PART FIVE LESSONS LEARNED AND EMERGING THREATS

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CHAPTER SIXTEEN

Forgotten Lessons

THE PRIMARY ANTAGONISTS in these histories of nuclear weapons testing, military training, pesticides, and diesel emissions have been large public and private institutions: the Departments of Defense and the Interior; the USDA, EPA, and FDA; and major chemical companies. All have played powerful roles in shaping our nation's chemical environment. Further, despite the very different types of risk posed in each case, there are striking similarities or patterns in how threats to the environment and to human health were discovered and either addressed or ignored. What are these lessons, and how might they guide government policymakers, corporate officials, and consumers to create a healthier and more sustainable world?

NUCLEAR WEAPONS

The discovery of hazards created and dispersed by nuclear weapons testing had a profound effect on the future of environmental science and law. Nuclear weapons were obviously intended to produce catastrophic environmental damage, but the Atomic Energy Commission's discovery of global fallout and ubiquitous human exposure was a surprise. Consequently, although each of the nearly five hundred atmospheric tests was first and foremost an experiment in nuclear destruction, gradually government scientists were compelled to expand their observations to include the persistence, movement through the atmosphere, unsuspected ecological

pathways, variable human exposures, and unanticipated health effects of the radionuclides that had been produced. As the destructive force of weapons grew, AEC officials gradually realized their failure to predict global circulation of fallout and universal exposure. The enormous scale of state science necessary to understand these effects became a model for later attempts to comprehend climate change and many other hazardous chemicals that circulated globally.

Public understanding of the problem was impossible at first due to the absence of environmental data, and later the government's determination to maintain exclusive control over both nuclear technology and the science used to understand its effects. This monopoly on intelligence created a potent ability to shape public opinion by restricting the release of information. It also empowered the government to weave its own narrative about the extent of fallout, health implications, and the relative threat of nuclear fallout when compared to natural sources of radiation. Secrecy effectively shut out the public from understanding and debating these risks; it also left public officials unaccountable, while preventing any impartial evaluation of scientific findings.

Most details regarding early health and environmental testing were classified and thus not publicly available until the 1990s, when the U.S. Department of Energy and the National Cancer Institute documented the extent of contamination, human exposure, and cancer risk attributable to the weapons testing program. The institute graphically displayed the variability of the threat by color-coding counties on a national map based on the concentration of fallout detected in the soils. Before release of the risk estimates, the government had reasoned that public understanding of the threat would jeopardize national security. Public panic, officials believed, could easily have led to economic collapse of markets for products or property where radionuclides concentrated. Certainly national leaders also wished to avoid being held accountable for their failure to prevent universal exposure.

The government's race to know what happened to radioactive fallout taught much about chemical pathways linking the atmosphere, oceans, soils, plants, animals, and our bodies. This ecological form of thinking in turn helped society to understand risks associated with other technologies circulating globally, including pesticides, flame-retardants, mercury, air pollutants, and persistent compounds.

Persistence is an important indicator of potential hazard. Strontium-90's half-life of twenty-seven years means that exposure threatens genetic damage for entire lifetimes. Chronic exposure to persistent compounds may lead to their accumulation, as was the case with strontium-90 in human bone and DDT in body fat. Chemicals that are immediately damaging and quickly dissipate are perhaps the most dangerous because there is no warning and often little trace of their source. Persistence, by contrast, allows scientists the opportunity to track chemical movement and fate, and often motivates testing for health effects. Tracking of radionuclides after weapons testing, for example, led to the unexpected discovery that the food supply had become the primary pathway for human exposure to radioactive particles. AEC scientists carefully documented the movement of these particles from blast sites to dinner tables, and by the early 1950s scientists could measure contaminants in human tissues such as bone, urine, blood, and fat, correlating the levels to fallout patterns. Recognizing the vulnerability of the food chain became one of the most important paradigms for future efforts to control pesticides, mercury, dioxins, PCBs, and plasticizers such as bisphenol-A. All may migrate from the environment to human tissues, hitchhiking as food residues. It is sobering to realize, however, that the cost of understanding the effects of a globally dispersed technology, and of developing such paradigms, is beyond the capacity of most nations and all but the largest corporations. Dow Agrosciences, for example, spent nearly $100 million to study the effects of only one insecticide. This expense inhibits research and explains much of society's ignorance about the fate and effects of toxic chemicals and other contaminants.

The dangers of nuclear weapons testing were underestimated and misunderstood, but concerns were voiced. In 1956 the National Academy of Sciences concluded: "How much of this radioactivity will actually reach the population depends on how successfully it can be kept out of the great network—ocean and air currents; food and water supplies—which connect man to his surroundings."[1] This was an obvious and authoritative warning that the only way to successfully prevent exposure was to cease atmospheric testing.

