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Environmental Data: —Providing Answers or Raising Questions?

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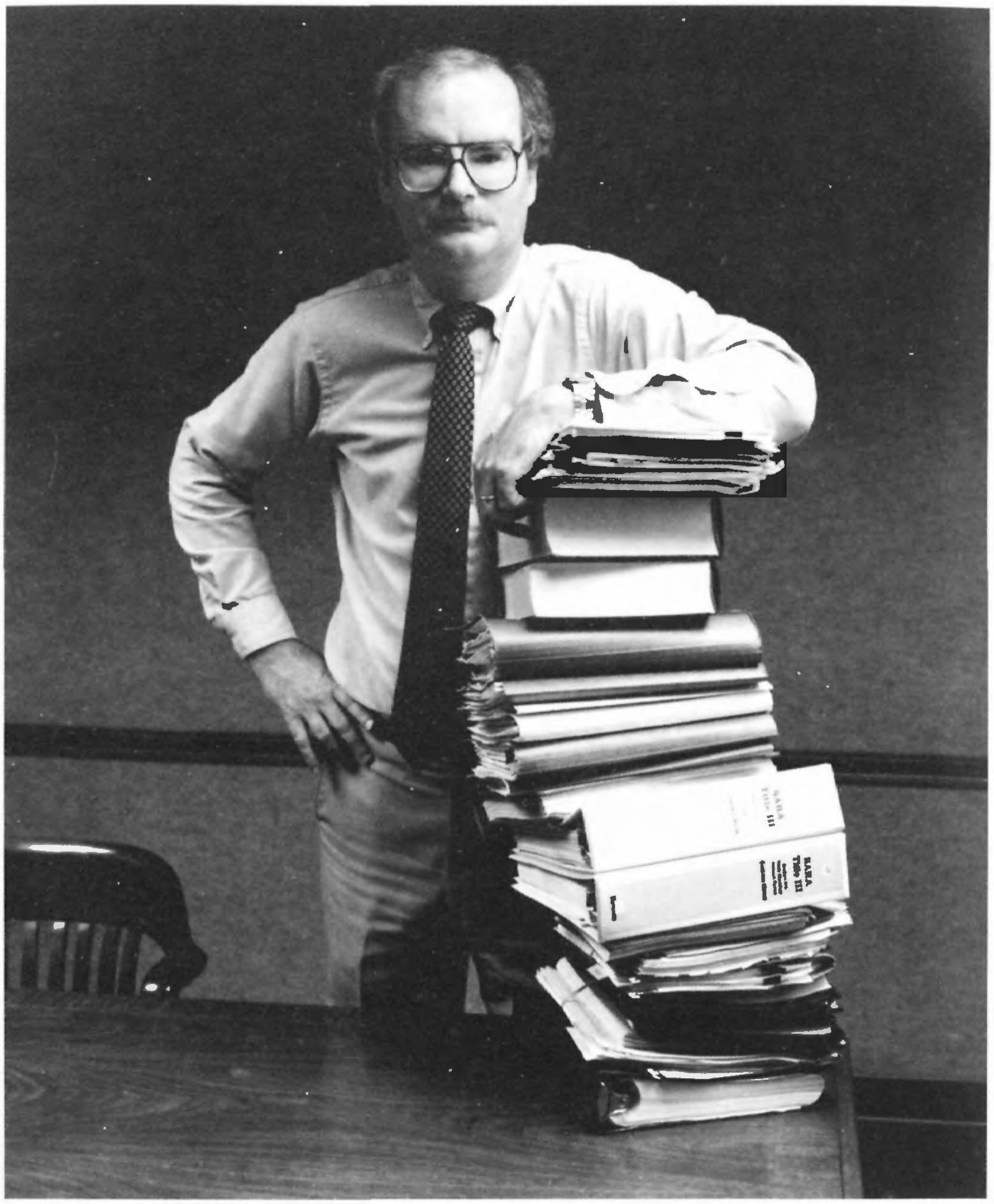

Monsanto photo

The new Emergency Planning and Community Right-to-Know Act means homework for industry and citizens. Bob Boland, an environmental protection superintendent with Monsanto Chemical Company, spent 20 months assembling information needed for a Monsanto plant to comply with reporting requirements.

Environmental data—foundation for decision-making and source of controversy. This issue of *EPA Journal* explores the subject.

In a lead-off article, the Agency's new Administrator, William K. Reilly, suggests a goal for EPA's widespread data-gathering efforts: measuring for environmental results.

Next, John A. Moore, the Agency's acting Deputy Administrator as the *Journal* went to press, discusses the scientific evidence on Alar and apples in light of recent public controversy.

A *Journal* forum follows, in which three outside observers answer the question, what kind of data does the public need to evaluate the safety of chemicals in the environment?

Three articles follow on the major new supply of data being provided under the Emergency Planning and Community Right-to-Know Act. Included are a piece on Right-to Know's potential usefulness and limitations for citizens, a piece on its uses for EPA, and a piece on the application of Right-to-Know data in local emergencies using the computerized CAMEO system.

Next is an article by two opinion analysts on how the public gets its information and develops its views on environmental problems.

Then five articles feature different aspects of environmental data-gathering at EPA. They include:

—How the Agency tracks air quality trends.

—How researchers are measuring pollution in clouds.

—The Agency's continued detective work on dioxin.

—How EPA is combining different data sources into "pictures" the public can understand and decision-makers can use.

—Finally, how Agency scientists are gearing up to better determine risks to ecological systems.

Next, an article explores how society might more successfully avoid environmental problems by looking more closely at available data.

Articles from an international perspective include a piece arguing that knowledge of the planet's ecology is seriously incomplete and a feature on how the gases that contribute to the Greenhouse Effect are being traced.

Also included in this issue is a special report on China's environment by an official visiting here under a U.S.-China bilateral exchange agreement.

The issue concludes with a regular feature—Appointments. □

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EPA JOURNAL

EPA is charged by Congress to protect the nation's land, air, and water systems. Under a mandate of national environmental laws, the agency strives to formulate and implement actions which lead to a compatible balance between human activities and the ability of natural systems to support and nurture life.

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Front Cover: Apples have taken their turn as the subject of controversy in the intensifying debate about environmental issues. See article on page 5. Photo by Don Carstens, Folio, Inc.

The next issue of EPA Journal *will concern the institutional challenges involved in tackling environmental problems.*

Beginning with this issue, the text of EPA Journal *will be printed on recycled paper.*

Design Credits: Ron Farrah; James R. Ingram; Robert Flanagan.

Price Change

Because *EPA Journal* has become a bimonthly publication, the subscription price has been changed. Now, the annual rate for subscribers is $8. The charge to subscribers in foreign countries is $10 a year. The price of a single copy of *EPA Journal* is $2.25 in this country and $2.81 if sent to a foreign country. Prices include mail costs. Previously, the magazine was being published 10 times yearly at an annual subscription price of $11 in the United States.

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Measuring for Environmental Results

by William K. Reilly

First, the good news:

Based on my years in the environmental movement, as well as my first four months as EPA Administrator, I believe EPA has the most talented, most dedicated, hardest-working professional staff in the federal government. What's more, I think this Agency does an exemplary job of protecting the nation's public health and the quality of our environment.

Now the bad news: I can't prove it.

I could cite facts and figures telling how many regulations and permits we've written since 1970, how many enforcement actions we've taken, how many lawsuits we've defended, how many chemicals we've tested, how many reports we've published. But what do all those activities add up to? Do they show that EPA is accomplishing its mission—or do they just show that we've managed to keep busy for the last 18 years?

By listing our activities we do not necessarily prove we're doing a good job. When it comes to environmental protection, the best measure of our success must be results. Is the public healthier than it was 18 years ago? Is the environment cleaner? The limited evidence we have is mixed and inconclusive; we really don't know how far we've come—or how far we still have to go.

Thus, as I begin a challenging assignment as manager of this vital agency, one of my first priorities is to build on the work of my predecessors in strengthening our ability to track the nation's, and EPA's, progress in cleaning up the environment.

A key element in any effort to measure environmental success is information—information on where we've been with respect to environmental quality, where we are now, and where we want to go. Since its beginning, EPA has devoted a great deal of time, attention, and money to gathering data. We are spending more than half a *billion* dollars a year on collecting, processing, and storing environmental data. Vast amounts of data are sitting in computers at EPA Headquarters, at Research Triangle Park, North Carolina, and at other EPA facilities across the country.

By listing our activities we do not necessarily prove we're doing a good job.

But having all this information—about air and water quality, about production levels and health effects of various chemicals, about test results and pollution discharges and wildlife habitats—doesn't necessarily mean that we *do* anything with it. The unhappy truth is that we have been much better at gathering raw data than at analyzing and using data to identify or anticipate environmental problems and make decisions on how to prevent or solve them. As John Naisbitt put it in his book *Megatrends*: "We are drowning in information but starved for knowledge."

Our various data systems, and we have hundreds of them, are mostly separate and distinct, each with its own language, structure, and purpose. Information in one system is rarely transferrable to another system. I suspect that few EPA employees have even the faintest idea of how much data are available within this Agency, let alone how to gain access to it. And if that is true of our own employees, how must the public feel when they ponder the wealth of information lurking, just out of reach, in EPA's huge and seemingly impenetrable data bases?

One of the main reasons for the proliferation of compartmentalized data bases can be found in our history. Congress created EPA by linking together several different agencies and bureaus, each with its own media-specific environmental responsibilities. Rather than integrating EPA's programs into a unified, cohesive framework, the environmental legislation of the 1970s only heightened the fragmentation by assigning EPA's pollution control responsibilities according to environmental medium or category of pollutant—air, water, solid and hazardous wastes, pesticides and toxic substances, and so on. Each program office, in pursuing its own distinct legislative mandate, has created and maintained its own unique information systems, geared to that program's specific needs and regulatory approaches. Until recently, few attempts have been made to generate or use data across programmatic lines.

This must change. EPA must take a strategic, "big-picture" approach to the collection and use of environmental data. Our knowledge and technology have matured to the point where we can not only integrate EPA's various data systems, but we can also combine our data with information from other sources to create elegant, information-rich pictures, or models, of the environment as a whole.

Using powerful new supercomputers, for example, we can create global and regional climate models that use

Analyzing environmental information. EPA chemist Marta Lukasewycz examines a sample at the National Effluent Toxicity Center, Duluth, Minnesota, in Region 5. Using innovative methods, the Center's 20 chemists and biologists test samples collected from rivers and municipal water treatment plants.

Charles Curtis photo, Duluth News-Tribune.

existing data to help predict the effects of heat-trapping "greenhouse" gases and ozone-depleting chlorofluorocarbons in the atmosphere. Within a few years, as the next generation of ultra-fast computers becomes available, these models will become more and more precise and useful in projecting future trends.

On a somewhat more modest scale, EPA is developing geographic information and environmental

EPA must take a strategic, "big-picture" approach to the collection and use of environmental data.

modeling systems which combine many different kinds of data—population density, meteorologic and topographic data, location of drinking water aquifers, etc.—to identify sensitive populations and ecosystems which may be at risk from pollution. One example among many is the Office of Research and Development's proposed Environmental Monitoring and Assessment Program (EMAP), which would improve EPA's ability to assess the effects of specific pollutants on ecosystems, as well as the impact of EPA programs on mitigating any adverse effects.

All EPA programs must begin looking for creative new ways to make use of the information gathered by their counterparts in other programs and agencies—as well as new, multimedia data such as the toxic chemical release information now available through the Emergency Planning and Community Right-to-Know Act of 1986. This information can be invaluable in helping to define total pollutant loadings in this country—as well as the effectiveness of our efforts to minimize them. It can also help us improve our ability to anticipate and head off future environmental problems.

The Agency's new Information Resources Directory, which lists and briefly describes all of EPA's data systems as well as other information sources, is a step in the right direction. So is our new Comprehensive Assessment Information Rule (CAIR), which allows all EPA programs and other federal agencies to obtain the information they need on the manufacture, importation, and processing of chemicals of regulatory interest. The strategic information effort I have described, however, will require a new attitude on the part of *every* EPA program manager—a willingness to break out of the traditional constraints of media-specific and category-specific thinking.

A number of suggestions have been made for ways to institutionalize this strategic approach to environmental data, both to improve our existing activities and to identify areas that are not being addressed. One such idea is a proposal to create within EPA a semi-independent Bureau of Environmental Statistics, which would be charged with overseeing the collection, analysis, and dissemination of environmental data. Another proposal, made last fall by the Research Strategies Committee of EPA's Science Advisory Board, is the creation of an Environmental Research Institute. Among other things, the Institute would conduct ecological research and monitor and report annually on overall environmental conditions and trends.

These and other suggestions should be given careful consideration as we look for ways to focus our resources where they can have the greatest impact on reducing environmental risk.

Just as important, we must find ways to share our data more effectively with the people who paid for it in the first place: the American public. Eventually, as EPA makes progress in standardizing and integrating its information systems,

Sharing information with the public is an important step toward establishing a common base of understanding with the American people on questions of environmental risk.

the information in those systems—apart from trade secrets—should be as accessible as possible. Such information could be made available through on-line computer telecommunications, through powerful new compact disc (CD-ROM) technologies, and perhaps a comprehensive annual report on environmental trends.

Sharing information with the public is an important step toward establishing a common base of understanding with the American people on questions of environmental risk. As the recent furor over residues of the chemical Alar on apple products shows, there can be a wide gap between public perceptions of risk and the degree of risk indicated by the best available scientific data. When this happens, government can become preoccupied with responding to public outrage over sensational, well-publicized hazards at the expense of dealing effectively with less obvious, but perhaps more significant, risks to public and environmental health.

EPA must share and explain our information about the hazards of life in our complex industrial society with others—with other nations, with state and local governments, with academia, with industry, with public-interest groups, and with citizens. We need to raise the level of debate on environmental issues and to insure the informed participation of all segments of our society in achieving our common goal: a cleaner, healthier environment.

Environmental data, collected and used within the strategic framework I have described, can and will make a significant contribution to accomplishing our major environmental objectives over the next few years. Strategic data will help us:

- Create incentives and track our progress in finding ways to prevent pollution *before* it is generated.
- Improve our understanding of the complex environmental interactions tha contribute to international problems lik acid rain, stratospheric ozone depletion, and global warming.
- Identify threats to our nation's ecology and natural systems—our wetlands, our marine and wildlife resources—and find ways to reduce those threats.
- Manage our programs and target our enforcement efforts to achieve the greatest environmental results.

With respect to environmental data, then, our long-term goal is clear. In the future, when someone asks us if EPA has done an effective job of protecting the environment, we should be able to reply without hesitation: "You bet—and we can *prove* it!" □

(Reilly is Administrator of EPA.)

Speaking of Data: The Alar Controversy

by John A. Moore

USDA photo.

American consumers have experienced a veritable media blitz concerning the pesticide Alar (daminozide), a plant growth regulator that may be used on apples to postpone fruit drop, enhance the color and shape of the fruit, and extend storage life. Not accidentally, this media attention coincided with the release of a report entitled *Intolerable Risk: Pesticides in Our Children's Food*, published by the Natural Resources Defense Council (NRDC).

The public was alarmed to the point of panic. Worried mothers dumped apple juice down the drain, despite EPA's repeated assurances that such measures were unnecessary and inappropriate. Apples were banished from school cafeterias. Consumers were further unsettled and confused as points of disagreement between EPA and outside groups on the risks of Alar played in the press and on TV. As one measure of the general confusion, it was necessary for EPA to issue a statement—responding to a query from "60 Minutes" following the program's feature story on Alar—saying that the dietary cancer risks of Alar had been overstated by the NRDC report on the one hand, but were understated on the other hand by the apple industry in its rebuttal.

The initial panic has subsided somewhat, but an uneasy confusion remains, and it is still very difficult for the ordinary consumer to sort through the issues on Alar. Moreover, as a consequence of the Alar case, the public, sadly, is left with lingering doubts about the safety of our food

Growers have used Alar to help firm up apples and prevent overripening and early dropping. However, in the last three years, the apple industry has been moving away from Alar use. Red delicious apples are pictured at left.

supply and whether our pesticide regulatory system is adequate to protect it.

In general, consumers, understandably enough, have limited patience with extended deliberations by scientists and regulators over scientific data, and in the case of Alar there have been protracted scientific deliberations. While scientists and regulatory officials are concerned with questions of scientific uncertainty and qualitative versus quantitative aspects of risk assessment, consumers—who generally do not speak the language of risk assessment—tend to ask very direct questions. Is it safe to eat apples? Is it safe for my child to consume apple products? Does Alar cause cancer?

Public opinion, understandably, tends to be impatient with extended deliberations by scientists and regulators while health effects questions have been raised, but not resolved.

The answers to the first two questions, concerning the continued consumption of apples and apple products, are definitely *yes* in both instances.

Two questions are implicit in the third question. First, is Alar a known human carcinogen? The answer is no; scientists do not have direct evidence in humans that traces actual cancer cases to Alar exposure. In fact, there are comparatively few chemicals in the world which have been demonstrated beyond doubt, on the basis of epidemiological data, to cause cancer in humans.

Second, does Alar cause cancer in laboratory animals? The answer is yes; Alar and its breakdown product called unsymmetrical dimethylhydrazine (UDMH) have increased the incidence of tumors in mice. Moreover, EPA has recently received interim data from new cancer studies on Alar and UDMH; final reports from these studies are due to EPA in September 1989 and January 1990. On analyzing these interim results, Agency scientists found a direct correlation between exposure to UDMH and the development of malignant tumors in test mice.

Because of the implications of these new cancer data, on February 1, 1989, EPA announced its intention to initiate cancellation proceedings, through its Special Review process, for all food uses of Alar; a final decision, through this formal process, will be forthcoming by mid-1990. But again, from the *standpoint of concerned consumers*, what *are* these implications?

It is difficult to understand cancer risks—or any kind of risk, for that matter—without a meaningful frame of reference. For perspective, one of the key words consumers should keep in mind in the Alar case, and generally in cases of chemicals said to pose cancer risks, is *long-term*. In evaluating the risks of pesticides to consumers, EPA uses the working assumption that dietary exposure to the pesticide occurs over a lifetime (70 years). This is one of a number of conservative assumptions that EPA factors into its chemical risk projections.

Another key word in chemical risk assessment is *incremental*. Using widely accepted quantitative risk assessment "models," EPA calculates "upper-bound" (worst-case) estimates of incremental (increased) risks due to pesticide exposure, above the background cancer risk in the general population. The background (lifetime) cancer risk in the general population is roughly one in four, or 0.25 (2.5×10^{-1}). *It is also important to note that these* incremental risk estimates represent the upper bound of *theoretical* risks and reflect highly conservative assumptions used in the risk extrapolation process.

"Pass it along. Apples are back."

Steve Delaney photo.

Faced with widespread panic, grocery stores across the country tried to satisfy consumers by providing apples certified to be Alar-free.

Since theoretical risks are, by definition, upper-bound estimates, actual risks may be lower or even zero.

As an index for regulatory decisions, EPA's stated policy is that lifetime incremental cancer risks from exposure to a pesticide in the diet should not exceed one in one million or 0.000001 (1×10^{-6})—meaning a one-in-one-million risk over and above the background risk of one in four. This is the definition of "negligible risk" applied by EPA and the Food and Drug Administration.

Since there is really no such thing as a risk-free pesticide, FIFRA requires EPA to balance the risks of a pesticide against its socio-economic benefits . . . .

Based on the new cancer data that we now have, EPA has preliminarily estimated cancer risks from dietary exposure to Alar over a 70-year lifetime as an increased risk of 4 cases per 100,000 persons (4×10^{-5}). EPA deems this lifetime, 70-year risk to be unreasonable under the meaning of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This conclusion, which is consistent with the Agency's negligible-risk policy, has led the Agency to start Alar cancellation proceedings under the law.

The term *unreasonable* is important here and has a specific legal meaning under FIFRA, which sets a risk/benefit standard for the registration (licensing) of pesticides. Under FIFRA, a pesticide fails the risk/benefit test for initial or continued registration if, when used according to label directions, it presents "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide." In other words, since there is really no such thing as a risk-free pesticide, FIFRA requires EPA to balance the risks of a pesticide against its socio-economic benefits in the pesticide decision-making process.

In addition to the regulatory option of cancellation when a pesticide is found to pose unreasonable risks, the law gives EPA the authority to suspend the registration of the pesticide immediately if its continued, short-term use poses an "imminent hazard" during the time required to complete cancellation proceedings. In separate calculations, the Agency has also estimated lifetime cancer risks from exposure to Alar over the 18-month period EPA needs to receive final study results and conclude cancellation proceedings on Alar. For the general population this risk is estimated at an additional 8 cases per 10 million persons (8×10^{-7}). For children, the estimated lifetime risk from exposure for this period is 8 additional cases in one million (8×10^{-6}). These risk projections, for either children or adults, do not in EPA's best judgment represent an imminent hazard to consumers and thus do not warrant suspension action.

Again, it should be understood that the short- and long-term risk projections EPA has calculated for Alar represent theoretical risks. Because of highly conservative assumptions built into EPA's risk extrapolation process, actual risks may be lower or even zero.

EPA's assessment of Alar-related risks to children and other consumers is severely at odds with the conclusions presented in the report released on February 27, 1989, by the NRDC and widely promoted through a coordinated publicity campaign. In this report, the NRDC presented cancer risk projections for children, from dietary exposure to UDMH, that are up to 100 times higher than EPA's estimates. The report alleges that Alar and UDMH thus account for 90 percent of the pesticide-related cancer risk to children and concludes that American children face a "massive public health problem" from pesticide residues in foods.

How could the cancer risks posed by Alar, as extrapolated from scientific data, be open to such drastically different projections? The primary and greatest difference between EPA's and the NRDC's estimates arises from the fact that the NRDC used cancer potency estimates from data on UDMH which were rejected in 1985 by a FIFRA

Scientific Advisory Panel. Mandated by FIFRA, the Scientific Advisory Panel is comprised of outside experts convened by EPA to review scientific questions related to major pesticide decisions or regulations. Following a public meeting held in September 1985, the panel issued a formal opinion stating that the existing cancer studies on Alar and UDMH, while raising concerns about possible cancer risks, were inadequate for the purpose of either quantitative or qualitative risk assessment.

Following the panel's vote of "no confidence" in these cancer studies, EPA decided to postpone its final regulatory decision on Alar and, as an interim regulatory measure, took steps to lower the tolerance (maximum legal residue limit allowed under the Federal Food, Drug, and Cosmetic Act, or FFDCA) for Alar on apples and to reduce the application rates. Meanwhile, the Agency used its data-collection authorities under FIFRA to require the manufacturer to sponsor and submit new cancer studies for both Alar and UDMH. EPA's risk assessment of Alar is based on data from these new cancer studies.

In addition, the NRDC used recent (1985) data on food consumption from a small survey (2,100 people) which had a relatively poor completion rate (65 percent), and these data were inappropriately used in the NRDC calculations. For dietary risk assessment, EPA used data from a much larger survey of over 30,000 persons conducted by the USDA in 1977-78, which had a 95-percent completion rate. (This USDA survey is currently being updated to reflect 1987-88 data.) These factors together with a number of differences in procedures account for the vast differences between EPA's and the NRDC's assessment of Alar-related dietary risks—including the 100-fold difference in the estimated risk that Alar poses for children.

In summary, the NRDC report is gravely misleading for a number of reasons, including the NRDC's use of data that were rejected in scientific peer review together with food consumption data of unproven validity. The report also misleadingly alleged that EPA's analyses of pesticides in the diet fail to take into account that children and infants typically eat more food in relation to their body weight, and more of certain types of food, than the average adult. Generally the Agency bases its pesticide tolerance decisions on a composite average lifetime risk, which includes a proportionately greater exposure occurring in childhood. However, EPA also routinely calculates exposure values for the two most sensitive subpopulations identified by our computerized Tolerance Assessment System; these calculations allow us to ensure that no particular group—such as infants and children—receives exposure that is likely to cause unreasonable risks.

