Chapter 5

The Regional Distribution of Risks

Contents

FIGURES

Chapter 5

The Regional Distribution of Risks

INTRODUCTION

Chapter 3 presented the risks of controlling and not controlling transported air pollutants for the Eastern 3 l-State region overall. However, the ways in which these risks are distributed throughout the region arc of prime significance to the policy debate. Most importantly, considerable variation is found in:

- the distribution of pollution sources, and hence, the distribution of potential control costs ;
- the distribution and extent of resources at risk, their levels of exposure, and their inherent sensitivity to transported pollutants; and
- the relative importance of the economic sector at risk to each State's economy.

Scientific uncertainties complicate the task of describing the distribution of risk. However, even if scientists attained ' 'perfect knowledge' of the causes and consequences of transported air pollutants, different *groups* and *regions of the country* would bear these risks. Thus, while it is impossible to precisely specify these groups and regions at present, the distributional aspects of transported pollutants are *inherently* part of the policy problem.

This chapter describes how the risks associated with three pollutants—acid deposition, ozone, and airborne sulfate— are distributed. The order of discussion closely follows the presentation in chapter 3 of the aggregate risks to the Eastern 31 -State region. This chapter, however, focuses on the regional distribution of these risks, and is extensively illustrated with maps.

Two situations are described: 1) the risk of resource damage and adverse health effects if Congress maintains the status quo for pollutant emissions, and 2) the costs and economic effects of additional pollution-control measures that might be adopted.

Some of the risks of controlling or not controlling transported air pollutants can be thought of as ' 'localized' risks. For example, fewer than half the States contain deposits of high sulfur-content coal; only in these States could current coal production be lost due to additional pollution-control requirements. Similarly, only parts of the Eastern United States contain lakes and streams considered potentially sensitive to acid deposition. Other risks can be characterized as ' 'distributed' '—risks that are present in Virtually all States in the Eastern region, For example, crops are grown in all States. Three factors determine the relative importance of ozone-caused crop damage: 1) the concentration of ozone in a State, 2) the sensitivities of a States crops to ozone, and 3) the importance of agriculture to the State economy. Likewise, the effects of utility pollution-control costs depend both on the amount of the State income spent on electricity and on a State pollutant emissions.

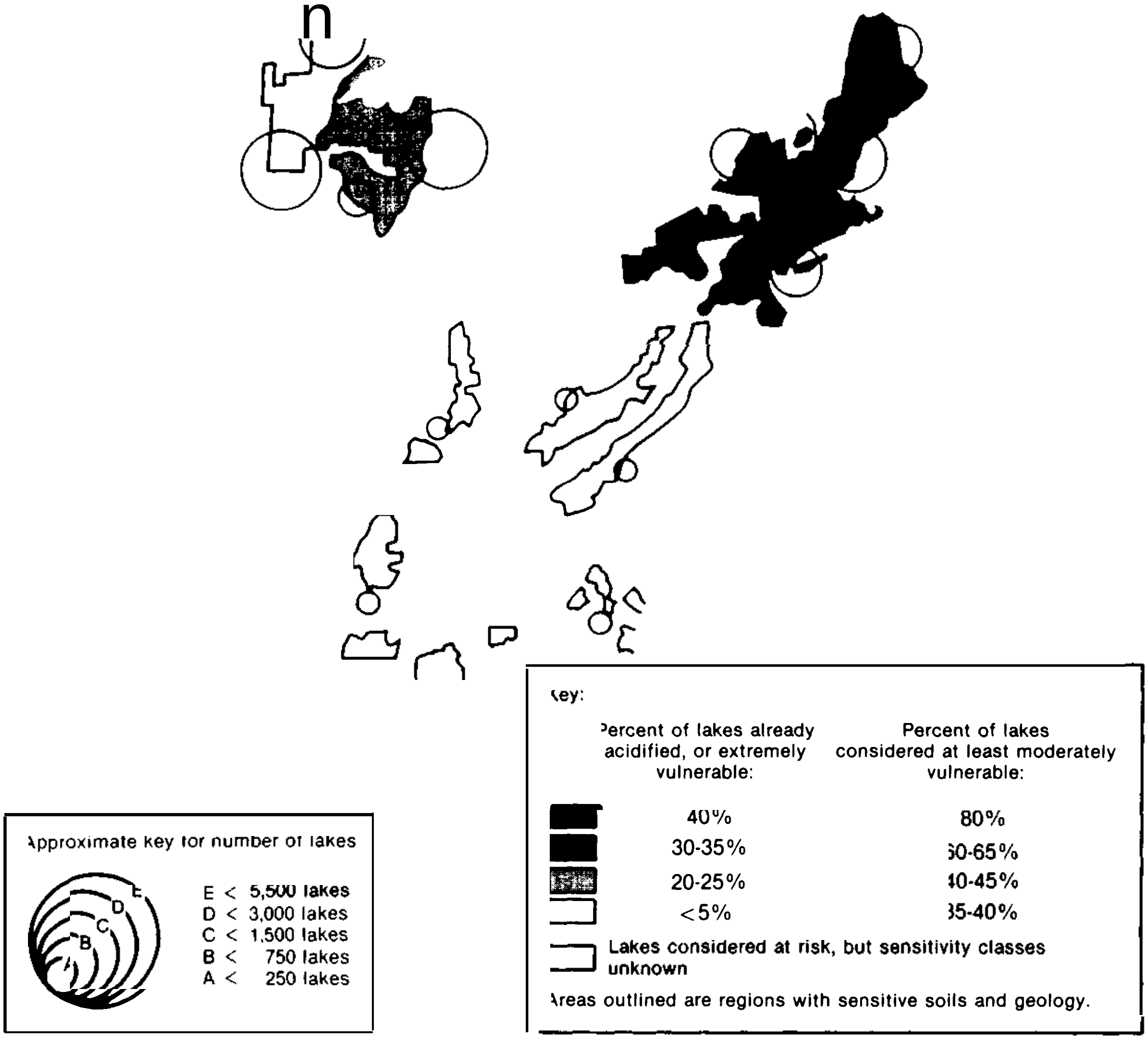
In addition to describing the geographic patterns of risk from transported air pollutants, this chapter assesses the relative importance of five economic sectors of concern: agriculture, forestry and forest product-related industries, freshwater recreational fishing, coal mining, and electricity generation. The first four sectors vary considerably in economic importance from State to State—from a small percentage of the regional average to several times that average. The last sector, electricity generation, is much more uniformly distributed.

NO CONGRESSIONAL ACTION

Aquatic Ecosystems

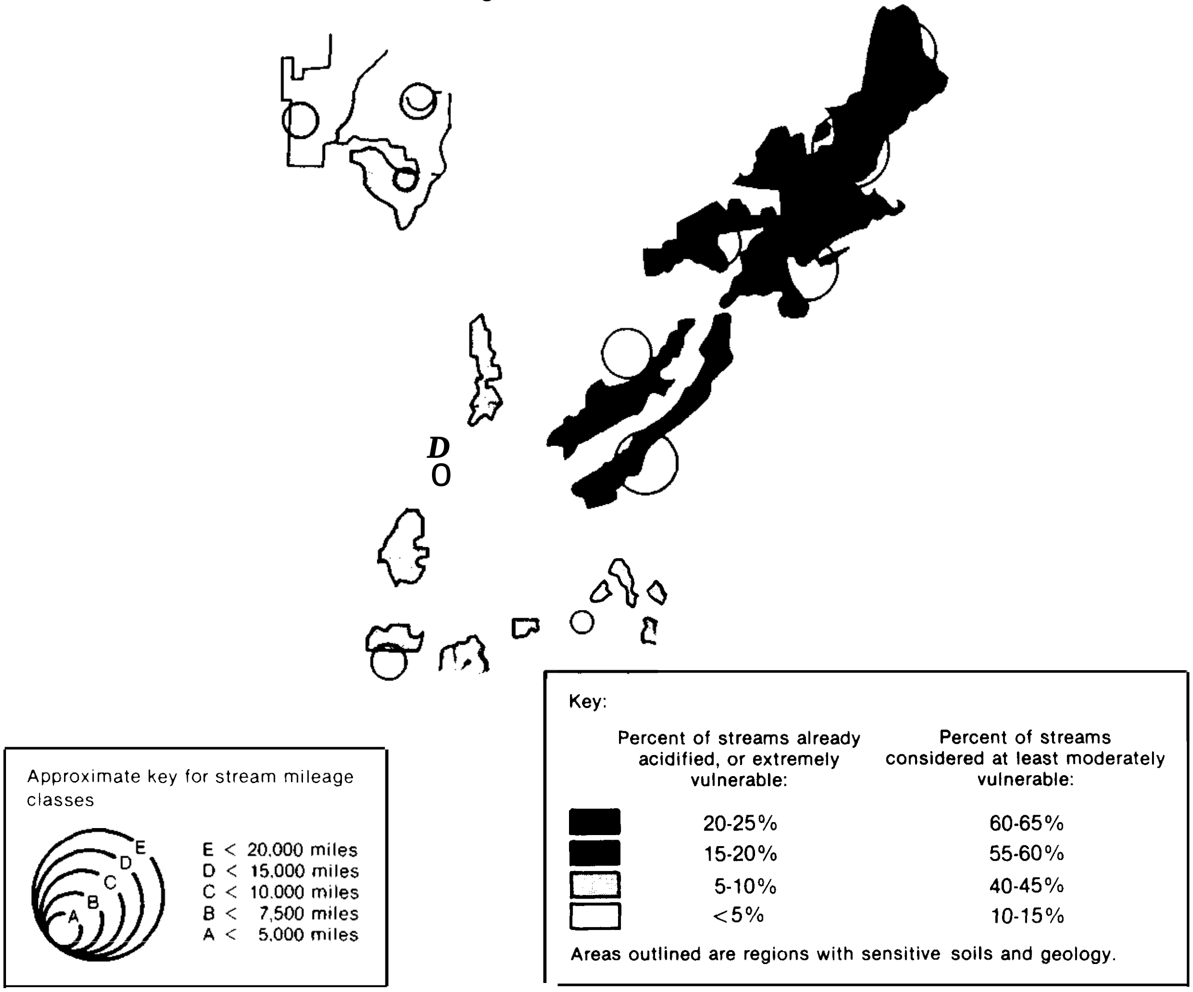
As discussed in chapter 3, lakes and streams are affected not only by the acid deposition falling directly on them, but also by the amount of acid-producing substances entering them from surrounding watersheds. Regions with soils and bedrock that neutralize acidic deposition are not likely to be affected. The areas outlined in figures 23 and 24 are thought to allow acidity to travel through watersheds to lake and streams. These areas contain soils that either cannot neutralize acidity, or are so steep and rocky that rainfall has little contact with soils and runs directly into lakes or streams. The ***size*** of the circles on each map illustrates the extent of lake and stream resources in each region. The greatest number of lakes is found in the upper Midwest, followed by New England. The greatest mileage of small streams is found in New England, followed by the mountain region of

Figure 23.-Estimated Percentages of Lakes Vulnerable to Acid Deposition in Sensitive Regions of the Eastern United States



SOURCE: The Institute of Ecology, "Regional Assessment of Aquatic Resources at Risk From Acid Deposition," OTA contractor report, 1982

Figure 24.—Estimated Percentages of Streams Vulnerable to Acid Deposition in Sensitive Regions of the Eastern United States



SOURCE: The Institute of Ecology, "Regional Assessment of Aquatic Resources at Risk From Acid Deposition, " OTA contractor report, 1982.

