land fertility LFERT constitutes a positive feedback loop in the normal operating range of World3 (that is, for food per capita FPC less than about 600 vegetable-equivalent kilograms per person-year). In this range, better maintenance of land results in higher land fertility, more food, higher food per capita, and finally even larger allocations to land maintenance. When food per capita declines, shortsighted attempts to increase current food production by neglecting long-term conservation leads to the destruction of land fertility and even less food in the longer run. The land maintenance loop (loop 6 in the agriculture sector, section 4.5) operates in Run 7-13 (and several of the following runs) to make the decline sharper and the recovery more spectacular during a crisis caused by shortages of a renewable resource. Even if one were to assume a continuation of land maintenance activities throughout a food crisis, as was explored in supplementary runs, the behavior mode described here stays the same but is less severe.

Resource and Air Pollution Technologies In the previous run, additional advances in resource technologies eliminated resources as a constraint to growth, but continued industrial expansion causes pollution to rise to intolerable levels. Run 7-14 (Figure 7-19) shows the behavior of the model if the technological policies of Run 7-13 are augmented by an increase in air pollution control technologies in 1975. These technologies decrease the adverse effects of air pollution on land yield, modeled as the land yield multiplier from air pollution LYMAP. Run 7-14 shows that this policy has practically no effect on the model's behavior. Although air pollution is the most visible form of pollution created by industrial output, the implementation of air pollution control technologies has solved only a small part of the pollution problem, the rise in the index of persistent pollutants PPOLX being the primary cause of the decline in food per capita FPC.

Persistent pollutants decrease food per capita FPC through the land fertility degradation process. As the index of persistent pollutants PPOLX increases above its normalized 1970 value of 1.0 (Run 7-14), the land fertility degradation rate increases. As the rate of fertility degradation rises above the fertility regeneration rate, land fertility is decreased. In the model, the exponential increase in persistent pollution from 1900 to 2060 causes land fertility to decrease exponentially until the year 2060. This decline in land fertility does not lower the amount of available food until 2025, for it is offset by the effects of increased agricultural inputs (fertilizers, pesticides) throughout this period. After 2025, however, increased agricultural inputs are no longer sufficient to offset the declining land fertility, and food per capita FPC begins to decline.

The combined effects of the decline in food per capita FPC and a decrease in life expectancy due to rising persistent pollution cause the population to decline quite rapidly after 2050. As in Run 7-13, industrial output begins to decline after the year 2045 because of the increased need to invest industrial output in the agriculture sector (thus decreasing the reinvestment of industrial output in industrial capital stock). Although industrial output declines after 2050, industrial output per capita IOPC begins to increase after 2065 because of the rapid decline in population POP.

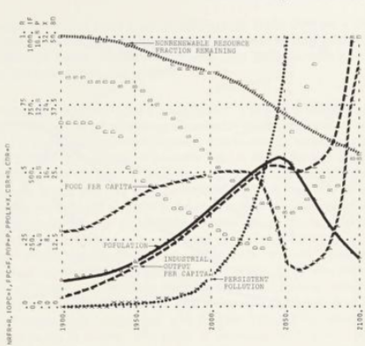

Figure 7-19 Run 7-14: resource and air pollution control technologies

As resource technologies eliminate the resource constraint to growth, industrial output continues to grow until it generates intolerable levels of pollution. To decrease the constraining effects of pollution on the system, Run 7-14 assumes that new air pollution control technologies are implemented in 1975. These additional technologies substantially reduce the adverse effects of air pollution on land yield. However, land yield and food per capita still decline, for the high index of persistent pollution PPOLX decreases the land fertility. The improvement in air pollution control technologies has solved only a small part of the pollution problem, for the rise in persistent pollutants ends growth in the other sectors of the model.

Resource and Pollution Technologies Run 7-15 (Figure 7-20) shows the behavior of the model if the resource and air pollution control technologies of Run 7-14 are supplemented by a technological policy that reduces the level of persistent pollution generated by each unit of industrial or agricultural output by a factor of 10 in 1975. As in all the technological policies tested so far, the real costs and delays of such a policy would undoubtedly be large, but in the model it is assumed that this policy is implemented at no additional cost and with no development and implementation delays.

The increase in pollution generation control technologies implemented in Run 7-15 reduces the index of persistent pollution PPOLX to a level that no longer interferes with agricultural production or growth in the population during the model run. As a result, both population POP and industrial output per capita IOPC continue to grow for 30 more years than in Run 7-14. Population POP reaches a level of 11 billion people in the year 2075 and subsequently declines. Industrial output per capita