ORBES

ESTIMATING REGIONAL LOSSES TO AGRICULTURAL PRODUCERS
FROM AIRBORNE RESIDUALS IN THE
OHIO RIVER BASIN ENERGY STUDY REGION, 1976-2000

PHASE II

OHIO RIVER BASIN ENERGY STUDY

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ESTIMATING REGIONAL LOSSES TO AGRICULTURAL PRODUCERS FROM AIRBORNE RESIDUALS IN THE OHIO RIVER BASIN ENERGY STUDY REGION, 1976-2000

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PREFACE

This is a final report of work completed for the Ohio River Basin Energy Study (ORBES) estimating monetary losses to agricultural producers from airborne residuals in the study region. Walter P. Page, West Virginia University, served as principal investigator for the research.

We wish to thank Randy Holliday and Kung Hun Lee, Ph.D. canditates in the Department of Economics, West Virginia University, for assistance with the calculations. Special thanks are extended to Mary Ann Albertazzie for her competent typing services and cooperative attitude and to the Bureau of Business Research, West Virginia University, for managing the project.

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SECTION 1

INTRODUCTION

This report is part of a larger U.S. Environmental Protection Agency (EPA) funded study, ORBES, which is charged with assessing "...the potential, environmental, social and economic impacts of the proposed concentration of power plants in the lower Ohio River Basin." Phase II of the project focuses on a regional analysis consistent with the above mandate. The study region is defined to include all of Kentucky and portions of Illinois, Indiana, Ohio, Pennsylvania, and West Virginia (see Figure 1). The regional boundaries for this phase of the project include most of the Appalachian and Eastern Interior coal fields, exclude portions of the states where Great Lakes water problems would be of concern and include most of the Ohio River drainage basin.

The ORBES project is an integrated technology assessment where a set of scenario models generate regional energy and fuel use characteristics out to 2000 which are then examined with a variety of impact models for assessment of the economic, environmental, health and social impacts from the specified developments. The research design is illustrated in Figure 2. Within this context, the present work focuses on economic impacts and makes use of research results from several studies earlier in the sequential information flow in the ORBES experimental design.

In this research, the principal input to the analysis consists of physical crop losses, by scenario, provided by The Institute of Ecology (TIE) [1]. These estimates, however, also rely upon several other research project outputs earlier in the sequence of information flow (figure 2) in the ORBES project. To illustrate the point, future energy and fuel use, by scenario, is derived from a model of ORBES-region energy and fuel use [2], which in turn provides input data on future coal-fired electric demand in the region to a siting model for generating facilities [3]. The siting model spatially and temporally allocates the additional capacity in terms of a set of exclusionary criteria. Given the output of the siting model, emission and concentration models [4 and 5] are used to estimate regional emissions and concentrations of airborne residuals. This information serves as input to TIE researchers for estimation of physical crop losses, 1976-2000, in the ORBES region. The integrated assessment process appears to be optimal in the sense that sets of analytic results in the information flow are tied to analytic models which capture the implications of energy and fuel developments in the region and reflect "state-of-the-art" modelling.

Scenarios in this research design may be thought of as sets of future energy and fuel use characteristics within the region which vary according to alternative values for economic or electric demand growth as well as alterations of policies, or compliance with policies, governing environmental standards. In all cases, alternative specifications or assumptions are designed to be feasible in the sense that they can be justified (documented) as plausible in terms of existing knowledge or literature. Impact results are investigated for alternative scenarios which are thought to represent quantitatively interesting differences.

Results for three different scenarios are reported in this work. Scenario 2 represents a base case or "business as usual" set of future economic and energy/fuel use characteristics. The scenario assumes State Implementation Plans (SIPs) on existing units will be complied with and New Source Performance Standards (NSPS) and Revised New Source Performance Standards (RNSPS) will be fully implemented for additions to generating capacity. Scenario 2d is identical to scenario 2 with respect to NSPS and RNSPS standards being met, but differs in that SIP requirements are not complied with. Hence, scenario 2d is more "lax" with respect to air quality than scenario 2. The last scenario discussed, scenario 7, is identical to scenario 2 except the growth rate for electric capacity, 1976-2000, is higher and plant life is assumed to be 45 years (35 years in scenarios 2 and 2d). All other assumptions (SIP, NSPS and RNSPS compliance, etc.) are identical to those in scenario 2. Comparing results as between scenarios 2 and 2d, then, provides differences in monetarized welfare losses to agricultural producers for alternative policy assumptions concerning compliance with SIPs. Differences between scenarios 2 and 7 reflect alternative assumptions concerning anticipated regional growth in electric demand and plant life. Reported tables are in 1975 constant dollars. In all cases, state designations in tables refer to the ORBES portion of each state and the ORBES region data is specifically in terms of the region identified in Figure 1.

Two different analyses were performed by TIE [1] and economic loss estimates were provided for both cases. The first case, discussed in detail in the main text, was based on nominal load emissions from utilities in the ORBES Region. The second case (Tables in Appendix A), was based on peak load emissions from utilities. The present authors are not in a position to advise the reader as to which set of figures are most appropriate. That is a question more appropriately resolved by ecologists and botanist working with physical dose-response curves. For completeness, we report the results of both calculations. The results reported in Appendix A (peak load emissions) are only for the probable case. The range between the minimum and maximum values would be approximately the same as that reported in the main text for the nominal load emissions.

SECTION 2

ESTIMATING LOSSES DUE TO AIR POLLUTION: GENERAL DISCUSSION

In terms of existing literature, the relationship between human health and ambient air quality has preoccupied economists, statisticians, engineers, epidemiologists and others in their search for understanding the social costs of productive activities. This is understandable in that primary air quality standards largely reflect a concern for human health. There are, however, significant production externalities and public goods effects associated with ambient air quality that have received far less attention and which fall under secondary standards. In this section, we discuss the general character of social costs and the appropriate economic measure of losses associated with technical externalities (the case of agricultural losses) [see Mishan [6] for an elementary analysis of these externalities].

An air pollution damage function is a statement of the level of the harmful physical effects that result from various levels of contaminants introduced into the air as a result of human and non-human activities or processes. Air pollution is costly because it reduces the capacity for the functioning of human activity and natural processes. The cost of air pollution may be defined as the value that people place on reducing damages suffered because of air pollution. The greater the reduction of damage, the greater will be the value attached by people to damage reduction. Cost, properly understood, is the entire schedule of valuations associated with various levels of damage reduction.

A host of problems stand in the way of measuring the cost of air pollution. No market exists which would permit people to make actual payments based upon their individual valuation. Many pollution costs are unknown or at best only vaguely perceived. Certain types of pollution damage though real, are not understood. Others do not effect some people directly, although they still place a value on their elimination. Still other costs are recognized and experienced directly, but individuals do not know the valuations they would place on their reduction. Ideally, an economic analysis of the air pollution problem entails a comparison of the schedule of the benefits of pollution reduction with the schedule of the costs of pollution abatement. Since optimal pollution abatement requires a comparison of incremental costs and benefits, it would be necessary to develop a schedule of incremental benefits. Since it is difficult to develop entire schedules of abatement benefits, it is at least desirable to estimate the benefits which would result from marginal reductions from current levels of air pollution.

Ridker [7] describes three approaches to the measurement of the cost of air pollution. The simplest measure is restricted to the estimation of direct effects in the absence of adjustments. Monetary estimates of damage are based upon physical relationships between levels of pollution and extent of damage, as measured by technical specialists. The dollar value of damage is derived from market information or independent economic studies. Estimates of total damage of a certain type may be obtained this way, as well as valuations derived from incremental reductions of pollution.

The other two approaches to the estimation of the monetary value of air pollution damage discussed by Ridker allow for individual adjustments to changes in air quality and for important changes that occur in related markets as the effects spread through the economy; a general equilibrium approach. Individual and market responses have an important bearing on the social costs of air pollution damage. Consequently, it is desirable to account for these responses in order to measure accurately the benefits which flow from alternative levels of air pollution abatement.

Examples of individual adjustments to increased air pollution given by Ridker are changing the amount of time spent in the polluted area and making greater use of protective measures such as air filters and medication. Such individual responses reduce the damages suffered from air pollution and distribute the cost over a variety of categories of goods and services that must be accounted for. Ridker explains market effects as the impact that individual responses to air pollution have on the market behavior of persons not directly affected by pollution. For example, spinach growers around Los Angeles bear the direct costs of air pollution, but increases in spinach prices transfer some of the losses from producers to consumers. The effect of the price increase should be taken into account in order to capture fully the value of crop damage done by air pollution. Additionally, effects in the spinach market cause reactions in related markets, such as asparagus, which should be taken into account.

In accounting for the market effects of air pollution, it is important to determine which effects to count as costs, and which effects merely represent a transfer of costs between parties. Ridker observes, "To a large extent such market effects represent a transfer of benefits or costs between economic units rather than an additional set of consequences not taken into account (in principle at least) by the second measurement strategy." [7].

In what follows, we present a brief discussion of general equilibrium-oriented cost-benefit analysis which provides the basis for sorting out the three types of reactions to air pollution damage. Cost-benefit analysis provides a set of principles which helps develop a consistent set of accounts in which pollution damage valuations are added up correctly.

The principles underlying our approach to analysis of air pollution damage functions are stated by Harberger as "three basic postulates for applied welfare economics" [8]. They are

a) the competitive demand price for a given unit measures the value of that unit to the demander;

b) the competitive supply price for a given unit measures the value of that unit to the supplier;

c) when evaluating net benefits or costs of a given action (project, program, or policy), the costs or benefits accruing to each member of the relevant group (e.g., a nation) should normally be added without regard to the individual (s) to whom they accrue.

In what follows, these principles are applied to an example in which a steel firm emits pollution which causes damages to a spinach crop. The three postulates are applied to develop economic measures of pollution damages, taking into account the individual and market responses by the steel firm and the spinach growers. The theory is applied to efficiently functioning markets assuming that the effects of pollution on unit production costs can be measured.

The market for spinach is depicted in Figure 3.

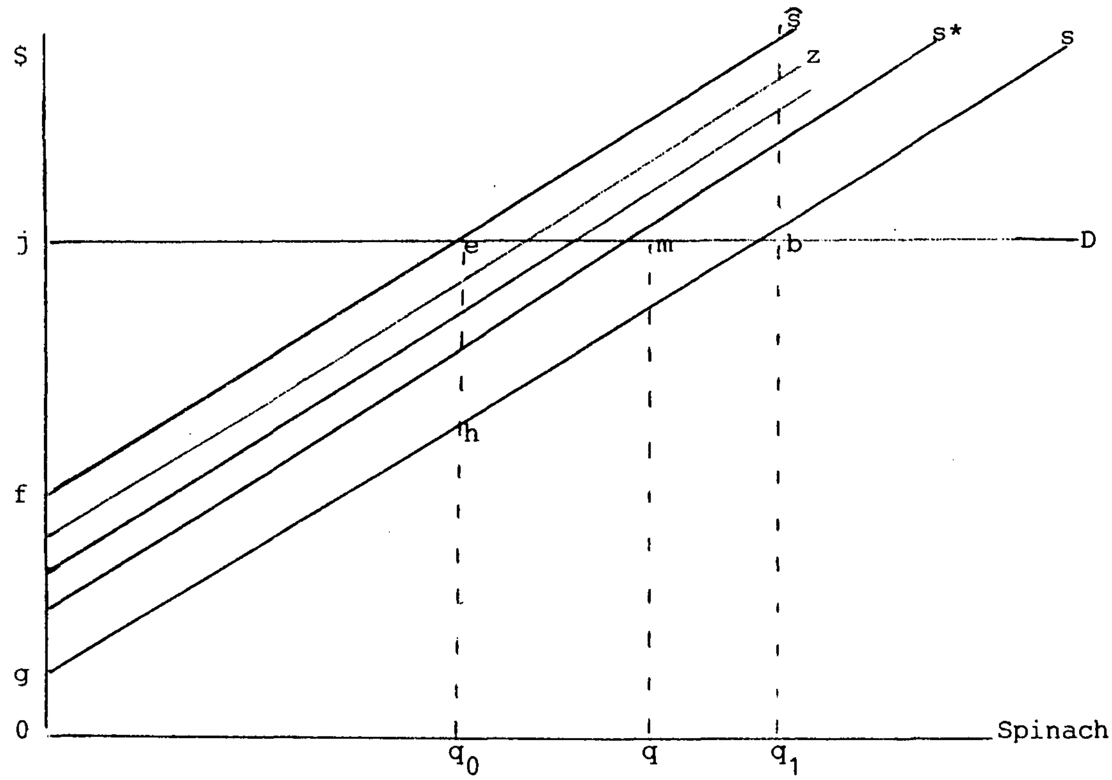


Figure 3

S and D are supply and demand curves for spinach in the absence of pollution. Air pollution is emitted by a steel mill in the area, raising the cost of spinach growing to $\hat{S}$ (supply curve with pollution).

$\hat{S}$ includes costs which farmers incur to mitigate pollution damage: Increased labor input may be hired; pollution resistant crop varieties having lower market value may be introduced; agricultural experiment stations may devote portions to their budgets to research mitigating pollution damage; production may be relocated to areas where pollution is less severe; as well as other productivity enhancing adjustments. It is assumed that once these and similar adjustments have been made, $\hat{S}$ becomes the operative supply curve and represents farmers' response to air pollution.

Equilibrium is q_o. Physical damage functions typically provide estimates of the percent reduction of crop caused by air pollution. Output q_1 is the pollution-free damage function estimate of output. If the spinach farmers are price-takers, then b is the pollution-free equilibrium point.

If liability for pollution damage is assigned to the steel industry, then pollution damage to spinach is calculated over Oq_1 spinach output. By bearing liability for pollution, the spinach growers have been subsidizing the steel industry by gbzf, the production cost added by pollution to the pollution-free level of output.

The welfare loss in the spinach market is gbef, the producer surplus that would be gained if pollution damage could be eliminated entirely (gbef = gbj (surplus without pollution) - fej (surplus with pollution)). The welfare loss from pollution is less than the associated subsidy to the polluter; the magnitude of the difference (ebh) depends upon demand and supply elasticities for spinach.

Generally, the optimal social solution to the pollution problem (the level of pollution reduction that maximized the net present value of benefits minus costs in both markets) will not entail complete elimination of pollution; it may not be socially desirable to return the spinach supply curve all the way to S. If the optimal policy leaves the supply curve to the left of S, then the welfare gain in the spinach market will be less than gbef.

In Figure 4, $\hat{S}$ represents the supply curve for steel. It excludes pollution costs imposed upon spinach growers, since these are not borne by the mill. $\hat{S}$ is unaffected by any other distortions. S is the mill's supply curve inclusive of pollution damage to the spinach crop. This cost is the payment to the spinach growers that would be required to compensate them for crop losses. Defined as a compensating variation [9], the difference between S and $\hat{S}$ is the minimum payment the growers would accept in order to tolerate the presence of pollution, at any level of steel output.

If the mill has no liability for pollution damage, it will produce at q_o: It enjoys a subsidy of $P_o gfP_1$ from the spinach farmers. $P_o gfP_1$ would be the compensating variation owed to the growers if the liability were shifted to this polluter. It is equal to gbzf in Figure 3. If the steel firm were required to compensate the growers (and had recourse to no other type of adjustment), S would be the steel supply curve and output would fall to q_1. $P_o P_1 eh$ would be paid to the spinach farmers as compensation, wiping out all of the $P_o geP_1$ of benefits enjoyed in the steel industry because of the subsidy. The welfare gain enjoyed by the steel industry is less than the subsidy received from the spinach farmers, just as the subsidy given by the spinach farmers to the steel industry is less than the welfare loss to the spinach industry.

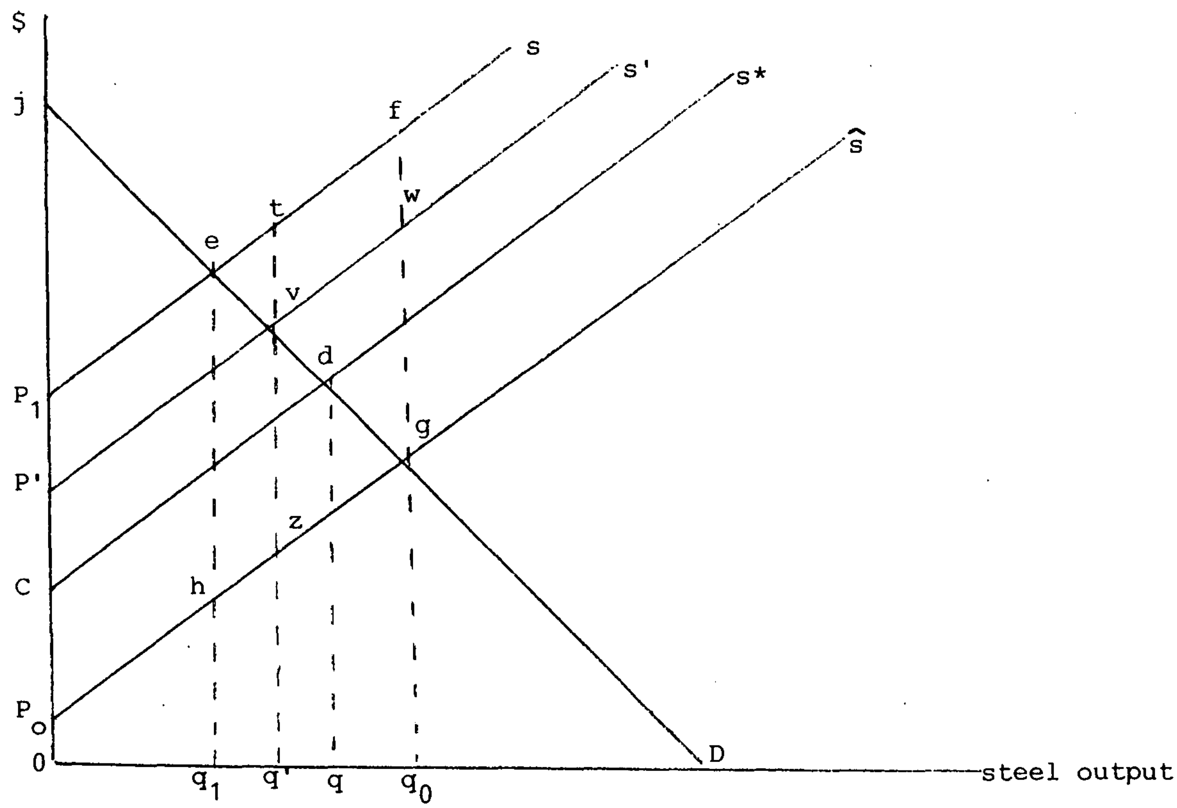


Figure 4

At this point, it would not be possible to calculate the net welfare effect of imposing pollution liability on the steel firm, because we have not analyzed the polluter's response to liability. Assume that the steel firm abates part of its pollution, but must pay compensation to the spinach producers for all unabated damage. Output and price adjustments do not exhaust the options of steel mills. By pursuing abatement, they can reduce their own pollution costs and confer additional benefit on society.

Faced with pollution liability, the mill will spend additional money on abatement so long as an additional dollar of abatement expenditure reduces required compensation by more than a dollar. The first dollar spent on abatement reduces compensation payments by more than a dollar, and likewise for each succeeding abatement dollar, until required compensation is reduced no more than additional abatement expenditure. For additional abatement expenditure, total firm cost (abatement plus compensation) would be greater.

Referring to Figure and 4, the first dollar of abatement expenditure reduces required compensation payments by more than a dollar. Compensation is required over all Oq_o units of spinach output. The steel firm's supply curve, S, shifts down. Each succeeding dollar of abatement expenditure shifts S further until S' is reached, and further abatement would be uneconomical for the steel firm. Unabated pollution damage to spinach is compensated, so that the operative supply curve in the spinach market is S. Spinach output is q_1 and steel output is q'.

S' is the steel firm's least cost solution to the problem of pollution cost. S' in Figure 4 is the mill's supply curve inclusive of both abatement costs and compensation payments, as compared with supply curve S, which the mill would face if it paid compensation without abatement. At the profit maximizing level of abatement, the mill incurs P_oP'vz pollution costs, including abatement and compensation, and produces q' level of output.

The response of the steel firm to pollution liability has the effect of eliminating ztfg + $P'P_{1tv}$ of pollution costs, and the steel firm pays P_oP'vz for abatement compensation. There is a welfare loss of P_oP'vg = $P_o$jg (surplus before liability) - P'jv (surplus after liability). In the spinach market, all of fzbg costs have been eliminated. The corresponding welfare gain is febg. The net welfare gain resulting from assigning full liability to the polluter, including the compensation requirement, is febg (spinach market) - P_oP'vg (steel market). That this is, in general, not an optimal solution, is explained in the next section. The welfare effect of the mixed strategy can be viewed as occuring in two steps. The first step, compensation plus output reduction, shifts the steel firm's supply curve to S. The second step (introduction of abatement equipment) shifts the firm's supply curve to S'. To evaluate the welfare effect (the first step), consider the supply curve shift from $\hat{S}$ to S with output remaining at q_o. Required compensation payments are $P_oP_1$fg. Growers are fully compensated for damages incurred at q_o steel output. Steel producers are induced to reduce their output to q_1.

It has been noted that the welfare loss in the spinach market (Figure 3) is smaller than the additions to the cost of producing the pollution-free amount of spinach. Likewise the subsidy enjoyed in the steel market (Figure 4) is larger than the welfare gain that results from it. The consequence of these differences is that the net welfare gain calculated in the preceeding section is generally not the greatest attainable. To establish this point, consider a special case in which that gain is the maximum attainable; suppose the demand curves in both markets are perfectly inelastic: q_1h in the spinach market (Figure 5) and q_{oh} in the steel market (Figure 6). With perfect inelastic demand curves there are no output adjustments to pollution, abatement or compensatory payments as illustrated in Figures 5 and 6. In this case as $\hat{S}$ shifts to S in the spinach market, the entire steel subsidy, fzbg, when removed from the spinach market, constitutes a welfare gain to spinach consumers. The removal of the subsidy constitutes a loss to steel consumers equal to $P_o$gwP'. But $P_o$gwP' is less than fzbg (recall that P_oqfP_1 = fzbg), the way S' is divided, the difference between the welfare gain to spinach consumers and the welfare loss to steel consumers is maximized.

Negatively sloped demand curves change the relationship between gains and losses in the two markets. Suppose that the spinach demand is more highly elastic than demand for steel. Then as price falls in the spinach market,

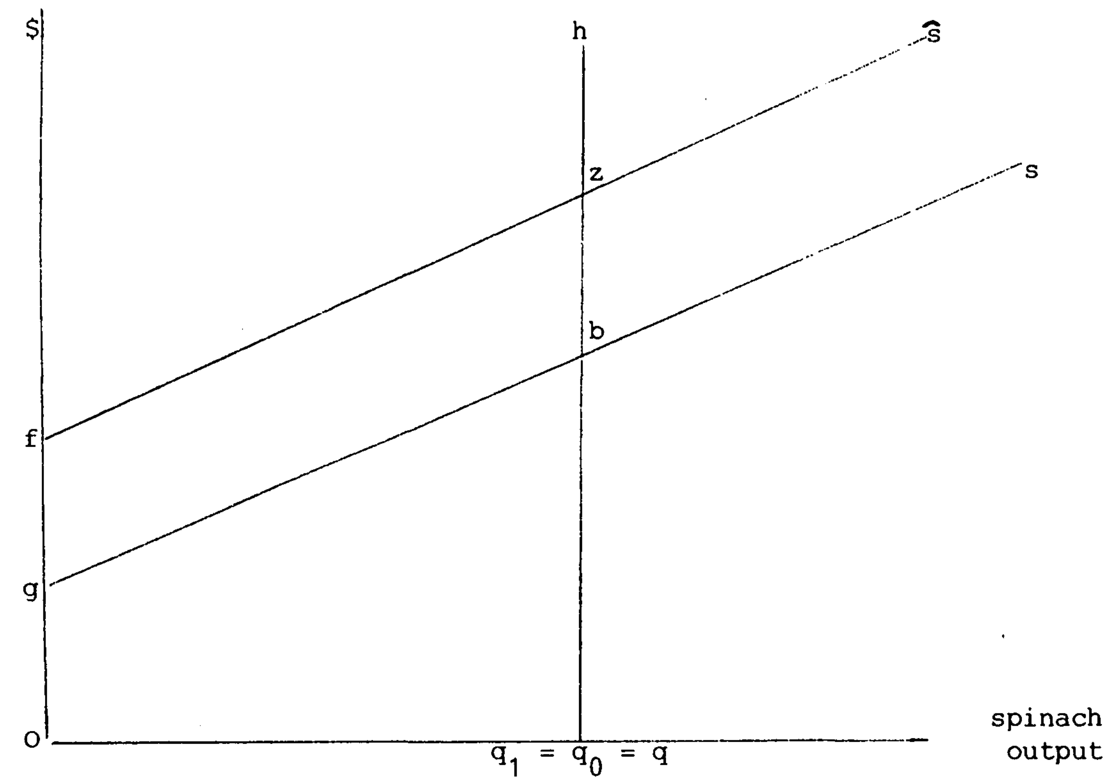


Figure 5

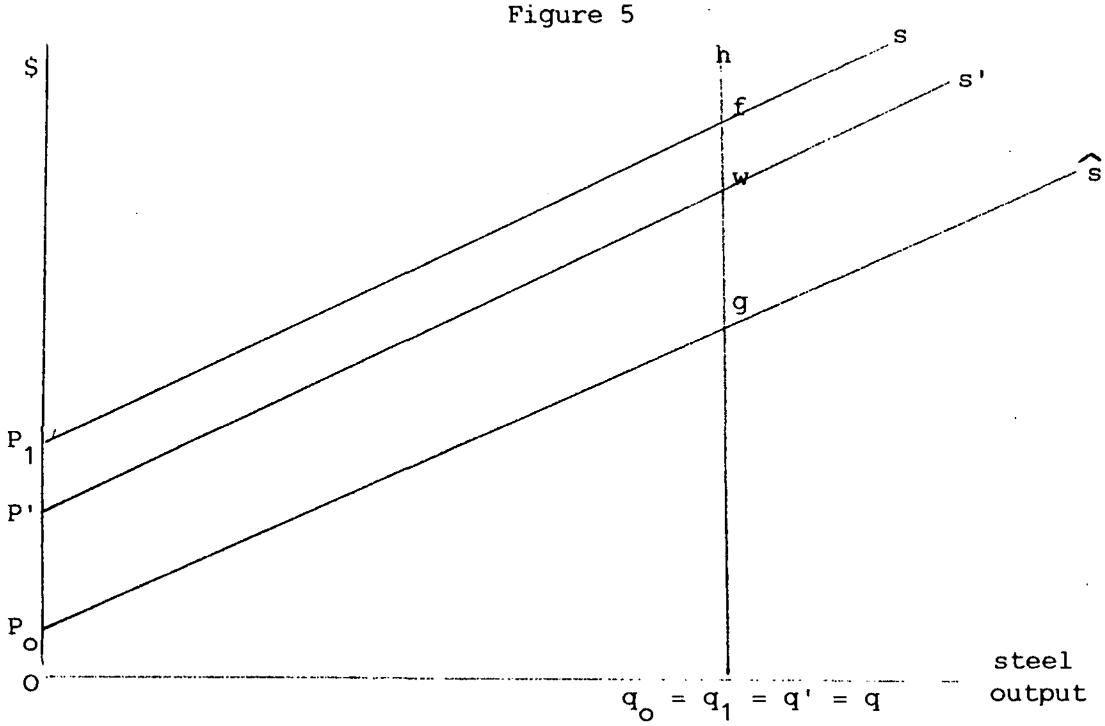


Figure 6

the welfare gain falls short of the subsidy reduction, more so as demand is more highly elastic. In the steel market, as price rises with the removal of the subsidy, the reduction in consumer surplus approaches the full value of the subsidy as demand is less elastic. The conclusion is that, depending upon demand elasticities, maximum net social benefit will be achieved with spinach output less than q_1 and steel output greater than q_1. The larger is ezb relative to vgw, the greater will be the divergence from the optimal solution of the previous section.

