RFF

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Contents

This twentieth annual Highlights issue of Resources *gives an account of events and issues that were of special interest in 1983 and will be of continuing concern for some time to come. The intent is to report events accurately and readably and to provide relevant background information and comment. The treatment is selective, representing the judgments of a number of RFF staff members and guest contributors, and does not purport to be a comprehensive roundup of resource and environmental issues. The views reflected here are those of individual contributors and are not official points of view adopted by Resources for the Future.*

Energy—Ten years after

ONE WAY TO DETERMINE which political and economic events truly are significant is to check whether their anniversaries provoke retrospective newspaper articles and conferences attempting to identify what we have (or should have) learned in the intervening years.

On this scale, the oil embargo of 1973 has done quite well. The past several months have seen numerous discussions in the press about the meaning of "the energy decade," conferences with titles such as "The Oil Embargo Legacy: Ten Years and Counting" and—the ultimate certification—a ten-part series in *The New York Times*.

What have we learned?

Many different lessons of the last ten years have been offered. Some observers say it now is clear that government price regulation only distorts energy markets and offers little protection to consumers. Others see an end to the "era of oil." Still others feel the chief lesson is that economic growth and energy use do not have to move in lockstep.

Leaving these points aside for the moment, I would like to nominate a more sweeping suggestion: what we should have learned during the last ten years is that basing policy and plans on the assumption that prevailing energy market trends will continue can be very dangerous. Two fundamental changes have occurred in energy markets since the beginning of 1973. First, energy supplies display extreme short-term sensitivity to political events. Second, high energy prices produce dramatically different energy demand–supply relationships. Each of these changes, which many now say were predictable, caught the energy world by surprise and, as a result, had major consequences. Indeed, the accompanying problems helped push the world economy into its current sad state. The last ten years cannot be described as a period of great success for energy policymakers.

In that time, the price of oil has jumped 345 percent in *real* terms, even after the recent downturn. The sharp price hikes of 1973–74 and 1979–80 were at least partly responsible for triggering deep, worldwide recessions. In the United States, households near the poverty level often were pushed over the edge by soaring heating bills. Abroad, the oil-related debts of the developing nations placed unprecedented strains on the international financial system. Perhaps most ominous of all, the United States was forced to announce that, because of oil, the Persian Gulf had become an area of vital strategic interest—making more conceivable a catastrophic confrontation with the Soviet Union.

Not all of this should be ascribed to the general failure to anticipate the two previously mentioned market changes. As a depleting resource, oil may face long-term increases in cost. And even if prepared for the new energy developments, industrial economies could not make easy and swift adjustments in energy use patterns. But in the final analysis, things were worse than they had to be, and a good part of the reason is that government and industry responses always seemed to be one step behind the market.

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Underrating political factors

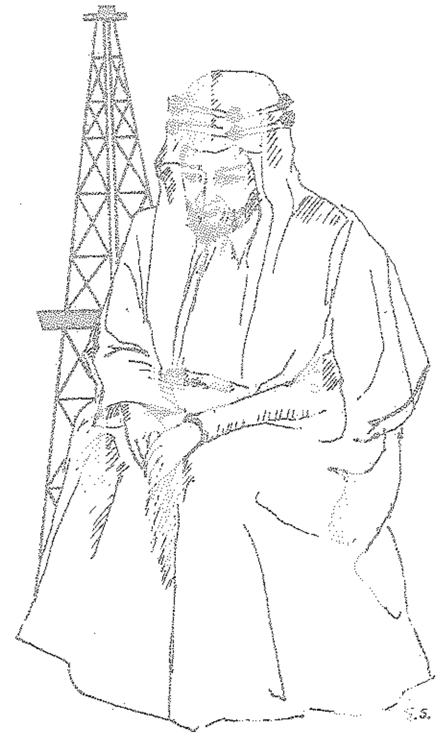
Take the first important change—the increasing sensitivity of energy supplies to political events. The inability to anticipate this was, of course, a major contributing factor to the disruption caused by the 1973–74 embargo and to the ability of Saudi Arabia and other oil producers to sustain the price hikes that followed that event. This failure often has been discussed since.

Unfortunately, despite all the discussion, government and industry continued to underrate the influence of political factors on world oil production. For example, attributing little importance to politics, many forecasters in 1974 and 1975 predicted that "revenue-maximizing" production increases by Organization of Petroleum Exporting Countries (OPEC) would lead to prices being forced down. In fact, predictions of OPEC's collapse were so widespread that U.S. policymakers actually spent a lot of time trying to set up a $7 per barrel floor price mechanism to protect investments in alternatives to OPEC oil.

Emergency unpreparedness

Even worse, as a result of the general tendency to downplay the likelihood of further significant, politically related interruptions in oil supplies, emergency planning measures were given low priority. True, after 1974, the formulation of responses to potential oil supply disruptions had begun. The industrialized nations set up the International Energy Agency (IEA) to coordinate energy policies, including stockpiling for emergencies and sharing oil during future crises. In the United States, the Department of Energy was authorized in 1976 to purchase 500 million barrels of oil by 1982 for a petroleum stockpile, the Strategic Petroleum Reserve (SPR). And Congress asked the president to draw up a gasoline-rationing plan for use during emergencies. But a singular lack of urgency surrounded these responses. The effectiveness of IEA's sharing system was—and is—a question mark, and worried member governments made sure the plan would go into effect only in the event of an extremely large disruption. In the United States, technical problems and stingy funding prevented a rapid filling of the SPR. And—whether a merciful outcome or not—the Carter administration dragged its feet in preparing the gasoline-rationing plan.

Thus, when the Iranian revolution began to affect oil production in November 1978, the oil-consuming nations were unprepared. In 1978 Iranian production av-



eraged 5.2 million barrels per day (mmbd). In January 1979, production fell to 410,000 and, for the entire year, averaged only 3 mmbd. Despite this shortfall, the IEA's emergency sharing mechanism was not triggered. The U.S. Strategic Petroleum Reserve, which then held only 91 million barrels, was not used. No gas-rationing plan could pass Congress until after the worst part of the shortfall was complete. In brief, there was no coherent response—a factor that undoubtedly contributed to panic buying on the international spot market and helped push the price of oil from $13.11 per barrel in January 1979 to $31.39 per barrel in December 1980.

Natural gas, electricity, coal, and nuclear

Unanticipated political influences on supplies also popped up in other energy markets. In natural gas, the shortages of 1976 prompted Congress to pass the Natural Gas Policy Act (NGPA) of 1978, a compromise measure that decontrolled the price of some gas and allowed other gas prices to escalate gradually toward market levels. Misunderstanding the importance of this legislation, the industry went about its business in the same way, with pipelines bidding anxiously for supplies while paying little attention to price and producers borrowing huge sums to produce and explore for gas reserves. But under the NGPA the problem of the natural gas industry—at least for the time being—changed from excess demand to excess supply. Thus, gas pipelines were left with contracts for supplies they could not sell and some producers of high-cost gas went broke. And government regulation designed to "back" gas out of certain markets looked foolish.

For electric utilities and for the coal and nuclear industry supplying them, the environmental movement was an important new political factor. Prior to the 1970s it was unusual to see major energy projects delayed, let alone canceled, because of environmental considerations. Nor were operations seriously restrained by air or water pollution regulations. In general, companies were able to evaluate projects almost entirely on the basis of how the investment would affect the company's earnings.

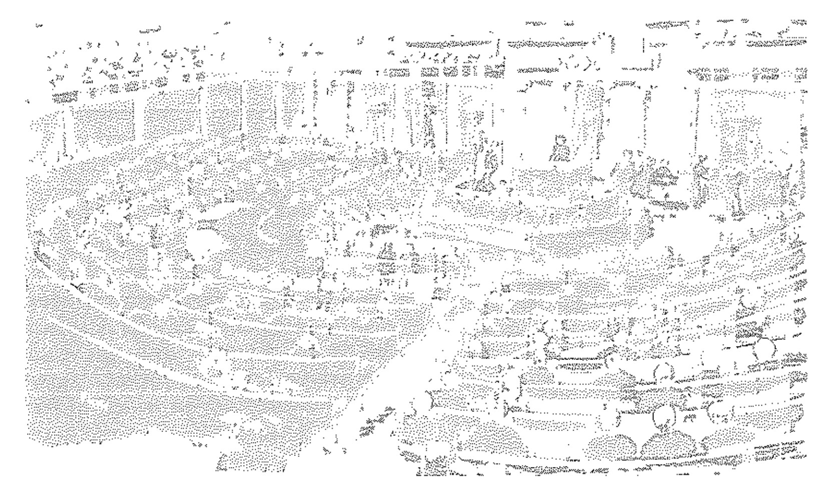
All that changed with the public's increased sensitivity to environmental issues. The Clean Air Act of 1970 and amendments to that act in 1977 restricted sulfur dioxide, nitrogen oxide, and particulate emissions from the burning of coal and forced many utilities to install expensive "scrubbers" to reduce such emissions. And, just as it is adjusting to that law, coal-burning utilities are faced with the prospect of acid rain legislation that could force additional, expensive, antipollution investments. Again, it looks as if those utilities that underrated the influence of the environmental movement will be penalized. On the nuclear power side, the accident at Three Mile Island in 1979 lent perhaps decisive weight to the arguments of the antinuclear activists who claimed that overwhelming safety, health, and environmental dangers were associated with nuclear power. As a result, safety standards were made more rigid and several plants were forced to shut down for short periods to bring them into compliance.

Planning for future disruptions

Has the importance of political events been fully recognized after these and other experiences? The answer is somewhat mixed. On the positive side, government planners have devoted much effort (with some results) to planning for oil disruptions. By late 1983, the SPR contained 341 million barrels, a size that would allow its effective use in any future disruption. The IEA periodically tests its sharing mechanism, although its efficacy in actual emergencies remains to be demonstrated. Every flare-up in the Middle East is examined for its possible effects on oil supplies.

Less encouraging is the expectation, underlying most of government and industry planning, that energy-supply trends will shift only gradually in coming years with insignificant year-to-year fluctuations. Several plausible scenarios could prove this view incorrect. In oil, many have pointed out the likelihood of another supply disruption in the Middle East. But there are other, less frequently mentioned, potential political influences on supply. One example is the possibility of political unrest in Mexico (which many Latin American experts cite) that could restrict oil production in the country that now is the leading oil exporter to the United States and a major source of oil for the SPR. On the other side of the coin, the Iran–Iraq war could end and flood the oil markets with as much as an additional 3 to 5 mmbd of oil. In domestic markets, different types of politically inspired disruptions such as new natural gas regulation or environmental laws easily could appear despite a recent political climate that favors less stringent regulation.

It should not be concluded that political forces necessarily are dominant. In the long term, supplies and prices may return to the path they were on prior to politically inspired diversion. But the past ten years have made clear that the damage political factors can wreak in the short term merits considerable attention.



Detours on historical demand paths

The second fundamental change on the energy scene in the last ten years is the reaching of price levels high enough to upset the preexisting demand and supply patterns of every major energy product. Before 1973, and for several years thereafter, it was assumed that prices could rise substantially without either significantly reducing energy consumption or increasing supply. This belief was bolstered by continuing increases in the consumption of oil, natural gas, and electricity in the face of sharply higher prices after 1973.

Lack of faith in the ability of prices to restrain growth in energy demand also created a host of beliefs that drove energy planning in government and industry. For one thing, it provided support for price controls on oil that were in place from 1971 until 1981. Since it was mistakenly thought that high prices would not dampen demand, those who advocated controls argued that allowing oil companies to set higher prices would merely increase corporate profits while doing little to reduce oil consumption. Partly as a result of oil price controls and the accompanying regulatory system, imports grew more rapidly than would otherwise have been the case—from 6.3 mmbd in 1973 to 8.8 mmbd in 1977. By 1983, however, they were down to an average of well below 5 mmbd.

Not foreseeing the market adjustments resulting from higher energy prices also contributed to fears of shortage and made many energy investments look more desirable then they would have otherwise. Several studies forecast resource exhaustion within the foreseeable future unless drastic action was taken. Backed with such "evidence," Congress passed legislation designed to restrict consumption of oil and natural gas for certain uses deemed "nonessential" or where coal could serve as a substitute. Impetus was given to large-scale energy projects which, if pushed to the maximum, would be ready just in time. The Synthetic Fuels Corporation, created in 1980 with authority to spend as much as $88 billion, was the most notable of several examples.

The assumption that demand trends would remain on historical paths also was common in industry. From 1963 to 1971, total U.S. energy consumption had grown at an annual average of 4.4 percent. Oil and natural gas companies created huge exploration budgets in the expectation that this sort of growth in consumption would continue. In electricity, where the size of investments makes looking at the long term critically important, electric utilities proceeded with plans to build large new nuclear and coal-fired plants. Without these facilities, projections showed the likelihood of brownouts and electricity shortages. As late as 1978, the electric power industry was projecting annual demand growth of more than 5 percent for the subsequent ten years.

Finally, not having to worry about prices made it possible to limit the uncertainty about the future. Thus, forecasts based on extrapolations of the past gave seemingly acceptable estimates of where demand would be in the future. Sometimes the calculations conveyed spurious accuracy by being carried out to a couple of decimal points. In general, not factoring in the reaction to price changes contributed to the notion that those in charge knew what they were doing, enabling leaders in government and industry to map out bold, ambitious plans for the future.

The trends turn

Unfortunately for these planners, beginning in 1979 demand trends for almost every energy product began to decline in reaction to higher prices. Compared to the first six months of that year, U.S. oil consumption in 1983 has fallen 23 percent, natural gas use has dropped 8 percent, and electricity demand has declined 2 percent. Total energy consumption has dropped 14 percent in this period. The trend also is apparent in other industrialized nations. As late as the third quarter of 1983, oil consumption in the OECD countries was below depressed 1982 levels

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despite the early signs of economic recovery.

Meanwhile, available low-cost energy supplies have grown. Oil production outside of OPEC countries increased from about 24 mmbd in 1973 to around 34 mmbd in 1982, with substantial additions coming from Alaska, the North Sea, and Mexico. The decline in the production of oil and gas in the United States seems—at least for the time being—to be halted.

For those with investments in high-cost energy supplies, the impact of the change in trends was serious. Oil service and equipment companies that had expanded to meet increased demand suddenly were forced to retrench. Oil and natural gas producers saw their profits dive. And, most critically, the electric utility industry found itself with a host of partially completed, unneeded power plants, many of them nuclear. Moreover, construction costs had soared in the years since the plants were ordered, making the cost of completing them prohibitive. It was no surprise, then, that many plants were canceled; in one case (the Washington Public Power Supply System), a massive default on bonds occurred. No new nuclear plants have been ordered since 1978.

What happens next?

The financial distress that accompanied these events has helped ease general acceptance of the idea that rising prices can place important limits on energy demand and encourage supply. Some still predict fairly large consumption increases will return with the reemergence of economic growth. The U.S. electric utility industry, for example, projects demand growth of more than 3 percent annually in the next ten years. However, the majority of planners within government and industry now accept that prices—including the lagged effect of past increases—will continue to hold down demand. Indeed, many are assuming that demand never again will grow at anything like the rates achieved in the 1960s and 1970s. In the wake of the experience of the past decade, these observers display more certainty about the relationship between economic growth and demand than perhaps is warranted. Nevertheless, this view of demand, along with the demonstrated flexibility on the supply side, seems to justify the Reagan administration's cutback on research and development expenditures and elimination of programs designed to enhance conservation. Similarly, a combination of low demand growth projections and less pessimism on the outlook for conventional energy supply has supported industry moves to back out of alternative energy investments. For example, the Synthetic Fuels Corporation still was barely active in 1983, three years after it began operation. As a result, it seems plausible that the United States will be confronted by a truly ironic situation. Having been burned by a refusal to believe that one trend will change and that price would limit demand, Americans now may be victimized by too-ready acceptance of a new trend and a belief that it is unswerving.

Avoiding this trap requires measures that acknowledge explicitly the uncertainty surrounding energy. In brief, such an approach would include greater government funding for basic energy research and development directed at a variety of different technologies. To allow for smooth adjustment to fast-changing market realities, it also would be desirable to make markets as free from price regulation as is politically possible while increasing direct aid for lower-income families in times of rapidly rising energy prices. A high priority should be placed on preparing for energy emergencies and on economically justified conservation activities that would allow industry and government to postpone some of the massive investments in energy supply that are so risky in the present environment. Most of all, the success of energy planning should not depend on the continuation of today's price, supply, and demand trends. After all, if anything has been learned about energy in the last ten years, it is that today is not a very good indication of what will happen tomorrow.

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The EPA today and yesterday

Two of the biggest news stories of 1983 surrounded resignations under fire of top presidential appointees—Environmental Protection Agency Administrator Anne McGill Burford and Interior Secretary James G. Watt. But while Watt went down because of a slip of the lip, leaving an intact staff and policies to be taken over by Secretary William Clark, Burford's departure came amid accusations of policy malfeasance and political chicanery. Moreover, nearly every other top EPA official also left under pressure, thus giving the new administrator, William Ruckelshaus, a relatively clean field on which to try to reconstruct his morale-shattered agency.

In April, just as Burford convened her last press conference as EPA head and President Reagan named Ruckelshaus, former administrator, to head the agency, RFF produced a radio show for the FOCUS public affairs series that examined the shake-up and assessed its portent for the future. An edited portion of the transcript of the program follows.

The participants are Harvey Alter, manager of the Resources and Environmental Quality Division of the Chamber of Commerce of the United States; J. Clarence "Terry" Davies, executive vice president of the Conservation Foundation; and Paul R. Portney, senior fellow in RFF's Quality of the Environment Division. They were interviewed by Daniel Zwerdling, who covers environmental affairs for National Public Radio.

Expectations versus reality

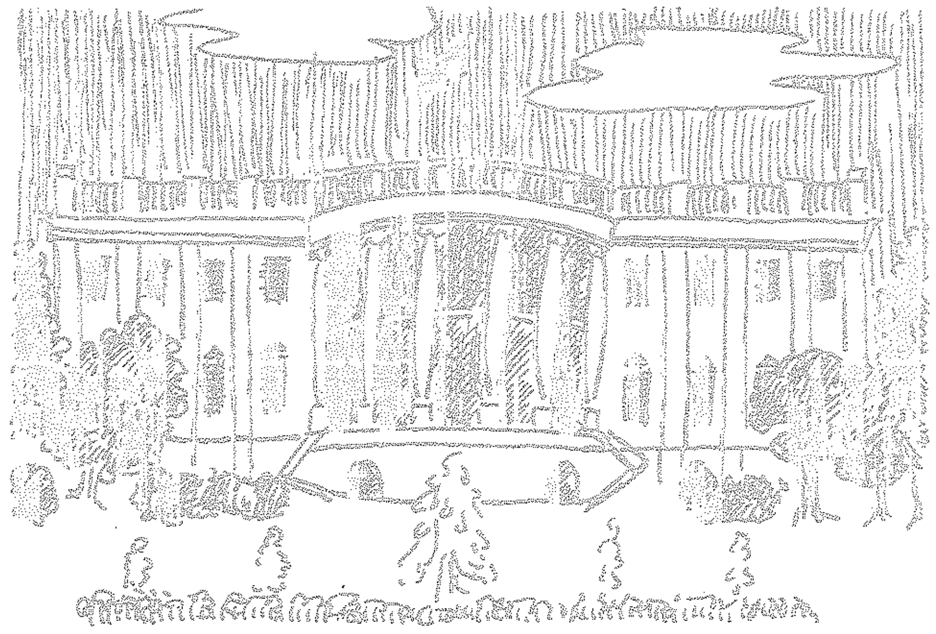
ZWERDLING: William Ruckelshaus was the first EPA administrator when it opened shop under President Nixon in the early 1970s and, as deputy attorney general, he gained fame when he refused to fire special Watergate prosecutor Archibald Cox. He's considered a man of integrity. But can he really change the EPA?