But although blast damage was obvious near test sites, fallout was invisible and its global spread was imperceptible. Most hazardous substance problems are similarly undetectable by nonspecialists because they cannot

be sensed by sight, smell, sound, touch, or taste. In the case of weapons testing, once inexpensive detection technology such as radiation badges, X-ray films, and Geiger counters made it possible for those without technical expertise to recognize the scale of the threat surrounding them, they challenged government claims of safety and purity. When a hazardous technology and the ability to detect it are both held exclusively by governments or corporations, however, the public cannot challenge such claims.

With no other evidence to consider, the AEC initially presumed that fallout was uniformly distributed beyond the test zone, which encompassed an area two hundred miles around the blast sites. This led them initially to believe that human exposures were minimal in different parts of the nation and world. By the mid-1950s, however, hotspots of fallout were being detected thousands of miles from the explosions; these hotspots had created unexpectedly higher exposures among populations as they consumed dairy products and meats from the contaminated areas. Several public agencies, including the Public Health Service and Weather Bureau, developed credible challenges to the commission's safety estimates by identifying this sort of concentrated fallout. Their challenges underlined the importance of separating the roles of technology development and testing from those of environmental monitoring and regulation. The conflict of interest created when the roles are joined under a single authority is obvious, and can easily work against the public's interest. Although the Atomic Energy Commission established a separate office to regulate the civilian use of atomic energy in 1957, it remained responsible for the study and regulation of its weapons programs—and the public continued to be left in the dark about the dangers of fallout and the extent of contamination at testing sites. The consequences of concentrating the powers of technological innovation and regulation in a single agency can be devastating, and given the legacy of the AEC, are well known. We need to remember this lesson as we consider how the EPA has come to rely on the private sector to monitor the levels and effects of its own polluting technologies.

Early in the testing program, the AEC had also assumed that all people were equally susceptible to health damage from radionuclides. It wasn't until several years later that scientists learned that children's rapid rates of bone formation had led to accumulations of strontium-90

to levels that in many cases exceeded those of adults. In 1955, the Department of Health and Human Services established a committee to explore the susceptibility of children to radiation from fallout, and to examine why the youngest are more susceptible to high doses of radiation (in this case, from X-rays) than adults. In 1956, the British Medical Council recommended lowering allowable U.S. levels of radiation tenfold, because of children's rapid absorption of the isotope and their heightened sensitivity to its ill effects. And during the 1950s and 1960s, the growing anxiety of Presidents Eisenhower and Kennedy over rising levels of radionuclides in the world's children and fears for their health and that of future generations played a prominent role in reversing international nuclear policy. This concern for the most vulnerable became a model for later inquiry into the effects of childhood exposure to pesticides, lead, air pollution, mercury, and more recently, ingredients in plastics.[2]

The nuclear weapons testing program also provided the first environmental model of cumulative irreparable damage.[3] By 1956 the U.S. National Academy of Sciences had concluded, "Anything that adds radiation to this radiation from naturally occurring background rate causes further mutations, and is genetically harmful. There is no minimum amount of radiation which must be exceeded before mutations occur. Any amount, however small, that reaches the reproductive cells can cause a correspondingly small number of mutations. The more radiation, the more mutations. The harm is cumulative."[4] Although this conclusion came too late for millions of people worldwide who were affected by increases in radioactive toxins in their environments, the message looking forward is clear: the public needs protection from unwarranted, unnecessary, and even accidental increases in environmental radiation.

During the atmospheric nuclear weapons testing era, messages to the public were crafted to be reassuring, not informative. Political and military leaders often compared natural hazards such as X-rays, cosmic radiation, and radon with fallout that they deceptively claimed was less threatening. They argued that any risks from testing were worth the benefits of having superior weapons that would supposedly deter nuclear war. They also compared costs to benefits when weighing the importance of developing new and more powerful weapons—a logic that resurfaced in later twentieth-century debates over nuclear power, pesticides, hazardous waste site management, air and water pollution control, and pharmaceutical

regulation. The cost-benefit approach, however, rarely considered the nonuniform distributions of the gains and losses—for example, unpredictable hotspots of fallout or the extraordinary concentration of radionuclides in children. Nor did it acknowledge that those reaping the benefits were rarely those who bore the greatest risks.