My own view is that the NRDC report struck a chord among consumers by providing "answers" in a case that EPA, facing scientific uncertainties, had not yet been able to bring to final closure under FIFRA.

EPA is also concerned about the possibility that children and infants may be more sensitive to toxic effects of pesticide residues in their diets than are adults. Scientific data to resolve this uncertainty are limited and inconclusive, and available studies actually show mixed results. EPA has commissioned the National Academy of Sciences to study this issue and make recommendations as to whether modifications are needed in the Agency's pesticide risk assessment process. We expect the report of this study in 1990.

Apropos of this issue of *EPA Journal*, and in the wake of the apple panic of 1989, what does the Alar case tell us about the applications of scientific data in the context of pesticide decision-making? On evaluating the overall weight of evidence that is now available concerning the dietary cancer risks associated with continued use of Alar, EPA has found the long-term risks to be unreasonable and, consequently, has taken steps to effect cancellation of the pesticide. Yet, to return to a point mentioned earlier, there are no "hard facts" on hand that directly link Alar with human cancer cases.

Moreover, Alar is not unusual in this respect. The truth is that hard evidence on the effects of pesticide chemicals is generally limited to those cases where short-term pesticide exposure has caused acute toxic poisoning in humans, or killed important non-target organisms in significant numbers. Such acute toxic effects are immediately apparent. Most risk scenarios are not so easy to assess, and this is especially true of chronic or delayed health effects such as cancer, reproductive dysfunctions, or effects on the unborn.

Such chronic or delayed effects do not become apparent for a long time, and when they do occur, it is almost always impossible to trace them with certainty to exposures to specific chemicals. Instead, the evidence at hand consists of the raw materials of risk assessment: animal data tabulations, cancer potency estimates based on animal study results, food consumption statistics, exposure estimates. As the Alar case has brought home, such data are susceptible to manipulation and may be used selectively and inappropriately to make calculations that misrepresent pesticide risks.

on the basis of informed judgments. As implied by this regulatory framework, we have decided, as a society, not to wait for conclusive evidence of widespread damage to health and the environment so that we can be absolutely certain of all the facts before we weigh the risks of a pesticide against its benefits.

Dealing with uncertainties in the regulatory process can be especially problematic for existing pesticides, such as Alar, which may remain on the market until EPA has gathered enough evidence to justify regulatory action under FIFRA. Under the law, the same health and ecological standards apply to both new and old pesticides. However, in dealing with new pesticides, EPA may withhold registration approval and keep the pesticide off the market as long as necessary to resolve uncertainties concerning its potential risks. With an existing pesticide, EPA must build a scientifically and legally defensible case as to whether the pesticide poses unreasonable risks before the Agency can take regulatory action.

For EPA, the Alar case has been problematic from a scientific and legal/procedural standpoint, and the Agency has tended to focus its attention primarily on resolving these problems, generally failing to anticipate a mounting problem in public perception. For the consumer public, on the other hand, I think it is fair to say that the Agency's ongoing review of Alar has been a lingering question mark without an answer. Public opinion, understandably, tends to be impatient with extended deliberations by scientists and regulators while health effects questions have been raised, but not resolved. Regarding Alar and the apple panic of 1989, my own view is that the NRDC report struck a chord among consumers by providing "answers" in a case that EPA, facing scientific uncertainties, had not yet been able to bring to final closure under FIFRA.

What can be done to avoid recurrence of the kind of confusion that prompted the Alar apple panic? I believe part of the answer lies in streamlining the cancellation process under FIFRA, and I have repeatedly stated the need for changes in the law to allow EPA to get a pesticide off the market more quickly and easily once a problem has been identified. This is particularly important as a follow-up to the 1988 amendments to FIFRA.

Is it really EPA's job, as a regulatory agency, to promote this kind of broad-scale consumer education effort? I believe the answer is yes . . . .

Under FIFRA '88, the review and "reregistration" of existing pesticides will be proceeding on an accelerated basis, to be completed in approximately nine years. Ultimately, this accelerated program will mean increased public confidence in pesticide regulation and the safety of the food supply, since all pesticides that remain registered must be supported by a complete data base. However, it is only realistic to expect that over the next few years, the accelerated review of existing pesticides will uncover risk concerns that will require resolution through EPA's Special Review process. As a result, it will not be surprising if pesticide issues are in the news with increasing frequency.

Finally, the Alar apple panic suggests a strategic failure of risk communication on the part of EPA and underscores the need for more comprehensive, more proactive public education and risk communication initiatives on pesticide issues than EPA has carried out in the past. In the Alar case, the public was very prone to give credence to the selective and inappropriate use of data regarding consumer risks and to believe "the worst" despite counterstatements from EPA. Clearly, consumers need a basic frame of reference for understanding pesticide issues if they are to become less vulnerable to alarmist publicity in the future.

Is it really EPA's job, as a regulatory agency, to promote this kind of broad-scale consumer education effort? I believe the answer is yes, if pesticide decision-making is to take place in an atmosphere that is relatively free of fear, confusion, and unnecessary economic disruption. Of necessity, I see consumer education and risk communication as increasingly an integral part of EPA's job. □

(Dr. Moore has served EPA as Assistant Administrator for Pesticides and Toxic Substances and as Acting Deputy Administrator.)

Editor's Note: As EPA Journal *went to press, Uniroyal Chemical Co. announced that all sales of Alar for food-crop uses are being voluntarily halted in the U. S. Uniroyal's voluntary stop-sale action will remain in effect until EPA has reached a final regulatory decision.*

What Kind of Data Does The Public Need?

What kind of data does the public need to evaluate the safety of chemicals in the environment? This issue comes up with increasing frequency in discussions of risk communication and recently enacted federal and state community right-to-know laws. EPA Journal asked three experienced observers to address the question. Their comments follow.

Elizabeth M. Whelan

Consider, for a moment, these chemicals: safrole, hydrazine, tannin, and ethyl carbamate. We ingest them every day when we consume pepper, mushrooms, tea, and bread. Now consider this: each of these chemicals is a naturally occurring carcinogen. Do they jeopardize human health? Should this information lead to a movement to eliminate tea, outlaw mushrooms, condemn pepper, and banish bread from our tables?

Of course not. Yet that's where a manipulation of the numbers, and a misinterpretation of the facts, can take us. The numbers can be made to show that a substance is killing us—even when there isn't the remotest possibility. How, then, can a mother be sure that her food-shopping purchases will nourish her family and not contribute to its morbidity?

If you listen to every restrictive environmental report that has received media attention, you know that in addition to apples, you shouldn't eat most other fruits, not to mention meats, fish, fowl, vegetables, eggs, or milk products. You shouldn't even drink the water. This begs the question, how can we make intelligent choices about risk?

Determining levels of safety in the environment, which is broadly defined to include lifestyle, must start with some basic premises. The first is that public health means preventing premature disease and death. The second is that public health policy should ensure safety, not harass industry or needlessly terrify the public.

What Americans suffer from is not a lack of data. It's something else entirely. The malady that needs immediate attention is called nosophobia. It's akin to hypochondria, but different.

Hypochondriacs think they are sick. Nosophobics think they will be sick in the future because of lurking factors in their diet and general environment. They fixate on an array of allegedly health-threatening gremlins. Due to this phobia, they believe that living—and eating and drinking—in America in 1989 is inherently hazardous to their health. They are sure there is a death-dealing carcinogen on every plate, a life-sapping toxin under every pillow. They see salvation only in ever-increasing federal regulations and bans.

The nosophobics' fears of Alar and other agricultural chemicals used in the United States are obviously purely emotional. These are fears of "invisible hazards," which have always played a special role in the mass psychology of paranoia, according to Park Elliott Dietz, Professor of Law and Psychiatry at the University of Virginia. Yesterday's invisible hazards gave rise to monster legends, claims of witchcraft, and vampire myths. Today, notes Dr. Dietz, we see the same phenomenon among those who exaggerate the hazards of radiation, chemicals, toxic waste, and food additives.

What Americans suffer from is not a lack of data. It's something else entirely. The malady that needs immediate attention is called nosophobia.

The most deadly public health issues that threaten our lives have been obscured in the face of trumped-up charges against the food we eat, the water we drink, and the air we breathe. They fall under the category of hazardous lifestyles. And the data detailing the toll they take on human lives—not the lives of laboratory rats and mice—are compelling and truly frightening.

Let's take a ride to Marlboro country. Cigarette smoking claims 1,200 lives a day. In just one year, over 400,000 will perish because they'd rather die than switch. Another obvious example of a hazardous lifestyle habit is excessive or abusive alcohol consumption, which claims 100,000 lives annually. Add to this the use of addictive substances, such as heroin, cocaine, and crack, which claim some 50,000 lives by each year's end.

These numbers are in. They aren't hypothetical. They aren't based on probability theories that require one to suspend disbelief. These data detail a real loss of life. Clearly, our focus should be on environmental lifestyle issues that, left unchecked, are systematically and prematurely killing our population. As a society, however, we seem more willing to assume the enormous and deadly risks of smoking or not wearing seatbelts—risks that are within our power to prevent. Ironically, what we appear to be unwilling to tolerate are the minute, infinitesimal risks we perceive to be outside our control. Today's prime example is the risk the public perceives when chemicals are married to food.

What most don't understand is that food is 100-percent chemicals. Even the foods on our holiday dinner tables—from mushroom soup to roasted turkey to apple pie—contain naturally occurring chemicals that are toxic when taken in high doses. Undoubtedly, there are some who may think we should start worrying about levels of allyl isothiocyanate in broccoli, because this naturally produced chemical is, in high doses, an animal carcinogen. Where does it end? Worrying about more numbers to focus more attention on non-issues accomplishes absolutely nothing. □

(Dr. Whelan is President of the American Council on Science and Health.)

David Roe

What's true of statistics is also true of chemical safety data: there are lies, there are damn lies, and then there are risk calculations.

The public emphatically does not need to be deluged with "the data" on health risks from chemical exposures, general or specific, and told to make up its own mind. This, in effect, is too often what happens now by default, particularly in controversial cases. The public is not interested in government's abandoning the responsibility for deciding where chemical regulatory limits lie.

What the public does want and need is a system that delivers a clear signal when a chemical exposure crosses a boundary from the trivial to the significant, like the red light above a hockey net that flashes when the puck enters the goal. The public also needs assurance that the system is hooked up and operating, so that the light goes on when the line is crossed, no matter which teams are on the ice. And people need to know that the line itself is not being curved back into the net, or even erased, just before the playoffs.

In other words, the public wants assurance that clear, consistent, and meaningful standards are in place and that those standards are being obeyed. This simple-sounding system is exactly what Congress, EPA, other agencies like the Food and Drug Administration, and their equivalents at the state level have been promising for the last 20 years, in the specific context of toxic chemical regulation. Part of the promise of such a system is that the data that ordinary citizens will be provided to evaluate the safety of chemicals in their environment will be a simple set of yes-or-no answers. Is there a red light and a goal line for that chemical? Is the system hooked up? And is the light flashing?

Of course, all this is easier said than done, as the last 20 years have shown. Progress on standard-setting has been excruciatingly slow. Enforceable numerical limits have been set at a rate averaging less than one chemical per year under key federal laws—the Toxics Substance Control Act (TSCA), the Safe Drinking Water Act, and the toxics section of the Clean Air Act. The standards that do exist have varied enormously in the amount of calculated health risk that they allow.

Is there a red light and a goal line for that chemical? Is the system hooked up? And is the light flashing?

In part, the reason is that calculation of health risks from toxic chemical exposures, based on the usual data, is genuinely uncertain and depends heavily on calculating conventions as well as direct results of laboratory experiments or epidemiological studies. As with the calculation of Gross National Product statistics, there is room for honest disagreement as to where the line should be drawn.

But another factor is at least as important in explaining the wholesale failure of chemical standard-setting over the last 20 years. Built into the structure of all of the major federal laws on toxic chemicals is a powerful disincentive to resolving disagreements and setting actual standards. In effect, under the prevailing legal structure, no enforcement (and thus no protection) whatsoever takes place with regard to a specific chemical until after a standard is set.

Industries responsible for the greatest excesses with a particular chemical, and the ones most worried about enforcement action therefore have a strong incentive to stall the process as long as possible. This means drawing out not only every scrap of honest potential debate over risk calculations but also trumped-up disputes and elaborate delaying tactics as well. The practical results of this incentive structure are only too apparent.

As long as clearly delineated, health-based standards for toxic chemicals are the rare exception rather than the rule, it is somewhat misleading to talk about the kinds of data that the public needs to evaluate the safety of chemicals in the environment. The answer is either "standards" or "all the elements necessary to calculate standards and consensus on the calculating methods." If the latter are available, of course, then the former will not be far behind.

Fortunately, the disincentives that inhibit standard-setting under conventional toxics laws are not immutable. A new law in California, designed with exactly this problem in mind, has created a structure in which industry is as eager as the public to succeed in setting standards for particular toxic chemicals. Passed by direct voter initiative in 1986, with first-stage enforcement beginning approximately one year ago, the law is commonly known by its ballot name: Proposition 65.

Under Proposition 65's new incentive structure, California's regulators managed to draw clear, numerical, health-based standards for more chemicals in 12 months than EPA had managed to address under TSCA in 12 years—in fact, more than twice as many. Most of the data on which the California lines were based came directly from EPA and other national and international bodies, which had long since completed critical evaluation of the research results; the difference was that, for once, there was a premium on getting to the bottom line.

Proposition 65 has also produced hundreds of pages of regulatory consensus on technical issues such as low-dose extrapolation models, exposure assumptions, and other elements of risk calculation, all now being applied in uniform fashion to some 280 different carcinogens and reproductive toxins. Perhaps most impressive to insiders is the fact that, despite intense controversy over these rules, not a single word of them has been challenged in court by any of the potentially affected industries. The contrast with federal agency experience concerning the same issues is dramatic.

Doing no more than adopting the methodological consensus and numerical standards that Proposition 65 has already generated would be a breathtaking leap of progress for EPA. But understanding why the new California law works the way it does, and incorporating its lessons into federal toxics laws, could have much greater impact. Proposition 65 has shown that gridlock over standard-setting is not inevitable, either scientifically or politically. To meet the public's needs, the top priority on the national level should be to catch up. □

(Roe is Senior Attorney with the Environmental Defense Fund.)

Ronald F. Black

Chemical companies are currently perceived by the public as "problem-creators" more often than problem-solvers. Some of the problems attributed to our industry—like the accident in Bhopal, India—are real; some are imagined. The mistrust, however, is very real.

This mistrust of industry is complemented by a general mistrust of government, particularly regulators, at the federal, state, and local levels. Public frustration over the perceived lack of progress in solving environmental problems has spawned "regulation by information" as the new environmental battle cry.

The first of these new laws are on the books, and volumes of information flow to EPA, state environmental agencies, and local emergency groups. The submissions provide page after page of data about chemical releases into the environment.

The news media already have begun dutifully reporting "the numbers." The Subcommittee on Health and Environment of the U.S. House of Representatives has fired its first salvo demanding emissions reductions. Government officials have expressed shock at emissions levels. The chemical industry has attempted to place the numbers in perspective. How the public will react, remains to be seen.

What kind of information, beyond raw numbers, does the public need to be able to draw its own conclusions regarding chemical releases? The question goes to the heart of regulation by information. Several kinds of supplemental information come to mind:

- *Health-Based Criteria:* Health-based criteria are the foundation upon which risk evaluations can be made. Merely knowing the amount of material released by a chemical plant does little to enlighten either risk managers or the public. An annual discharge of 1,000 pounds of a carcinogen, for example, is meaningless without some reference to the increased chances of contracting cancer.

Unfortunately, little information concerning the relationship between the volume of chemical releases and its potential impact on human health has been made available to the public. Without this information, people are likely to react to the sheer magnitude of the numbers.

- *Exposure Assessments:* Another factor that would assist the public's ability to make judgments is actual exposure to chemicals released into the environment. Any release of chemicals from a facility into the air, water, or land poses a potential risk to people and the environment. However, the amount and nature of substances being released are meaningful only when translated into public exposure levels: the amount of these materials that can reach people.

The importance of the exposure factor holds true for all environmental media: ambient air, drinking water, ground water, etc. Most exposure projections come from computer models that predict potential exposure to the public. These predictions use the traditional strategy of "overestimating" exposure and are designed to provide margins of safety. The models are, by their very nature, complex, difficult to understand, and even more difficult to communicate. However, if people are to judge their exposure to chemicals, this information is vital.

- *Incident Information:* In addition to statistics on routine chemical emissions, the public needs information when something goes wrong—when an accident happens and an instantaneous release occurs. When accidents happen, and they will, there is little time for industry and regulators to compute human exposure; immediate answers are demanded.

Information on accidental releases should be shared with the public, regardless of whether there is an impact on human health.

Information on accidental releases should be shared with the public, regardless of whether there is a impact on human health. This includes the "raw" numbers and some explanation of their impact on the community. To prepare for these events, chemical facilities should routinely perform accident simulations in order to predict possible impacts. The information gleaned from such simulations should be shared with the public.

- *Emissions Reduction:* The chemical industry must also continue to communicate, not only concerning its criteria for determining what it deems to be acceptable levels of exposure, but its plans for reducing releases. Several companies have announced emissions-reduction goals, some after soliciting community input. Information about what the industry is doing to reduce releases helps provide a realistic context for evaluating potential exposure. It can also engender public support for the efforts being made.

- *Risk Management Systems:* Finally, the public needs to see how industry has structured its risk management systems. These systems are not new, but they haven't been talked about. There is one possible explanation for the industry's traditional lack of communication on these systems: in order to explain how a facility manages risk, the existence of risk must first be acknowledged. This remains a very uncomfortable concept for many facility managers. However, the risks do exist, they are being managed, and we must learn to talk about them.

Maintaining the confidence of our constituencies is a major challenge for the chemical industry. Stewardship implies a responsibility that transcends legal requirements: it means earning trust and cooperation from others; it means listening to concerns and sharing information.

In industry's defense, let me say that major strides have been made in recent years to break down communication barriers. A good example is the Chemical Manufacturers' Association's Community Awareness and Emergency Response Program, which has improved communication concerning many chemical facilities in this country. The Association's new Responsible Care Program will build on this initiative, heralding a new era of openness.

If we can demonstrate that we can operate facilities safely, and if we continue to look outward to the community and seek opportunities to communicate effectively, we can begin to gain social legitimacy. By meeting the communication challenges of "regulation by information," we may find a better way to live and work together. □

(Black is Corporate Environmental Manager for the Rohm and Haas Company, a U.S. chemical firm.)

Right-to-Know: What It Can Mean for Citizens

by Susan G. Hadden

Photo provided courtesy of Washington Convention and Visitors Association.

In Thomas Jefferson's vision of democracy, an informed citizenry participates actively in the political process. Since Jefferson's time, however, society has become considerably more complex, and it has become increasingly difficult for citizens to keep informed about public policy-related issues, especially those that require an understanding of scientific or technical information.

In the twentieth century, government has gradually assumed much greater responsibility for making information available to citizens, particularly information concerning risks to health and the environment. In fact, information has become an important means of regulating risks in the workplace and from consumer products. For example, many consumer products carry requisite labeling that provides information about safe storage and use, and many food products must display ingredient labels.

The chemical reporting requirements of Title III create a vast new resource of data about the presence of potentially hazardous chemicals in communities. . . .

In 1986, Congress enacted the Emergency Planning and Community Right-to-Know Act—also known as Title III of the Superfund Amendments and Reauthorization Act (SARA)—which extends a late twentieth-century Jeffersonian approach to the risks posed by hazardous chemicals in our communities. Title III, as the new statute is often called, contains a number of new provisions related to emergency planning, emergency notification, and a Toxic Chemical Release Inventory as well as Community Right-to-Know reporting on chemicals.

Thomas Jefferson believed that the democratic process depends on informed citizens. In our modern technological age, it is particularly difficult for citizens to stay informed concerning complex issues such as environmental quality.

Responding to community concerns about chemicals in the environment, Monsanto Company's Chairman and Chief Executive Officer Richard Mahoney has pledged to reduce air emissions by 90 percent by the end of 1992. At right, the company's W. G. Krummrich Plant in Sauget, Illinois, across from downtown St. Louis.

The chemical reporting requirements of Title III create a vast new resource of data about the presence of potentially hazardous chemicals in communities, and this new resource opens up a vast opportunity for citizens to assume a stronger role in environmental affairs. However, the new law also raises important questions about the respective roles of government, citizens, and the private sector in monitoring, disseminating, and interpreting data. For example, who should be responsible for analyzing Title III data? Who should ensure that the analysis is balanced?

Title III is a complex statute that differentiates among three categories of hazardous chemicals, mandates three different kinds of reports and several reporting formats, and embodies multiple goals. Since it was passed in part as a response to the accidental release of a highly toxic chemical in Bhopal, India, in 1984, one important purpose of Title III is contingency planning by state and local governments as well as commercial facilities for emergencies involving hazardous chemicals. Facilities subject to Title III requirements include such diverse establishments as warehouses, drycleaning and manufacturing establishments, and hardware stores.

Title III requires facilities to report to new Local Emergency Planning Committees concerning the storage on their premises of "extremely hazardous" chemicals in amounts over a "threshold" quantity. These local committees are charged with developing emergency response plans, using this storage information as well as other information they may request from facilities. Emergency reporting, a second purpose of Title III, is achieved by requiring facilities to report whenever they accidentally release these hazardous chemicals.

Facilities must also submit annual hazardous chemical inventories, covering a much greater number of chemicals at higher thresholds, both to assist local planning committees and to enable citizens to learn about the chemicals present in their communities. Finally, manufacturing facilities must annually submit an emissions inventory detailing emissions into air, water, and ground of certain toxic chemicals. EPA is charged with compiling these emissions data in its Toxic Chemical Release Inventory and making this information available to the public in electronic as well as other forms.

Title III and other similar laws raise a number of questions about who should have responsibility for turning data into information.

Since it has previously been difficult to learn the identities of chemicals stored and emitted by local facilities, Title III has given citizens access to important new data. The first chemical inventories were submitted in March 1988, and the first emissions inventories in July 1988. The sheer complexity of the law's reporting requirements may adversely affect the consistency, quality, or utility of the data, at least in the first few years of the program. Nevertheless, citizens have already begun to use the information in a variety of ways.