ALTER: The biggest change that Mr. Ruckelshaus can make is to rebuild public confidence that the environment and health will be protected. The remaining question, and just as large, is what other changes he's going to make. Will he, under whatever external pressure, seek more and more regulation, as had been the trend under President Carter? Or is he going to try to reexpress what I believe to be the Reagan administration's view—achieve protection, but at a lower cost?

ZWERDLING: Let's say that Mr. Ruckelshaus simply tries to enforce the environmental laws now on the books. How can he possibly do it when his budget is in shreds? The Reagan administration's budget request for EPA this coming year is one-third less than what President Carter asked in his last year in office; President Reagan wants almost 50 percent less for research at EPA than actually was spent in 1981; the staff has been slashed by almost 20 percent.

ALTER: But those are nonsensical numbers, because every president puts in an inflated budget request, especially when it's his last year. Everyone knows that a final-year request is not going to Congress, is not perceived as reality by Congress: It's a fictitious number, and it's the wrong one to use for comparisons.

DAVIES: They're very meaningful numbers. The research and development function within the agency has been basically devastated by the Reagan budget cuts.



Major parts of the agency—pesticides, toxics, enforcement—similarly have been terribly handicapped if not destroyed altogether. The agency's responsibilities have increased tremendously and there is no way, despite statements from the administration, that you can do more work with less money when you have a reasonably efficient operation to begin with. The workload essentially has doubled in a lot of programs, and the budget has been halved. The results already have shown up in the law not being adequately enforced.

ZWERDLING: If you were going to take over EPA right now, what could you do and not do, given the budget?

PORTNEY: I would try to do what I think Bill Ruckelshaus is going to try to do. That is, wangle a supplemental appropriation for this fiscal year. Also, I'd try to get some kind of supplement to what the administration has requested for FY 1984. Obviously, I wasn't privy to the conversation between Mr. Ruckelshaus and the president, but I would guess that one of the terms he got the president to agree to before he would accept the job is an increase in the EPA budget.

ZWERDLING: But let's suppose that the EPA will have pretty much the same amount of money it had last year. What can it accomplish?

PORTNEY: That's a fairly difficult question. Keep in mind that even in the Carter administration, when the budgets were much higher than they are now, EPA was behind in getting out standards for all new sources of air pollutants, behind in approving State Implementation Plans to regulate air quality in the fifty states, behind in issuing water pollution standards, behind in a lot of respects. One reason for that was a budget that was inadequate in view of the tremendous responsibilities that Congress loads on the EPA year in and year out. It's an easy way for Congress to appear to be doing a lot about the environment, but it has the effect of creating an agency that's going to be perpetually behind these deadlines.

ZWERDLING: So you're saying that Congress is actually creating unrealistic expectations among the public?

PORTNEY: In a lot of cases, it is. In many other cases, EPA is given a fairly general mandate but chooses to interpret the mandate in such a way that it's going to be chronically behind the deadlines that Congress establishes.

Cleaning up toxic wastes

ZWERDLING: Let's talk about a specific: can EPA clean up the country's toxic waste dumps?

ALTER: Well, we're talking about priorities. Of course you clean up the dumps; it's a question of which ones come first.

ZWERDLING: The EPA has identified 418.

ALTER: That doesn't include federal sites, and the federal government has been guilty as well of having inadequate facilities. Also, some other sites have been omitted. But whether you have 400, 500, or 600—which ones come first?

DAVIES: I would disagree in thinking it's just a matter of priorities. It's also a matter of changing basic strategies in the agency. Up till now the agency has chosen to negotiate with the dumpers first and to clean up later, which accounts for much of the delay. The law allows them to clean up first.

ZWERDLING: Let's go back to the basic question. Given the amount of money that EPA has now, and will have over the next years, can the government clean up those 400-some toxic waste dumps that citizens are so worried about?

PORTNEY: No. It's clear that there's not enough money in the Superfund to clean up the 418 priority sites or a number of other sites not on the priority list, but of serious concern to local residents. The important point is that there *is* enough money to begin cleaning up some of the most serious sites. Failure to do so results from two things: (1) As Terry indicated, the EPA has preferred to negotiate with the parties they think are responsible for the mess before cleaning up the sites; and (2) political problems always exist when there are representatives who want their site rather than someone else's cleaned up first. But there certainly is enough money to begin. To my mind, there is no way to explain or to offer an alibi for the delay in taking that money and beginning to work on the worst sites.

ALTER: The Superfund and, indeed, the congressional appropriations are not all the money that is available. There's a dynamic process going on that leverages the money. In short, you can use all the strategic tools at once: you can get people to settle out of court and speed it up; you can go after the scofflaws and collect from them; and you can use the reserve fund to clean up. Also, we need to marshal enough engineers and other knowledgeable people to do the job right. In fact, we don't have a lot of experience in cleaning up hazardous sites and perhaps what's worse than a hazardous site is to make it even more dangerous with an inept cleanup.

Future priorities

ZWERDLING: The Congress and President Reagan have only a short time to address the nation's environmental problems before the next election. What are the priorities going to be? What should they be?

PORTNEY: When President Reagan was candidate Reagan, he was correct, I think, in criticizing decision making at EPA. He pointed out that the monitoring network was such that we had too little idea of whether things were getting better or worse, of which areas were improving, of which were deteriorating, and at what rates, and that we had too little knowledge of what roles the Clean Air Act and other environmental statutes were playing in those areas where environmental quality was improving. So I thought that one of the administration's first moves

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Acid rain . . .

What is it?

WHATEVER GOES UP, must come down. But does it? And if so, where, and in what form and concentration?

Acid deposition—acid rain is only one form—seems easily understood at first glance: gases of sulfur and nitrogen are released into the air, where portions of them are converted to acids that fall to ground in rain, snow, or as dry deposits on surfaces. Since some lakes, trees, and other biological species apparently are adversely affected by the acids, it is desirable to reduce the amount deposited.

But how can or should this be done? Logic suggests reducing the amounts of sulfur and nitrogen released into the atmosphere. In the northeastern quadrant of the United States, where the problem is greatest, most of the sulfur dioxide and about half of the nitric oxide are released by power plants burning oil and coal. The most obvious solution—forcing such plants to reduce their emissions of one or both of these compounds—would require for most the use of sulfur dioxide scrubbers at costs that could total $100 billion during the remainder of this century. Many laymen have a "sock-it-to-them" attitude toward the power companies, but ultimately utility customers would pay the bill. Thus, solutions to the problem affect a large segment of the population, and not only power company shareholders.

What is acid rain?

An acid is a substance that releases hydrogen ions in water solution. Chemists use "pH" to describe the relative acidity or alkalinity of a solution, and this term has been picked up by the popular press. This often is misleading because, as the negative logarithm of acid concentration, pH varies much less than the concentration itself and, for acids, in the opposite direction of acidity. To a layman, the difference between pH5 and pH4 appears to be only a 20 percent change, and pH4 sounds better than pH5, but in reality a solution with pH4 contains ten times as much acid as one of pH5. In this article I use the actual hydrogen ion concentrations in terms of microequivalents (μeq) per liter. For example, pH4 is 100 μeq per liter and pH5 is 10 μeq per liter.

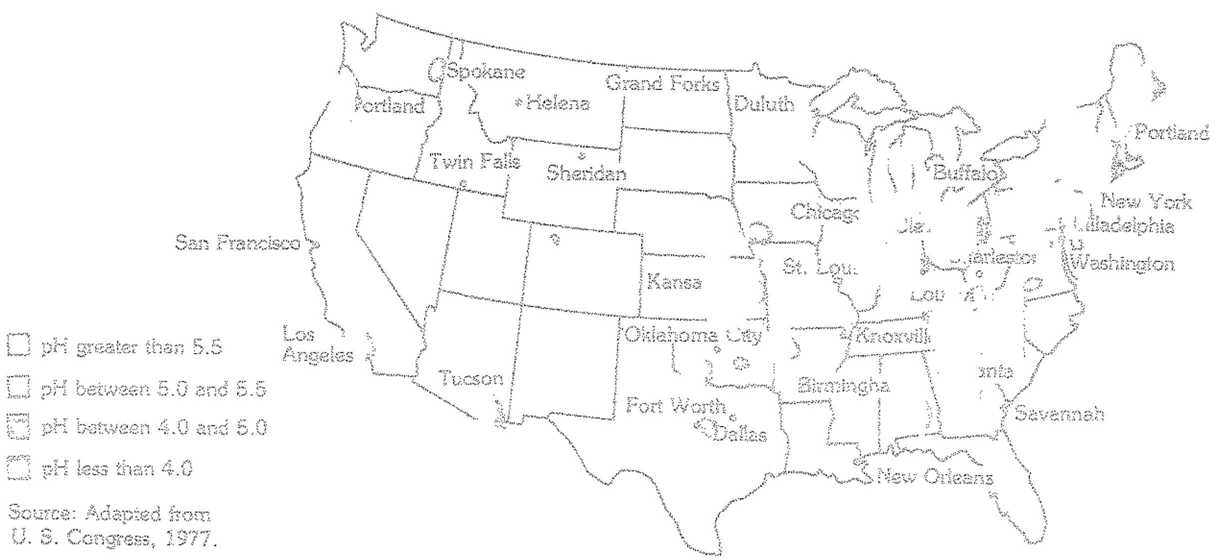
All water contains some acid. In pure water a few water molecules break up into hydrogen and hydroxide ions, so the acid concentration is 0.1 μeq per liter. Pure water in the natural, unpolluted atmosphere contains additional acid because carbon dioxide from the air dissolves to form weak carbonic acid, producing a hydrogen ion concentration of about 3 μeq per liter. In addition, the atmosphere contains natural sulfur dioxide, resulting from biological activity in the oceans and on land, with some of it being transformed into sulfuric acid. The amount of acid from natural sources is not well known, but it is rarely more than 10 μeq per liter. Thus, rain naturally is somewhat acidic, but human activities clearly have made it more so: For example, in the eastern United States, the acid concentration in individual rainfall events ranges from 50 to 200 μeq per liter or five- to 20-fold larger than natural concentrations.

Drops in the bucket

Since the mid-1960s, acid rain has been of serious concern in Scandinavia, especially Sweden, but it received little attention in the United States until the mid-1970s, when Gene Likens and his coworkers, then at Cornell University, published maps of rainfall acidity in the Northeast showing that acidity had increased substantially between the mid-1950s and the mid-1970s. These maps, coupled with reports of "dying lakes" in areas such as upper New York State and Canada, greatly increased public awareness of this possibly growing problem. However, careful examination of the data raises serious doubts about their reliability, especially those gathered in the 1950s.

Accurate measurements of rainfall acidity are difficult to perform. For example, if a bucket is placed in a field and the rain collected in it is analyzed once each week, the results can be wrong for many reasons. One is that particles suspended in the atmosphere that contain alkaline substances may fall into the bucket and neutralize the acids, thus producing acid concentrations that are too low. Until recently, reliable techniques had not been established for measuring the acidity of rainwater, so that the older data cannot be corrected for problems associated with their measurement.

The longest continuous record of rainfall acidity is that obtained at Hubbard Brook Experimental Forest, New Hampshire, beginning in 1964. Between 1964 and 1980, the annual average acidity ranged between 60 and 95 μeq per liter and, if there is a long-term trend, it is slightly downward. Even when data for acidity (or concentrations of most other pollutants) are averaged over twelve months, year-to-year fluctuations are so great that data must be obtained for many years to establish a clear trend. Since 1964, sulfate concentrations in precipitation at Hubbard Brook have declined by about 20 percent, possibly reflecting reduced emissions of sulfur dioxide in the East. Nitrate concentrations rose from 1964 to 1971 (probably because of increased emissions of nitrogen oxides by motor vehicles) and have been fairly constant since then. Thus, the Hubbard Brook record of acid precipitation suggests that acidity has remained constant, or has declined slightly, since 1964, and that the reduction in sulfuric acid has been balanced approximately by increased nitric acid, with the former now accounting for about two-thirds of the acid.



Source: Adapted from U. S. Congress, 1977.

Producing acid rain

Whether or not rainfall acidity is increasing, considerable political pressure is being exerted, especially from Canada, New England, and New York, for its reduction. The classic scenario resulting from many studies is that air masses move up the Mississippi and Ohio River valleys, collecting emissions from many power plants, especially those along the Ohio River. During transit, the air pollutants slowly form acids and sulfate particles, causing acid precipitation in that area and to the northeast. Indeed, maps of acid precipitation show that the region of high acidity extends considerably farther toward the Northeast than does the area of high-density sulfur dioxide sources. Despite the apparent strength of this argument, two major questions must be answered before it is clear that reducing emissions will be beneficial: Will a given reduction of sulfur and nitrogen oxide emissions produce a proportionate reduction of acid? And if reductions are made in a given area, at what distance will there be a significant effect on precipitation acidity?

Oxidizing agents

These questions can be answered only when the major mechanism(s) that produce acid precipitation are fully understood or when empirical studies demonstrate the relationship between release of pollutants at one point and deposition of acids at another. Production of acid requires at least two reactants: the sulfur or nitrogen oxide gas and an oxidizing agent that transforms them into sulfuric and nitric acids. Until the most important oxidizing agents are established, it is impossible to know which species is in excess. If, for example, it is sulfur dioxide, then the amount of sulfuric acid formed will be limited by the amount of oxidant available. If that were the case, emissions of sulfur dioxide would have to be reduced to the point at which its concentration was equal to the available oxidant before further reductions would decrease the acidity of precipitation. This is a definite possibility, as it is fairly certain that much of the sulfur dioxide released in the Northeast is not deposited within the area. Of the estimated 8 million metric tons of sulfur released there, about 3 million metric tons are transported to the Atlantic Ocean without being deposited and another 1 million tons go to Canada. Thus, additional sulfur could be deposited in the area, but luckily it is not. Is that because there is a shortage of the oxidizing agent?

Although present knowledge of the atmospheric chemistry of sulfur and nitrogen oxides is far from complete, progress in research has been rapid during the past several years.

Photochemical reactions

It is known, for example, that during the summer, some sulfur dioxide is oxidized by a hydroxyl radical, a highly reactive, transient species produced by reactions caused by sunlight, that is, photochemical reactions. Because hydroxyl radicals react so quickly, their concentrations are never very large and, as a consequence, no reliable, direct measurements have been made. Reactions of hydroxyl radicals may produce much of the sulfate borne by atmospheric particles, which causes the haze that blankets the Midwest and East, especially during summer. But even if they are all brought down by rain, these particles do not carry enough acid to account for the acidity of the rainfall. Other photochemical reactions convert nitric oxide to nitric acid, which is a gas unless water droplets are present. If this is the case, most of it dissolves. But even if the nitric acid below the clouds also is collected by the falling rain, the total acid is not enough to produce such an effect. Apparently, much of the acid is produced in clouds.

The role of clouds

Clouds provide a good medium for chemical reactions, as gases can dissolve in cloud droplets and react with each other. Dissolved oxygen and sulfur dioxide can form sulfuric acid, but the reaction is too slow in pure water to account for the amount of acid that has been observed. The reaction can be speeded up (catalyzed) by dissolved metals such as iron and manganese, but the process slows down after some acid has been formed.

One important oxidizing agent in cloud droplets is hydrogen peroxide, which is produced by photochemical reactions of nitrogen oxides and hydrocarbons. Unlike other reactants, hydrogen peroxide keeps on reacting after some acid has been produced. However, hydrogen peroxide is far from being established as the most important oxidant. Only recently has it been possible to measure its concentrations in the droplets of very calm, non-raining clouds.

Another possible oxidant in the cloud droplets is ozone, yet another product of photochemical reactions. Concentrations of both sulfate particles in the air and acid in rainfall are higher in summertime, when the intensity of the light is greatest, despite the fact that the concentration of sulfur dioxide is higher in the winter and nitrogen oxides are fairly constant throughout the year. Some acid and sulfate are produced in winter, which leads one to believe that other reactions may

be important as well, for example, catalysis by manganese and iron.

Clouds play an important role in the production of acid, but aspects of their performance remain poorly understood. Most people are not aware that few clouds produce rain. Instead, they evaporate, leaving behind the solid material that was present in the droplets. Such a particle released into the air passes through about ten cloud droplets before it is deposited at ground level; the average suspended particle has been through five clouds. Measurements taken in clouds show that they contain much more acid than do the residual particles. What happens to the acid between clouds? Part of the answer is that the nitric acid gas dissolved in cloud droplets evaporates along with the water. However, this does not explain why more sulfuric acid is not found on the particles. Perhaps this dilemma results from poor knowledge of bases, the acid-neutralizers. Much of the particulate matter in the atmosphere is soil and rock dust containing basic substances, such as limestone, that neutralize some of the acid. However, an even more important base is ammonia gas, released by feedlots, fertilized fields, and biological processes. The concentration of ammonia gas probably never gets very large because it reacts rapidly with sulfuric acid particles to neutralize them.

According to this picture, acid is made in clouds that evaporate, but much of the acid formed is neutralized by ammonia while the particles are between clouds. In my view, the majority of acid is made in the clouds that produce rain. In these clouds—the more active of which cannot be sampled safely by aircraft—huge updrafts suck in large volumes of air at their bases. The turbulence promotes mixing of various species, giving them an opportunity to react in the cloud droplets. Such clouds may make acid so rapidly that it cannot be neutralized by ammonia gas before it falls to earth in rain or snow.

This scenario, based on clues gleaned from studies of air and gentle clouds, is speculative, but the enormous progress being made in atmospheric research should provide fairly clear knowledge of the important pathways for acid formation and neutralization within the next five years. Measurement methods for some key species, available only in the last year or so, already are providing vital new information.

Report of the National Research Council

Last year, a group of distinguished atmospheric scientists, brought together by the National Research Council, reviewed all available information and arrived at the following carefully worded conclusion:

> If we assume that all other factors, including meteorology, remain unchanged, the annual average concentration of sulfate in precipitation at a given site should be reduced in proportion to a reduction in SO_2 and sulfate transported to that site from a source or region of sources. If ambient concentrations of NO_x, nonmethane hydrocarbons, and basic substances (such as ammonia and calcium carbonate) remain unchanged, a reduction in sulfate deposition will result in at least as great a reduction in the deposition of hydrogen ion.[1]

Although I respect the opinion of the panel, I am not as confident that reducing sulfur oxide emissions by X amount would yield a proportional reduction in acid deposition. If the acid is produced in clouds that rain, those clouds may exhaust their oxidants before they convert all the sulfur dioxide into acid. If so, a small reduction in sulfur dioxide emissions might produce no observable change in acid deposition, especially in view of the great year-to-year variability of average acidity.

The panel's report indicates that it is impossible to predict the distance at which rainfall acidity would be affected by reducing sulfur dioxide emissions in a particular locale. As noted above, the area of highly acid rainfall extends considerably farther toward the Northeast than the area of high sulfur dioxide emissions of the Ohio River Valley, empirically suggesting that, for long-term averages, the effects probably would extend several hundred miles. However, in my view, if one considers a particular mass of air traveling from the Ohio River Valley to the Northeast, the area of acid deposition can be determined largely by the pattern of rainfall along its path. If rain occurs near the midwestern sources, then little acid will be carried to New York and New England. But if no rain occurs in the air mass until it reaches the Northeast, then acid in that area will result in part from emissions released in the Midwest.