West Virginia, Kentucky, western Virginia, North Carolina, and eastern Tennessee.

However, because of local variation in soil and watershed characteristics, not all the lakes and streams within these regions will be vulnerable to acidic deposition. The intensity of shading within each outlined area indicates the percentage of lakes and streams estimated to be vulnerable to acid deposition, based on water quality characteristics. The northeastern regions have the greatest percentages of 'extremely' vulnerable lakes and streams—we estimate about 30 to 40 percent of the over 5,000 lakes and 10 to 20 percent of the 65,000 stream miles in the area. These regions also receive high levels of acidic deposition. In addition, large numbers of moderately vulnerable lakes are found in the upper Midwest, and extensive mileages of moderately vulnerable streams are found in the central Appalachian/Blue Ridge regions.

Directly comparing current conditions to historical data, only a small number of surface waters in North America are ***known*** to have acidified. Data from several decades ago are sparse; in addition, differences in sampling and measurement techniques make comparisons with current data difficult. A review of the available evidence for acidification found significant changes in water body chemistry in studies of: 250 lakes in Maine, 94 lakes in New England, 40 lakes in the Adirondacks, and two streams in the New Jersey Pine Barrens, as well as in 16 lakes near Halifax, Nova Scotia, 22 lakes in the LaCloche Mountains, Ontario, and Clear Lake, Ontario. Changes in water chemistry over time have also been reported for 38 North Carolina streams, 6 Nova Scotia rivers, and 314 surface waters in Pennsylvania; however, firm conclusions cannot be drawn from these studies. [1]

In the Adirondack Mountains, the only U.S. location in which scientists have documented fish *population* declines, the New York State Department of Environmental Conservation has reported the disappearance of fish populations in about 180 lakes. Researchers have found correlations between acidity levels and survival of fish in Adirondack lakes and streams. Four other areas are known to have experienced losses of fish populations associated with surface water acidification: 1) the LaCloche Mountain region of Ontario, 2) Nova Scotia, 3) Southern Norway, and 4) Southern Sweden.

Acid deposition may not be the sole cause of the changes discussed above. Other man-induced stresses and natural processes can also alter surface water chemistry. However, the largest numbers of acidified and extremely sensitive lakes and streams are located in regions currently receiving the highest levels of acid deposition.

Though the economic value of these particular sensitive resources cannot yet be estimated, the Fish and Wildlife Service has estimated that about 21 million people spent $6.3 billion on all recreational freshwater fishing activities in the Eastern United States during 1980. Figure 25 illustrates how these expenditures vary by State, displaying the importance of recreational fishing to each State's economy *relative* to the 3 1-State regional average.

Because there are few data to determine whether lakes and streams sensitive to acid deposition are those preferred for recreational fishing, OTA cannot estimate potential regional economic losses resulting from the elimination of fish populations. One local-scale study, however, has estimated losses to New York resident anglers of approximately $1.7 (1982 dollars) million annually from lost fishing opportunities in about 200 acidified Adirondack lakes and ponds. [2] Potential losses to individuals whose livelihoods depend on the recreational fishing industry were not estimated. On a regional scale, the States at greatest economic risk are those with: 1) the greatest numbers of sensitive lakes, 2) the highest levels of acid deposition, and 3) the highest relative expenditures for recreational fishing. Among these are the New England States of Maine, Vermont, and New Hampshire; the Appalachian region of West Virginia and eastern Kentucky; and parts of the Midwestern States of Wisconsin and Minnesota.

Terrestrial Ecosystems

Figure 26 shows major agricultural production areas for two major crops, corn and soybeans. Figure 27 presents the location of forests.

Figure 28 illustrates the crop yield gains that might occur if ozone concentrations were lowered to estimated natural background levels. The regions of highest crop production—an area slightly north of the peak ozone concentrations—show the greatest improvement. Here, in the corn and soybean belt of the Midwest, even moderate levels of ozone can cause substantial crop damage. For Iowa, Indiana, and Illinois, reducing ozone concentrations to background levels might cause both soybean and corn yields to increase by about 20 to 40 million bushels per year in each State. (See app. B for potential productivity gains in wheat and peanuts with decreased ozone concentrations.)

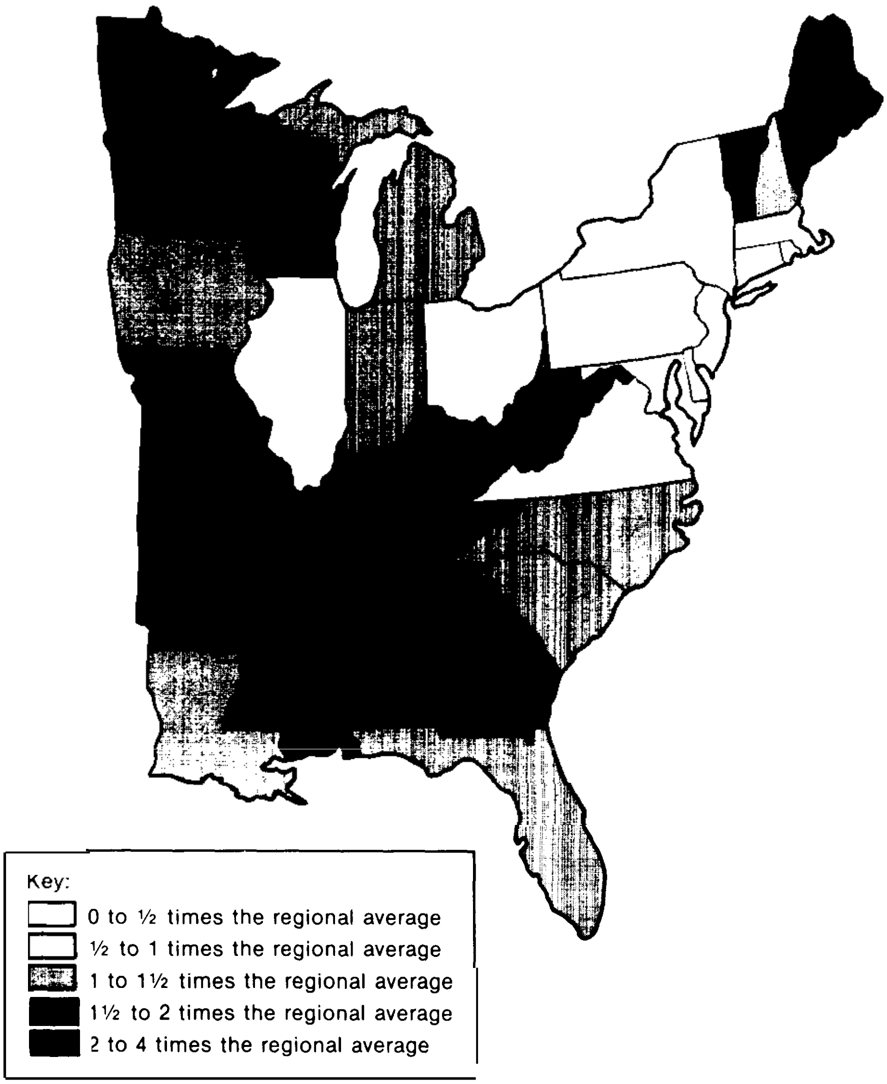
Comparing figures 15 (patterns of acidity) and 26 (current corn and soybean yields) indicates that elevated levels of acid deposition occur within several major crop-producing States, including Illinois, Indiana, and Ohio. Reductions in both soy-

[1] R. A. Linthurst, J P. Bake r, and A. M Bart uska, " F; ffects of Acidic Deposition A Brief Review, " *Proceedings of the APCA Specialty Conference on Atmospheric Deposition*, Air Pollution Control Association, November 1982, reviewing International Electric Research Exchange, *Effects of SO_2 and Its Derivatives on Health and Ecology*, Central Electricity Generating Board, Leatherhead, England; National Research Council of' Canada, *Acidification in the Canadian Aquatic Environment: Scientific Criteria for Assessing the Effects of Acidic Deposition on Aquatic Ecosystems*, Associated Committee on Scientific Criteria for Environmental Quality, National Research Council of Canada, NRCC No. 18475, 1981 ; and J Baker, ' 'Effects on Aquatic Biology, *Draft Critical Assessment Document: The Acidic Deposition Phenomenon and Its Effects*, Chapter E-5, 5.6 Fishes (October 1982)

[2] F. C. Menz and J. K. Mullen, ''Ac edification Impact on Fisheries: Substitution and the Valuation of Recreational Resources, *Economic Perspectives on Acid Deposition, '1'.11.* Crocker (ed) (Ann Arbor: Butter-worth Press, 1984).

Figure 25.—Freshwater Recreational Fishing— Relative Economic Importance

1980 recreational fishing expenditures by State (expenditures on freshwater recreational fishing, scaled by State income, compared to regional average)



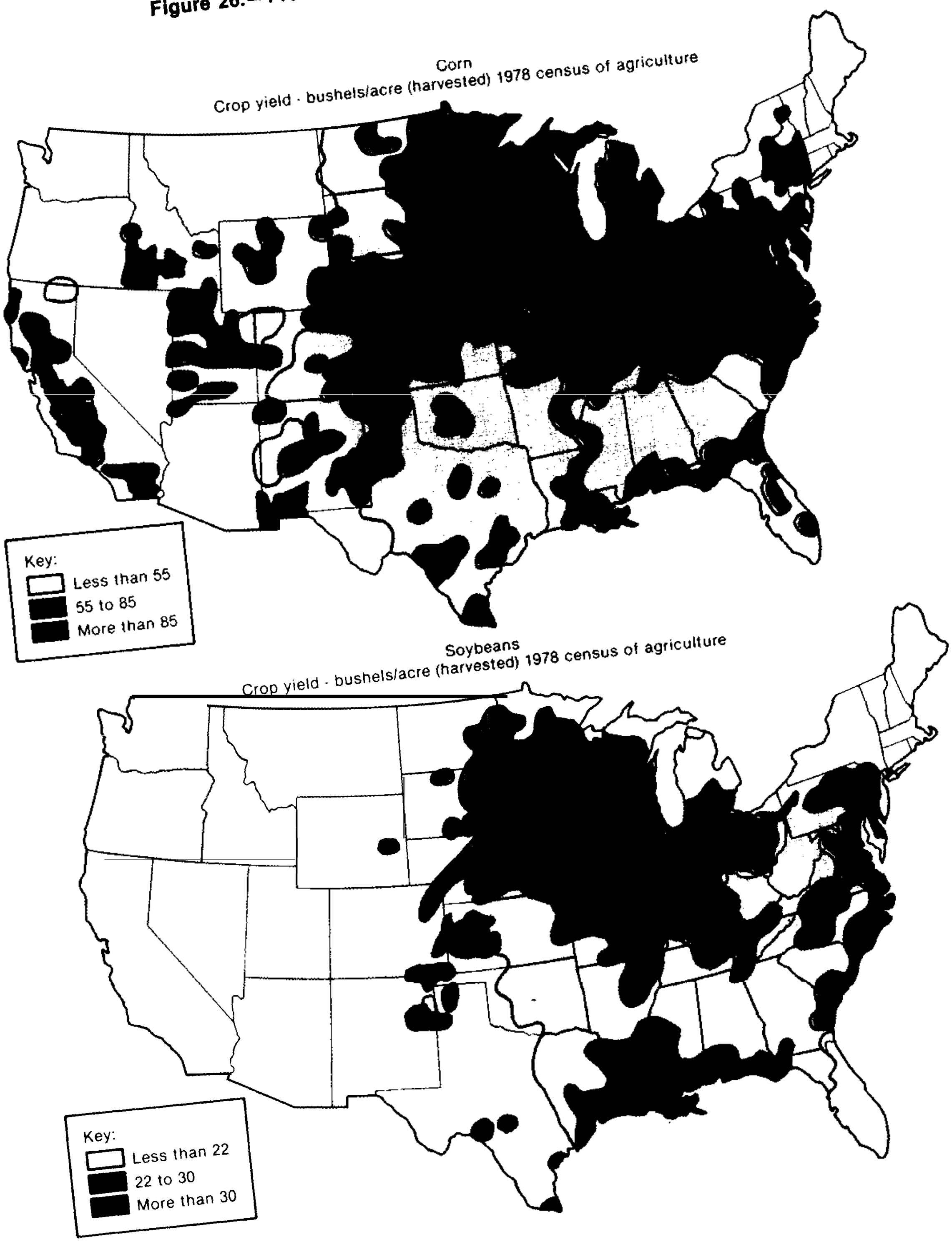
SOURCE: Office of Technology Assessment, from U.S. Census Bureau and U.S. Fish and Wildlife Service data