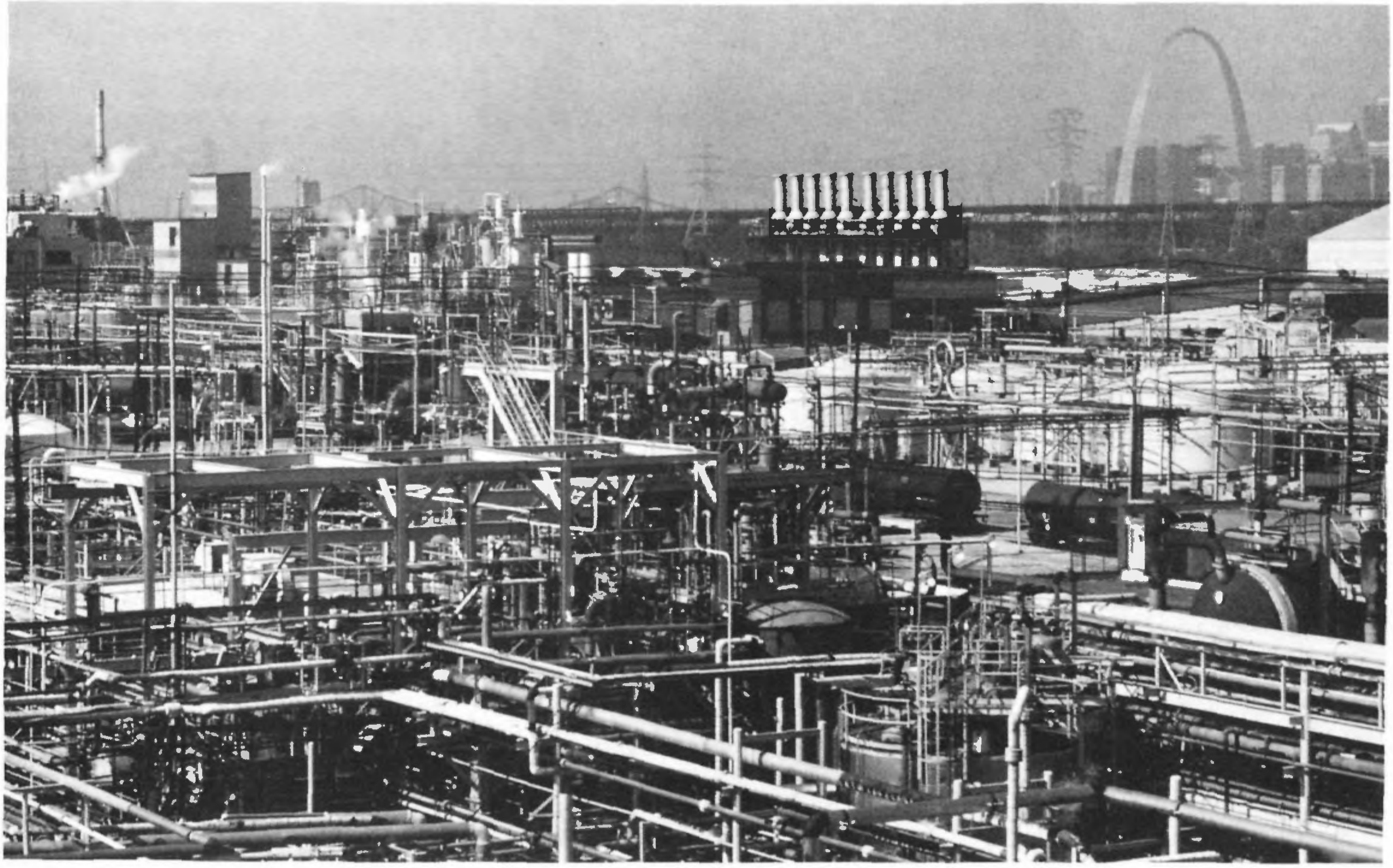
It is not unusual for community and environmental groups to band together temporarily to combat a perceived hazard in the community. In many instances, such community action committees have worked with their Local Emergency Planning Committees to conduct assessments of the hazards posed by particular facilities. Focusing first on the facilities storing the most (or the most toxic) chemicals, citizens have asked industry to create scenarios illustrating what would happen if an accident occurred.

Such scenarios typically include, for example, the plotting of plumes showing how chemicals would disperse in air and an analysis of whether and how especially vulnerable persons like children and the elderly would be affected in an emergency. Appropriate emergency plans are also developed. Many citizens have taken tours of local facilities and learned how chemicals are being stored. They have begun working with facilities to achieve reductions in inventories of hazardous chemicals stored in large quantities.

Although the chemical inventories constitute the largest part of the data collected under Title III, the Toxic Chemical Release Inventory emissions data have drawn the greatest attention from the press and the public.

Anticipating public concerns about the quantities of emissions that they would be reporting on July 1, 1988, several major companies previously announced plans to reduce their emissions over several years by amounts ranging from 50 to 90 percent. Conversely, in one neighborhood near Houston, Texas, citizens are working directly with a local plant to develop an emissions-reduction plan, using the emissions report filed in July 1988 as the basis for their negotiations.

Other citizens are more interested in using Toxic Chemical Release Inventory data to develop a picture of conditions area-wide or industry-wide. The Massachusetts Public Interest Research Group, for example, compiled state-wide emissions data based on the



Monsanto photo.

following factors: location by city, potential adverse health effects, and disposal sites. The group then helped draft a bill, introduced in the state legislature, designed to accelerate adoption of pollution-prevention strategies by industry.

In another example, a national public interest group, OMB Watch, used the emissions inventory data to obtain an overview of routine emissions of heavy metals, which can cause a range of adverse health effects in humans.

Citizens for a Better Environment examined the chemicals emitted in Richmond, California, identifying facilities responsible for the greatest amounts of emissions and the most hazardous chemicals both stored and emitted. This group noted that lower income and minority citizens are most at risk, because they live nearest to the facilities.

Another California group, the Silicon Valley Toxic Coalition, is focusing on the semiconductor industry, examining industry-wide patterns in emissions. All reports of these groups call for citizens to work with industry to obtain reductions in both use and routine emissions of toxic chemicals as well as to develop strong accident-prevention programs.

Citizen groups are also investigating how Title III data can be used in local enforcement efforts. For example, many of them have suggested correlating emissions inventory data with the air and water permits of each facility. In many cases, however, the permits may not mention the particular chemicals

Citizens have already begun to use the information in a variety of ways.

that are reported under Title III. An alternative approach, now being explored in Texas, is to compare the emissions data with the chemical inventories, in order to identify any possible inconsistencies. Apparent inconsistencies would then lead citizens to question facilities about substances stored in large quantities but not cited in the emissions data; even more concern might be aroused by substances reported to the emissions data base but not included on the chemical inventories. Obtaining answers to such questions will require citizens to work closely with industry and government.

These kinds of activities, which are going on throughout the nation, suggest the important opportunities that the new data available under Title III provide citizens to become involved in monitoring and reducing risks from hazardous chemicals in their environments. However, raw data and statistics do not constitute useful information. Such data must be analyzed and placed in context to provide information that can be the basis for citizen participation in decision-making. Title III and other similar laws raise a number of questions about who should have responsibility for turning data into information.

First, citizens who wish to take an active role in reducing risks from hazardous materials in their communities need information beyond that submitted under Title III. The precise nature of this supplementary information is beyond the scope of this article, but it is clear that at the very least, citizens need detailed information about the potential health effects of chemicals and information about appropriate storage, use, and disposal techniques. Should government, industry, or someone else be responsible for providing this supplementary information?

For citizens who are in potential danger, it is unquestionably worthwhile to obtain the necessary information to reduce their risks; on the other hand, it is a waste of resources for many different citizens to duplicate the same searches for information. Another factor to be considered is that citizens do not trust all sources of information equally; they generally prefer information that comes from environmental groups or, in the case of health effects information, physicians.

In many cases, however, industry is likely to have a monopoly on the necessary information. Should government step in to evaluate the quality of supplementary information and ensure its availability? If the answer is "no," and if citizens are unable to acquire or use the supplementary information, they will not be able to participate fully in the decision-making process.

Second, although Congress ensured that Title III emissions inventory data would be computerized, it did not require that the inventories of stored chemicals also required under the statute be computerized. The same advantages derived from computerized emissions data would also apply if the other data were computerized. These advantages include expanded capability for data analysis, more effective community-wide emergency planning, and better, speedier emergency response. In short, computers can help turn data into information by sorting out data based on the needs of the particular user, analyzing the data selected, and even providing needed context.

At present, computerization at the state and local levels depends on the availability of resources, and there is no way to ensure that local data are compatible with data compiled by neighboring constituencies. In cases where Local Emergency Planning Committees cover small geographic areas, such as those near Boston Harbor or in New Jersey, citizens and emergency response planners are likely to need information from neighboring jurisdictions because they could so easily be affected by events at plants in adjacent areas. Should an effort be made to link existing emergency response networks to Title III data and to each other to ensure that statewide or even national data are available to everyone? Who would pay for such an effort, and how should such a data base be constructed to be useful and meaningful?

The role citizens play in decisions about the acceptability of risks from hazardous chemicals in the community is changing . . . from ignorance and impotence to knowledge and power.

Third, Title III provides data so that citizens may participate more fully in decisions concerning hazardous materials in their communities. However, our society does not presently have many institutions that encourage interactions between citizens and private industry. Existing institutions for citizen participation are usually intended to foster direct access to government rather than industry. The Community Awareness and Emergency Response program (CAER) sponsored by the Chemical Manufacturers Association—part of which includes an effort to remedy this institutional deficiency—has, in practice, focused more on reducing risk and developing emergency plans than on establishing ongoing relationships between member companies and citizens other than elected officials.

Local Emergency Planning Committees, which by law must include representatives from all three sectors—citizens, government, and industry—could serve as forums in which decisions are made about risks from hazardous chemicals. At present, most local committees are absorbed with their primary statutory tasks of emergency planning and emergency response, but with some encouragement and assistance, their responsibilities could be expanded to include negotiation about emissions reduction and the substitution of less hazardous for more hazardous chemicals. If appropriate channels are not developed, these decisions are likely to become subject to an adversarial process that will be costly and time-consuming for all parties.

Title III has provided citizens, emergency managers, and regulators with a rich new source of data. So far the reports concerning citizen initiatives around the country indicate that the data are likely to be used to a greater extent once this new resource has been available longer and citizens have had an opportunity to become familiar with its strengths and weaknesses. Even these early activities are evidence, however, that the role citizens play in decisions about the acceptability of risks from hazardous chemicals in the community is changing: a change from ignorance and impotence to knowledge and power. Fully realized, this change will have widespread effects on both our environment and our polity. ☐

(Dr. Hadden is Associate Professor at the Lyndon B. Johnson School of Public Affairs, University of Texas at Austin. She is author of A Citizen's Right to Know: Risk Communication and Public Policy *(Westview Press, 1989).)*

Right-to-Know: What It Means for EPA

by Charles L. Elkins

Epichlorohydrin is a caustic, flammable chemical used in the production of epoxy resins, solvents, plastics, and other products. Breathing its vapors can irritate your eyes, nose, and lungs. High-level or repeated exposure can damage your liver and kidneys and could cause a fatal buildup of fluid in your lungs.

What's more, breathing epichlorohydrin has been shown to cause nasal cancer in laboratory rats. Based on these and other animal studies, EPA has classified epichlorohydrin as a "probable human carcinogen."

Sound like a good candidate for regulation by EPA? Not necessarily. With effects such as these, the key question is: how extensive is public exposure to the substance? Until recently, data available to EPA did not indicate that significant numbers of people were being exposed to epichlorohydrin.

Now, however, thanks to information in a new EPA data base called the Toxic Chemical Release Inventory (TRI), EPA's Office of Air and Radiation is taking another look at epichlorohydrin. The reason: TRI data show that there are at least three times as many manufacturing plants releasing epichlorohydrin into the air in the United States as the Agency had previously estimated. According to the data base, 70 facilities in 24 states emitted a total of 363,300 pounds of epichlorohydrin into the air in 1987. Before the TRI data were available, EPA had identified only 20 sources of epichlorohydrin emissions.

Locating previously unknown sources of toxic chemical releases is only one of dozens of potential uses of the TRI that are being identified by EPA's various programs. Other uses include:

- The Air Office has used TRI data to support the development of administration proposals to amend the air toxics provisions of the Clean Air Act. In addition, the Air Office and the Office of Solid Waste will use the data to help set their regulatory agendas.
- The Office of Water plans to use the TRI to spot possible violations of water-pollution discharge permits; to target enforcement activities; to help in reviewing permit requests; and to set water quality standards.

EPA received about 75,000 reports from some 18,000 facilities for 1987—one for each chemical reported by each facility.

- The Office of Toxic Substances is screening TRI data to locate candidates for regulatory investigation under its existing chemicals program and to verify production estimates for asbestos and other regulated chemicals.
- The Pollution Prevention Office expects to use the TRI in developing its strategy for assessing progress in pollution prevention; to determine research needs; and to identify industries or facilities that need technical assistance.

The toxic chemical release data, which must be submitted to EPA and the states every year by thousands of manufacturing facilities across the country, are providing EPA with an unprecedented national "snapshot" of toxic chemical emissions from some industries to all environmental media—air, water, and land.

The reporting is required by Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (Title III of the Superfund Amendments and Reauthorization Act). The Act also requires industries to participate in contingency planning for chemical emergencies and to notify their states and communities of the presence and accidental release of hazardous chemicals.

As envisioned by Congress, a primary purpose of the Emergency Planning and Community Right-to-Know program is to inform communities and citizens of toxic chemical hazards in their own localities, so they can work together to reduce risk. Used in this way, TRI and other Title III data can be a potent force for environmental change.

A unique aspect of the TRI is that it is made available to the public directly, without analysis or interpretation by EPA or any other intermediary (see box). As discussed in another article (see page 13), citizens already are using the data to lobby for stronger federal and state regulation of toxic chemicals. They also are using this new information to pressure local industries to implement pollution prevention programs in order to cut back on unregulated releases. Several companies, after reviewing their own TRI reports, have announced ambitious plans to voluntarily reduce their toxic chemical emissions within the next few years.

Because of its multi-media nature, however, the TRI has potential value that extends well beyond the boundaries of individual facilities and local communities. It can also be a valuable source of information for environmental regulators and public health officials at all levels of government.

EPA and the states can, for example, use the information to better understand what toxic chemicals are released and where, in order to get a more complete picture of the total toxic loading in a given geographic area. With this information, regulatory agencies will be able to set priorities, focus their activities, identify gaps in regulatory

The worst industrial accident in history occurred in Bhopal, India, in 1984, when methyl isocyanate leaked from the Union Carbide plant. The U.S. Emergency Planning and Community Right-to-Know Act was passed largely as a result of the Bhopal disaster. Below, survivors who were exposed to the chemical line up for free medicine.

Reuters/Bettmann News photo

coverage, and integrate their programs more effectively. EPA has prepared a "risk screening" guidebook to help state and local officials use the TRI data for these purposes. Other documents, including toxicity fact sheets on the TRI chemicals and "roadmaps" to other sources of information, also are being distributed.

The TRI also will make it easier to monitor pollution trends from year to year, as well as shifts of pollutants among air, land, and water (to determine, for example, if restrictions on land disposal cause greater releases to air, or vice versa). Before the TRI, much of this information had never been collected, and what *was* collected was scattered in separate, mostly incompatible, EPA program files.

The first industry reports under Section 313 were due to EPA and the states last July 1, covering both accidental and routine releases of more than 300 reportable chemicals during 1987. Manufacturing facilities with 10 or more employees that used more than 10,000 pounds of one of the chemicals, or manufactured or processed more than 75,000 pounds of a reportable chemical, were required to report. The 75,000-pound threshold drops to 50,000 pounds for 1988 releases and to 25,000 pounds for 1989 and thereafter.

EPA received about 75,000 reports from some 18,000 facilities for 1987—one for each chemical reported by each facility. The reports showed that at least 2.7 billion pounds of toxic chemicals were emitted into the air in 1987, 9.7 billion pounds were released to streams and other bodies of water, 2.4 billion pounds were placed in landfills or otherwise disposed of on land, and 3.2 billion pounds were injected underground. In addition, an estimated 1.9 billion pounds of toxic chemicals were sent to municipal wastewater treatment plants for processing and disposal, and 2.6 billion pounds were transported off site to other treatment and disposal facilities.

While these numbers are large and clearly indicate the need for additional efforts by both government and industry to reduce toxic chemical emissions, they do not suggest an immediate public health crisis. In fact, the overall risk to the public health from these releases is probably low. It is likely that only a few facilities are exposing the public to toxic chemicals at a rate that could warrant immediate action; others, however, may be creating risks due to long-term, low-level exposures, and these must be dealt with as well.

From a regulatory standpoint, the value of the TRI data lies primarily in their ability to pinpoint specific facilities, industries, or geographic areas of particular concern for further investigation and follow-up action. For example, the information can call attention to a facility or category of facilities that may be releasing excessive amounts of toxic chemicals.

It is important to note that the data are only annual *estimates*, not measurements of actual releases. No additional monitoring by reporting companies is required by the law. Nor does the TRI show the relative toxicity of the chemicals or the rate at which they are released, although EPA will consider adding reporting on "peak releases" to the inventory in the future. (Some high-volume chemicals, such as sodium sulfate, are relatively harmless and are scheduled for removal from the TRI list of reportable chemicals.) If an inventory user is concerned, for instance, about acute exposures rather than bioaccumulation, he or she would want to know whether most of the emissions were discharged in a few days or over the course of the entire reporting year.

Despite these limitations—which will diminish over time as companies improve their estimation techniques and as EPA takes steps to improve the accuracy and usefulness of the data base—Title III is nothing less than a revolutionary approach to environmental protection. It fundamentally challenges the notion that decisions about the control of toxic chemicals should be left to the "experts" in government, industry, and academia.

Since Title III data are made available to the public and EPA at the same time, the program creates a new opportunity for a working partnership between the public and the Agency. By sharing information, the public and EPA can also share in finding solutions—for example, by developing new programs to identify options for reducing the production and use of toxic chemicals. The development of a creative new partnership involving EPA, state and local governments, and the public may, in fact, be the most important benefit of all to flow from the Emergency Planning and Community Right-to-Know program. □

(Elkins is Director of EPA's Office of Toxic Substances.)

How To Obtain Emissions Data

EPA's Toxic Chemical Release Inventory (TRI) data base is being made available directly to the public through computer telecommunications and other means. Here are some of the ways members of the public can obtain information from the TRI:

- If you have a home computer and a telephone modem, you can "dial up" the data base, which is housed at the National Library of Medicine (NLM) in Bethesda, Maryland, and review the data on your monitor or "download" it onto a computer disc or printer. A nominal access fee will be charged. For information on obtaining an account with NLM, call 301-496-6531.
- If you have access to a microcomputer, you can obtain TRI data for each state on diskettes.
- You can review microfiche copies of data on TRI releases in your state either at the Government Printing Office (GPO) federal depository library in your Congressional district or at a designated public library in your county. The complete national data base will be available at EPA libraries and at regional and state depository libraries. Call the toll-free Emergency Planning and Community Right-to-Know Hotline at 800-535-0202 (in Washington, DC, 202-479-2449) for the address of the library with TRI data nearest you.
- The national data base will also be available in compact disc (CD-ROM) format at 400 federal depository libraries, 200 other research and academic libraries, and all EPA libraries. The Hotline can help you locate these libraries as well.
- EPA is publishing a National Report with detailed summaries and analyses of the TRI data. The report will be available at the federal depository libraries or can be purchased from GPO or the National Technical Information Service (NTIS). In addition, all versions of the TRI data base—magnetic tape, CD-ROM, microfiche, and diskettes—can be purchased from GPO (202-275-2091) or NTIS (703-487-4650). Call the Hotline for ordering information.
- You can obtain copies of TRI reports for individual facilities from your State TRI Coordinator. The Title III Hotline can tell you who to contact.
- Finally, the TRI Reporting Center in Washington, DC, will make data from individual facilities available in its reading room, will mail out limited numbers of TRI reports, and will conduct limited searches of the data base and provide printouts on request. The Reporting Center's address is: Title III Reporting Center, P.O. Box 70266, Washington, DC 20024-0266 (Attn: Public Inquiry).

On the Scene with CAMEO

by Jean Snider and Tony Jover

Not long ago, fire department personnel responding to fires or other incidents involving hazardous materials were severely hampered by a lack of information. More often than not, they didn't know either the nature of the chemicals involved or the problems they would face on arrival at the scene.

Today, such lack of information need no longer be a problem. Computerized emergency and chemical information data systems are available to provide the vital information, even before the response team gets to the fire or hazardous material spill.

CAMEO—which stands for Computer-Aided Management of Emergency Operations—is one of these systems. A computer program developed by the National Oceanic and Atmospheric Administration (NOAA) and EPA to help firefighters and emergency managers respond effectively to HAZMAT incidents, CAMEO is already being used by about 3,000 fire departments and emergency management agencies. The Macintosh version of CAMEO contains response recommendations for over 2,600 chemicals, an air dispersion model, and the capability to access local maps and information stored in the community—information required to be provided to local government and response personnel under the Title III Emergency Planning and Community Right to Know amendments to Superfund.

How does this emergency information system work? Just suppose you are fictional fire lieutenant Joe Sackler when the firehouse bells sound at 2:35 A.M. . . . Sackler jumps from his bunk and wipes the sleep from his eyes. It was only a short catnap, but it sure has helped; in the last 10 hours, he and his crew have been through several fire runs and one hazardous material incident. Now the bells and the public address system are signifying another HAZMAT problem: a strange sulfur-like smell being reported by people living near the Freeland Chemical Company.

As the fire officer pulls his boots on, he thinks about the way HAZMAT runs used to be—and how they have changed over the past two years. Formerly, firemen responding to a hazardous materials incident or a fire involving chemicals had no idea what they might encounter when they arrived on site. This was especially true when the incident was at one of the smaller, marginally profitable companies. On "pre-fire" visits to such facilities to determine what chemicals might be stored on the site and the location of fire hydrants, fire department inspectors were often rebuffed by owners who said, in effect, "Trust us, we are safe operators and will take care of any spills on our property. The people who live around here won't be affected."

CAMEO is already being used by about 3,000 fire departments and emergency management agencies.

Although most plant operators are responsible and cooperative, one bad incident involving a "fly-by-night" operator was enough to convince the lieutenant that his department must have all available information in its possession and readily accessible when the alarm sounds. In the past, it was simply too uncertain and nerve-wracking to depend on others to provide it after the firefighters reached the scene—assuming, of course, that someone was there on site with the necessary information.

But now things are different. Lieutenant Sackler has his Mac (nickname for the Macintosh computer)! He jumps into the back of the HAZMAT van as the driver pulls out of the firehouse. While the driver switches on the siren and flashing lights, Sackler turns on his computer and calls up his CAMEO system. The sooner he knows what problems they face, the better off they'll be.

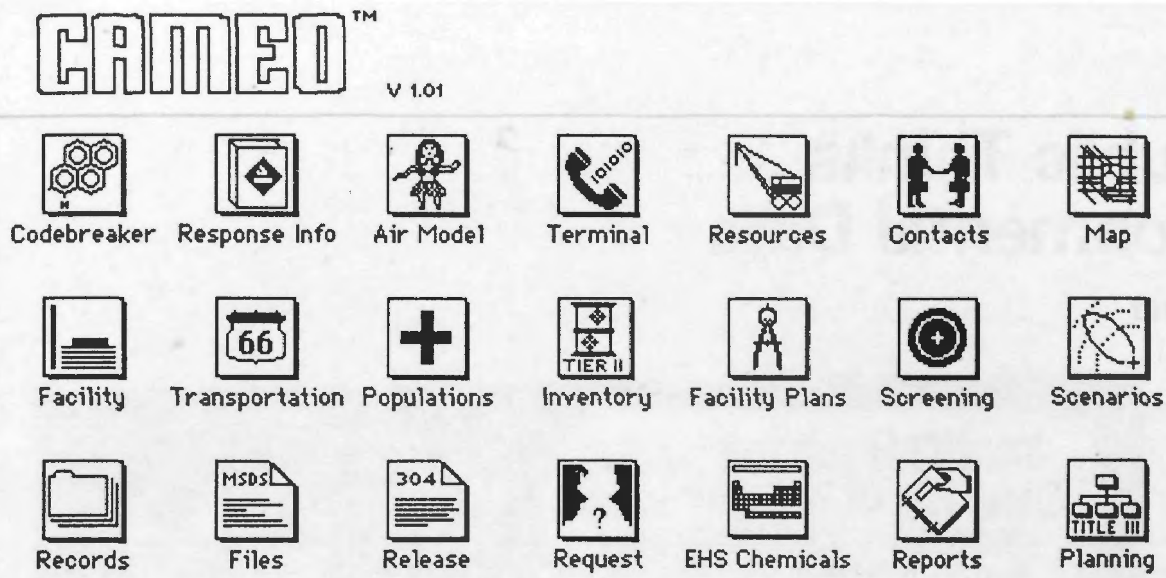
As the van races down the street and the sirens wail outside, Sackler hears the familiar sound of the computer warming up and sees the smiling face on the Macintosh before CAMEO's opening screen comes up. This is the "Navigator," which allows him to select the data base he needs by a simple click of the mouse, pointing to the picture representing the data base he wants. First, he reads what chemicals Freeland Chemical has stored on its premises. Next, he learns the name of the company contact person and how to reach him if he is not already at the site, in order to verify the chemical identification.

Fortunately, his Captain previously insisted on stepping up efforts to survey the chemical plants in the community, especially since new federal laws provide additional leverage to collect critical information from chemical facilities on what hazardous chemicals were stored in the community, and to plan for possible accidents. As a result, the information is in his CAMEO program, organized in a logical retrieval form, including recommendations for response actions. The new law—popularly known as SARA Title III—and the computer program have certainly reduced much of the uncertainty associated with past HAZMAT runs.