Since the U.S. bombing of Japan at the end of World War II, nuclear weapons have not been used in an offensive campaign. But the costs of deploying them for deterrence, in terms of both dollars and loss of health, have also been enormous and are often discounted simply as the price of security. Several hundred thousand innocent people died in Japan while many more suffered lifelong illness and economic devastation. In 1995, the National Cancer Institute estimated that between 11,000 and 212,000 additional cancers are expected in the U.S. population due to the weapons testing program; and many production sites such as Savannah River in Georgia, Hanford in Washington, and Rocky Mountain Arsenal in Colorado remain among the most seriously contaminated sites in the world. The costs to restore these sites to a safe and habitable condition were estimated in 2006 to be nearly $500 billion.

Consider what the world might have done with the $5.5 trillion expended by the government to create, store, and deploy nearly 65,000 nuclear weapons held by both the United States and the Soviets during the 1980s. Imagine the improvements in health, education, environmental protection, parks, transit, technology, sustainable development, and foreign aid that might have changed the course of civilization if these resources had been redirected for the greater good. As Richard Rhodes wrote in 2007, "Far from victory in the Cold War, the superpower nuclear-arms race and the corresponding militarization of the American economy gave us ramshackle cities, broken bridges, failing schools, entrenched poverty, impeded life expectancy, and a menacing and secretive national-security state."[5]

Unlike the other historical examples reviewed in this book, radionuclide contamination was caused by a single manmade source: the atmospheric testing of nuclear weapons. When tests ceased in 1963, the fallout, as well as its associated health hazards, gradually declined. Like the national ban on lead in gasoline, and the consequent declines in lead levels in children's blood, once the cause and effects were identified, the problem could be addressed. Unfortunately the problems of climate

change, pesticide contamination, and hormonally active chemicals in plastics cannot be countered as easily.

A final cost of the weapons program has been a continuing and growing threat of proliferation. The technology is so desirable to governments of all kinds that exclusive control has been impossible to contain. Seven nations now acknowledge possession: the United States, Russia, Great Britain, France, China, India, and Pakistan, with most of the 20,000 weapons in existence held by the United States and Russia. Israel also probably has nuclear weapons, although it will neither confirm nor disavow an arsenal. North Korea tested its first nuclear device in 2006, while many experts fear the same capacity in Iran.

This history also demonstrates two distinctive forms of risk: the potential for massive and immediate destruction of human life, and the potential for chronic environmental contamination that would threaten health for generations. The two threats became inseparable and once the public understood this, continued testing became intolerable. The eventual diffusion of knowledge from the AEC scientists to the lay public also left an indelible impression on the structure of environmental science and law.

THE PESTICIDE PARADIGM

Although many know Rachel Carson's *Silent Spring* as a work decrying the hazards of pesticide use in the United States, few realize that the 1962 book grew from Carson's perception of the growing ecological threat created by the U.S. and Soviet nuclear weapons tests. Carson kept files documenting rising strontium-90 concentrations in crops and human tissues through the late 1950s and early 1960s, then worried about genetic damage and cancer in humans.

Pesticides have long been released to the environment to protect plants, animals, and even humans from vector-borne illnesses. After their initial use, residues continue to travel through air, water, and food chains. Between 1945 and 2008, billions of pounds of pesticides have been released annually to indoor and outdoor environments, usually to improve agricultural productivity and protect human health. Everyone in the United States lives, works, studies, plays, or rides in environments where pesticides are applied, and residues are detectable in the tissues of most people on the planet. For this reason, and because of international

trade in tens of thousands of pesticide products and the deliberate addition of pesticides to hundreds of thousands of consumer and industrial products, this technology has been exceedingly difficult and expensive to detect and regulate. The ever-changing combinations of chemicals that humans experience are beyond the capacity of any government to comprehend or contain.

The way intelligence has been gathered on the environmental and health effects of pesticides has complicated the problem: this information has been produced almost exclusively by manufacturers seeking government licenses. Government reliance on private science has created obvious conflicts of interest. The process discourages industry disclosure of damaging effects and demonstrates well the need for a government-sponsored independent testing regime to assure full disclosure and transparency. Like the AEC's tight control over intelligence concerning the effects of nuclear weapons testing, pesticide manufacturers' directed and secretive "science" has obstructed the public's right to know.

The failure by government to ask obvious questions has also stood in the way of public intelligence regarding pesticide risks. The EPA and the USDA before it have neglected to demand or collect the data necessary to understand a pesticide's hazards before allowing it to be sold in global markets. Although the federal government has been regulating pesticides for more than sixty years, no government agency has yet done the testing needed to understand where pesticide residues linger, how people are exposed, and what dangers they pose to the health of all people, but especially children, infants, and fetuses.