Two other points should be noted. First, I have focused on the deposition of acid, especially sulfuric acid. Acids, of course, attack a wide variety of materials. However, many experts on biological effects are more concerned about total sulfate deposition, as some biological processes convert sulfate of any type of sulfuric acid. Second, only recently have scientists begun to study fogs, whose droplets usually contain much greater concentrations of acid and sulfate than raindrops—and the fog droplets are deposited directly on the leaves of vegetation. Much damage to trees and other vegetation in areas of frequent fogs may be caused by acid fog rather than rain.

Reducing emissions

Some proponents of strong measures to control sulfur oxide emissions note that many past decisions, though based on incomplete information, have been successful. One, they point to the control of coal burning in London after thousands died as a result of the great London fog of 1952. But other similar decisions probably have been ineffective. For example, no convincing case has been made for the benefits (outside of southern California) of reducing carbon monoxide and hydrocarbon emissions from automobiles by requiring catalytic converters. (Indeed, the major benefit may have been a great reduction in atmospheric lead: leaded gasoline cannot be used in vehicles equipped with converters.)

Congress currently is considering several bills calling for reduction of sulfur oxide emissions, primarily by the electric power industry. Not surprisingly, states with the greatest emission densities favor regulations that would require uniform percentage rollbacks, while those with low emissions favor a reduction by states with high emissions. It is unfortunate that this decision will be based on regional political considerations rather than on maximizing environmental benefits while minimizing costs. Certain areas are much more sensitive to acid rain than others, in part because their soil and rocks do not have much capacity for neutralizing acid. As some of the areas of greatest sensitivity are in upper New York State, New England, and eastern Canada, any plan to reduce sulfur oxide emission should focus there.

One probable side benefit of reducing sulfur dioxide—clearer skies—has received little attention. Even if the reduction of acidity of rainfall is not proportional to the reduction of sulfur dioxide emissions, there is a good chance that concentrations of sulfate particles in the atmosphere will decrease. And as sulfate particles cause most light scattering in the atmosphere, significantly fewer of them should mean reduced haze and improved visibility.

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[1] National Research Council, *Acid Deposition—Atmospheric Processes in Eastern North America* (Washington, D.C., National Academy Press, 1983). This excellent summary of present knowledge about acid rain contains references to original sources of most of the facts mentioned above.

Acid rain . . .

Making sensible policy

Spurred by mounting concern about acid deposition, Congress is considering reducing total annual emissions of sulfur dioxide, the gas that apparently is its major precursor. The issue is full of questions—how much to cut back, how to apportion cuts among the forty-eight contiguous states, whether nitrogen dioxide emissions should be included and whether, and if so how, the cost of the reductions should be subsidized. This article concentrates on an equally important question, How much discretion about the means of reducing sulfur dioxide should be given the electric utilities and other sources that would be affected by any reduction that Congress might wish to mandate?

Two broad approaches have emerged to this last question. Under the first, affected sources would be given complete freedom to choose how they would meet mandated reductions in sulfur dioxide emissions. They could switch to coal or other fuels with a lower sulfur content, install complicated devices known as scrubbers that remove sulfur dioxide from flue gases, "wash" the coal prior to burning it, or use a combination of these means or any others. Under the second approach, many sources would be given no latitude in selecting control measures. Rather, they would be forced to reduce their sulfur dioxide emissions with scrubbers.

For reasons to be discussed shortly, the former approach has come to be referred to as the least-cost alternative. When compared to forced scrubbing, it would save U.S. citizens a considerable sum of money—$20 billion in capital costs alone over the next ten years—and, *on net*, create 5,600 additional jobs in mining and transportation at a time when employment is a particularly important national concern. However, the least-cost alternative apparently would result in some job shifts or losses for miners of high-sulfur coal in a few regions because of a probable shift to low-sulfur coal by many large utility power plants. It is these location-specific job losses that the forced scrubbing approach is designed to prevent.

Federal protection for coal interests

Nearly every administration and Congress since 1932 has come under pressure to assist the citizens of Appalachia by protecting from domestic and foreign competition or otherwise subsidizing the coal companies that operate there.[1] The arguments for such protection have ranged from national security to market failure.

This pressure was resisted until recently. Instead, where federal action seemed called for, Congress opted for income assistance and social service programs targeted at affected individuals and regions rather than at industries. The creation of the Appalachian Regional Commission and the Great Society programs in the Kennedy and Johnson administrations are perhaps the best examples.

In 1977, however, Congress reversed nearly thirty-five years of bipartisan precedent. Bowing to pressures from special interest groups, Congress amended Section 111 of the Clean Air Act, which deals with federally established emissions standards for new sources of air pollution. Specifically, Congress mandated that any newly constructed electric power plant meet the emissions limit established in the Environmental Protection Agency's 1971 new source standard via technological means—scrubbing.

This only thinly veiled attempt to protect high-sulfur coal producers in one small part of the country has been criticized as a needlessly expensive way to reduce sulfur emissions from new power plants,[2] and also for apparently exacerbating acid deposition in the eastern United States, where some of the most sensitive ecological areas are located.[3] (If this view is correct, it is indeed ironic that an approach that has increased acid rain now is advanced as a partial cure.) It is against this history that the current debate over controls on existing power plants and other sources should be viewed.

Pros and cons of the alternatives

Before discussing the strengths and weaknesses of the least-cost alternative and of forced scrubbing, let us be clear about their environmental effects: *they are identical*. Both are designed to achieve the same aggregate annual reduction in sulfur dioxide emissions, and whatever effects such a reduction would have on acid deposition would be identical as between the two plans. Thus, the cost savings and favorable overall job impacts associated with the least-cost approach would *not* come at the expense of environmental quality.

In comparing the two plans, I rely primarily on an analysis prepared by ICF Incorporated for the Alliance for Clean Energy (referred to here as the ICF report).[4] This analysis is consistent with those conducted by ICF for the EPA and other interested parties. Like all analyses, its conclusions depend critically on underlying assumptions and the data on which the appropriate models are estimated—in this case, data and assumptions about coal prices and availability, labor productivity and wage rates, pollution control costs, and other factors. While it is important not to attach too much certainty to the

[1] This section draws heavily on Milton Russell, "Energy Politics Looking Backward," in Martin Greenberger, ed., *Caught Unawares: The Energy Decade in Retrospect* (Cambridge, Mass., Ballinger, 1983) pp. 29–66.

[2] According to the Congressional Budget Office, the technological approach embodied in the 1977 amendments will, by the year 2000, cost the nation $3.4 billion more *per year* than would be required to achieve the same emissions reduction using low-sulfur coal. See Congressional Budget Office, "The Clean Air Act, the Electric Utilities, and the Coal Market" (Washington, D.C., April 1982).

[3] Bruce A. Ackerman and William T. Hassler, *Clean Coal—Dirty Air* (New Haven, Conn., Yale University Press, 1981) p. 68.

[4] ICF Incorporated, September 22, 1983.

estimates, I believe they represent the best available information about expected results.

The forced scrubbing alternative analyzed in the ICF report is that embodied in H.R. 3400, introduced by Reps. Henry A. Waxman (D–Calif.) and Gerry Sikorski (D–Minn.). This bill would give some power plants the flexibility to select how to reduce sulfur but would force the fifty "dirtiest" plants to install scrubbers to meet their mandated reductions. H.R. 3400 is selected as the basis for comparison with the least-cost approach only because its specific provisions make cost and employment estimates possible. The qualitative conclusions in this article would apply equally to other forced scrubbing approaches.

Cost impacts

Almost all of the fifty power plants targeted for scrubbers under H.R. 3400 could reduce sulfur dioxide emissions at less cost by shifting to low-sulfur coal.[5] Indeed, the savings would be substantial. Between now and 1995, forced scrubbing would require an additional $20 billion in capital investment in the electric utility industry compared to the least-cost approach. This would, of course, have to be shouldered by electricity rate-payers already troubled by recent cost increases, or by others no more eager to bear the burden.

Even after taking into account the increased price of low-sulfur coal expected to result from added demand, the least-cost approach would save $1 billion annually when compared to the forced scrubbing route. (ICF's estimates of these savings thus are less than $1.6 billion per year estimated in a July 12, 1983, staff memorandum issued by the Office of Technology Assessment.)

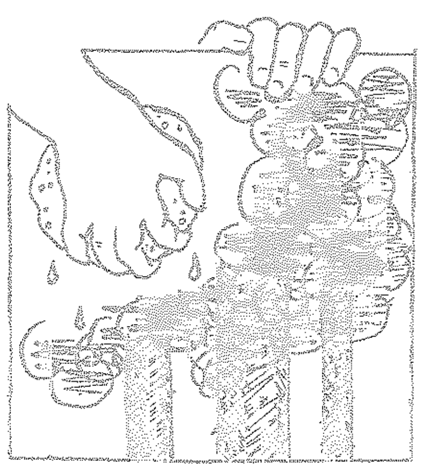
Overall job impacts

Many programs that rank high with respect to one criterion do less well when measured against another. Thus, it is possible that the least-cost approach to acid rain control, while saving considerable amounts of money, might have unfavorable effects on, say, overall employment when compared to the forced scrubbing alternative. But no: according to the ICF report, the least-cost alternative would result *on net* in 5,600 more jobs by 1995 than the more expensive forced scrubbing approach. Some 1,500 additional coal miners would be employed under the least-cost approach as jobs open up in low-sulfur coal mines in both eastern and western states; and 4,100 new jobs would be created for coal transportation workers on trains, trucks, and the barges that would move on U.S. intracoastal waterways, the Great Lakes, and ocean shipping routes.

[5] According to ICF, under the least-cost alternative an additional 2.5 gigawatts (GW) of scrubber capacity would be installed by 1995 relative to a base case of 100.6 GW. Under H.R. 3400, however, an additional 67.7 GW of scrubber capacity would be installed relative to the base case.

Moreover, in broad terms the distribution of job shifts would appear to be quite even under the least-cost alternative. For instance, the states that comprise Appalachia would be better off under the least-cost alternative than the forced scrubbing approach by nearly 9,000 jobs. Similarly, the states of the Northern Great Plains as well as the rest of the western states would fare better by a combined total of about 19,000 new jobs. One region—the Midwest—does less well under the least-cost approach, a problem taken up below.

At a more disaggregated level, only four states—Illinois, Ohio, Maryland, and Missouri—would suffer net mining job losses from 1980 employment levels under the least-cost option, with predicted losses in the latter two being nearly indistinguishable from zero. On the other hand, 21 states would enjoy an increase in coal-mining jobs relative to 1980 levels. While the jobs gained in coal transportation cannot reliably be allocated to states or regions, they too should be evenly distributed given the additional low-sulfur coal that will be mined in both the eastern and western United States.



Clearly, without *some* saving grace, the forced scrubbing option could scarcely long survive careful scrutiny. In fact, it does appear to have one important advantage over the least-cost approach.

Localized job losses

The sole advantage to forced scrubbing is that under that approach no coal-producing states would have fewer people employed in mining in 1995 than were employed in that industry in 1980. This cannot be said of the least-cost alternative. Even though its *overall* effect would be 5,600 more jobs in mining and transportation than would result from forced scrubbing, it would leave two states—Ohio and Illinois—with a combined total of 17,600 fewer mining jobs in 1995 than now exist. Maryland and Missouri would lose 300 jobs between them. By way of contrast, West Virginia—which borders Ohio to the south and east—would gain 49,400 mining jobs from increased low-sulfur coal production under the least-cost alternative. Job gains in Kentucky—which forms part of the southern boundary of Illinois—would amount to 12,200. New mining jobs in New Mexico, Virginia, Pennsylvania, and Texas all would exceed 6,000 by 1995. But Illinois and Ohio indeed would lose jobs as the high-sulfur coal mined there gave way to cleaner coals mined nearby in the East and in western states as well. Before discussing what might be done to cushion this disadvantageous feature, it is useful to examine these predicted job losses carefully and to place them in perspective.

In Illinois, the 9,800 jobs that would be shifted elsewhere amount to less than one-fifth of 1 percent of total employment in that state.[6] The corresponding percentage is even lower for Ohio.

It also is instructive to view the predicted shifts in 17,600 jobs in Ohio and Illinois against the secular trends in employment in coal mining. Between 1923 and 1969, employment in bituminous coal mining in the United States fell from more than 704,000 to fewer than 125,000, a decline of 82 percent.[7] By 1979, however, employment in America's mines had doubled to more than 250,000 and is expected to increase to nearly 350,000 by 1995.

No matter how familiar miners may be with secular or short-term fluctuations in employment, however, involuntary unemployment is a debilitating prospect. Moreover, the two states where mining employment would be adversely affected both have suffered recent reversals in employment in other basic industries—steel and automobiles being the best examples. It is worth giving special attention to their plight.

[6] U.S. Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States: 1982–83* (Washington, D.C., 1983) p. 378.

[7] National Coal Associaton, *Coal Facts: 1978–79* (Washington, D.C., 1979) p. 54.

Retirements among an aging workforce and secondary employment effects associated with the expansion of low-sulfur coal mining may well lower the total number of jobs affected. Still, the job shifts that would occur should be viewed as serious impediments to the least-cost approach. Because it otherwise is so very attractive—in terms of cost and in overall employment effects—it is worth considering measures to ease the adverse impact of pursuing the least-cost option.

Easing job shifts

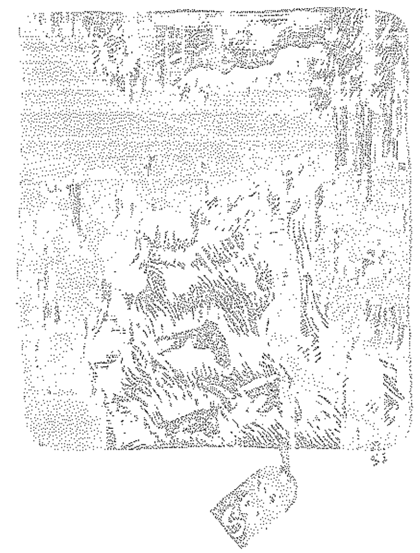
Of the many ways to soften any adverse employment effects of the least-cost option, three general methods are discussed here. The first would involve the companies that stand to benefit from the least-cost approach. Specifically, companies mining or transporting low-sulfur coal ought to offer first rights of refusal for the new jobs they can anticipate to those in Ohio and Illinois likely to be displaced by the shift to cleaner coal. In fact, in view of the financial stake involved, these companies could make a concerted effort to identify and even help relocate affected parties.

Relocation would not necessarily be very costly, as much of the new production under the least-cost option would come from West Virginia, Kentucky, and Pennsylvania—all close to the affected areas. In fact, in the Appalachia and Midwest coal-producing regions, new hires are estimated at 17 percent of the total number of coal miners each year.[8] This implies about 37,000 new openings annually, or about twice as many as the number of miners in Ohio and Illinois likely to be displaced. In addition, the mining equipment companies in the East North Central states that will see their business expand might be expected to give precedence to displaced miners in hiring decisions not involving specialized technological skills. A commitment of the sort described here even might be made part of any legislation Congress passes to deal with acid rain.

In recent years, Congress has created more than twenty different programs to assist workers dislocated for various reasons, including airline deregulation, consolidation of the railroad system, expansion of the Redwood National Park, competition from imported goods and services, and many others.[9] Thus, under

[8] Malcolm Cohen and Arthur Schwartz, "U.S. Labor Turnover: Analysis of a New Measure," *Monthly Labor Review* (November 1980) pp. 9–13.

[9] Marc Bendick, Jr., "Assisting Coal Miners Dislocated by Sulfur Emissions Restrictions: Issues and Options," Urban Institute Project Report no. 3002-01 (Washington, D.C., July 1981) pp. 54–63.



a second approach, such a program could be established to assist coal miners adversely affected by the least-cost approach to reducing sulfur emissions. Assistance might take a number of different forms. Dislocated workers might be assured full salary for several years if they could not find new work, with the amount of assistance declining with time as new opportunities became available to them. If miners do find new jobs, but at wages less than those earned in mining, the compensation might replace the full difference for a period of years and decline annually thereafter. Alternatively, compensation could be provided in lump-sum payments.

Assistance could take other forms besides direct compensation. For example, programs could be established to help miners search for new jobs; these might be administered through the United Mine Workers or other unions with which they are affiliated, or through state human resource departments or regional economic development organizations. Alternatively (or in addition), special retraining or relocation assistance or both might be provided.

However, special compensation programs can pose a number of difficulties.[10] It is not always clear, for example, who are deserving recipients: some miners may leave jobs of their own volition or for other reasons unrelated to fuel switching. Also, to what degree, if at all, should compensation go to those whose jobs are threatened by fuel switching even though they are not directly employed in the mines, those, say, who sell equipment to companies mining high-sulfur coal? Drawing the line on compensation is no easy matter.

[10] See Ibid., pp. 22–35; also Edward Cavin and Walter Corson, "A Discussion of Alternative Policies to Aid Unemployed Coal Miners," report prepared by Mathematica Policy Research for the U.S. Environmental Protection Agency (Washington, D.C., June 1981) pp. 26–57.

Knotty problems also arise in the design of payment rules if a compensation program is adopted. Will compensation continue to be paid even if the worker is quickly reemployed? If so, the apparent fairness of the program is threatened. If not, dislocated workers will have little or no incentive to search for new jobs, at least while they are receiving full benefits. These and other issues must be confronted in the design and operation of a special compensation program.

Equity considerations

It is important to keep in mind that the coal miners would not be dislocated through any reversal of previous government policy, or even by some new policy that would fundamentally alter the rules of the game. With few exceptions, existing power plants always have had the option to meet their emission limits via the purchase of low-sulfur coal. The least-cost alternative merely would extend that policy to the additional sulfur reductions thought to be necessary to address the problem of acid rain. In fact, it is the forced scrubbing approach that can be seen in this light to represent a fundamental shift in federal policy.

That miners dislocated by the least-cost alternative would not in any sense be double-crossed tends to undercut the rationale for special compensation and underlines the usefulness of viewing their very real plight as akin to that of steel, automobile, textile, or other workers who suffer because of inevitable, long-term changes in the industries in which they are employed. This suggests that equity would best be served by not differentiating between those who lose their jobs because environmental policy is sensibly designed and those disadvantaged by foreign competition, declining domestic demand, or a whole host of other reasons.

In other words, perhaps the best way to deal with the dislocations that might result from the least-cost alternative is as part of a comprehensive national program aimed at reducing unemployment. Because of the geographic dimensions of the problem, such a program no doubt would be targeted in particular at those very regions where mining dislocations are expected to occur. It would, therefore, assist not only miners but also steel, auto, and other dislocated workers. A national employment program might include job search and relocation assistance, educational or retraining programs, and perhaps public employment where legitimate purposes can be served, as with infrastructural improvements and the like. This is always to be preferred to indirect and hidden measures that poorly serve both employment and environmental policy.

A clear choice

In pointing out how unemployment—and especially that resulting from otherwise clearly desirable policies—is best addressed broadly and directly, we return to the historical background with which this article began. The message of that section is clear: until 1977, Congress always dealt directly with unemployment in mining areas through regional or nationwide policies that also would extend to other deserving individuals. No attempt was made to assist miners by propping up the mining industry artificially.

It would be well to keep this record in mind when weighing the alternative approaches to controlling acid rain. For while it perhaps is not obvious, forced scrubbing is no more than a domestic tariff on low-sulfur coal designed to protect those who own and mine high-sulfur coal. While economists may disagree on much, they are in nearly unanimous agreement on the potentially very harmful effects of such tariffs. Forced scrubbing would offer job protection to some, but only at the expense of even greater job losses to others and the additional loss of $1 billion per year. If implemented, such a policy eventually would harm even those it would protect in the short run. As there are a number of ways the nation could take advantage of its vast reserves of low-sulfur coal while at the same time assisting those harmed by such an approach, the way seems clear.