From the CAMEO screen, Sackler learns that Freeland has a number of nasty substances that could produce a sulfur smell. He checks out methyl disulfide and sulfur tetrafluoride to see which would be the more likely culprit and what types of problems these particular chemicals might cause firemen trying to control the situation.

The van sways as the driver races over potholes and around corners. The lieutenant wishes his boots were bolted down, like the computer. CAMEO has more to tell him: only sulfur tetrafluoride is a gas and likely to give off a sulfur smell. And, says CAMEO, to control a spill the firemen are going to have to suit up in full gear with protective breathing apparatus AND NOT USE WATER!

Next question: where is the stuff stored (and what would be a good staging area)? Click, and the screen shows the facility site plan. More questions: Who would be affected by the fumes? The worst-case scenario run several months earlier had shown several schools in the area, although they would not be in session at this hour, and hospitals are out of range of the airborne plume, given the amount of the chemical stored by Freeland. But a



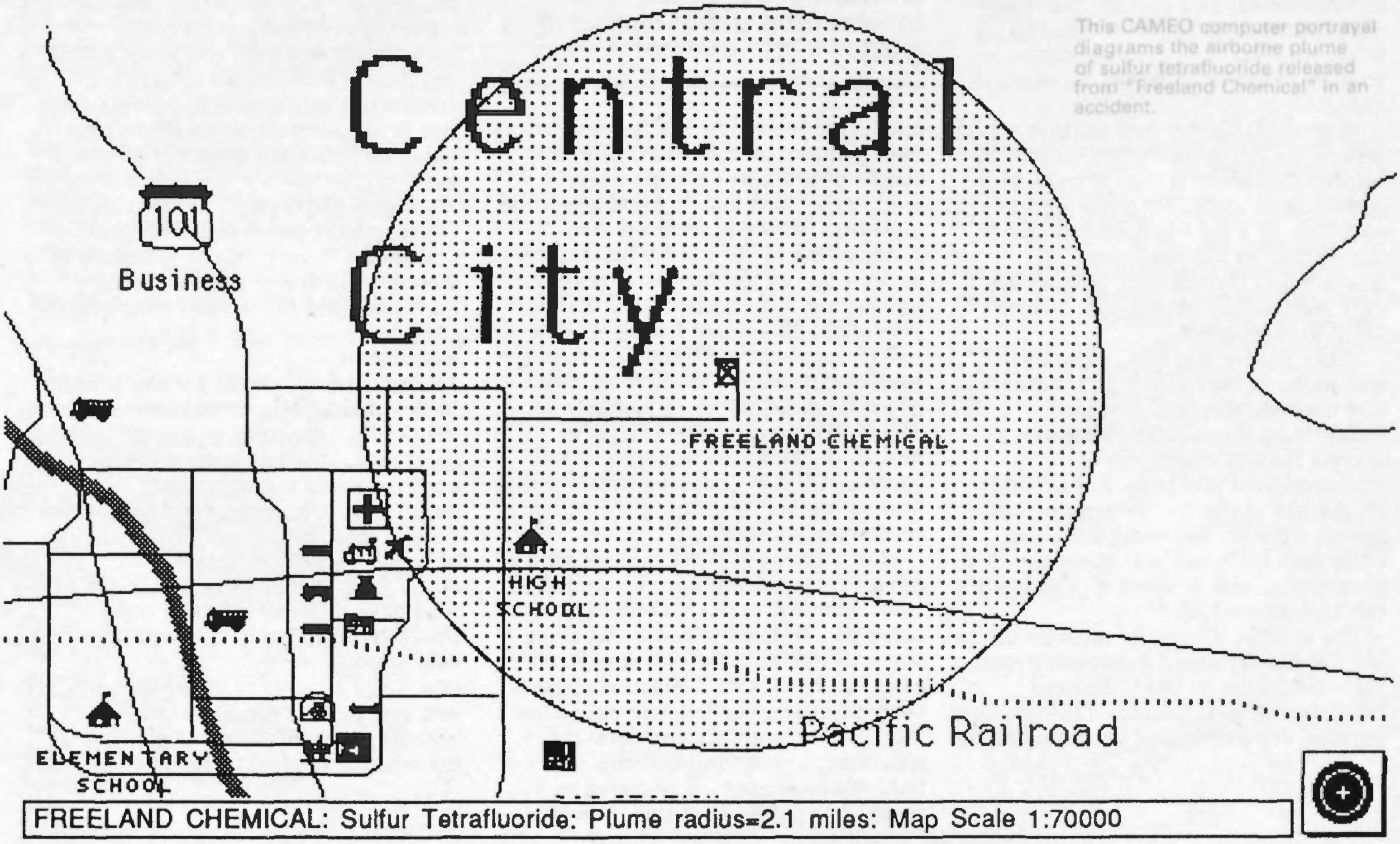
CAMEO's main menu, the "Navigator." An emergency response technician can select the data base needed with a click of the on-screen "mouse."

rest home is close by. What kind of ventilation does it have? Can it be shut off for a few hours? Click: the answer.

Now, as the van nears the scene, Sackler and his crew are ready for what they have to do. What a difference from the old days, when they spent precious time on arrival to get the same information they are ready with as the van rocks to a stop ... thanks to CAMEO!

CAMEO's Macintosh version (15 diskettes and a manual) is available from the National Safety Council (312-527-4800) for $115. An MS-DOS compatible version on 9-track tape including only the chemical data base and vulnerability calculation (and lacking graphics capability and Title III information) is available from NOAA (206-526-6317) at no cost. □

(Snider is with the Hazardous Materials Response Branch of the National Oceanic and Atmospheric Administration. Jover is Director of the Information Management and Program Support Staff in EPA's Chemical Emergency Preparedness and Prevention Office.)



This CAMEO computer portrayal diagrams the airborne plume of sulfur tetrafluoride released from "Freeland Chemical" in an accident.

What the Public Thinks about Environmental Data

by David B. McCallum and
Vincent T. Covello

Through state and federal community right-to-know laws, vast amounts of data about toxic substances are newly available to the public. In research jointly conducted by Georgetown University's Institute for Health Policy Analysis and Columbia University's School of Public Health, public knowledge, attitudes, and behavior were examined at the community level with respect to this new resource. Our survey results indicate that the capacity of citizens and many local officials to understand and effectively discuss these data is generally not keeping pace.

Recognizing their own lack of technical knowledge, many citizens depend on others to interpret environmental data and provide them with information in terms they can relate to. Who does the public trust as sources of information about chemical risks?

In general, doctors and environmental groups are the most trusted sources of information about chemical risks. Our respondents identified news reporters and Title III local emergency planning committees as the next most trustworthy. Government officials are only moderately trusted, and industry officials least trusted.

Many people fear that government and industry may withhold information, and they are skeptical that the information they routinely receive reveals the full magnitude of environmental problems. For example, 85 percent of our survey respondents agreed with the following statement: "The only time you hear about a chemical release is when it is so big it can't be covered up."

The sources the public most trusts are not necessarily those it considers most knowledgeable. In fact, industry officials, the least trusted of information sources, are widely considered to be the most knowledgeable about chemical risk issues. Next most knowledgeable in public opinion are environmental groups, followed by the government. Respondents felt that physicians, cited by many as the most trustworthy, were less knowledgeable than other sources; however, physicians are among the least frequently used sources of information about chemical risks.

In practice, the public depends most of all on the mass media for information about chemical risks. Our respondents cited local television and newspapers as their primary sources. Ironically, the source people rely on most often is neither the most knowledgeable nor the most trustworthy in their opinion.

In general, doctors and environmental groups are the most trusted sources of information about chemical risks.

According to our survey results, most citizens do not follow environmental issues on a daily basis. We found that only about 25 percent had read or heard something about toxic substances in the past week. The public attention tends to be captured primarily by sensational events like the chemical release at Bhopal, India, or the intense media coverage of Alar in apples, rather than routine reports concerning environmental topics.

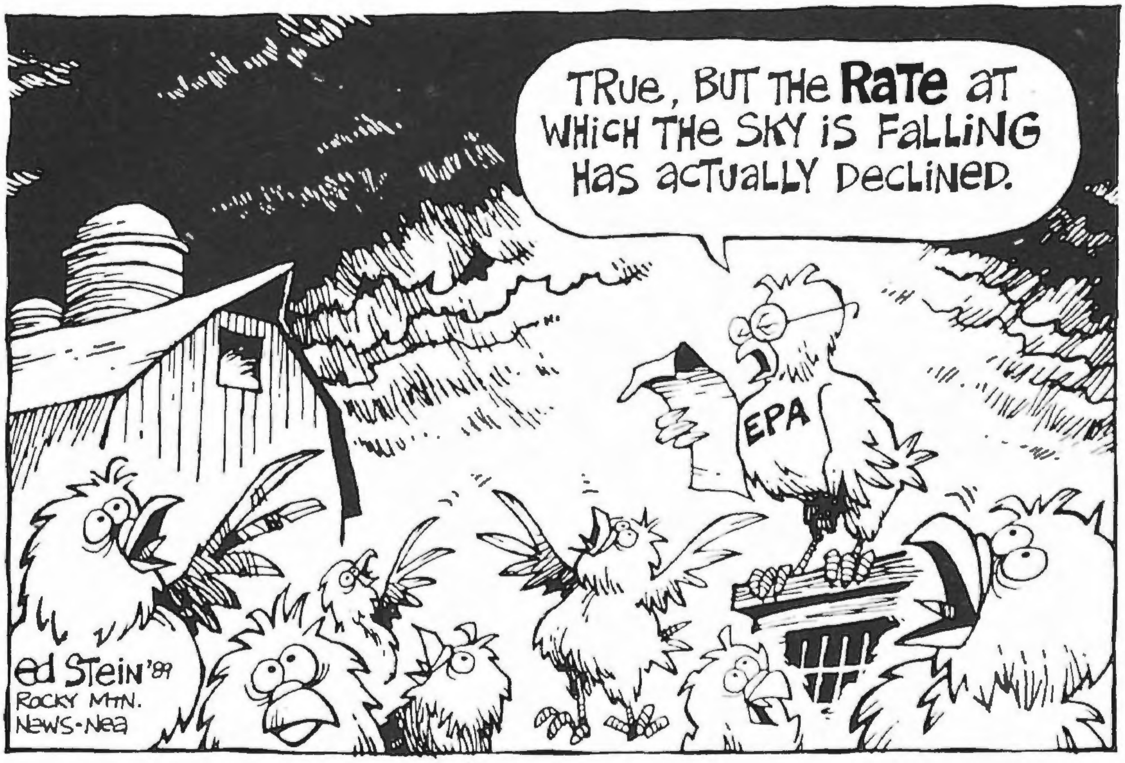
Most citizens express only moderate interest in gathering information on environmental issues. In this context, many people cited unrewarding prior attempts to obtain information. In many cases, contacts with local sources have been unsatisfactory because only a few local government officials, teachers, librarians, health professionals, and industry personnel are prepared to respond to public inquiries. A majority indicated that their personal motivation to pursue environmental data under the new right-to-know provisions would depend on whether they or their families were directly affected by an environmental hazard.

On the general subject of risk communication, a majority of our respondents did not understand the concepts of exposure, dose-response, or fundamental concepts of probability. For instance, the majority equate *release* of a toxic substance in the community with *exposure* for citizens and assume the exposure has an adverse effect. This may in part explain the incredulous reaction to the concept of "permitted releases" (releases allowed by air quality standards): "You mean that they are releasing toxic substances and the government knows it and is not doing anything?" Participants clearly recognized, on the one hand, that zero risk is not achievable; on the other hand, they thought it should be the goal.

Citizens did express concern about the long-term and interactive effects of pollutants. In many cases, adequate data are not available to answer their questions, and this erodes their overall confidence in risk assessment information.

Clearly there is room for improvement in the process of communicating risks to the public. What can be done? In the short term, it seems imperative for environmental managers and policymakers to understand the current flow of information and to use existing channels to deliver clear messages that speak to the needs of various publics who have different kinds of skills, interests, and needs. This will require everyone concerned with risk communication to be aware of the needs and concerns of various audiences.

Perhaps alliances among various information sources could serve as a



Ed Stein, *Rocky Mountain News*. Reprinted with permission.

way of pooling knowledge and credibility in order to better serve the public's need for information. Moreover, new channels for information dissemination in the community, in addition to existing information sources, should be developed and supported.

Many people fear that government and industry may withhold information . . . .

To date, public hearings have been emphasized over mass media strategies in environmental risk communication programs. If carefully planned and run to avoid confrontation, such hearings can establish contact with the public at an early stage in the communication process before or during risk assessment. Public hearings provide forums for expression of the public's concerns, apprehensions, misconceptions, and information needs. They give citizens the satisfaction of "being heard" and can build trust in effective risk communicators and focus public attention on the issues. However, public hearings and town meetings reach only those citizens who are most actively concerned about an environmental problem. Only 25 percent of those we surveyed had attended a town meeting.

The long-term challenge will be to create more active interest and better skills among a greater percentage of the general public to foster better understanding of environmental data. This will require institutionalized educational efforts. As a beginning, environmental issues could be addressed in public schools, preferably allied with science and math curricula. Also, substantial benefits might be gained from greater emphasis on chemical risk issues in the training of physicians and increased involvement of physicians and medical organizations in communications about chemical risks. □

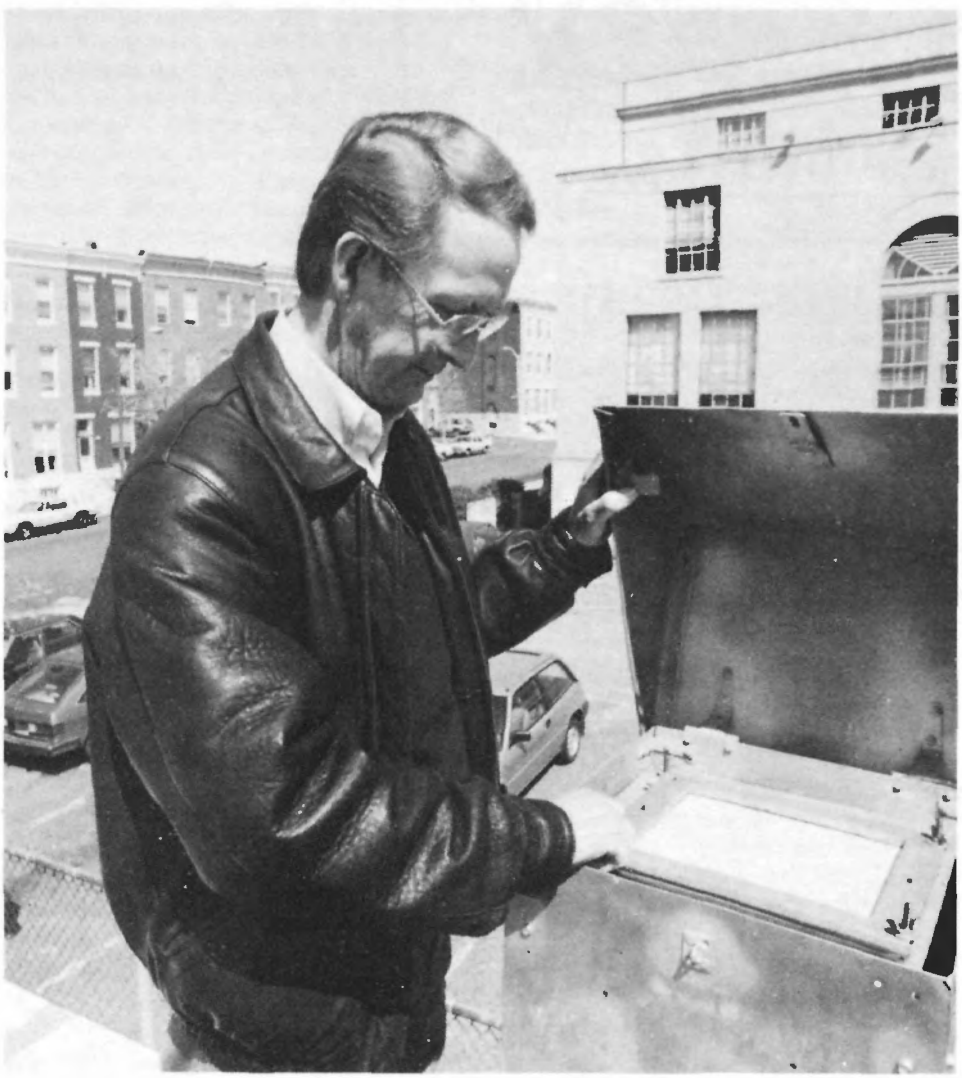
(McCallum is Associate Professor in the School of Medicine, Georgetown University, and Director of Georgetown's Program on Risk Communication at the Institute for Health Policy Analysis. Covello is Associate Professor of Environmental Sciences in the School of Public Health, Columbia University, and Director of Columbia's Center for Risk Communication.)

Keeping Tabs on Air Quality

by Roy Popkin

Air quality nationwide continues to show considerable progress over the years, offset by concerns that many areas still do not meet applicable air quality standards. Despite the overall progress, almost 102 million people in the United States reside in counties which exceeded at least one air quality standard in 1987. Ground-level ozone, in particular, continues to be a problematic air pollutant in many urban areas.

These conclusions are presented in EPA's recently issued *National Air Quality and Emissions Trends Report* covering the 10-year period January 1978 through December 1987. But how does EPA know what air-pollution trends are from day to day and year to year across the country? The answer is the national air quality monitoring system that keeps track of the nation's progress in cleaning up the air we breathe.



Steve Delaney photo.

The national monitoring system focuses on the six criteria air pollutants for which National Ambient Air Quality Standards have been established by EPA under the Clean Air Act. These are: airborne particulate matter, sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, and lead.

The daily, sometimes hourly, data that are collected, compiled, transmitted, and analyzed through this system have very specific practical applications:

- The data provide feedback to state and local governments regarding their success, under individual State Implementation Plans, in meeting national air quality standards.
- The monitoring data alert EPA as well as state and local officials when individual metropolitan areas are in violation of air quality standards.
- The data also serve as a warning system for local environmental agencies concerning pollution problems that may require emergency response measures in order to protect the public health. Accidental releases, air inversions, or brush fires, among other things, may trigger emergency air pollution conditions.

The national air quality monitoring system is a network involving millions of data points gathered by hundreds of "environmental meter readers" from thousands of instruments in over 5,000 locations across the country. The data-gathering process typically begins when a technician pulls a filter or reads a tape from a measuring device at one of the many sites maintained by state or

Dick Wies, head of the monitoring analysis group of the Maryland Department of the Environment, checks the filter on a high-volume air sampler atop the Guilford Avenue station in an industrial area of Baltimore. State and local agencies feed extensive data into EPA's air trends reporting system.

local governments. Some pollutants are measured hourly using continuous monitors, while others are measured as daily averages. The data-gathering process continues as these technicians gather up and replace filters, collect taped data, maintain the equipment and check calibrations, and do whatever else is necessary to keep the system functional and accurate, 365 days a year.

The monitoring sites must meet uniform criteria for siting, instrument selection, quality assurance, analytic methodology, and sampling intervals; the sites must also satisfy annual "completeness criteria" appropriate to pollutant and measurement methodology. This assures data of consistent quality across the United States.

State and local monitoring stations and special-purpose monitors must meet the same strict criteria. Data from only those locations with sufficient historical data are included in the annual trends analysis to ensure that trends are in fact due to changes in air quality, and not simply the result of using data from different sites.

Monitoring site instrumentation must meet EPA specifications and standards. The Agency works closely with universities and manufacturers to improve the technology used to gather air trends report data.

Recently, for example, it was necessary to adopt a new indicator for airborne particulate matter in conjunction with revisions to the national air quality standards for particulate matter. The original standards, established in 1971, treated all particles as the same, regardless of their size or chemical composition. Since then, however, new studies have shown that the smaller particles penetrate more deeply into the human respiratory tract, thus posing a particularly significant health risk. In 1987, in light of this new information, EPA revised the National Ambient Air Quality Standards and replaced the original instrument (called a "high-volume" sampler) for measuring overall particulate matter levels with a new indicator that measures particles that are 10 micrometers or smaller.

The monitoring data alert EPA as well as state and local officials when individual metropolitan areas are in violation of air quality standards.

In general, a practical problem that confronts air pollution agencies is where to place the monitors to get an accurate idea of what the air pollution levels are. They need to know what levels people are breathing, what levels are coming into the area from other locations, and what normal ambient air levels are. At the same time, they must have ready access to the monitor sites.

These logistical considerations sometimes lead to the creative placement of monitoring sites. Many air sampling instruments are located in or on top of schools and suitably located government buildings. Others are placed in more exotic locations, such as the top of the World Trade Center in New York and the ninetieth floor of the Sears Tower in Chicago. A specially rented apartment on Waikiki Beach in Hawaii houses instruments measuring pollutants originating from the busy beach road. Others are atop water intake "islands" in Lake Michigan, several miles from the Chicago lakefront; in heavily trafficked midtown city areas and equally busy suburbs; or in areas where power stations or heavy industry emit a variety of pollutants. The monitoring station closest to the Office of Air Quality Planning and Standards in Durham, North Carolina, is on top of the county jail in downtown Durham.

It is important to realize that the tremendous volume of data that feed into EPA's air trends reporting system come from state and local agencies. EPA, itself, does very little of this monitoring.

Maryland, for example, has one of the nation's most sophisticated air-monitoring systems. It extends from Cumberland, an old industrial city in the state's western mountain region, to southern Maryland's Chesapeake Bay coastal region. Some of Maryland's sites are checked twice daily year round; others less frequently. Some report their information automatically via telemetry. In addition to monitoring for the six criteria pollutants, the state measures various toxic air pollutants and acid rain. Moreover, its laboratory also analyzes air toxics samples from a number of northeastern states.

The state agency's three laboratories, where Maryland's daily pollutant levels and statistics for the air trends report are compiled and analyzed, are in a section of a long building that was once a wire factory, near the Dundalk Marine Terminal and across the harbor from a steel plant at Sparrows Point. One laboratory unit analyzes monitor samples, dust, soil particles, lead, sulfates, and pyrene derivatives found in filters and other manual recording devices.

Another deals with "dry surveillance" (levels recorded on tapes or printouts by recording devices) of carbon monoxide, sulfur dioxide, nitrogen oxide, and ozone. The third lab analyzes non-methane organic compounds and other toxics. This unit also has its own workshop, built by the technicians, where instruments are regularly checked, and recalibrated if necessary; motors are rebuilt every six months. The

Chicago Tourism Council photo.

Chicago's Museum of Science and Industry is one of 5,000 sites around the country that provide data for the national air quality monitoring system.

workshop is dubbed the "music room" because of the shrill sound of new motor bushings being tested.

The Maryland "meter readers" also monitor the effectiveness of the state's own air quality improvement program, and they watch for anomalies that could necessitate immediate regulatory action. For example, smoke from a recent series of brush fires raised particulate matter levels almost to "the point where we might have had to shut down Baltimore's industry," according to Dick Wies, head of the monitoring analysis group.

The Illinois monitoring network likewise satisfies both state and federal reporting and regulatory requirements, and state and EPA Region 5 personnel have collaborated in the design of instruments that meet both state and federal criteria for valid data collection. Illinois owns 250 monitoring devices, including 39 intended to measure ozone levels. One monitor is "hidden" in the Chicago Museum of Science and Industry. Five of the state's 18 carbon monoxide stations are installed around O'Hare airport to monitor emissions from both planes and cars.

Data from Illinois flow, almost continuously, into the capital city of Springfield, where a staff of 28 validates the information and oversees the maintenance of equipment. The data are fed directly into EPA's new Aerometric Information and Retrieval System (AIRS).

