

Environmental Science

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Sure, the Cuyahoga River Is No Longer on Fire, but the Planet Is Still a Mess. The Challenge of the Future Is to Confront the Increasingly Complex Threats to Our Air and Food and Water and Children.

By Marla Cone

Halfway into the new century, the Earth will still suffer from an array of frightening ills: Foul water? Inevitably. Sickening air? Quite likely. Vanishing wildlife? Definitely. Environmental scientists, though, can predict one thing with certainty: The hole in the ozone layer will be virtually healed. For that you can thank a chemist nobody knew, at a university few people had heard of and a discovery that shook the world.

Twenty-five years ago chemicals in everyday products such as deodorants and air conditioners were rising in the atmosphere, chewing a huge hole in the ozone layer that protects Earth. Experts had long thought these chlorine-based chemicals were harmless. Nobody suspected they were slowly building up far away, in the stratosphere. Until F. Sherwood Rowland spoke up. Even then, people were slow to believe the breakthrough in atmospheric chemistry that Rowland and postdoctoral fellow Mario Molina discovered in their UC Irvine lab in 1973.

Today, as the millennium ends, ozone depletion is common wisdom. The compounds, called chlorofluorocarbons, were finally banned in developed nations under a famous international treaty. And in 1995, Rowland and Molina won a Nobel Prize for their work. It was a stunning success story, a watershed moment for environmental science. Yet it shows that knowledge doesn't always bring immediate cures. Indeed, it will be 50 years before the hole closes.

Half a century after an atmospheric chemist discovered the composition of Los Angeles smog, and almost 40 years after biologist Rachel Carson described pesticides silencing birds, scientists are still struggling to understand—and undo—the complex layers of damage that humans have inflicted on nature. Yet this isn't "gee whiz" stuff that we can sit around and ponder for another century. Credible answers are critical to the world's economy and health. Scientists will help shape environmental-protection efforts that cost hundreds of billions of dollars yearly, altering the products we buy, the food we eat, the vehicles we drive, the fuel we burn.

THIRTY YEARS AGO, AMERICA'S PROBLEMS WERE MUCH MORE OBVIOUS. Rivers caught fire because they were so polluted. The Great Lakes were so filthy that you could put your hand in the water and pull it out covered with slime. DDT was wiping out pelicans, eagles and falcons in California. Lakes were acidified in the Northeast. Raw sewage and industrial waste routinely flowed into the ocean and waterways. Air pollution was so severe that Angelenos were warned to spend virtually the entire summer indoors. But as Y2K dawns, the problems are more subtle, and that means science is even more critical when it comes to designing—and defending—costly cures.

Today, more than one-third of U.S. waterways are still unsafe for people and aquatic creatures. The list of endangered animals and

plants keeps growing. More than 1,000 Superfund sites exist. The Los Angeles basin—specifically San Bernardino County—still tops the list of polluted U.S. metropolises, with air deemed unhealthy to breathe on 62 days last year alone. In the next millennium, environmental researchers will wrestle with issues that are fundamental to the quality of life—some say even the survival of humans and other life forms that share the planet.

Certain areas of exploration will be especially hot:

How are children and fetuses harmed by chemicals in our food, water and air? What are the cumulative health effects of the things we eat, drink and breathe? What is happening to biodiversity in our backyard and around the world, and what does that mean to life on Earth? How much can we expect our climate to change from greenhouse gases? How healthy are the world's oceans? What are the best ways to clean up the toxic legacies that linger from our past?

Although most environmental problems in the United States are improving, scientists are finding new ones as they hone their ability to detect changes. They now measure pollutants in the parts per trillion. They run complex computer models predicting the future. They use satellites and geographic information systems to map endangered animals or track a plume of polluted ocean water. They test the DNA of whales, of eagles, of viruses. They detect seemingly slight variations in climate.

"It is certainly true," says UC Irvine's Rowland, "that within the scientific community, the ability to measure with greater sensitivity and with greater precision allows you to be sure that something is happening. Before you might have only *thought* something was happening. Now, more frequently, we can actually get the evidence." What that means, Rowland adds, is that "it is harder for politicians to deny it."

Ozone depletion taught scientists that they can prompt international action if their message resonates. With that problem, "we've already taken control of the next millennium," says Michael Prather, a UCI atmospheric scientist.