bean and corn productivity have been observed in field experiments with simulated acid rain, but other experiments have yielded contradictory results.

Scientists have recently discovered productivity declines in several tree species throughout the Eastern Unitcd States from New England to Georgia. Acid deposition, ozone, heat)-metal deposition, drought, severe winters or a combination of these are possible causes under investigation.

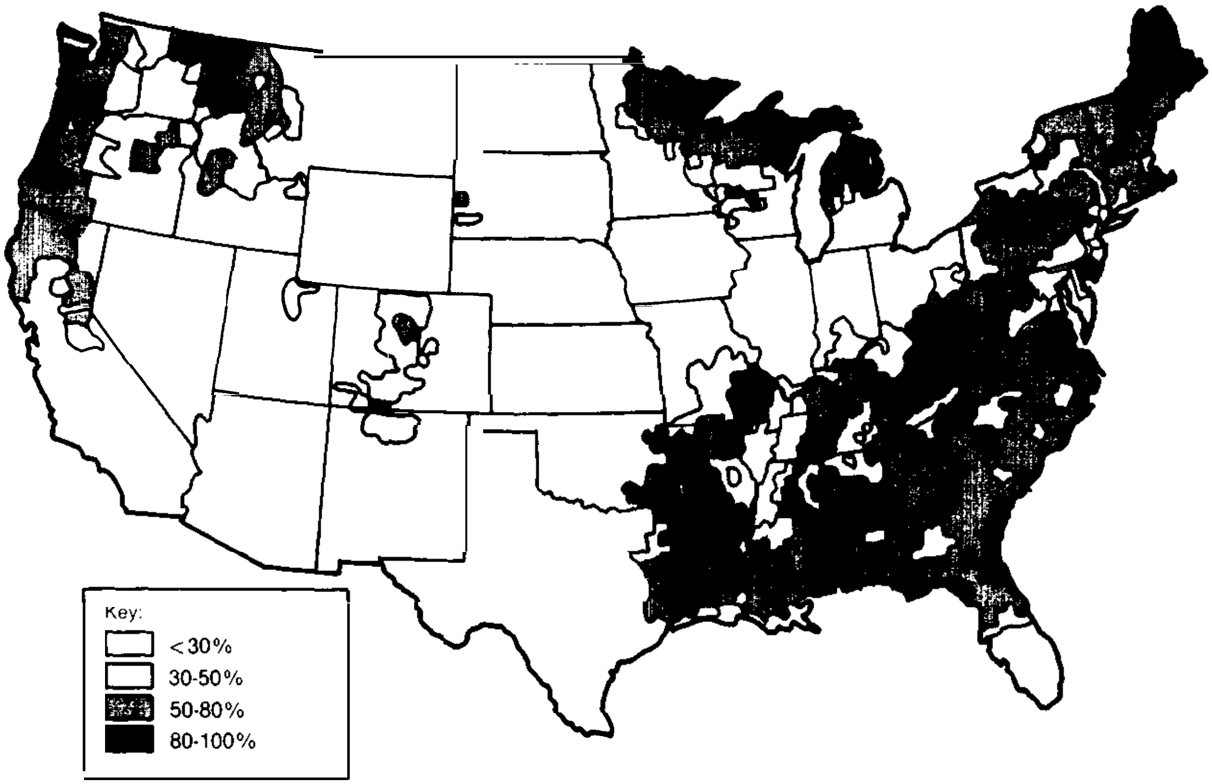
By coring trees and measuring the thickness of' annual growth rings, scientists have observed marked reductions in productivity beginning about 1960 in red spruce, shortleaf pine and pitch pine, Corings from about 30 other species at 70 sites throughout the East are currently being analyzed to deter-

Figure 26.—Production of Corn and Soybeans in 1978



SOURCE: Oak Ridge National Laboratory, from 1978 Census of Agriculture.

Figure 27.— Percent of Land Area Capable of Commercial Timber Production



ªThe U S Forest Service defines commercial timberland as lands capable of producing greater than 20 cubic feet of industrial roundwood per acre per year, in natural stands

SOURCE Oak Ridge National Laboratory, 1981, U S Forest Service State forest Inventory

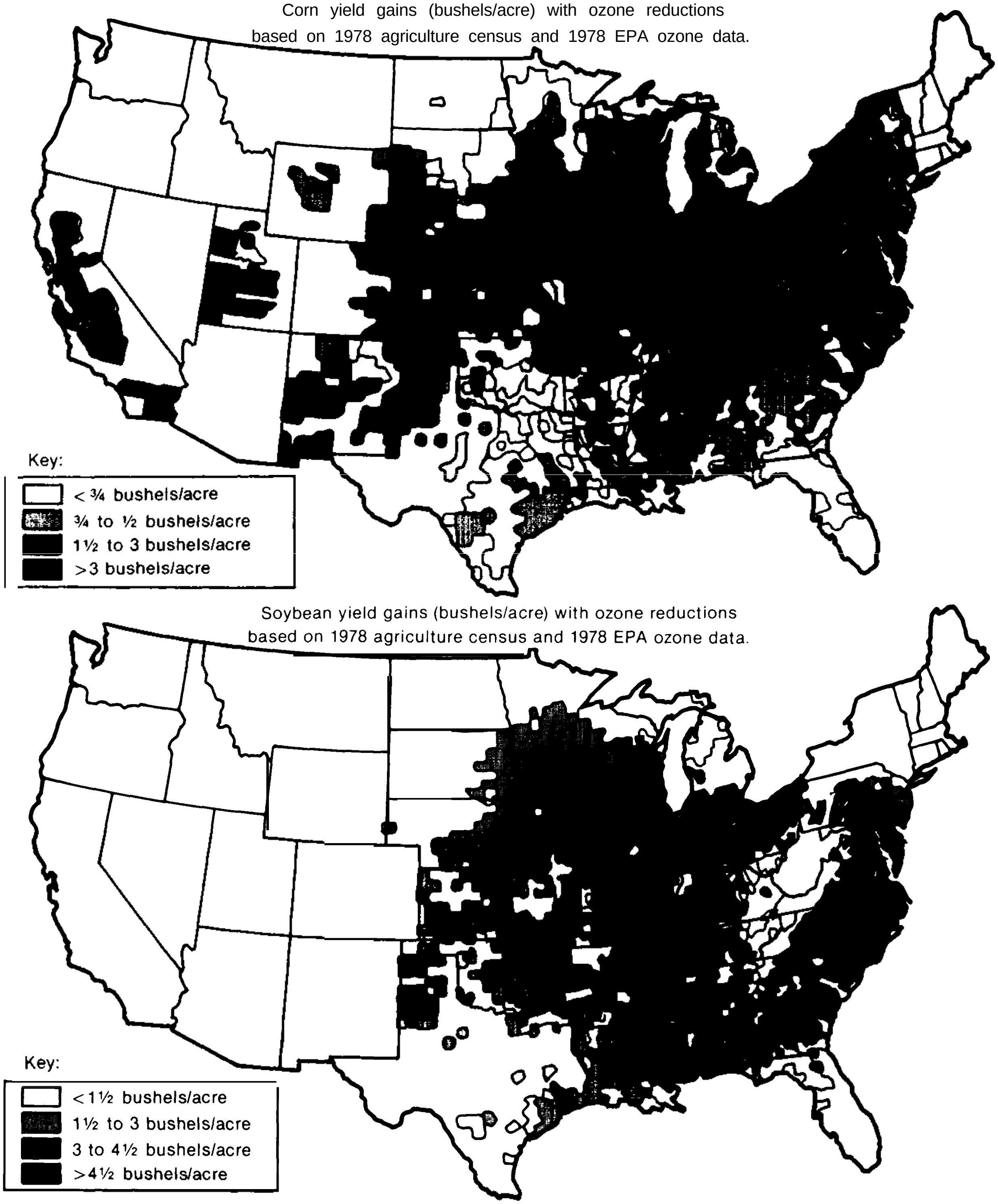
mine the geographic extent and severity of the problem. Routine measurements of tree growth by the U.S. Forest Service have shown productivity declines in loblolly pine and shortleaf pine during the 1970s in the Piedmont region of South Carolina and Georgia.

Although ozone is known to harm trees, quantitative estimates of forest productivity losses due to ozone are lacking because of the difficulty of performing experiments on long-lived species. By comparing figures 18 and 27, one can observe that elevated ozone concentrations coincide with forested regions in the southern Appalachian Mountains, the Ozark Mountains, and parts of the southern softwood area of the Southeastern and South Central States.

Much of the forested area of New England, the Appalachian Mountains, and parts of the southern soft wood forests of Alabama and Georgia receive elevated levels of acid deposition, as can be seen in figures *15* and **27.** However, the relationships between forest health and levels of deposition are not well known. The nitrogen deposited is a beneficial nutrient, but the acidity might damage leaf surfaces, remove nutrients from foliage, alter susceptibility to pests (either beneficially or detrimentally), or alter forest soil chemistry.

Forest soils are at risk from acid deposition due to: 1) release (mobilization) of soil-bound metals, such as aluminum, that are toxic to plants if present in sufficient quantity, 2) potential leaching of calcium, magnesium, and other nutrients essential for plant growth from the soil, and 3) further acidification of soils. Figure 29 displays the geographic distribution of these risks. Available information allowed OTA to identify' those counties in which soils susceptible to these effects predominate; other locations where they occur to a lesser extent could not be determined.