Illinois and other states not only provide raw monitoring data to EPA but can also serve as a valuable sources of supplemental information. For example, some initial studies by Dave Kolaz of the Illinois Environmental Protection Agency have provided insight into the effects of meteorological conditions on ozone trends in the midwest. According to Kolaz, the reduction in carbon monoxide levels can be attributed to "a tremendous reduction in carbon monoxide in Chicago because of tax incentives in Illinois to use ethanol." On the other hand, ozone levels have been going up in Illinois, "so our technicians take note of temperature levels and what's coming into our air from other states."

Raw data from the states can be held in AIRS computer system screening files for review by state analysts before being made available to EPA. Quality assurance checks by state agencies flag unusual readings, such as those caused by forest fires or temperature inversions. In addition, the monitoring sites are visited periodically by state and EPA staff to double check not only technical performance but also the continued validity of the location itself. For instance, a monitoring site may need to be relocated if a heavily trafficked street has been replaced by a pedestrian mall, or if fast-growing trees have partially blocked the air flow to the instruments.

The tremendous volume of information gathered each year winds up at the Office of Air Quality Planning and Standards (OAQPS) in North Carolina, where it is subject to detailed analysis. The data currently reach the OAQPS compilers and analyzers by two routes: the "old path" from localities and states through the EPA regions, where they are processed and relayed to the EPA National Computer Center at Research Triangle Park; or directly from the states to the Computer Center by way of AIRS.

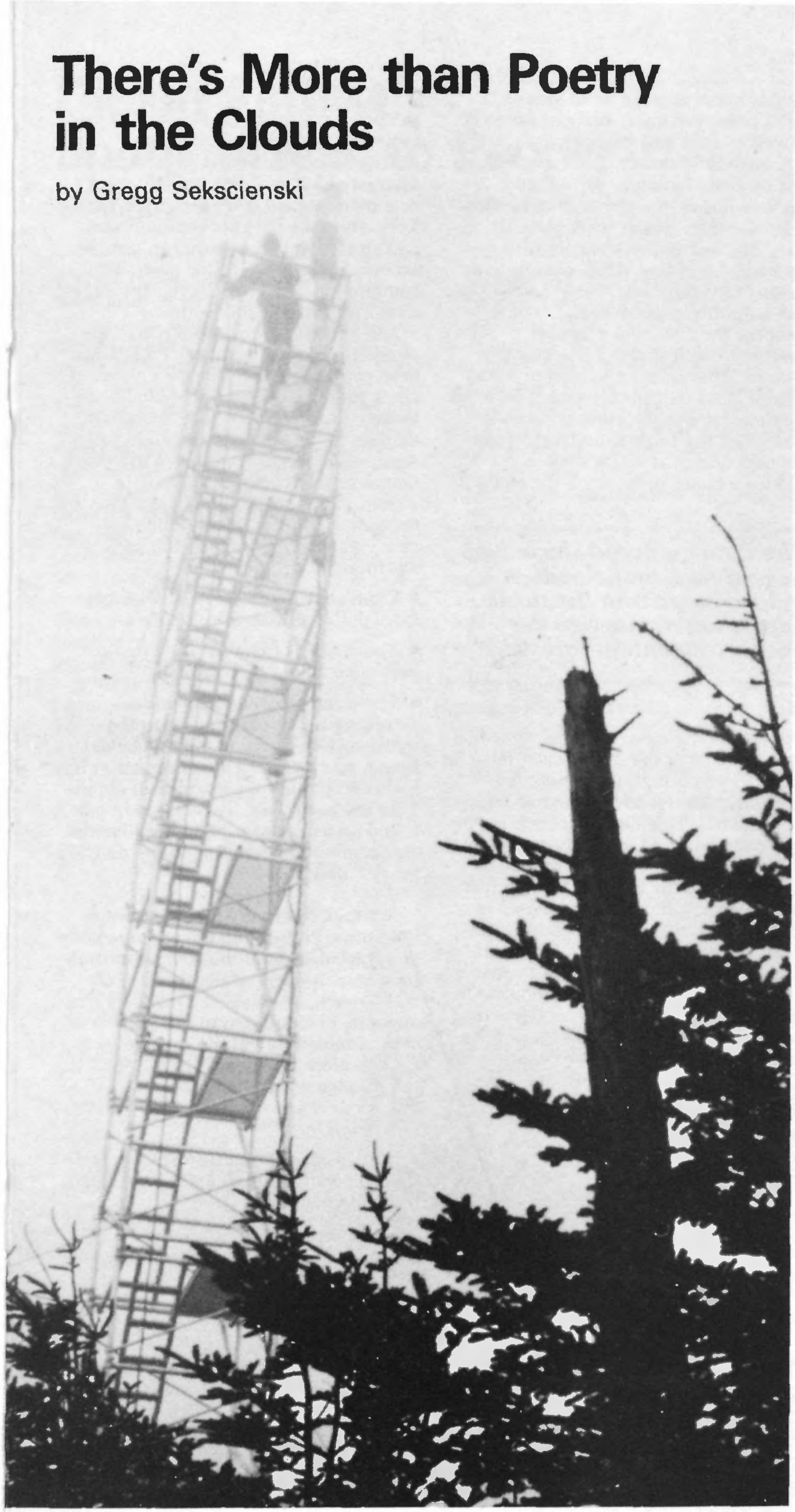
As its acronym implies, AIRS is EPA's new computerized information management system for data on ambient air quality and emissions; AIRS also tracks compliance with data requirements. By the end of 1988, 28 states and Puerto Rico were plugged into the AIRS system, and at least 14 more state-level agencies are scheduled to go on line in 1989.

Throughout the entire air trends monitoring and analysis process, there is a scrupulous regard for accuracy. Tom Curran, Chief of the Data Analysis Section at OAQPS, stresses the integrity and cooperative aspects of the monitoring system at all levels, even when work loads are heaviest. "We're dealing with professionals who know the importance of their work," he says. "When the data reflect downward pollution trends, we take pride in the accomplishments of EPA and state air pollution agencies. When the trend is up, we know there's a lot of work to do to clean up the air." □

(Popkin is a Writer-Editor in EPA's Office of Public Affairs.)

There's More than Poetry in the Clouds

by Gregg Sekscienski



John Shaw photo.

This moisture collection tower must be checked at least hourly. The cloud moisture collects on teflon strings and drips into a trough; researchers check the amount of water that has collected and analyze its contents. This site is one of six staffed by EPA's Mountain Cloud Chemistry Project.

A man-made spider web of teflon string sits atop a tower on Mt. Mitchell in North Carolina's Mt. Mitchell State Park. As clouds roll in, cloud droplets deposit on the teflon strings. Slowly, the water drips off the strands of the web and into a small trough. Every hour, a man climbs up the 70-foot tower and empties the trough. He climbs other towers to empty other troughs. Whenever clouds appear he performs this ritual.

The man works for the Mountain Cloud Chemistry Project, which is managed by EPA's Office of Research and Development. The project is designed to measure the impact clouds have in distributing chemicals and other pollutants—primarily sulfates and nitrates—to high-altitude forests. Catching clouds may sound unscientific, an act better left to poets and dreamers, but for the Mountain Cloud Chemistry Project it is serious business.

Acid rain damage was first studied extensively in Europe, when the effect known as *Waldsterben*, or "tree die-back," began destroying the forests of Germany, especially the legendary Black Forest. But something puzzled researchers. They knew rain carries airborne pollution to forests in a process called wet deposition. They also knew that some chemical particles find their way to forested areas by wind and air currents, a process known as dry deposition. But pollutant levels measured in the forests were greater than these two sources could produce. Therefore, pollutants must be reaching the forests by some other means. Clouds were suspected as the culprits.

As clouds move through a line of mountains, they collide with the high-altitude, spruce-fir areas of the forests. Chemicals contained in the clouds are deposited in the forest canopy. This phenomenon is known as cloud interception and is believed to be responsible for a considerable amount of the pollutants that are being measured in these areas. According to Volker A. Mohnen, the Principal Investigator for the project, the areas of the forest that clouds regularly collide with can have deposition levels twice as high as areas just below the cloud-impact level.

With clouds fingered as possible culprits, the idea was born, in 1984, for a project designed to collect reliable, accurate data that might prove clouds were contributing to the *Waldsterben* problem here in the United States. The project would need to situate site-monitoring stations in areas representative of the problem, transport reliable monitoring equipment to those areas, and catch, collect, and analyze the clouds.

In choosing the monitoring areas, the project directors decided that three northern sites and three southern sites would best represent the different weather systems that affect East Coast forests. The northern forests receive clouds primarily from the industrial Midwest and Canada, while the southern forests receive clouds from the Midwest and the southern states.

Also, to help insure the accuracy of the data, the sites had to be located near people qualified to collect and analyze the data. So each site has an associated lab close by, where the data can be reliably analyzed. In addition, a central analytical laboratory has been designated for performing overall quality checks.

By 1986, the six sites were selected and data collection began. Howland Forest, Maine, Mt. Moosilauke, New Hampshire, and Whiteface Mountain, New York, make up the northern half of the study. Shenandoah Forest and Whitetop Mountain, both in Virginia, and Mt. Mitchell, North Carolina, comprise the southern forest sites of the project. Most of the sites are relatively remote, but all must be accessible by vehicles. Power lines were strung to provide electricity for the monitoring equipment. Towers were installed so instruments could be positioned at the same height as the forest canopy level. At the Shenandoah site, a helicopter was needed to fly the monitoring towers in.

At each site monitoring devices were installed. Some were adapted from lab-based equipment when possible, but others had to be designed specifically for the project. They had to withstand the hazards of the mountain environment: average wind speeds of 15-25 miles per hour, and gusts over 80, as well as cold and precipitation.

A method of detecting cloud presence was needed. To catch, collect, and analyze clouds, the researchers needed to know when clouds were present. They decided to use a variety of methods, including visual observations by on-site technicians, video recordings, and humidity measurements, and to compare the results to a newly developed optical cloud detector that uses an infrared beam system to detect clouds. A 95-percent agreement between the detector and the other methods has convinced the project directors to use the new device at all its sites.

Once a cloud is detected, the amount of water in the cloud must be measured and a sample of the cloud water must be taken. A cloud liquid-water-content monitor measures the amount of water in the cloud. This device collects water in a cylinder filled with a honeycomb of polypropylene mesh. A blower is used to draw cloud air through the cylinder, and the exact amount of air drawn is measured. The exact amount of water collected is also measured. With both these figures known, the liquid water content of the cloud can be calculated.

The data gathered since 1986 have shown that clouds are indeed culprits in the acid deposition damage to the nation's mountain forests.

Two devices are used to collect cloud water. The first is a "passive" collector. It looks like a cylinder standing on end, approximately two feet high and one foot in diameter. The cylinder's wall is actually made of spider-web-like strands of teflon string. Cloud water collects on these strings and drains into a trough at the bottom of the cylinder, where it is collected.

The second device, an "active" collector, looks like two window screens, again made of teflon string. Teflon is used because it is chemically inert and will not affect the chemical composition of the cloud water. Cloud air is drawn through the screens by a blower. Again, water is deposited on the strings and collected. These samples, from either device, are stored for later chemical analysis.

The on-site data and cloud water samples, collected in a May-to-October measuring season each year, are analyzed and verified at each site's associated lab and sent to the project's data management center in Albany, New York. Here the data are computerized and stored. This data base can now be accessed by anyone in the assessment community. The project even shares data with Canada and Germany.

The hypothesis that gave rise to the Mountain Cloud Chemistry Project has been proved correct. The data gathered since 1986 have shown that clouds are indeed culprits in the acid deposition damage to the nation's mountain forests. Analyses of cloud water have indicated that significant amounts of sulfate, nitrate, ammonia, and hydrogen ions are deposited to the forests through the cloud water. In particular, the project has found that:

- Clouds are between 5 and 20 times more polluted than rain.
- The acidity of clouds is 1/2 to 1 pH unit more acidic than rainfall.
- The chemistry of clouds varies according to their pathways. In the northern forests, for example, clouds from a southwestern direction are higher in pollution content than clouds from the northwest. This is due in part to the heavy concentration of industrial emissions from areas including the Ohio River Valley.

The data from the Mountain Cloud Chemistry Project join the growing body of knowledge about the acid deposition problems throughout the world. This new knowledge about the intensity and amounts of cloud deposition will be crucial in sorting out the relative contribution of regional air pollution to the damage of spruce-fir forests. □

(Sekscienski, a journalism student at the University of Maryland, is an intern with EPA Journal.)

Dioxin Pathways: Judging Risk to People

by Michael A. Callahan

Since the 1970s, when the controversy surrounding Vietnam veterans' exposure to the defoliant Agent Orange first attracted national media coverage, the word "dioxin" has crept into the vocabulary of average Americans. After Vietnam, we heard about dioxin at Times Beach, Missouri, where property was contaminated by flood waters containing dioxin. We heard about dioxin again when an industrial plant exploded in Seveso, Italy, about a decade ago. A couple of years ago, we heard it connected with some forms of paper products. It is said to be present at some Superfund sites. More recently, dioxin has been mentioned in connection with incinerators.

What is dioxin? More importantly, how can we get a handle on dioxin exposure? Are we likely to see more data on dioxin, in more and more places and things, in coming years?

Dioxins, or CDDs (see boxes), are formed as unwanted byproducts in chemical reactions involving hydrocarbons and chlorine, usually at elevated temperatures. From studying data on the amounts of CDDs formed in different reactions, scientists today know a lot more about what conditions are favorable to CDD formation than they did in the 1970s.

During the 1960s and 1970s, pesticide manufacturing processes and other industrial reactions sometimes were unknowingly performed under conditions favorable to production of CDDs, and the byproducts or wastes from these reactions have become the Agent Oranges, Times Beaches, Sevesos, and Superfund sites of later years. Many industrial processes have since been changed to avoid the formation of CDDs.

More recently, analytical data indicating that minute quantities of dioxin were present in certain bleached paper products and sludges have again caused some rethinking and revision of manufacturing processes. The tipoff in this case was the analysis of data from aquatic organisms downstream from a few paper plants. Puzzling at first, the levels of CDDs found downstream led to collection of more data, by both EPA and the paper industry, which showed that some processes being used to bleach paper involved conditions which resulted in trace-level CDDs.

What about incinerators? Evidently, the small amounts of chlorine present from various materials in municipal trash—coupled with hydrocarbons and the heat of the incinerator—are enough to produce tiny quantities of various CDD compounds, depending on the exact conditions present in the incinerator's burn chamber. Only a small percentage of the CDD compounds (typical data indicate less than 10 percent) formed in an incinerator appear

When the Meramec River flooded the town of Times Beach, Missouri, in December 1982, residents were left with not just flood damage, but dioxin contamination of their property. Shortly before Christmas, the federal Centers for Disease Control issued a health advisory urging families not to resume residence in Times Beach, due to high levels of dioxin. At right, a couple ponders flood damage around their Times Beach home.

AP/Wide World photo.

to be 2,3,7,8-TCDD. This dioxin can leave the incinerator adsorbed onto particles ("soot"), or perhaps as a vapor, or in "fly ash" (trapped particulate matter that is filtered out before the exhaust from the incinerator leaves the stack).

Once it enters the environment, the chemical properties of the CDD molecules, the conditions in the environment, and the activities of the persons involved determine potential human exposure to dioxin. Typically, laboratory data for CDD molecules indicate very low water solubility, very low vapor pressure, and a high tendency to dissolve in lipid (fatty) material. CDD molecules also have a tendency to stick to surfaces, especially surfaces with high organic content such as soot or soil. Both laboratory and field data indicate that CDD molecules do not degrade rapidly, although some CDDs degrade much faster than others in the environment.

In the case of incinerators, these and other data allow scientists and engineers to estimate where the dioxin molecules may go after leaving the incinerator and how people might ultimately be exposed to it. The dioxin in the exhaust of an incinerator stack, whether emitted in vapor or particulate form, becomes diluted and may eventually be inhaled by persons in the vicinity of the incinerator. The dioxin may also be deposited on soil, crops, or water.

Risk assessors must combine the insights gained by analyzing data from the laboratory with analytical results from measurements from the field in order to begin to evaluate exposure. For example, dioxin in soil can be inadvertently ingested (say, by children playing), blown around as dust, or washed into waterways. Soil analysis data can show how much dioxin is in the soil, but experimental data on how much soil is inadvertently ingested—as well as data on how often children might play in a contaminated area—must be gathered and interpreted before estimates can be made as to how much exposure children might get from contaminated soil.

Because of its properties, scientists believe that dioxin is unlikely to dissolve in water to such an extent that it will contaminate ground water through leaching. However, in cases where organic solvents are present, there have been some data indicating that small amounts of dioxin may move to ground water. Persons who inadvertently ingest or inhale contaminated dust, or drink contaminated drinking water (a less likely event), would thus be exposed to dioxin.

Dioxin falling on crops or waterways presents a different sort of problem. Although data on whether dioxin is taken up through the roots of plants are controversial, many scientists believe that transport of dioxin from soil through roots to edible portions of a plant above ground is unlikely to be significant.

Less is known about whether root crops such as potatoes may take up dioxin from the soil. Plants can also be contaminated by particles falling on the plant, which can then be eaten by either livestock or humans. Because of dioxin's preference for fatty material, it can then accumulate in the animals. If livestock are used for human food, this can be another exposure pathway.

Although these food-related "pathways" can be logically surmised from laboratory test results, actual data tracing these potential exposure pathways are sparse. On the other hand, once dioxin contaminates a waterway, its preference for soil (sediment) or lipid means that it is very likely to turn up in those substances. Fish bioconcentration is a well-known

What Is "Dioxin?"

The term "dioxin" is chemical shorthand for a large family of compounds more correctly termed *chlorinated dibenzo-p-dioxins* (CDDs). One of these compounds, *2,3,7,8-tetrachlorodibenzo-p-dioxin* (2,3,7,8-TCDD), is a very potent animal carcinogen; based on this evidence in laboratory animals, it is classified as a probable human carcinogen.

Although no one is absolutely sure of its *potency* as a human carcinogen, based on its animal potency—and following the customary policy on implications of animal evidence—EPA has treated 2,3,7,8-TCDD as potentially one of the most potent human carcinogens known. There are more than 100 other CDDs, and all are less toxic than 2,3,7,8-TCDD, some considerably less toxic.

It is unusual to find 2,3,7,8-TCDD alone, without other CDDs present also. Scientists have therefore devised a system of "toxic equivalency factors" (TEFs), which converts the toxicity of a mixture of many CDD compounds into the amount of 2,3,7,8-TCDD that represents the equivalent toxicity of all the CDDs in a mixture.

Measuring Dioxin Concentrations

Because of its toxicity, 2,3,7,8-TCDD is perhaps one of the most well-studied organic chemicals. The current analytical capabilities for CDDs, and especially 2,3,7,8-TCDD, are nothing short of remarkable. For example, the well-known tests for the 129 priority pollutants usually allow detection limits in the low parts-per-billion (i.e., one part pollutant in a billion parts of the material being tested for contamination). It is not unusual for analytical tests for 2,3,7,8-TCDD to be a thousand times more sensitive, and laboratory researchers have discussed getting to parts-per-quadrillion levels, or a million times more sensitive than more routine pollutants. With this sort of analytical capability, we can be much more aware of CDD contamination than we are of contamination from many other pollutants.

Contaminated furniture from Times Beach houses and house trailers was taken away in covered trucks escorted by the State Highway patrol, then dumped in pits. The town is now abandoned and posted, "Stay Out!"

EPA photo

phenomenon in areas where dioxin has contaminated waterways, and some areas have been closed to fishing due to measured levels of dioxin contamination in fish.

Finally, to continue the incinerator exposure assessment, the dioxin in the fly ash must be tracked down. Usually, fly ash is landfilled, and if precautions are taken to contain the ash and eliminate solvent leaching, scientists believe the dioxin will be relatively immobile, although long-lived. This conclusion is mainly based on laboratory data, although field data tend to back this up with "non-detects" in ground water. Improper care of the fly ash could lead to the same types of exposures as outlined above for contaminated soil.

What does all this mean? Dioxins, especially 2,3,7,8-TCDD, are treated as a very potent toxicants that may cause health effects at quite low levels of exposure. Risk assessors must use a combination of laboratory and field data to make estimates of exposure and risk. Analytically, we find dioxin in many places; however, our analytical techniques allow us to "see" it much better than many other pollutants.

Dioxins are even found in human fat tissue. At least one estimate has been made, from data on adipose tissue levels in the U.S. population, that virtually everyone in the United States has a very small "background" level of dioxin exposure, perhaps on the order of one millionth of one millionth of a gram of dioxin ingested per kilogram of body weight per day. Even using conservative assumptions, this level indicates a low level of risk as "background"; however, many other exposure and risk factors need to be considered in assessing dioxin-related risks for any individual's specific situation.

Tracing exposure to persons around a site such as a landfill or incinerator is a complicated matter involving the types of CDDs produced, the environmental conditions, and the activities of the people involved. Preliminary calculations show that in these cases, food-chain exposures or inadvertent soil ingestion may ultimately be the most important pathways, but much depends on site-specific factors. In fact, the environmental and population activity factors are important enough to preclude categorical statements on the risk levels from landfills or spill sites.

As a closing thought, there is some reason for optimism about the future concerning dioxin. As time goes by, we discover more about this class of compounds known as dioxins, and the more we know, the more likely we are to be able to put bounds on what we might see in the future.

We cannot rule out a future surprise or two as to where dioxin may be discovered. (Paper products certainly caught many people unaware a couple of years ago, and just recently CDDs have been found in certain petroleum-refining process streams.) However, we now have a general idea how CDDs are formed and how they're not formed. Although dioxins have been detected in many places, the resulting exposure and risk have in many cases been low. And the active interest in research on dioxin means we will continue to learn more about these compounds and there will be fewer data gaps in our knowledge. We may then truly get a handle on dioxin. □

(Callahan is Director of the Exposure Assessment Group in the Office of Environmental Health, Assessment, Research, and Development in EPA's Office of Research and Development.)

Getting It Together with GIS

by Thomas H. Mace

EPA collects, processes, and interprets massive amounts of data on the environment. Such data come in the form of tables, maps, or images from space-sensing systems and reflect everything from water quality, air emissions, and soil gas measurements to the results produced by models of the global environment. How can the Agency's scientists, managers, and decision-makers absorb this influx without being paralyzed by "information overload?"

Now there is an important new tool that makes it possible for computers to integrate diverse, multi-media information into a common data base. It is called a Geographic Information System (GIS), and it has the potential to revolutionize the way EPA analyzes environmental data and significantly improve the Agency's ability to make complicated environmental decisions.

GIS in its most rudimentary form can be a series of transparent overlays to a map showing land use, soils, land ownership, surface elevation, and other information about a particular portion of landscape. Following a visual analysis of a set of overlays, conclusions can be made, for example, concerning where airborne emissions are coming from—or even about the suitability of actions such as siting a landfill. But using overlays without computer assistance has obvious limitations. It is difficult to integrate more than a few layers at a time and still know what one is looking at. Also, compiling data onto a common map base is a very time-consuming process.

The modern GIS, as it was developed first by Canadian geographers and adapted for various uses in the United States, is a computer and software system that permits the automated overlay and analysis of multiple data layers (called "themes") for data management, mapping, and decision-making. The GIS used by EPA has a "relational" data base that stores themes such as land uses, soils, population, and well logs for a particular area and enables users to explore the interrelationships among them. Another computer file contains "earth-coordinate" data—latitude and longitude—and other information on the relationships between a specific location and surrounding areas. The GIS software enables coordinates and their associated themes to be related to other sets of coordinates and themes—e.g., where drinking water sources are located in relation to pollution sources.

GIS in its most rudimentary form can be a series of transparent overlays to a map showing land use, soils, land ownership, surface elevation, and other information . . . .

This capability has a number of practical applications. Suppose an environmental agency wishes to know the population served by a well that has been found to be contaminated. GIS can graphically overlay the well location with a map of the subsurface contaminant plume and then add an overlay of census data for the area; the potentially affected population can then be determined by census category. An alternative would be to plot the well locations for an area, point out a well, and simply ask for a printout of the measurements that have been taken there.