Figures 3 and 4 illustrate the determination of maximum net welfare gain. The first unit of abatement raises $\hat{S}$ in the steel market slightly. In the spinach market, $\hat{S}$ falls relatively much compared to the increase in steel cost. A relatively large reduction in required compensation over Oq_1 spinach output is achieved. Also a relatively large gain in surplus is achieved. The next unit of abatement raises steel production costs more than the first, and required compensation to spinach growers falls, but by less than the first decrement. Likewise, the gain in surplus in the spinach industry increases by a lesser amount than the first increment. Additional units of abatement are purchased by the steel industry so long as the gains in surplus in the spinach industry exceed the losses of surplus in the steel industry. When the gains and losses of surplus are equalized at the margin, the net welfare gain from abatement is maximized. The solution is labelled in both markets. The gain is femn - $P_o$cdg.

To achieve this solution it is required that no compensation be paid for abatement pollution. The resulting supply curves, labelled S* in both markets, represent the optimal adjustment, and in this sense are undistorted. The optimal result is achieved by applying the principle of compensation, or willingness to pay, to both markets, but not actually paying compensation for unabated pollution.

Measurement of pollution damage costs consistent with the foregoing analysis requires knowledge of elasticity of demand and supply both for the product whose production generates pollution and the product damaged by pollution. ASsume that spinach farmers are price-takers in the market for their output. This is a realistic assumption for agricultural output affected by air pollution in the ORBES region. While it simplifies demand analysis on the output side of the agricultural market, nevertheless it is still necessary to match supply prices with demand prices from time series price data in a way which is consistent with the agricultural output decision.

On the supply side, it is essential to estimate the effect of pollution on unit costs of production. In the spinach industry, the supply curve inclusive of pollution ($\hat{S}$) must be estimated. In order to determine S* (the spinach supply curve with socially optimal abatement), the responsiveness of units costs to spinach production with pollution reduction must be determined. In the steel industry, it is necessary to estimate S and the extent to which unit costs increase with various levels of abatement. We have assumed less than perfectly elastic demand in the steel industry. In order to measure the social cost of pollution reduction, it is necessary to determine the steel demand curve in the relevant output range, because social cost of abatement will exceed abatement expenditures to the extent that steel demand is curtailed by increased steel cost.

If physical damage function information is sufficiently complete to permit estimation of the change in unit costs of both steel and spinach, then it will be possible to determine the optimal level of abatement. With less complete damage function information, it would be necessary to settle for estimation of net present values of discrete abatement strategies.

Up to this point, the analysis has been focused solely on the markets directly affected by air pollution, and it has been assumed that air pollution creates the only relevant market distortion. However, a complete analysis of the problem requires that other distortions, such as tax distortions, be taken into account, and that reactions in other markets which occur because of air pollution, be considered.

To illustrate what is involved, suppose that because of air pollution damage to the spinach crop, the price of spinach rises, causing the demand curve for asparagus to shift to the right from D_1 to D_2. Suppose also that the sale of asparagus is subject to tax. In Figure 7, $\hat{S}$ is the supply curve for asparagus inclusive of the tax, and S is the undistorted supply curve showing competitive supply price at each level of output. At the equilibrium output, q_1, competitive demand price measured from D_1 exceeds competitive supply price measured from S. A welfare loss, equal to the distance between S and $\hat{S}$ at q_1, exists because of the tax. Expansion of

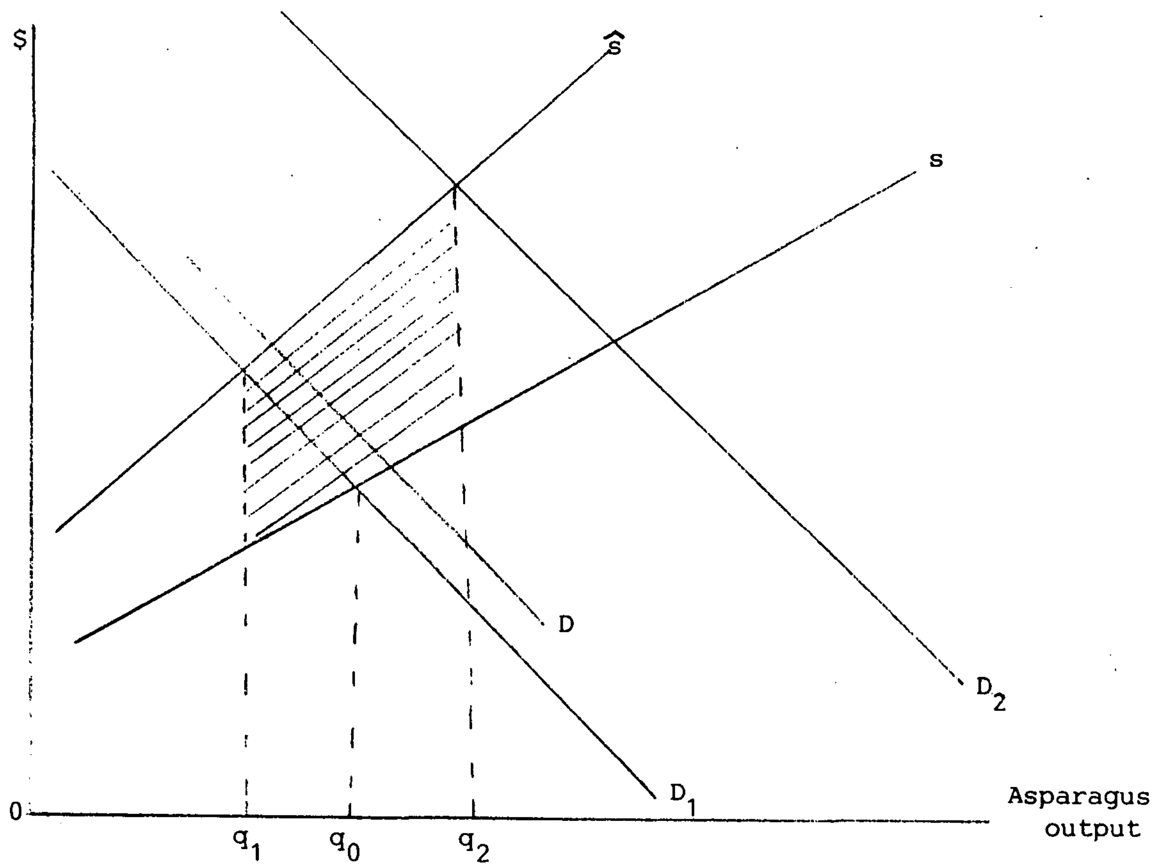


Figure 7

output to q_e along D_1 would eliminate the welfare loss equal to the triangle between q_1 and q_e. Consider demand curve D, which represents a small portion of the increase in demand for asparagus. Output expands slightly, and over that range of output competitive demand price exceeds competitive supply price. Consequently, there is a welfare gain associated with the expansion in output. This condition persists throughout the entire range of output, yielding a welfare gain equal to the shaded area in the diagram. Since this effect is caused by market activity attributable to air pollution, it should be counted as a welfare gain and included in the account of costs and benefits developed earlier.

In the development of a general equilibrium analysis of the costs and benefits of air pollution control, ideally the researcher should identify all such related markets where substantial welfare gains or losses are likely to occur. A more complete analysis of the steel and spinach markets in the present example would also have included an analysis of the welfare effect of tax and other distortions. For a detailed treatment of the analysis of tax distortions, see Harberger [10].

SECTION 3

ESTIMATION OF AGRICULTURAL LOSSES DUE TO AIR POLLUTION: THE ORBES REGION ANALYSIS

The discussion in the preceeding section illustrated an ideal analysis for estimating the optimal pollution level taking into account the pollution recipient and generator as well as general equilibrium effects on closely related markets. Resources did not permit undertaking such an activity in terms of agricultural damages in the ORBES region. The present effort is restricted to estimation of direct social costs borne by agricultural producers from airborne residuals in the region. The appropriate monetary loss value is still the notion of "surplus" (in this case, producer surplus only) and represents an underestimate of total direct and indirect social losses in that effects on closely related markets (transportation sector, etc) are not considered. Nonetheless, this analysis does provide a consistent and theoretically correct measure of direct social costs borne by ORBES-region agricultural producers. A shortcoming of the analysis is the failure to estimate the optimal pollution level in the region in terms of agricultural damages. In point of fact, however, such an estimate would be an inappropriate guide to setting standards in that other externalities (damage to property, health damages, etc.) would not be included nor would other pollution sources (industrial boilers, for instance).

Agricultural damages due to "dirty-air" represent a technological externality. That is to say, various economic activities produce combustion-related airborne residuals which directly enter the production (cost) functions of agricultural producers. These residuals reduce agricultural productivity below those levels which would be associated with "clean-air" and represent, therefore, external costs to producers. Producers experience such losses in terms of reduced productivity per unit input (higher costs per unit output) and consumers in terms of potentially higher prices for agricultural goods [11, 12].

The appropriate welfare measures of external costs to agricultural producers and consumers from a given level of ambient air quality would be the sum of producer and consumer surplus losses in agriculture [13].

As noted in the preceeding section, full accounting of all social costs for purposes of cost-benefit or policy analysis would also require estimating costs and benefits in all closely related markets; a general equilibrium approach. This work focuses only on direct welfare losses in the agricultural sector experienced by producers.

Figure 8 illustrates the measure of producer welfare losses used in this

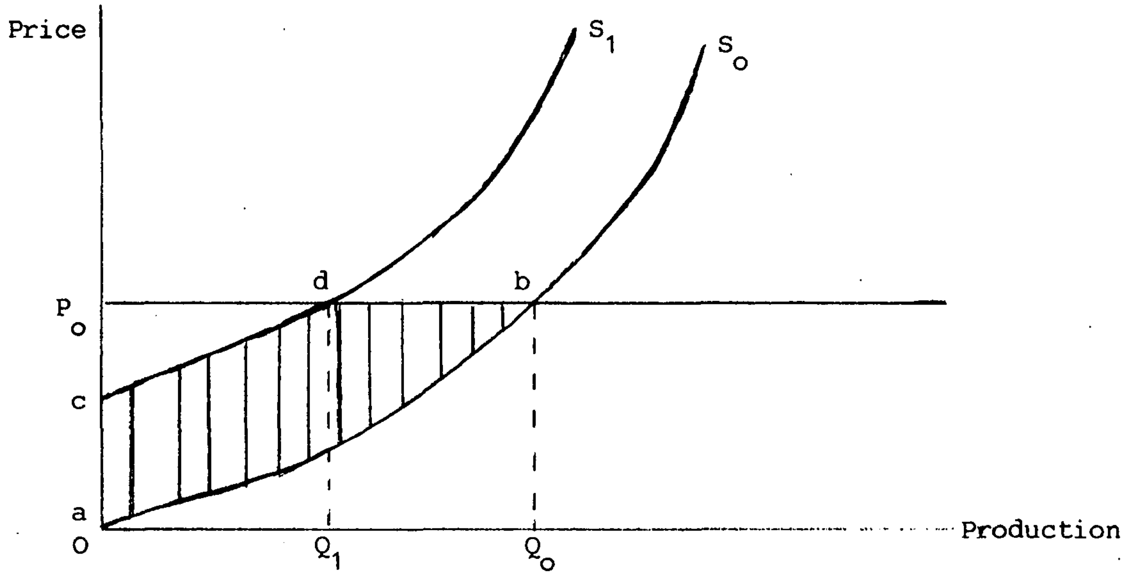


Figure 8

work. Curve S_o represents a "pollution-free" supply curve for ORBES producers. Producer surplus with a pollution-free environment consists of the area aP_ob. The effect of SO_2 and O_3 within the region is to reduce productivity and, hence, production to Q_1. This is associated with a shift leftward of the supply curve to form a new curve, S_1, passing through the fixed price line, P_o, at point d. With the dirty-air supply curve S_1, producer surplus is measured by the area cP_od. The losses due to SO_2 and O_3, then, consist of the difference in producer surplus or the area $aP_ob - cP_od$ = acdb. It is this magnitude that we wish to measure annually over the period 1976-2000 for the ORBES region.

In this analysis, we assume regional producers are "price takers". That is, the producers of specified crops operate in competitive markets and variations in individual output levels do not influence market price. This is a potentially limiting assumption in the ORBES region as regional corn production, for instance, constituted 35% of total U.S. production in 1977. By using a fixed price assumption, then, we may underestimate the producer surplus losses: The market price for corn might have been lower in 1977 if all producers were not affected by ambient air quality and, as a consequence, potential welfare losses would reflect both price (from changes in market supply) and quantity (from supply shifts within the region) effects. On the other hand, the potential influence on market price might be negligible or zero if productivity enhancing methods or crop substitution possibilities were not feasible in the region [see 11, 12, 13, 14, 15 for a discussion of these matters]. In this case, regional producers would simply derive a lower "rent" on agricultural land which would ultimately be reflected in lower land prices than would be realized with clean-air production while unaffected producers would expand output.

Following the analysis suggested in Figure 8, producer discounted losses are estimated for each year, 1976-2000, with a 10% discount rate. Discounted losses are then summed to estimate the present discounted value of cumulative producer surplus losses. For comparative purposes, we also estimate the cumulative present discounted value, 1976-2000, of potential clean-air production assuming the real price of agriculture goods, 1976-2000, is unchanged as is clean-air crop production. The above calculations assume (1) prices of affected crops increase at the same rate as inflation and (2) the size of the regional agricultural sector is unchanged over time with respect to the affected crops.

SECTION 4

DATA BASES AND PARAMETER ESTIMATES

The procedure described in the previous section requires estimates of several parameters. We need estimates of the annual real price and output of affected agricultural goods, 1976-2000, supply elasticities for each, the size of the regional agricultural sector with respect to the three crops, and clean-air production as well as anticipated annual production over the period in the presence of airborne residuals.

Tables 1-3 contain the seasonal average prices, 1965-1978, for the three affected crops (corn, soybeans and wheat) in each of the six states wholly or partially in the ORBES region. No prices were recorded for soybeans in Pennsylvania and West Virginia as there is no production. These data are used for calculation of the fixed price lines, one for each crop, represented in Figure 8. The prices used in the analysis were calculated as weighted average prices of crops, by state, based on the annual prices received by farmers over the 1965-78 period. The weighted averages were computed by weighing state price in each year by the percent that years' production is of the 1965-1978 total production in the state. The results of these calculations appear in Table 4. By using weighted averages, we avoid the influence on average price associated with a few years of unusual crop conditions. In the analysis, we assume the weighted price for each crop and state is unchanged, 1976 to 2000. This is equivalent to assuming agricultural prices increase at the overall inflation rate over the study period.

The production data for the three crops and six states used in weighting annual prices received from farmers is contained in Tables 5-7. These data describe the size, in physical units, of the agricultural sector in the respective states as well as the six-state area. The reader is cautioned that production for, say 1978, already includes adverse effects from ambient air quality.

As our calculation of annual producer surplus losses relies on a procedure for shifting supply curves, it was important to have reliable estimates of supply elasticity for each crop. This is the case as the magnitude of losses identified in Figure 8 (abdc) is uniquely dependent (given fixed prices) upon the elasticity of supply. It has been our experience that secondary source information on supply elasticities for the three crops was not adequate for our purposes. The primary problem was the large range in estimated values even in the case of studies focusing on producing areas which overlapped with the ORBES region. The variation in literature estimates was even more pronounced when considering regional, as contrasted with national, studies [16]. Further, it was not possible to select literature elasticities for each crop based on similar specifications, geographic areas, and years covered by data sets. We provide, then, our own supply elasticity estimates for each crop based on six-state output and price data, 1965-1978.

We follow, as does most recent literature, the Nerlove distributed lag structure for estimating agricultural supply elasticities [17]. Nerlove's model incorporates past (observed) information as well as information about future expectations of the economic agent. Expectations are formulated on the basis of past information. However, not all past information has equal influence on the producer. Recent past values are more indicative of future price expectations than more distant past values. Hence, a decisionmaker's formulated future expectation can be expressed as a weighted moving average of past values in which the weights decline as one goes back in time. Model construction using an adaptive expectations process is more representative of decisionmaking and yields inferences more useful for theoretical and policy analysis than a naive model where the present fully represents the future.

The model reduces to a form representative of either a stock adjustment or an adaptive expectations process where a Koyck distributive lag prevails. In reduced form the two processes are of identical specifications making them indistinguishable. Following Nerlove [17], this work uses an adaptive expectations form. In structural form the system is represented as follows:

$$(1) \quad Q_t = \alpha P^*_t + U_t$$

$$(2) \quad P^*_t - P^*_{t-1} = \delta(P_{t-1} - P^*_{t-1})$$

where

Q_t = observed output in acreage harvested

P^*_t = expected price

P^*_{t-1} = expected price lagged one period

P_{t-1} = observed price lagged one period

α = observed price parameter

δ = reaction or adjustment coefficient ($0 < \delta \leq 1$)

and U_t = error term.

Equation (2) can be made stochastic by the inclusion of an error term, however this does not alter the postulates, the analysis, nor the estimates.

Simplification yields equation (2) as

$$(3) \quad P^*_t = \delta P_{t-1} + (1 - \delta) P^*_{t-1}$$

and substituting into equation (1) provides

$$(4) \quad Q_t = \alpha\delta P_{t-1} + \alpha(1 - \delta) P^*_{t-1}$$

where from equation 1

$$P^* = 1/\alpha\ Q_t - 1/\alpha\ U_t.$$

Lagging we get,

$$(5) \quad P^*_{t-1} = 1/\alpha\ Q_{t-1} - 1/\alpha\ U_{t-1}$$

and substituting this expression for P^*_{t-1} into the equation for Q_t above and simplifying yields

$$Q_t = \alpha\delta P_{t-1} + \alpha(1-\delta)\ 1/\alpha\ Q_{t-1} - \alpha\ 1/\alpha(1-\delta)\ U_{t-1} + U_t$$

$$Q_t = \alpha\delta P_{t-1} + (1-\delta)\ Q_{t-1} + U_t - (1-\delta)\ U_{t-1}$$

and finally

$$(6) \quad Q_t = \alpha\delta P_{t-1} + (1-\delta)\ Q_{t-1} + E_t.$$

In structural form equation (1) relates observed output (acreage harvested) Q_t as a function of expected price P^*_t and an error term U_t and equation (2) relates the change in expected price P^*_t from one period to the next to the difference in prior observed and prior expected prices, P_{t-1} and P^*_{t-1} respectively, by an adjustment factor δ. Alternatively expressing equation (2) as

$$P^*_t = P^*_{t-1} + \delta(P_{t-1} - P^*_{t-1})$$

or

$$0 < \delta \leq 1$$

$$P^*_t = \delta P_{t-1} + (1-\delta)\ P^*_{t-1}$$

for substitution into equation (1) reveals expected price P^*_t as a function of lagged observed price P_{t-1} and lagged expected price P^*_{t-1} where the adjustment factor δ appropriately determines the corresponding coefficients of P_{t-1} and P^*_{t-1}. If the value of δ is equal to zero, actual price would not influence expected price. On the other extreme, if δ is equal to one the expectations equation reduces to a naive model where expected price would equal the previous year's actual price. Following Nerlove, δ can be called the coefficient of expectation which underlies the postulate that decisionmakers formulate expected price in some proportion to the difference in the previous observed price and their previous concept of expected price.

Equation (2) is a first order difference equation that can be solved for P^*_t. Solving yields

$$(7) \quad P^*_t = \sum_{i=o}^{t} \delta(1-\delta)^{t-i} P_{i-1}$$

which expresses the decisionmakers concept of expected price as a weighted average of past prices where the weights decline as one goes back in time, since $0 < \delta \leq 1$.

Empirical application requires reduction of the Nerlove system to an estimable form as expressed in equation (6). This is the resultant specification for deriving short-run agricultural supply elasticities. In this reduced form, observed output (acreage harvested) Q_t becomes a function of lagged observed price P_{t-1}, lagged observed output Q_{t-1}, and an error expression. For the short-run elasticity case, the Nerlove model is in reduced and empirical form becomes a Koyck distributed lag and is estimated accordingly.

There are problems obtaining unbiased estimates and significant coefficients with this specification, although the model is widely used for estimation of crop supply elasticities [18, 19, 20].

While a number of estimating procedures were tried, our best results for all three crops were obtained with autoregressive procedures utilizing a maximum likelihood technique for the Koyck lag specification. The best specifications for equation (6) above for, respectively, soybeans, wheat and corn were as follows:

$$(8) \quad Q^s_t = \alpha^s_1 + B^s_t Q^s_{t-1} + B^s_2 P^s_{t-1} + B^s_3 P^c_{t-1} + B^s_4 t + U^s_t$$

$$(9) \quad Q^w_t = \alpha^w_1 + B^w_1 Q^w_{t-1} + B^w_2 P^w_{t-1} + B^w_4 t + U^w_t$$

$$(10) \quad Q^c_t = \alpha^c_1 + B^c_1 Q^c_{t-1} + B^2_2 P^c_{t-1} + B^c_3 P^s_{t-1} + B^c_4 t + U^c_t$$

where superscripts denote the crop and t represents a time trend. Soybeans and corn are substitutes in consumption and appear also to be production substitutes within the region. The best results were obtained when corn and soybeans were treated as substitutes by entering the substitute prices lagged one period in the estimating equation for each of the two crops (equations 8 and 10). The resulting mean elasticities for soybeans, wheat, and corn, respectively, are .263, .56, and .187. In all three cases, these values are within the range of values reported in existing literature. Complete results of our estimations are in Table 8.

Estimation was based on price and output data reported in Tables 1-3 and 5-7. The quantity variable which proved most successful was acreage harvested rather than bushels. This information was calculated from Tables 5-7 and data on yield per acre. After the transformation to acres harvested, state level data was aggregated to the six-state region. The price series was calculated by summing over the six states for each reported crop price and calculating a weighted average where the weights were the proportion each state's production was of total six-state production.

An adjustment to the formulation of the supply curve for each crop was required in our estimation of direct producer welfare losses. Econometric estimates of supply curves are based, of course, on observed time series, cross-section or pooled time series and cross-section data. In general, the estimated elasticities are valid only over the range of observations used in estimation. Whatever the estimation techniques, the supply curve is not well defined outside the range of observations (there are other approaches to estimation which can avoid this problem, although they were not feasible in this case). Many literature estimates of agricultural supply functions, particularly using linear models, suggest negative intercept terms. This was true in our estimating equation for soybeans. For dealing with questions of supply responses in the neighborhood of equilibrium, this is not a problem. When conducting welfare analysis which relies on areas such as aP_0b in Figure 8, however, this is a serious problem. If curve S_0 in Figure 8 is drawn with a negative intercept, the notion of producer surplus as a welfare measure is, in our view, vacuous. Accordingly, we adjust our empirical supply curves to reflect a "constant elasticity of supply" over the relevant range. This is equivalent to assuming b (elasticity) is constant in the equation

$$Q = aP^b.$$

The parameter a is solved for in each year and fixes the position of the supply curve. This procedure appears justified in that our estimated elasticities are "mean" elasticities. The adjustment produces analytic supply curves with zero intercepts and convex from below.

The final information requirement for the analysis is for physical crop loss estimates to corn, soybeans and wheat from airborne residuals. As noted in the introduction, this work was performed by The Institute of Ecology (TIE) [1] and serves as input to our own analysis. Details concerning the estimation of crop losses may be had from the TIE reports [1].

TIE data consists of physical crop losses at three points in time; 1976, 1985, and 2000. To properly estimate cumulative welfare (monetary) losses to agricultural producers, it is necessary that we have annual loss estimates. The emissions and concentrations data provided to TIE by Teknekron Research, Inc. (TRI), as well as the methodology for estimation of physical crop losses, are roughly linear over the 1976-1985 and 1985-2000 periods. Losses, then, are the product of two linear schedules and linear interpolation can be used for intervening year estimates of physical losses. Accordingly, we estimate annual losses by using linear interpolation within each of the two subperiods. Losses are broken down by crop, by ORBES-portion of states, by pollutant, and in terms of total and utility-related losses.

SECTION 5

EMPIRICAL ESTIMATION OF MONETARY WELFARE LOSSES TO AGRICULTURAL PRODUCERS

The procedure for estimating monetarized welfare losses to ORBES-region agricultural producers from airborne residuals consists of several steps. The best way to illustrate the procedure is with a detailed example calculation. For that purpose, we describe below the method of calculating monetarized losses to Illinois (ORBES-portion) corn producers in 1984. Similar calculations are performed for the ORBES-portion of each state, each crop, each year, each scenario, for minimum, maximum, and probable losses. The example calculation is with respect to scenario #2 conditions and probable physical losses.

Four different calculations are performed for estimating 1984 monetarized losses to Illinois corn producers:

1. Monetary damage avoided due to implementation of SO_2 regulations.

2. Monetary damage remaining after implementation of SO_2 regulations.

3. Monetary damage attributable to power plant share in O_3 damages.

4. Total monetary damage due to all O_3 sources.

The following data are input to the calculations:

1. The constant real price of Illinois corn ($2.05 per bushel from Table 4).

2. Illinois corn production in the absence of SO_2 and O_3 pollution ("clean-air production" level of 1,087,859,915 bushels).

3. The corn price elasticity of supply (.18666 from Table 8).

4. Probable corn loss due to SO_2 pollution (calculated from data in TIE report [1]).

5. Probable corn loss from all sources of O_3 (calculated from data in TIE report [1]).

6. Percent of O_3 induced corn loss due to power plants (40% as provided to us by TIE researchers).

Two assumptions are made. First, the supply function is of the constant elasticity form, $Q = aP^b$, where Q is output of corn, P is price, b is the price elasticity of corn and a is a parameter implicitly defined by Q, P, and b. Secondly, we assume that crop losses increase or decrease at a constant rate between benchmark years (1976, 1985, and 2000).

SO_2 Monetary Estimates

With no further abatement over and above that realized in 1976, SO_2 corn losses are 263,265 bushels in 1976 and 263,990 bushels in 1985. The growth rate relating these losses is given by r in the equation

$$263{,}990 \text{ bu} = (263{,}265)e^{9r}.$$

The value of r is .00031 and estimated SO_2 physical losses in 1984 are

$$(263{,}265)e^{8(.00031)}$$

or 263,999 bushels. Corn output in 1984 would have been 1,087,596,006 bushels (1,087,859,915 - 263,909) if 1976 conditions prevailed throughout.

With SIP compliance (scenario #2), corn losses are 263,265 bushels in 1976 and 132,245 bushels in 1985. The growth rate between 1976 and 1985 is -.07650 and projected loss in 1984 is 142,760 bushels $=(263{,}265)e^{8(-.07650)}$. Corn production is estimated to be 1,087,716,155 bushels (=1,087,859,915 bushels - 142,760 bushels) in 1984.

The "pollution-free" output level is 1,087,859,915 in 1984. The reader is reminded that we assume the size of the agricultural sector is invariant over time so that the pollution-free output level for any year is always identical to the 1976 value.

Figure 9 illustrates the calculation of monetary damage in terms of areas. We define two areas of concern; damage avoided and remaining damage. Damage avoided is the monetary value of the difference between producer surplus if 1976 conditions had continued throughout the period and producer surplus with SIP compliance. This is represented by the area between supply curves L and M. Remaining damage is the difference in producer surplus between clean-air production conditions and conditions associated with SIP compliance (scenario #2) or the area between supply curves R and M. It is the remaining damage area that we report as the losses to Illinois corn producers in 1984. The damage avoided area is included in the discussion only for completeness in the analysis. One can think of the entire area between curves L and R as the damage that would have resulted from a scenario which asserts 1976 air quality continues throughout the entire period. Such a scenario was not analyzed in the ORBES project.

Each of the three supply functions has the form $Q = aP^b$ and the implied values of the a parameter for each curve is as follows: L, 952,509,635 bushels; M, 952,614,861 bushels; and R, 952,740,765 bushels.