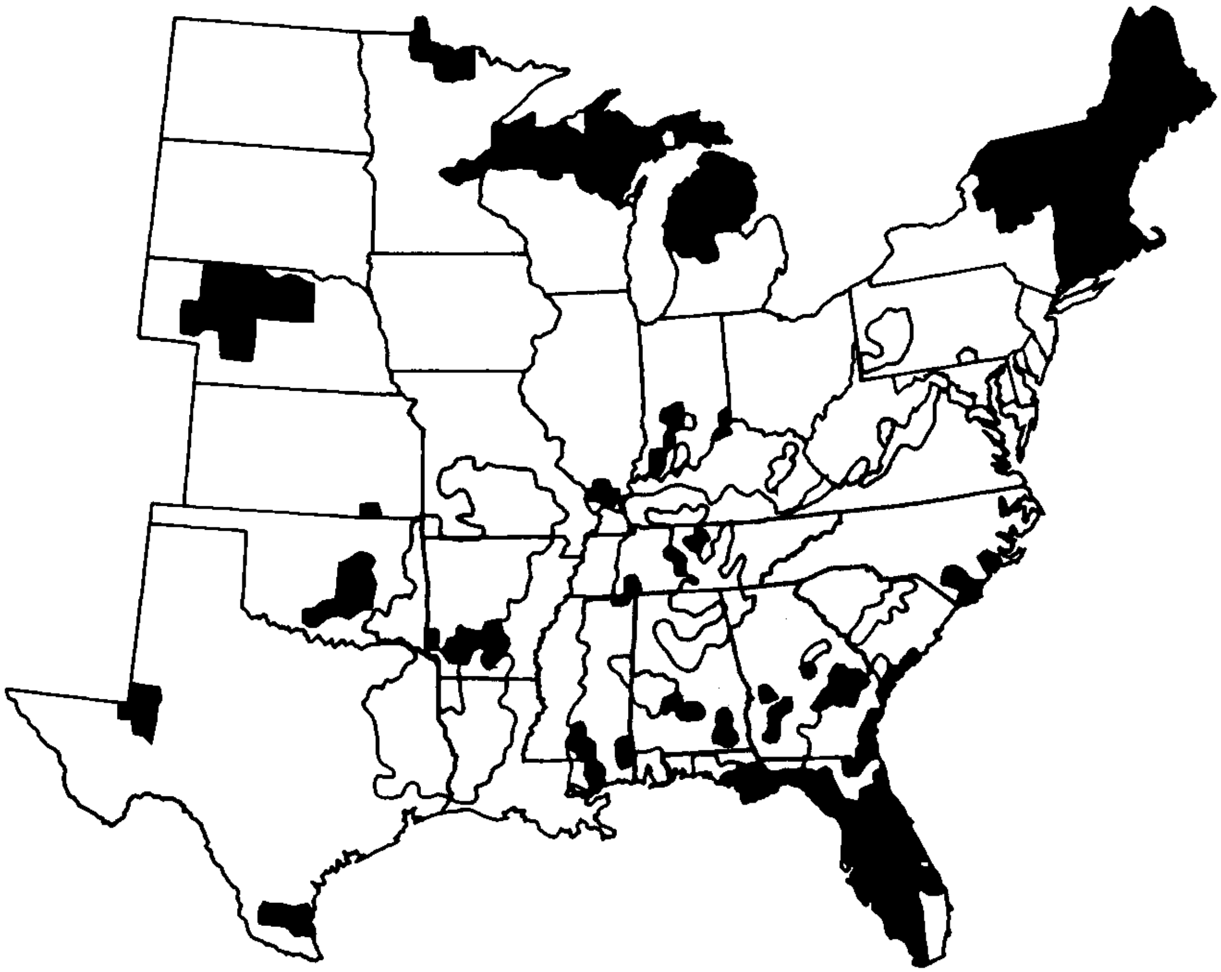
Figure 28.—Estimated Gains in 1978 Corn and Soybean Yields From Reducing Ozone Concentrations to "Natural" Levels

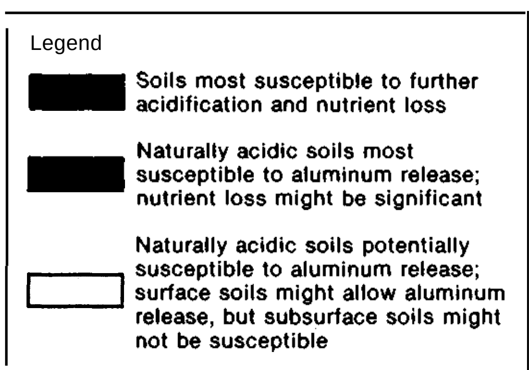


SOURCE Oak Ridge **National Laboratory,** "An Analysis of Potential Agriculture and Forest Impacts of Long-Range Transport Air Pollutants, " OTA contractor **report 1983**

Figure 29.-Soil Sensitivity to Acid Deposition (nonagricultural)

Forested and range areas with soils thought to be susceptible to the effects of acid deposition. Shaded areas represent counties in which a susceptible soil type predominates. The three levels of shading correspond to different soil types, and potential effects, rather than to degrees of susceptibility.



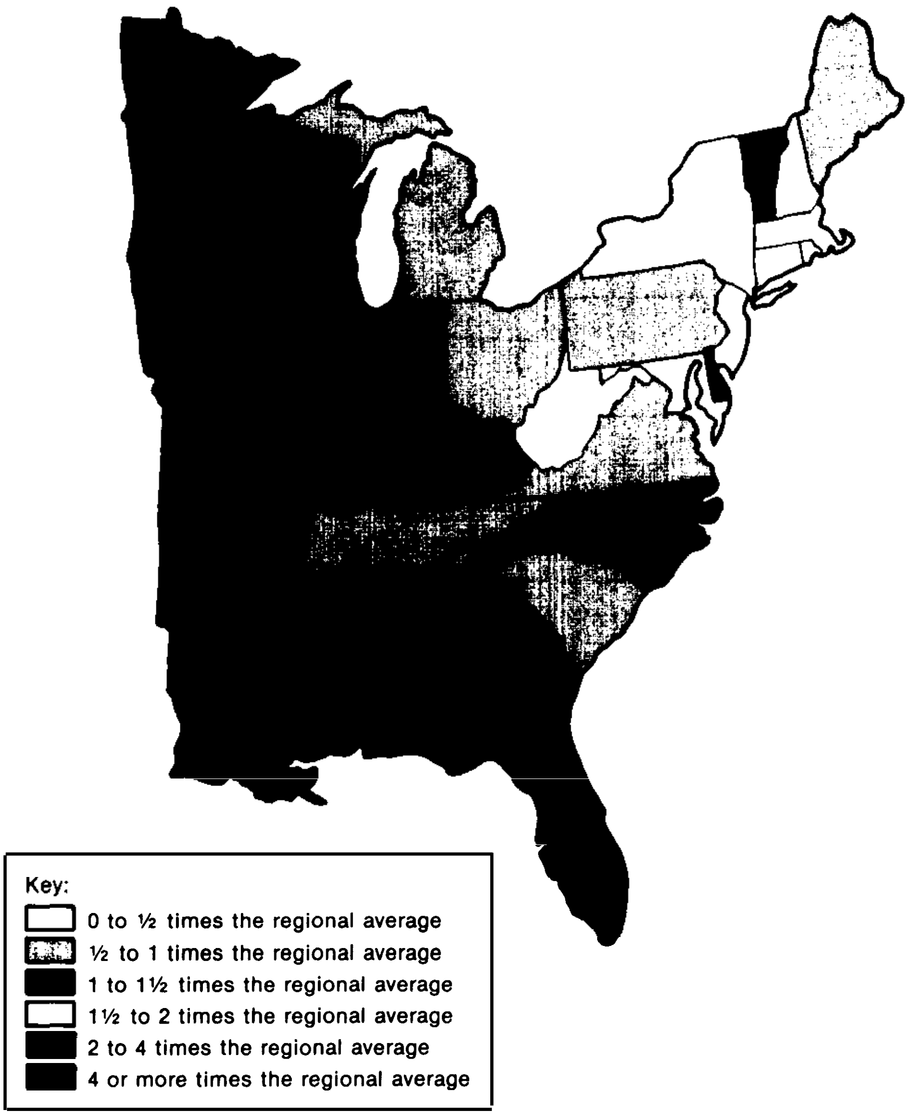


SOURCE: Oak Ridge National Laboratory, "An Analysis of Potential Agriculture and Forest Impacts of Long-Range Transport Air Pollutants," OTA contractor report, 1983.

99-413 0 - 84 - 7 : QL . 3

Figure 30.-Agriculture—Relative Economic Importance

elative importance of agriculture-related income to State income, 1978-80



SOURCE: Office of Technology Assessment, from U.S. Census Bureau data.

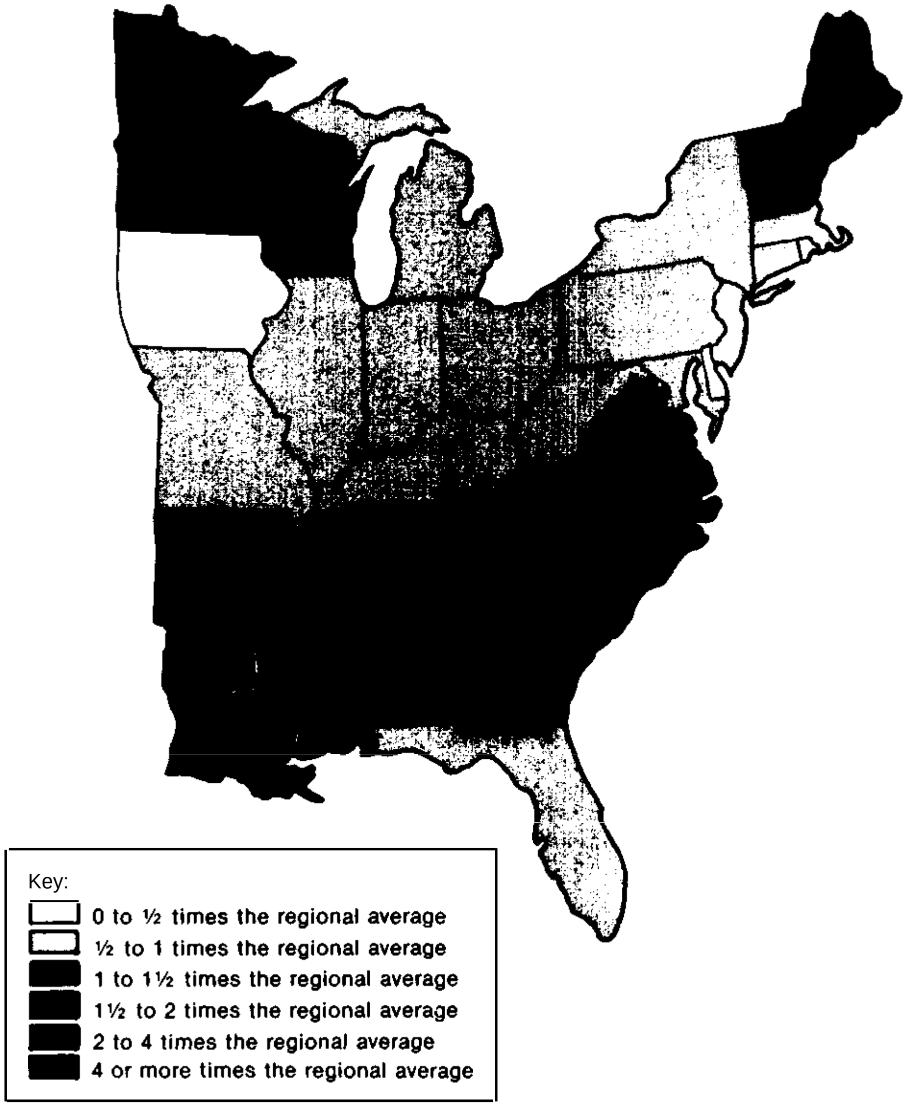
Soils must already be acidic—about pH 5 or lower—to release aluminum in the presence of the strong acids in acid deposition. Regions where naturally acid soils predominate are shown as the medium and light gray areas in figure 29. However, the soils in the light gray areas trap sulfate in their lower layers, which somewhat reduces the amount of this strong acid available for releasing aluminum.