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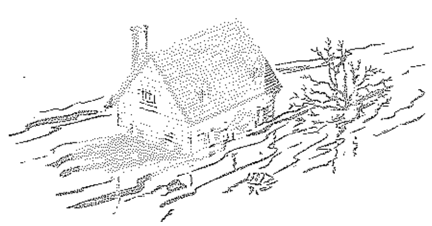
The year of *the* El Niño

THIS PAST YEAR will undoubtedly go down in climate history as the year of *the* El Niño—one of the most profound events in recorded climate history. It first came to the attention of Americans in the form of heavy rains and storms, unsuitably timed for a visit by the Queen of England. However, as reports from other parts of the world started coming in, it became apparent that more than royal discomfort was involved.

Crippling drought in southern Africa, Sri Lanka, southern India, Indonesia, the Philippines, and Australia; floods and heavy rains in the U.S. Gulf states and the Northeast, in Ecuador, northern Peru, Bolivia (where 26,000 people were left homeless), and in western Europe all followed a rise in the surface temperature of the eastern Pacific ocean and an invasion of warm water known as El Niño. El Niño—Spanish for the Christ Child—is so named in South



America because it usually occurs during the Christmas season.

The cost of these events can be only estimated. Hundreds of people died in Peru and Ecuador from floods and mudslides. Total damage to crops and property worldwide is estimated at $13 billion by the National Oceanic and Atmospheric Administration (NOAA). And this does not measure the misery of the homeless or those who died or will die from the famine and pestilence that accompany drought.

El Niño is not a new phenomenon, but a cyclical warming of the ocean that has long been known to Peruvian fishermen (whose anchovy fishery usually is destroyed by it) and by scientists at least since 1877.

However, the most recent El Niño was different in several ways. For one thing, it started in late spring instead of in December. The magnitude of the rise in sea temperature was remarkable—in some places 15° to 18°F above normal temperatures for that time of year. A typical El Niño has a rise of 5° to 6°F. The 1983 El Niño began in the mid-Pacific, not off the coast of South America as it usually does, and involved changes in sea level that covered millions of square miles of water and massive transfers of heat and water.

The Southern Oscillation

Scientists who have been exploring the El Niño phenomenon are reluctant to use terms like "causes" or "produces." Instead, they prefer the more cautious "associated with." One of the events that appears to be associated with an El Niño is a large-scale seesaw of air between the Pacific and Indian oceans in the tropics and subtropics that occurs every two to seven years. This seesaw, called the Southern Oscillation, is suspected of being linked to a whole family of ocean and atmospheric fluctuations around the globe. For example, precipitation and pressure during the monsoon in India vary with changes in the Southern Oscillation. Significantly, there are also huge changes in sea surface temperature in the equatorial Pacific that are associated with the Southern Oscillation.

In fact, the oceans and the atmosphere are in constant communication—the ocean storing, rearranging, and releasing heat to drive the atmospheric circulation system while the heated air masses above help move the ocean current system and affect the release of heat from the ocean surface. This interaction operates most effectively in the tropics. If the physics and dynamics of this interaction were understood, they might provide a key to understanding and anticipating global fluctuations in climate. For instance, there were early signals of the recent El Niño in the form of sharp changes in the usual pattern of air pressure and flow between May and June and large-scale changes in rainfall in the Pacific, but they were not recognized as precursors of an El Niño.

An improved understanding of how the oceans and atmosphere interact not only would allow meteorologists to anticipate El Niño, but also could lead to improved medium- and long-term weather prediction for the North Pacific and North America. For example, it might be possible to predict extremely cold winters several seasons in advance with reasonable accuracy in some parts of the United States since there seems to be a link between temperature patterns in the North Pacific and cold winters in the eastern United States.

The TOGA study

A decade-long international program to study large-scale ocean-atmosphere interactions has been in planning for some time and will get under way this year. Dubbed TOGA, for Tropical Ocean Global Atmosphere, it will attempt to answer some key questions about climate changes. Among them are:

- What triggers the sequence of events that are connected with warming of the sea surface in the first place?
- What determines the frequency of the Southern Oscillation? An El Niño occurs every four to five years with a corresponding major swing in the Southern Oscillation, but individual events can range from two to ten years.
- Why do the sea surface changes leading to an El Niño begin early in the calendar year, with maximum warming taking place a few months after the normal maximum sea surface temperature in February? Does this offer any clues to ocean-atmosphere coupling?
- There is also the question of El Niños that occur at unexpected times or that last longer than the typical two years.
- How is the El Niño–Southern Oscillation signal transmitted from the western Pacific, where the weakening of the trade winds occurs, to the coast of South America, the site of the greatest changes in ocean temperature?
- Allied with this is the question of how these events interact with conditions in the midlatitudes. Anomalies in midlatitude sea surface temperature occur too soon after the equatorial changes for them to be the consequence entirely of ocean processes. It is possible that changes in sea surface temperature in the tropics affect air circulation in the midlatitudes, but this is not at all certain.

Research will be carried out by NOAA, the Office of Naval Research, the National Science Foundation, and the National Aeronautics and Space Administration.

The TOGA research program will seek answers to these questions by monitoring wind fields, atmosphere and ocean thermal structure (this is a description of how temperature changes over vertical and horizontal space), and sea surface topography. Some of these observations are already being done as part of research on the equatorial Pacific. Additional studies are planned for the eastern, central, and western Pacific. Monitoring equipment includes fixed and drifting buoys, expendable bathythermographs, and meters to measure current. A variety of observation platforms will also be needed, including aircraft, ships, satellites, and island-based stations.

The weather satellites are critical for this project since they are the only way atmospheric measurements can be obtained on a global scale. Currently the geostationary and polar-orbiting satellites daily produce information on cloud cover, snow or ice, and thermal radiation, as well as data that can be used to determine the vertical distribution of atmospheric temperature and moisture, and wind field. Continued and reliable coverage by both sets of satellites is essential to research on the El Niño–Southern Oscillation connection.

Despite its human costs, last year's El Niño was a scientific bonanza. Not only has the rapid exchange of information among meteorologists, oceanographers, and fishermen provided information far superior to anything previously existing, but for the first time it was apparent that El Niño is not the result of random, unconnected events, but of events that may be driven by physical laws. If these laws can be discovered, it may be possible to correctly interpret the signals that precede an El Niño and plan for the weather changes that accompany it.

While the old saw that you can't do anything about the weather is largely true, if an El Niño can be anticipated early enough, it may be possible to mitigate its effects and its costs.

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EPA (*continued from page 5.*)

would be to improve the air-quality and water-quality monitoring networks. That was one area I had thought would be a bright spot. And it's not proved to be so.

ZWERDLING: So one of your first priorities would be to figure out just how badly things are being polluted?

PORTNEY: Exactly. We have to know whether the programs we have in place now are really making any difference, or how much difference they're making, before we can know what kinds of changes to make in those programs.

ALTER: I would try both to gain the confidence of the public in the handling of hazardous wastes and to educate them that they can be managed safely. We suffer from a weakness in the law and a weakness in the language in that waste is classified either as hazardous or nonhazardous. That's like saying everything is either black or white, that people are either good or bad, that there's no gray area in between. The result is that we panic people into thinking that their health and even their lives are always in a great deal of danger, when this is not true.

DAVIES: Enforcement is a top priority. Also, one of the most discouraging things about this administration has been its attitude that if you don't know about a problem, it doesn't exist. As a result, nearly all the research on new environmental problems, as well as the monitoring, has been stopped.

ZWERDLING: So let's say you're the new administrator, what are you going to do about it?

DAVIES: You have to strengthen enforcement; you have to increase the resources to implement things like the Pesticides Act and the Toxic Substances Act; you have to change strategy on hazardous wastes so that you clean up first and negotiate later; and you have to have a major increase in your research and monitoring budgets so that you can begin to know whether you are addressing the right questions in the right way.

ZWERDLING: How do you predict that William Ruckelshaus will be remembered for his tenure at EPA?

PORTNEY: My guess is that he will be remembered for having restored credibility at EPA. I think he's going to do that. Above all, he is honest, and I think even if he makes decisions that are unpopular with environmentalists, he's going to do so after consulting with them and basing his decisions on careful scientific studies and as much other knowledge as he can assemble.

But I also think he may be remembered as a person who came back to an agency that was much easier to administer in his first stay than it will be in his second. There are many more laws and programs for the EPA to administer; it's a much more controversial area now than it was in the early 1970s, when there was little disagreement regarding such statements as, "Oh, we can't afford to do this, it's costing us too much," or "It's hurting our industrial base." That is not the case now, and I think Bill Ruckelshaus will find this is a far tougher job now than it was when he first had it.

Twenty-first century agriculture— Critical choices for natural resources

As AMERICA NEARS the year 2000, two major issues warrant attention. Will the availability of natural resources seriously constrain U.S. agriculture? And how will agriculture affect the quality of the environment? Neither is novel, but each poses critical choices.

Availability of natural resources

In speculating on the future abundance of natural resources, we must consider the demand for them in both agricultural and nonagricultural uses, their future supply, and what new technologies could complement or substitute for them in agricultural production.

Increased demand for agricultural products

Consensus is strong—even among economists—that the prospective expansion in domestic demand for food well into the twenty-first century poses no major threat to the U.S. resource base. Increases in U.S. population and economic growth suggest that growth in aggregate demand for food will amount to slightly less than 1 percent annually by the year 2000. Of course, a heavily subsidized program to produce alcohol fuel (ethanol) could add to domestic agricultural demand for resources. However, barring precipitous increases in petroleum prices, and assuming that current U.S. energy policy will continue relatively unchanged, it is reasonable to predict only marginal growth—at least to the turn of the century—in U.S. commercial demand for agricultural commodities.

But if consensus exists regarding domestic demand, the same cannot be said for exports. Based on the relatively high export levels of the 1970s, some project that annual growth rates up to 2000 would range between 2.3 and 6.5 percent. Others argue that the high growth rates achieved in the 1970s cannot be sustained for another sixteen years, in part because the price increases attending such growth in all likelihood would dampen foreign demand and encourage production outside the United States. Moreover, some of the events of the seventies that triggered rapid expansion of U.S. exports were cyclical or transitory, not long-term, shifts in export demand. And there is cautious, but growing, optimism that the developing countries—where much of the potential growth in food demand resides—will continue to enhance their own productive capacity through appropriate mixes of capital investments, research and development, and farsighted public policies.

Resource demand for nonagricultural uses

Over the past decades, U.S. agriculture has become increasingly interdependent—economically, socially, and politically—both domestically and internationally. This trend probably will grow into the twenty-first century, and with it will come increased competition for natural resources. On the margin, the value of water and, generally, the value of land in nonagricultural uses will continue to exceed their value in agriculture. Thus, where markets operate freely and efficiently, agriculture will compete just as weakly for those resources in the next century as it does now. But by that time, the agricultural sector will find it increasingly difficult to obtain or even to maintain "special-interest" policies for water, other resources, or, for that matter, agricultural commodities themselves.

Transfers of resources from agriculture clearly will continue in the next two decades and beyond. Indeed, water transfers could be much larger than those of the sixties and seventies because of the expanding market for groundwater rights and institutional interbasin transfers. However, the rate of converting agricultural land to nonagricultural purposes may decline as a result of several factors: national population growth rates are slowing; the dramatic migration from metropolitan to nonmetro areas seen in the seventies will diminish; the rate of household formation probably will decline in the late 1980s.

Construction rates for new airports, water and highway transport systems, dams and reservoirs—all significant claimants on cropland in the past—already have slowed, and recision or deferral of plans for continuation of several major synfuels plants have lowered projections for conversion of coal- and shale-endowed agricultural land in the next decade or two.

Thus, competition and demand for resources will continue to increase into the twenty-first century even if the "demand-pull" thesis, which suggested the more extreme food- and resource-scarcity scenarios of the 1970s, now seems overstated. Still, perhaps as much as 20 to 25 million acres of agricultural land (8 to 10 million acres in cropland) will be converted to nonagricultural uses by 2000. Considering that demand and the infrastructure needed to accommodate domestic and export demand for agricultural commodities, a plausible guess is that total additional demand for cropland from the current "cropland reserve" (about 127 million acres) might reach 35 to 50 million acres in the next century.

Does this mean that real cost for both food and resources will continue to rise into the twenty-first century? It is tempting to say yes. After all, land and water are finite. But resource fixity is meaningful only in a physical context. Resource use is determined by human choice and is influenced greatly by socioeconomic criteria. As a given resource becomes more scarce and consequently more socially valuable, users conserve it by substituting other resources and by adopting resource-saving technologies and management practices. This principle of substitution has been dramatically evident in the performance of U.S. agriculture during the past century.

Water—How much? How expensive?

The availability and price of water, not land, appear to be the more critical variables for agriculture through the remainder of the century, particularly in the West. In the absence of subsidized, large interbasin water transfers it seems clear that water will be increasingly costly in the southern Great Plains, and this could force conversion of substantial amounts of land from irrigated to dryland farming systems. Transferring water from agriculture to meet demands in growing urban centers in the West and Southwest almost surely will induce major adjustments in agriculture in those areas. Native American and federal claims to the waters of the Colorado River and other sources in the West raise potentially unsettling issues for agriculture. And it seems evident that in the next few decades the federal government will be unwilling to invest in large-scale water-development projects. Today, western water policy emphasizes efficient management of this increasingly valuable resource rather than developing additional supplies.

What seems likely to ensue over the next several decades is a series of marginal agricultural adjustments to higher-priced water—more efficient water application, reduced rates of application, shifts from lower- to higher-valued crops, and shifts in resource use and production patterns throughout the country. Such adjustments have the potential to conserve substantial amounts of water; for example, estimates are that current water application efficiencies of about 50 percent could be boosted to 85 percent by changing application techniques—a 70 percent gain. In the context of the West as a whole, the physical requirements for water to meet projected urban and other nonagricultural uses up to 2000 are small relative to the total quantities now being used in agriculture. Nevertheless, the water issue will generate many difficult, controversial choices in the decades ahead. The task is to develop more effective institutions for reducing the distortions caused by policies that assume an abundant, low-priced natural resource.

Adjusting to higher energy prices

Agricultural adjustments to the higher energy prices of the 1970s have been substantial—conservation in use of energy-based products through such technologies as minimum till, integrated pest management, and others. RFF's Pierre Crosson predicts that by 2010 as much as 50 to 60 percent of the nation's cropland might be farmed by means of conservation tillage.[1] Although agriculture is vulnerable to any major interruption of energy supplies, moderate, gradual increases in energy prices apparently can be accommodated without major impacts on the nation's food supply by 2000.

When the so-called cropland crisis of the 1970s is viewed in light of the principle of resource substitution it presents a less foreboding prospect than the popular press reported at the time. Although the annual net conversion to nonagricultural uses of 875,000 acres of cropland during 1967–75 has been highly dramatized (and possibly overstated), it constituted only slightly more than one-tenth of 1 percent of the 540-million-acre cropland base. Even if conversions were to continue at that rate—which seems highly unlikely—the cumulative losses by 2000 would be only 3 to 4 percent of the 540 million acres. Nevertheless, cropland is a valuable national asset, and its future use deserves careful attention.

But all land is not created equal! Soil characteristics differ and, when combined with climate and management variables, offer unique opportunities for the production of high-value crops. Thus, the fact that the cropland base probably will not physically or economically limit the expansion of U.S. aggregate food production does not suggest that actions to conserve and maintain its quality or to regulate its rational, economic use at the local level are either irrelevant or unnecessary. Indeed, the issues and choices of land use planning to serve multiple demands are likely to have great local importance as this century gives way to the next.

Resource-saving technologies

Scientists suggest that yields for major crops probably could be increased 40 to 50 percent by 2000, by using either current technologies or those available "on the shelf." Impressive gains in livestock productivity also are possible within the next ten to twenty years. And many suggest that additional investment in basic research could produce major break-

[1] Pierre R. Crosson, *Conservation Tillage and Conventional Tillage: A Comparative Assessment* (Washington, D.C., Soil Conservation Society of America, 1981).

throughs to enhance both crop and livestock yields, perhaps even before 2000.

The effect of agriculture on environmental quality

Agriculture's relationship to the quality of the natural environment poses another set of controversial issues and crucial choices.

Some critics argue that the current "high-tech" agricultural production system is a major source of environmental degradation in the United States. In this view, the system simply is not sustainable in the long run because it impairs the quality of the natural resources on which it depends. But the system's defenders emphasize that current technology and improved management regimes (and others can be developed) can ameliorate, if not eliminate, the worst of the environmental abuses attributed to such a high-tech agriculture. Contending that no practical alternative is possible unless Americans are prepared to pay much higher prices for food, they point out that life consists of a series of tradeoffs between the optimum and the attainable.

Uncertainty prevails

Resolving these issues is complicated by the lack of scientific evidence on the basic relationships involved in the controversy. For example, no one knows with much precision what happens to pesticides when they leave the farmer's field. Also, it is difficult to value the social cost of the environmental externalities—soil erosion, sedimentation, and salinity—deriving from agricultural production. Indeed, existing institutional mechanisms are incapable of internalizing the social costs of environmental degradation.

Pierre Crosson and Sterling Brubaker have speculated on the resource and environmental effects of U.S. agriculture to 2010.[2] Among the troublesome environmental problems associated with agricultural production—pesticide, insecticide, and herbicide pollution, soil erosion, eutrophication, salinity of soils and water—they conclude that soil erosion is the most important, both through its effects on water quality and because of potential productivity losses on cropland.

Air pollution, which is generated mostly by nonagricultural sources, is of growing concern not only because of its immediate effects on agricultural production in highly urbanized areas, but also because of its potential longer-run effects on global climate and life-support systems. Acid deposition and increasing temperatures because of the greenhouse effect are two prime examples. Reliable assessments of the impacts of such phenomena depend on more scientific research but, looking far into the next century, such issues readily could provoke sharp social concern and require difficult public choices in the United States and around the world.

The questions surrounding agriculture and the quality of the natural environment are neither transitory or ephemeral, nor are their solutions simple or absolute. Perhaps the only certainty is that it is impossible to reduce the environmental risks of high-tech agriculture to zero: tradeoffs between food production and the quality of the environment are inevitable. And just as clearly, the choices by the twenty-first century will be even more complex, difficult, and far-reaching.

Predicting the future

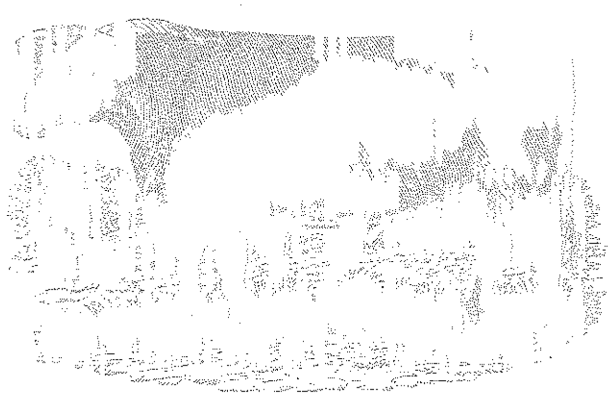
My scenario of U.S. agriculture in the year 2000 is based on a cautiously optimistic view of the sector's capacity to adjust to what is clearly an uncertain and potentially highly unstable economic and political environment—one in which any forecast is subject to a wide range of error. It may be that the best strategy is to hope for the best and to be prepared for something less.

Nothing I see suggests an approaching crisis in U.S. agriculture or in the availability of natural resources for future agriculture development. But no crisis does not imply no cause for concern. To the contrary: the concerns are many and the individual and collective choices involved are critical. One such is the development of institutions to encourage more efficient use and the socially desirable allocation of water. Others concern policies and institutions to guide rational, more orderly, and farsighted use of land, based on long-term needs to serve multiple uses and to protect the quality of an ever-more valuable resource. Some of the most difficult and critical choices will turn not on the quantity of natural resources *per se,* but on their quality and their relationship to agriculture. Common property resources—those such as clean air and water that lie outside the operation of commercial markets—increasingly will be central topics of concern in this regard. The nation is ill-prepared to address scientifically or quantitatively the tradeoff between environmental quality and food and fiber production.

