sions of the potential health effects from persistent materials are provided in Ehrlich and Ehrlich (1972), Brubaker (1972), and Lee (1972). Concern and knowledge about the health implications of persistent materials are increasing, but it is difficult to make a convincing case for any precise assumption about secular trends in the industrial materials toxicity index IMTI. However, the imminent increase in the generation of plutonium by fast breeder reactors is alone sufficient to increase the toxicity index. Each reactor will contain about 1,000 kilograms of plutonium, even though U.S. federal health standards in 1972 limited maximum body burdens of plutonium to 0.06 microgram per person. Because of the stronger case for harmful effects from industrial emissions we set the industrial materials toxicity index IMTI equal to 10, ten times the agricultural materials toxicity index AMTI.

Because of uncertainty about the long-term determinants of FRPM, IMEF, and IMTI, all three factors were simply held constant during our simulations. In reality none of these three factors are likely to be constant in different countries or over time. As synthetics replace natural fabrics and metals and as nuclear fuels replace fossil fuels, the fraction of resources in the form of persistent material FRPM will probably tend to increase. Emission factors may decline in the industrialized countries, but that trend will be offset to some extent by the low priority assigned to pollution control in the less industrialized countries. Since the total quantity of resources consumed in the less industrialized countries is increasing, the practices of the poorer countries are potentially important determinants of the globe's industrial pollutant burden. The relative toxicities of industrial and agricultural emissions in the future are equally uncertain. Thus, in view of our limited knowledge about the nature and future direction of possible future variations in these factors, no specific, elaborate assumption about these three factors appears to be any better than the simple approximation that they are constant.

Persistent Pollution Generated by Agricultural Output PPGAO To avoid double counting we distinguished between agricultural and industrial pollution in terms of where the persistent materials were released into the environment rather than according to the chemical nature of the materials. For example, emissions associated with the manufacture of fertilizers or pesticides are defined as industrial pollutants. The pesticides and fertilizers themselves become pollutants only when they are released into the environment as agricultural inputs. We defined persistent pollution from agriculture PPGAO as the persistent materials that result from agricultural activities and remain in the soil, air, or water for more than a short period of time. The materials meeting those criteria are primarily organic chemicals employed as pesticides and herbicides; inorganic chemicals used as nutrients; salts; and small quantities of heavy metals, primarily mercury, used in fungicides. Since these materials are useful to farmers only when released into the environment, the emission factor is 1.0. It was therefore omitted from the equation defining PPGAO.

Three generic factors determine the rate of agricultural pollution generation:

1. The total usage rate of inputs to the agricultural sector, defined as agricultural inputs per hectare times arable land (AIPH × AL).

2. The fraction of the total inputs that consists of persistent materials FIPM.
3. The agricultural materials toxicity index AMTI.

Industrial pollution results from a flow of resources that we measured in "resource units." Agricultural pollution is created by the application of agricultural inputs, measured in "dollars per hectare-year." Thus both the agricultural materials toxicity index AMTI and the fraction of inputs that are persistent materials FIPM differ somewhat from their counterparts employed in the equation for industrial pollution.

Whereas we examined the production rates of various resources, measured in tons, to obtain a crude index of the fraction of resources in the form of persistent materials FRPM, in the agriculture sector we were interested in the fraction of the total dollars of agricultural inputs that is in the form of persistent materials. In the equation for industrial pollution the toxicity index IMTI serves to convert resource units into standard persistent pollution units. In the agriculture sector the agricultural materials toxicity index AMTI is a factor that converts dollars of inputs into standard persistent pollution units.

The fraction of agricultural inputs that is composed of persistent materials FIPM depends both upon the fraction of the total agricultural inputs that is composed of fertilizers, heavy metals, and chemicals and upon the fraction of all these materials that remains for more than a few months in the soil, air, or water.

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PPGAO.K=AIPH.K*AL.K*FIPM*AMTI                              140, A
FIPM=.001                                                  140.1, C
AMTI=1                                                     140.2, C
     PPGAO  - PERSISTENT POLLUTION GENERATED BY
                 AGRICULTURAL OUTPUT (POLLUTIONUNITS/YEAR)
     AIPH   - AGRICULTURAL INPUTS PER HECTARE (DOLLARS/
                 HECTARE-YEAR)
     AL     - ARABLE LAND (HECTARES)
     FIPM   - FRACTION OF INPUTS AS PERSISTENT MATERIALS
                 (DIMENSIONLESS)
     AMTI   - AGRICULTURAL MATERIALS TOXICITY INDEX
                 (POLLUTION UNITS/DOLLAR)
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In the United States in 1968 the total inputs to the agriculture sector were valued at about 11.1 billion dollars (Census 1971, p. 593):

Repairs and operations of capital items	4.6 billion dollars
Fertilizer and lime	2.1 billion dollars
Miscellaneous inputs (including pesticides)	4.4 billion dollars
	11.1 billion dollars

The total U.S. production of pesticides and related chemicals was valued at about 850 million dollars (Census 1971, p. 718). Since most of these materials were used domestically and the value of heavy metal inputs was negligible, we assumed that approximately 30 percent of the total inputs to agriculture in the United States is composed of lime, fertilizers, and pesticides. Figure 4-31 indicates that this fraction may be about the same in less industrialized areas. However, most of these materials are not truly persistent. They are quickly degraded or absorbed in plant tissues and harvested. We could find no good basis for an estimate of the fraction of these materials that actually remains in the environment beyond one crop season. There-