Soils that are both acidic and do not impede the flow of sulfate (shaded a medium gray in fig. 29) predominate in New England and northern New York State, and parts of the upper Midwest and Florida. These regions are considered most susceptible to the toxic effects of aluminum; however, whether resulting aluminum concentrations will be high enough to significantly alter forest productivity is not yet known.

Figure 29 also displays regions of the Eastern United States where nutrient loss is of concern. The dark patches are areas with moderately acid soils.

Figure 31.— Forestry -Relative Economic importance

Relative importance of forestry-related income to State income, 1978-80

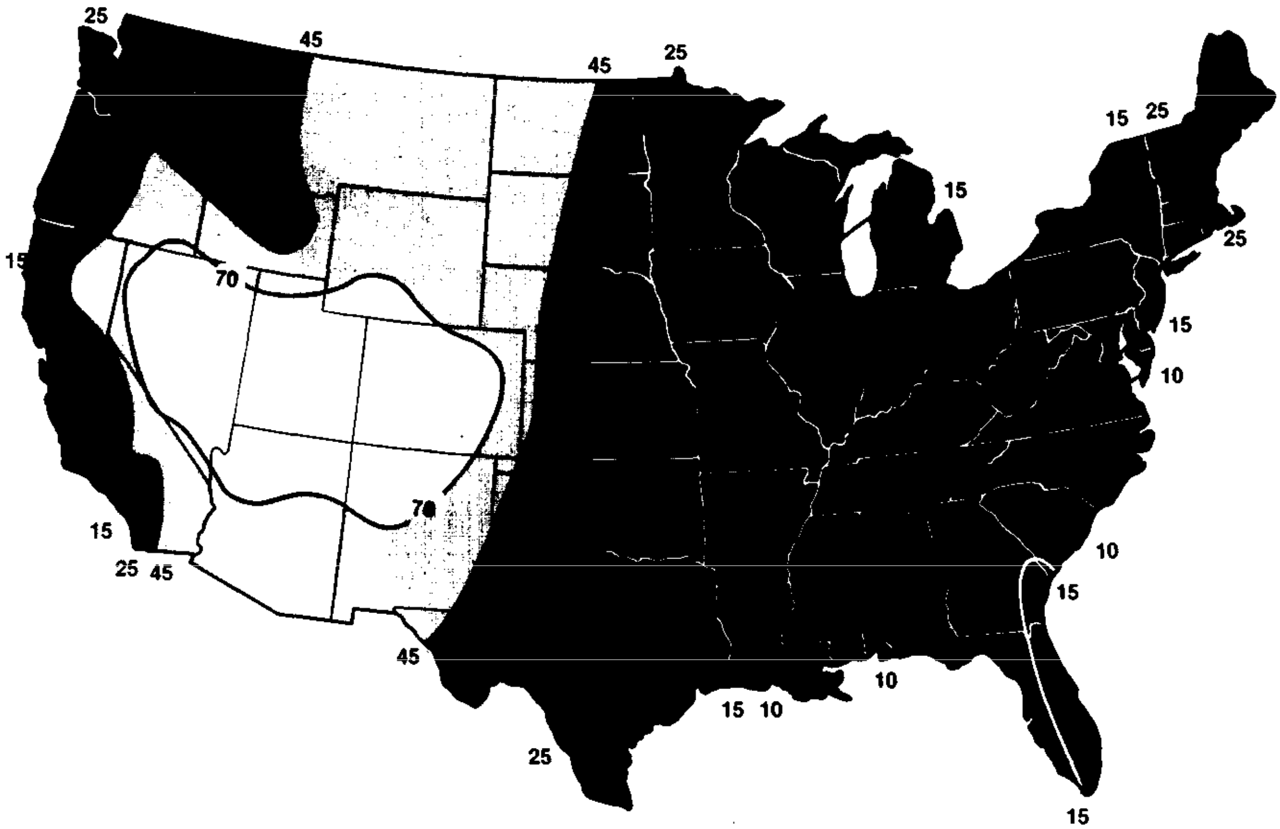


SOURCE: Office of Technology Assessment, from U.S. Census Bureau data.

Loss of calcium, magnesium, and other nutrients from these relatively uncommon soils through decades of exposure to acid deposition might cause these soils to further acidify. Nutrients can also be lost from more acidic soils—typically already nutrient poor—but probably at a slower rate. Most susceptible are those regions (shaded medium gray) with nutrient-poor acid soils that allow sulfate to move freely, potentially carrying away nutrients from the soil, plant canopy, and decaying plant material. However, whether the ***rate*** of nutrient loss from these soils is more rapid than replacement by weathering is unknown.

Both agriculture and forestry are important to the overall economy of the Eastern United States, each providing about 3.7 percent of the total regional income. Agriculture and related services are responsible for about $22 billion of the region's income; forestry, wood, lumber, paper, and allied

Figure 32.—Median Yearly Visual Range (miles) for Suburban and Nonurban Areas



Data from 1974-76, estimated from visual observations and other methods

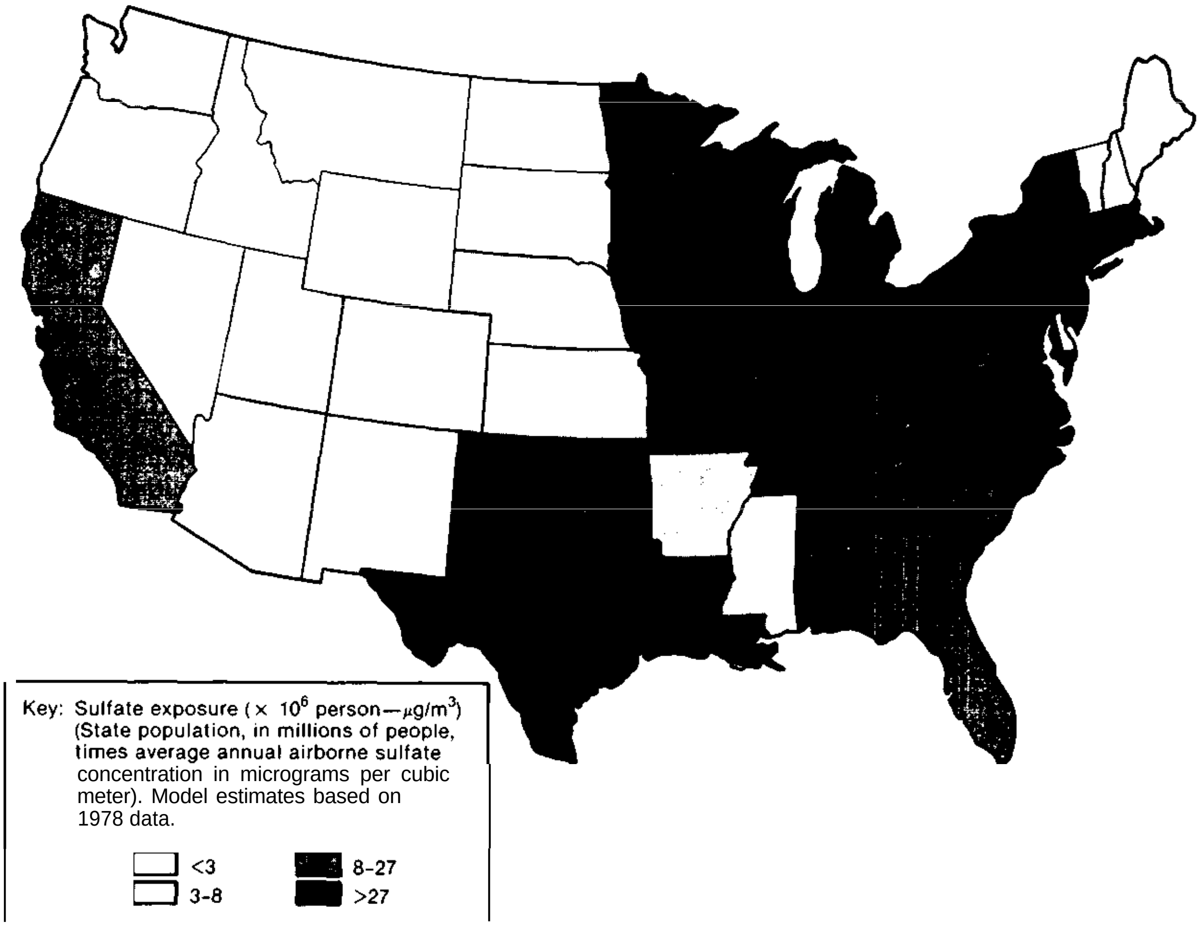
SOURCE. Trijonis, J., and Shapland, R., 1979: Existing Visibility Levels in the U. S.: Isopleth Maps of Visibility in Suburban/Nonurban Areas During 1974-76, EPA 450/5-79-010, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina.

industries generate about $21 billion in personal income.

Figures 30 and 31 display those States' economies that depend most on these sectors. When considering potential crop damage, States subject to the greatest monetary risk are those that are both: 1) exposed to elevated ozone (fig. 18), acid deposition (fig. 15), or both; and 2) generate the largest share of State income from agriculture (fig. 30). Iowa, Illinois, Indiana, Missouri, Arkansas, Mississippi, Alabama, and North Carolina are at greatest economic risk from ozone damage. If acid deposition affects crops, the above States plus Vermont would be at greatest risk.

When considering potential forestry-related effects, States at greatest economic risk are those that: 1) generate the largest share of income from forestry (fig. 31); 2) are exposed to elevated ozone (fig. 18), acid deposition (fig. 15), or both; and 3) contain soils susceptible to change (fig. 29). States at greatest economic risk from ozone include the southern softwood region extending from Arkansas to North Carolina. Many of these States receive high levels of acid deposition and have soils considered susceptible to mobilization of toxic aluminum or nutrient loss, as do the New England States of Vermont, New Hampshire, and Maine.