And choices also must be made about public and private investments in research to maintain or broaden options in the use and conservation of natural resources and the environment. In the past, society made substantial investments in agricultural research based on the premise that they were a form of social insurance against long-term food and resource shortages and on the merits of rising productivity. This was so even when current technology was contributing to an economic surplus. Will we choose to do so again? If so, what strategies will be most appropriate?

For all our scientific advances, expanding knowledge of nature and the environment, and larger, more sophisticated models of technological, economic, and social systems, the future remains uncertain and enigmatic.

Author Kenneth R. Farrell is director of RFF's Food and Agricultural Policy Program. This article is based on a speech he presented at the April 1983 symposium on Agriculture in the Twenty-First Century, sponsored by the Colgate Darden Graduate School of Business Administration, University of Virginia, funded by Philip Morris, Incorporated. A proceedings volume, Agriculture in the Twenty-First Century, *edited by John W. Rosenblum, was published by John Wiley & Sons, Inc. in 1983.*



[2] Pierre R. Crosson and Sterling Brubaker, *Resource and Environmental Effects of U.S. Agriculture* (Washington, D.C., Resources for the Future, 1982).

RESOURCES CUMULATIVE INDEX

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Leasing of federal coal resources— A continuing problem

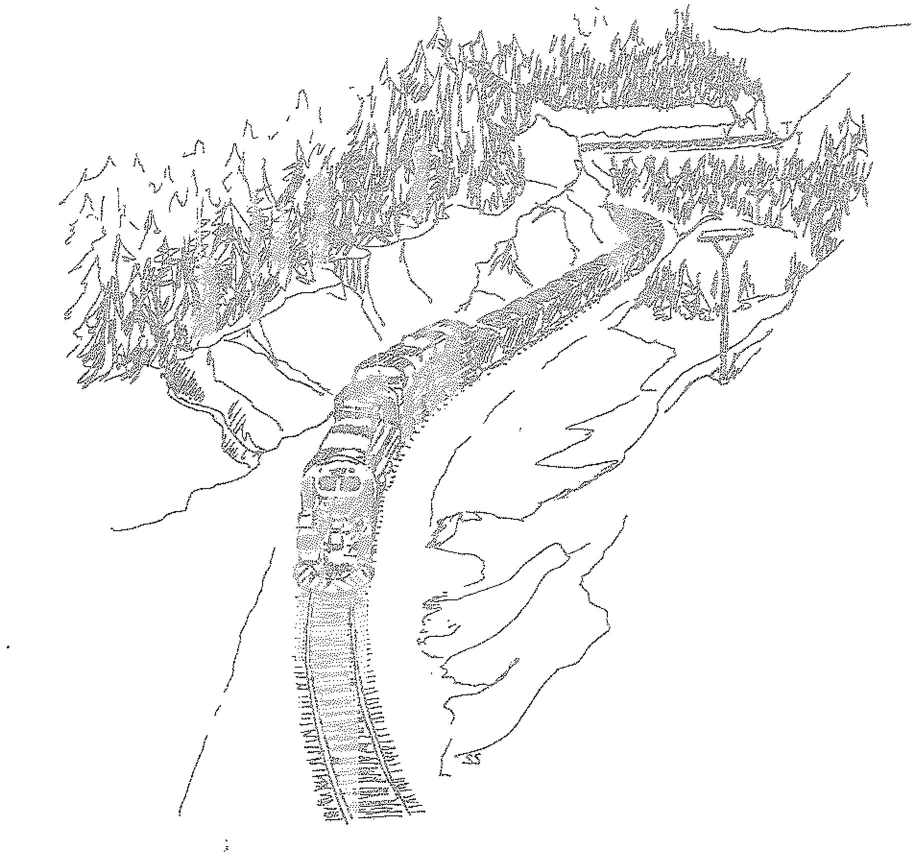
The early years

THE BASIC LEGISLATION authorizing leasing of federal coal lands is the Minerals Leasing Act. Enacted on February 25, 1920, it gives a lessee exclusive rights to mine coal subject only to the terms of the lease and to federal and state laws. Because nearly all of the federal coal is found west of the Mississippi River, where past demand was low, for the first forty years (1920 to 1960) only 166 leases covering 143,000 acres were granted. As a result, neither potential policy issues nor the administration of the leases by the Department of the Interior received much public or congressional attention.

About 1960 the character and ownership patterns of the coal industry changed rapidly as coal production started to recover from the depressed state it was in during the 1950s. A large share of production came from surface mining operations, and mines became increasingly mechanized, with a resulting rapid rise in productivity. Mechanization required much larger capital investments, and productive capacity became concentrated in larger companies. In addition, while in the past the industry had been characterized by many companies engaged only in coal production (and a few steel companies with captive mines), it came to consist mainly of energy companies heavily involved in oil and gas production and of conglomerates engaged in a variety of industrial activities.

These larger firms had much greater capital resources, a wider interest than coal, and were faced with declining domestic reserves of oil and natural gas. They actively sought to acquire western coal resources for eventual use in synthetic fuel production and as a fuel source for the rapidly expanding western utility industry. This meant acquiring federal leases as 50 to 60 percent of western coal resources are on federal lands. As a result, from 1960 to 1970 the number of federal coal leases increased nearly threefold and the leased acreage by fivefold.

Those federal leases were acquired at relatively low cost and with minimum difficulty. Under terms of the Mineral Leasing Act, by exploring for and discovering coal on land where no deposits previously had been known, a prospector could obtain a lease under a procedure known as a Preference Rights Lease Application. On federal lands with known coal deposits, a competitive lease sale was required. Most sales attracted only one bidder and acquisition costs also were low under this "competitive" means of attaining a federal lease. In all, nearly three-quarters of the leases were acquired under essentially noncompetitive conditions. A third method of acquiring a lease was by assignment (sales of existing leases); by 1970 a large number of leases had been assigned to new owners—often more than one time.



The 1971 leasing moratorium (1971–81)

The rapid expansion in new leases and the increased rate at which leases were being assigned demonstrated clearly that federal coal resources had acquired an important economic value. With this change, a new method of lease disposal was needed that was fairer to prospective lessees and to the public—owners of the resource. To provide time to devise a new method, Interior Secretary Rogers Morton created an informal moratorium on leasing in 1971; a formal moratorium was adopted in February 1973.

Congress also recognized the need for changes and, after considerable debate, provided a new legislative basis for a comprehensive leasing program through the Federal Coal Leasing Amendments Act of 1976. This was designed to provide a more orderly procedure and "less-speculative" means for development of federally owned coal with its newly enhanced economic value. The major provisions were:

- All leasing was to be by competitive bidding and at fair market value.
- The Preference Rights Lease Application procedure was abolished.
- All new leases were to be in commercial production within ten years or the lease was to be terminated.

◦ Holders of old leases not in production in ten years were to be penalized in other ways.
◦ Higher royalty fees were to be collected.

Nearly all of these and other provisions were directed at preventing what Congress considered the greatest threat—"speculation" on federal coal leases.

Even before leasing was resumed in January 1981, it had become obvious that efficient and fair management of the federal coal resources would be more difficult in the future because of their greater value. Further complicating the administration of these lands were about twenty other new legislative actions that would affect the coal leasing program once it was resumed. Two of the most important were the Federal Land Policy and Management Act of 1976 and the Surface Mining Control Act of 1977. The first introduced a much more extensive land use planning requirement as an integral part of the leasing process and the second greatly strengthened the environmental regulations controlling surface mining, the method used nearly universally on federally owned coal deposits. Other evidence that increased difficulties were to be expected in the leasing and effective management of these resources was litigation over various provisions of these new legislative acts and over the regulations issued to implement them.

After much, sometimes acrimonious, discussion, the Department of the Interior issued regulations in 1979 to implement the new legislative requirements and court decisions, particularly provisions relating to fair market value, competition, and diligent development. The new leasing procedure included detailed land use planning, a method for selecting tracts to be offered, and a "minimum acceptable bid" concept for each tract, which became the official estimate of fair market value. The minimum bids were to be published before the sale and a sealed cash-bonus fixed-royalty bidding method was to be used, followed by oral bidding where more than one bid was received. As with nearly everything else involving coal leasing in that period, the regulations were challenged in the courts.

Lifting the moratorium

These problems did not prevent lifting the moratorium in January 1981 and Interior conducted a number of sales under the provisions of these new regulations that resulted in the leasing of 0.5 billion tons of coal that year. In March 1982, just about one month before the Powder River Basin coal lease sale (the largest ever conducted) was to be held, the first of two changes in the 1979 regulations was issued. A number of procedural and substantive modifications were made, with the major one shifting the determination of fair market value from before the bidding to after it. The "minimum acceptable bid" concept was replaced with an "entry level bid" procedure. This set a minimum acceptable bid *below* the department's evaluation of the estimated tract value in the hope that the oral competition at the sale, following the opening of the sealed bids, would establish a "true" value for the tract or a fair market value. With the apparent failure of the earlier presale evaluation procedures to establish a satisfactory fair market value, it was thought that a postsale evaluation method would overcome the difficulties.

Unfortunately, the Powder River Basin sale was marred by allegations that proprietary and lease valuation data had been disclosed prior to the sale. Moreover, strong disagreement was voiced about whether the new bidding system had resulted in more or less competition and a more realistic approach to reaching a fair market value. There was general agreement, however, that competition was weak at the Powder River Basin sale. Of the thirteen tracts offered, two received no bids and eight received only one bid.

The fallout from the Powder River Basin sale

If the sale did not generate strong competition, it did create what coal leasing has been best at—vigorous controversy. The March 1982 notice of sale was challenged in the courts for the standards and procedures that had been adopted. In addition, two court actions were initiated with respect to the sale itself—one by the Cheyenne tribe and the other by various environmental groups, both charging violations of various federal laws. These suits have not yet been adjudicated.

The allegations of unauthorized disclosure of valuation data also resulted in two separate investigations of the sale—one by the General Accounting Office (requested by the House Interior and Insular Affairs Committee) and another by the Surveys and Investigations staff of the House Appropriations Committee. Both reports went much beyond the question of unauthorized disclosure. They discussed the wide range of problems and conflicting goals that coal leasing was expected to satisfy and recommended new changes in regulations and procedures to ensure competition and bids that reflected fair market value. The General Accounting Office (GAO) report recommended a "postponement" of leasing until some of these policy issues, standards, and procedures could be reviewed carefully.

As these studies were proceeding, a second Powder River Basin lease sale was held on October 15, 1982, at which only two tracts were offered (one of which had been previously offered), using still another bidding procedure. In this sale a participating bidder was allowed only one sealed bid, with no oral bidding. The "entry level" bid system used in the first Powder River Basin sale was abandoned and minimum bidding was used. Although these minimum bids were floors below which bids would not be considered, they did not officially represent a fair market value. As in the first Powder River Basin sale, emphasis was placed on postsale evaluation. Only one bid was received on each of the two tracts offered, so that the effectiveness of this third leasing method in achieving competition and reaching fair market value cannot be judged.

At least part of the complexity and the frequent changes in the leasing procedures and program resulted from the large number of interested parties to the debate—the coal industry, environmental groups, representatives of several levels of government, ranchers, and Indian tribes. To add further confusion, in November 1982, Secretary of the Interior James Watt met with nine Western governors who were seeking further modifications in the leasing regulations and procedures to meet the special desires of their states. After the meeting the governors submitted extensive written suggestions on a large number of issues, but "concessions" were made on only a few minor points.

Congressional reaction

No general lease sales were scheduled during the early part of 1983, but Interior's intention to offer for lease large tonnages of federally owned coal remained unchanged. The department continued to defend its policy vigorously despite congressional and public concerns and directly challenged those who questioned the adequacy of the competition and receipt of fair market value for the leases already offered. The Interior appropriations hearing before the House in late April brought into focus the policy, economic, and procedural issues that had been raised. The committee's investigative report had been released and Interior's comments on the report were available, as were the responses of the House committee staff. The hearings can best be described as "heated."

Shortly afterward, hearings were held on the GAO report on coal leasing by a subcommittee of the House Interior and Insular Affairs Committee. In the Fiscal Year 1983 supplemental appropriations the House recommended a leasing moratorium. The Conference Committee recommended the creation of a Commission on Fair Market Value for Federal Coal Leasing in place of the House moratorium. The Senate rejected a moratorium in June but by September had adopted it. The final bill adopted by the Congress in late October mandated a partial moratorium on coal leasing until the commission had reported.

The switch in sentiment in the Senate and a hardening of the resolution on the moratorium in the House probably resulted from several factors. One was the continuing confrontation between Secretary Watt and a number of critics over a multitude of environmental and resource administration policies, of which coal was only one. The other was the department's resolve to carry out its large coal leasing program as originally planned. The secretary insisted on holding the Fort Union leasing sale in September 1983, even though the newly appointed Commission on Fair Market Value to study ways of improving the leasing process had not started to function. The position of the department was reflected by Watt's statement that "I've leased more coal than was leased during the previous ten years, but I'm a piker compared to Secretary Udall—he's six secretaries ago. I've leased 50 percent of what he did." By October, when the moratorium was under active consideration, the secretary had come under severe criticism for his comments on the membership of the commisson.

Tying the moratorium to the commission's work increased the potential importance of its final report. The commission's charter is very broad: it was directed "to review the Department of the Interior's coal leasing statutes, policies, and procedures to ensure receipt of fair market value." Composed of five members appointed by the secretary, the commission was sworn in at the end of August and hearings started in September. A final report is due January 29, 1984.

The task of the commission

Given the tortuous history, and the many interest groups with different agendas for coal leasing, the commission faces an enormously diverse and complicated set of problems that even a superb report will not "solve." The issues range from procedural matters (how to offer and value a lease) and establishment of standards (how to manage them) to a host of major public policy objectives relating to leasing of any federal resource. At one level, the commission must examine the impact of various methods of bidding and leasing terms on federal and state income compared with other leasing objectives that might be achieved. At another level, it must study the question of whether emergency leases, production maintenance leases, small business tracts and public body set-asides should be treated differently from each other and from general lease sales. If so, how? What is the justification for treating them differently?

To illustrate, consider only two major issues. The commission has been directed to examine methodologies for determining fair market value and for increasing competition. Fair market value seems to be an easily understandable economic concept but, as evidenced by the debate over the issue, in practice it can be interpreted in a variety of ways. Even the economic questions can be difficult. What evaluation method results in the "best" estimates of fair market value? A number of different methods already have been used, with disagreement over their effectiveness. Even leaving aside what probably is the most important economic consideration—the existing market for coal and its uncertainty and variability over time—a large number of other factors must be considered. They include the quality of the coal (with respect to a number of physical and chemical characteristics), the differing geologic conditions (coal and overburden thickness, overburden type, and slope of coal seam), ease of environmental controls, water conditions at the site, and availability of transportation. Finally, there is the key question, To receive fair market value, how much coal should be offered and at what rate?

It is no easier to determine the adequacy of competition for leases. It too is tied to coal leasing rates and tonnage, but in a different way. Because of the large size of the leases required to produce competitively in western coal markets and the large capital investments and long development time before any economic return can be expected, there will be comparatively few lease bidders. But the major coal consumers, the electric utility industry, which uses vast tonnages over long periods, need a large number of suppliers if they and their customers are not to be at the mercy of the suppliers—the coal lessees. Thus, to maintain competition in the coal market, large blocks of uncommitted reserves have to be available at any time. Unless the federal government wants to play the role of "speculator," it should lease so as to be certain that coal buyers are in a competitive market to assure that electricity consumers are not penalized.

The commission cannot provide answers to these and many other questions without some agreement on the social as well as the economic goals of leasing. Coal-leasing history leaves no room for optimism that any reasonable compromise will be possible, let alone durable.

In early December the commission released thirty-nine tentative draft recommendations with requests for public comment by December 18, but with no accompanying report showing how the recommendations were reached. If adopted, the recommendations would make major modifications in the federal coal-leasing program, including repeal of the requirement for commercial coal production on pre-1976 leases by 1986 and of the restrictions on railroads holding federal coal leases. Other recommendations included endorsement of accelerated coal leasing to ensure adequate competition among mining companies, providing for the right of eminent domain for coal-slurry pipelines and a number of changes in leasing procedures.

The recommendations were generally well received by industry, but several environmental groups that commented on the recommendations believed the commission had avoided addressing its assignment and had only further aggravated the existing leasing controversy.

The political process will gnaw at the commission report when it is completed, and long delays in developing any new leasing program are probable since no single solution will be best for all the parties at interest. Once "settled," the room for further delaying actions is enormous and some of those unsatisfied with the outcome will be certain to reopen the question at the political level or in the courts, or both.

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Erosion—How big a threat?

SPURRED BY RISING CROP DEMAND, especially for export, and relatively slow growth in crop yields, American farmers brought an additional 60 million acres under crops between 1972 and 1982. According to the U.S. Soil Conservation Service, this added land suffers more erosion than does already-producing land. Moreover, under the pressure of rising demand, many farmers sought to squeeze more production out of the land by abandoning such soil-conservation practices as strip cropping and windbreaks. The combination of additional, more erosive land and fewer conservation practices convinced many in the conservation community that soil erosion poses a major threat to the productivity of the nation's cropland. Anticipating a steadily increasing demand for crops, both at home and abroad, many conclude that the nation's ability to feed future generations at reasonable cost is at serious risk.

Concern about erosion, of course, is not new, but in the 1970s and early 1980s it acquired an intensity not felt since the Dust Bowl years of the mid-thirties. Reacting to this concern, RFF researchers undertook a major study of the erosion problem in the United States, and the first results were published late in 1983.

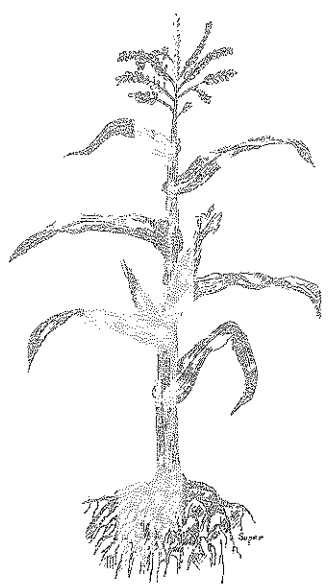
What do we know?

Curiously, until recently little has been known about U.S. soil erosion. Tens of billions of dollars (in 1980 prices) were spent on soil-conservation programs over the last five decades, but reliable information about the extent of erosion was not compiled until the National Resources Inventory (NRI) of 1977. Nor was much known about erosion's effects on soil productivity. Soil science demonstrated that sustained erosion could reduce productivity by carrying away soil nutrients, lessening the capacity of the soil to make water and air available to plants, and diminishing the space in which crop roots could spread. And studies on experimental plots showed that stripping away topsoil would reduce crop yields by amounts varying from 10 to 40 percent, depending primarily on characteristics of the subsoil. But because these studies were on a small scale and highly specific to particular soils and climates, they provided no useful information about erosion effects on average U.S. crop yields—the kind of information needed for judgments about the threat of erosion to future capacity for crop production.

Assessing T values

For these judgments soil conservationists depend on measures of "tolerable" soil loss—T values—defined as the maximum amount of annual soil loss per acre consistent with indefinite maintenance of the productivity of the soil. T values vary from 5 tons per acre per year on deep soils to 1 ton on shallow soils.