The histories of the AEC and the EPA have their differences. Within ten years of the initial 1945 Alamogordo test, the AEC understood well the risks created by exploding nuclear devices in the atmosphere. The EPA, in contrast, spent much of its first thirty-five years misunderstanding the effects of pesticide mixtures. One likely explanation for this distinction is that the AEC effort evolved as highly centralized state science that quickly became global in scale, whereas the EPA effort depended on highly decentralized and incrementally produced corporate science.

Just as the AEC gradually recognized that radiation posed a greater threat to children than adults, EPA scientists eventually became convinced that children are more susceptible and exposed to pesticides than others. This realization, however, was long in coming. For nearly half a

century between 1947 and 1998, neither the EPA nor the USDA asked if young people are especially vulnerable to pesticide hazards before offering licenses to manufacturers. Eventually political leaders chose not to tolerate the presence of radionuclides in children's bodies, while allowing thousands of pesticide combinations to accumulate in their tissues. Why would the government not infer that if animals were building pesticide residues in their milk, humans might do so as well? Why would society tolerate children's exposure to pesticides, but not to radiation?

Pesticide law now relies on safety factors to manage environmental dangers. The practice emerged from the need to address the question of what level of exposure the public should be allowed to experience. EPA experts have tried to identify the threshold level beyond which harm is likely to occur. The answer is crucial if the government is to license drugs, set pesticide residue limits in foods, limit contaminants in drinking water, and identify acceptable levels of ozone or particles in the air. If adverse effects are found in animal studies above a certain dose, what relevance does the threshold have for humans? Many uncertainties surround the answer, and the government's approach has been to employ a safety factor to buffer against any underestimate of danger.

In fact, safety factors have become keystones of corporate arguments to limit rather than ban marketplace hazards. They can use them to justify the sale of very dangerous products, avoiding their prohibition. Bans still may become necessary, however, if normal exposures exceed government limits. For example, in 1996 Congress raised the pesticide safety factor from 100 to 1,000 to offer children additional protection. As a result, hundreds of pesticide tolerances in foods consumed frequently or in large amounts by children had to be revoked or reduced.

Since 1954 the government has defined the task of regulating pesticides mostly as one of managing residues in foods, in part due to amendments to the Food, Drug, and Cosmetic Act made in the mid-1950s and in part because of bureaucratic inertia. This focus has distracted federal officials from the more dangerous conditions created when pesticides contaminate drinking water, workers labor in recently sprayed fields, sprays drift from farms to nearby lands, and pesticides are released indoors. Each of these scenarios occurs tens of millions of times each year, and has produced intense exposures that far exceed those created when residues persist in foods. In particular, the EPA knows least about exposures to

pesticides within indoor environments, even though people spend most of their time indoors and their exposure is likely to be far higher there than outdoors. Although a hundred different pesticides were still permitted by the EPA to be used indoors in 2008, the fate of most of these chemicals remains poorly tested.

In addition, among nearly a thousand active pesticide ingredients now registered by the EPA, only twenty-six are limited in drinking water. The absence of a comprehensive surface- and groundwater testing program has guaranteed government and public ignorance of pesticide levels in these important sources. Federal regulators also know almost nothing about the presence of residues in wells that are exempt from testing requirements—but that provide water each day to 60 million people in the United States.

The EPA's traditional chemical-at-a-time testing protocol guarantees that the potential for additive, synergistic, and even antagonistic effects among mixtures of compounds will remain unknown. As recently as 2006, the agency assessed risks posed by a group of organophosphate insecticides and concluded that since individual chemical risks were insignificant, then exposure to mixtures of the same chemicals would be acceptable. This logic neglects many instances of unpredicted chemical interactions and synergy, some among insecticides.

To manage the risks of pesticide exposures, the government has long relied on consumer product warning labels. These certify to the public that if the product is used properly, the risks may be safely controlled. This approach, however, has failed to prevent significant damage to the environment and human health. Tens of millions of users have limited vision that precludes them from reading the small sized print on pesticide labels. Others do not take the time to read labels, or don't have the educational background needed to understand them. Some are careless and do not mix chemicals precisely, apply the chemical as instructed, or properly dispose of unused portions. In fact, most pesticide poisonings occur among children, who could not be expected to understand how best to avoid health risks. Despite these serious limitations, labeling persists as our nation's dominant legal strategy to protect against dangerous commercial chemical exposures.