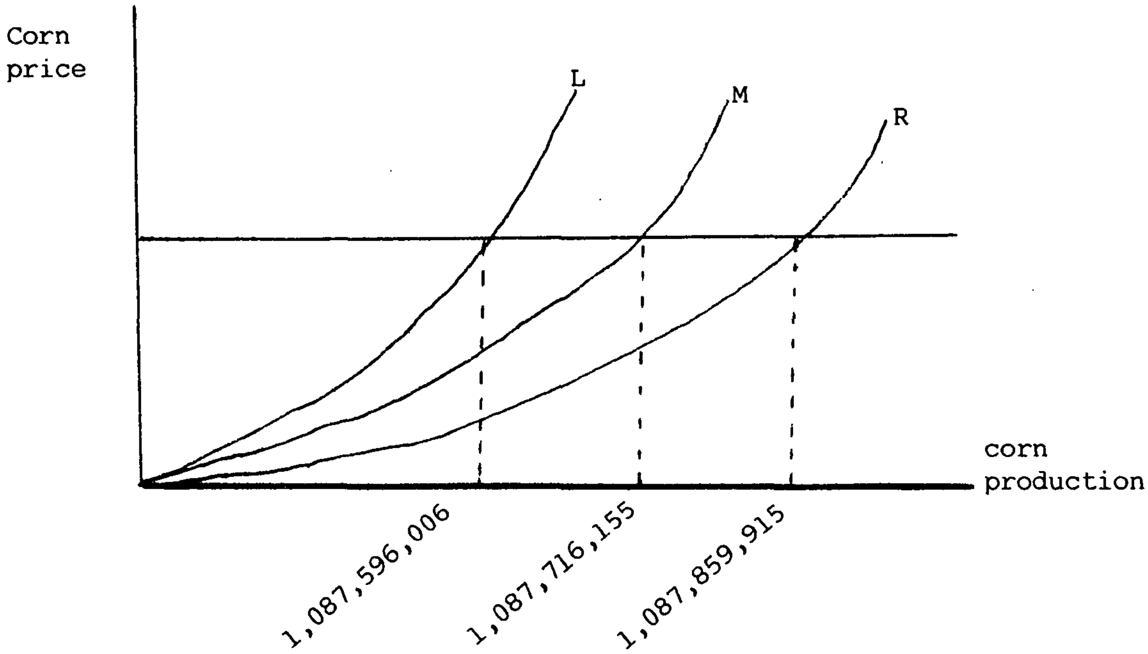


Figure 9

The area bounded by the price of corn, the vertical axis and any supply function is given by

$$\int_{0}^{\$2.03504} aP^{.18666}\,dP$$

or

$$= a\left(\frac{1}{1.18666}\right)(\$2.03504)^{1.18666}$$

where a takes on different values for L, M, and R. Each such area represents the appropriate measure of producer surplus for the relevant supply curve. In this instance, the areas are as follows: L, \$1,865,152,087; M, \$1,865,358,135; and R, \$1,865,604,673. The difference in areas define damages avoided and remaining damages. The former is the difference in areas as between L and M while the latter is between M and R. In this instance, damages avoided are \$206,048 and remaining damages are \$246,538. Remaining damages are what we report as monetarized agricultural loss estimates for Illinois corn producers from SO_2 levels in 1984. One way to view the benefits of SIP compliance under scenario #2 would have been to consider the difference between L and M as the benefits of compliance (\$206,048); benefits from not continuing with the same level of air pollution (SO_2) as was experienced in 1976. This perspective was not persued as the ORBES project does not analyze such a scenario. Conceptually, then, the damages reported are representative of the difference in consumer surplus between what would have been experienced with clean-air production levels and what is anticipated to occur under SIP compliance assumption of scenario #2.

O_3 Monetary Estimates

Corn losses due to O_3 are 8% of pollution-free output for 1976 and 11% for 1985. Thus, pollution losses are 87,028,793 bushels in 1976 and 119,664,591 bushels in 1985. The implied growth rate is given by r in the equation

$$119{,}664{,}591 \text{ bushels} = (87{,}028{,}793 \text{ bushels})e^{9r}$$ where

r is .03538 and the estimated loss in 1984 is

$$115{,}504{,}444 \text{ bushels} = (87{,}028{,}793 \text{ bushels})e^{8(.03538)}$$

Forty percent of this loss is attributed to power plants, some 46,201,777 bushels. Corn production in the presence of all sources of O_3 pollution is 972,355,471 bushels (=1,087,859,915 bushels - 115,504,444 bushels). If there were no power plant O_3 pollution, output would be 1,018,557,248 bushels = (972,355,471 bushels + 46,201,777 bushels). These estimates and the monetary damage due to all sources of O_3 pollution and that part attributed to power plants are illustrated in Figure 10.

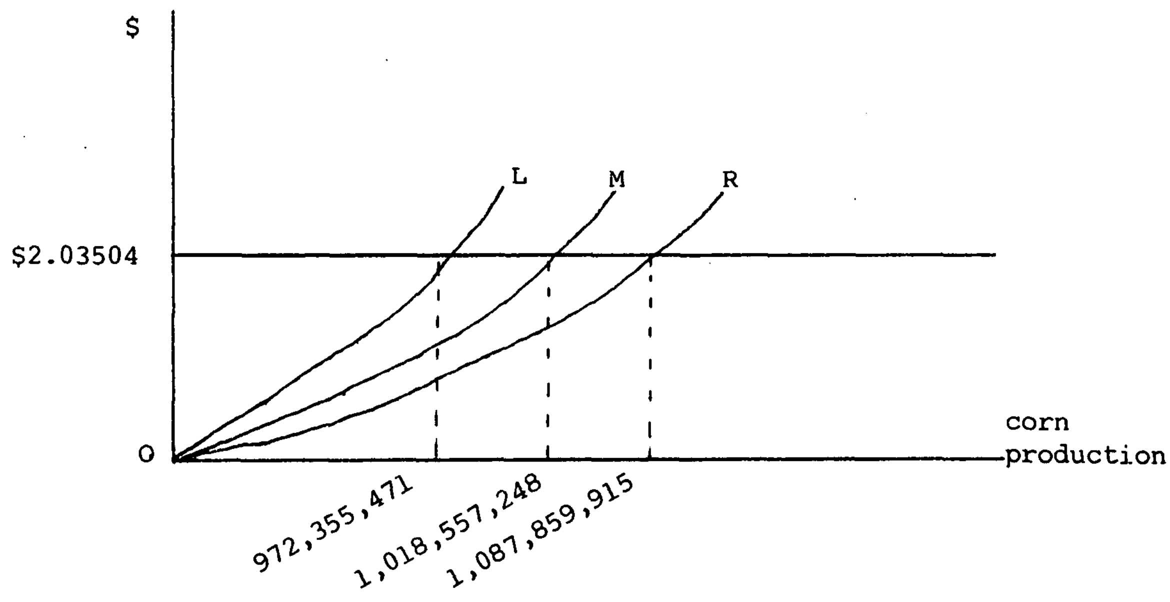


Figure 10

The monetary damage attributed to O_3 power plant pollution is the area between supply functions M and L. Total O_3 damage is the area between R and L. Before solving for these areas, we find the values of the "a" parameter in the equation $Q = aP^b$. These are given below.

Supply function	"a" parameter
L	851,582,711 bushels
M	892,045,932 bushels
R	952,740,765 bushels

The areas bounded by the supply functions, the price line, and the vertical axis are

Supply function	Areas bounded by price, vertical axis and supply function
L	$1,667,522,524
M	$1,746,755,383
R	$1,865,604,673

Total O_3 damage (R-L) is $198,082,149. Power plant damage (M-L) is $79,232,859.

Total monetary losses to Illinois corn producers in 1984 is the sum of SO_2 losses ($246,538) and total O_3 losses ($198,082,149) for the scenario #2 probable case. Losses attributable to utilities are SO_2 losses ($246,538) plus 40% of total O_3 losses ($79,232,859).

All results are in constant 1975 dollars with a 10% discount rate applied to annual losses.

The above procedure, then, is followed for each crop, each state, each scenario and for minimum, maximum, and probable estimates. Total damages to the ORBES region are calculated as the sum over the ORBES-portion of each state.

SECTION 6

DISCUSSION OF RESULTS

All results and quantitative interpretation of nominal load emission results are found in Tables 9 through 64 and Figures 11 through 28. Results for the peak load probable case are in Appendix A.

Table 9 contains present discounted value, by crop and area, of pollution-free cumulative production, 1976-2000. Tables 10-15 contain net present value of cumulative crop losses, 1976-2000, for scenario #2 in terms of total and utility related losses for minimum, maximum and probable cases. Tables 16-21 contain similar information to that in Table 10-15 except results are reported by individual crop. Tables 22 and 23 contain the same information as found in Tables 10-15 except losses by individual pollutant (SO_2 and O_3) are presented. For scenario #2, then, Tables 10-15 provide information on losses where damages to the three crops are aggregated as well as damages from both pollutants. Tables 16-21 provide similar information, but damages to individual crops are presented. Finally, Tables 22 and 23 isolate the damages by pollutant for the aggregate of the three crops. In all of the above tables, results are presented in terms of the net present value of cumulative losses (annual results are not presented). Tables 24-37 and 38-51 provide analagous information for, respectively, scenarios 2d and 7.

Tables 52 through 57 contain annual information on individual and aggregate crop losses, by scenario, for the probable damage case in terms of total and utility losses. These tables are in 1975 dollars but values are not discounted with the 10% rate. The purpose of the tables is to reveal the time trend (in 1975 dollars) of individual and aggregate monetarized crop losses, by scenario, for the probable case. Annual minimum and maximum loss tables are not presented as the time trend of such losses are identical to those for the probable case although the absolute values, of course, are different.

Tables 58 through 63 again present annual data as in Tables 52 through 57, except the data breaks out the aggregate three-crop damages in terms of SO_2 and O_3 and total damage.

The last table, Table 64, contains information on the benefits from compliance with SIP regulations (contrast between scenarios 2 and 2d). This table provides benefit calculations for the minimum, maximum and probable cases by crop area.

Figures 11 through 16 provide visual representation of the distribution of regional losses, both total and utility, across ORBES-portions of the six states for all three scenarios based on nominal load emissions. In each case, the first bar contains information on maximum, probable and minimum losses while the remaining bars portray the percent of aggregate three-crop loss percent shares for the ORBES-portion of each state, probable case. Minimum and maximum percentages are not shown as they are, for all practical purposes, identical to those for the two probable cases.

The last two sets of figures, Figures 17 through 22 and Figures 23 through 28, contain, respectively, computer plots of data found in Tables 52 to 57 and Tables 58 through 63. The plots are designed to provide the reader with a more intuitive grasp of the time trends of, respectively, annual losses by crop and annual aggregate crop losses by pollutant.

There obviously exists a great deal of information contained in these tables. Below we provide interpretation of those results which are thought most relevant or interesting in terms of the ORBES project. Interested readers may find other reported results of more relevance.

In general, we discuss our results with respect to probable losses. Minimum and maximum results are briefly discussed in order that the reader may understand the range of possible losses. Minimum and maximum results are presented in order that the reader may explore further the range of results. For the most part, however, we think the probable estimates are the most likely outcome to be experienced in the context of the ORBES scenarios.

Losses Based on Nominal Load Emissions

As a percent of probable losses, the total regional losses for the minimum and maximum cases are, respectively, 65.2% and 161.5% of the probable losses for scenario #2. For losses uniquely attributable to utilities, the corresponding percentages are 49 and 201.7. For scenario 2d (non-compliance with SIPs), minimum and maximum estimates for total losses are, respectively, 65.1% and 161.5% of the probable loss while corresponding percentages for utility related losses are 48.6 and 201.6. Finally, for scenario 7 (high growth in electric demand and 45 year plant life), minimum and maximum total losses are, respectively, 66.7% and 160.7% of probable losses while for utilities the corresponding percentages are 73.7 and 266.2. There exists, then, rather a large range in estimates as between minimum and maximum cases. This range in monetary values is attributable to the range in physical crop damages reported by TIE [see 1]. These absolute amounts correspond to the percentages represented in the first bar of each bar graph in Figures 11 through 16.

Most results reported here (except annual results) are relative to the present discounted value of pollution-free cumulative value of production, 1976-2000 (Table 9). These calculations reveal the present value of producer surplus from corn, soybean and wheat production in the ORBES-region, by state and for the region, if production levels were consistent with clean-air and were constant through time. The cumulative value of clean-air production is unevenly distributed over the region with respect to crops and ORBES-portion of states. In terms of the three-crop total value, approximately 78% of clean-air value is concentrated in Illinois and Indiana and 93% in Illinois, Indiana, and Ohio. Corn alone accounts for 57% of total clean-air discounted value and corn and soybeans together account for 94%. Clearly, wheat is a minor crop in the ORBES region and ORBES-portions of Kentucky, Pennsylvania, and West Virginia minor producers of all crops. One expects, then, that losses will be concentrated both by crop and by ORBES-portions of states.

The discounted present value of probable cumulative total crop losses under scenario #2 are 11.9% of the corresponding value of clean-air production. Utility losses are 4.8% of the value of clean-air production. These values are largely invariant across scenarios: In scenario #2d, total and utility losses, respectively, are 12% and 4.8% of clean-air production while corresponding percentages in the case of scenario #7 are 12.3 and 4.2. The first important conclusion, then, is that probable total crop losses, 1976-2000, are approximately 12% of the discounted present value of clean-air production and utility related losses approximately 4.8%. These percentages are invariant with respect to alternative assumptions concerning utility compliance with SIPs (scenarios 2 and 2d) or alternative rates of regional growth (scenarios 2 and 7) in electric demand.

The distribution across the ORBES-portions of states of total and utility losses are also invariant with respect to the three scenarios. In the case of scenario #2, the percent of total regional losses attributable to ORBES-portions of states for, respectively, Illinois, Indiana, Kentucky, Ohio, Pennsylvania and West Virginia, are 53.6, 25.1, 6.9, 14, 0.4 and 0.1. With respect to utility losses, the corresponding percentages are 53.6, 25, 6.9, 14, 0.4, and 0.1 (Tables 14 and 15). The percentages are almost identical for scenarios 2d and 7 (Tables 28, 29, 42 and 43). Similarly, losses are invariant in the case of minimum and maximum losses. The three-crop total losses, then, are highly concentrated: Illinois and Indiana accounting for approximately 78.6% of total ORBES-region losses and Illinois, Indiana, and Ohio accounting for 92.6% of losses. This conclusion is invariant with respect to the three scenarios considered in this work and reflects the spatial distribution of losses for both total and utility related cases.

Figures 11 through 16 provide visual representation of the above data for the cases of total and utility related probable losses. As noted earlier, minimum and maximum percent bar graphs are not presented as the distribution across ORBES-portions of states is virtually identical.

The distribution of regional losses by crop is also unevenly distributed for the minimum, maximum and probable cases, although invariant with respect to scenario conditions. For the probable case (Tables 20, 21, 34, 35, 48, and 49), total and utility related regional losses for scenario #2 are, respectively, 40% and 39.9% for corn, 56.7% and 56.7% for soybeans and 3.4% and 3.4% for wheat. In percentage terms, the largest regional losses, then, occur in the case of soybeans, the second largest in corn and the least in wheat production. With respect to both total and utility related losses, corn and soybean losses dominate the total: 96.7% for total losses and 96.6% for utility related losses. This distribution of losses tends to reflect the prominent role of both corn and soybeans in the region and the relatively minor role of wheat production. It also reflects the concentration of pollution-free production of corn and soybeans in Illinois, Indiana, and Ohio.

In terms of the three-crop losses associated with the two pollutants, SO_2 and O_3 , the conclusions are quite clear: O_3 damages dominate both total and utility-related damages in the ORBES region. For the probable case, scenario #2, regional-wide total and utility losses, respectively, from O_3 constitute 99.7% and 99.4% of total SO_2 and O_3 damages while corresponding percentages for scenarios 2d and 7, respectively, are 99.5% and 98.0% and 99.7% and 99.4%.

Tables 52 and 57 provide information on the annual losses by crop, scenario, and total versus utility related, from SO_2 and O_3 concentrations in the region. The reader is reminded that these data are in terms of 1975 dollars but are not discounted to present value. Figures 17 through 22 provide computer plots of that data found in Tables 52 through 57. Examination of the undiscounted annual data provides two important conclusions; (1) undiscounted monetary losses for moderate growth in electric demand (scenarios 2 and 2d) level off after approximately 1985 with respect to both total and utility losses as well as by crop and (2) high growth in electric demand entails an increasing value of undiscounted losses, both total and by crop, through year 2000. Examination of annual undiscounted monetary losses provides the only case where results are different as between the three scenarios examined. In the cases of scenarios 2 and 2d, year 2000 undiscounted losses are approximately 61% greater than losses experienced in 1976 whereas in scenario 7 they are 87.3% higher than the 1976 level. The reader is reminded, however, that the present discounted losses are of the present value of discounted clean-air production is only marginally higher for scenario 7 as compared with scenario 2 (8.5% compared with 8.4%). Nonetheless, the time trend of monetary losses is distinctly different for scenario 7 as compared with scenarios 2 and 2d and reflects the larger capacity requirements in the region for scenario 7. The reason for the small difference in the present value of losses as a percent of clean-air production relates, of course, to the use of a discount rate.

Tables 58 through 63 provide annual loss information for the region (probable case) in terms of aggregate three-crop damage attributable to SO_2 and O_3. Figures 23 through 28 provide computer plots of the corresponding data. Again, the reader is reminded that the data in Tables 58 through 63 are not discounted values. It is almost always true that the difference between total and O_3 damages in Figures 23 through 28 is so slight that the plotting routine fails to pick up the O_3 contribution; it generally is 98% or more of total damages. The figures, then, graphically portray the overwhelming contribution of O_3 to total damages in the ORBES region for the probable case (the same is true for the minimum and maximum cases). As the damages by crop portrayed in earlier figures leveled off by 1985 for scenario 2 and 2d, the same pattern emerges with respect to the three-crop total and O_3 contributions for those scenarios. Again, however, the total damages for the high electric growth scenario (scenario 7) continue to rise through year 2000, although almost all the incremental increase is attributable to O_3 damages. This is true for both the total and utility related damages.

The final results reported are found in Table 64. The purpose of these calculations is to assess the benefits which accrue from SIP compliance (scenario 2) as contrasted with non-compliance (scenario 2d). As O_3 contributions from utilities are virtually identical under both scenarios, the benefit is wholly related to compliance with SO_2 SIP regulations. The benefits are very small: benefits as a percent of total clean-air production for the minimum, maximum and probable cases, respectively, are 0.6%, 4.2%, and 2.3%.

Several general conclusions emerge from above results. First, monetary losses to agricultural producers in the ORBES region are on the order of 12% of the present discounted value of clean-air production. Second, similarly defined losses from utilities are on the order of 4.8%. Third, losses are highly concentrated in the ORBES-portion of Illinois, Indiana, and Ohio and primarily related to soybean and corn production. Fourth, the overwhelming monetary losses are attributable to O_3 concentrations in the region. Fifth, high growth in electric demand produces annual losses (undiscounted) which rise through year 2000 while scenarios 2 and 2d level-off after 1985. And sixth, all of the above trends are true with respect to minimum, maximum, or probable monetary losses.

Appendix Tables A-1 to A-3 provide the summary results on regional agricultural losses based on peak load rather than nominal load emissions. The tables contain total losses by ORBES-portions of states as well as utility related losses and reveal the percent losses are of pollution-free output for the region and ORBES-portions of states as well as the percent ORBES-portions of state losses are of total regional losses. In the table footnotes will be found the calculations of the distribution of regional losses as between SO_2 and O_3 damages. Extensive tables for these calculations are not presented because they tend to reflect the same conditions as the main tables in the text related to nominal load emissions.

Examining Tables A-1 through A-3, the only major difference observed between economic losses using peak load emissions and those using nominal load emissions is that losses as a percent of pollution-free output are uniformly on the order of 2% lower for the case of peak load emissions, scenarios 2 and 2d. The distribution of these losses by crop and by ORBES-portions of states tends to be identical to the results reported in the text as is the range for minimum and maximum losses relative to probable losses. The only case in which losses as a percent of pollution-free output are almost identical as between calculations based on peak load and nominal load emissions occurs with respect to the high growth scenario, scenario #7.

The conclusion when comparing regional losses using peak or nominal load emissions, then, is that for compliance or non-compliance scenarios the use of peak load emissions results in a present discounted value of losses approximately 2% less than was the case with nominal load emissions, whereas in the high growth scenario the loss value as a percent of pollution-free value are almost identical for both cases. As noted in the introduction, it is not the province of the present authors to determine whether peak or nominal load emissions should be used for the estimation of physical crop damages. That determination is left to others in the project or to the reader.

TABLE 1. SEASONAL AVERAGE PRICES FOR CORN
(Dollars)

Year	Illinois	Indiana	Kentucky	Ohio	Pennsylvania	West Virginia
1965	1.09	1.06	1.23	1.08	1.36	1.35
1966	1.30	1.28	1.40	1.30	1.54	1.43
1967	1.04	1.02	1.16	1.04	1.20	1.25
1968	1.06	1.03	1.18	1.03	1.23	1.26
1969	1.14	1.11	1.26	1.15	1.33	1.34
1970	1.42	1.40	1.56	1.40	1.53	1.50
1971	1.08	1.03	1.12	1.06	1.31	1.24
1972	1.34	1.28	1.44	1.33	1.57	1.48
1973	2.50	2.40	2.50	2.45	2.60	2.50
1974	3.00	3.00	3.00	3.00	3.00	3.25
1975	2.50	2.40	2.55	2.40	2.50	2.65
1976	2.35	2.25	2.35	2.25	2.50	2.50
1977	2.15	2.00	2.30	1.95	2.35	2.05
1978	2.15	2.15	2.35	2.15	2.45	2.20

SOURCE: Agricultural Prices, Annual Summaries 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

TABLE 2. SEASONAL AVERAGE PRICES FOR SOYBEANS
(Dollars)

Year	Illinois	Indiana	Kentucky	Ohio	Pennsylvania	West Virginia
1965	2.55	2.50	2.45	2.50	--	--
1966	2.80	2.80	2.75	2.80	--	--
1967	2.50	2.50	2.45	2.55	--	--
1968	2.45	2.35	2.40	2.40	--	--
1969	2.35	2.30	2.30	2.35	--	--
1970	2.90	2.80	2.80	2.85	--	--
1971	3.05	3.00	3.00	3.05	--	--
1972	4.30	3.90	4.00	4.00	--	--
1973	5.65	5.65	5.55	5.65	--	--
1974	6.60	7.00	6.95	6.70	--	--
1975	4.70	4.70	4.65	4.65	--	--
1976	7.60	6.95	7.10	7.40	--	--
1977	5.90	5.50	6.20	5.65	--	--
1978	6.65	6.75	6.70	6.75	--	--

SOURCE: Agricultural Prices, Annual Summaries 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

TABLE 3. SEASONAL AVERAGE PRICES FOR WHEAT
(Dollars)

Year	Illinois	Indiana	Kentucky	Ohio	Pennsylvania	West Virginia
1965	1.35	1.32	1.34	1.39	1.35	1.63
1966	1.75	1.71	1.58	1.71	1.65	1.64
1967	1.40	1.29	1.39	1.31	1.31	1.49
1968	1.20	1.11	1.22	1.14	1.14	1.23
1969	1.18	1.14	1.22	1.19	1.27	1.27
1970	1.30	1.31	1.33	1.41	1.42	1.40
1971	1.40	1.33	1.47	1.35	1.49	1.56
1972	1.47	1.40	1.45	1.55	1.55	1.70
1973	3.00	3.00	3.05	3.80	3.30	3.40
1974	3.85	3.95	3.70	4.00	3.65	3.75
1975	3.15	3.20	3.00	3.25	2.95	3.10
1976	3.05	3.00	2.95	2.90	3.00	3.00
1977	2.10	2.20	2.00	2.15	2.40	2.20
1978	3.05	3.00	3.15	3.20	3.30	3.00

SOURCE: Agricultural Prices, Annual Summaries 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

TABLE 4. WEIGHTED PRICES, BY CROP AND STATE FOR THE SIX-STATE REGION, 1965-78*
(1975 dollars)

State	Corn	Soybeans	Wheat
IL	2.04	5.08	2.49
IN	1.98	4.98	2.51
KY	2.16	5.31	2.52
OH	1.99	5.09	2.57
PA	2.27	--	2.48
WV	2.29	--	2.53

SOURCES: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia Crop Reporting Services, Agricultural Statistics, 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

Agricultural Prices, Annual Summaries 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

* Weights are calculated as the percent that each year's output is of the states total production, 1965-78. All prices are in constant 1975 dollars.

TABLE 5. SIX-STATE CROP PRODUCTION, 1965-78:
CORN
(1,000 bushels)

Year	IL	IN	KY	OH	PA	WV	Six-state total production
1965	919,038	441,894	72,381	225,996	55,760	2,900	1,717,969
1966	848,044	396,006	65,018	261,660	32,928	2,256	1,605,912
1967	1,121,952	462,852	93,440	255,960	81,048	3,584	2,018,836
1968	907,920	416,768	69,366	248,024	56,700	2,773	1,701,551
1969	989,196	462,000	72,765	241,251	76,384	3,479	1,845,075
1970	735,560	374,148	46,950	240,160	81,346	3,551	1,481,715
1971	1,067,420	556,409	91,091	322,595	77,700	4,071	2,119,286
1972	1,014,750	507,936	83,248	284,280	64,800	3,975	1,958,989
1973	981,590	534,480	85,850	243,200	81,120	5,229	1,931,469
1974	811,800	387,630	88,150	265,500	89,100	5,016	1,647,196
1975	1,253,960	551,740	87,780	310,620	88,560	5,525	2,298,185
1976	1,240,130	693,000	138,720	393,460	103,500	5,368	2,574,178
1977	1,163,400	633,420	132,300	380,100	106,720	3,996	2,419,936
1978	1,191,030	637,200	119,850	379,050	113,050	4,466	2,444,646

SOURCE: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia Crop Reporting Services, Agricultural Statistics, 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

TABLE 6. SIX-STATE CROP PRODUCTION, 1965-78:
SOYBEANS
(1,000 bushels)

Year	IL	IN	KY	OH	PA	WV	Six-state total production
1965	177,620	80,388	7,080	50,078	-	-	315,166
1966	160,407	73,164	7,750	59,992	-	-	301,313
1967	186,279	71,001	10,864	50,198	-	-	318,342
1968	209,884	103,872	12,349	70,913	-	-	397,018
1969	228,820	105,952	12,600	73,013	-	-	420,385
1970	210,800	101,618	14,310	72,675	-	-	399,403
1971	235,950	111,441	20,798	80,337	-	-	448,526
1972	259,440	108,796	23,598	79,765	-	-	471,599
1973	287,595	135,135	26,000	91,545	-	-	540,275
1974	206,780	97,250	24,990	81,640	-	-	410,660
1975	299,520	119,790	29,700	102,300	-	-	551,310
1976	249,480	111,520	28,890	95,040	-	-	484,930
1977	336,300	144,300	40,920	119,990	-	-	641,510
1978	303,270	140,420	42,300	123,750	-	-	609,740

SOURCE: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia Crop Reporting Services, Agricultural Statistics, 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

TABLE 7. SIX-STATE CROP PRODUCTION, 1965-78:
WHEAT
(1,000 bushels)

Year	IL	IN	KY	OH	PA	WV	Six-state total production
1965	56,800	36,205	5,376	40,256	14,280	522	153,439
1966	61,008	44,616	5,780	46,137	14,400	484	172,425
1967	71,955	45,769	7,854	51,476	17,280	740	195,074
1968	51,208	34,195	6,240	44,850	12,000	496	148,989
1969	48,374	34,800	5,746	38,646	10,650	462	138,678
1970	38,110	28,144	5,724	35,150	9,075	518	116,721
1971	46,000	31,924	7,200	41,536	9,396	420	136,476
1972	54,000	39,648	7,020	46,305	8,608	385	155,966
1973	39,000	24,605	5,412	25,600	7,392	279	102,288
1974	51,900	50,040	11,340	59,450	11,520	396	184,646
1975	67,470	64,500	10,880	70,560	10,144	352	223,906
1976	72,150	54,000	10,230	64,000	9,000	352	209,732
1977	67,510	55,800	10,138	72,380	8,910	310	215,048
1978	35,340	31,785	6,825	43,875	8,085	297	126,207

SOURCE: Illinois, Indiana, Kentucky, Ohio, Pennsylvania, and West Virginia Crop Reporting Services, Agricultural Statistics, 1965-78, Crop Reporting Board, Economic Statistics and Cooperatives Service, U.S. Department of Agriculture.