Figure 33.—population Exposure to Airborne Sulfate (an indicator of potential health effects from sulfates and other airborne particulate in each State)



SOURCE Brookhaven National Laboratory, Biomedical and Environmental Assessment Division, “Long Range Transport Air Pollution Health Effects, ” OTA contractor report, May 1982

OTHER RISKS

Materials

Materials at greatest risk from exposure to acidic deposition include metals, such as steel and zinc, and stone masonry. Regions at greatest risk correspond to those with the greatest population densities and areas with historically significant buildings and monuments, Scientists estimate that the bulk of materials damage is caused by local-scale pollutants, and that sulfur dioxide emissions are responsible for a major share of pollutant-induced damages to a broad range of materials, Elevated ozone concentrations are harmful to such materials as paint on home exteriors and rubber. The distribution of materials sensitive to air pollutants is not well known, since inventories have been taken in very few areas.

Visibility

For the Eastern United States, sulfate is the single most important contributor to visibility degradation; patterns of impairment in the region correlate fairly well to airborne sulfate concentrations (presented earlier as fig. 17). Sulfate is currently estimated to account for 50 percent of visibility degradation annually, and 70 percent of summer visibility degradation in the East. In the West, nitrates may play a larger role than sulfates in visibility impairment. Figure 32 shows annual average risibilities throughout the Nation for the mid-1970's, the most recent information available to OTA. Visibility in the Eastern United States has improved slightly over the past decade, but is still less than pre-1960 levels.

Current Eastern visibility levels are generally far lower than those in the West. However, it should be noted that ***unimpaired*** Eastern visibility levels would be significantly lower than in the West, due to higher Eastern humidity levels. In addition, where visibility is already low, an increment of additional sulfate may not reduce visibility much further; in more pristine areas, the same increment of additional sulfate may significantly decrease visibility.

Risk of Health Effects

The health risk to any ***individual is*** thought to be correlated to sulfate concentrations in the atmosphere. However, whether premature mortality observed in statistical studies actually results from sulfate in air pollution, from different components of the sulfate-particulate mix, or from other factors not considered, is unknown. This risk varies from increases of less than 1 percent in excess mortality in the West to about 4 percent (a range from about O to 10 percent) in the regions of highest sulfate concentration. The health risk to a State is determined both by the potential increase in mortality and by the State's population. Some of the Northeastern States with the highest population densities (e.g., New York, Pennsylvania, and Ohio) are also exposed to the highest airborne sulfate concentrations, and are therefore at greatest risk. Figure 33 displays the total exposure of each State's population to airborne sulfate, an indicator of the relative risk of premature mortality in each State.

IF FURTHER EMISSIONS REDUCTIONS ARE MANDATED

Rates of Pollutant Emissions

The regional patterns of pollutant emissions are perhaps the best indicator of how costs to control transported air pollution might be distributed. Figures 12 and 13 in chapter 4 display maps of emissions ***densities*** (in tons per square mile) for sulfur dioxide and nitrogen oxides. This section discusses another measure of pollutant emissions more directly related to potential control costs—emission ***rates,*** expressed as pounds of pollutants per quantity of fuel burned.

To date, the major legislative proposals to control acid deposition have focused primarily on sulfur dioxide emissions. Though emissions reductions can be allocated to States in many ways, most of these bills propose reductions based on emission rates. This approach avoids penalizing areas emitting large quantities of sulfur dioxide because of high electrical or industrial productivity; instead, reductions are concentrated in areas that emit greater-than-average amounts of sulfur dioxide for a given amount of production.

Sulfur dioxide emission rates vary widely among States. Emission rates can be decreased either by using: 1) a lower sulfur fuel, or 2) technological means, such as capturing the sulfur dioxide gas with "scrubbers' after the fuel is burned.

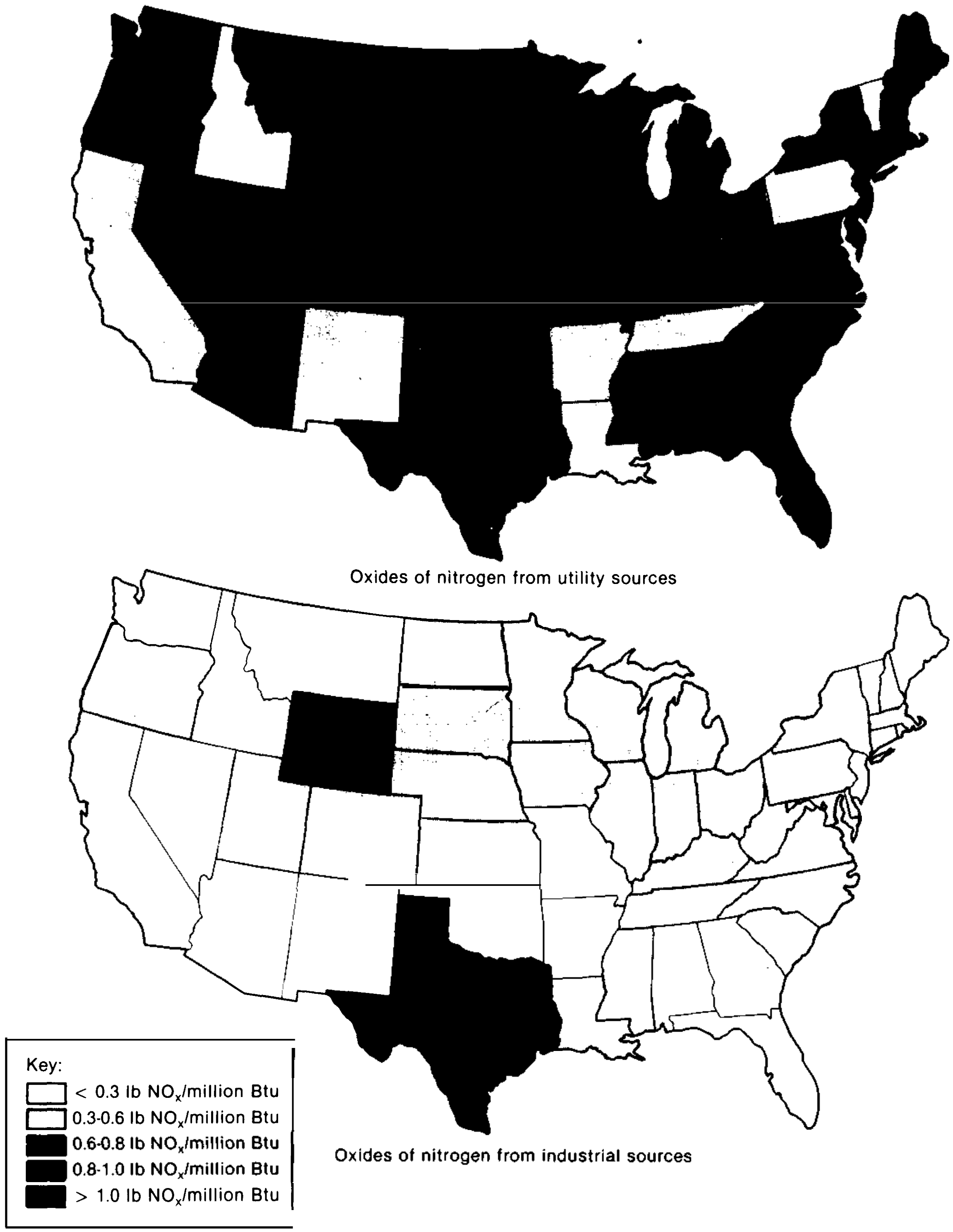
Figure 34 displays estimates of statewide average sulfur dioxide emission rates from utilities and industrial boilers. Within the Eastern 31-State region, utilities account for about 70 to 75 percent of sulfur dioxide emissions, and industrial boilers for about 10 to 15 percent.

The Midwestern States have the highest utility emission rates, and are therefore at greatest risk from additional pollution control regulations. In-

Figure 34.—Average 1980 Emission Rates for Sulfur Dioxide From Utility and Industrial Sources (lb SO_2/MMBtu)

SOURCE: E. H. Pechan & Associates, from Energy Information Administration data (EIA forms 4 and 423), and EPA National Emissions Data System (NEDS).

Figure 35.—Average 1980 Emission Rates for Nitrogen Oxides From Utility and Industrial Sources (lb NO_2/MMBtu)



SOURCE: E. H. Pechan & Associates, from Energy Information Administration data (EIA forms 4 and 423), and EPA National Emissions Data System (NEDS) dustrial boiler emission rates are more evenly distributed, with highest average rates occurring in the Midwestern and Central Atlantic States.

Nitrogen oxides are both a component of acid deposition and a precursor to ozone. Reducing nitrogen oxides emissions from existing sources has not been proposed to date, although some bills have prohibited further increases in nitrogen oxides emissions or allowed reductions to substitute for sulfur dioxide reductions.

The three major sources of nitrogen oxides in the 31 -State region are mobile sources (45 percent), utilities (35 percent), and industrial boilers (15 to 20 percent). Highway vehicles account for about 75 percent of the emissions from mobile sources, *or* about one-third of total Eastern U.S. nitrogen oxides emissions.

Figure 35 displays State-average nitrogen oxides emission rates from utilities and industrial boilers, respectively. As with sulfur dioxide emissions, proposals for controlling nitrogen oxides might allocate reductions on the basis of emission rates. Emission rates are more evenly distributed for nitrogen oxides than for sulfur dioxide. Additional mobile-source controls would regionally distribute costs according to patterns of new vehicle purchases.

Utility Control Costs

Figure 36 displays the effects of further pollution control on the cost of electricity. Annual increases in a typical residential consumer's electricity bills are estimated for a 10-million-ton reduction in sulfur dioxide emissions from existing utility sources. Total costs of such a program would be about $3 to $4 billion per year (1982 dollars), assuming each utility chooses the most cost-effective method of reducing emissions. Emissions reductions are allocated to States on the basis of 1980 utility emission rates. (Similar to several legislative proposals, reductions are based on each State's share of sulfur dioxide emitted in excess of 1.2 lb per million Btu of fuel burned.) For this hypothetical pollution-control plan, the reduction formula applies to the contiguous 48 States; however, reductions, in the Eastern 31 States would be quite similar if the formula applied only to these Eastern States. * The highest rate increases occur in the Midwestern States and a few Southeastern and New England States.

Figure 37 displays the cost of a smaller pollution control program. About 6 million tons of sulfur dioxide could be eliminated annually in the Eastern 31 States by limiting utility emission rates to 2 lb per million Btu, at a cost of about $1 to $1.5 billion per year. If the control program was confined to the 22-State region receiving the highest levels of acid deposition, about 4.8 million tons per year could be eliminated for annual costs of $1 billion or less.

These cost estimates assume that all required emissions reductions would come from utilities, and that additional emissions coming from new utility plants or increased use of existing plants are not offset by further reducing existing plant emissions. In addition, these cost estimates assume that the use of control technology (e. g., scrubbers) is not required.

