The reduction of plant growth by photo-induced smog is well documented in local areas. It occurs partly because the decrease in sunlight penetration reduces the photosynthesis taking place in the leaves. In addition, toxic substances deposited on the leaves can damage or destroy them. Examples of these substances are hydrofluoric acid, sulfur dioxide, ozone, and ethylene, which are released into the air as by-products of industrial processes.

> Smog in the Log Angeles basin contributes to the slow decline of citrus groves south of the city and damages trees in the San Bernardino National Forest 50 miles away. Fluoride and sulfur oxides, released into the air by phosphate fertilizer processing in Florida, have blighted large numbers of pines and citrus orchards. Livestock grazing on fluoride-tainted vegetation develop a crippling condition known as fluoresis. In New Jersey, pollution injury to vegetation has been observed in every county and damage reported to at least 36 commercial crops. [CEQ 1970]

The loss of crops due to air pollution is not a new phenomenon in local areas. It is well recorded in the Los Angeles basin. Figure 4-49 shows losses as early as in 1949. The scale of the problem has been rising; currently in the United States the direct costs of air pollution on both (construction) materials and vegetation are estimated at 4.9 billion dollars annually, or 0.5 percent of the GNP (CEQ 1972, p. 107).

Because of the high mobility of materials in the atmosphere, the effects of air pollution are not necessarily constrained to the area close to the source. The air pollution load is heaviest in densely populated (and hence usually industrialized) areas, but the air pollution from urban areas also affects nonurban areas. The data in Figure 4-50 show that in the United States the urban air pollution level increases with urban population size and that the nonurban pollution levels, although lower, are far from zero. Similarly, Figure 4-51 shows the extent to which sulfur dioxide originating in Germany and England makes precipitation acidic even as far away as northern Norway.

Crop	Total Acres Planted	Acres Affected	Percentage of Total Affected	1949 Average Yield per Acre	Percent Loss	Dollar Value per Unit	Total Dollar Loss
Alfalfa	53,400	9,000	17	5.3 tons	15	$24.00	$171,720
Spinach	3,350	1,000	30	5.1 "	50	33.50	85,425
Parsley	300	300	100	500 crates	25	1.50	56,250
Celery	2,300	200	4	950 "	25	2.00	47,500
Romaine	500	300	60	300 "	25	1.50	33,750
Endive	350	275	79	300 "	20	1.40	23,100
Radish	750	500	67	400 "	10	1.10	23,100
Turnip	750	300	40	500 "	10	1.00	15,000
Table beets	700	250	36	300 "	10	1.50	11,250
Mustard greens	600	200	33	400 "	10	1.00	8,000
Chard	50	40	80	450 "	25	1.00	4,500
Total							$479,495

Figure 4-49 Economic loss of crops caused by air pollution in Los Angeles County, 1949

Source: Middleton, Kendrick, and Schwalm 1950.

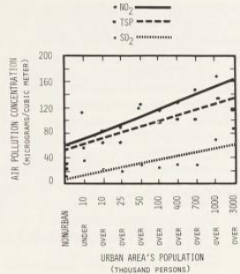

Figure 4-50 Air pollution levels in nonurban and different sized urban areas in the United States, 1969–1970

Source: CEQ 1972, p. 215.

We assumed in World3 that air pollution is uniformly distributed over agricultural land. We also chose the global total industrial output IO as the most reasonable indicator of the level of air pollution. Although much has been said and written about the effects of air pollution on land yields, we could only speculate about how much an increasing air pollution load might depress agricultural output. Our assumption about the value of the land yield multiplier from air pollution LYMAP is represented in Figure 4-52. This figure expresses the rather conservative assumption that industrial output must increase to more than ten times its 1970 value before air pollution will begin to decrease land yield LY on a global scale. We also recognize that the load of air pollutants can be reduced with proper control methods, so we tested the effect of making this relationship even less severe in some of the model simulation runs.

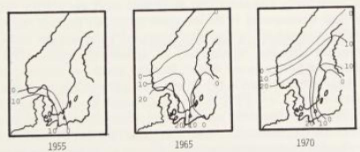

Figure 4-51 The development through time in Scandinavia of the deposition of excess acid through precipitation during one year (in milligrams of hydrogen ions per square meter)

Source: SMFA-SMA 1971, p. 28.