TABLE 8. ESTIMATED SUPPLY ELASTICITIES FOR CORN, SOYBEANS, AND WHEAT PRODUCTION IN THE OHIO RIVER BASIN ENERGY STUDY REGION

Variable	Estimated coefficient	t-Ratio*	Elasticity	Adjusted R^2
		Corn		
Q^c_{t-1}	.61913	2.7324	.61138	.8458
P^c_{t-1}	2349.2	2.8005	.18666	
P^s_{t-1}	-453.73	-1.0510	$-.89215 \times 10^{-1}$	
t	-13.062	-.11021	-1.2189	
intercept	31901.0	.13761	1.5096	
		Soybeans		
Q^s_{t-1}	.88368	11.320	.85029	.9935
P^s_{t-1}	954.53	6.3970	.26297	
P^c_{t-1}	-3343.1	-11.742	-.38037	
t	172.04	3.3210	22.989	
intercept	$-.33529 \times 10^6$	-3.3090	22.720	
		Wheat		
Q^w_{t-1}	.25636	3.2818	.26217	.9475
P^w_{t-1}	1166.9	11.048	.55956	
t	-173.41	-7.4699	-80.751	
intercept	$.34273 \times 10^6$	7.5033	80.932	

* Underlined values are significant at the 95% level.

TABLE 9. PRESENT DISCOUNTED VALUE OF POLLUTION-FREE CUMULATIVE PRODUCTION, 1976-2000*
(millions of 1975 dollars)

ORBES area	Corn	Soybeans	Wheat	Three crop total
IL	19891.895	14151.809	1574.944	35618.648
IN	10594.992	5860.365	1210.970	17666.326
KY	2469.632	1812.788	252.171	4534.591
OH	5155.554	3492.335	1055.882	9703.771
PA	388.398	0	27.554	365.952
WV	55.160	0	2.737	57.897
ORBES total	38505.632	25317.297	4124.257	67947.185

* Assumes a 10% discount rate.

≁ Calculations assume annual pollution-free output, 1976-2000, is always equal to 1976 pollution-free output and agricultural prices for the crops, in real terms, are unchanged.

TABLE 10. NET PRESENT VALUE OF MINIMUM CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2*

ORBES area	Total losses† (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	2855.740	8.0	54.0
IN	1314.390	7.4	24.8
KY	364.410	8.0	6.9
OH	734.531	7.6	13.9
PA	17.644	4.8	0.3
WV	2.828	4.9	0.1
ORBES total	5289.550	7.8	100.0§

* Assumes a 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 11. NET PRESENT VALUE OF MINIMUM CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO2*

ORBES area	Total utility losses≁ (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	861.486	2.4	54.0
IN	396.626	2.2	24.9
KY	110.555	2.4	6.9
OH	220.885	2.3	13.8
PA	5.302	1.4	0.3
WV	0.851	1.5	0.1
ORBES total	1595.700	2.3	100.0§

* Assumes a 10% discount rate.

≁ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 12. NET PRESENT VALUE OF MAXIMUM CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2*

ORBES area	Total losses≁ (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	7019.260	19.7	53.6
IN	3292.800	18.6	25.1
KY	899.155	19.8	6.9
OH	1829.630	18.9	14.0
PA	51.309	14.0	0.4
WV	8.277	14.3	0.1
ORBES total	13100.400	19.3	100.0§

* Assumes a 10% discount rate.

≁ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 13. NET PRESENT VALUE OF MAXIMUM CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2*

ORBES area	Total utility losses≠ (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	3520.310	10.0	53.6
IN	1648.080	9.3	25.1
KY	454.121	10.0	6.9
OH	916.194	9.4	13.9
PA	25.762	7.0	0.4
WV	4.198	7.3	0.1
ORBES total	6568.660	9.7	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 14. NET PRESENT VALUE OF PROBABLE CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3. SCENARIO 2*

ORBES area	Total losses≠ (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	4349.100	12.2	53.6
IN	2032.810	11.5	25.1
KY	557.455	12.3	6.9
OH	1136.640	11.7	14.0
PA	30.324	8.3	0.4
WV	4.859	8.4	0.1
ORBES total	8111.190	11.9	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 15. NET PRESENT VALUE OF PROBABLE CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2*

ORBES area	Total utility losses≠ (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	1747.130	4.9	53.6
IN	814.237	4.6	25.0
KY	226.088	5.0	6.9
OH	455.411	4.7	14.0
PA	12.180	3.3	0.4
WV	1.971	3.4	0.1
ORBES total	3257.020	4.8	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 16. NET PRESENT VALUE OF MINIMUM TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	992.573	5.0	2.6	51.7
IN	528.645	5.0	1.4	27.5
KY	123.261	5.0	0.3	6.4
OH	257.255	5.0	0.7	13.4
PA	16.886	5.0	§	0.9
WV	2.753	5.0	§	0.1
ORBES total	1921.370	5.0	5.0#	100.0**
		Soybeans		
IL	1819.880	12.9	7.2	55.9
IN	752.463	12.8	3.0	23.1
KY	234.218	12.9	0.9	7.2
OH	448.257	12.8	1.8	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	3254.820	12.9	12.9#	100.0**

(continued)

TABLE 16 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	43.292	2.7	1.0	38.2
IN	33.281	2.7	0.8	29.4
KY	6.931	2.7	0.2	6.1
OH	29.019	2.7	0.7	25.6
PA	0.757	2.7	§	0.1
WV	0.075	2.8	§	0.1
ORBES total	113.356	2.7	2.7#	100.0**

TABLE 17 NET PRESENT VALUE OF MINIMUM UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	992.573	1.5	0.8	51.7
IN	528.645	1.5	0.4	27.5
KY	37.007	1.5	0.1	6.4
OH	77.194	1.5	0.2	13.4
PA	5.067	1.5	§	0.9
WV	0.827	1.5	§	0.1
ORBES total	576.532	1.5	1.5#	100.0**
		Soybeans		
IL	548.748	3.9	2.2	55.9
IN	226.081	3.9	0.9	23.1
KY	71.392	3.9	0.3	7.3
OH	134.573	3.9	0.5	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	980.794	3.9	3.9#	100.0**

(continued)

TABLE 17 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	12.997	0.8	0.3	38.2
IN	9.987	0.8	0.2	29.4
KY	2.081	0.8	0.1	6.1
OH	8.708	0.8	0.2	25.6
PA	0.227	0.8	§	0.7
WV	0.022	0.8	§	0.1
ORBES total	34.022	0.8	0.8#	100.0**

TABLE 18. NET PRESENT VALUE OF MAXIMUM TOTAL CUMULATIVE CROP LOSSES 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	2853.560	14.3	7.4	51.7
IN	1517.640	14.3	3.9	27.5
KY	356.987	14.5	0.9	6.5
OH	739.787	14.3	1.9	13.4
PA	48.621	14.4	0.1	0.9
WV	8.005	14.5	§	0.1
ORBES total	5524.600	14.3	14.3#	100.0**
		Soybeans		
IL	4011.960	28.3	15.8	55.9
IN	1657.510	28.3	6.5	23.1
KY	517.557	28.6	2.0	7.2
OH	987.250	28.3	3.9	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	7174.280	28.3	28.3#	100.0**

(continued)

TABLE 18 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	153.746	9.8	3.7	38.3
IN	117.636	9.7	2.9	29.3
KY	24.611	9.8	0.6	6.1
OH	102.594	9.7	2.5	25.5
PA	2.688	9.8	0.1	0.7
WV	0.273	10.0	§	0.1
ORBES total	401.548	9.7	9.7#	100.0**

TABLE 19. NET PRESENT VALUE OF MAXIMUM UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	1430.270	7.2	3.7	51.6
IN	759.552	7.2	2.0	27.4
KY	180.281	7.3	0.5	6.5
OH	370.898	7.2	1.0	13.4
PA	24.408	7.2	0.1	0.9
WV	4.058	7.4	§	0.1
ORBES total	2769.460	7.2	7.2#	100.0**
		Soybeans		
IL	2012.590	14.2	7.9	55.9
IN	829.554	14.2	3.3	23.1
KY	261.446	14.4	1.0	7.3
OH	493.852	14.1	2.0	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	3597.440	14.2	14.2#	100.0**

(continued)

TABLE 19 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	77.451	4.9	1.9	38.4
IN	58.973	4.9	1.4	29.2
KY	12.395	4.9	0.3	6.1
OH	51.444	4.9	1.2	25.5
PA	1.353	4.9	§	0.7
WV	0.140	5.1	§	0.1
ORBES total	201.757	4.9	4.9#	100.0**

TABLE 20. NET PRESENT VALUE OF PROBABLE TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	1672.120	8.4	4.3	51.7
IN	889.773	8.4	2.3	27.5
KY	208.645	8.4	0.5	6.4
OH	433.459	8.4	1.1	13.4
PA	28.474	8.4	0.1	0.9
WV	4.671	8.5	§	0.1
ORBES total	3237.150	8.4	8.4#	100.0**
		Soybeans		
IL	2571.210	18.2	10.2	55.9
IN	1062.070	18.1	4.2	23.1
KY	331.879	18.3	1.3	7.2
OH	632.567	18.1	2.5	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	4597.730	18.2	18.2#	100.0**

(continued)

TABLE 20 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output†	Percent losses are of ORBES total pollution-free crop output†	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	105.759	6.7	2.6	38.3
IN	80.966	6.7	2.0	29.3
KY	16.931	6.7	0.4	6.1
OH	70.613	6.7	1.7	25.6
PA	1.850	6.7	§	0.7
WV	0.187	6.8	§	0.1
ORBES total	276.306	6.7	6.7#	100.0**

TABLE 21. NET PRESENT VALUE OF PROBABLE TOTAL UTILITY CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss#
		Corn		
IL	670.425	3.4	1.7	51.6
IN	356.243	3.4	0.9	27.4
KY	84.283	3.4	0.2	6.5
OH	173.842	3.4	0.5	13.4
PA	11.433	3.4	§	0.9
WV	1.894	3.4	§	0.1
ORBES total	1298.120	3.4	3.4#	100.0**
		Soybeans		
IL	1033.980	7.3	4.1	56.0
IN	425.495	7.3	1.7	23.0
KY	134.967	7.4	0.5	7.3
OH	253.216	7.3	1.0	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	1847.660	7.3	7.3#	100.0**

(continued)

TABLE 21 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	42.724	2.7	1.0	38.4
IN	32.498	2.7	0.8	29.2
KY	6.838	2.7	0.2	6.1
OH	28.353	2.7	0.7	25.5
PA	0.746	2.7	§	0.7
WV	0.078	2.8	§	0.1
ORBES total	111.237	2.7	2.7#	100.0**

TABLE 22. NET PRESENT VALUE OF TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, BY POLLUTANT: SCENARIO 2*

ORBES area	SO_2 losses† (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses† (millions of dollars)	Percent O_3 losses are of area total losses‡
		Minimum losses		
IL	4.077	0.1	2851.670	99.9
IN	0.511	§	1313.880	100.0
KY	1.652	0.5	362.758	99.5
OH	0.164	§	734.367	100.0
PA	0.002	§	17.641	100.0
WV	0.001	§	2.827	100.0
ORBES total	6.408	0.1	5283.140	99.9
		Maximum losses		
IL	21.329	0.3	6997.930	99.7
IN	3.373	0.1	3289.420	99.9
KY	9.088	1.0	890.067	99.0
OH	2.756	0.2	1826.880	99.8
PA	0.214	0.4	51.096	99.6
WV	0.119	1.4	8.159	98.6
ORBES total	36.877	0.3	13063.600	99.7

(continued)

TABLE 22 (continued)

ORBES area	SO_2 losses≠ (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses≠ (millions of dollars)	Percent O_3 losses are of area total losses‡
		Probable losses		
IL	12.495	0.3	4336.600	99.7
IN	1.854	0.1	2030.960	99.9
KY	5.176	0.9	552.280	99.1
OH	1.257	0.1	1135.380	99.9
PA	0.084	0.3	30.240	99.7
WV	0.047	1.0	4.812	99.0
ORBES total	20.912	0.3	8090.270	99.7

* Assumes 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ For total losses, see Tables

§ Less than .05%.

TABLE 23. NET PRESENT VALUE OF UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, BY POLLUTANT: SCENARIO 2*

ORBES area	SO_2 losses† (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses† (millions of dollars)	Percent O_3 losses are of area total losses‡
		Minimum losses		
IL	4.077	0.5	855.499	99.5
IN	0.511	0.1	394.163	99.9
KY	1.652	1.5	108.827	98.5
OH	0.164	0.1	220.310	99.9
PA	0.002	§	5.292	100.0
WV	0.001	0.1	0.848	99.9
ORBES total	6.408	0.4	1584.940	99.6
		Maximum losses		
IL	21.329	0.6	3498.980	99.4
IN	3.373	0.2	1644.710	99.8
KY	9.088	2.0	445.034	98.0
OH	2.756	0.3	913.438	99.7
PA	0.214	0.8	25.548	99.2
WV	0.119	2.8	4.079	97.2
ORBES total	36.877	0.6	6531.790	99.4

(continued)

TABLE 23 (continued)

ORBES area	SO_2 losses† (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses† (millions of dollars)	Percent O_3 losses are of area total losses‡
		Probable losses		
IL	12.495	0.7	1734.640	99.3
IN	1.854	0.2	812.383	99.8
KY	5.176	2.3	220.912	97.7
OH	1.257	0.3	454.154	99.7
PA	0.084	0.7	12.096	99.3
WV	0.047	2.4	1.925	97.6
ORBES total	20.912	0.6	3236.110	99.4

* Assumes 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ For total losses, see Tables

§ Less than .05%.

TABLE 24. NET PRESENT VALUE OF MINIMUM CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2d*

ORBES area	Total losses≁ (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	2857.650	8.0	54.0
IN	1316.340	7.5	24.9
KY	364.486	8.0	6.9
OH	734.941	7.6	13.9
PA	17.651	4.8	0.3
WV	2.830	4.9	0.1
ORBES total	5293.900	7.8	100.0§

* Assums a 10% discount rate.

≁ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 25. NET PRESENT VALUE OF MINIMUM CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2d*

ORBES area	Total utility losses≠ (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	859.576	2.4	54.0
IN	394.674	2.2	24.8
KY	110.480	2.4	6.9
OH	220.475	2.3	13.9
PA	5.295	1.4	0.3
WV	0.849	1.5	0.1
ORBES total	1591.350	2.3	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 26. NET PRESENT VALUE OF MAXIMUM CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2d*

ORBES area	Total losses† (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	7030.850	19.7	53.6
IN	3305.480	18.7	25.2
KY	899.582	19.8	6.9
OH	1832.650	18.9	14.0
PA	51.891	14.2	0.4
WV	8.349	14.4	0.1
ORBES total	13128.800	19.3	100.0

* Assumes a 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 27. NET PRESENT VALUE OF MAXIMUM CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2d*

ORBES area	Total utility losses† (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	3531.890	9.9	53.3
IN	1660.760	9.4	25.2
KY	454.548	10.0	6.9
OH	919.212	9.5	13.9
PA	26.343	7.2	0.4
WV	4.269	7.4	0.1
ORBES total	6597.030	9.7	100.0§

* Assumes a 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 28. NET PRESENT VALUE OF PROBABLE CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2d*

ORBES area	Total losses≠ (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	4355.690	12.2	53.6
IN	2039.810	11.5	25.1
KY	557.691	12.3	6.9
OH	1138.240	11.7	14.0
PA	30.575	8.4	0.4
WV	4.886	8.4	0.1
ORBES total	8126.900	12.0	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 29. NET PRESENT VALUE OF PROBABLE CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2d*

ORBES area	Total utility losses† (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	1753.730	4.9	53.6
IN	821.242	4.6	25.1
KY	226.323	5.0	6.9
OH	457.013	4.7	14.0
PA	12.430	3.4	0.4
WV	1.999	3.5	0.1
ORBES total	3272.74	4.8	100.0§

* Assumes a 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table

§ Sum may not be 100% due to rounding.

TABLE 30. NET PRESENT VALUE OF MINIMUM TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2d

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	992.623	5.0	2.6	51.7
IN	528.709	5.0	1.4	27.5
KY	123.262	5.0	0.3	6.4
OH	257.274	5.0	0.7	13.4
PA	16.892	5.0	§	0.9
WV	2.754	5.0	§	0.1
ORBES total	1921.510	5.0	5.0#	100.0**
		Soybeans		
IL	1821.720	12.9	7.2	55.9
IN	754.338	12.9	3.0	23.1
KY	234.292	12.9	0.9	7.2
OH	448.646	12.8	1.8	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	3259.000	12.9	12.9#	100.0**

(continued)

TABLE 30 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	43.306	2.7	1.1	38.2
IN	33.294	2.7	0.8	29.4
KY	6.932	2.7	0.2	6.1
OH	29.022	2.7	§	25.6
PA	0.759	2.8	0.7	0.7
WV	0.075	2.8	§	0.1
ORBES total	113.388	2.7	2.7#	100.0**

TABLE 31. NET PRESENT VALUE OF MINIMUM UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2d*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	297.881	1.5	0.8	51.7
IN	158.670	1.5	0.4	27.5
KY	37.009	1.5	0.1	6.4
OH	77.213	1.5	0.2	13.4
PA	5.073	1.5	§	0.9
WV	0.828	1.5	§	0.1
ORBES total	576.674	1.5	1.5#	100.0**
		Soybeans		
IL	550.594	3.9	2.2	55.9
IN	227.955	3.9	0.9	23.1
KY	71.466	3.9	0.3	7.2
OH	134.961	3.9	0.5	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	984.976	3.9	3.9#	100.0**

(continued)

TABLE 31 (continued)

ORBES area	Losses to crop (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	13.011	0.8	0.3	38.2
IN	10.000	0.8	0.2	29.4
KY	2.081	0.8	0.1	6.1
OH	8.711	0.8	0.2	25.6
PA	0.229	0.8	§	0.7
WV	0.022	0.8	§	0.1
ORBES total	34.054	0.8	0.8#	100.0**

TABLE 32. NET PRESENT VALUE OF MAXIMUM TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2d*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	2857.760	14.4	7.4	51.6
IN	1523.000	14.4	4.0	27.5
KY	357.147	14.5	0.9	6.5
OH	741.262	14.4	1.9	13.4
PA	49.109	14.5	0.1	0.9
WV	8.072	14.6	§	0.1
ORBES total	5536.340	14.4	14.4#	100.0**
		Soybeans		
IL	4018.070	28.4	15.9	55.9
IN	1663.710	28.4	6.6	23.1
KY	517.796	28.6	2.0	7.2
OH	988.544	28.3	3.9	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	7188.110	28.4	28.4#	100.0**

(continued)

TABLE 32 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	155.020	9.8	3.8	38.3
IN	118.772	9.8	2.9	29.4
KY	24.639	9.8	0.6	6.1
OH	102.844	9.7	2.5	25.4
PA	2.782	10.1	0.1	0.7
WV	0.277	10.1	§	0.1
ORBES total	404.335	9.8	9.8#	100.0**

TABLE 33. NET PRESENT VALUE OF MAXIMUM UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2d*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	1434.470	7.2	3.7	51.6
IN	764.905	7.2	2.0	27.5
KY	180.441	7.3	0.5	6.5
OH	372.373	7.2	1.0	13.4
PA	24.896	7.4	0.1	0.9
WV	4.125	7.5	§	0.1
ORBES total	2781.210	7.2	7.2#	100.0**
		Soybeans		
IL	2018.700	14.3	8.0	55.9
IN	835.747	14.3	3.3	23.1
KY	261.684	14.4	1.0	7.2
OH	495.145	14.2	2.0	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	3611.270	14.3	14.3#	100.0**

(continued)

TABLE 33 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	78.725	5.0	1.9	38.5
IN	60.109	5.0	1.5	29.4
KY	12.423	4.9	0.3	6.1
OH	51.694	4.9	1.3	25.3
PA	1.447	5.3	§	0.7
WV	.144	5.3	§	0.1
ORBES total	204.543	5.0	5.0#	100.0**

TABLE 34. NET PRESENT VALUE OF PROBABLE TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2d*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	1673.710	8.4	4.3	51.6
IN	891.790	8.4	2.3	27.5
KY	208.694	8.5	0.5	6.4
OH	434.013	8.4	1.1	13.4
PA	28.658	8.5	0.1	0.9
WV	4.697	8.5	§	0.1
ORBES total	3241.560	8.4	8.4#	100.0**
		Soybeans		
IL	2575.450	18.2	10.2	55.9
IN	1066.370	18.2	4.2	23.1
KY	332.052	18.3	1.3	7.2
OH	633.465	18.1	2.5	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	4607.340	18.2	18.2#	100.0**

(continued)

TABLE 34 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	106.533	6.8	2.6	38.3
IN	81.653	6.7	2.0	29.4
KY	16.945	6.7	0.4	6.1
OH	70.764	6.7	1.7	25.5
PA	1.916	7.0	§	0.7
WV	0.190	6.9	§	0.1
ORBES total	278.001	6.7	6.7#	100.0**

TABLE 35. NET PRESENT VALUE OF PROBABLE UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 2d*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	672.014	3.4	1.7	51.6
IN	358.261	3.4	0.9	27.5
KY	84.332	3.4	0.2	6.5
OH	174.396	3.4	0.5	13.4
PA	11.618	3.4	§	0.9
WV	1.919	3.5	§	0.1
ORBES total	1302.540	3.4	3.4#	100.0**
		Soybeans		
IL	1038.220	7.3	4.1	55.9
IN	429.795	7.3	1.7	23.1
KY	135.139	7.5	0.5	7.3
OH	254.113	7.3	1.0	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	1857.270	7.3	7.3#	100.0**

(continued)

TABLE 35 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≁	Percent losses are of ORBES total pollution-free crop output≁	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	43.498	2.8	1.1	38.5
IN	33.185	2.7	0.8	29.4
KY	6.852	2.7	0.2	6.1
OH	28.504	2.7	0.7	25.2
PA	0.812	2.9	§	0.7
WV	0.080	2.9	§	0.1
ORBES total	112.933	2.7	2.7#	100.0**

TABLE 36. NET PRESENT VALUE OF TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, BY POLLUTANT: SCENARIO 2d*

ORBES area	SO_2 losses≠ (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses≠ (millions of dollars)	Percent O_3 losses are of area total losses‡
		Minimum losses		
IL	5.986	0.2	2851.670	99.8
IN	2.462	0.2	1313.880	99.8
KY	1.728	0.5	362.758	99.5
OH	0.575	0.1	734.367	99.9
PA	0.010	0.1	17.641	99.9
WV	0.002	0.1	2.827	99.9
ORBES total	10.763	0.2	5283.140	99.8
		Maximum losses		
IL	32.913	0.5	6997.930	99.5
IN	16.055	0.5	3289.420	99.5
KY	9.515	1.1	890.067	98.9
OH	5.774	0.3	1826.880	99.7
PA	0.795	1.5	51.096	98.5
WV	0.190	2.3	8.159	97.7
ORBES total	65.241	0.5	13063.600	99.5

(continued)

TABLE 36 (continued)

ORBES area	SO_2 losses≠ (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses≠ (millions of dollars)	Percent O_3 losses are of area total losses‡
		Probable losses		
IL	19.093	0.4	4336.600	99.6
IN	8.858	0.4	2030.960	99.6
KY	5.411	1.0	552.280	99.0
OH	2.859	0.3	1135.380	99.7
PA	.334	1.1	30.240	98.9
WV	.073	1.5	4.812	98.5
ORBES total	36.630	0.5	8090.270	99.5

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ For total losses, see Tables

TABLE 37. NET PRESENT VALUE OF UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, BY POLLUTANT: SCENARIO 2d*

ORBES area	SO_2 losses≠ (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses≠ (millions of dollars)	Percent O_3 losses are of area total losses‡
		Minimum losses		
IL	5.986	0.7	855.500	99.3
IN	2.462	0.6	394.163	99.4
KY	1.728	1.6	108.827	98.4
OH	0.575	0.3	220.310	99.7
PA	0.010	0.2	5.292	99.8
WV	0.002	0.3	0.848	99.7
ORBES total	10.763	0.7	1584.940	99.3
		Maximum losses		
IL	32.913	0.9	3498.980	99.1
IN	16.055	1.0	1644.710	99.0
KY	9.515	2.1	445.034	97.9
OH	5.774	0.6	913.438	99.4
PA	0.795	3.0	25.548	97.0
WV	0.190	4.4	4.079	95.6
ORBES total	65.241	1.0	6531.790	99.0

(continued)

TABLE 37 (continued)

ORBES area	SO_2 losses≠ (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses≠ (millions of dollars)	Percent O_3 losses are of are total losses‡
		Probable losses		
IL	19.093	1.1	1734.640	98.9
IN	8.858	1.1	812.383	98.9
KY	5.411	2.4	220.912	97.6
OH	2.859	0.6	454.154	99.4
PA	0.334	2.7	12.096	97.3
WV	0.074	3.7	1.925	96.3
ORBES total	36.630	1.1	3236.110	98.9

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ For total losses, see Tables

TABLE 38. NET PRESENT VALUE OF MINIMUM CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 7*

ORBES area	Total losses≠ (millions of dollars)	Percent losses are of Pollution-free output‡	Percent losses are of ORBES total losses
IL	3003.140	8.4	54.0
IN	1381.950	7.8	24.8
KY	383.451	8.5	6.9
OH	772.612	8.0	13.9
PA	18.560	5.1	0.3
WV	2.966	5.1	0.1
ORBES total	5562.680	8.2	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 39. NET PRESENT VALUE OF MINIMUM CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 7*

ORBES area	Total utility losses≠ (millions of dollars)	Percent utility Losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	1144.760	3.2	54.0
IN	525.090	3.0	24.8
KY	147.043	3.2	6.9
OH	293.733	3.0	13.7
PA	7.197	2.0	0.3
WV	1.113	1.9	0.1
ORBES total	2118.940	3.1	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 40. NET PRESENT VALUE OF MAXIMUM CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 7*

ORBES area	Total losses† (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	7150.440	20.1	53.6
IN	3351.810	19.0	25.1
KY	917.578	20.2	6.9
OH	1865.090	19.2	14.0
PA	51.907	14.2	0.4
WV	8.353	14.4	0.1
ORBES total	13345.200	19.6	100.0§

* Assumes a 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 41. NET PRESENT VALUE OF MAXIMUM CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 7*

ORBES area	Total utility losses≠ (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility losses are of ORBES total losses
IL	4102.660	11.5	53.6
IN	1919.450	10.9	25.1
KY	529.861	11.7	6.9
OH	1068.940	11.0	14.0
PA	29.321	8.0	0.4
WV	4.815	8.3	0.1
ORBES total	7655.050	11.3	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 42. NET PRESENT VALUE OF PROBABLE CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 7*

ORBES area	Total losses† (millions of dollars)	Percent losses are of pollution-free output‡	Percent losses are of ORBES total losses
IL	4473.010	12.6	53.6
IN	2087.100	11.8	25.0
KY	574.105	12.7	6.9
OH	1167.980	12.0	14.0
PA	30.790	8.4	0.4
WV	4.927	8.5	0.1
ORBES total	8337.920	12.3	100.0§

* Assumes a 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 43. NET PRESENT VALUE OF PROBABLE CUMULATIVE CROP LOSSES TO UTILITIES, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 7*

ORBES area	Total utility losses≠ (millions of dollars)	Percent utility losses are of pollution-free output‡	Percent utility Losses are of ORBES total losses
IL	1538.950	4.3	53.7
IN	714.997	4.0	25.0
KY	200.413	4.4	7.0
OH	400.329	4.1	14.0
PA	10.591	2.9	0.4
WV	1.713	3.0	0.1
ORBES total	2867.000	4.2	100.0§

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ Discounted present values of pollution-free output are in Table 16.