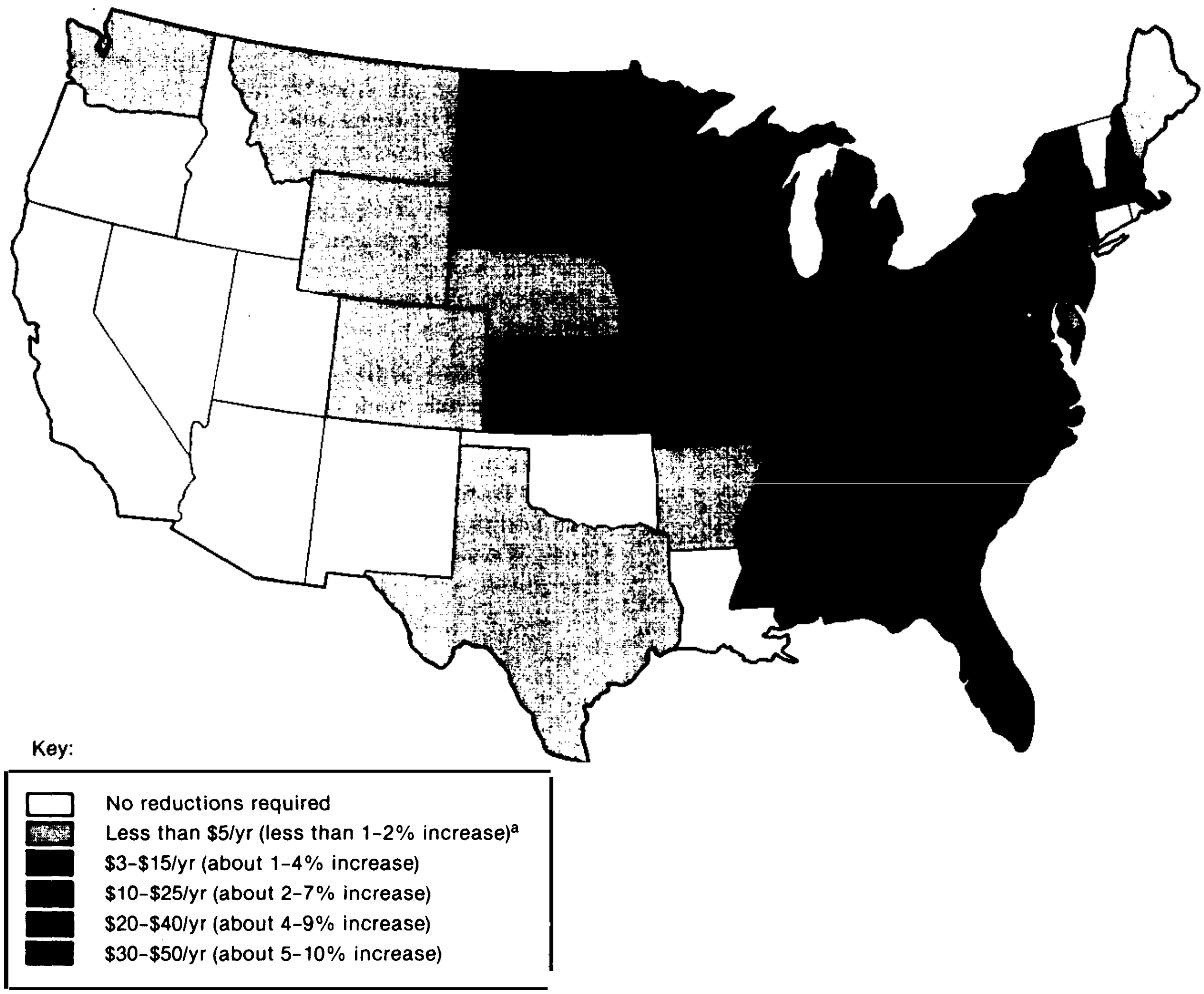
Similar to the maps presented earlier depicting the relative economic importance of recreational fishing, agriculture, and forestry, figure 38 displays the relative share of State income spent on residential electricity. For the region as a whole, about 2.3 percent of personal income, or $26 billion, is spent on electricity. The distribution of these expenditures by State is much more uniform than for the sectors discussed above, but is somewhat higher throughout the South.

Risk to the Utility Industry

Additional expenditures to control emissions could potentially affect the financial health of individual utilities. Three major factors determine the extent to which utility companies could be affected: 1) the extent of emissions reductions required under a given control program, 2) the utility's financial position, and 3) State-level regulatory policies that affect a utility's short- and medium-term ability to pass on the costs of pollution control to consumers. OTA did not attempt to analyze how these factors would affect the financial health of the more than 100 major publicly owned utilities in the 31 Eastern States, but drew on available information to assess the *relative* sensitivity of each *State* utility sector to further emissions control.

*Western sulfur dioxide emissions in excess of 1.2 lb per million Btu are less than 5 percent of the allocated reductions.

Figure 36.-Cost of Reducing Sulfur Dioxide Emissions 10 Million Tons per Year, Nationwide Increases in Annual" Average Electricity Bills for a Typical Residential Consumer



[a]Average annual cost increase (1982 dollars) for a typical residence consuming 750 kWh/month electricity. Percentage rate increases in each State are calculated from State-average 1982 electricity costs (ranging from about $200 to $900/yr; United States average about $600/yr).

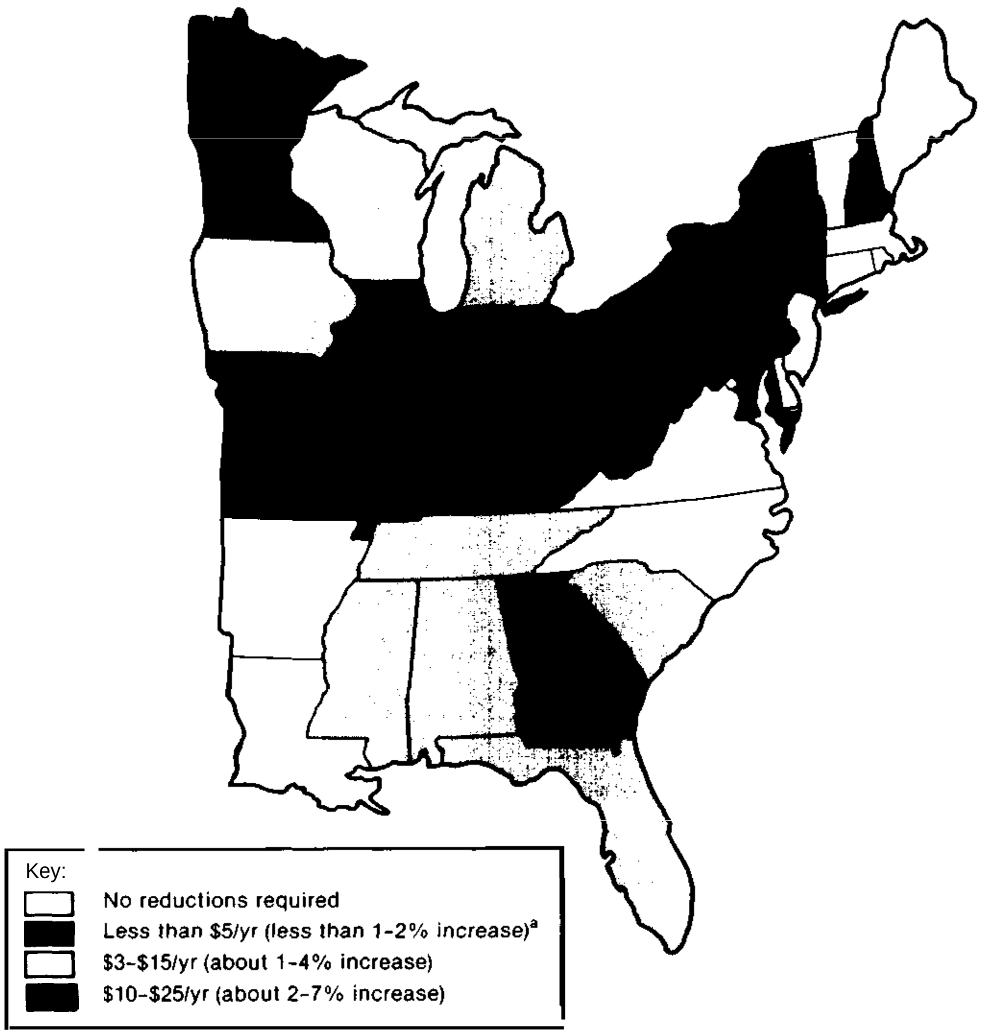
SOURCE: Office of Technology Assessment, based on analyses by E. H. Pechan & Associates, Inc.

Figure 39 displays patterns of utility earnings and bond ratings for 1980 in each State, two indicators of the financial health of a State's utility sector. Figure 34 shows statewide average 1980 utility emission rates for sulfur dioxide—the best indicator of the extent of utility-sector reductions likely to be required under most of the control proposals introduced in the 97th and 98th Congresses.

Comparing figures 34 and 39 shows that few States ***both: 1)*** had high emission rates, and 2) fell into the least favorable financial category, in 1980. However, several Midwestern States with high emission rates (and, therefore, potentially subject to extensive control requirements) fell into the moderately favorable financial categories.

Policies established by State public utility commissions can affect an individual utility's near-term ability to pass on the costs of pollution control to consumers. For example, for coal-burning utilities that might choose to use scrubbers, the State's pol-

Figure 37.—Cost of Reducing Sulfur Dioxide Emissions 6 Million Tons per Year, Eastern 31 States Increases in Annual-Average Electricity Bills for a Typical Residential Consumer



[a]Average annual cost increase (1982 dollars) for a typical residence consuming 750 kWh/month electricity. Percentage rate increases in each State are calculated from State-average 1982 electricity cost (ranging from about $200 to $900/yr, United States average about $600 yr).

SOURCE Office of Technology Assessment, based on analyses by E. H. Pechan & Associates, Inc.

icies regarding capital investment, in combination with the utilities' current financial ratings, determine the burden of raising capital for constructing scrubbers. Results of a survey of current State regulatory policies, and a discussion of their relative importance, are presented in appendix A. However, these policies might change considerably if a major Federal program to further limit pollution emissions is enacted.