GIS also allows users to "create" buffer zones around a well, a stream, or the habitat of an endangered species, look at circumstances within these special zones, and then take action having considered several possible scenarios. GIS can, for example, create a 200-meter zone around all streams within a particular metropolitan area. Then, using census street corner address information, service station locations can be inserted into the data base. By extracting stations within the 200-meter buffer, planners can develop an emergency response strategy for potential spills or leaking underground storage tanks. In much the same way, GIS can aid the analysis of an air pollution problem and who is being affected by it.

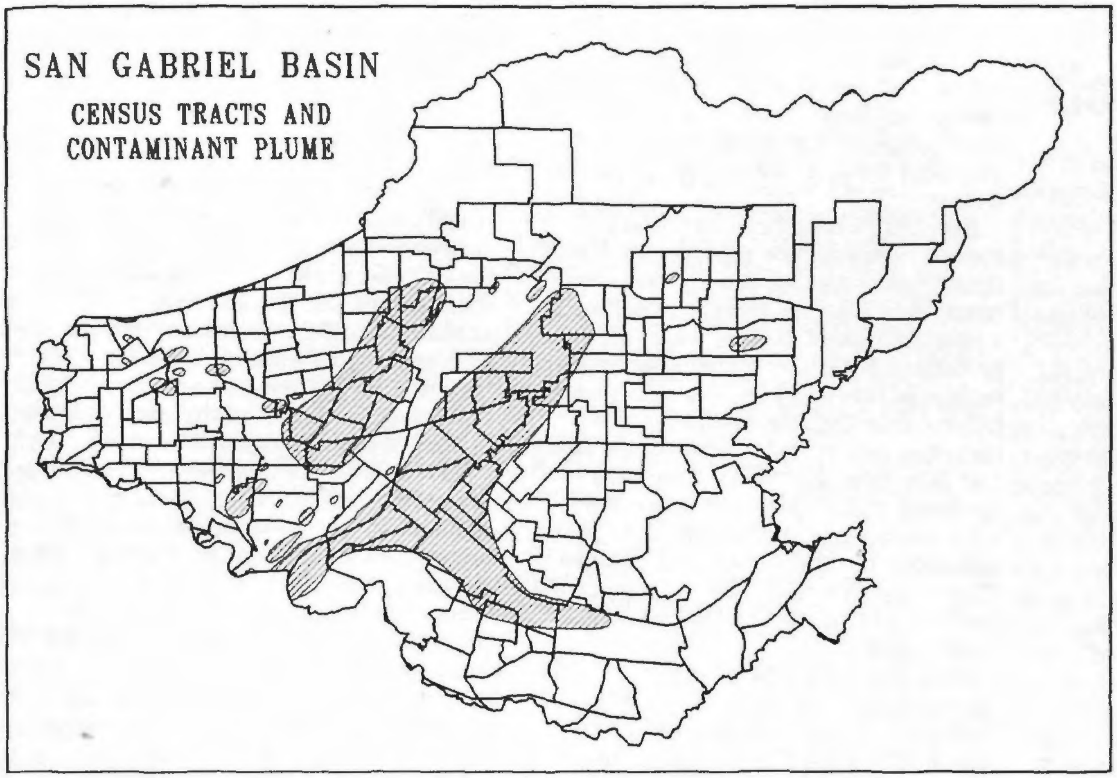
Various environmental models can "interact" with the GIS by directly using the functions it provides. Alternatively, data can be extracted from the GIS data base for external model use, and the results then placed back into the GIS for use in further analyses.

More than just a mapping system, the GIS functions as a window on data bases, allowing users to interrelate and manage data, models, and maps. It enables users to develop scenarios and visually shows the results in either permanent paper map form or as temporary presentations on a color computer screen. GIS not only helps users answer site-specific questions, offering new perspectives on complex environmental interactions, but also facilitates the use of such data in environmental decision-making.

The Superfund Program's approach to dealing with problems in the San Gabriel Basin is a good illustration of how GIS can be used to solve complex environmental problems, in this case dealing with ground-water contamination by industrial chemicals and solvents whose sources are still unknown.

The San Gabriel Basin site is one of the largest and most complicated sites on EPA's National Priorities List. Encompassing over 200 square miles, it is located in the heavily urbanized Los Angeles Basin of EPA Region 9.

Region 9 is faced with the problem of reaching a documented, systematic decision on a clean-up strategy that takes into account not only environmental data from all media, but also human and ecological risk and the tremendous costs associated with



One of EPA's largest and most complicated Superfund sites is the 200-square mile San Gabriel Basin near Los Angeles, California. The Agency's Geographic Information System has been put to a number of uses in dealing with the San Gabriel site, including the strategic monitoring of underground water pollution.

ground-water cleanup over so large and populous an area. With hundreds of thousands of people potentially affected, and with millions of dollars at stake, the Region 9 final Record of Decision *must* be supported by the best available information and presented in a way that the public can understand and support. The pilot study, begun in 1985 by EPA's Environmental Monitoring Systems Laboratory at Las Vegas and EPA Region 9, is the Agency's first extensive application of GIS technology by a mainstream EPA program.

The study began with the assembly of a spatial data base containing information about the characteristics of the aquifer and the Basin's physical environment, locations of potential pollution sources, and information on current pollution, land use, and population. The data came from other federal agencies, Region 9, and state, local, and private sources. The data base integrated both what was known through environmental measurements and what could be reliably surmised through the use of environmental models. Immediately successful, the GIS data base is still in use today by Region 9 as an operational part of the Remedial Investigation; it is continually being expanded and updated as our understanding of the San Gabriel Basin increases. Eventually, it will be a valuable tool for enforcement and compliance actions.

Among the steps already taken through the use of GIS in the San Gabriel situation has been the mapping of a number of significant factors related to the present and future pollution of the Basin's water supply. These factors include: the area's generalized geology; locations of drinking water wells; the movement, actual and projected, of underground waters; observed and projected underground volatile organic chemical pollutant plumes; wells actually within the plume areas; location of water supply district within the plumes; census tracts; and data about the potentially affected census tracts. GIS has also aided in the determination of the principal responsible parties involved.

The combinations of overlays that are being developed for this project have already enabled Region 9 to pinpoint sites for continuous monitoring so that the advance of underground water pollution can be detected if and when it happens. In addition, Region 9 will be able to tell if large numbers of children or older persons are at risk in specific areas, and where potentially serious pollution sources are located in relation to such populations. The region will also have access to other information critical to planning for long-range prevention—or cleanup where necessary.

Use of GIS is increasing within the Agency. The Office of Information Management Systems has developed and is actively managing a plan of action for its implementation. Seven regional offices already have GIS systems, and the others are conducting pilot studies to assure that the technology applies to their programs. The Office of Research and Development has developed GIS capabilities at several laboratories and is providing research and technical support to the regions through the Environmental Monitoring Systems Laboratory at Las Vegas. The payoff will be better use of data in decisions and the integration of multimedia information supporting environmental management. The San Gabriel Superfund program is just the beginning. □

(Dr. Mace is Chief of the Remote and Air Monitoring Branch at EPA's Environmental Monitoring Systems Laboratory in Las Vegas. He is responsible for the research program in Geographic Information Systems in EPA's Office of Research and Development.)

Keeping a Closer Watch on Ecological Risks

by Jay J. Messer

It seems that almost every week, the news media confront us with accounts of new ecological disasters. Some result from localized accidents, spills, or system failures; others result from intentional breaches of sensible environmental housekeeping, such as dumping medical wastes in our coastal waters.

Even more troubling than these events, however, are reports that our coastal resources are slowly but inexorably wasting away—casualties of a combination of air and water pollutants acting on global and regional scales. Bolstered by an alarming rate of habitat loss and fragmentation, the resulting rate at which species are being lost may rival the mass extinctions in the fossil record generally associated with catastrophic meteor impacts. As a barometer of this widespread concern, *Time* magazine replaced its "man of the year" in 1988 with the "planet of the year": Earth.

How can society best respond to this emerging environmental crisis? Currently, the United States alone spends $70 to $80 billion annually on environmental programs, most of them targeted at protecting human health. Protecting ecological resources while controlling acid rain, reducing emissions of greenhouse gases, replacing chlorofluorocarbons that destroy stratospheric ozone, reducing inputs of nonpoint source pollutants to surface waters, and preserving critical habitats will further increase the cost of environmental protection.

If the nation's economic resources are insufficient to address all of these concerns, there certainly will not be enough to proceed on any course less than a solid understanding of environmental processes and effects. EPA must have a sound basis for targeting its limited research and regulatory resources at the most critical threats to our ecological resources.

EPA sets its standard-setting priorities for pesticides and toxic substances released to the environment based on a formal risk assessment procedure. The results of toxicological tests on laboratory organisms are coupled with pollutant exposure models to calculate estimated rates of illness or mortality in humans. This procedure is sometimes backed up using human health statistics obtained in surveys of clinical records, where available. The most toxic or carcinogenic chemicals with the highest exposure levels are given priority for regulatory attention.

This risk assessment procedure is also useful in comparing the relative toxicity to plants and animals of single chemicals, but it develops limitations in assessing risks from multiple pollutants to processes that operate at the community and ecosystem level. Instead of relating animal test results to one species (*Homo sapiens*), toxicological results must be extrapolated from a few species that can be reared in the laboratory to hundreds of thousands of species that may be exposed to a pollutant in the natural environment. Unknown effects of pollutants on reproduction, competition for resources, and susceptibility to predators and disease that are not fully testable under laboratory conditions further reduce our confidence that we are truly protecting

Ray Muzika photo.

A commercial fishing boat. The decline in U.S. coastal resources such as fisheries presents a major challenge for ecological monitoring.

ecosystems from harm. Furthermore, decreased finfish and shellfish harvests in near-coastal systems, dying high-elevation forests, and loss of biodiversity may stem from a combination of human-induced causes not restricted only to toxic pollutants.

Assessing current and future risks to our ecological resources requires two components in addition to th traditional toxicological approach. The first is ecological field data to allow us to determine which problems are the most widespread or most rapidly becoming worse. The second is a sufficient understanding of complex ecological processes and effects to allow us to adequately predict the response to regulatory alternatives. The focus of this article is the first issue: the need for data on status and trends in the condition of our ecological resources.

Despite the hundreds of millions of dollars spent on monitoring, we appear unable to determine with confidence if the conditions of our resources are getting better or worse.

We are certainly not without environmental data. Although no official statistics are kept, the federal government spends more than $500 million each year on environmental monitoring. State and private organizations more than double this figure. The majority of environmental monitoring dollars are spent on compliance monitoring: making sure polluters obey regulations. The majority of ambient monitoring is targeted at urban air quality and contamination of food and drinking water. The remaining programs provide us with what we do know about the condition of our ecological resources.

Ambient water quality is monitored by the U.S. Geological Survey (USGS) NASQAN and Benchmark networks, as well as by EPA and at least 10 other federal agencies. Air quality is monitored in metropolitan areas, and acid deposition rates have been measured in rural areas by a consortium of USDA Agricultural Experiment Stations, EPA, USGS, the National Park Service, and others since 1983.

Levels of toxic and carcinogenic organic compounds and certain heavy metals have been measured in bottom fish and shellfish by the National and Oceanic and Atmospheric Administration at 200 near-coastal sites since 1984. The U.S. Fish and Wildlife Service currently monitors contaminant levels in fish in 200 rivers, as well pesticide and metal residues in bird tissues.

State and private monitoring also add to what we know about environmental quality. The states monitor air and water pollutants, and many conduct biological surveys of surface-water and terrestrial systems. The Audubon Society conducts an annual Christmas bird count, and the Nature Conservancy tracks changes in availability of wildlife habitat. University researchers have provided ecological monitoring data that alerted society to the threats of surface-water eutrophication, acid rain, stratospheric ozone depletion, and global warming.

Despite the apparent "glut" of monitoring data, the most recent Conservation Foundation report on the "State of the Environment" in 1987 contains fewer than 10 figures (out of 150) that describe field data on ecosystem contamination or conditions. Most of the other figures describe pollutant releases, industrial and economic activity levels, and population and transportation statistics that serve only as surrogates for pollutant releases. The authors of the report noted with some frustration that more data on the actual condition of ecosystems simply were not readily available.

What is missing?

To meet our ecological field data requirements, two needs must be met. The first is better coordination and communication among the agencies that collect environmental data. The second is a framework for data interpretation and reporting that meets our ecological assessment needs and for identifying and filling the critical data gaps. The second need is a prerequisite if the first is to result in more than a few scientific workshops and exchanges of data tapes.

In order to be useful in the risk assessment process, monitoring data must affect decisions concerning whether or where to target research or regulatory resources. Such decisions are facilitated when the data provide answers to certain specific questions:

- What is the resource of concern (e.g., the number of lakes subject to acidification or the acres of wetland subject to loss)?
- What fraction of this resource appears to have suffered damage, and where is the problem most pronounced?
- Are the magnitude, extent, and location of the damage changing over time?
- Are patterns of damage related to patterns in pollutant exposure or other disturbances?
- What level of uncertainty is associated with each of these assessments?

Many monitoring programs provide vital clues to the condition of the environment, but were never meant to characterize a particular resource of concern. Some programs are based on an "early warning" or sentinel concept in which highly sensitive monitoring sites are chosen. Other program designs focus on resources that are of particular management interest, such as national parks, commercial timber, or fishery landings. The NASQAN network monitors the quality of 90 percent of the major riverine water discharges in the nation, and the data have been used to document decreases in lead concentrations in runoff resulting from declining use of leaded gasoline. The network is not designed, however, to describe the distribution of water quality or biotic conditions in the thousands of miles of stream that make up the aquatic habitat.

Despite the hundreds of millions of dollars spent on monitoring, we appear unable to determine with confidence if the conditions of our resources are getting better or worse. In order to provide an estimate of the percentage of a particular resource that appears to have suffered some damage, the sites selected for a monitoring program must be representative of the overall resource. In other words, if 20 percent of the resource is damaged or experiencing a trend, approximately 20 percent of the monitoring sites should show the same pattern or trend. Such a correspondence would be expected if the sampling sites were randomly selected.

In most cases, however, monitoring sites are not selected randomly but deliberately and justifiably located to determine the effects of a known pollutant source or to serve as a background or an experimental control for such a site. In other cases, monitoring sites placed at "convenient" locations (e.g., near roads or bridges or in parks with unusual geology or landforms) may unknowingly introduce a bias into the sampling network. Such bias in status or trends estimates may result in incorrect or inefficient management decisions.

Incomparability among data collected by different organizations, or by the same organization at different times, makes it difficult to clearly separate patterns and trends from differences in techniques and sampling schemes. For example, there is no question that wastewater treatment plants reduce inputs of pollutants to receiving waters and that many lakes and rivers have undergone marked improvements in water quality since the early 1970s.

In spite of hundreds of thousands of water quality measurements, however, it has so far proved impossible to document unequivocally, on a national basis, overall changes in the condition of aquatic life or the extent of eutrophication in lakes, streams, and estuaries due to the billions of dollars spent on water-related pollution control programs. The biannual reports on the status of surface waters required by the Clean Water Act cannot document trends because of changing station locations and differences in measurement and reporting procedures among states and from year to year. Could we be winning the battles but losing the war?

Finally, few of the current programs were ever meant to relate changes in the ecological resources to changes in pollutant exposure. Programs that monitor natural resources typically cannot distinguish between effects of harvesting (e.g., commercial fishery landings), management (e.g., crop and forest planting and cultivation), and actual environmental change (e.g., effects of climate, pollutants, and disease).

Could we be winning the battles but losing the war?

This problem could be partially solved if organizations with overlapping programs could coordinate reporting of monitoring results. Unfortunately, monitoring programs often take a back seat to more urgent issues, and resources are diverted away from interpretation, coordination, and reporting. This situation has led Paul Portney, Director of the Center of Risk Management, Resources for the Future, to call for a Bureau of Environmental Statistics to coordinate and facilitate the communication of ecological monitoring data to decision-makers and the public.

An EPA helicopter crew samples water during the National Lake Survey to assess the effects of acid rain.

EPA photo.

What can EPA do to address this critical data gap? In response to an extensive review by the Administrator's Science Advisory Board, EPA's Office of Research and Development is undertaking a research program to bolster the Agency's ability to assess the effects of individual pollutants at the population, community, and ecosystem level; to assess the extent and causes of existing damage where the damage already appears to have occurred; and to determine whether the sum total of EPA regulatory programs and policies are having the desired or predicted effects on our ecological resources.

The Environmental Monitoring and Assessment Program (EMAP) represents the first step in this program and is aimed at filling the critical gaps in our ability to assess the status and trends in the condition of our ecological resources, particularly as they relate to EPA's commitment to protect the environment.

EMAP will begin pilot testing in 1990 a set of interlocking monitoring networks that will monitor changes in indicators of ecological conditions and environmental progress in terrestrial and aquatic ecosystems, including estuaries and near-coastal systems. The program will focus on both biological resources and exposure to pollutants and will meet the criteria outlined above to assure its usefulness in making policy and management decisions.

EMAP will be highly coordinated with ongoing monitoring efforts, both within and outside EPA, to add value to existing monitoring data and to avoid duplication of effort. The program will provide regular statistical summaries and interpretive reports on its activities and will serve as a means to focus the ecological research needed to understand and prevent the most serious future ecosystem-level impacts.

Only through the development of scientifically sound and rational methods of comparing environmental risks can we hope to protect the planet's life support system with the resources that are available. □

(Messer is Program Manager for EPA's Environmental Monitoring and Assessment Program in the Office of Research and Development.)

Our Record with the Environmental Crystal Ball

by William R. Moomaw

As the articles in this issue of *EPA Journal* clearly demonstrate, data have become a major commodity in our society. Quantitative information is needed to understand any environmental problem, evaluate its seriousness, and develop a control strategy by establishing regulatory standards. It is virtually unthinkable that we could manage our vast environmental programs today without the wealth of analytical and statistical information that has been collected and is now available to us instantly at the touch of a few key strokes from a computer terminal.

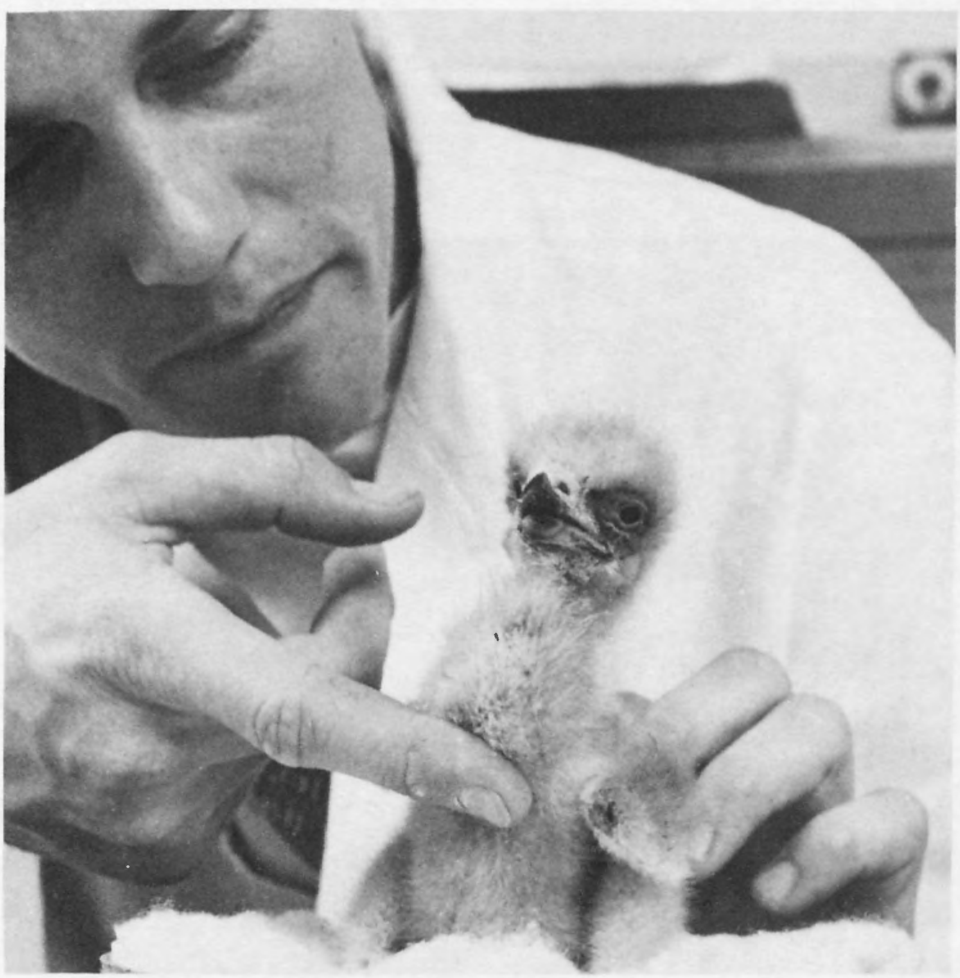
Yet, how often when working on a particular environmental problem are we brought up short by the need for additional data? One need only remember how often in recent years we have hesitated in our response to such major issues as acid deposition, urban and regional air pollution, stratospheric ozone depletion, ground-water contamination by toxic chemicals, or the Greenhouse Effect because someone argued that we needed more data.

I certainly do not intend to argue that we should act on these or any other environmental problems without adequate information; I firmly believe that effective solutions must be grounded on a solid scientific basis. Instead, I propose to raise the question of why we have allowed ourselves to create some of these environmental dilemmas in the first place, sometimes even when we possessed knowledge that should have forewarned us of the consequences.

It appears to me that we have made at least three major kinds of mistakes in the past that have led us into difficulty. The first is implicitly assuming that the law of the conservation of matter has somehow been revoked instead of remembering that whatever we put into the environment ends up somewhere. The second is ignoring the complexity of biological systems and (in our ignorance about them) being surprised when they respond in an unexpected way. Our third type of mistake is failing to include, within the boundaries of our concern, all ecological and social systems affected by our proposed actions.

The modern era of environmental concern is often said to have its origins in the 1962 publication of *Silent Spring*. This book created a storm of outrage among chemists and the agricultural community with its attack on then-current practices of pesticide use.

Rachel Carson was a gifted writer, but with only a master's degree in biology, was not considered by most to be a real scientist. Yet, despite her somewhat



A U.S. Fish and Wildlife Service researcher weighs a five-day-old bald eagle chick. When the bird became our national symbol in 1782, there were 25,000 to 75,000 nesting in the lower 48 states. By the 1970s, the number had plummeted to roughly 3,000, due to the use of DDT and other pesticides which affected eagle egg shells. DDT was banned in 1972, and U.S. bald eagles seem to be making a comeback, with the current population estimated at more than 10,000.

U.S. Fish and Wildlife Service photo

It appears to me that we have made at least three major kinds of mistakes in the past that have led us into difficulty.

problematic opening chapter and an accusatory tone, she did what no other scientist had done. She simply asked what had happened to the 300 million pounds of chlorinated pesticides and a comparable amount of other agricultural chemicals being sold each year. Her answer, documented by the wealth of data available in the specialty literature, demonstrated that persistent chemicals do not simply disappear, but due to such phenomena as bioconcentration, often end up in surprising places in large and damaging amounts.

In our well-intentioned desire to promote agricultural productivity and protect public health through the use of pesticides, we had ignored all three principles: we failed to ask where these vast quantities of sprayed pesticides might go; we ignored the question of how they might interact with living organisms; and we narrowly defined our region of concern to a particular sprayed field or forest.

In the decade and a half following the publication of *Silent Spring*, several other issues involving the massive release of substances to the environment were the focus of environmental policy concern and debate.

In 1974, Sherwood Rowland and Mario Molina examined the fate of the nearly one million tons of chlorofluorocarbons (CFCs) that were being produced annually. These amazing and versatile chemicals were inert, non-toxic, and non-flammable, which made them suitable for a remarkable variety of industrial and commercial uses. Because of their benign properties, there was virtually no concern that the majority of each year's production was being released directly into the atmosphere.