§ Sum may not be 100% due to rounding.

TABLE 44. NET PRESENT VALUE OF MINIMUM TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 7*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	1040.430	5.2	2.7	51.7
IN	554.119	5.2	1.4	27.5
KY	129.208	5.2	0.3	6.4
OH	269.657	5.2	0.7	13.4
PA	17.701	5.2	§	0.9
WV	2.886	5.2	§	0.1
ORBES total	2014.000	5.2	5.2#	100.0**
		Soybeans		
IL	1916.580	13.5	7.6	55.9
IN	792.376	13.5	3.1	23.1
KY	246.857	13.6	1.0	7.2
OH	472.037	13.5	1.9	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	3427.850	13.5	13.5#	100.0**

(continued)

TABLE 44 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	46.125	2.9	1.1	38.2
IN	35.456	2.9	0.9	29.3
KY	7.385	2.9	0.2	6.1
OH	30.917	2.9	0.7	25.6
PA	0.858	3.1	§	0.7
WV	0.080	2.9	§	0.1
ORBES total	120.821	2.9	2.9#	100.0**

TABLE 45. NET PRESENT VALUE OF MINIMUM UTILITY CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 7*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	333.337	1.7	0.9	51.7
IN	177.503	1.7	0.5	27.5
KY	41.422	1.7	0.1	6.4
OH	86.395	1.7	0.2	13.4
PA	5.672	1.7	§	0.9
WV	0.925	1.7	§	0.1
ORBES total	645.254	1.7	1.7#	100.0**
		Soybeans		
IL	625.527	4.4	2.5	55.9
IN	257.740	4.4	1.0	23.0
KY	81.479	4.5	0.3	7.3
OH	153.435	4.4	0.6	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	1118.180	4.4	4.4#	100.0**

(continued)

TABLE 45 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	14.806	0.9	0.4	38.2
IN	11.375	0.9	0.3	29.3
KY	2.370	0.9	0.1	6.1
OH	9.920	0.9	0.2	25.6
PA	0.259	0.9	§	0.7
WV	0.026	0.9	§	0.1
ORBES total	38.756	0.9	0.9#	100.0**

TABLE 46. NET PRESENT VALUE OF MAXIMUM TOTAL CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 7*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	2878.640	14.5	7.5	51.6
IN	1530.690	14.4	4.0	27.5
KY	360.746	14.6	0.9	6.5
OH	746.301	14.5	1.9	13.4
PA	49.088	14.5	0.1	0.9
WV	8.068	14.6	§	0.1
ORBES total	5573.540	14.5	14.5#	100.0**
		Soybeans		
IL	4110.790	29.0	16.2	55.9
IN	1697.980	29.0	6.7	23.1
KY	531.044	29.3	2.1	7.2
OH	1011.360	29.0	4.0	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	7351.170	29.0	29.0#	100.0**

(continued)

TABLE 46 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area Pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	161.007	10.2	3.9	38.3
IN	123.138	10.2	3.0	29.3
KY	25.788	10.2	0.6	6.1
OH	107.433	10.2	2.6	25.6
PA	2.819	10.2	0.1	0.7
WV	0.285	10.4	§	0.1
ORBES total	420.469	10.2	10.2#	100.0**

TABLE 47. NET PRESENT VALUE OF MAXIMUM UTILITY CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 7*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	1491.820	7.5	3.9	51.6
IN	792.021	7.5	2.1	27.4
KY	188.568	7.6	0.5	6.5
OH	386.866	7.5	1.0	13.4
PA	25.496	7.5	0.1	0.9
WV	4.222	7.7	§	0.1
ORBES total	2888.990	7.5	7.5#	100.0**
		Soybeans		
IL	2140.540	15.1	8.5	55.9
IN	882.092	15.1	3.5	23.1
KY	278.663	15.4	1.1	7.3
OH	525.148	15.0	2.1	13.7
PA	0	0	0	0
WV	0	0	0	0
ORBES total	3826.440	15.1	15.1#	100.0**

(continued)

TABLE 47 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	84.409	5.4	2.0	38.4
IN	64.243	5.3	1.6	29.2
KY	13.524	5.4	0.3	6.2
OH	56.080	5.3	1.4	25.5
PA	1.479	5.4	§	0.7
WV	0.152	5.5	§	0.1
ORBES total	219.886	5.3	5.3#	100.0**

TABLE 48. NET PRESENT VALUE OF PROBABLE TOTAL CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 7*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	1696.950	8.5	4.4	51.7
IN	902.874	8.5	2.3	27.5
KY	211.973	8.6	0.6	6.5
OH	439.929	8.5	1.1	13.4
PA	28.912	8.5	0.1	0.9
WV	4.738	8.6	§	0.1
ORBES total	3285.380	8.5	8.5#	100.0**
		Soybeans		
IL	2668.700	18.9	10.5	55.9
IN	1102.140	18.8	4.4	23.1
KY	344.949	19.0	1.4	7.2
OH	656.433	18.8	2.6	13.8
PA	0	0	0	0
WV	0	0	0	0
ORBES total	4772.220	18.8	18.8#	100.0**

(continued)

TABLE 48 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area Pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	107.359	6.8	2.6	38.3
IN	82.089	6.8	2.0	29.3
KY	17.184	6.8	0.4	6.1
OH	71.618	6.8	1.7	25.5
PA	1.878	6.8	§	0.7
WV	0.190	6.9	§	0.1
ORBES total	280.317	6.8	6.8#	100.0**

TABLE 49. NET PRESENT VALUE OF PROBABLE UTILITY CROP LOSSES, 1976 TO 2000, FROM SO_2 AND O_3, BY CROP: SCENARIO 7*

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Corn		
IL	710.664	3.6	1.8	51.6
IN	377.551	3.6	1.0	27.4
KY	89.524	3.6	0.2	6.5
OH	184.305	3.6	0.5	13.4
PA	12.134	3.6	§	0.9
WV	2.003	3.6	§	0.1
ORBES total	1376.180	3.6	3.6#	100.0**
		Soybeans		
IL	1128.110	8.0	4.5	56.0
IN	464.169	7.9	1.8	23.0
KY	147.606	8.1	0.6	7.3
OH	276.252	7.9	1.1	13.7
PA	0	0	§	0
WV	0	0	§	0
ORBES total	2016.130	8.0	8.0#	100.0**

(continued)

TABLE 49 (continued)

ORBES area	Losses to crops (millions of dollars)	Percent losses are of area pollution-free crop output≠	Percent losses are of ORBES total pollution-free crop output≠	Percent losses are of ORBES total crop loss‡
		Wheat		
IL	45.565	2.9	1.1	38.5
IN	34.576	2.9	0.8	29.2
KY	7.289	2.9	0.2	6.2
OH	30.189	2.9	0.7	25.5
PA	0.797	2.9	§	0.7
WV	0.082	3.0	§	0.1
ORBES total	118.498	3.0	3.0#	100.0**

TABLE 50. NET PRESENT VALUE OF TOTAL CUMULATIVE CROP LOSSES, 1976 TO 2000, BY POLLUTANT: SCENARIO 7*

ORBES area	SO_2 losses† (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses† (millions of dollars)	Percent O_3 losses are of area total losses‡
		Minimum losses		
IL	4.251	0.1	2998.890	99.9
IN	0.430	§	1381.520	100.0
KY	1.934	0.5	381.517	99.5
OH	0.120	§	772.492	100.0
PA	0.003	§	18.556	100.0
WV	0.001	§	2.965	100.0
ORBES total	6.739	0.1	5555.940	99.9
		Maximum losses		
IL	22.083	0.3	7128.350	99.7
IN	2.877	0.1	3348.930	99.9
KY	10.673	1.2	906.905	98.8
OH	2.671	0.1	1862.420	99.9
PA	0.261	0.5	51.646	99.5
WV	0.112	1.3	8.240	98.7
ORBES total	38.677	0.3	13306.500	99.7

(continued)

TABLE 50 (continued)

ORBES area	SO_2 losses≠ (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses≠ (millions of dollars)	Percent O_3 losses are of area total losses‡
		Probable losses		
IL	13.056	0.3	4459.960	99.7
IN	1.595	0.1	2085.510	99.9
KY	6.073	1.1	568.032	98.9
OH	1.215	0.1	1166.770	99.9
PA	0.104	0.3	30.686	99.7
WV	0.044	0.9	4.883	99.1
ORBES total	22.088	0.3	8315.830	99.7

* Assumes a 10% discount rate.

≠ Crops are corn, soybeans, and wheat.

‡ For total losses, see Tables

§ Less than .05%.

TABLE 51. NET PRESENT VALUE OF UTILITY CUMULATIVE CROP LOSSES, 1976 TO 2000, BY POLLUTANT: SCENARIO 7*

ORBES area	SO_2 losses† (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses† (millions of dollars)	Percent O_3 losses are of area total losses‡
		Minimum losses		
IL	4.251	0.4	969.418	99.6
IN	0.430	0.1	446.188	99.9
KY	1.934	1.5	123.338	98.5
OH	0.120	§	249.629	100.0
PA	0.003	0.1	5.928	99.9
WV	0.001	0.1	0.950	99.9
ORBES total	6.739	0.4	1795.450	99.6
		Maximum losses		
IL	22.083	0.6	3694.680	99.4
IN	2.877	0.2	1735.480	99.8
KY	10.673	2.2	470.082	97.8
OH	2.671	0.3	965.424	99.7
PA	0.261	1.0	26.713	99.0
WV	0.112	2.6	4.262	97.4
ORBES total	38.677	0.6	6896.640	99.4

(continued)

TABLE 51 (continued)

ORBES area	SO_2 losses† (millions of dollars)	Percent SO_2 losses are of area total losses‡	O_3 losses† (millions of dollars)	Percent O_3 losses are of area total losses‡
		Probable losses		
IL	13.056	0.7	1871.280	99.3
IN	1.595	0.2	874.700	99.8
KY	6.073	2.5	238.346	97.5
OH	1.215	0.2	489.532	99.8
PA	0.104	0.8	12.827	99.2
WV	0.044	2.1	2.041	97.9
ORBES total	22.088	0.6	3488.730	99.4

* Assumes a 10% discount rate.

† Crops are corn, soybeans, and wheat.

‡ For total losses, see Tables

§ Less than .05%.

TABLE 52. PROBABLE, YEAR BY YEAR, INDIVIDUAL AND AGGREGATE THREE-CROP TOTAL MONETARY LOSSES: SCENARIO 2 *

Year	Corn	Soybeans	Wheat	Total
1977	300.235	339.761	19.4854	659.481
1978	310.939	366.561	21.1796	698.680
1979	322.043	395.553	23.0336	740.629
1980	333.557	426.902	25.0606	785.520
1981	345.496	460.793	27.2749	833.563
1982	357.871	497.423	29.6925	884.987
1983	370.700	537.008	32.3309	940.040
1984	383.996	579.783	35.2093	998.989
1985	397.777	625.998	38.3488	1062.120
1986	397.758	625.954	38.3478	1062.060
1987	397.741	625.916	38.3470	1062.000
1988	397.726	625.881	38.3462	1061.950
1989	397.712	625.851	38.3455	1061.910
1990	397.699	625.824	38.3448	1061.870
1991	397.688	625.801	38.3442	1061.830
1992	397.678	625.781	38.3436	1061.800
1993	397.669	625.764	38.3431	1061.780
1994	397.661	625.749	38.3426	1061.750
1995	397.653	625.736	38.3421	1061.730
1996	397.646	625.726	38.3417	1061.710
1997	397.640	625.718	38.3413	1061.700
1998	397.634	625.712	38.3410	1061.690
1999	397.629	625.708	38.3406	1061.680
2000	397.624	625.706	38.3403	1061.670

* Millions of dollars, undiscounted values.

TABLE 53. PROBABLE, YEAR BY YEAR, INDIVIDUAL AND AGGREGATE THREE-CROP POWER PLANT MONETARY LOSSES: SCENARIO 2 *

Year	Corn	Soybeans	Wheat	Total
1977	120.637	137.344	7.9389	265.920
1978	124.872	147.940	8.5973	281.409
1979	129.274	159.428	9.3226	298.025
1980	133.846	171.873	10.1195	315.839
1981	138.592	185.346	10.9935	334.932
1982	143.516	199.924	11.9505	355.391
1983	148.624	215.692	12.9974	377.313
1984	153.921	232.743	14.1414	400.805
1985	159.415	251.174	15.3909	425.980
1986	159.396	251.130	15.3899	425.916
1987	159.379	251.092	15.3891	425.860
1988	159.364	251.057	15.3883	425.809
1989	159.350	251.027	15.3876	425.765
1990	159.337	251.000	15.3869	425.724
1991	159.326	250.977	15.3863	425.690
1992	159.316	250.957	15.3857	425.659
1993	159.307	250.940	15.3852	425.632
1994	159.299	250.925	15.3847	425.608
1995	159.291	250.912	15.3842	425.587
1996	159.284	250.902	15.3838	425.571
1997	159.278	250.894	15.3834	425.556
1998	159.272	250.888	15.3831	425.544
1999	159.267	250.884	15.3827	425.534
2000	159.262	250.882	15.3824	425.527

* Millions of dollars, undiscounted values.

TABLE 54. PROBABLE, YEAR BY YEAR, INDIVIDUAL AND AGGREGATE THREE-CROP TOTAL MONETARY LOSSES: SCENARIO 2d*

Year	Corn	Soybeans	Wheat	Total
1977	300.340	340.003	19.5288	659.872
1978	311.137	367.013	21.2609	699.411
1979	322.324	396.189	23.1485	741.661
1980	333.915	427.703	25.2056	786.823
1981	345.923	461.744	27.4473	835.114
1982	358.366	498.512	29.8902	886.768
1983	371.259	538.227	32.5523	942.038
1984	384.616	581.123	35.4533	1001.190
1985	398.456	627.456	38.6145	1064.530
1986	398.442	627.422	38.6126	1064.480
1987	398.431	627.393	38.6110	1064.440
1988	398.420	627.369	38.6094	1064.400
1989	398.411	627.349	38.6080	1064.370
1990	398.404	627.332	38.6067	1064.340
1991	398.398	627.319	38.6056	1064.320
1992	398.393	627.310	38.6046	1064.310
1993	398.389	627.303	38.6036	1064.300
1994	398.386	627.299	38.6029	1064.290
1995	398.384	627.298	38.6022	1064.280
1996	398.383	627.299	38.6016	1064.280
1997	398.382	627.302	38.6011	1064.290
1998	398.383	627.308	38.6007	1064.290
1999	398.384	627.315	38.6004	1064.300
2000	398.385	627.324	38.6002	1064.310

* Millions of dollars, undiscounted values.

TABLE 55. PROBABLE, YEAR BY YEAR, INDIVIDUAL AND AGGREGATE THREE-CROP POWER PLANT MONETARY LOSSES: SCENARIO 2d*

Year	Corn	Soybeans	Wheat	Total
1977	120.742	137.587	7.9823	266.311
1978	125.070	148.391	8.6786	282.140
1979	129.555	160.064	9.4375	299.057
1980	134.203	172.674	10.2645	317.142
1981	139.019	186.298	11.1659	336.483
1982	144.010	201.014	12.1482	357.172
1983	149.182	216.911	13.2187	379.312
1984	154.540	234.083	14.3854	403.009
1985	160.094	252.632	15.6566	428.383
1986	160.080	252.598	15.6547	428.334
1987	160.069	252.569	15.6531	428.291
1988	160.058	252.545	15.6515	428.255
1989	160.049	252.525	15.6501	428.224
1990	160.042	252.508	15.6488	428.199
1991	160.036	252.495	15.6477	428.179
1992	160.031	252.486	15.6467	428.163
1993	160.027	252.479	15.6458	428.151
1994	160.024	252.475	15.6450	428.144
1995	160.022	252.474	15.6443	428.140
1996	160.021	252.475	15.6437	428.140
1997	160.020	252.478	15.6432	428.142
1998	160.021	252.484	15.6428	428.148
1999	160.022	252.491	15.6425	428.155
2000	160.023	252.500	15.6424	428.166

* Millions of dollars, undiscounted values.

TABLE 56. PROBABLE, YEAR BY YEAR, INDIVIDUAL AND AGGREGATE THREE-CROP TOTAL MONETARY LOSSES: SCENARIO 7 *

Year	Corn	Soybeans	Wheat	Total
1977	300.238	339.763	19.4899	659.492
1978	310.945	366.569	21.1877	698.702
1979	322.051	395.568	23.0445	740.663
1980	333.568	426.924	25.0735	785.565
1981	345.508	460.822	27.2893	833.619
1982	357.886	497.459	29.7079	885.053
1983	370.717	537.050	32.3468	940.114
1984	384.014	579.830	35.2255	999.070
1985	397.795	626.051	38.3649	1062.210
1986	400.096	634.172	38.5504	1072.820
1987	402.415	642.407	38.7382	1083.560
1988	404.750	650.752	38.9278	1094.430
1989	407.100	659.209	39.1187	1105.430
1990	409.465	667.777	39.3108	1116.550
1991	411.842	676.457	39.5041	1127.800
1992	414.235	685.250	39.6985	1139.180
1993	416.642	694.159	39.8938	1150.700
1994	419.062	703.184	40.0901	1162.340
1995	421.498	712.326	40.2875	1174.110
1996	423.946	721.587	40.4859	1186.020
1997	426.409	730.970	40.6853	1198.060
1998	428.887	740.474	40.8857	1210.250
1999	431.379	750.103	41.0871	1222.570
2000	433.886	759.856	41.2894	1235.030

* Millions of dollars, undiscounted values.

TABLE 57. PROBABLE, YEAR BY YEAR, INDIVIDUAL AND AGGREGATE THREE-CROP POWER PLANT MONETARY LOSSES: SCENARIO 7 *

Year	Corn	Soybeans	Wheat	Total
1977	120.640	137.347	7.9435	265.931
1978	124.878	147.948	8.6054	281.431
1979	129.283	159.443	9.3334	298.059
1980	133.857	171.895	10.1324	315.885
1981	138.604	185.376	11.0079	334.987
1982	143.530	199.960	11.9659	355.457
1983	148.640	215.734	13.0133	377.388
1984	153.939	232.790	14.1576	400.887
1985	159.433	251.227	15.4070	426.067
1986	163.244	259.052	15.7575	438.053
1987	167.063	266.991	16.1092	450.163
1988	170.889	275.039	16.4614	462.390
1989	174.720	283.200	16.8138	474.733
1990	178.557	291.471	17.1663	487.194
1991	182.396	299.854	17.5187	499.769
1992	186.243	308.350	17.8711	512.465
1993	190.094	316.961	18.2234	525.279
1994	193.949	325.688	18.5755	538.213
1995	197.810	334.533	18.9275	551.271
1996	201.676	343.496	19.2794	564.451
1997	205.547	352.580	19.6313	577.758
1998	209.423	361.786	19.9830	591.192
1999	213.306	371.116	20.3346	604.756
2000	217.193	380.570	20.6862	618.449

* Millions of dollars, undiscounted losses.

TABLE 58. PROBABLE THREE-CROP TOTAL ANNUAL MONETARY LOSSES BY POLLUTANT: SCENARIO 2
(millions of dollars)

Year	SO_2 damage	O_3 damage	Total damage⌿
1977	3.547	655.934	659.481
1978	3.230	695.451	698.680
1979	2.956	737.673	740.629
1980	2.718	782.801	785.520
1981	2.511	831.053	833.563
1982	2.326	882.660	884.987
1983	2.162	937.877	940.040
1984	2.016	996.973	998.989
1985	1.884	1060.240	1062.120
1986	1.820	1060.240	1062.060
1987	1.764	1060.240	1062.000
1988	1.713	1060.240	1061.950
1989	1.669	1060.240	1061.910
1990	1.628	1060.240	1061.870
1991	1.594	1060.240	1061.830
1992	1.563	1060.240	1061.800
1993	1.536	1060.240	1061.780
1994	1.512	1060.240	1061.750
1995	1.491	1060.240	1061.730
1996	1.474	1060.240	1061.710
1997	1.459	1060.240	1061.700
1998	1.448	1060.240	1061.690
1999	1.438	1060.240	1061.680
2000	1.431	1060.240	1061.670

* Values are in constant 1975 dollars.

⌿ Crops are corn, soybeans, and wheat.

TABLE 59. PROBABLE THREE-CROP UTILITY RELATED ANNUAL MONETARY LOSSES BY POLLUTANT: SCENARIO 2 (millions of dollars)

Year	SO_2 damage	O_3 damage	Total damage/
1977	3.547	262.373	265.920
1978	3.230	278.180	281.409
1979	2.956	295.069	298.025
1980	2.719	313.121	315.839
1981	2.511	332.421	334.932
1982	2.326	353.064	355.391
1983	2.162	375.151	377.313
1984	2.016	398.789	400.805
1985	1.884	424.096	425.980
1986	1.820	424.096	425.916
1987	1.764	424.096	425.860
1988	1.713	424.096	425.809
1989	1.669	424.096	425.765
1990	1.628	424.096	425.724
1991	1.594	424.096	425.690
1992	1.563	424.096	425.659
1993	1.536	424.096	425.632
1994	1.512	424.096	425.608
1995	1.491	424.096	425.587
1996	1.474	424.096	425.571
1997	1.459	424.096	425.556
1998	1.448	424.096	425.544
1999	1.438	424.096	425.534
2000	1.431	424.096	425.527

* Values are in constant 1975 dollars.

/ Crops are corn, soybeans, and wheat.

TABLE 60. PROBABLE THREE-CROP TOTAL ANNUAL MONETARY LOSSES BY POLLUTANT: SCENARIO 2d (millions of dollars)

Year	SO_2 damage	O_3 damage	Total damage*
1977	3.938	655.934	659.872
1978	3.960	695.451	699.411
1979	3.988	737.673	741.661
1980	4.022	782.801	786.823
1981	4.062	831.053	835.114
1982	4.108	882.660	886.768
1983	4.161	937.877	942.038
1984	4.220	996.973	1001.190
1985	4.287	1060.240	1064.530
1986	4.237	1060.240	1064.480
1987	4.195	1060.240	1064.440
1988	4.159	1060.240	1064.400
1989	4.128	1060.240	1064.370
1990	4.103	1060.240	1064.340
1991	4.083	1060.240	1064.320
1992	4,067	1060.240	1064.310
1993	4.055	1060.240	1064.300
1994	4.048	1060.240	1064.290
1995	4.044	1060.240	1064.280
1996	4.043	1060.240	1064.280
1997	4.046	1060.240	1064.290
1998	4.051	1060.240	1064.290
1999	4.059	1060.240	1064.300
2000	4.070	1060.240	1064.310

* Values are in constant 1975 dollars.

† Crops are corn, soybeans, and wheat.

TABLE 61. PROBABLE THREE-CROP UTILITY RELATED ANNUAL MONETARY LOSSES BY POLLUTANT: SCENARIO 2d (millions of dollars)

Year	SO_2 damage	O_3 damage	Total damage‡
1977	3.938	262.373	266.311
1978	3.960	278.180	282.140
1979	3.988	295.069	299.057
1980	4.022	313.121	317.142
1981	4.062	332.421	336.483
1982	4.108	353.064	357.172
1983	4.161	375.151	379.312
1984	4.220	398.789	403.009
1985	4.287	424.096	428.383
1986	4.237	424.096	428.334
1987	4.195	424.096	428.291
1988	4.159	424.096	428.255
1989	4.128	424.096	428.224
1990	4.103	424.096	428.199
1991	4.083	424.096	428.179
1992	4.067	424.096	428.163
1993	4.055	424.096	428.151
1994	4.048	424.096	428.144
1995	4.044	424.096	428.140
1996	4.043	424.096	428.140
1997	4.046	424.096	428.142
1998	4.051	424.096	428.148
1999	4.059	424.096	428.155
2000	4.070	424.096	428.166

* Values are in constant 1975 dollars.

‡ Crops are corn, soybeans, and wheat.

TABLE 62. PROBABLE THREE-CROP UTILITY RELATED ANNUAL MONETARY LOSSES BY POLLUTANT: SCENARIO 7 (millions of dollars)

Year	SO_2 damage	O_3 damage	Total damage⌿
1977	3.558	655.934	659.492
1978	3.252	695.451	698.702
1979	2.990	737.673	740.663
1980	2.764	782.801	785.565
1981	2.566	831.052	833.619
1982	2.393	882.660	885.053
1983	2.237	937.877	940.114
1984	2.098	996.972	999.070
1985	1.971	1060.240	1062.210
1986	1.940	1070.880	1072.820
1987	1.921	1081.640	1083.560
1988	1.910	1092.520	1094.430
1989	1.902	1103.530	1105.430
1990	1.897	1114.660	1116.550
1991	1.892	1125.910	1127.800
1992	1.889	1137.300	1139.180
1993	1.886	1148.810	1150.700
1994	1.883	1160.450	1162.340
1995	1.880	1172.230	1174.110
1996	1.877	1184.140	1186.020
1997	1.875	1196.190	1198.060
1998	1.873	1208.370	1210.250
1999	1.870	1220.700	1222.570
2000	1.867	1233.160	1235.030.

* Values are in constant 1975 dollars.

⌿ Crops are corn, soybeans, and wheat.

TABLE 63. PROBABLE THREE-CROP UTILITY RELATED ANNUAL MONETARY LOSSES BY POLLUTANT: SCENARIO 7 (millions of dollars)

Year	SO_2 damage	O_3 damage	Total damage≠
1977	3.558	262.373	265.931
1978	3.252	278.180	281.431
1979	2.990	295.069	298.059
1980	2.764	313.120	315.885
1981	2.566	332.421	334.987
1982	2.393	353.064	355.457
1983	2.237	375.151	377.388
1984	2.098	398.789	400.887
1985	1.971	424.096	426.067
1986	1.940	436.114	438.053
1987	1.921	448.242	450.163
1988	1.910	460.480	462.390
1989	1.902	472.831	474.733
1990	1.897	485.297	487.194
1991	1.892	497.876	499.769
1992	1.889	510.576	512.465
1993	1.886	523.393	525.279
1994	1.883	536.330	538.213
1995	1.880	549.390	551.271
1996	1.877	562.574	564.451
1997	1.875	575.883	577.758
1998	1.873	589.319	591.192
1999	1.870	602.886	604.756
2000	1.867	616.582	618.449

* Values are in constant 1975 dollars.

≠ Crops are corn, soybeans, and wheat.

TABLE 64. NET PRESENT VALUE OF COMPLIANCE BENEFITS FOR SO_2 EMISSIONS: SCENARIOS 2d AND 2 COMPARED*
(millions of dollars)

	Corn	Soybeans	Wheat	Total benefits	Total benefits as percent of total clean-air production≠
			Minimum benefits		
IL	0.050	1.845	0.014	1.909	0.0054
IN	0.063	1.874	0.013	1.950	0.0110
KY	0.002	0.074	‡	0.076	0.0017
OH	0.019	0.388	0.003	0.410	0.0042
PA	0.006	0	0.001	0.007	0.0019
WV	0.001	0	‡	0.001	0.0017
ORBES total	0.141	4.181	0.031	4.353	0.0064
			Maximum benefits		
IL	4.203	6.107	1.274	11.584	0.0325
IN	5.353	6.193	1.136	12.682	0.0717
KY	0.160	0.239	0.028	0.427	0.0094
OH	1.475	1.293	0.250	3.018	0.0311
PA	0.488	0	0.094	0.582	0.1590
WV	0.067	0	0.004	0.071	0.1226
ORBES total	11.746	13.832	2.786	28.364	0.0417

(continued)

TABLE 64 (continued)

	Corn	Soybeans	Wheat	Total benefits	Total benefits as percent of total clean-air production/
			Probable benefits		
IL	1.589	4.235	0.774	6.598	0.0185
IN	2.018	4.299	0.687	7.004	0.0396
KY	0.049	0.172	0.015	0.236	0.0052
OH	0.554	0.897	0.151	1.602	0.0165
PA	0.184	0	0.066	0.250	0.0683
WV	0.025	0	0.002	0.027	0.0466
ORBES total	4.419	9.603	1.695	15.717	0.0231

* Assumes a 10% discount rate.