The ideal regulatory regime would encourage the rapid substitution of less hazardous new products for older, riskier ones. Yet the EPA routinely

licenses new chemicals in the absence of full hazard testing, which can create false impressions of safety. DDT, for example, was indeed an effective substitute for pesticides made from metals such as lead, arsenic, and mercury, all recognized early in the century to pose a serious threat to human health. But when concerns arose about DDT, it was replaced with methyl parathion, which is now banned. Also missing from current policy is a way quickly to remove products from the marketplace when they are discovered to be dangerous. Instead, credible evidence of hazard has often been followed by decades-long delays and debates over the quality of the data, acceptable exposures, and the potential of proposed schemes to manage risk. The result is a regulatory paralysis that normally allows exposures to continue if the technology in question is highly profitable. Litigation similarly slows government decisionmaking, extending market life for profitable but risky technologies. Even regular reviews of pesticide tolerances have become bogged down; the EPA often fails to meet its deadlines, but no penalty is applied. In 2006, the agency institutionalized the delay by adopting a regulation requiring that chemicals be reviewed only every fifteen years. At this rate, an entire generation could easily grow up being exposed to a chemical known to be dangerous.

The government and the pesticide industry have long presumed that risks are knowable and manageable, and that human exposure can be minimized using a variety of educational strategies. Yet the history of pesticide regulation teaches that effective protection against dangerous exposures can occur only if information is available and understood by all who might be exposed. Without a government willing to mount the large-scale independent scientific inquiry needed to identify and control the dangers of pesticide residues, and willing to disentangle influential business interests from regulatory decisionmaking, people will continue to poison themselves and their environments simply because they don't know better.

LAND RESTORATION

U.S. national security has long relied on the capacity to launch a strong and rapid offensive, one that is intentionally destructive to the environment and human life often on a massive scale. Military operations normally target highways, power plants, pipelines, bridges, water supplies,

and sewage facilities. If they are to succeed in a real conflict, soldiers and sailors must first practice using the weapons they will employ on the battlefield. Maintaining military readiness with live-ammunition training, however, has created some of the most contaminated landscapes and seascapes in the world. The intent of this training is to destroy and disable, and historically there has been little concern for the places that are bombed, shot at, and invaded.

Prior to 1970, the U.S. Department of Defense was free to ignore the environmental consequences of its weapons development and training programs. The passage of the Clean Air Act, Clean Water Act, National Environmental Policy Act, Endangered Species Act, and hazardous site restoration laws, however, changed the political landscape by requiring that environmental conditions be monitored and reported, by increasing accountability to the public, and by creating opportunities for litigation.

When Congress adopted these laws, neither the EPA nor the Defense Department understood the scale of environmental damage incurred by former military activities. The Defense Department simply had not paid attention to the problem of chemical management at any of its facilities. Live-ammunition training and weapons testing facilities were especially contaminated. Base commanders licensed, subsidized, or directed the release into the environment of hundreds of millions of pounds of munitions at some sites, as well as fuels, solvents, pesticides, radioactive materials, chemical and biological weapons, and many toxic metals. Fleets of ships were intentionally scuttled at sea by the Navy, leaving them to rust slowly while leaking fuels, solvents, and munitions. Between 1951 and 1966, weapons and radioactive wastes from nuclear-powered vessels were also routinely dumped at sea. More than 150,000 containers were tossed overboard with little regard for how radionuclides move through marine food webs to human dinner tables. Highly radioactive wastes produced at the Hanford weapons production facility in Washington, for example, were dumped into pits and tanks that still leak into the Columbia River watershed. Radioactive materials were also intentionally released to the atmosphere at Hanford without community knowledge or consent.[6]

For its part, the EPA for the first two decades of its existence was overwhelmed by private-sector air and water pollution problems along with its inherited responsibility to regulate pesticides. Although in 1986 Congress enacted the Superfund law, which directed the agency to prioritize and

restore the nation's most hazardous sites, the EPA still had neither the expertise nor the resources to assess damage at Department of Defense facilities. Nor had Congress allocated the funds needed to restore them.

Since 1990, Congress has directed the Defense Department to close many bases and facilities as recommended by the U.S. Base Realignment and Closure Commission. This effort was motivated by the expectation that defense costs will decline in the transition to a more technologically sophisticated and less labor-intensive military force. It also grew from the belief that most current facilities are designed to prepare for conflict among Cold War superpowers, whereas warfare in the future would more likely involve civil and sectarian conflicts in which nonuniformed opponents would need to be confronted, often in urban settings.