The 1977 NRI indicated that erosion exceeded 5 tons per acre on about one-third of the nation's cropland, with erosion by water exceeding the limit on 23 percent and wind erosion on an additional 10 percent. These numbers were taken as a measure of erosion's threat to the productivity of the land and a challenge, both to individual farmers and to those responsible for soil-conservation policy.



But T values are a faulty guide to farmers and to policymakers. Little scientific backing exists for the 5-ton limit, a fact widely recognized by soil scientists. Experience shows that on deep soils with favorable subsoils—for example, those in western Iowa—erosion may exceed 5 tons per year for many years with no perceptible effect on productivity. T values also are misleading because they ignore the vital issue of the timing of erosion-control efforts. For the farmer, the proper time is when the present value of future productivity losses exceeds the present value of erosion control costs. On deep soils the present value of the losses is likely to be low for a long time, even though annual erosion is well in excess of 5 tons per acre. Eventually the present value of the losses will begin to rise, perhaps because erosion threatens to shrink the crop-rooting zone, and when that happens farmers will begin to pay serious attention to erosion control. By contrast, the T-value criterion requires the farmer to bring erosion down to T "now," even though the present value of the productivity losses may be well under the present value of erosion control costs. Not surprisingly, conservationists often express frustration at the refusal of many farmers to follow the T-value criterion.

Erosion in excess of T often is taken as a measure of the amount of soil permanently lost to agriculture. It is the basis for dramatic statements picturing billions of tons of topsoil being washed each year down the nation's rivers to the sea. Yet most eroded soil is deposited somewhere on land, not in waterways; and therefore it is not necessarily lost forever to agriculture. A key question concerns the effect of the eroded soil on productivity where it is deposited. It is astonishing how little is known about this, considering its importance for judging net productivity effects of erosion. Clearly, depositing nutrient-poor material on fertile soil will diminish productivity; but just as clearly, productivity may be increased by nutrient-rich silt and clay particles. Apart from effects on fertility, deposition builds soil depth, thus putting off the day when diminishing crop-rooting zones begin to limit productivity.

Another implication of T values is that erosion in excess of T permanently reduces productivity. Yet the soil science literature leaves no doubt that farmers can repair part—and on some soils all—of the damage to productivity. On deep soils with favorable subsoils simple replacement of soil nutrients with fertilizer often will restore productivity completely. Where subsoils are unfavorable, especially in water-holding capacity, fertilizers typically will not suffice. Even on these soils, however, practices that put back some of the lost soil organic matter will improve soil structure and often restore much of the productivity loss.

Adding fertilizer and adopting practices to build organic matter increase production costs; but so does controlling erosion. For the farmer, therefore, the issue is whether control costs are more or less than the costs of repairing damage to productivity. This "real world" choice, of crucial importance to the farmer, is ignored by strict application of the T-value criterion.

The rationale for T values is fairness to the future—intergenerational equity. And for soil conservationists, intergenerational equity requires that land should be managed to avoid imposing higher costs of food and fiber on future generations. But the T-value criterion is unnecessarily restrictive for achieving this objective. It implicitly assumes that any loss of soil productivity means higher future production costs, despite the fact that it may be less costly for farmers—and for society—to accept some productivity loss now and repair it later. Beyond this, investing in research to develop new technology can more than offset erosion-induced losses of productivity. At the margin, technology is a substitute for land in the production process.

An alternative to T values

One may accept the imperative of intergenerational equity, therefore, but reject the T-value criterion as a guide to achieving it: allowing for technological advance broadens the options. To be sure, technological advance should not be taken for granted, and achieving it inevitably imposes costs. In general, the slower the expected development of new technology and the more it depends on costly factors, such as fossil fuels, the greater the value of the soil as a productive resource and the more important its preservation to achieving intergenerational equity. This way of viewing obligations to the future clearly retains a place for soil conservation policies. But it puts them in the context of a broader set of policies, all aimed at avoiding rising costs of producing food and fiber.

What the record shows

A part of the RFF study examined the relationship between erosion, as measured in the NRI, and the growth of yields of corn, soybeans, and wheat between 1950 and 1980. Data were for counties in the Corn Belt, Northern Plains, and the Palouse region of the Pacific Northwest. The results showed that erosion had no effect on the growth of wheat yields. For corn and soybeans the effect was small but significant: for both crops, yields between 1950 and 1980 increased about 4 percent less because of erosion than they would have otherwise.

Despite the effect of erosion on yields of corn and soybeans, the prices of both crops, adjusted for inflation, were less at the end of the 1970s than at the beginning of the 1950s. The decline reflected the fast pace of technological advance over the period, and was all the more impressive because demand for both crops increased substantially and real prices of farm inputs also rose. The cost-increasing tendencies of erosion-induced productivity loss, rising demand, and higher inputs prices were more than offset by the cost-decreasing tendency of technological progress. Compared to the cost effects of technology and demand growth, those of erosion were small.

Work by others, reviewed in the RFF study, indicates that continuation of 1977 rates of erosion for one hundred years would reduce national average crop yields by 5 to 10 percent. Even a modest rate of technological advance—say, half that achieved since the 1930s—would far outweigh the erosion effect on productivity, suggesting that current erosion presents no serious threat to intergenerational equity. But no one really understands the process of technological change, so that even a modest rate of advance should not be taken for granted, especially where the interests of future generations are at stake. Moreover, the prospective erosion-induced productivity loss, although small, is not negligible.

To illustrate, assume that erosion reduces corn and soybean yields by 10 percent over one hundred years in equal annual increments, that "normal" yields are 110 bushels per acre for corn and 32 bushels for soybeans, that corn is priced at $3 per bushel and soybeans at $7, that there are 72 million acres of land in corn and 70 million acres in soybeans, and that the rate of discounting future productivity losses is 10 percent. Under these assumptions, the productivity loss in the first year is 33 cents per acre for corn and 22 cents per acre for soybeans, apparently trivial sums. For the 142 million acres in the two crops the first-year loss is somewhat more impressive—almost $40 million—but still small relative to the total value of corn and soybean production.

This way of calculating the cost of erosion-induced productivity loss understates the true cost of erosion because it does not account for costs farmers may incur in order to restore some of the lost productivity, for example, by putting on more fertilizer. The amount of these uncounted costs may be significant.

Moreover, the cost of lost productivity is cumulative, each year's cost being added to that of the previous year. Even if the incremental loss were no more than $40 million annually, the undiscounted value of the loss would be $4 billion in the hundredth year. Of course, discounting at 10 percent annually greatly reduces the present value of the more distant losses. But even so, the sum of the discounted losses over one hundred years is about $4.3 billion at 10 percent, assuming the annual incremental loss is $40 million. Discounted at 5 percent, its present value is almost $17 billion.

Thus, the cumulative loss of productivity is more impressive than the first-year loss would suggest. Whether the loss would be consistent with intergenerational equity is uncertain. It probably would be, unless the nation enjoys markedly less technological progress in the next one hundred years than the record documents for the last fifty. Until this is settled, erosion-induced productivity loss, while perhaps not a major threat, deserves a place on the nation's policy agenda.

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Suriname—Politics, technology, and Third World energy strategy

The oil shocks and developing countries

THE TWO OIL SHOCKS of 1973–74 and 1979–80 boosted the real price of energy five-fold; each transferred around 2 percent of gross world product to the oil-exporting developing countries. For the oil-importing developing countries, oil jumped from one-twelfth to one-quarter of their total imports from 1973–80, requiring either the expansion of competitive exports to absorb the cost or the reduction of other imports and consequent loss in economic growth. In the developing countries as a whole, the rate of growth of gross domestic product fell from 6 percent per annum during 1960–73 to 5.3 percent for 1973–79 and 2.3 percent for 1980–82 (table 1).

The slowdown in the developing countries was significantly less than that in the industrial countries, which failed to react decisively to the oil cost realignment. However, the aggregate figure for the developing countries masks important regional differences: most Asian countries successfully rode out both oil shocks; the Latin American nations scarcely faltered until the 1979–80 shock; while many countries of sub-Saharan Africa were adversely affected on both occasions (see table 1). These regional differences are linked to fundamental domestic policy decisions.

The developing countries that fared best were those that followed domestic policies that did not unduly favor import substitution industries at the expense of domestic agriculture and competitive labor-intensive exports. Such countries, like the newly industrializing countries of southeast Asia and other middle-income commodity exporters in that region, diversified their economies more quickly, so that they were better able to switch from slower-growing to faster-growing economic activities as it became necessary to do so. Many Latin American countries, which borrowed heavily to ease the implementation of economic change, were caught by the unexpectedly sharp rise in interest rates and the associated fall in export opportunities that followed the second oil shock. Other countries, including many in sub-Saharan Africa, which pursued inward-looking domestic policies and were considered high credit risks, were forced to resort to growth-curbing import restrictions; for some, development has been set back two decades.

However, the shift to high-cost energy created the opportunity for some oil-importing countries to exploit hitherto marginal domestic gas and hydroelectric resources, not simply to substitute for imported oil, but also to generate energy exports. These exports might be direct, such as liquefied natural gas or electricity, or they might be indirect, in the form of energy-intensive industrial products, such as aluminum or steel, or gas-based petrochemicals, such as ammonia and methanol. The latter strategy carried the added attraction of accelerating economic diversification through resource-based industrialization. However, the technical and economic difficulties in launching such energy-intensive industrial complexes are formidable and place severe strains on the political fabric of the developing countries. The attempts of Suriname to establish a hydro-based aluminum project illustrate the technical and political problems involved.

The Multi-Annual Development Plan

Suriname, a country of 160,000 square kilometers and 400,000 people on the northern coast of South America, depended heavily on bauxite exports and sought to develop a large hydroelectric project to substitute for oil-generated electricity and expand its aluminum exports. The hydrosmelter project was designed to stimulate development in the empty western region of the country. Related aspects of the project called for regulation of river flow in order to triple the irrigated acreage and expand rice production on the coastal lowland in the extreme northwest of the country.

In the early 1960s, Suriname had successfully launched a hydrosmelter complex at Paranam, south of the capital city of Paramaribo. The second hydrosmelter complex formed the core of the country's Multi-Annual Development Plan. This was initiated when Suriname became independent of the Netherlands in 1975, and was backed by a $1.5 billion grant from the Dutch government. As implementation of the plan proceeded, the initially complementary development of the hydrosmelter complex and agricultural expansion increasingly were portrayed as competing projects that represented "hard"-technology and "green"-technology options and became linked to an emerging right-left political struggle within the newly independent nation.

The original hard-technology proposal

Suriname's Kabalebo River hydrosmelter scheme had greater flexibility than a similar project under consideration in neighboring Guyana since it could be executed in three discrete stages rather than a large single stage. These comprised a first stage of 300 megawatts (MW) for oil substitution; a second stage of 200 MW for the new smelter; and a 300-MW final stage for long-term power needs. The Multi-Annual Development Plan envisaged the construction of the first stages for a total of 500-MW capacity. The first stage, which included much of the basic infrastructure, carried a disproportionately high share of the total costs. It required the construction of a dam with three 100-MW turbines and a diversion dam to double the flow of Kabalebo water through the turbines.

The 1980 cost was estimated at $460 million, yielding just over 800 gigawatts (GW) of base-load power and a further 400 GW of seasonal power. At an average price around 6.5 cents per kilowatt hour, the dependable power from stage one was relatively expensive for hydroelectricity generated on such a scale, though it still would be half the cost of power produced in the country's existing small, oil-fired power station, located in the capital city.

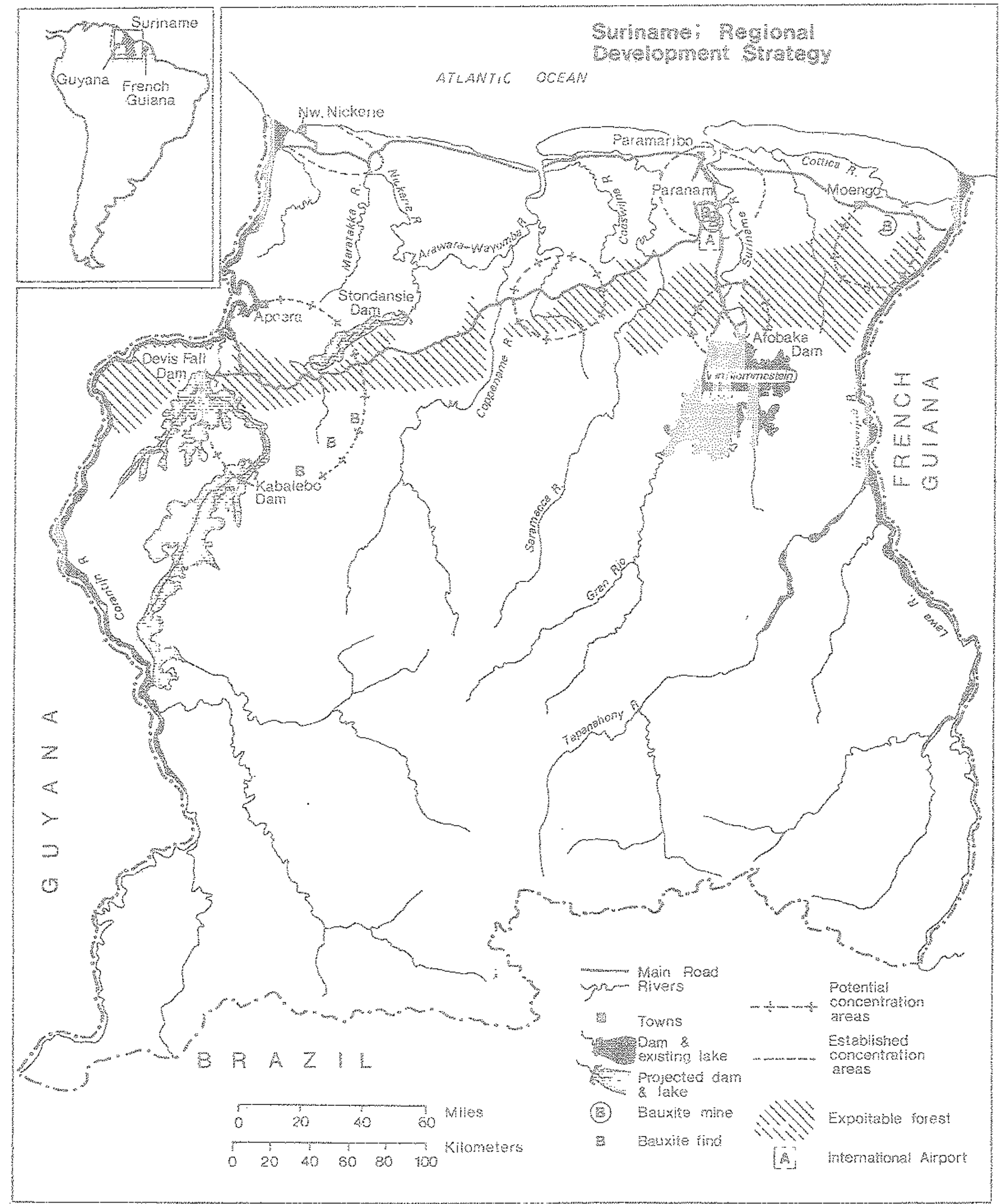
The economics of stage two were more attractive: two additional turbines could be installed at the original dam fed by waters from the Corantijn River, which flows along Suriname's western border with Guyana, raising the Kabalebo flow and providing an additional 1,300 GW of dependable power for one-third of the investment required by the first stage. This would reduce the average cost of power from the first two stages combined to below 4 cents per kilowatt hour, while the marginal cost of power from the second stage would be only 1.5 cents per kilowatt hour. This was 0.5 cents below the average power cost for the global aluminum industry and comfortably within the range required to justify new capacity.

Negotiations were begun in 1975 with potential equity partners to develop a 70,000-ton smelter, together with a refinery to process ores from new bauxite mines in the western Bakhuis mountain range. A railroad was built from the ore range to the proposed refinery site on the Corantijn River and a sawmill was built to

Table 1. Economic Development 1960–82: Regional Summary of Gross Domestic Product Growth

Group	1980 Population (in billions)	1980 GDP (in trillions U.S. $)	1960–73 (%)	1973–79 (%)	1980–82 (%)
Industrial countries	1.030	7.395	5.0	2.8	0.7
High-income oil exporters	0.016	0.221	10.7	7.5	[2.0][a]
Developing countries	3.360	2.145	6.0	5.1	2.3
Middle-income oil exporters	0.466	0.681	7.0	4.8	0.7
Middle-income oil importers					
Southeast Asia	0.183	0.204	8.2	8.5	4.9
Mediterranean	0.186	0.229	6.4	4.7	2.1
Latin America	0.249	0.444	5.6	4.9	0.7
Sub-Saharan Africa	0.087	0.043	3.5	1.5	0.7
Low-income oil importers					
Asia	1.988	0.492	4.6	5.6	4.9
Sub-Saharan Africa	0.175	0.052	3.5	1.5	0.7

Source: World Bank, *World Development Report 1983* (New York, Oxford University Press, 1983) p. 7; and World Bank, *World Development Report 1981* (New York, Oxford University Press, 1981) p. 3.
[a] Percentage decrease.



Source: Suriname Ministry of Finance, Paramaribo.

provide railroad ties as well as construction materials for the planned new town of Apoera.

Delay, inflation, and deteriorating prospects

Large capital-intensive projects such as Suriname's proposed hydrosmelter complex take many years to execute and are, therefore, very vulnerable to inflation. Suriname's first such project, the Afobaka dam and Paranam smelter south of Paramaribo, had taken fourteen years to complete, with five years spent on firming up the technical and economic aspects, two years on negotiating the financial terms and electricity tariff, and seven years on construction. The final Afobaka power cost of 0.25 cents per kilowatt hour in 1966 was little changed from the original estimate and testifies to the low inflation rates of the 1950s and 1960s.

In contrast, the second hydrosmelter complex was being launched in the face of high inflation and market uncertainties. As feasibility studies and negotiations dragged on, inflation pushed up the cost of the project and individual elements in the scheme were jettisoned one by one. In 1977 the alumina refinery was costed out at 50 percent above the cost of competing facilities, and by 1979 it became clear that the proposed 70,000-ton smelter would be half the size of efficient new smelters under consideration elsewhere. Unfortunately, the power available from stage two of Kabalebo was insufficient for a larger smelter and even if stage three were immediately constructed, the average power cost from the combined second and third stages would be above the level needed to ensure viability.

Worse still, it became clear that the new Bakhuis bauxite deposits were much smaller, more difficult to reach, and of lower quality than those of Australia, Brazil, and Guinea, and required processing prior to export in order to offset the resulting high mining costs. While the new western ores could be processed at the existing Paranam complex, even that would be a somewhat risky venture.

Other aspects of the Multi-Annual Development Plan also were falling behind schedule and being unfavorably affected by inflation. By 1980, three agricultural schemes, of which the northwest irrigation project linked to the Kabalebo River was by far the largest, were requiring twice the capital allocated only five years earlier. The additional sum required to complete the agricultural projects was almost equal to what Suriname would contribute from the Dutch-established Independence Fund to the Kabalebo project. At this juncture a military coup destabilized the domestic political situation and set the scene for confrontation between proponents of the hard-technology Kabalebo project and supporters of the green-technology agricultural schemes. The two components of the original development plan, which had appeared complementary, increasingly were presented as alternatives.