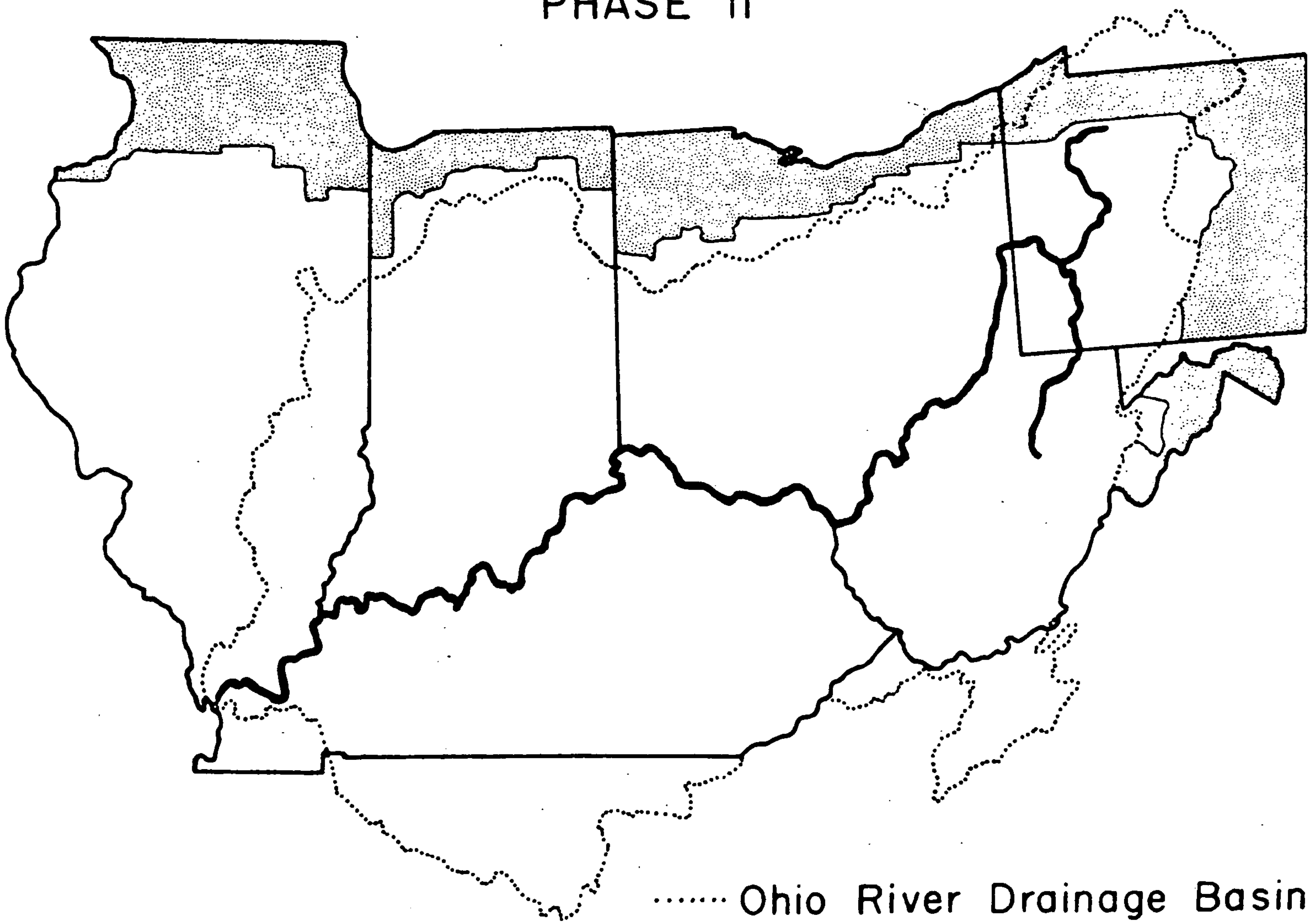
/ Discounted present values of pollution-free output are in Tables

‡ Less than .05%.

FIGURE I

OHIO RIVER BASIN ENERGY STUDY REGION

PHASE II



SCENARIO AND IMPACT MODELS: SEQUENTIAL STEPS IN ORBES ASSESSMENT

FIGURE 2

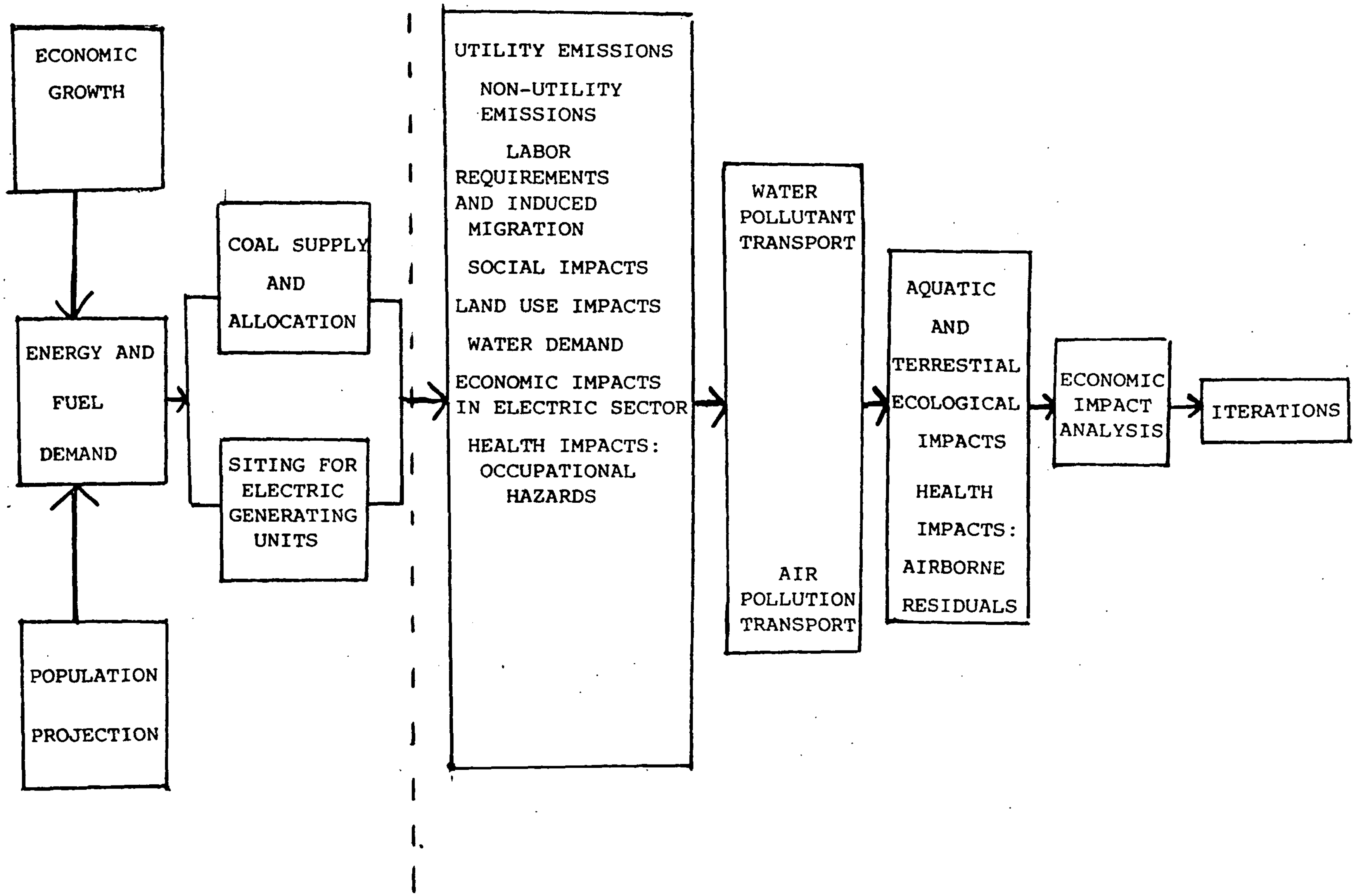
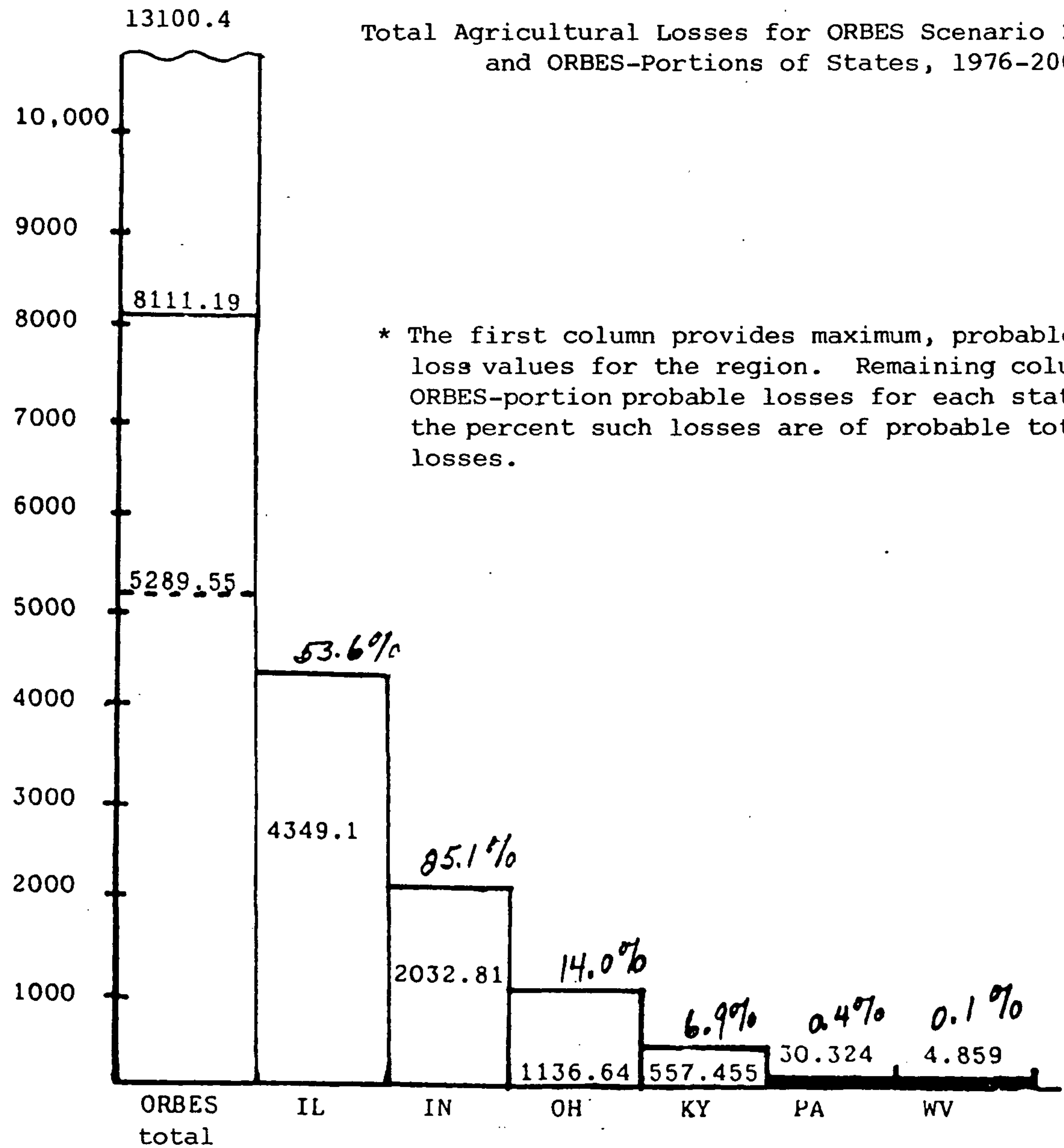


FIGURE 11

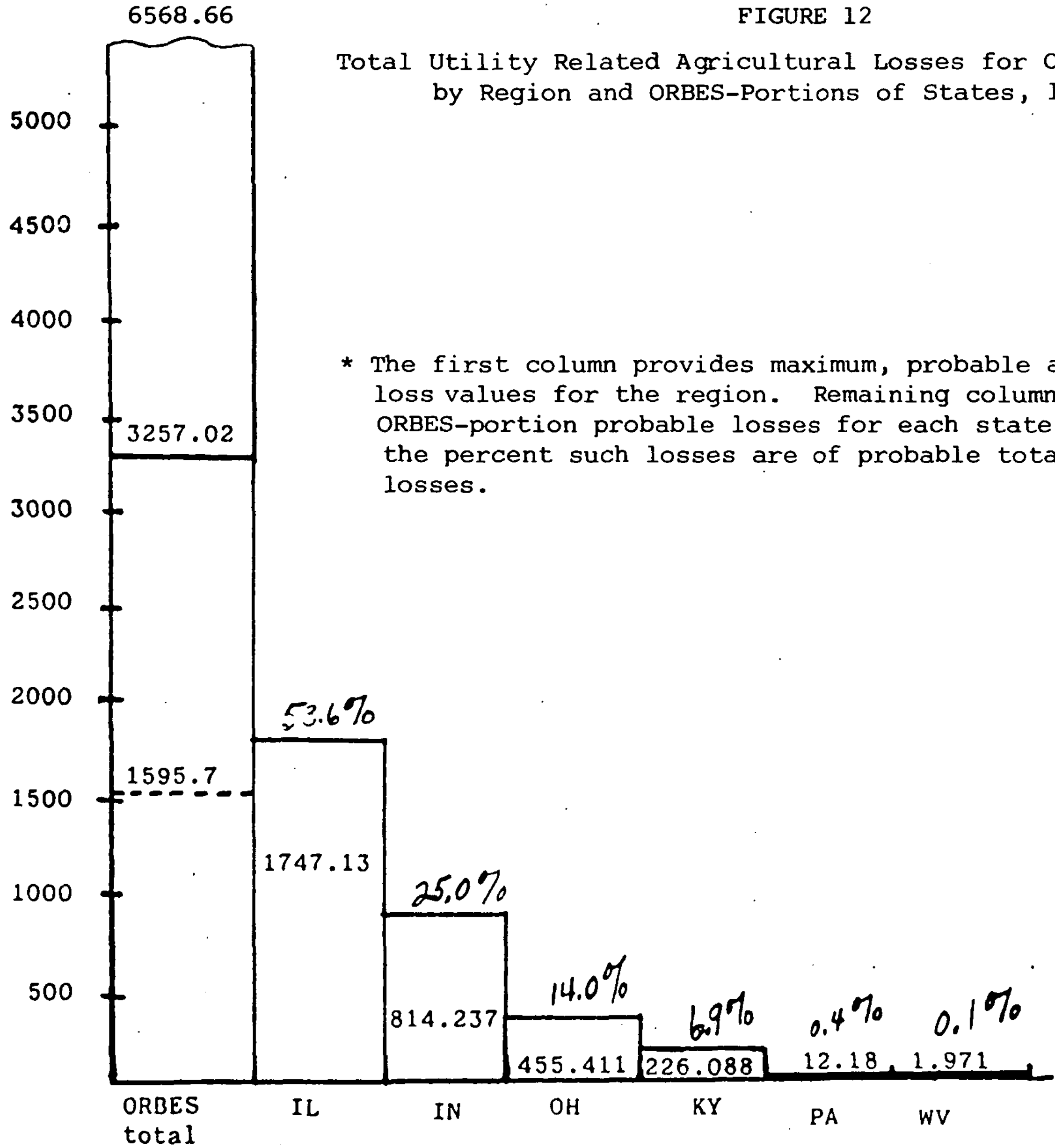
Total Agricultural Losses for ORBES Scenario 2 by Region and ORBES-Portions of States, 1976-2000*



* The first column provides maximum, probable and minimum loss values for the region. Remaining columns show ORBES-portion probable losses for each state as well as the percent such losses are of probable total regional losses.

FIGURE 12

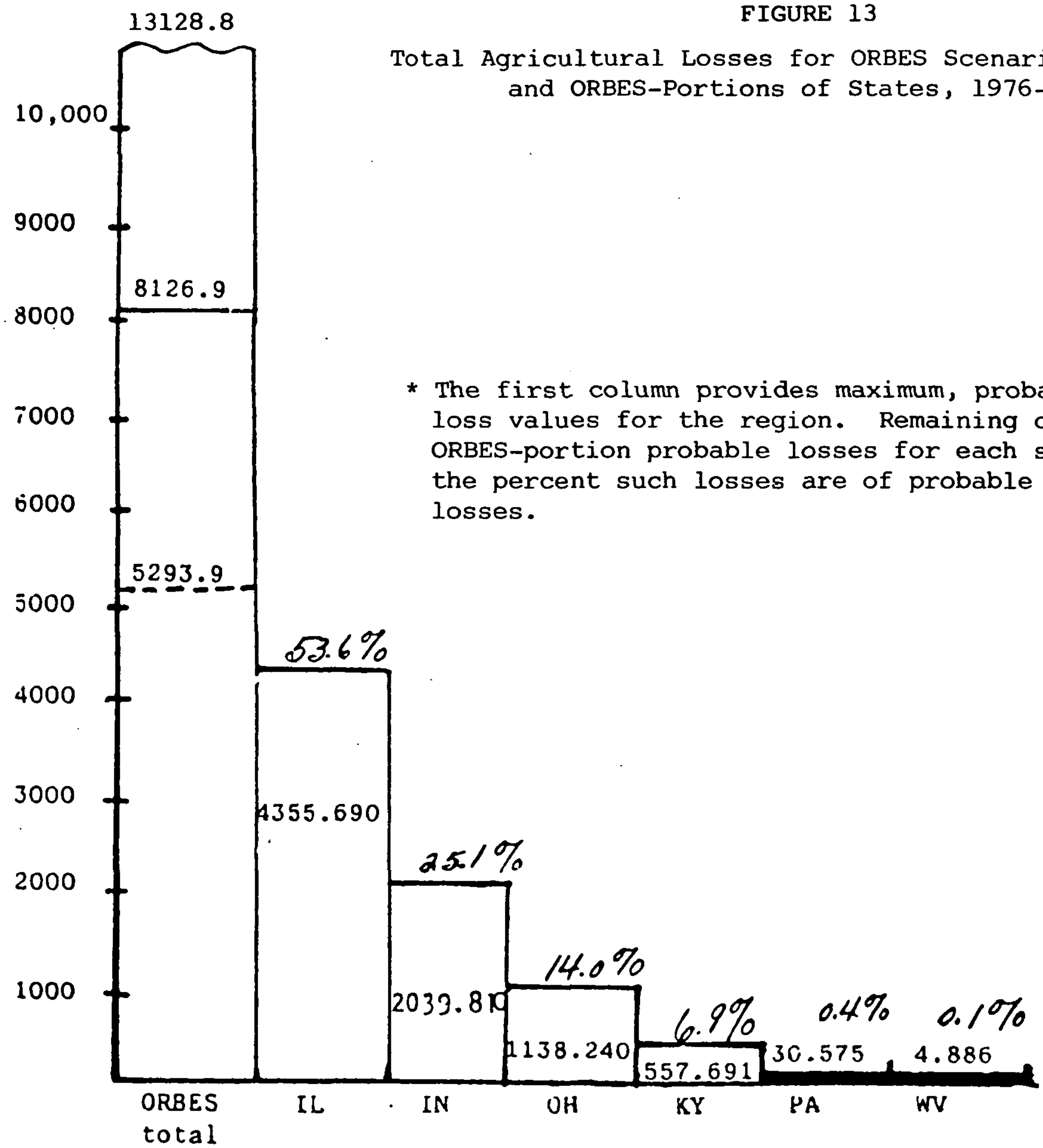
Total Utility Related Agricultural Losses for ORBES Scenario 2 by Region and ORBES-Portions of States, 1976-2000*



* The first column provides maximum, probable and minimum loss values for the region. Remaining columns show ORBES-portion probable losses for each state as well as the percent such losses are of probable total regional losses.

FIGURE 13

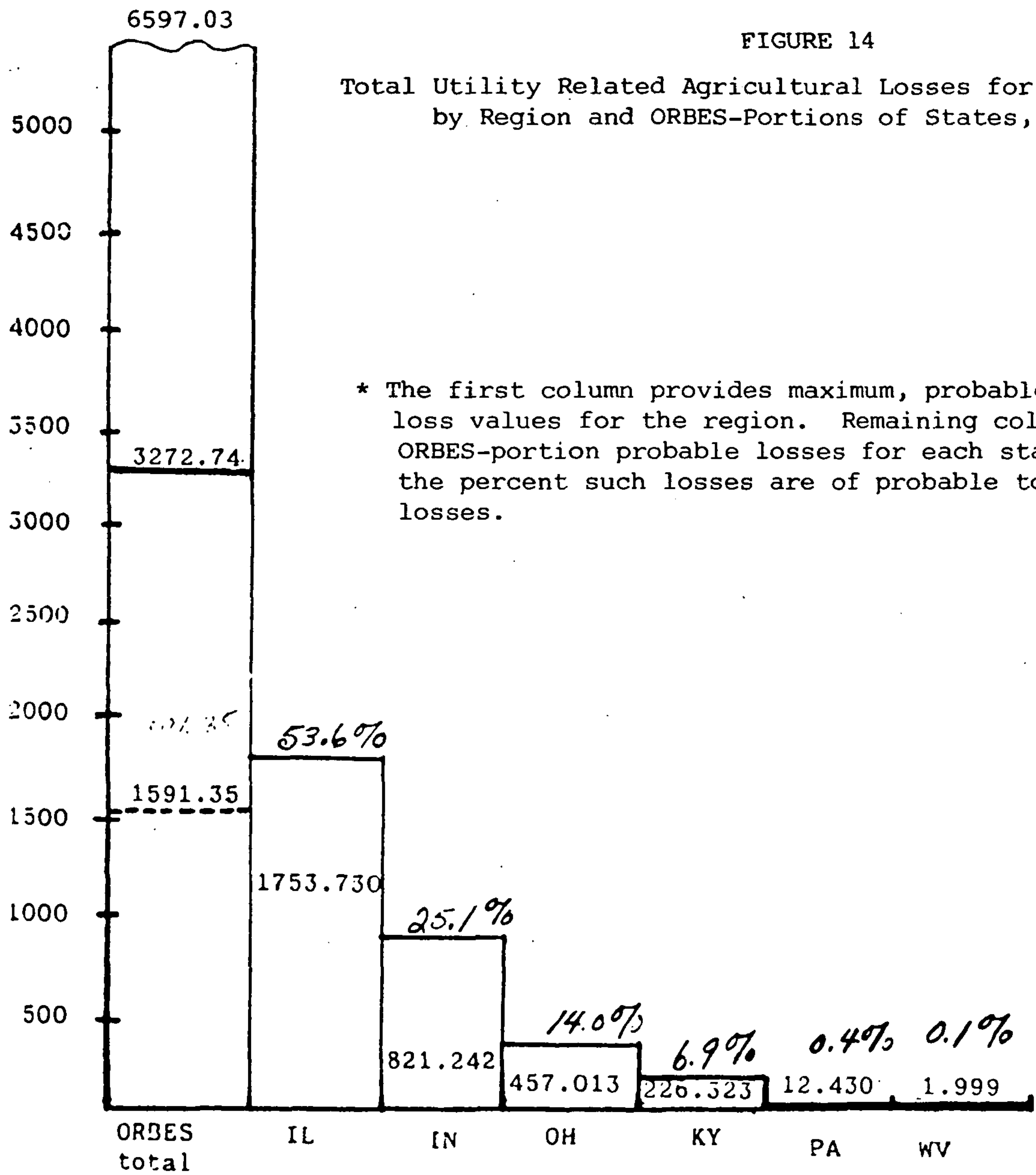
Total Agricultural Losses for ORBES Scenario 2d by Region and ORBES-Portions of States, 1976-2000*



* The first column provides maximum, probable and minimum loss values for the region. Remaining columns show ORBES-portion probable losses for each state as well as the percent such losses are of probable total regional losses.

FIGURE 14

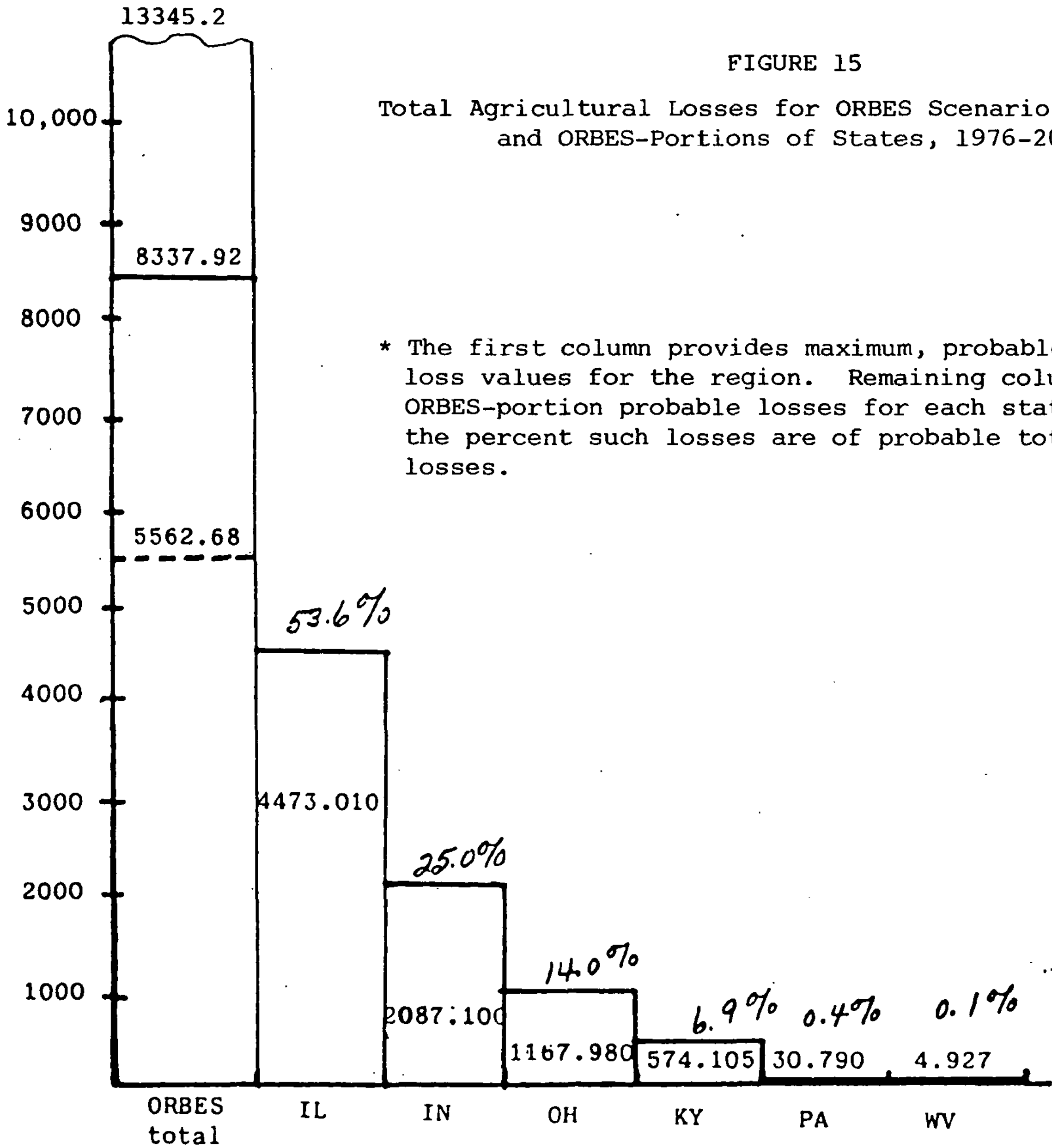
Total Utility Related Agricultural Losses for ORBES Scenario 2d by Region and ORBES-Portions of States, 1976-2000*



* The first column provides maximum, probable and minimum loss values for the region. Remaining columns show ORBES-portion probable losses for each state as well as the percent such losses are of probable total regional losses.

