PPGR suddenly increases to 1 billion units per year and remains constant at that high value for the next 80 years before dropping to zero in the year 2000. In Run 6-2 as in Run 6-1, the persistent pollution appearance rate PPAPR lags behind PPGR. Fifty-five years are required for PPAPR to rise enough to equal PPGR.

Seventy-five years after the step increase in pollution generation, the assimilation rate PPASR finally equals PPAPR, and both PPOL and PPOLX cease to grow. At this point PPOL equals approximately 5 billion units and PPOLX equals 38. The assimilative capacity of the environment is slightly impaired at this level of pollution, and the assimilation half-life AHL equals 4 years. If the generation rate PPGR were maintained at 1 billion units per year, no further change would occur in the system after the year 1995. The system is in dynamic equilibrium at that point. All flows are equal and the pollution level is constant.

However, in the year 2000 the simulated rate of pollution generation PPGR is assumed to drop suddenly back to zero. Again, the level of persistent pollution is

slow to respond; only after 45 years do PPOL and PPOLX drop to zero. Note that the response pattern is asymmetric, with a faster response to pollution decrease than to pollution increase because of the variable delay time represented by the assimilation half-life AHL. This asymmetry results in part from our assumption that the assimilative capacity of the environment is not permanently impaired by high levels of pollution. Once pollution declines sufficiently, the assimilation returns to its former level.

Runs 6-1 and 6-2 are the results of entirely hypothetical patterns of pollution generation, but they illustrate several important dynamic properties of the pollution sector. Most important is the fact that a decline in pollution generation is not accompanied by a simultaneous decline in the level of pollution. The level of pollution may continue to rise for many years after pollution generation has declined. Second, because of the lag between the rate of appearance and the rate of assimilation, the pollution assimilation rate PPASR is always less than the pollution appearance rate PPAPR when the latter is rising. Thus a growing pollution appearance rate is always accompanied by increasing levels of pollution and hence increases in pollution damage.

Historical Run

Run 6-3 (Figure 6-29) shows the behavior of the persistent pollution sector when the sector is driven by historical values of arable land AL, agricultural inputs per hectare AIPH, population POP, and the per capita resource usage multiplier PCRUM. Figure 6-28 portrays the values of the exogenous inputs used to derive Run 6-3 for the 70-year period from 1900 to 1970. Over that interval all four inputs exhibit approximately exponential growth. Arable land AL grows at an average of 0.6 percent per year, from an initial value of 0.9 billion hectares in 1900 to a value of 1.4 billion hectares in 1970. Agricultural inputs per hectare AIPH increase from 6.6 to 45 dollars per hectare from 1900 to 1970, an average growth rate of 2.7 percent per year. Over that period population POP increases from 1.6 to 3.6 billion persons, an average growth rate of 1.2 percent. The per capita resource usage multiplier PCRUM rises from 0.17 in 1900 to its normalized value of 1.0 resource units per person-year in 1970, a growth rate of 2.5 percent per year. Note that since the rate of pollution generation is defined as the product of several growing factors, pollution generation PPGR always grows faster than any of its causes. The combined growth of these four inputs causes the persistent pollution generation rate PPGR to grow at an average rate of 3.6 percent per year, rising from 0.011 billion to 0.15 billion persistent pollution units per year over the 70-year period.

Run 6-3 also shows the behavior of the persistent pollution sector in response to the growth in the rate of persistent pollution generation PPGR from 1900 to 1970. Because of the persistent pollution transmission delay PPTD, the rising persistent pollution appearance rate PPAPR lags behind the persistent pollution generation rate PPGR by 20 years. The net growth in the level of persistent pollution (here represented by the index of persistent pollution relative to 1970 levels PPOLX) is determined by the difference between the persistent pollution appearance rate PPAPR