Unfortunately, in many other cases, researchers impede problem-solving by failing to present their work in such a way that rivets people's fragmented attention and lets them see how scientific data and reasoned speculation can interact—and environmental disorder can alter their lives.

Most atmospheric experts, for example, agree that the burning of fossil fuels is responsible for a "greenhouse effect" that is causing a slow overheating of the planet. Only the rate of warming and the scope of the impact remain a puzzle. That message, however, has failed to awaken much public concern, in part because the coal and oil industries have led a highly publicized campaign to dispute conflicting research.

Still, some experts predict that carbon dioxide and other green-



house gases will surge over the next century, and will only begin stabilizing around 2100 even if strong action is taken now to cut use of fossil fuels. The warming trend will become more obvious, with scientists able to forecast, down to a specific city, what will happen to farms, beaches, ecosystems and other features of life. Some localized predictions could emerge as soon as next year and gain more credibility over the next decade. As with most science, it won't take a single breakthrough. Instead, scientists will become more comfortable with their ability to use computer models to make sense of the chaotic world of climate trends.

"Scientists are not convincing to the public because we are not convinced that we can predict these effects," says Prather. "If we become a uniform voice predicting what will specifically happen to the L.A. basin, that's stronger than a 'what if.'"

YET "WHAT IF?" REMAINS A KEY QUESTION FOR ENVIRONMENTAL scientists. In the field of ecology, biologists are trying to unravel the web of life—what happens if one creature disappears from a landscape? If tiny organisms on the ocean floor are wiped out by pollution, what does that mean?

One challenge, for example, pits science against the question of just what happens when people and wildlife are exposed to the sort of low-level pollution that is commonplace around the world. Scientists already agree that many pesticides and compounds in plastics can mimic sex hormones, feminizing wildlife and damaging their reproduction. When mothers in the wild are exposed to these chemicals, they pass the damage to their embryos, and their male offspring are born with confused hormones, sometimes rendering them half-male, half-female and sterile. What no one knows yet is whether these chemicals, in lower doses, are harming humans. But it could be why some global studies have found drops in human sperm counts. Evidence is also emerging that many of these same chemicals can damage children's immune systems and alter their brains and behavior.

Scientists, however, may never know what, if any, effect everyday levels of pollution are having on people because of the intrinsic difficulty of studying humans, who tend to move, travel, breathe air in many different cities, eat a varied diet and maybe even smoke. Teasing out a cancer cluster or some other health effect and linking it to an environmental cause is tricky. The effects have to be dramatic or they escape detection.

For months, a state panel of experts debated how many Californians might be dying from exposure to diesel exhaust. At one point last year, UCLA's John Froines, who chairs the panel, reminded his fellow scientists that the numbers "aren't real anyway." The audience was taken aback—this calculation was supposed to be critical for helping regulators decide how much to reduce exhaust from trucks and other engines. But Froines was being honest about the imprecision of the science of risk assessment. The number of lives lost can be estimated. But it's theoretical at best, wildly inaccurate at worst. The upshot is: "The stuff is dangerous. We just don't know how dangerous."

IN THE MEANTIME, POLICY MAKERS KEEP PUSHING FOR THE PERFECT models to predict future smog or climate conditions or water quality. They want to know precisely how much pesticide residue on fruit is safe, how many swordfish can be caught without depleting the species. While science will provide better and better answers, public-health decisions often cannot wait. Politicians and regulators are left hanging, making critical judgments based on too little science.

As biologists strive to say precisely what damage we're causing, engineers are curing the ills. New fuels, new engines, new sustainable lifestyles, new technologies to clean up tainted water, new tricks to rebuild wetlands or manage forests—they'll all be available. Drinking water, for instance, will soon improve tremendously as new "micro-filters" screen tiny, sickening organisms such as cryptosporidium and giardia.

Michael Stenstrom, an engineer who directs UCLA's Institute of the Environment, believes that technology can solve virtually any environmental problem. But he stresses that the ones that get fixed are the ones the public wants fixed. "It's not an issue of what technology *can* do," he said, "but of what people are interested in doing."

Here, in the Smog Capital of the United States, the encouraging news is this: If the Earth can be saved, Southern Californians will likely be among its most innovative and hard-working saviors. Experts at USC, UCLA, UC Irvine, Caltech, Scripps Institution of Oceanography and others have all contributed pioneering work. And nowhere in the world can California's expertise about the causes, effects and cures of air pollution be matched.

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