What Rowland and Molina found was that good data existed on the production of CFCs and that new measurements of their atmospheric concentration (of the order of several parts per trillion I might add) suggested that most of the released CFCs remained in the atmosphere. Having asked the conservation-of-matter question, these researchers then jumped to principle number three and asked questions about the proper bounds of the system and of our concern. They realized from the work of others that chlorine might cause depletion of stratospheric ozone and, from their own research, that CFCs, while stable in the lower atmosphere, could be broken down by high-altitude ultraviolet

Mike Brisson photo.

Data may provide us with answers, but only if we can formulate the right questions.

radiation to release chlorine right in the midst of the ozone layer. In this case, the biota are affected by the biologically damaging ultraviolet radiation that can penetrate a depleted ozone layer.

Subsequent data-gathering has largely confirmed the principle concern that chlorine released into the upper atmosphere by CFCs can deplete the earth's protective ozone shield. What has come as a surprise is the sudden appearance of the Antarctic ozone hole by a previously unanticipated chlorine pathway and the much more rapid depletion occurring at mid-latitudes than was previously predicted.

Our heavy reliance on fossil fuels has presented us with a plethora of unanticipated environmental problems that all arise because we implicitly assume that there is no cost involved nor any problem related to our release of vast quantities of carbon dioxide and other gases into the atmosphere. From an engineering perspective, we quite reasonably drew the boundary of our concern around the technology we were developing. We treated the environment as a continuing source of fuels and materials and a limitless dump for the products of combustion and the waste heat that must be released in order for our engines to run.

Would we have made different technology choices had we known a century ago what we know today? I am certain that "automobility" would still have occurred. But would we have chosen the gasoline-powered internal combustion automobile had we realized that, even when meeting today's U.S. fuel efficiency standards, the average new American car releases approximately its own weight in carbon to the atmosphere each year? Would we have at least favored a different propulsion technology that could avoid the large amounts of carbon monoxide, nitrogen oxides, and volatile organic compounds that—despite impressive pollution control technology—acidify precipitation and prevent approximately 70 metropolitan regions from meeting air quality standards?

Would Henry Ford have believed this? America the Beautiful, littered with junked cars.

In our enthusiasm to solve the remaining vehicle air pollution problem by shifting to alternative fuels such as methanol, have we once again drawn the boundaries of the problem too narrowly by ignoring both the local air and water problems associated with any synfuels program, or the greenhouse (and hence biological) implications of large increases in carbon dioxide release should we manufacture methanol from coal?

Given the increase in the average number of miles driven per year and the large amount of highly polluting idling time arising from traffic congestion, a new fuels strategy may slow the deterioration of local air quality a bit, but in my view this is unlikely to be a real solution to the problem.

Let me close with an example of a future that we are just beginning to address that illustrates my point. Human-induced global climate change is believed to be caused by the trapping of the earth's radiant heat by increasing quantities of carbon dioxide, methane, CFCs, and other gases. Of these, the only one whose concentration can potentially be lowered once it is "out of the bottle" and in the atmosphere is carbon dioxide.

Since green plants absorb carbon dioxide during photosynthesis, several proposals have been made to increase the growth rate of plants in order to offset carbon releases from fossil fuel combustion. The more conventional plan is to halt net deforestation to ensure the existence of large carbon stocks on land and to replant areas that have already been cut in order to remove atmospheric carbon dioxide by sequestering it in new growth.

More recently, some have called for increasing the oceanic photosynthetic rate through ocean fertilization. This would have the advantage of automatically sequestering large amounts of dead organic matter that sinks to the ocean floor.

Before such a massive project is undertaken, I would suggest that we carry out an environmental impact assessment since we have learned the hard way from inadvertent eutrophication experiments on a more limited scale that the response of the biota can often surprise us.

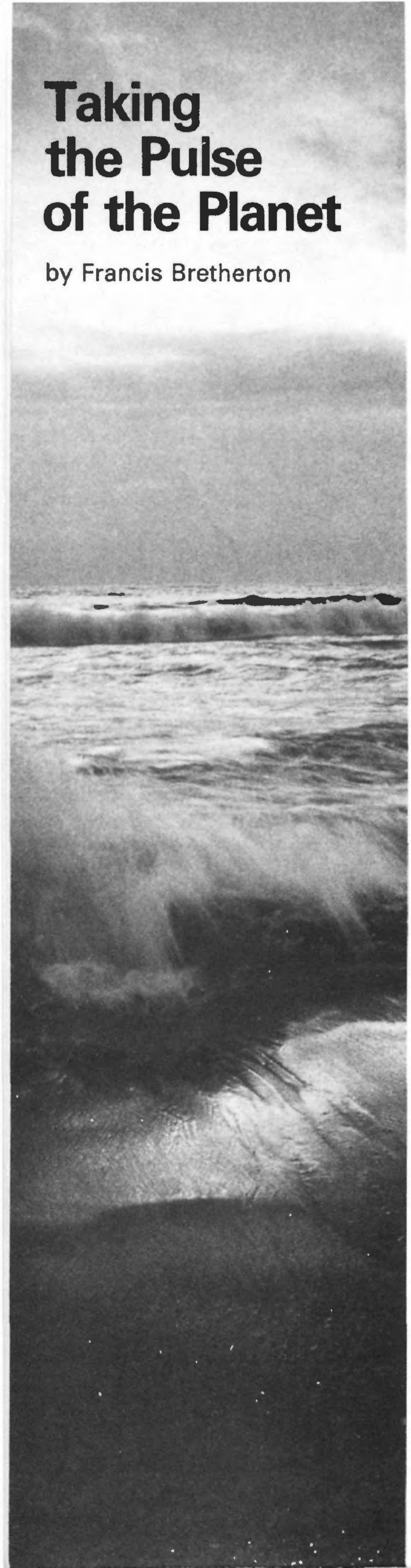
One question that particularly needs to be addressed is whether some of the microorganisms in the oxygen-deficient waters into which these dead plants might sink are capable of converting biomass into methane. Were this the case, it would have the unfortunate consequence of ultimately converting one molecule of atmospheric carbon dioxide into a molecule of methane, which, after bubbling up and entering the atmosphere, is capable of producing 20 to 30 times the global warming of the carbon dioxide it replaced.

It is clear from these examples as well as many others that the development of a sound, high-quality data base has been critical to our understanding and treatment of environmental problems. What is also illustrated, however, is that if we fail to analyze our actions properly, possessing data is not going to avoid major environmental problems. Data may provide us with answers, but only if we can formulate the right questions. □

(Dr. Moomaw directs the Climate, Energy, and Pollution Program at the World Resources Institute in Washington, DC. He is a physical chemist who was formerly on the faculty of Williams College, where he was Professor of Chemistry and directed the Center for Environmental Studies.)

Taking the Pulse of the Planet

by Francis Bretherton



Mike Brisson photo.

A second dust bowl in the nation's heartland, sweltering humidity all summer long in New York City, balmy days in Alaska: these are examples of climate changes that might be in store for our children and grandchildren—consequences of the burning of coal and oil worldwide. Other symptoms of the ever-increasing impact of human activities on the global environment include acid rain, the ozone hole, desertification (productive land turning to desert), and the destruction of tropical forests.

Scientists know that these changes are all interrelated. They cannot be understood or reliably predicted without considering the earth as a complete system of interacting parts: the atmosphere, the oceans, the ice sheets and glaciers, the solid earth, the soils, and the biota. Yet our knowledge of how this system functions is woefully incomplete.

For example, there is consensus that the global average temperature will increase over the next century, but there is no agreement about the changes this will bring in individual regions. Thus, we must develop new programs of research to acquire new knowledge. We must monitor the vital signs of this planet that is our home. The earth must be placed in "intensive care."

Two years ago, the World Commission on Environment and Development issued its aptly titled report, *Our Common Future*, which underscored the mutual interdependence of world population, environmental problems, and economic imperatives worldwide. The common future of the world's citizens, according to the Commission's findings, will depend on the success of internationally coordinated efforts to achieve "sustainable development."

The basic message of *Our Common Future*, concerning the need for solutions that take into account the global interrelationships of ecological and economic concerns, is more urgent than ever. We need to develop new ways of thinking about basic national policies on the environment, energy, industrial development, and foreign aid. We need to recognize the synergisms and conflicts of our choices on a global scale and work with other nations to minimize the adverse consequences of our common actions.

To feed the world population and satisfy its needs for a decent way of life, many compromises and accommodations will be necessary, as well as resolute action, where feasible, to mitigate the most undesirable impacts. Protecting our global environment cannot be successfully accomplished in isolation but must be approached as an integral part of the economic and technological realities and value systems of the peoples of the world.

We must monitor the vital signs of this planet that is our home. The earth must be placed in "intensive care."

Central to any dialogue about these issues must be reliable environmental information. We need to document the changes that are actually occurring on a global scale, understanding how much is natural variability and how much is due to human activities. We need proven models that can be used to examine the effects on the environment of different policies, and to make credible predictions about specific regions and nations. Developing such information will be a tremendous challenge, requiring new modes of cooperation among scientists in different disciplines, among various federal agencies, and among the nations of the world. Although the United States and other nations are beginning this effort, a sustained long-term program will be required, with few quick returns.

Monitoring the earth's vital signs must start with observation. Measurements are needed of such variables as the temperature and rainfall all over the globe, together with the action of clouds, winds, ocean currents, the extent of sea ice, vegetation cover, and many other factors that determine climate. Also important is the measurement of increasing concentrations in the atmosphere of "greenhouse" gases that act to warm the earth by retaining heat that would otherwise be radiated into space.

Also crucial, but more difficult to document, is the state of health of ecosystems such as forests and grasslands as climate changes and nutrients in the soil are exhausted. Fires, droughts, pest epidemics, and wind storms are major influences on what species flourish and how the system reacts to change; the frequency

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of these catastrophic events is sensitive to land management practices like harvesting trees and controlling fires.

Measuring these variables requires scientific instruments at many sites around the globe, combined with the perspective that can be obtained from earth-orbiting satellites, which are maintained consistently over many decades. Some of the systems required are already deployed for other purposes, including weather prediction. However, modifications are necessary to achieve the accuracy needed to document global change. In other cases, the most critical information can be obtained by small groups of dedicated scientists, provided they are given suitable encouragement and support. In some situations, research is required to develop suitable methodology.

In all cases a major effort is needed to establish adequate monitoring systems. Accomplishing this will be difficult and expensive, requiring an indefinite commitment. But we must make this investment because our future depends on it.

Measurements by themselves are not enough. They must be integrated into a coherent framework of information of established reliability. Enormous amounts of complex data have to be organized and retained for future use because we are certainly not wise enough to know just what will turn out to be critical in the years to come. Currently, we cannot even evaluate the quality of some data. Our successors 20 years from now will have to decide whether the changes they observe are real or artifacts of either the way the measurements were made or the data processed. We continually find that critical information from the past was not recorded or has been lost. We must not repeat these mistakes.

Computer models play an essential part in this integration process. These models range from simple conceptual relationships among variables in some part of the earth system calculated on a personal computer spreadsheet to models providing comprehensive simulations of the weather systems and ocean currents of the world. Models have many different roles, each requiring different input information.

Models encapsulate what is known about how the different parts of the earth system function, serving as the common language in which specialists in different scientific disciplines can communicate. They can also be used to assimilate many different kinds of measurements into a self-consistent analysis, as the daily weather patterns are inferred from isolated observations of atmospheric pressure and temperature. They are used to simulate observed phenomena, as a test of the model itself. Once tested, they are used in experimental mode to examine cause and effect relationships—for example, showing what would happen if the burning of fossil fuels were reduced by one quarter.

Finally, models are used to predict what actually will happen, including the effects of natural variability, given our best available estimate of the present state of the system and of future inputs. At present, we have only separate subsystem models, each describing an isolated piece of the earth system. A major effort will be required over the next decade to integrate these pieces into a tested comprehensive model that can be used for specific predictions.

Caring for the earth will require translating this predictive capability into effective policies. For example, estimates of regional changes of temperature and rainfall will have to be combined with specialized models of river flow and economic development to estimate the impact upon water resources. The impact on agriculture of changes in climate and of enrichment in atmospheric carbon dioxide depends also on the breeding of new crop varieties and prices on the world market.

Analyses of the processes of industrial societies will be required to project plausible scenarios for the emission of greenhouse gases and other air pollutants, including the secondary effects of various control strategies. It is essential to develop methodologies for making these analyses objective, relatively uncontaminated by the value system of one particular social group or nation. As the interrelationships between populations, economic development, and the environment are taken seriously, evaluating policy options will become much more difficult.

Placing the earth in intensive care is not just a scientific problem, although science has a crucial role to play. We all have to develop an awareness of the consequences of our collective actions, of the cumulative effect of the simple choices we make in our everyday life as they are multiplied by the billions of people on this planet. We will never positively know the consequences. However, we must act now where action is clearly needed, while continuing to develop a better basis of knowledge and understanding for the future. It will be a long and difficult road. Yet, facing this challenge might possibly draw the peoples of the world closer together as they face their common future. □

(Dr. Bretherton is the Director of the Space Science and Engineering Center and a professor in the Department of Meteorology at the University of Wisconsin-Madison.)

Tracking the Greenhouse Gases

by Pieter P. Tans

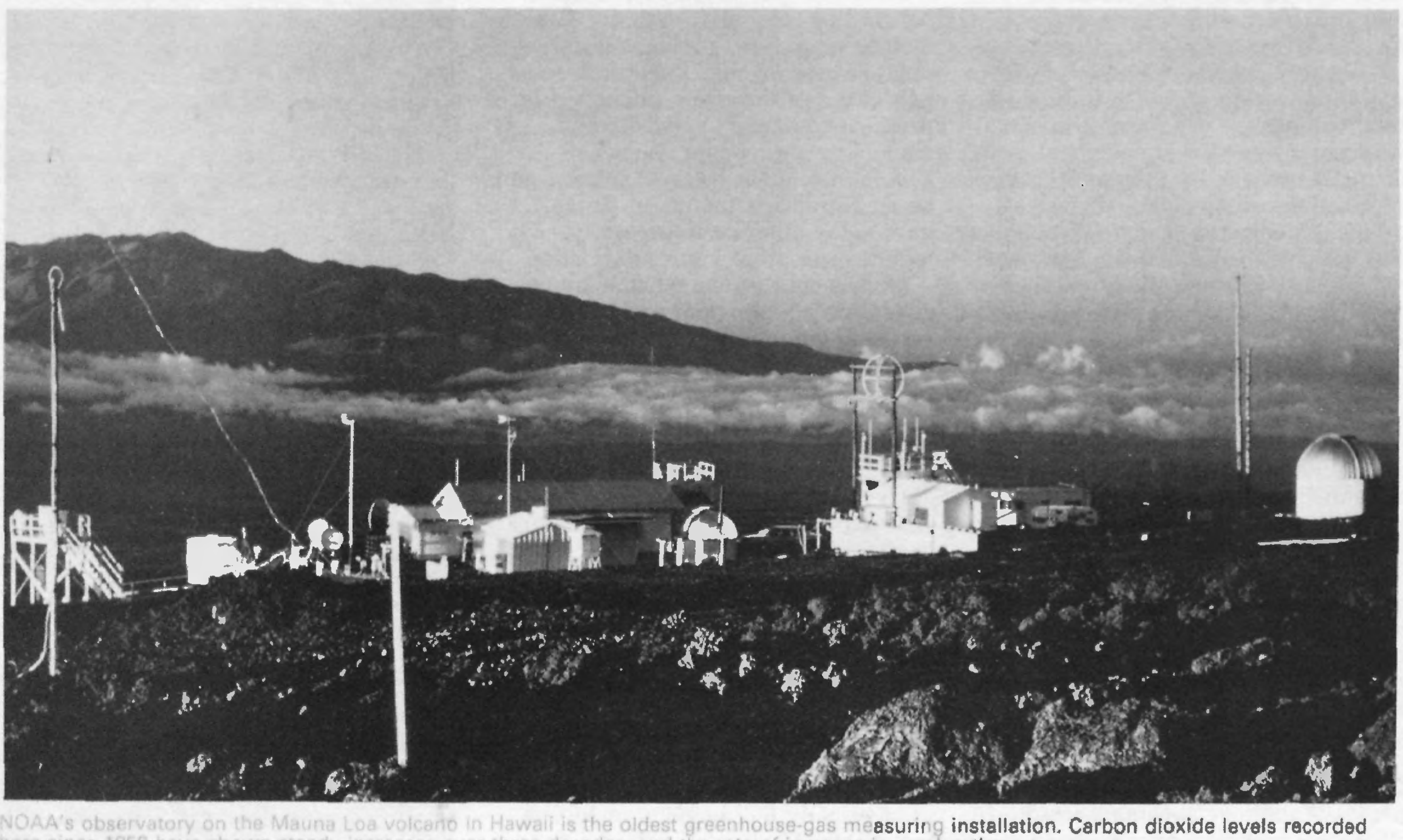
As a graduate student, I ran across a book on climate that grabbed my imagination. Written in 1971, its shocking message was that we humans were busily changing the earth's climate. Since then, my research has focused on trying to find out how man has apparently been able to "compete with the sun" in influencing the global temperature and other properties of our world climate. Part of this work concerns keeping track of the so-called "greenhouse gases," which have been increasing with the expanding scope of human activity.

Energy from the sun amounts to more than 10,000 times the heat liberated by coal, oil, natural gas, and wood that people burn worldwide. Nevertheless, it is the combustion that impacts the earth's global heat balance. Once in the atmosphere, the combustion product, carbon dioxide, stays there for a long time. Year after year it absorbs the infrared heat radiation emanating from the earth, thereby causing the surface to get warmer.

In the last 10 years, scientists have come to realize that it is not solely carbon dioxide that is making the earth's surface warmer. Other greenhouse gases doing the same include, most importantly, methane, nitrous oxide, and the chlorofluorocarbons (also held responsible for the enormous springtime stratospheric ozone decreases over Antarctica). Like carbon dioxide, these greenhouse gases also remain in the atmosphere for a long time; they are all increasing in concentration due to human activities.

Paradoxically, without greenhouse gases the earth would be too cold for life to exist. The Greenhouse Effect seems to have kept the earth warm enough for life to develop over billions of years, but now we may be creating too much of a good thing. Studies of air bubbles buried deep underneath the Antarctic and Greenland ice show that our present atmosphere contains higher levels of greenhouse gases than during the last 150,000 years. It is virtually certain that disturbance of the atmospheric heat balance resulting from these increases will lead to some profound changes in climate because the heat balance is the ultimate driving force of climate elements like temperature, humidity, and wind. One climate element in particular, cloudiness, has, in turn, a great impact on the heat balance.

NOAA photo



NOAA's observatory on the Mauna Loa volcano in Hawaii is the oldest greenhouse-gas measuring installation. Carbon dioxide levels recorded here since 1958 have shown steady increases over three decades, and the rate of increase is accelerating.

The changes being produced by humans are competing with natural fluctuations that appear to be, so far, at least as large. At this time, we are still not able to explain many important features of today's observed climate or predict precisely which regions might become warmer, wetter, or drier during the next decades.

Part of the climate prediction puzzle is that scientists don't have precise information about the amount of methane produced from various sources, which include rice paddies, wetlands, livestock, landfills, and fossil fuel burning. We can only begin to estimate the range of future methane concentrations. At the same time, we don't have all the answers about

Studies of air bubbles buried deep underneath the Antarctic and Greenland ice show that our present atmosphere contains higher levels of greenhouse gases than during the last 150,000 years.

controlling methane. Likewise, the separate roles of the oceans and the land plants in determining the carbon dioxide concentration have still not been defined in quantitative terms.

To find answers to such questions, an international scientific effort is making precise measurements of greenhouse gases all over the world. There are atmospheric observatories ranging from Alert at 81 degrees north latitude in the high Canadian Arctic all the way to the Amundsen-Scott station exactly at the South Pole. Additional air samples are collected regularly in glass flasks at many more sites and sent back to laboratories for analysis. For example, the Geophysical Monitoring for Climatic Change division of the National Oceanic and Atmospheric Administration (NOAA) operates four observatories and collects air samples from over 20 additional sites. Thousands of flask samples per year are analyzed in the division's Boulder, Colorado, laboratory. In a tightly choreographed sequence, the flasks are hooked up to three different analyzers, then prepared again for shipping, so that they can be used for the next air sample.

In earlier times, after chemists discovered that the atmosphere is made up primarily of a mixture of nitrogen and oxygen, scientists climbed into balloons to find out that the composition does not change with altitude. As a precaution, they took with them a small bird in a cage, hoping the animal would pass out before they would if the upper-atmosphere turned out to be less than healthy for breathing. Determinations of carbon dioxide were first made around 1880. The famous Swedish chemist Svante Arrhenius hypothesized before the turn of the century that carbon dioxide played an essential role in keeping the earth warm.

Today observatories and sampling sites are carefully located to avoid local contamination of the air measurements. The oldest greenhouse-gas measuring installation is at NOAA's observatory high on the Mauna Loa volcano in Hawaii. It is surrounded by many miles of bare lava rock, which minimizes the effects of local vegetation on the measurements.

The modern measurements of carbon dioxide were started at Mauna Loa in 1958 by David Keeling of the Scripps Institution of Oceanography. The measurements recorded there reflect repeated seasonal oscillations and steady increases, which have accelerated since the beginning of the measurements. The former results from photosynthesis and respiration of land plants in the northern hemisphere. The latter is mainly due to increased burning of coal, oil, and natural gas.

The Mauna Loa station records "the breathing of earth." During the growing season, plants take up carbon dioxide from the air and with sunlight convert it into organic material, while in the other seasons respiration and decay predominate.

The South Pole station is farther from human civilization than any other. The buildings are continuously being buried by unrelenting snow drifts. A few hundred thousand years from now, the slowly moving glacier will eventually dump the original buildings of the station, now abandoned and buried in the ice, into the ocean. The present station, the second, is already much deeper into the ice than when it was first built. During the brief Antarctic summer, 80 scientists perform special experiments and install equipment, but in the winter only about 20 scientists remain.

Since the South Pole has the cleanest air on earth, the worldwide increasing trends of many greenhouse gases show up very clearly. Records of its methane concentration, for example, show a seasonal cycle due to photochemical destruction of methane in the atmosphere. There is good evidence that the steady upward trend is due mainly to human activities. Methane is about three times higher today than a few hundred years ago, and six times higher than during the last ice age.

One of the important developments in the last decades is the growing realization that the chemical composition of the atmosphere bears the heavy imprint of the existence of life on the surface of the earth. Living organisms in the sea and on the land are responsible for the presence of oxygen. They lower the concentration of carbon dioxide, and they emit a host of minor atmospheric constituents of which methane is one. We have learned by analyzing gas bubbles in ice that levels of many gases in the atmosphere varied considerably with the coming and going of ice ages.

Yet there is still much to learn from these measurements and other research. At present, the Greenhouse Effect from these variations in the gas concentrations is calculated to be much weaker than the temperature fluctuations actually observed in the ice core record. Either the greenhouse warming is amplified many times by changes in circulation and cloudiness, or the variations in the greenhouse gases themselves are relatively unimportant compared to other processes that are still not sufficiently understood. In the latter case, the gas concentrations would have primarily responded to the new conditions that living organisms were experiencing when the world slipped from an ice age into a warm period, or vice versa.

Scientific understanding of the climate, and the role played by changing greenhouse gas concentrations, is still far from complete. The pressure is on environmental scientists to attain a much better grasp of what controls the earth's climate and the greenhouse gas "budgets" in a relatively short time. Decisions made today will continue to have an impact on greenhouse gases a hundred years from now. I hope the measurement of greenhouse gases can contribute to decisions that will be both rational and protective. □

(Tans is a scientist at the Cooperative Institute for Research in Environmental Sciences, University of Colorado.)

China's Environment: A Special Report

by Changsheng Li

Chinese civilization has existed for more than 4,000 years. It has created a remarkable cultural history. However, the use of natural resources in the development of the nation has sometimes had negative impacts. In fact, soil erosion and desertification caused by deforestation and land misuse affected economic growth in the basins of Yellow River and Liao River in China even during ancient dynasties.