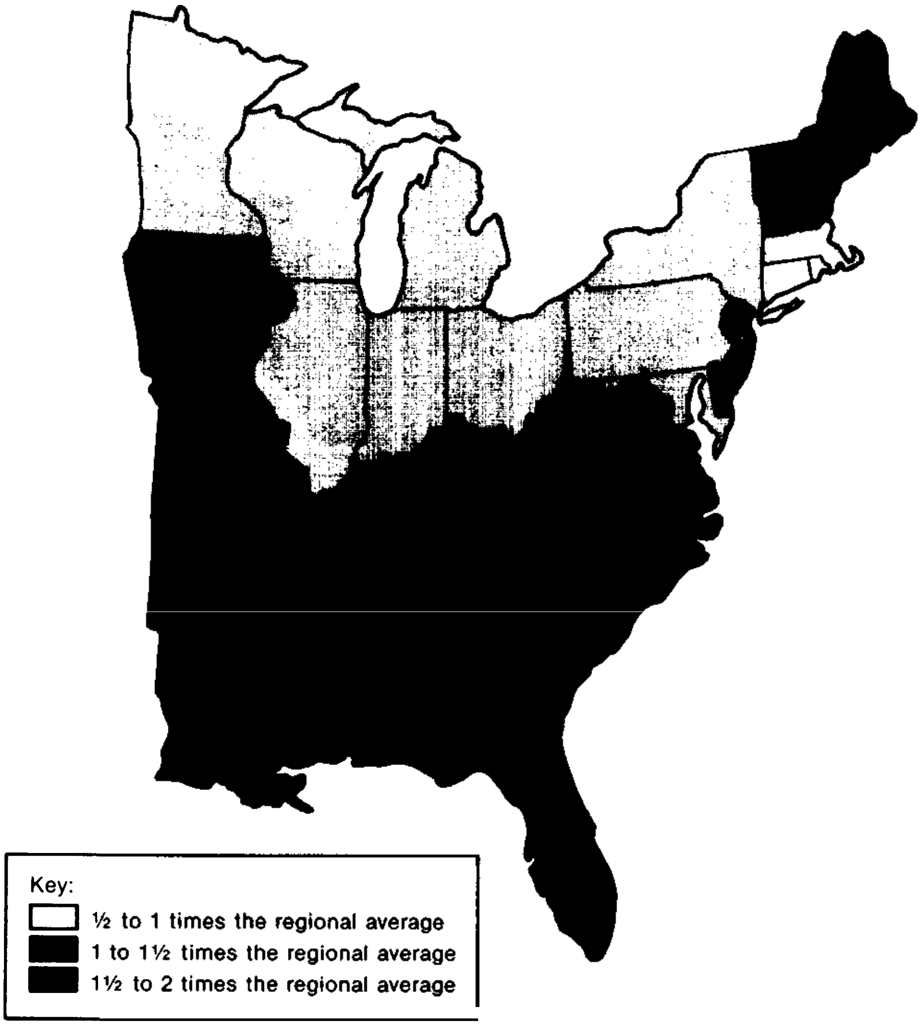
Risks of Shifts in Coal Production

Because switching to lower sulfur fuel is often a cost-effective way to reduce sulfur dioxide emissions, emission-reduction schemes could cause coal production to shift from high-sulfur coal regions to low-sulfur coal regions.

Figure 40 displays coal production by State for both high- and low-sulfur coal. The size of each

Figure 38.—Expenditures for Residential Electricity—Relative Economic Importance

Relative share of State income spent for residential electricity, 1980



SOURCE: Offfice of Technology Assessment, from U.S. Census Bureau and Edison Electric Institute data.

circle indicates the ***magnitude*** of State coal production. The shading indicates the average sulfur content of the coals mined, using the darkest shadings for the highest sulfur coal. Midwestern and northern Appalachian high-sulfur coal States incur the greatest risk of production losses, However, total coal production is projected to be unaffected; production gains of similar magnitudes would occur in the low-sulfur coal regions of Central Appalachia and the West.

Of all the economic sectors at risk, coal mining is the least evenly distributed across the Eastern region. The approximately $7 billion of regional income from coal mining in the Eastern 31 States is concentrated in 9 States, as shown in figure 41. States at greatest economic risk are those in which: 1) a large share of State income comes from coal mining (fig. 41), and 2) most of the coal produced is of relatively high-sulfur content (fig. 40). States meeting these criteria include West Virginia, Kentucky, Pennsylvania, Alabama, and Virginia. For these States, the income from coal mining is more than twice the regional average, and more than 80 percent of the coal produced emits greater than 1.2 lb sulfur dioxide per million Btu when burned.

Figure 39.— Electric Utilities-Selected Financial Indicators of Sensitivity to Control Expenditures

Key for financial indicators

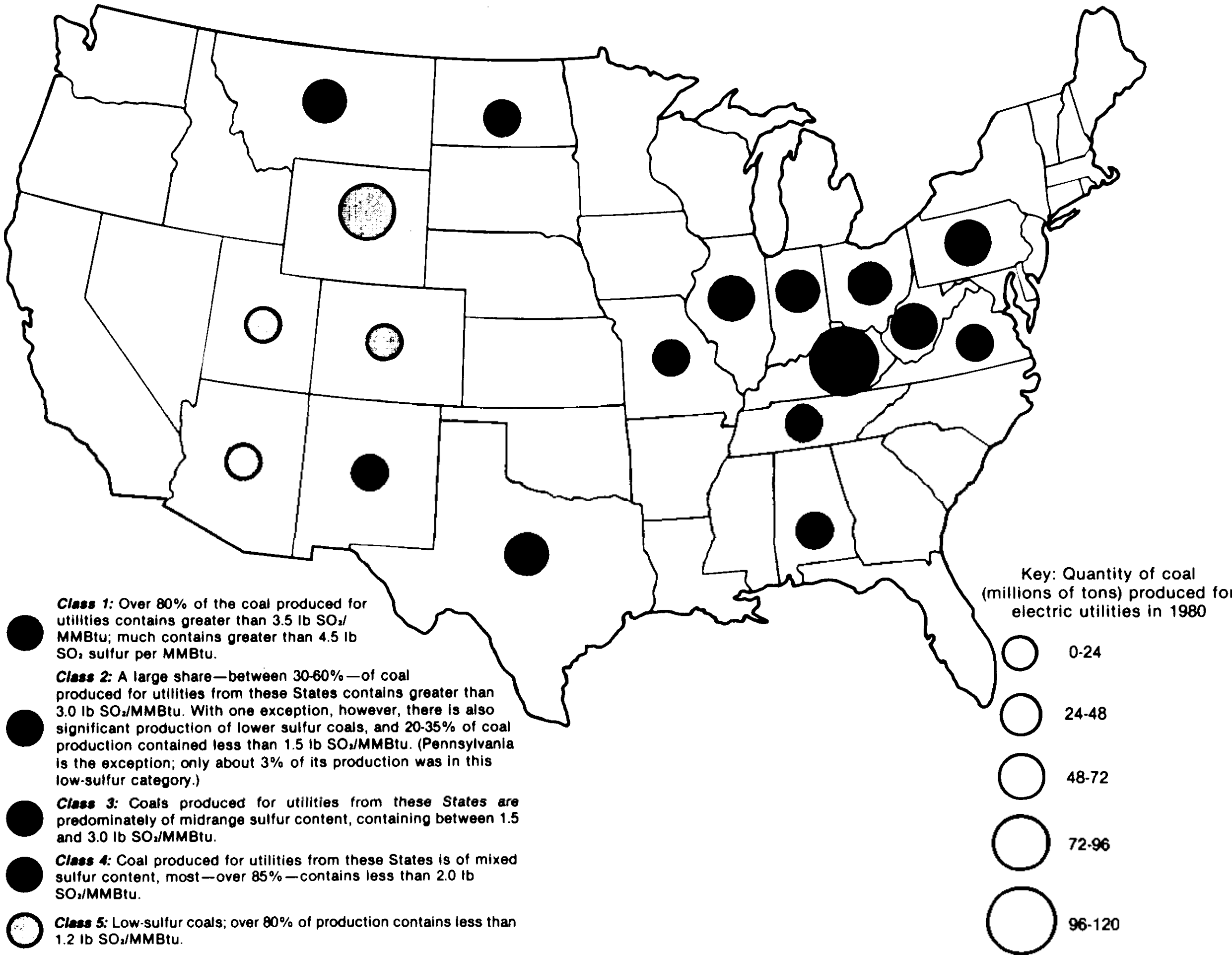
Sensitive to additional air pollution control requirements: relatively poor bond ratings *and* below-average return on common equity in 1980.

Moderately sensitive to additional air pollution control requirements: poor bond ratings *or* below-average return on common equity in 1980.

Insensitive to additional air pollution control requirements: relatively good bond ratings *and* above-average return on common equity in 1980.

SOURCE K. Cole, et. al., "Financial and Regulatory Factors Affecting the State and Regional Economic Impact of Sulfur Oxide Emissions Control, " OTA contractor report, 1982

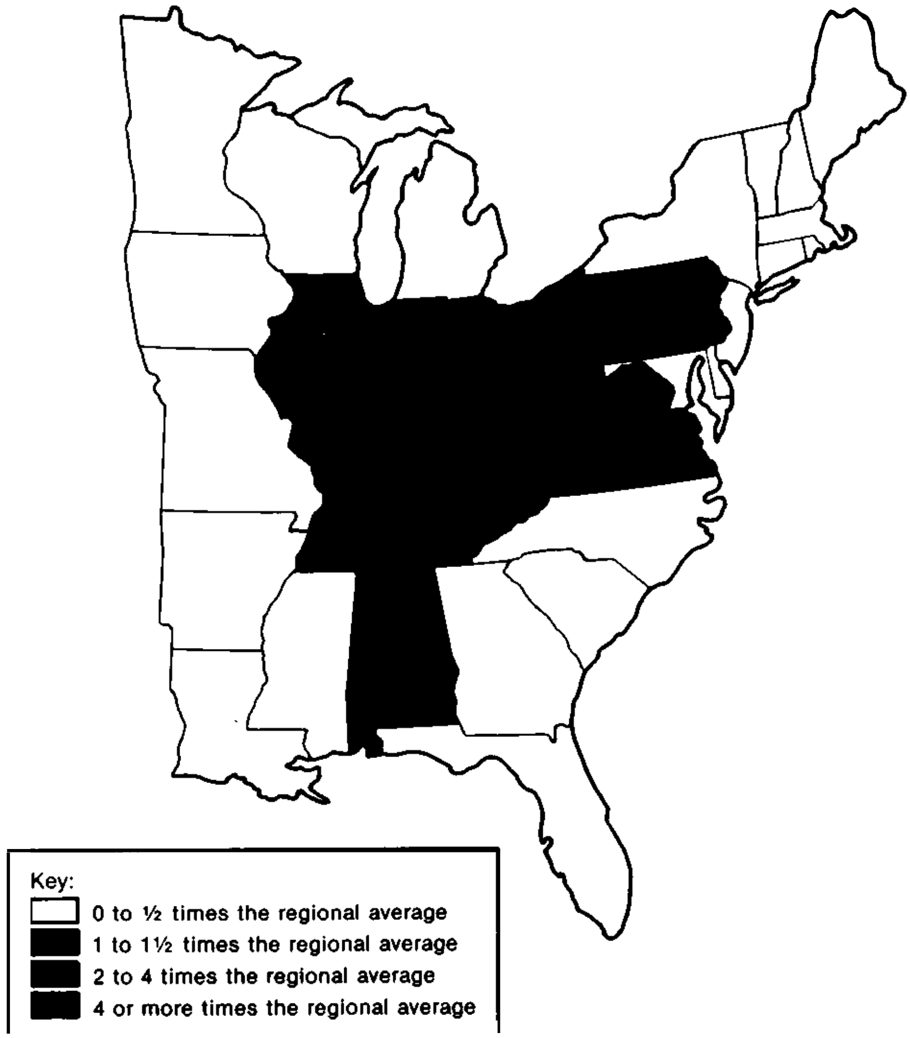
Figure 40.–Quantities and Sulfur Content of Coals Produced for Electric Utilities, by State–1980



SOURCE: E. H. Pechan & Associates, from Energy Information Administration data (EIA forms 4 and 423), and EPA National Emissions Data System (NEDS).

Figure 41 .—Coal—Relative Economic Importance

Relative importance of coal-related income to State income, 1978-80



SOURCE: Office of Technology Assessment, from U.S. Census Bureau data.