FIGURE 15

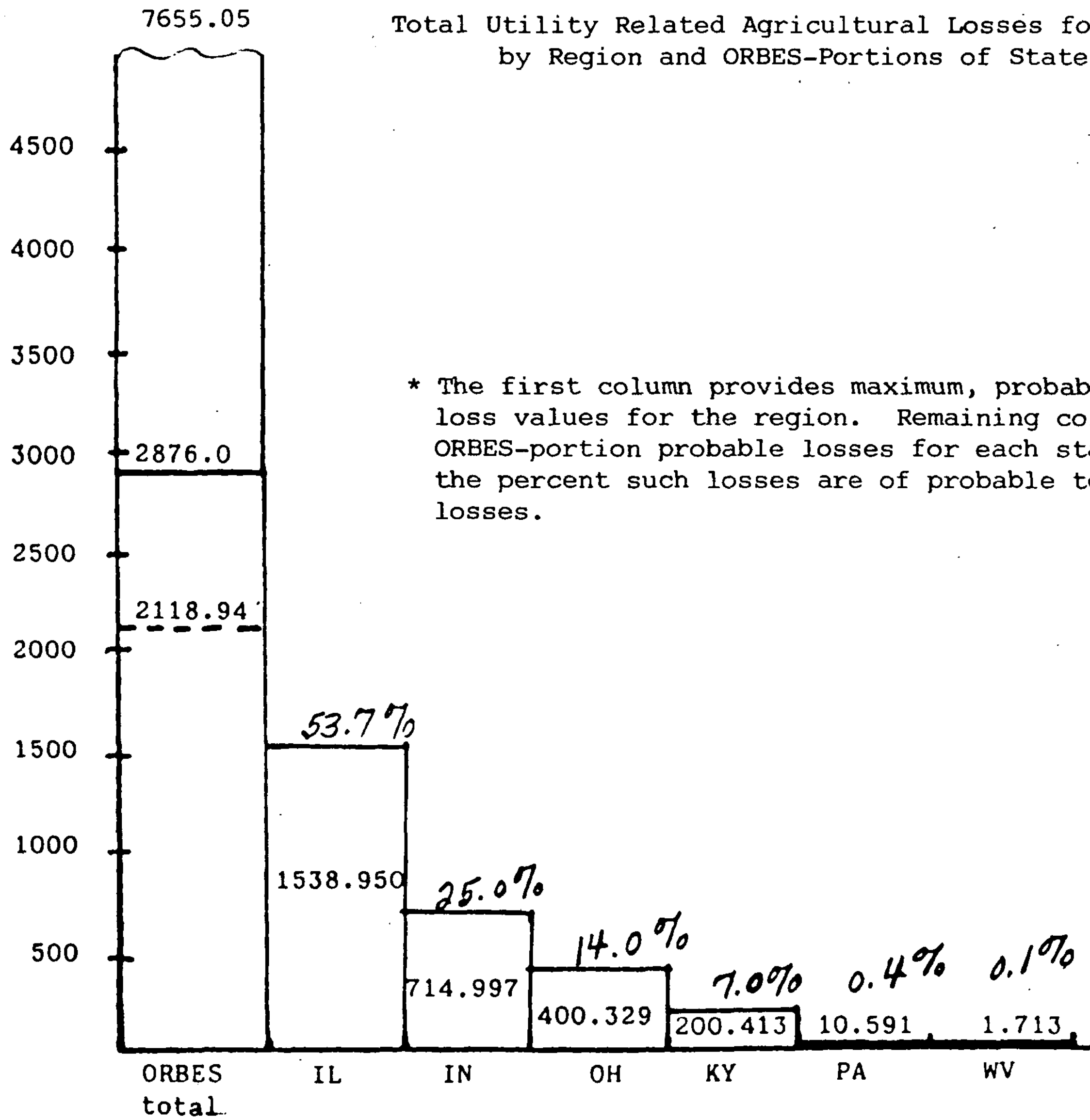
Total Agricultural Losses for ORBES Scenario 7 by Region and ORBES-Portions of States, 1976-2000*



* The first column provides maximum, probable and minimum loss values for the region. Remaining columns show ORBES-portion probable losses for each state as well as the percent such losses are of probable total regional losses.

FIGURE 16

Total Utility Related Agricultural Losses for ORBES Scenario 7 by Region and ORBES-Portions of States, 1976-2000*



* The first column provides maximum, probable and minimum loss values for the region. Remaining columns show ORBES-portion probable losses for each state as well as the percent such losses are of probable total regional losses.

FIGURE 17

Plot of Total Regional Monetary Losses, by Crop, 1976-2000, Scenario 2 (undiscounted values, millions of dollars)

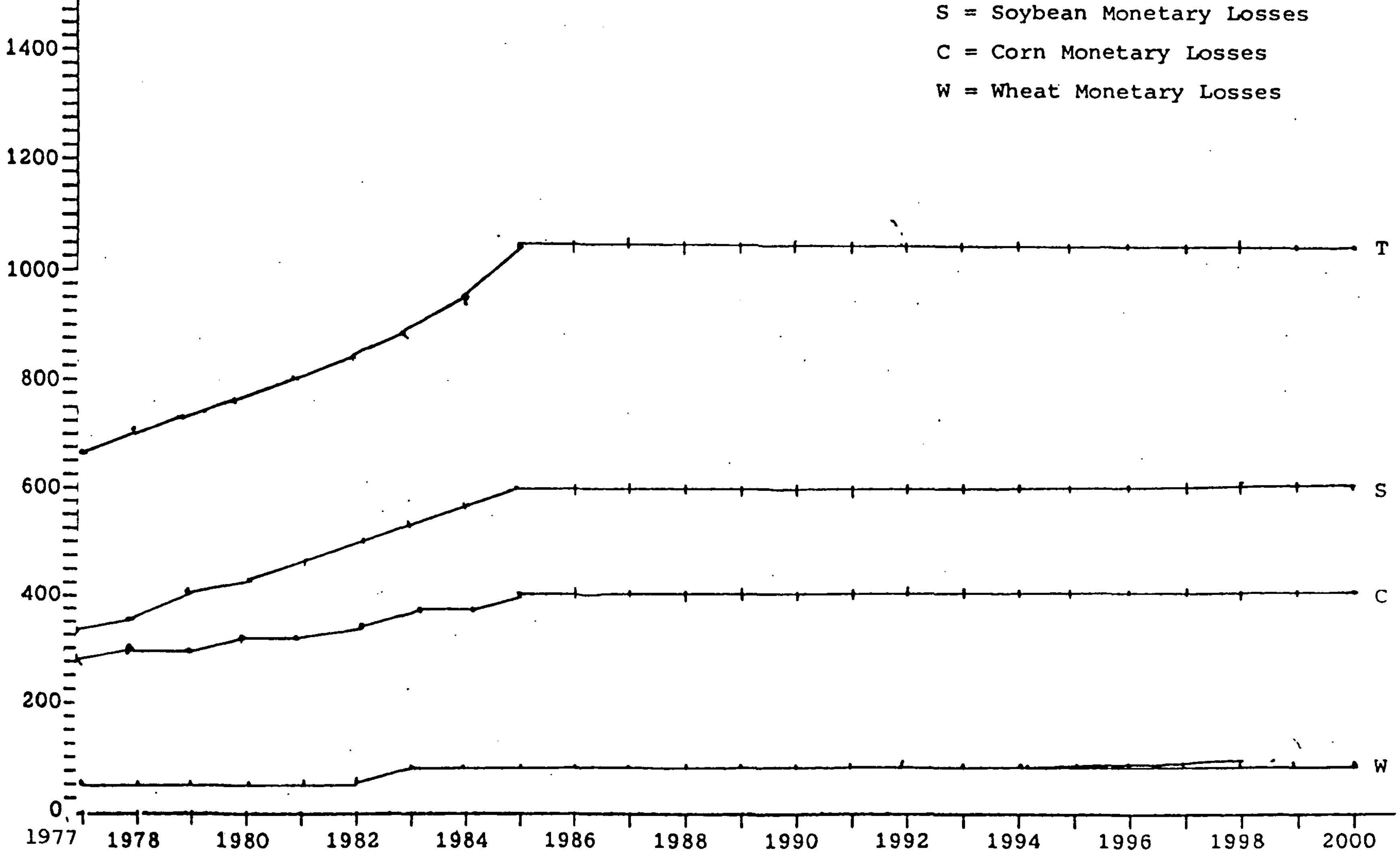


FIGURE 18

Plot of Utility Related Total Regional Monetary Losses, by Crop, 1976-2000, Scenario 2 (undiscounted values, millions of dollars)

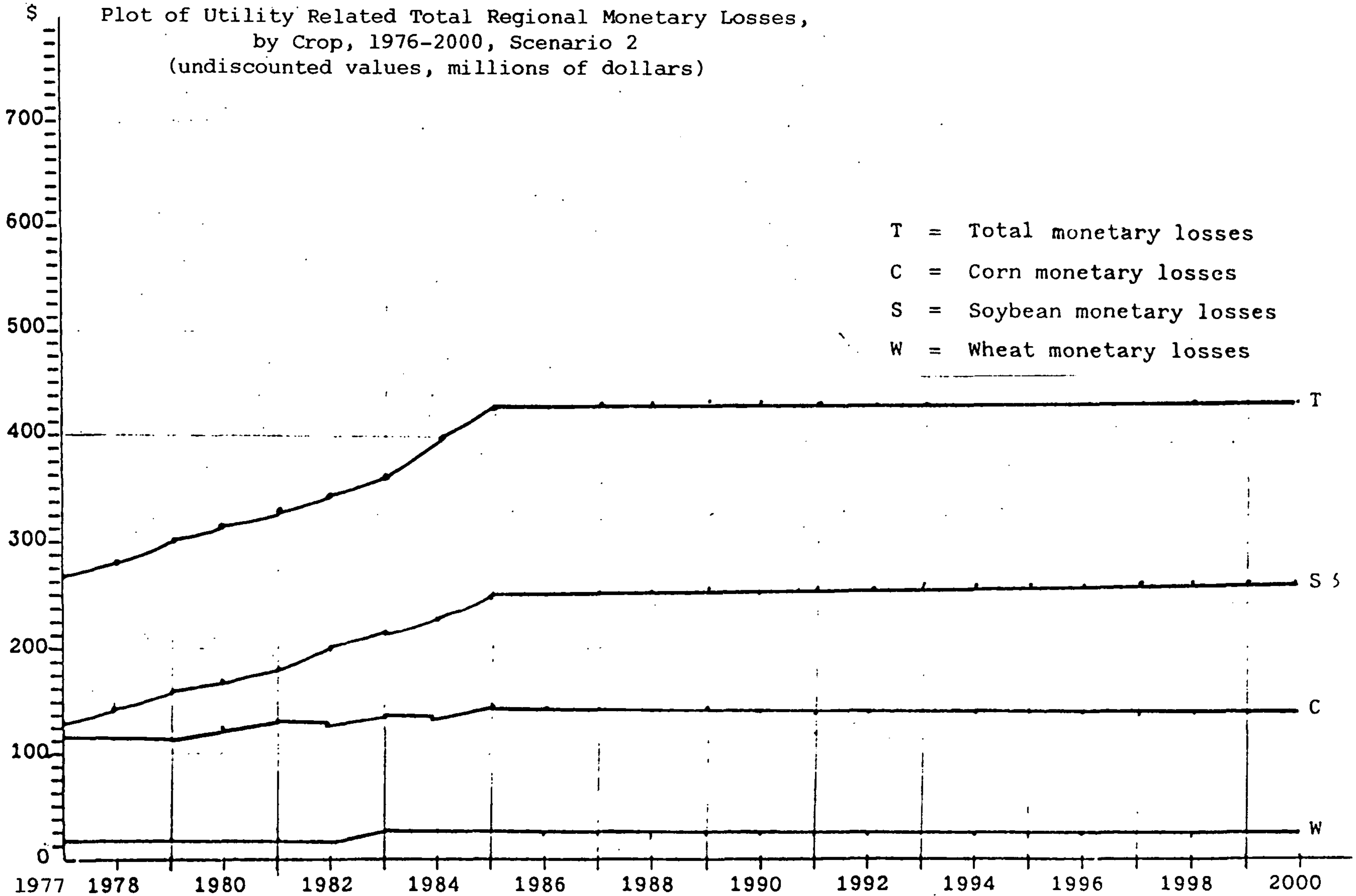


FIGURE 19

Plot of Total Regional Monetary Losses, by Crop, 1976-2000, Scenario 2d (undiscounted values, millions of dollars)

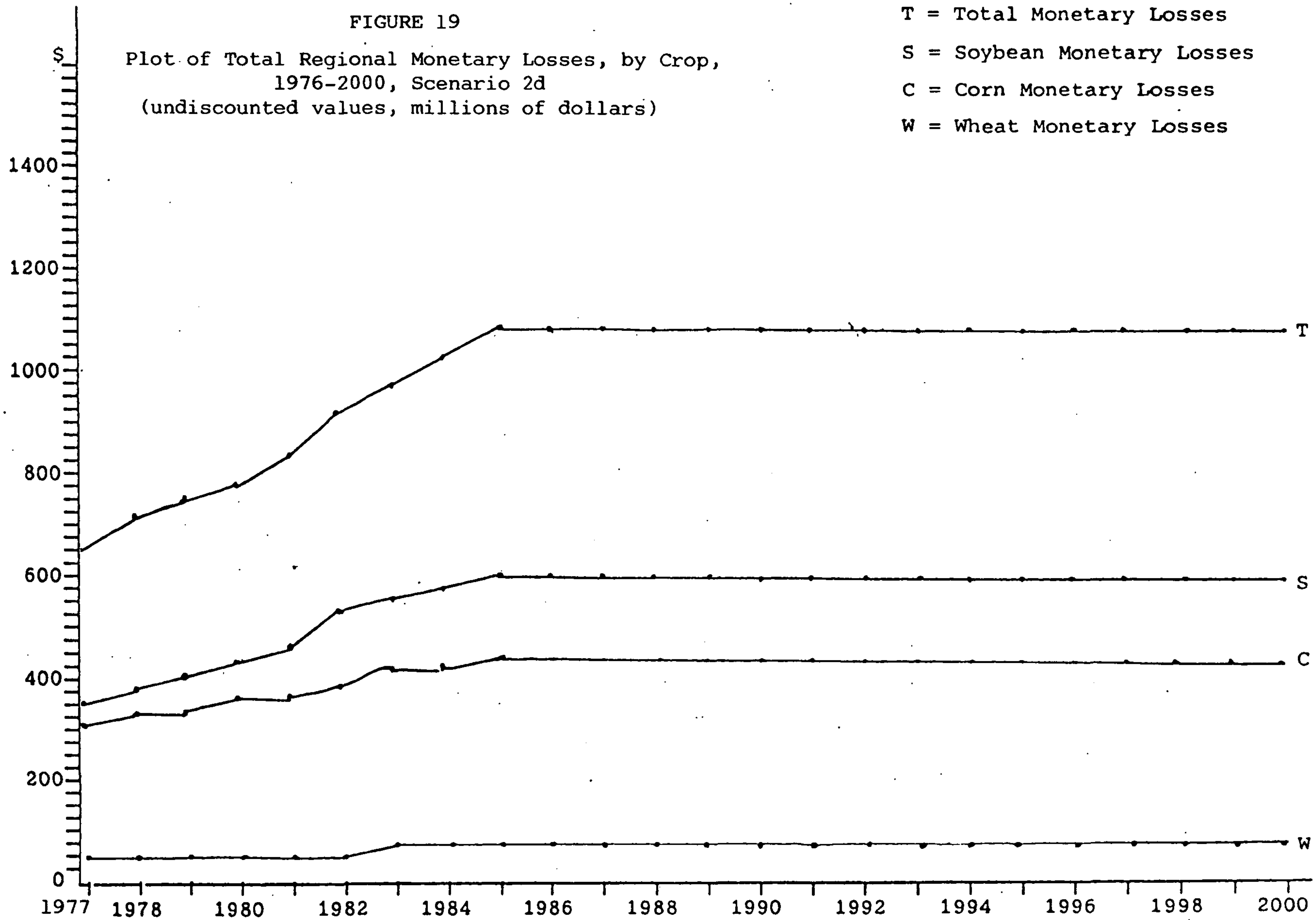
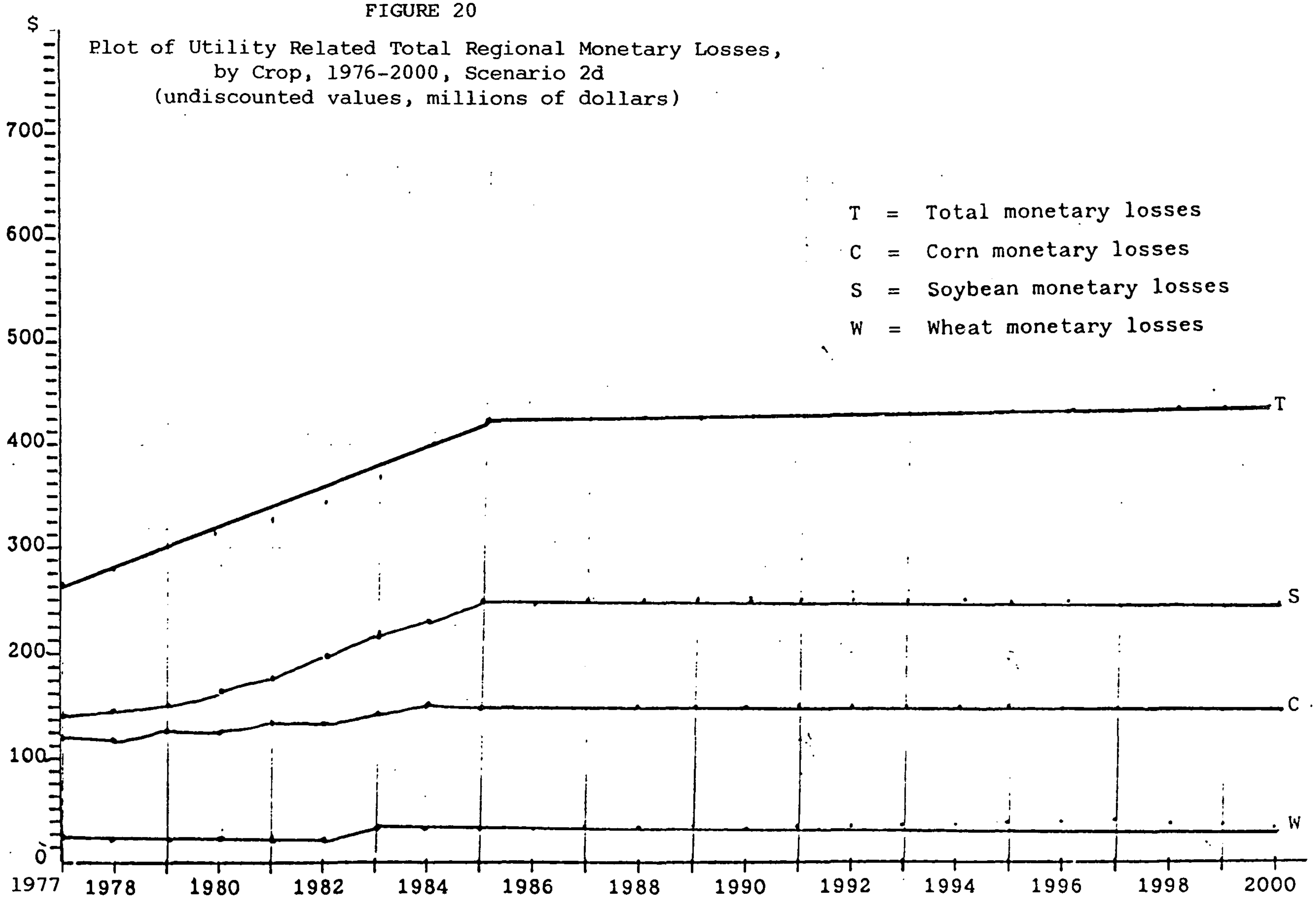


FIGURE 20

Plot of Utility Related Total Regional Monetary Losses,
by Crop, 1976-2000, Scenario 2d
(undiscounted values, millions of dollars)



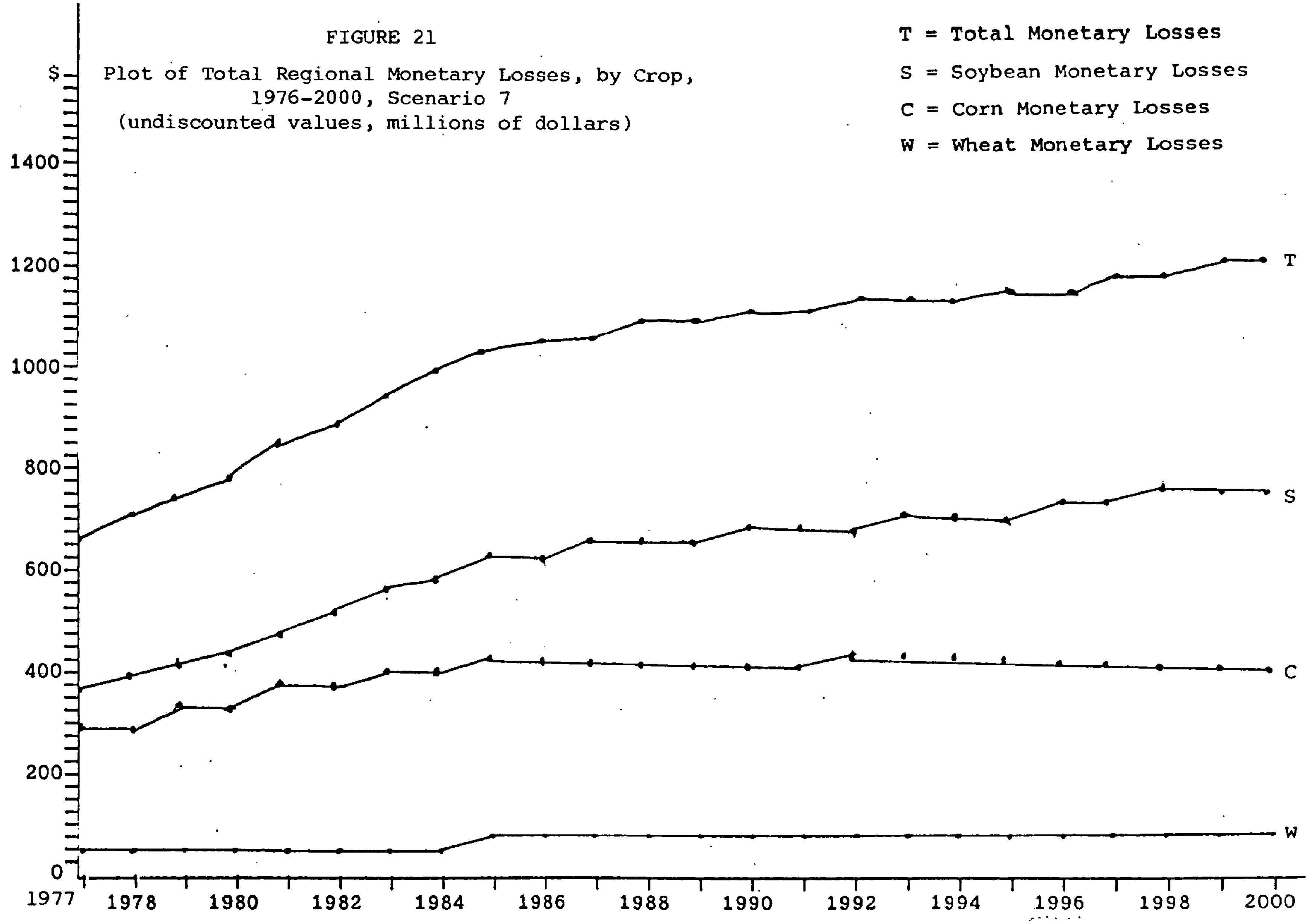
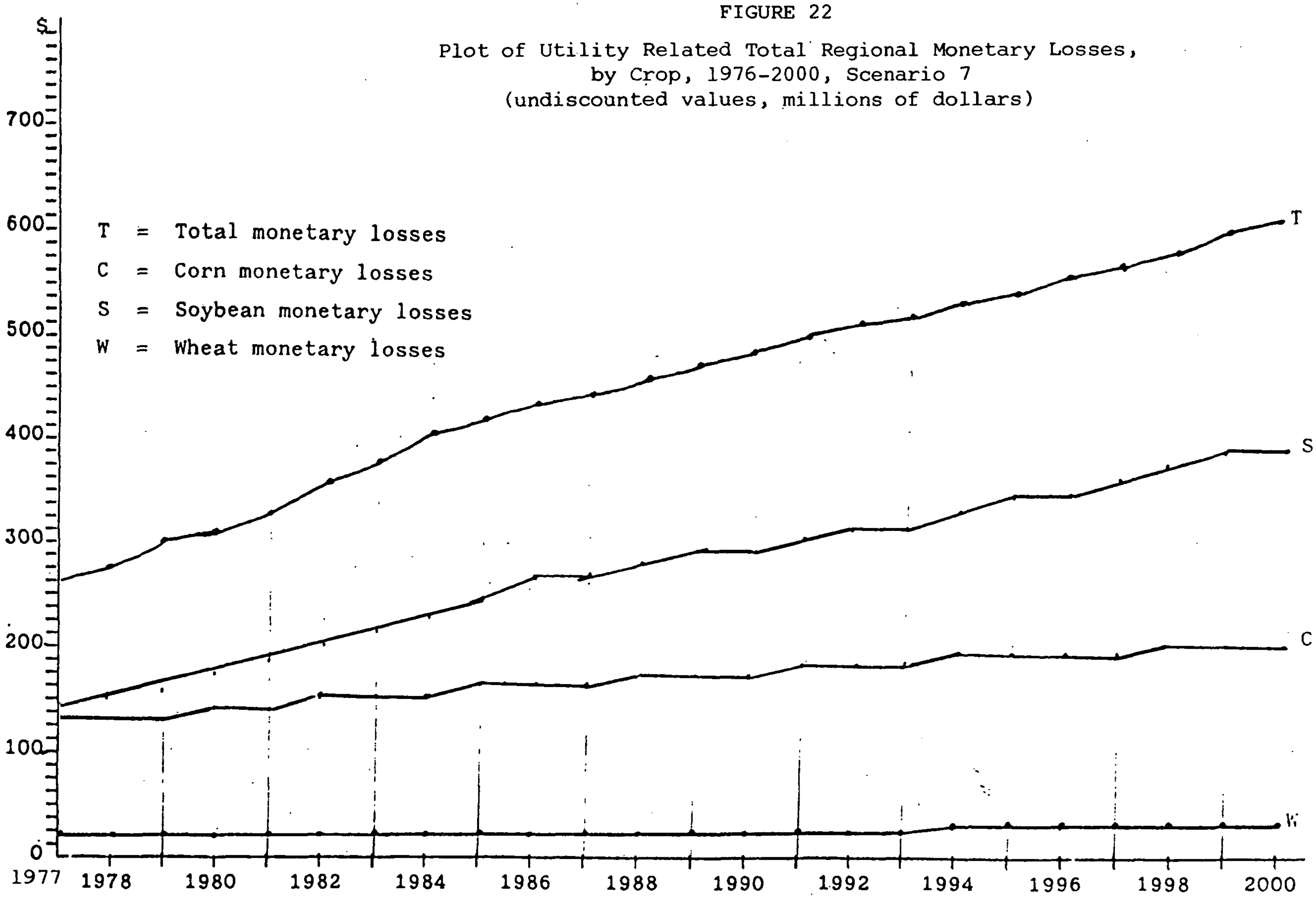