Rejection of Kabalebo

The final cost of Kabalebo stage one, as proposed by the World Bank and after allowing for inflation, was estimated to be around $740 million, of which the Surinamese government would meet one-third; the rest would be secured from overseas sources at low rates of interest. The average cost of power would be around 10 cents per kilowatt hour and a straight substitution for existing tariffs was proposed at 17 cents for public users and 5 cents for replacement of diesel power generators at Suralco's Paranam complex. Plans were for the aluminum company to gradually turn over its power allocation to the public system as domestic demand outside the bauxite-aluminum industry expanded. Estimates projected that all the foreign debt would be retired within a decade, providing an expanded cash flow to the government as the owner of the hydro facility. Meanwhile, the power available to the bauxite industry could be used to extend the small existing aluminum smelter, expand the large alumina refinery, and boost domestic production of higher-valued calcined exports. These changes were required to offset falling exports of unprocessed bauxite, which were becoming uneconomic as the Paranam mines went deeper and the extraction cost grew. The higher value commanded by processed bauxite can better absorb the higher mining costs.

At first the military coup of 1980 did not appear to affect the implementation of Kabalebo stage one. The objectives of the coup were not immediately clear, beyond a desire to overthrow a parliamentary government that had refused to improve pay and conditions in the army and was considered to be corrupt. The new Military Council had nationalistic overtones and resentment of the two large foreign bauxite companies—Suralco, a subsidiary of Alcoa, and Billiton, a Royal Dutch Shell subsidiary—became more open. In addition, there was a desire to assist the poorer citizens of the new country, but a clear-cut political platform did not emerge because internal power struggles frequently changed the complexion of the government. However, as the World Bank neared the successful conclusion of its long effort to finance the Kabalebo project, the ascendancy of the proagriculture lobby in Suriname, supported by sympathizers within the central planning bureau, created a powerful opposition to the hard-technology scheme. In November 1981, an appealing green argument in favor of small-scale, essentially rural development was skillfully deployed in rejecting the World Bank proposals for implementation of Kabalebo stage one and its associated long-term development strategy.

The green-technology option

The green-technology option revolved around the diversion of investment funds from Kabalebo to the three agricultural schemes, with oil imports substituted by extracting small heavy oil resources, backfitting small turbines to the existing Afobaka hydro system to increase its output, and in the late 1980s harnessing small hydro schemes elsewhere. The successful expansion of rice cultivation in the northwestern lowlands during the 1970s was the inspiration for the agroindustry schemes. State-owned lands, rented by yeoman farmers in 20-hectare plots, would generate adequate rural incomes to help stem the drift to the capital city. The initial rate of return for the proposed large northwestern extension originally was estimated at twice the 8 percent return sought on public investments. Although highly mechanized, the proposed rice farms and other agricultural projects in the center and east of the country were expected to make a significant contribution to generating new employment. Emigration had caused the population to decline slightly during the 1970s, but new immigration restrictions in the Netherlands were expected to produce a sharp increase in the demand for jobs during the 1980s.

The opponents of Kabalebo advanced five pragmatic arguments in support of the agricultural strategy, backed by a philosophy favoring small-scale, rural, locally controlled developments. First, inflation and currency depreciation had shrunk the real value of the Netherlands Independence Fund so that hitherto complementary projects now were competitors. Second, with the loss of the western aluminum complex and with no alternative large energy user to permit implementation of stage two, Kabalebo had become unattractive. Third, inflation had doubled the cost of the three job-providing agricultural schemes launched under the Multi-Annual Development Plan, so that they required a much larger share of the Independence Fund. Fourth, reliance on slow-moving overseas agencies for funding was seen as responsible for the costly delays in the Multi-Annual Development Plan: small-scale schemes, directed by Surinamese nationals were expected to speed implementation. And fifth, the proposed power tariff for Kabalebo stage one unduly favored the country's very large multinational corporation at the expense of other power consumers, including the urban poor. The green-technology arguments promised maximum self-reliance in developing the country, immediate and equitable distribution of benefits throughout society, greater job provision per unit of investment, and ecologically benign agroindustry development powered by small hydro and augmented by biomass and the small heavy oil deposits.

The outcome

As the Military Council drifted politically leftward and sought closer links with the Cuban-backed Bishop government in Grenada, it became increasingly clear that the green-technology arguments had been marshaled to support left-of-center objectives at the expense of a viable development strategy. The green philosophy suited the central planning bureau and the agricultural labor unions because it gave their projects the main role in future national development. The military rulers seized the green case as a coherent and respectable justification for retaining political power, though the army's initial move sprang from discontent over pay levels.

The alternative development plan that integrated the green schemes and was to replace the one built around Kabalebo's stage one was promised for mid-1982. It never materialized, and it became ever more clear that firm proposals for harnessing small hydro schemes on the Afobaka system and elsewhere never had been formulated, while revised rates of return on the agricultural projects had declined to half the targeted rate for the investment of public sector funds, and around one-quarter of the original estimates.

Unlike its neighbor Guyana, which could not raise the capital to implement its hydrosmelter scheme, Suriname had come within an ace of executing a long-term development strategy for oil import substitution, the upgrading of bauxite exports to maintain viability of that industry, and the scaled-down expansion of the agricultural schemes. Instead, a decade after the first oil shock, the country has still to formulate a coherent response to the oil import challenge. In that respect, Suriname is not unlike many other small and undiversified developing countries. The technical and economic solutions to the oil shocks may be difficult, but they are known. The political problems associated with implementation are the most difficult to resolve.

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Nonpoint-source water pollution

A RECENT INTERNAL report from the U.S. Environmental Protection Agency states that, in six of the ten EPA regions, pollution from such nonpoint sources as farms and urban streets is the principal cause of their water quality problems. Yet EPA policy has focused mainly on point-source pollution, while nonpoint sources so far have been largely uncontrolled.

This assessment came as no surprise to RFF researchers (and others) who, for the past five years, have been developing data and models that distinguish the causes of water pollution from point and nonpoint sources. According to RFF data, about half of the biochemical oxygen demand (BOD) pollutants and nearly all the discharges of suspended solids, phosphorus, and nitrogen originate from rural nonpoint sources. In certain urban areas—even some which are highly industrialized—nonpoint sources can account for the majority of certain toxics, including cadmium and lead.

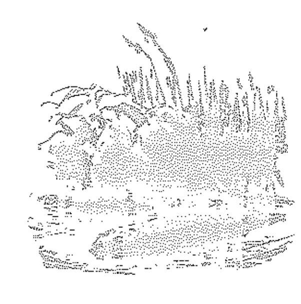
Of course, nonpoint source residuals usually are accompanied by large amounts of runoff water, so their effect on ambient water quality is much less than what might be expected considering the discharge tonnages alone. Nevertheless, RFF models suggest that the nonpoint contribution to degraded water quality is very significant for most pollution problems, with the possible exception of those due to coliform bacteria and low levels of dissolved oxygen, both of which are associated with BOD loadings in warm summer months under low stream flow and, hence, low nonpoint-source runoff conditions. Importantly, nonpoint pollution may be the principal cause of excessive nutrient problems (eutrophication) in lakes or slowly moving bodies of water.

Federal attitudes and actions

The federal government's attitude toward nonpoint pollution control is characterized by an implicit belief that the problem is best approached with state and local policy initiatives. Thus, in its 1972 version, the Clean Water Act's Section 208 relegated nonpoint pollution to state and local areawide planning processes. But while Section 208 required planning agencies to address nonpoint sources of pollution, it did not mandate specific implementing steps. As a result, this approach certainly was far weaker than that adopted for point sources—mandated discharge permits drawn up under EPA guidelines.

Perhaps in response to insufficient attention to agriculturally related pollution, the 1977 amendments to the Clean Water Act established a new demonstration program in cooperation with the Department of Agriculture. Under this program, the EPA and USDA could contract with farmers to implement "best management practices" designed to minimize agricultural runoff, with the federal government picking up as much as 50 percent of the capital costs. Of course, such incentive programs are successful in reducing pollution only to the extent that farmers perceive that their own self-interests are worth the other 50 percent, plus operation and maintenance expenses not funded as part of the original grant. This may be the case if the farmer is motivated by a desire to preserve topsoil, save on plowing and irrigation costs, conform with state laws, or be a good citizen.

Despite this new provision, the 1977 version of the Clean Water Act failed to secure increased pollution control from nonpoint sources. Indeed, on balance the 1977 amendments may have lessened control. For example, prior to 1977, agricultural pollution originating from irrigation return flows was considered a point source



and was subject to mandatory permitting processes. However, in 1977, Sections 208, 402, and 502 were amended to specifically exclude irrigated agriculture as a point source.

Little in the legislative history explains the relatively small attention paid to nonpoint sources. Obvious possibilities are that it is technically too difficult to control nonpoint sources; that nonpoint pollution is less harmful than that from point sources; or that Congress found it more expedient to focus attention and control efforts at industrial and municipal sources than agricultural and other nonpoint sources.

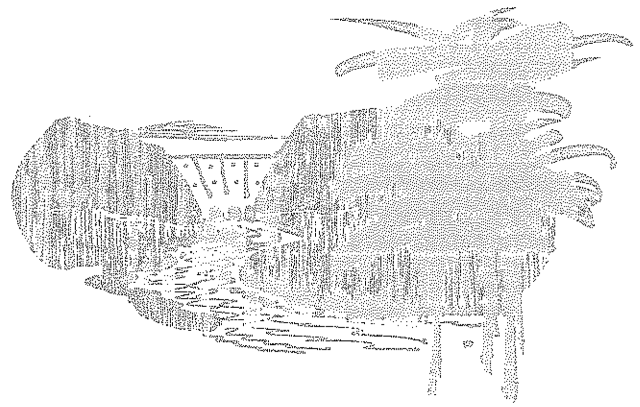
Although the first two possibilities might appear to have merit, in our opinion the first oversimplifies the true state of affairs. For example, while some nonpoint sources, such as runoff from urban streets, may present severe technical challenges, evidence drawn from EPA demonstration projects and from the experience of farmers using limited-till plowing techniques suggests that large quantities of nonpoint pollution can be controlled fairly easily at relatively low cost. Monitoring the effectiveness of control practices may be more difficult for nonpoint than point sources. Yet, since accurate monitoring has not been an essential feature of current approaches, it is a mistake to ignore nonpoint sources for this reason.

Similarly, even if it were true that point-source pollution contained more harmful constituents than nonpoint sources, that still would not explain the relative neglect of nonpoint pollution: the conventional pollutants targeted in the first few years of the Clean Water Act are common to both sources. In addition, RFF data indicate that often nonpoint sources, especially urban runoff, are the chief source of highly toxic substances in many locations.

On the other hand, the third possibility—that the influence of the agricultural sector on the Congress may account for its relative neglect of nonpoint-source pollution—appears confirmed by recent events. For example, Sen. John Chafee (R.–R.I.) was persuaded by farmers to eliminate language from his suggested amendment to the Clean Water Act that would have mandated nonpoint agricultural controls if voluntary actions proved inadequate.[1] In addition, Chafee dropped language that would have tied other agricultural programs to compliance with EPA agricultural runoff control objectives.

Similar factors, combined with a reluctance to support new (and possibly very expensive) regulatory initiatives may explain the lack of enthusiasm for nonpoint-source pollution policy on the part of the Office of Management and Budget

[1] *Inside EPA*, July 1, 1983.



(OMB). Caught between disparate viewpoints, the agency has opted (at the present time) for a cautious approach to nonpoint pollution that will not require new legislative initiatives and would limit the EPA's role to providing technical assistance to state and local governments.

During 1982, however, the EPA did begin a small effort focusing on nonpoint-source issues. The effort's developers held several common thoughts and viewpoints that have shaped it to date and that could provide a basis for different approaches to controlling nonpoint sources in the future.

- In many instances, control of point sources has been pushed to the limit of economic feasibility.
- Substantial cost savings may result from looking at point- and nonpoint-source problems together to meet water quality goals.
- Nonpoint-source water pollution is largely a local or regional (for example, river basin) problem for which a national mandatory control program may not be well suited.
- Millions of dollars have been spent under different federal programs on nonpoint-source research over the last few years. The time may have come to begin using that knowledge.
- However, many unanswered questions remain about the nature and extent of nonpoint-source pollution. For example, environmental effects of chemically similar pollutants from point and nonpoint sources are not fully understood; and the stochastic nature and geographic dispersion of nonpoint-source pollution make it conceptually and practically more difficult to control.

The EPA has begun a number of cooperative studies and demonstration projects to study these aspects of nonpoint-source pollution. Built largely on existing information, these studies are regionally dispersed and designed to provide both geographically representative results and examples of where trades between point and nonpoint sources can be implemented. They also will identify unanswered research issues and suggest specific studies to resolve them. These efforts may identify alternatives to traditional regulatory approaches, such as trading between point and nonpoint sources to achieve water quality standards.

The Dillon Reservoir study

A typical example is a case study of the Dillon Reservoir being conducted jointly by the EPA and state and local governments. This reservoir is located in Summit County in the Colorado Rockies, the fastest growing county in the nation according to the 1980 census. Recreation is the basis of the local economy, centered on water-based sports in the summer and skiing in the winter. Completed in the early 1960s and supplying half of Denver's water supply, the reservoir's water quality is limited with respect to phosphorus and is in danger of becoming eutrophic; algal blooms in summer are common.

Municipal sewers discharging into the reservoir are its only major point sources of pollution. The sewage undergoes advanced wastewater treatment, but because the reservoir is approaching the limits of its waste-load allocation, the community either must control for more phosphorus at the point sources or take steps to control nonpoint-source pollution—the single biggest contributor of phosphorus to Dillon.

The purpose of the Dillon Project—an actual demonstration of a combination of detention ponds and infiltration pits—is to examine the economic and environmental effects of controlling nonpoint sources of phosphorus in lieu of point sources. Preliminary test results show that, should such nonpoint devices be more widely applied in the Dillon watershed, they would be 85 percent effective in removing total phosphorus at an estimated annual cost savings of several million dollars compared to additional point-source control. The project also aims to develop a model permit that might allow pollution trades between point and nonpoint sources of phosphorus to realize these potential savings.

The Colorado Salinity Project

Another example, just getting under way, is the Colorado Salinity Project, a cooperative effort between the EPA and various state agencies. Excessive salinity in the Colorado River affects more than 12 million users of the river in both the United States and Mexico. This project will use the RFF Water Network Model and associated data bases to identify sources of salinity, much of which is thought to originate from nonpoint sources. The cost effectiveness of existing salinity control mechanisms will be critically evaluated, and the possibility of instituting selected potential innovations—bubbles, offsets, and others—to achieve better results on the Colorado at less cost will be analyzed. The Network Model then will be used to evaluate the effectiveness of selected policies in controlling salinity.

It is, of course, difficult to predict the implications of these and other studies of the nonpoint pollution problem at the EPA. At minimum, they may better sensitize agency decision makers to the extent of the problem. More tangible results may follow if these efforts reinforce the findings of other EPA-funded research undertaken at RFF. In a survey of the extent of nonpoint source pollution and possible policy responses, RFF researchers concluded that, while the problem has unique features, it is not nearly so intractable to policy solutions as many have believed. EPA and RFF research may show that nonpoint-source pollution is more a problem of implementation than of technology.

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The high cost of contaminated groundwater

PRICE'S LANDFILL OCCUPIES some 22 acres about 5 miles west of Atlantic City, New Jersey. Once a sand and gravel quarry, the pit was excavated to within 2 feet of the water table in 1968 and people from the surrounding area began to dump trash into it with the permission of the owner, Charles Price.

In 1969 Price began commercial landfill operations, and in 1970 he applied to the New Jersey Department of Environmental Protection (NJDEP) for a license to run a sanitary landfill; the application specifically excluded "Chemicals (Liquid or Solid)." The department issued a certificate authorizing operation of a solid waste disposal facility.

The New Jersey State Sanitary Code requires every landfill operator to submit a detailed sanitary design so the NJDEP may determine whether planned operations pose a threat to health or the environment. Price's plan—not submitted until late 1971—did not mention chemicals, despite the fact that the landfill already was beginning to fill with chemical wastes.

Only in 1972 did Price seek authorization to accept and dispose of liquid and chemical wastes. In its response, the NJDEP granted him a certificate, subject to the condition that "no liquid or soluble industrial wastes, petrochemicals, waste oils, sewage sludge, or septic tank wastes shall be received for disposal at this site." But Price continued to accept significant quantities of chemical and liquid wastes. Minimal precautions were taken: wastes often were poured into the landfill from an open spigot on a tank truck, and drums of chemicals were buried under piles of refuse.

In July 1972, the NJDEP inspected the landfill, cited Price for accepting chemical wastes, and formally advised him of the violation. Nonetheless, he continued to handle chemical wastes until November 1972. After that date, no chemical wastes were disposed of at the landfill, although it continued in operation. In 1976 Price terminated the landfill operation and covered the site with fill material. It has not been used since.

During the period from May 1971 to November 1972, Price accepted some 9 million gallons of the following toxic and flammable chemical and liquid wastes, either in drums or directly into the ground: acetone, acids (glycolic, nitric, and sulfuric) and spent acid wastes, acryloid, acryloid monomer and poly acryloid, caulking and spent caulking solvent, caustics and spent caustic wastes, cesspool waste, chemical resins and other waste chemicals, chloroform, cleaning solvents, ether and spent ether wastes, ethyl acetate, ethylene dichloride, fatty acids, glue wastes, grease and spent grease solvents, heptane, hexane, inks and waste ink residues, isopropanol, isopropyl alcohol, isopropyl ether, lacquer thinner, manganese dioxide, methanol, methyl ethyl ketone, methyl isobutyl ketone, methyl vinyl ketone, miscellaneous chemical laboratory wastes, mineral spirits, oil and waste oil products (No. 6 waste oil), paint, paint sludge, paint thinner and spent paint wastes, perfume wastes, phenols, phenolics and phenolic solvents, resins, septic waste and sludge, still bottoms, styrene and styrene wastes, tar, titanium wastes, xylene, and xylol. And this is only a partial list; there were many more.

Extensive water level measurements show that the hydraulic gradient near Price's Landfill slopes generally east and east-northeast from the landfill. The groundwater in the area, and contaminants in that groundwater, therefore tend to flow east and east-northeast. The landfill sits roughly 1 mile west of the sites from which the Atlantic City Municipal Water Authority pumps most of its drinking water. A leachate plume has been defined near the landfill, although its precise contours have not been determined.

No isolated incident

Price's Landfill is not an aberration. According to the U.S. Water Resources Council, "Every region in the country experiences groundwater pollution problems, both point and non-point. . . . Their widespread nature supports concern with degradation of groundwater supplies throughout the Nation."[1] The Congressional Research Service identifies more than 100 incidents in which 1,363 wells were closed.[2] The Council on Environmental Quality claims, on the basis of evidence gathered from numerous case studies across the nation, that "hundreds of wells supplying drinking water to millions of people have been closed because of toxic organic chemicals in high concentrations. . . ."[3]

[1] U.S. Water Resources Council, *A Summary of Groundwater Problems* (Washington, D.C., September 1981).

[2] Congressional Research Service, *Resource Losses from Surface Water, Groundwater, and Atmospheric Contamination: A Catalog* (Washington, D.C., 1980).

[3] Council on Environmental Quality, *Contamination of Groundwater by Toxic Organic Chemicals* (Washington, D.C., January 1981).

Moreover, it is impossible to know whether the available data reflect the entire range of water quality problems. In almost every case studied to date, only a few of several hundred possible compounds actually were tested for, and then only after contamination was suspected. In many of the cases, well water was found to contain concentrations above—and often several orders of magnitude higher than—those commonly encountered in drinking water drawn from badly contaminated surface water sources. Even at extremely low concentrations, many toxic organic chemicals pose serious, irreversible, health risks.

Among the principal sources of groundwater contamination are waste disposal landfills and impoundments, accidental spills, and abandoned oil and gas wells. In the fall of 1983 the U.S. Environmental Protection Agency warned of an additional and ubiquitous source—underground gasoline storage tanks at thousands of service stations across the country. But most groundwater contamination can be traced to chemicals leaching into the aquifer from poorly constructed and managed industrial or municipal landfills, surface impoundments, or outright illegal dumps. Contamination from such sources often has been in process for years—sometimes for decades—and most contamination incidents are discovered only after a drinking water source has been affected.