Congress expected that the closed bases would be transferred to other public or private institutions, but understood little about their environmental conditions or lingering health hazards. The discovery of concentrated hazardous chemicals in soils, water, and structures created the unexpected need for exceptionally costly restorations. Full restoration of these sites has never been considered due to cost; instead military leaders and the EPA negotiate "how clean is clean enough." The choice of cleanup level often depends on the area's anticipated future uses: residences or schools, for example, would require a higher standard than industrial facilities that could be capped with concrete. But because markets will drive what happens to the site in the future, there is no guarantee that the anticipated use will end up being the only use—and there will be little incentive to remember or warn others about imperceptible chemical residues.

As discussed earlier, the people of Vieques have endured government confiscation of property, severe environmental damage, and economic stagnation due to the military's use of the area as a training site. The U.S. Navy in particular consistently neglected to monitor the movement of chemicals it released to the Vieques environment during bombing exercises. The Navy freely admits it released tens of millions of pounds of hazardous materials within the island's environment, yet no one knows precisely where, or what happened to them (unless they are unexploded ordnance and happen to be visible). Nor did it monitor the islanders' health. Nearly sixty years after the United States acquired the site, the Navy finally began to develop scientific estimates of exposure, using the expertise of large national defense contractors.

Government agencies and corporations normally avoid intensive environmental and health monitoring because it is very expensive. In addition, this type of intelligence may lead to causal claims of responsibility. Without detailed information, the Viequense and others could not understand past exposures and how these might relate to illnesses among the islanders. The absence of environmental monitoring and poor recordkeeping (regarding the types, location, and timing of chemical releases) also left the Centers for Disease Control and Prevention with the impression that there was no significant exposure or threat to health.

The nature of the problem made it easy to ignore, at least at first. Except for obvious problems, such as unexploded bombs lying on the Vieques landscape or beneath its coastal waters, the dangers are imperceptible. Failure to conduct routine tests for the presence of chemical residues in the environment, in island animals, and in the Viequense themselves also contributed to a collective ignorance that has worked to the Navy's narrative advantage.

Secrecy has also been a factor. Finding out what chemicals have been released, which sites are contaminated, and who has been exposed has been impossible due to classified information and restrictions on site access. The Defense Department has argued, with merit, that disclosure of the amounts and types of weapons released during training exercises could damage U.S. security. Community activists have countered that their health and environmental security have been diminished, along with their property values, all with no compensation.

Perhaps the core problem has been that the Navy never internalized a sense of environmental stewardship normally associated with property ownership. Routine changes in command, troops, and technology make it difficult to assign individual accountability or responsibility for the toxic mixture that remains on the island and in nearby coastal waters. For example, when a former Marine who had trained on Vieques was asked why he ordered unused boxes of live munitions to be buried on a beach following a mock assault, rather than ferrying them back to their waiting offshore troop ship, he explained that his team was late moving to a different training site. In the haste to make a deadline during a mock war experience, munitions were buried that could leach contaminants into the environment for years to come. No one bothered even to record where the boxes were buried.

The extraordinary expense of removing dangerous chemicals from soils, groundwater, and the ocean floor have shaped and limited the government's restoration goals. Despite the deceptive symbolism of Vieques's federal "wilderness" designation, neither the EPA nor the Navy intend to return the island to a natural, wild state. Instead, technical experts will define "cleanup targets," "acceptable levels of exposure and risk," and "future use and site access restrictions," all designed to facilitate transfer of the lands to other responsible parties while limiting costs. The Department of Defense spent nearly $42 billion on its environmental programs between 1997 and 2007, and nearly $4 billion in 2008, yet 90 percent of those funds have been spent to restore fewer than 5 percent of the seriously contaminated military and energy sites.[7]

Vieques residents often express the belief that the Navy is responsible for a variety of illnesses prevalent among longtime residents. Proof that the Navy's wastes have caused disease remains elusive, however, mostly because exposures are difficult to reconstruct with precision, and plausible alternative causes are difficult to discount. It is far easier to demonstrate the absence of causal evidence than its existence. No funds have been set aside for health surveillance, epidemiology, or medical care, meaning that these questions are likely to remain unanswered. Islanders have been intelligent, articulate, and aggressive in their requests to the Navy for island restoration and restitution. Yet the cost of scientific and legal expertise limits the capacity of the local community and their ability to influence cleanup decisions. Significantly, too, Puerto Rico has no voting representation in Congress.

