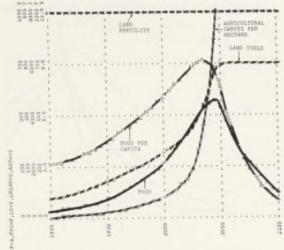
tent pollutants. Since land fertility has not been significantly impaired between 1900 and 1970, such a policy was modeled here by setting the land fertility degradation rate LFDR to zero throughout the simulation, without significantly altering the fit to historical behavior. This run shows that the overshoot and decline mode remains, even though land fertility maintains its maximum values throughout the run. The decline in total food production F occurs at about the same time (2040) as in the standard run. Also as in the standard run, arable land AL declines because of land erosion LER and land removal for urban and industrial use LRUI. Land yield LY declines due to the direct effects of air pollution.

To eliminate the decline in land yield LY exhibited in Run 4-12, the next simulation, Run 4-13 (Figure 4-85), assumes the initiation of policies in 1975 that completely eliminate both the adverse effects of air pollution on land yield LY and the impairment of land fertility LFERT by persistent pollution. Land yield LY is determined only by the amount of agricultural inputs per hectare AIPH, which are driven upward by the exponentially growing industrial output. When agricultural inputs per hectare AIPH exceed 1,000 dollars per hectare after the year 2050, land yield LY stabilizes at the maximum possible value of 10 times the inherent land fertility, or 6,000 vegetable-equivalent kilograms per hectare-year. The higher land yield LY causes food production F to peak at a higher value (about 20 percent higher) than it reached in the standard run. Higher land yield LY also leads to more land erosion LER, however, and this increased land erosion causes arable land AL to decline more sharply than it did in the standard run. The decline in arable land AL causes a decline in food production F, which occurs around the year 2045—only five years later than in the standard run.

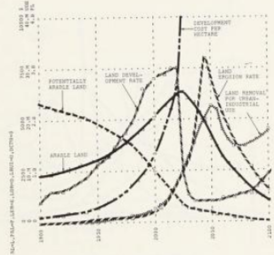
Run 4-14 (Figure 4-86) simulates the initiation of policies in 1975 to combat erosion, in addition to the previous policies that eliminated the effects of persistent pollutants and air pollution. In this simulation, land removal for urban and industrial use LRUI still causes arable land AL to decline around the year 2030. High land yield LY delays the decline of food production F till around 2055, 15 years later than in the standard run.

If the land required for urban and industrial use UILR is reduced to 25 percent of expected requirements, and if the other three factors contributing to the decline in food production capacity (land erosion and the effects of persistent pollutants and air pollution) are eliminated, the agriculture sector finally achieves a sustainable mode of high food production F as shown in Run 4-15. (Figure 4-87). Here total food production F levels off at its maximum value in the year 2060. Since population POP continues to grow, however, food per capita FPC gradually falls after the year 2060. Because of the continuing exponential growth in population POP, the decline in food per capita FPC is delayed only 30 years by this comprehensive set of technological policies that has removed all possibility of reducing the carrying capacity of the agriculture sector.

These policy runs have shown that the agriculture sector is capable of high sustained food production only if the four factors that erode the sector's carrying



A. The behavior of land yields and food production



B. The behavior of arable land

Figure 4-85 Run 4-13: policy run in which the adverse effects of air pollution on land yield and the impairment of land fertility by persistent pollutants are completely eliminated in 1975

capacity are eliminated. Even then a decline in food per capita FPC is inevitable if the population POP is assumed to be growing exponentially. Because of the continuous exponential growth of the exogenous variables, the exact timing of the decline in food per capita is relatively insensitive either to parameter changes or to policy changes designed to maintain a constant carrying capacity.