FIGURE 21

Plot of Total Regional Monetary Losses, by Crop, 1976-2000, Scenario 7 (undiscounted values, millions of dollars)

FIGURE 22

Plot of Utility Related Total Regional Monetary Losses, by Crop, 1976-2000, Scenario 7 (undiscounted values, millions of dollars)



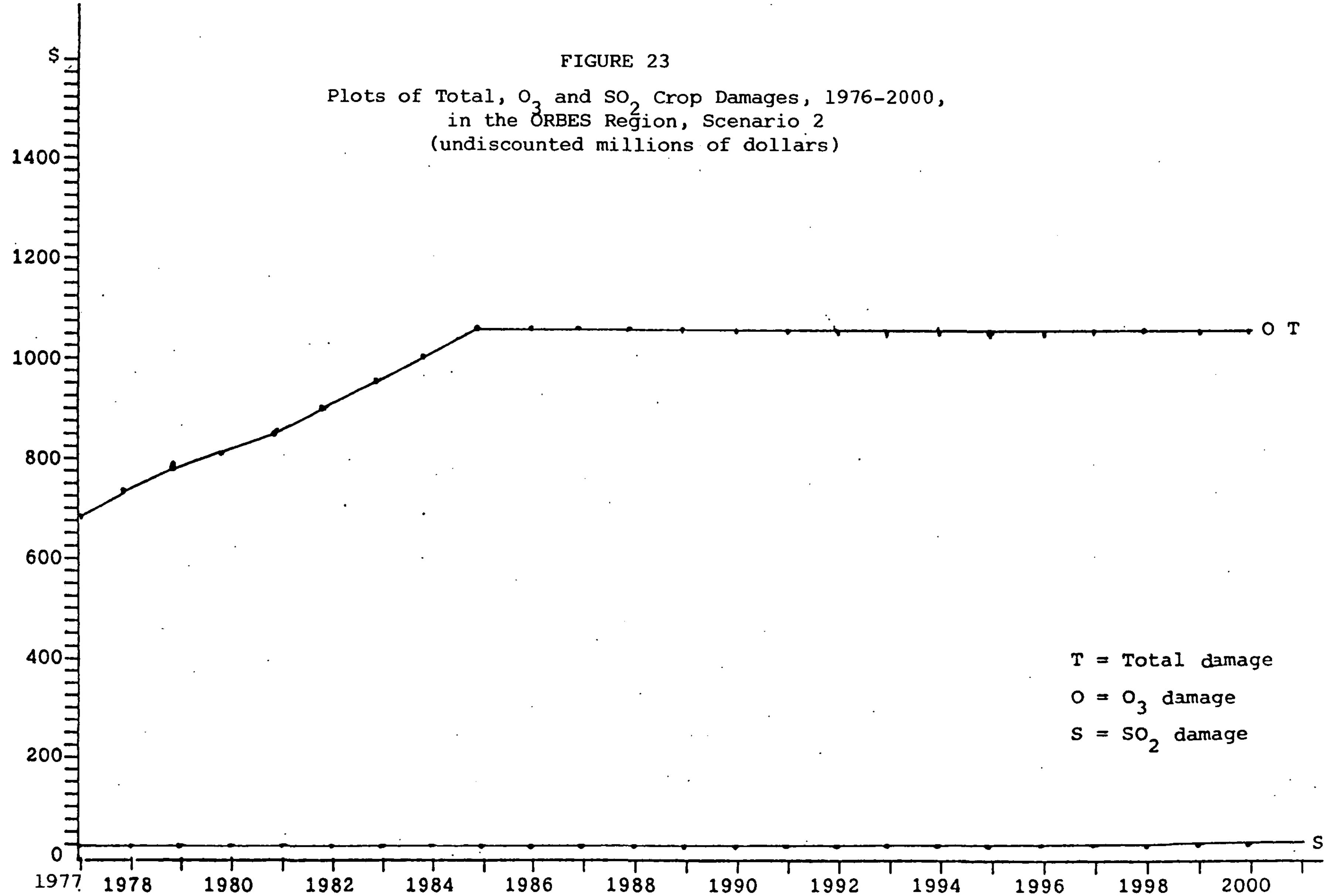


FIGURE 23

Plots of Total, O_3 and SO_2 Crop Damages, 1976-2000, in the ORBES Region, Scenario 2 (undiscounted millions of dollars)

FIGURE 24

Plots of Total, O_3 and SO_2 Utility Related Crop Damages, 1976-2000, in the ORBES Region, Scenario 2 (undiscounted millions of dollars)

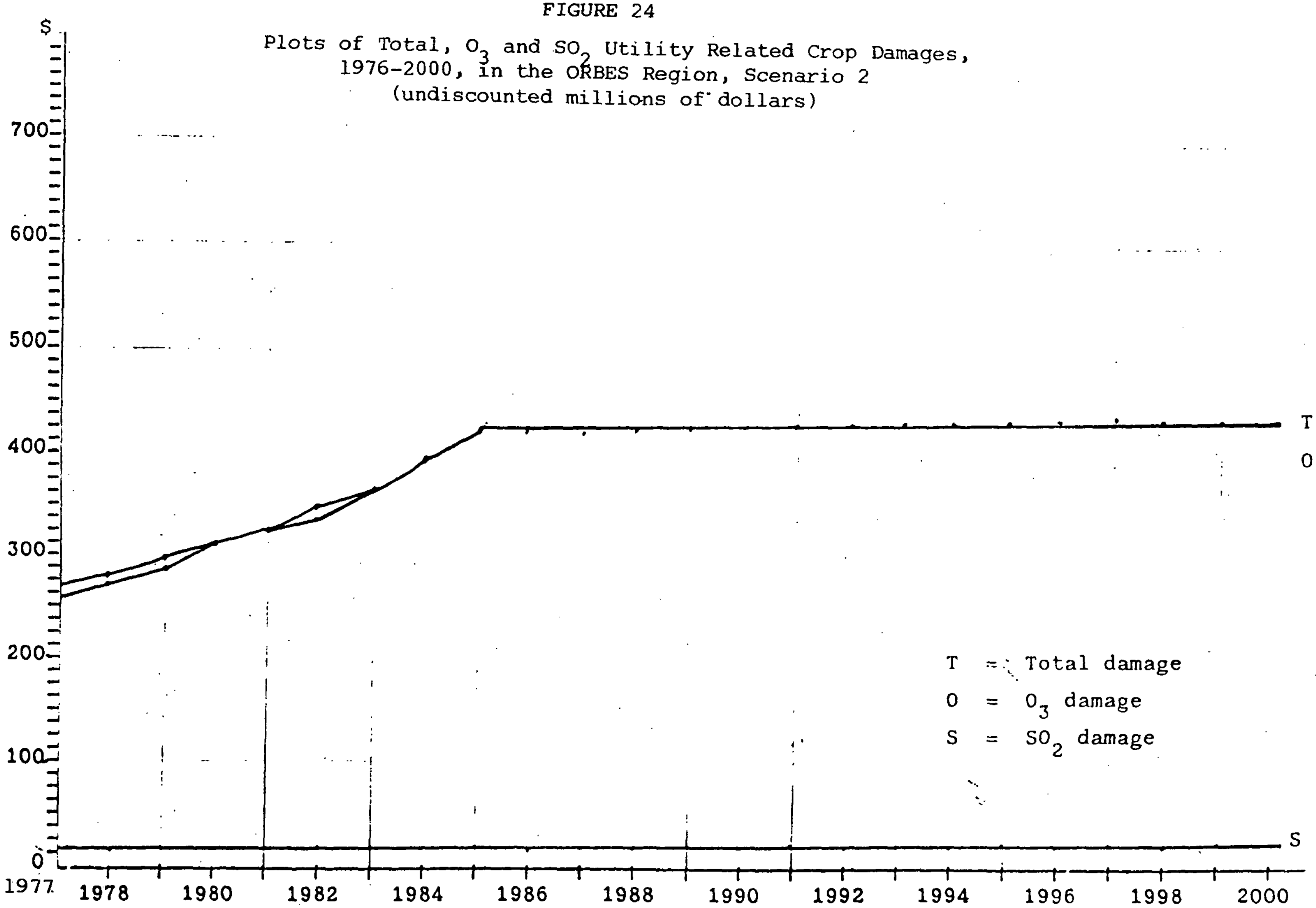


FIGURE 25

Plots of Total O_3 and SO_2 Crop Damages, 1976-2000, in the ORBES Region, Scenario 2d (undiscounted millions of dollars)

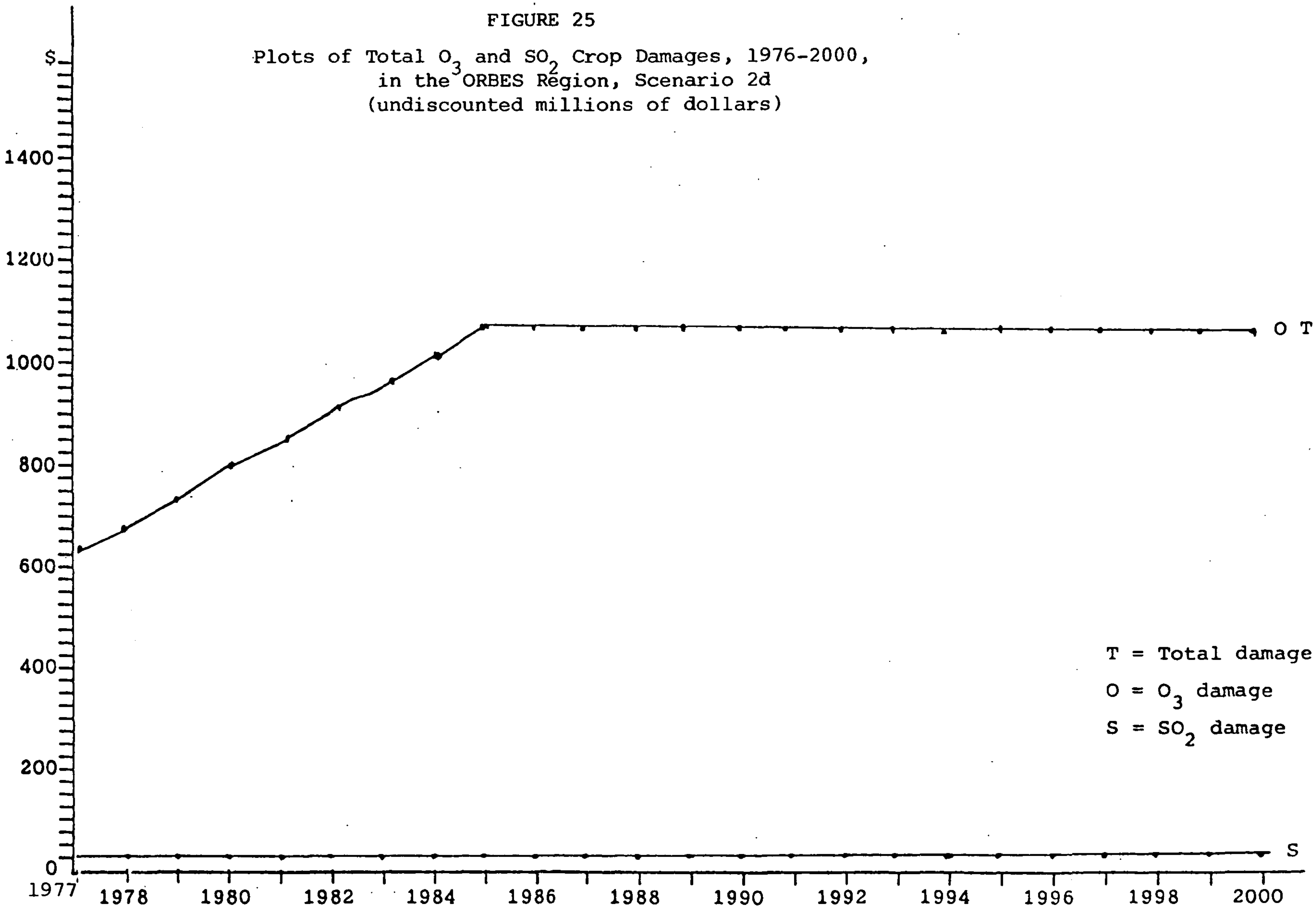


FIGURE 26

Plots of Total, O_3 and SO_2 Utility Related Crop Damages, 1976-2000, in the ORBES Region, Scenario 2d (undiscounted millions of dollars)

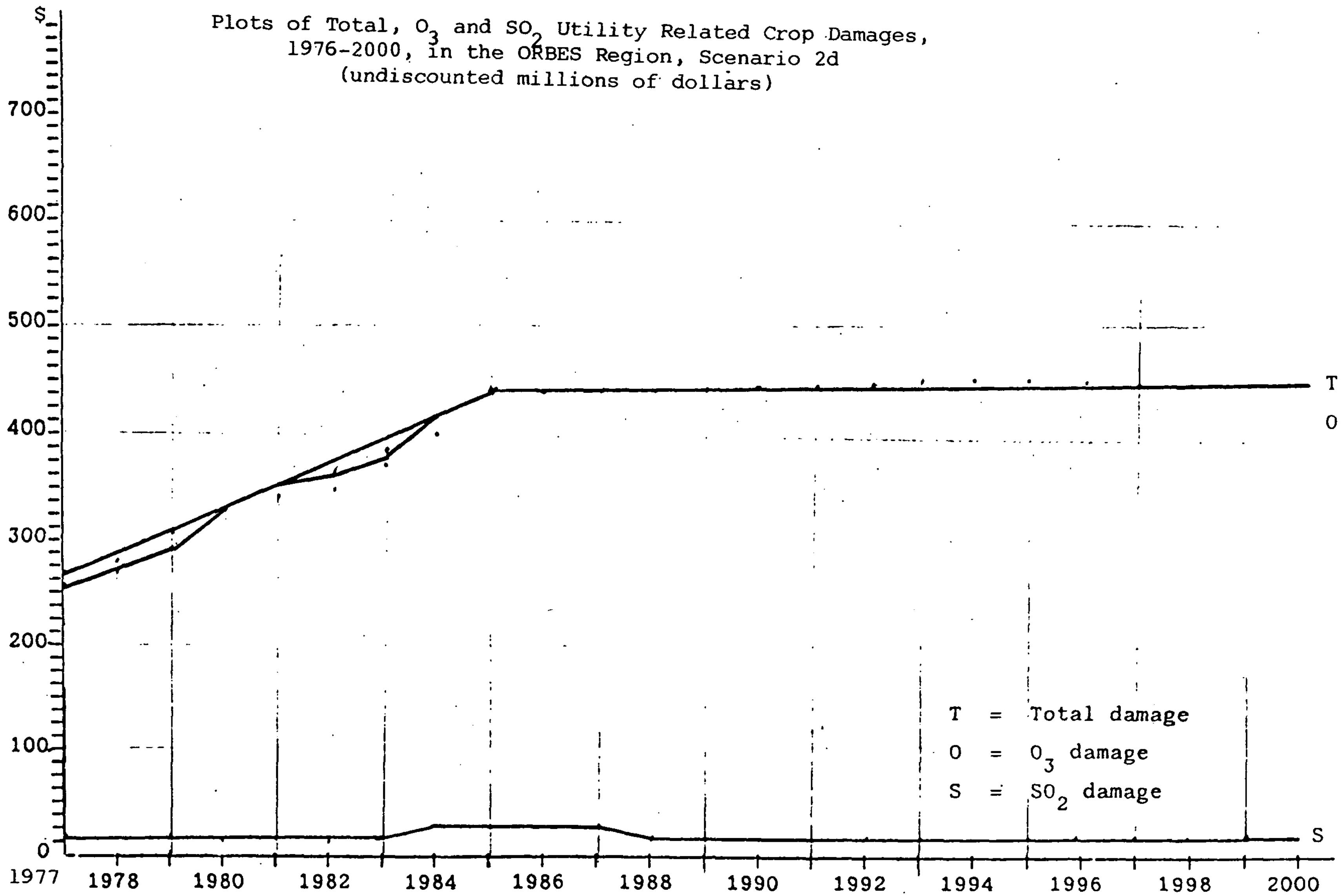


FIGURE 27

Plots of Total O_3 and SO_2 Crop Damages, 1976-2000, in the ORBES Region, Scenario 7 (undiscounted millions of dollars)

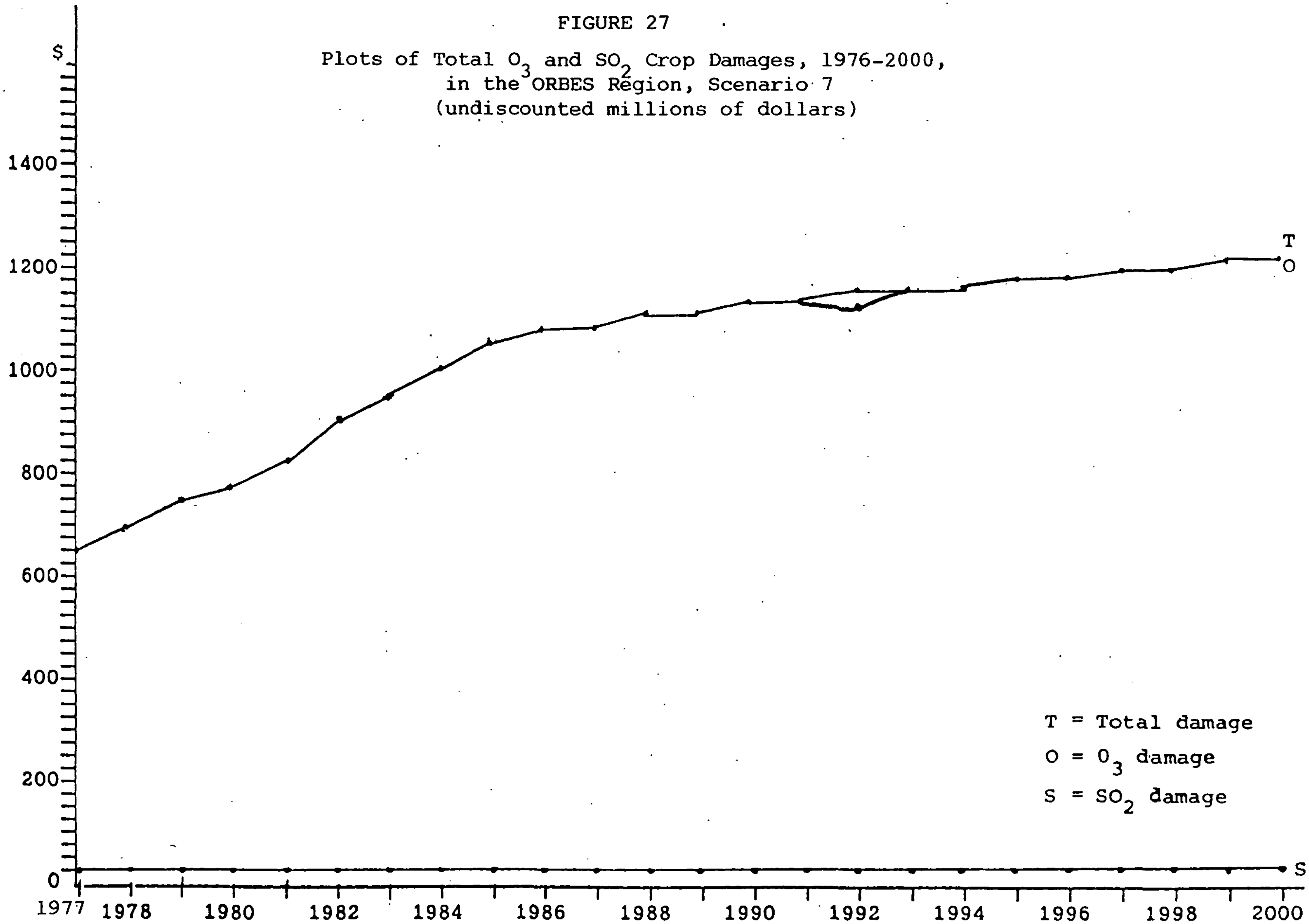
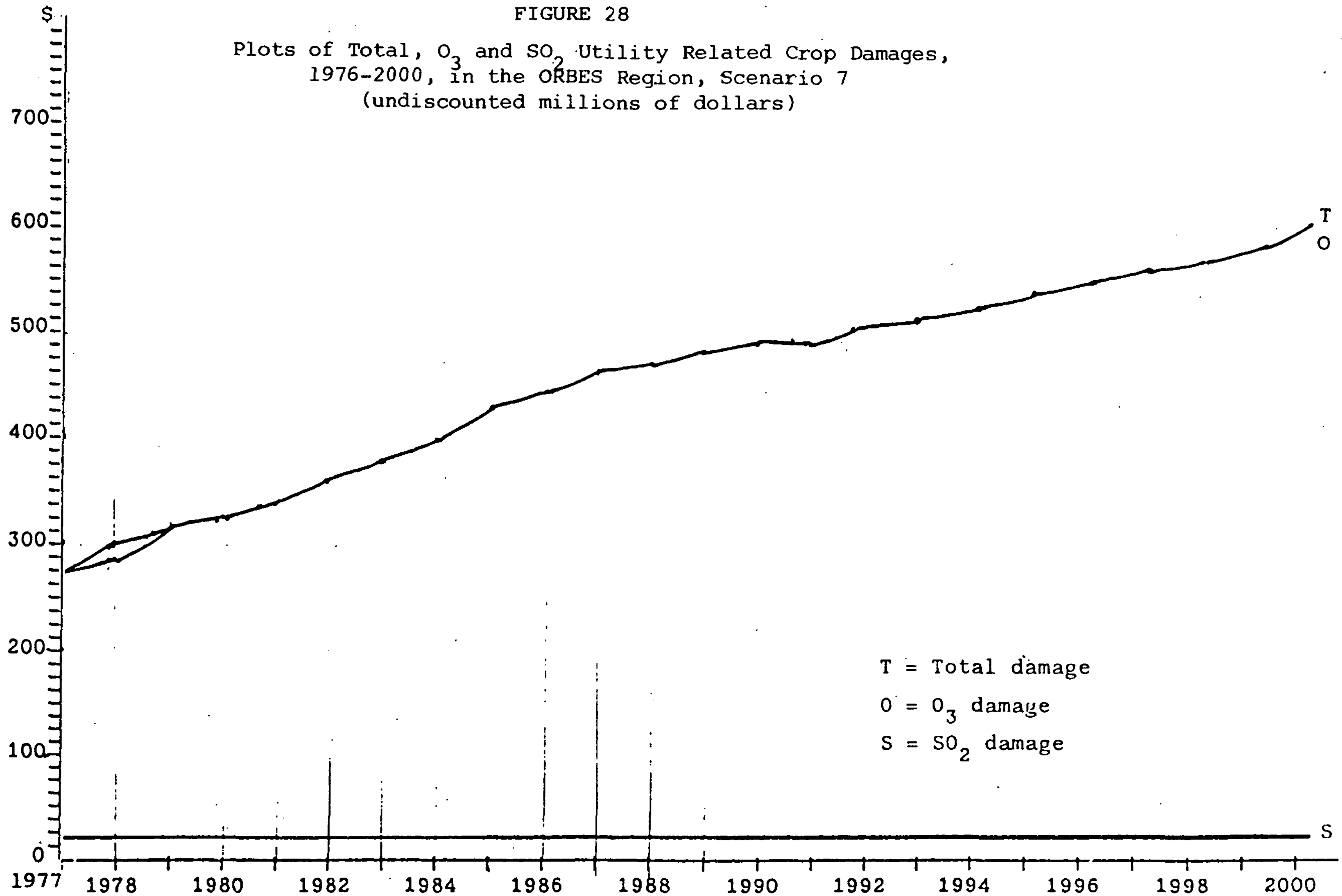


FIGURE 28

Plots of Total, O_3 and SO_2 Utility Related Crop Damages, 1976-2000, in the ORBES Region, Scenario 7 (undiscounted millions of dollars)



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APPENDIX A
Table A-1

NET PRESENT VALUE OF PROBABLE TOTAL AND UTILITY-RELATED CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 2*

ORBES area	Losses ≠ (millions of dollars)	Percent losses are of pollution-free output	Percent losses are of ORBES total losses#
IL	3755.56 (1565.78)	10.5 (4.4)	53.6 (53.8)
IN	1758.51 (727.60)	10.0 (4.1)	25.1 (25.0)
KY	479.76 (201.18)	10.6 (4.4)	6.1 (6.9)
OH	976.00 (403.18)	10.1 (4.2)	13.9 (13.8)
PA	27.71 (11.58)	7.6 (3.2)	0.4 (0.4)
WV	4.48 (1.91)	7.7 (3.3)	0.1 (0.1)
ORBES TOTAL	7002.03& (2911.22)	10.3 (4.3)	100.0 (100.0)

* Assumes a 10% discount rate. Numbers in parentheses are for utility-related losses.

≠ Crops are corn, soybeans, and wheat.

Sum may notbe 100% due to rounding.

& SO_2 losses are .7% of total and O_3 99.3%.

Table A-2

NET PRESENT VALUE OF PROBABLE TOTAL AND UTILITY-RELATED CUMULATIVE CROP LOSS, 1976 to 2000, FROM SO_2 AND O_3: SCENARIO 2d*

ORBES area	Losses⌿ (millions of dollars)	Percent losses are of pollution-free output	Percent losses are of ORBES total losses#
IL	3767.02 (1577.24)	10.6 (4.4)	53.6 (53.6)
IN	1771.41 (740.50)	10.0 (4.2)	25.2 (25.2)
KY	482.59 (204.01)	10.6 (4.5)	6.9 (6.9)
OH	977.96 (405.11)	10.1 (4.2)	13.9 (13.8)
PA	27.95 (11.82)	7.6 (3.2)	0.4 (0.4)
WV	4.51 (1.93)	7.8 (3.3)	0.1 (0.1)
ORBES TOTAL	7031.41& (2940.61)	10.4 (4.3)	100.0 (100.0)

* Assumes a 10% discount rate. Numbers in parentheses are for utility-related losses.

⌿ Crops are corn, soybeans, and wheat.

\# Sum may not be 100% due to rounding.

& SO_2 losses are 1.1% of total and O_3 98.9%.

Table A-3

NET PRESENT VALUE OF PROBABLE TOTAL AND UTILITY-RELATED CUMULATIVE CROP LOSS, 1976 TO 2000, FROM SO_2 AND O_3: SCENARIO 7*

ORBES area	Losses ≠ (millions of dollars)	Percent losses are of pollution-free output	Percent losses are of ORBES total losses#
IL	4491.960 (1998.010)	12.6 (5.6)	53.7 (53.8)
IN	2090.910 (924.048)	11.8 (5.2)	25.0 (24.9)
KY	574.604 (256.996)	12.7 (5.7)	6.7 (6.9)
OH	1168.870 (516.399)	12.0 (5.3)	14.0 (13.9)
PA	30.909 (13.649)	8.4 (3.7)	0.4 (0.4)
WV	4.978 (2.231)	8.6 (3.9)	0.1 (0.1)
ORBES TOTAL	8362.221 & (3711.345)	12.3 (5.5)	100.0 (100.0)

* Assumes a 10% discount rate. Numbers in parentheses are for utility-related losses.

≠ Crops are corn, soybeans and wheat.

Sum may not be 100% due to rounding.

& SO_2 losses are .6% of total and O_3 99.4%.