In the last 100 years, the social instability in China has accelerated the degradation of the environment. During wars, natural pest infestations, or political movements, the conservation of natural resources and the environment was frequently minimized as a priority.

China missed an opportunity to start controlling its exploding population in the 1950s. Due to the misdirection of the population policy in the 1950s, 1960s, and early 1970s, the population increased from less than 500 million at the beginning of the 1950s to one billion in the early 1980s. The pressure of population growth accelerated the consumption of natural resources and the deterioration of the environment, resulting in soil erosion, desertification, deforestation, shortages of fresh water, and pollution. The pollution of air, rivers, and lakes was apparent in the industrial areas in China by the latter 1950s. But the problem was not recognized by our society until the early 1970s.

In China, we have inherited a thorny legacy of history regarding the environment that we have to grapple with. In 1973, to initiate the management of environmental protection in China, the central government set up a specific agency, the Office of Environmental Protection, in the State Council to coordinate the relevant ministries on affairs concerning environmental protection. During the last 15 years, the office expanded and improved, and finally became an independent government agency, the National Environmental Protection Agency (NEPA) in 1988, in charge of policy analysis, developing and implementing regulations, and monitoring environmental management in the country.

With large amounts of sulphur dioxide (15 million tons) emitted every year, it is not surprising to find acid precipitation in China.

It is not hard to imagine the feeling within the ranks of the agency when it began confronting China's environmental problems. There were a variety of serious problems and limited financial resources. Mr. Qu Geping, the director of NEPA, and his colleagues made pollution their priority and coordinated with other agencies to deal with this and other environmental problems. The agency has played an important role during the last 15 years in monitoring environmental quality, organizing research programs, increasing public awareness, setting regulations, and initiating other aspects of environmental management in China. The perspective on environmental problems in China has become clearer and broader through the agency's work.

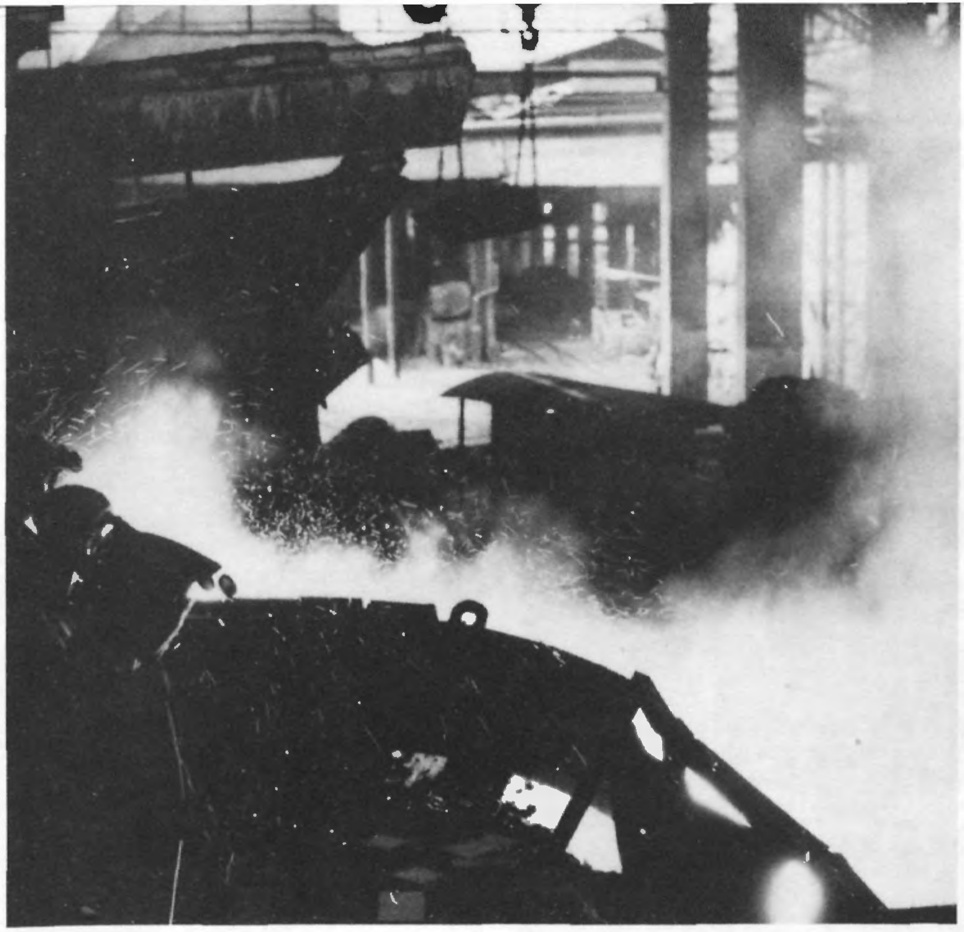
Visitors to China, especially in winter or springtime, can scarcely fail to be aware of the air pollution in urban or industrial areas. In fact, air pollution has been designated a priority of pollution control in China by NEPA. Epidemiological studies have shown significant differences in the incidence of respiratory diseases, including lung cancer, between urban and adjacent rural areas around most of the cities in China.

The main source of air pollution in China is coal combustion. The Chinese consume about 580 million tons of coal annually as fuel, including 430 million tons for industrial use and 150 million tons for domestic use. The pressure of market demand is so high, and facilities for processing coal are so deficient, that 75 percent of the raw coal flows directly into plant boilers or home stoves, without washing or other processing.

The "dirty" coal contains, on average, 23 percent ash and 1.7 percent sulphur. Dust and sulphur dioxide are the major air pollutants in most of the urban or industrial areas in China. Although particulate removal devices have been installed in most of the modern plants, there are still great numbers of sources, including small factories and domestic stoves, which emit dust into the air. Sulphur dioxide emissions control is progressing somewhat slowly because of the high cost involved. To reduce serious air pollution during heating seasons, emphasis is placed on developing central heating systems to replace the hundreds of thousands of small heating boilers or stoves in urban areas.

Meanwhile, working in concert with other agencies in charge of energy resources, NEPA is going to set up a long-term program to encourage the processing of raw coal, including washing, briquetting, and gasification. Coal is and will continue to be the major source of energy in China for some time, even though new projects using nuclear or hydropower are being planned or considered.

With large amounts of sulphur dioxide (15 million tons) emitted every year, it is not surprising to find acid precipitation in China. Monitoring during the last 10 years has found that acid rain occurs mainly in southern China, although there is no obvious



UPI/Bettmann Newsphoto

fields in 1985. Legislation and regulations are being initiated to encourage the recycling of water resources in industry and agriculture, to reduce the total amount of waste water. In the northern part of China, certain recycling practices have been encouraged since the 1970s, as a strategy for solving both the problems of sewage treatment and the shortage of irrigation water.

Ground water is the main source of drinking water for most cities in northern China, and overdraft is a common problem. For example, the water table has been lowered at the rate of about 0.5 to 1 meter per year in the Beijing area during the last 20 years. At the same time, there is a shortfall of clean water supplies to meet the demand of our cities, and the shortage of clean water is placing a dark shadow on urban development plans. The concentration of nitrites and nitrates in the ground water is also increasing. For a number of reasons, regulations are needed to control the consumption of ground water.

About 480 million tons of solid waste are produced annually by industries. Only 20 percent of the solid waste is recycled; most of it is disposed of by landfilling. There are few incinerators in China to treat hazardous waste. Landfilling is also the major approach to disposing of hazardous waste.

To handle future pollution problems, it will be necessary to establish a data base to collect information on the location, hydrogeology, etc., of existing landfill sites and measures for preventing leaching. A specific office in NEPA will be set up soon to implement the management of hazardous waste, including the registration of chemical production, use, and disposal; the new office will also collect relevant information for computerized data bases.

During the last five years, small factories have proliferated in the countryside. As a result, China's gross national product has been boosted considerably. (The industrial output of township enterprises increased from $20 billion in 1983 to $68 billion in 1986.) However, some of these small enterprises have inadvertently caused serious pollution around their locations. For example, sulphur dioxide pollution from small factories which produce sulphur from pyrite nearly destroyed all of the vegetation on the surrounding hills. Moreover, the incidence of occupational diseases is quite high

difference between the southern and northern cities in terms of sulphur dioxide emissions. The high content of ammonium and alkaline particles, including clay and weatherable minerals, in the air plays a role in buffering the atmospheric acidity in the northern part of China.

Acid rain is most common in the Sichuan and Guizhou Provinces in southwest China, where high-sulphur coal, humid climate, and acidic soils exist. The ecological impact of acid rain is not yet clear and studies will continue. Like most of the countries in the world, China is inclined to wait to see if any new scientific evidence comes out before taking serious actions to reduce emissions of sulphur dioxide.

Recently, there has been a new awareness of the impact of carbon dioxide and other "greenhouse" gases on the global climate. Several groups of senior scientists have been organized within the Chinese Academy of Sciences, as well as the NEPA system, to initiate interdisciplinary studies in China. China will be joining the relevant international programs. Since a large portion of the world's fossil fuel is consumed in China, its action should be significant.

Water pollution is another big issue in China. An investigation of the total length of 55,000 kilometers of rivers in China was made in 1982 and 1983. The study found 85.9 percent of our river length unsuitable for drinking or fishing; 47 percent did not meet national standards; 23.7 percent was unsuitable for irrigation; and 4.3 percent was found to be severely polluted. The study also showed that pollution was more serious in the branches than in the main streams of the big rivers. The dominant pollutants—ammonium, phenol, oil, and other organic pollutants—were found in most of the polluted rivers, especially in the sections around big cities.

During the last five years, small factories have proliferated in the countryside.

The lack of adequate facilities for municipal sewage treatment is a significant problem for most of the cities in China. Non-point source pollution makes the problem worse, especially in southern China, where many lakes and estuaries are threatened with eutrophication.

The application of chemical fertilizers and pesticides has rapidly increased in farming areas in order to maintain high yields during the last two decades. According to our statistics, 40 million tons of chemical fertilizers and 500,000 tons of pesticides were applied to farm

A shaft mine being built in Yenchon Coal Mines, Shantung Province, 1978. To increase resources for environmental protection, China has adopted the principle of "the polluter pays."


UPI/Bettmann Newsphoto

among workers in these factories. To monitor and handle this new situation, NEPA is going to extend its management to the town level in areas where township enterprises are prevalent.

Environmental pollution has depleted China's natural resources at an accelerated rate. For example, total farmland area in China has decreased at the rate of 822,000 acres per year as a result of erosion, desertification, industrial or municipal construction, and pollution—including landfilling, which has taken 1,310,000 acres of farmland during last 30 years. The pollution of rivers, lakes, reservoirs, and ground water has reduced our capacity to supply clean water for industrial and domestic uses. Further degradation of key resources would have profound implications on sustainable development and would have negative impacts on the economy. These negative economic effects would reduce the revenue available to improve environmental quality.

China faces a shortage of funds on the one hand and a variety of severe environmental problems on the other. To handle this situation, the government and the public recognize that environmental management must be enhanced through legislation and regulation. The Constitution of the People's Republic of China states:

> The State protects and improves the living environment and ecological environment, and controls pollution and other public hazards. (Item 26 of the Constitution)

Based on this statement, four acts were issued by the People's Congress:

- The Environmental Protection Act (September 13, 1979)
- The Marine Environmental Protection Act (March 1, 1983)
- The Water Pollution Control Act (May 11, 1984)
- The Atmospheric Pollution Control Act (June 1, 1988)

The environmental regulations China has issued so far have covered air, surface water, marine water, irrigation water, fishing water, sludge for agricultural use, pesticides, and noise. NEPA is the main government agency in charge of implementing these regulations, through its headquarters in Beijing as well as bureaus or divisions at the province, city, district, and county levels.

The environmental laws and regulations have played an important role in moderating the pollution trend in China during the last 10 years, although there is still some resistance, possibly due to a traditional skepticism regarding legislation. Educating the public, industry, and government on environmental legislation should be a major future priority. Environmental policy analysis also needs to be improved. Risk assessment, benefit-cost analysis, and environmental and ecological impact analysis are just beginning to be incorporated into the process of environmental regulation.

"Prevention First" has been adopted as the primary principle of environmental policy in China. The national social-economic development plans reflect this principle. For example, during the sixth 5-Year-Plan (the first half of 1980s), $3.22 billion was allocated for pollution control facilities in new construction (0.36 percent of the total industrial output in that period of the time). In 1983, the State Council issued a regulation requiring every industrial ministry to target 7 percent of its total investments to reduce pollution through technical innovation. The State Council also required all provinces to consider environmental protection issues in their city reconstruction plans. Environmental impact statements have been used in approving individual engineering projects for years, resulting in reduced pollution from new enterprises.

To increase the resources for environmental protection, the principle of "the polluter pays" is followed by NEPA. NEPA is in charge of enforcing environmental regulations, collecting fines, and managing funds, including disbursements to industry to enhance pollution monitoring and control.

To face environmental problems in China, there is still a long way to go. There will be a lot of difficulties as well as challenges to meet. But we have made a beginning. □

(Changsheng Li, Ph.D, is Senior Scientific Adviser of the National Environmental Protection Agency of China (NEPA) and Deputy Director of the Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences (Academia Sinica). He is currently visiting EPA under a U.S.-China bilateral exchange agreement.)

Appointments

William G. Rosenberg is the new Assistant Administrator for Air and Radiation at EPA.

Before coming to EPA, Rosenberg was chairman of The Investment Group of Ann Arbor, Michigan, and Washington, DC, which is engaged in the acquisition, development, and financing of income-producing real estate. From 1977 to 1982, he was president of Rosenberg, Freeman and Associates, an Ann Arbor real estate development and syndication firm, specializing in low- and moderate-income housing.

Rosenberg was Assistant Administrator, Energy Resource Development, Federal Energy Administration from 1975 to 1977. He was a presidential appointee on the Project Independence Advisory Commission, formed in 1974 to establish a national energy policy.

Rosenberg is a graduate of Syracuse University and holds a law degree and MBA from Columbia University. He practiced law in Detroit from 1965 to 1969.

Edwin B. ("Ted") Erickson is the new Regional Administrator for Region 3.

Erickson was Delaware County, Pennsylvania, Council Chairman, with responsibility for a $150 million county budget and a workforce of 2,500 people. He joined the Council in 1982 and currently is chairman of the Delaware Valley Regional Planning Commission, founder and chairman of Delaware County Human Services Partnership, and a member of the advisory committee for EPA's Folcroft Landfill/Tinicum Marsh Environmental Study, which is measuring the impact of a landfill on the Tinicum Wildlife Refuge.

Erickson holds a doctorate in biochemistry and microbiology from Bryn Mawr College, Bryn Mawr, Pennsylvania. He joined the faculty at Drexel University, Philadelphia, in 1962. In 1969, he became an assistant professor of biology at Hamilton College in Clinton, New York.

He was the Director of Public Health from 1973 to 1976 and Chief Administrative Officer from 1976 until 1982 in Upper Darby Township, Pennsylvania. In 1983 and 1984, he served as liaison between the Governor's Office in the Commonwealth of Pennsylvania and the EPA for the Chesapeake Bay Program.

Gordon L. Binder is the new Chief of Staff in the Office of the Administrator.

A long-time associate of William K. Reilly's, he was the Administrator's Assistant at The Conservation Foundation since 1974, and at World Wildlife Fund since the two affiliated in 1985. He also served as a member of Reilly's transition team.

Binder earned a master's degree in architecture from the University of Michigan in 1972. From 1972 to 1973, Binder was a staff member on the Rockefeller Brothers Fund Task Force on Land Use and Urban Growth for the Citizen's Advisory Committee on Environmental Quality.

Binder also worked for the Federal Architecture Project of the National Endowment for the Arts. He was a Loeb Fellow in Advanced Environmental Studies, Graduate School of Design, Harvard University, from 1979 to 1980.

James P. Moseley has been named as Agricultural Consultant to the Administrator.

Moseley is owner and general manager of Jim Moseley Farms Inc., AgRidge Farms, Moseley Genetics Plus Inc., and Moseley Land Corp. He is also chairman of the Indiana Institute of Agriculture, Food, and Nutrition, a non-profit organization that promotes agribusiness development, and a member of the board of directors of the Farm Foundation, a national non-profit organization which addresses agricultural and rural problems.

He is currently a member of the Dean's Advisory Council, School of Agriculture, Purdue University, and chairman of the Indiana Agricultural Leadership Program. A 1970 graduate of Purdue University with a B.S. in horticulture, Moseley has served on EPA's Ground-Water Workshop Committee and is a past president of the Indiana Farm Management Association.

Clarice E. Gaylord has been named the new Deputy Director for Policy, Programs, and Executive Resources in the Office of Human Resources Management.

She came to EPA in 1984 as Director of the Research Grants Program in the Office of Research and Development.

In 1987, she was selected for the Senior Executive Service Candidate Development Program. While in the program she worked as Chief of the Risk Analysis Branch in the Office of Toxic Substances, Chief Executive Officer of the Office of Compliance Monitoring in the Office of Pesticides and Toxic Substances, and Director of the Policy and Management Staff in the Office of Ground-Water Protection.

Gaylord implemented EPA's Minority Summer Intern Program, under which minority college honor students work as researchers in EPA labs. She received a B.S. in zoology from UCLA in 1965. She earned a master's degree in zoology from Howard University in 1967, and a doctorate in the same field from Howard in 1971.

Gaylord then worked for the National Institutes of Health as a health scientist administrator and joined EPA in 1984. She has been awarded two EPA bronze medals for exceptional service, as well as the Special Achievement and Public Service Recognition awards.

Dr. Gary J. Foley has been appointed Director of EPA's Atmospheric Research and Exposure Assessment Laboratory (AREAL) in Research Triangle Park, North Carolina.

As Director of the Environmental Monitoring System's Laboratory since 1988, Foley reorganized and combined the lab with the Atmospheric Sciences Research Laboratory to create AREAL. From 1982 to 1988, he worked in the Acid Deposition Research Program, leaving the program as Division Director.

He started his career with the Agency in 1973 with the Control Systems Laboratory, moving on to the Office of Energy, Minerals, and Industry in 1974. In 1976, Foley left the Agency to work for the Organization for Economic Cooperation and Development. He returned to the Office of Energy, Minerals, and Industry in 1979 and went on to become Division Director in the Office of Environmental Processes and Effects Research.

Foley holds a master's and a doctorate in chemical engineering from the University of Wisconsin at Madison. He has received three EPA bronze medals for exceptional service.

Martha R. Steincamp is the new Regional Counsel for Region 7. She previously served as Acting Regional Counsel since January 1988.

Steincamp joined the Agency in 1977, as a staff attorney. She became Associate Regional Counsel in 1983 and Deputy Regional Counsel in 1985.

Steincamp received a B.A. in political science at Fort Hays State University. She earned a Juris Doctorate from Washburn University in 1971. After completing law school, she was Assistant General Counsel for the Kansas Corporation Commission until 1975. Before joining EPA, she was an assistant professor of Law and Society at the University of Nebraska at Omaha for two years.

Marcia E. Mulkey is the new Regional Counsel for Region 3. She had been Chief of the Air and Toxics Branch in the Office of the Regional Counsel for Region 3.

Mulkey joined EPA in 1980 as a General Attorney in the Pesticides/Toxic Substances Division in the Office of General Counsel. She worked for the U.S. Nuclear Regulatory Commission as an Attorney-Advisor from 1976 until joining EPA.

Mulkey received a B.A. from the University of Georgia in 1967, and a master's degree in 1968. She was an assistant professor at Western Illinois University and debate coach from 1970 to 1973.

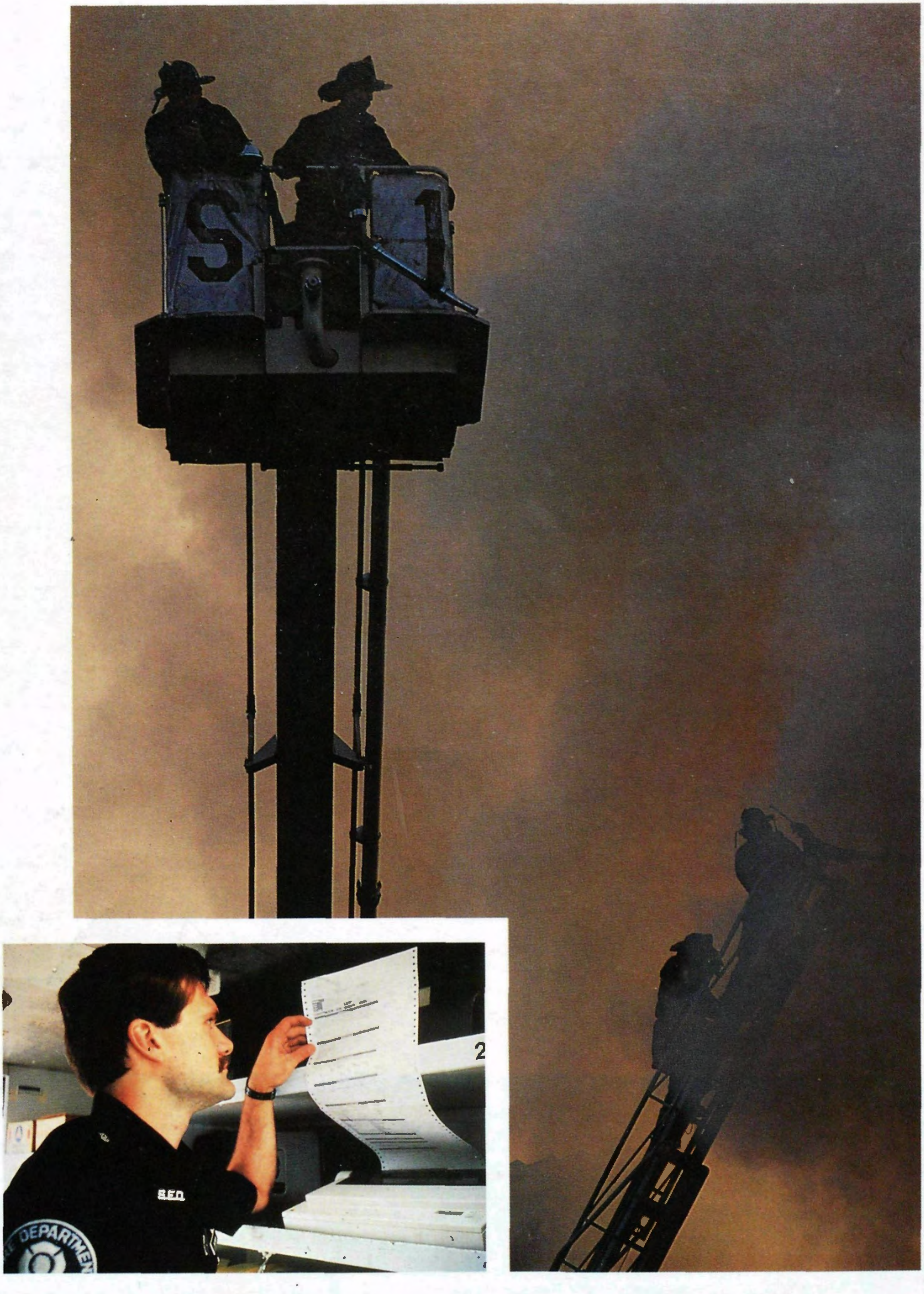
A 1976 graduate of Harvard Law School, she coached the university's debating team while earning her degree. She has been awarded EPA's silver medal for exceptional service. □

Editor's note: While this issue was at the printer, EPA Journal learned that F. Henry (Hank) Habicht had been confirmed as the Agency's new Deputy Administrator. A full report will follow in the next issue.

Thinking. (Lake Mendota, Madison, Wisconsin) *Photo by Mike Brisson*

Back Cover: The computerized CAMEO system developed by EPA and the National Oceanic and Atmospheric Administration provides on-the-spot information about how to deal with chemical emergencies. See article on page 20.

Firefighter photo by Robert Frerck, Woodfin Camp, Inc Computer photo by Seattle Fire Department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