Information and support are supposed to be more readily available. Congress created the Agency for Toxic Substances and Disease Registries (ATSDR) in 1980 to examine whether hazardous chemicals found at Superfund sites have created exposures and illness. Any citizen can petition the ATSDR to request an evaluation, and Congress intended that the agency would provide scientific support for communities surrounding Superfund sites worried about prevalence of illness. When the ATSDR investigated Vieques, it found that exposures to chemicals released by the Navy were detectable in fish commonly consumed by islanders, but not in sufficient amounts to induce illness. They also concluded that it was safe to eat fish without restriction, despite the EPA's warnings that levels were sufficient to threaten the health of pregnant women and women of

childbearing age. But the ATSDR sampled so few fish—including some obtained from the local fish market that may have been caught far from Vieques—that no sweeping conclusion of safety is justified. Moreover, although many studies are flawed by small sample sizes, the agency concludes that their absence of proof demonstrates safety. Common sense should suggest that fishing near a former bombing range is potentially hazardous, unless a rigorous scientific study demonstrates otherwise.

When compared to abandoned privately owned hazardous sites, former Defense Department properties have features that should make it easier to return them to their original condition. Unlike many private waste sites that have been orphaned, there is no dispute over who is to blame, and thus no lengthy search for "potentially responsible parties." The Defense Department controls the cleanup process and clearly has the potential to act quickly. It possesses the exclusive expertise to understand what happened at the site in terms of operations, weapons deployment, and chemical release. It also has access to necessary funding for site evaluation and cleanup. Still missing, however, is necessary political will. Although the Defense Department budget is near $500 billion a year, less than half a percent of that amount has been spent on site restoration.

The Navy's sixty-year presence on Vieques not only contaminated large areas of the island, but also assured economic stagnation: compare the still quiet island of Vieques to thriving tourist economies on nearby St. Thomas and St. John. The high unemployment rate on Vieques is a result of the Navy's tenure, and like many other impoverished areas, is accompanied by a lack of health insurance and inaccessible medical care. Not only has the Navy left the island with a chemically polluted environment; it has left a poor population with long-lasting economic, health, and social hazards.

Since 1986 when the Superfund law was enacted, tens of thousands of government facilities and bases have been determined to need restoration, yet fewer than 1 percent of these have been fully restored. Cleanup expenses are so high that government has become content to extend restoration deadlines for listed sites until 2075. Meanwhile, those living near or within these facilities, that is, those who face the highest potential exposures, are limited in their ability to influence cleanup goals and deadlines. Access to information remains a significant issue: the problem is highly technical, and the military has not established the health-

monitoring programs needed to examine possible associations between chemical exposures and health loss. And yet the government continues to transfer responsibility for these sites to other public and private institutions without completing full site restoration.

Can a nation prepare for war in a manner less destructive to the environment and less threatening to civilian health? Certainly it could, but doing so would require a far different culture than that demonstrated by the U.S. Defense Department in the twentieth century.

AIR POLLUTION

The surge in respiratory illnesses in the United States since 1980 has perplexed many scientists, but most agree that the change has been too sudden to be explained by genetic evolution and that environmental change could be the primary cause. Homes, schools, and other buildings built since the mid-1970s have better insulation and tighter windows and doors in order to conserve heat or reduce cooling costs, but these advances also reduce the exchange of indoor air with the usually cleaner outdoor air. Use of synthetic chemicals in building materials grew quickly during the same period, and eventually may prove to be the cause of the surge in illnesses. Plastics, for example, are often used in modern homes for siding, flooring, sewer and water pipes, electrical wiring, windows, doors, countertops, cabinets, wood finishes, paints, rugs, and furnishings, including bedding. Consumer products such as electronics, cosmetics, air fresheners, cleaners, and dryer sheets also emit mixtures of chemicals to indoor air. Children who spend more time indoors watching television, using computers, or playing video games increase their exposures to whatever is floating in the air.

Some outdoor pollutants such as diesel exhaust are more concentrated outside rather than indoors. The lure of diesel is its power; its downfall is its incomplete combustion, which produces a mixture of very dangerous substances. Recognized by scientists in the early 1970s to be mutagenic to bacteria, diesel exhaust is now associated with allergies, a variety of respiratory diseases including asthma, cardiac arrhythmias, heart attacks, diabetes, cancer, and premature death. The State of California declared diesel exhaust to be a "known human carcinogen" in 1990, and an "air toxic" in 1998. California and other scientists estimate that diesel emissions account for nearly 70 percent of the total risk from toxic air pollutants.

Diesel fuel is less refined than gasoline, and has more energy per gallon, but it burns less efficiently, causing it to emit a very complex mixture of chemicals. Beginning in 1971, early air quality regulation of diesel-related toxics focused on "total suspended particles," that is, particles of all sizes. The EPA effectively reduced the large-diameter carbon particles by nearly 90 percent (and decreased visible black smoke), but the required engine modifications also produced more of the smaller particles. By 1987, the agency had become convinced that particles smaller than 10 microns in diameter, PM-10, were more worrisome and set a limit for them. By 1997, the agency was recognizing that even smaller particles were still more threatening to health, so it set a new standard for PM-2.5, that is, those particles smaller than 2.5 microns.