By the time suspected aquifer contamination is verified in samples drawn from drinking water wells, the problem may be irreversible. Stricter regulation of the disposal of potential contaminants in other environmental media, particularly air and surface waters, and the consequent rising cost of such disposal, is likely to increase the flow of wastes to land disposal. But groundwater use has grown faster, over the past twenty-five years, than population: from 12.4 trillion gallons per year in 1950 to almost 30 trillion gallons per year in 1975. It is thus likely that a growing portion of the population is being exposed to contaminants in groundwater. Because cleanup is a formidable task, often prohibitively expensive or technically infeasible, preventive measures may be the only effective means of protecting groundwater resources.

As researchers, we are particularly concerned with assessing the benefits (costs avoided) of controlling groundwater contamination. But benefit–cost analyses of groundwater contamination require quantification of several links between sources and receptors. We must know the location and strength of actual or potential sources of contamination. We must be able to model the spread of the contaminant plume in the aquifer. We must know the numbers of persons exposed to contaminated groundwater and the extent and timing of their exposures. We must know the "dose-response relationship"—the nature and extent of health effects on the population at risk. And finally, we need a way of converting health effects into monetary, or dollar, values.

This is a very tall order, and we are far from being able to quantify these links with precision. In each case, we need substantially improved methods and data. For the purposes of this article, therefore, we concentrate on a few less ambiguous aspects of the problem.

Remedial and decontamination measures

In contemplating the future of hazardous waste disposal and the protection of groundwater, the main task for public policy is providing appropriate institutions and incentives for environmental protection. But for a case like Price's Landfill, a *fait accompli,* the choices are narrow: either to bear the risk or take remedial action.

Groundwater contamination can be contained using various techniques. *Direct methods* are designed to prevent contaminated fluids from an impoundment, or leachates from a landfill, from coming into contact with uncontaminated groundwater. These include installation of impermeable material below the site (applicable chiefly to new sites), collection and treatment of contaminated groundwater and recharge to the aquifer or to a surface stream, construction of a groundwater cutoff wall, and capping the surface of an impoundment or a landfill to prevent leaching induced by precipitation. *Indirect methods* involve developing or providing substitute sources of water or treating contaminated water just before use.

In almost all actual groundwater contamination episodes, only the least expensive of the direct methods have been employed, such as covering the site to prevent leaching. Cleaning an aquifer is an extremely costly, complicated, and lengthy undertaking, with success uncertain, and authorities usually resort to indirect methods.

Here we consider two alternative remedial schemes for cleaning the Cohansey aquifer, the principal source of Atlantic City's water supply. Both involve indirect cleaning operations: pumping contaminated water, treating it, and then recharging the aquifer with the treated water. The two schemes are:

- Cessation of pumping at the shallow Atlantic City Municipal Authority wells; pumping 30 million gallons per month from the upper Cohansey at three specified locations in the well field; and decontaminating the water and injecting it at three locations near the landfill.
- The first two steps are identical to those in the first alternative, with the addition of three wells downgradient, but near the landfill. The treated water is reinjected at four locations between the landfill and the well field at a rate of 8 million gallons per month.

For both schemes we assume that contamination of the Cohansey aquifer by leachate from the landfill has been in progress for ten years when remedial measures are initiated and that leachate infiltration is halted at that time. Both alternatives involve flushing pollutants from the aquifer with the help of a hydraulic gradient created by pumping and reinjection.

Analyses of the first alternative indicate that, after ten additional years, the contaminant plume has moved eastward and been halted just short of the production well field. At the cost of pumping, treating, and injecting 30 million gallons per month for ten years, we still are far from effective decontamination of the aquifer.

The second scheme attempts removal of the contaminant at the landfill itself. Here only 8 million gallons per month (out of the total 30) are reinjected at points downstream, with the rest disposed of outside the aquifer through sales to industrial users or discharges into streams. This seems much more effective. The leading contour of the contaminant plume remains stationary during the first five years and contracts during the second five years. This is achieved by pumping the mass of the contaminant near its source, and then containing the plume and diluting it by the injection of treated water downstream from the landfill. But even under this second alternative, which is about as costly as the first, effective cleanup is achieved only after twenty-five years of continuous operation.

The cost estimates for cleanup techniques presented in table 1 are "average-site" costs; actual costs will depend on the situation at the particular site. Within each method category one or more of the listed activities may be required in any given case. Some actions are complementary, such as those listed under groundwater flow control and plume management. Groundwater flow control must be accompanied by pumping to prevent overflow conditions at the landfill.

If contaminated water removed is reinjected or discharged to a surface water conduit, it must be treated to some extent beforehand (in fact, it is difficult to envisage a situation where it would not). That cost of treatment does not appear in table 1, and must be added to the cost of remedial actions. A recent study estimates the annual cost of such treatment at $500,000.[4] The Cohansey aquifer would require about twenty years of treatment and reinjection. At a discount rate of 10

[4] Camp Dresser & McKee, Inc., "Immediate Action and Remedial Investigation, Price's Landfill, N.J.," Draft report prepared for U.S. Environmental Protection Agency (Boston, Mass., March 1982).

Table 1. Summary of Estimated Average Costs and Characteristics of Direct Remedial Methods
(in thousands of 1980$)

Method	Average estimated costs[a]	Characteristics
Surface water control		
Contour grading	510	Increases runoff, reduces infiltration.
Surface water diversion	55	Diverts surface water from fill.
Surface sealing (Clay, fly ash, concrete, PVC)	639–1,336	If locally available, native clay is an economical means of retarding infiltration.
Groundwater flow control		
Bentonite slurry trench (1,700-ft-long by 60-ft-deep wall)	1,860	Simple construction methods; retards groundwater flow. Mainly used for shallow, unconsolidated aquifers.
Grout curtain (1,700-ft-long by 60-ft-deep wall)	3,880	Very effective in permeable soils.
Sheet piling (1,700-ft-long by 60-ft-deep wall)	2,218	Widely used for shoring. Mainly used for shallow, unconsolidated aquifers.
Bottom sealing (4-ft-deep)	11,000	Leachate collection may be needed: difficult to accomplish results under unconsolidated aquifers.
Plume management[b]		
Drains	64	Effective in lowering water table a few meters in unconsolidated materials; can be used to collect shallow leachate.
Well point dewatering	514	Suction lift limits depth to 20–30 ft; inexpensive installation; can be used to collect shallow leachate.
Deep well dewatering	508	Used in lowering deep water tables; high maintenance costs.
Injection–extraction barrier	552	Creates a hydraulic barrier to stop leachate movement; operation and maintenance costs are high.
Chemical immobilization		
Chemical fixation of cover	403	Uses chemically fixed sludge to provide a top seal; provides means of disposal for sludge; helps stabilize landfill.
Chemical injection	239	Immobilizes a single pollutant; in most cases not feasible; results unpredictable.
Excavation and reburial		
Excavation and reburial	12,686	Very expensive; difficult construction.

[a] For a 22-acre landfill. Original costs updated using the Consumer Price Index.
[b] Costs include present worth of twenty years, operation, maintenance, and, where applicable, power for a 22-acre landfill.
Sources: "Groundwater Strategies," *Environmental Science and Technology,* vol. 14, no. 9 (September 1980); U.S. Environmental Protection Agency, *Guidance Manual for Minimizing Pollution from Waste Disposal Sites,* EPA 600/2-78-142 (Washington, D.C., August 1978).

percent, the present value cost of treatment would be some $4.25 million.

Excavation and reburial cannot eliminate the need for remedial measures designed to remove contaminants already leached into the aquifer. Those additional costs must be added to whatever other costs are incurred in cleaning the aquifer. Using the table as a rough guide, the cost of plume containment and management, including water treatment but excluding excavation and reburial, may be in the range of $5 to $8 million in present value. With excavation and reburial, the period of plume management and groundwater flow control probably could be shortened, but total costs could rise to $15 to $18 million in present value.

Other unofficial estimates have focused on securing alternative sources of supply to meet Atlantic City's water demand. If that requires a new well field to replace the four threatened wells (one already was shut down in 1981), estimates vary from $6.5 to $9.3 million. But since growth in demand would have required developing a new supply source in the late 1980s in any case, only part of the cost of the new well field should be attributed to the contamination episode, namely, the additional cost incurred by pushing forward the date of construction.

All this leaves open the question of whether cleanup costs should be excluded from the cost of damage avoidance, since providing an alternative supply source seems to be the efficient remedial alternative. By not including cleanup costs we are effectively scrapping the upper Cohansey aquifer as a groundwater source, until such time as it cleanses itself by natural processes. Recall that the more effective cleanup scheme did not result in complete decontamination even after twenty-five years of simulated discharge, treatment, and reinjection operations (although it did halt the spread of the plume). Natural processes take much longer to accomplish the same task. And acquiescence in indefinite resource degradation is rational only if water in the aquifer is a free good with zero scarcity rent in all the periods along an optimal management path. Given trends in groundwater use, this seems unlikely. Uncontaminated groundwater almost surely has some positive present worth that would justify some decontamination steps.

Finally, there is the question of assigning property rights. As a matter of principle, and in connection with the determination of damages and liability, it would seem imperative to assume that the right to pollute does not reside with the owner of the landfill. Whether or not compensation for damages can be achieved through the courts, remedial measures are taken, and the perpetrator of the incident bears the full cost of those measures, the cost of reverting to the status quo ante must be determined. Questions of liability for damages and its effect on future behavior are an important part of the research agenda.

Preventing future episodes

The general principle drawn from economics is that the producer of toxic wastes should pay the cost of disposal plus any additional "external" costs that may be associated with them. This provides an incentive for "optimum" generation of wastes. But illegal disposal already is a large problem, and effective imposition of the "polluter pays" principle presumably would aggravate it. Thus, what is needed is a way to impose some—or all—of the costs of safe disposal on the generator *and* to provide an incentive to actually deliver the toxic residuals to a suitable disposal site. This invites consideration of what have come to be called deposit-refund systems.

In particular, a system that was put into effect for waste oil in Germany in the early 1970s may hold some lessons for other types of toxic chemicals. Waste oil almost always is contaminated with such toxins as carcinogenic hydrocarbons and heavy metals and, if improperly discharged, can become an important source of groundwater contamination. Improper disposal appears to be a problem in all industrialized countries.

Richard Irwin describes the German approach as follows:[5] The German law both encourages recycling and ensures that recycled oil is properly disposed of, through a system of reporting requirements and program-funded, nationally coordinated collection and disposal contracts. All persons who import or produce certain lubricating oils (including refenders) pay, in addition to an existing tax on mineral oils, a compensation fee of 9.00 DM (about $3.60) per 100 kilograms of product. This money goes into a special fund reserved for the support of the disposal of used oils by controlled burning or recycling, the two methods deemed safe from environmental and public health viewpoints. The fund also supports the program-related administrative expenses of the Federal Office for Trade and Industry.

The enterprises that contract with the Federal Republic are reimbursed for the costs of collection, transportation, and disposal to the extent that these are not covered by the revenues from selling refined products. These reimbursements are made at standard rates subject to some flexibility.

In return, the disposal firm has obligations, described by Irwin:[6] The disposal firms' contracts obligate them to (1) pick up all amounts of used oils over 200 liters in the district assigned to them; (2) do so at no charge to the user unless the oils contain more than 10 percent foreign matter; (3) provide suitable containers for lesser amounts so they can be collected later; (4) keep records of their costs, making their books and other relevant information available to the Federal Office or to appointed auditors; (5) file their applications for payments monthly; (6) install equipment specified by the Federal Office for purposes of checking their output; (7) give notice of any refined products shipped to other member nations of the European Community and return any payments received for producing these products (this requirement is necessary to avoid favoring German refiners in violation of the Treaty of Rome); and (8) give receipts for used oils collected which contain more than 10 percent foreign matters.

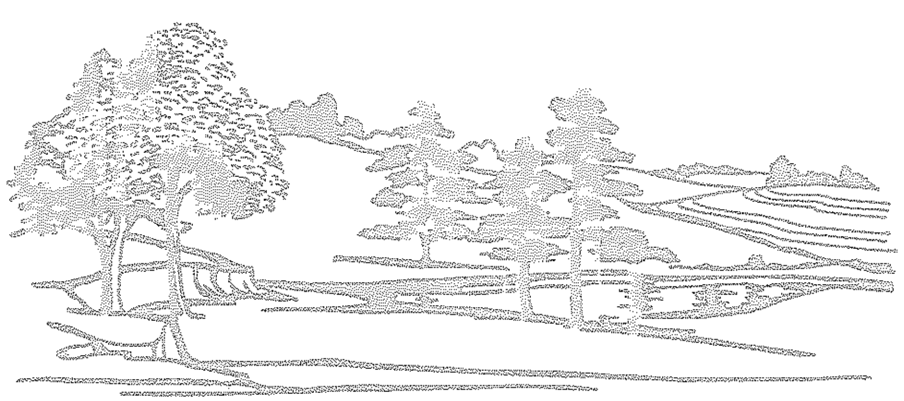
The German system is a deposit–refund system where the refund is free disposal of the generators' waste oil. Irwin sums up:[7] The German program is designed to minimize program costs while encouraging recycling. By placing the financial burden of administrative costs and compensation payments on those using the oil, costs to the government are kept to a minimum. Further, since only lubricating oils subject to the existing mineral oil tax are also subject to the disposal fund compensation fee, the paperwork, procedures, and personnel for levying the fee are integrated almost completely with the collection of the mineral oil tax, resulting in substantial administrative cost savings. Finally, the compensation payments encourage collection and recycling of oils that otherwise could not be handled economically in the private sector.

Waste oil may be much more amenable to a deposit-refund system than most toxic wastes. Still, the functioning of the German law deserves careful study, and it would seem to be worth examining other types of toxic waste (contaminated industrial acids and plating plant wastes, for example) to see if an effective deposit-refund system could be devised.

[5] *Ecology Law Quarterly* vol. 6, no. 699.

[6] Ibid.

[7] Ibid.



Research needs

In an expanded version of this article we consider three kinds of issues that seem particularly troublesome.[8] The first might be called the need for casting groundwater solute transport modeling in a suitable decision-theoretic framework. Each of the existing models requires knowledge of many geohydrological parameters and, of course, of the solute source terms before ambient concentrations (and thus exposures) can be predicted. But information on those parameters, and on the source terms, only can be gotten at substantial cost—in drilling and sampling. Since costs always will be constrained, there is an obvious question, What is the best way to allocate any such sum among drilling, sampling, and modeling? "Best" should mean something like "giving the most precise exposure forecast."

The second area of needed research is valuation of the particular kind of risk posed to human health by exposure to groundwater contamination. A substantial spread exists in the values individuals attach to risks to life, a range open to at least two interpretations: Individuals may value different kinds of risks to life very differently; or the descriptive realism of expected utility theory is questionable. Both interpretations warrant close investigation, but the latter is particularly important because it is risk perceptions that matter to individuals and determine individual valuation of risk. Expected utility theory grew up around the study of insurance and gambling behavior, both of which have an actuarial basis for risk assessment. Perceptions of the risks of major hazardous episodes—by definition infrequent events—almost certainly work very differently.

Third is the general area of institutional arrangements for reducing risks from major episodes, and for allocating the burdens of those remaining risks society chooses to bear. Our brief discussion of the German waste oil program only suggests how much remains to be done here. In that case, there was an (implicit) decision that the benefits of the program outweighed the considerable transaction costs involved. For other hazardous substances, can similarly beneficial arrangements be devised? Put another way, how many Price's Landfills can the nation afford?

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Book review

Natural Resources: Bureaucratic Myths and Environmental Management, Richard L. Stroup and John A. Baden, eds. (San Francisco, Calif., Pacific Institute for Public Policy Research, 1983). $20.00, cloth; $9.95, paper.

Private thoughts on public choice

This lively book is part of the growing property rights and public choice literature that attempts to apply microeconomic concepts to nonmarket behavior. While resisting the excessive formalization and jargon sometimes found in neoclassical economics, and making an effort to be more empirical, the authors heavily rely on that field's traditional assumption that individuals and organizations seek to maximize their self-interest. They argue that the federal presence in land, water, wildlife, energy, and pollution policy has harmed the public interest by making public servants do the wrong thing, and has led businesses astray as well. The authors believe that well-defined and enforced property rights in an unfettered (and idealized) market would handle these matters better. Thus they are able to excoriate self-interest in government as the cause of waste, inequity, and environmental harm, while glorifying that same self-interest in the private sector as the best guarantee of an efficient, good, and clean society. If it were only so simple.

Government and the market each have their advantages and disadvantages as ways to allocate resources, and the best solution is likely to be some combination of the two. This book confuses the question by portraying the choices as mutually exclusive, and consistently stacking the deck against government. Consider this typically breathtaking statement: "It is, after all, obvious that despite reasonable intentions, bureaucratic entrepreneurs in the Forest Service, the BLM (Bureau of Land Management), the Bureau of Reclamation, the Army Corps of Engineers and the Bureau of Indian Affairs have consistently and systematically subsidized the deterioration of environmental quality" (page 102). The book shows nothing of the kind. It does show that *sometimes* government has damaged the environment, and *sometimes* the market has protected it. But in their highly selective use of examples, the authors fail to weigh the favorable impacts of government and the unfavorable impacts of the market. For example, they repeatedly flay the BLM for chaining piñon-juniper habitat, but do not mention that private ranchers have also engaged in this practice, or that the BLM has drastically reduced this practice in recent years. (Chaining is a process of clearing brush by attaching a chain to two tractors and driving them across the land.)

The notion of self-interest is undeniably useful in studying bureaucracy, as political scientists and sociologists long have recognized. But it is also notoriously ambiguous. Stroup and Baden find self-interest in so many different situations that it is difficult to envision many outcomes that they would not attribute to it. The fixation on this standard contrasts with the growing acceptance by leading economists that other motivations such as habit, loyalty, shame, pride, envy, altruism, fraternity, and compassion are important not only in nonmarket situations but often in the marketplace itself.

The book's *a priori* approach leads to assertions that, on the evidence, are simply false. Anyone familiar with the natural resources bureaus will recognize the absurdity of claims that there is little accountability in the public sector (page 64) and that there is "no check" on bureaucrats (page 45). One mechanism for government accountability is competition not unlike that in the market. For example, the various land and water agencies for generations have competed against one another, with sometimes beneficial results that Stroup and Baden unaccountably ignore. However, the most characteristic instrument of government accountability is "regulation" of the bureaus by the president and his Office of Management and Budget, Cabinet members and their staffs, and the many units of Congress, the courts, countless interest groups, the news media, and others. The fact that these external controls are necessary is no more an indictment of bureaus and government than the need for economic and social regulation is an indictment of businesses and the market.

These authors could have written, and they are good writers, a thoughtful critique of dilemmas in the modern quest for equality and democracy, but what comes out is a reaction against these widely shared ideals. The authors deride as "rent-seekers" the recipients of government benefits, even where the public generally regards this help as just. They regard democracy as at best a waste of time, even where the public clearly cares more that decisions be reached fairly than it cares what those decisions are. In effect, Stroup and Baden would prefer a constitutional counterrevolution that would remove much of today's public life from the reach of democratic politics. Few readers would welcome such a move, and even fewer would regard it as politically practical. What we need today—and what this book does not provide—is a more pragmatic and balanced effort to recognize that governments and markets alike have strengths and weaknesses and that each has a role to play.

Reviewer Christopher Leman is a visiting scholar in RFF's Renewable Resources Division.

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