This standard was challenged in court by the American Trucking Association soon after it was adopted and lower courts prevented its implementation. Not until the Supreme Court ruled in 2001 that the EPA could not consider costs when setting health-protective standards, as stated in the Clean Air Act, was the agency free to move ahead. Finally, in 2004, a full seventeen years following the last significant attempt to control particles, the EPA implemented the new PM-2.5 rule by declaring thirty-nine areas of the country beyond compliance. The glaciers are retreating faster than the EPA adopts new air quality rules (and in fact these two processes are related since carbon is very effective at absorbing solar radiation). More recent scientific reports demonstrate that the fight is far from over: nearly 90 percent of diesel particles are far smaller than the new 2.5 micron limit. Once again, the laws and regulations remain far behind the state of the science. These nanoparticles, less than a billionth of a meter in size, are larger in number and have a carbon surface that attracts some of the other gases in exhaust, including aldehydes, carbon monoxide, nitrogen oxides, and sulfur compounds, forming a toxic mixture. Moreover, their exceptionally small size means they more easily and deeply penetrate the lungs.

A rapid decline in hospital admissions for respiratory and cardiac distress in Atlanta during the Olympic Games in 2000 occurred when auto traffic was restricted in the city's center. In fact, the recent discovery that groups with preexisting illnesses are vulnerable to sudden and severe health loss following high pollution episodes is one of the most significant scientific findings in the field of environmental health in

the past two decades. Dozens of peer-reviewed studies published during this period illustrate special vulnerability among those with illnesses including asthma, chronic obstructive pulmonary diseases, cardiovascular diseases, diabetes, and lung cancer. Nearly a quarter of the nation's population suffers from these illnesses. Those most at risk include children, the elderly, and those with compromised immune systems. The EPA estimated in 1999 that tens of thousands of premature deaths are caused annually by outdoor particulates that are smaller than PM-2.5. Although some scientists who are sponsored by the EPA are now acknowledging the seriousness of the threat posed by these ultrafine particles, no regulation limits human exposure.[8]

Another distinctive trait of the diesel engine is its longevity: a new long-haul diesel truck is now expected to last nearly thirty years, and new diesel cars, twenty years. Consequently, it will be difficult to improve air quality in the next generation by relying on improved engine design. Changes in fuel chemistry can have more immediate effects on emissions. For example, the removal of lead from gasoline quickly reduced blood lead levels in children who had inhaled the metal as airborne particles.

The environmental history of vehicle emissions is complicated by the wide range of vehicles, engines, and fuel types, which produce variable mixtures of particles and gases. In addition, the government's pollution data are generally averaged over extended periods and over large areas. By including less polluted times and places in the calculations, high pollution episodes are not discernable—the data show that the public is safe, even if bursts of high exposures may cause serious illness. The failure of federal officials to monitor individual or "personal" exposures has left tens of millions in the United States at serious risk of both acute and chronic illness. This situation is remarkably similar to the government's mismanagement of pesticide exposure. When pesticide residue levels are averaged across all foods, higher residues in a few foods become imperceptible. And when food intake is averaged across the entire U.S. population, the fact that children eat more of some foods is not discernable. But if only 1 percent of children consume foods with pesticide hazards, this means that 800,000 children are at risk. The government, by relying on averaging techniques to support its narrative of safety, is allowing a minority to be exposed to known toxic substances so that the majority of consumers can enjoy the pest reduction benefits that pesticides offer.

What matters most to your health is the quality of air where you spend your time, not where governments monitor pollution. Because we tend to live close to places where we burn fossil fuels—in homes and vehicles—the disparity in air pollution between your exposure and that predicted by federal monitors is likely to be large for carbon particles and hundreds of organic compounds in gaseous form. (Ozone, by contrast, tends to be more uniformly distributed than particulate matter.) Knowledge about the spatial variability of pollution grew from more intensive air monitoring—in a story remarkably similar to that of the Atomic Energy Commission's discovery that fallout settled unevenly around the world. Some elements of vehicle exhaust such as large-diameter particles do settle close to their source, while fine particles and gases may move regionally, and some others such as carbon dioxide circulate globally. The lesson here is that the only way to obtain a refined measurement of individual risk is to follow individuals through their daily routines. When we investigated the individual exposures of children riding diesel buses to and from school, for example, we discovered that they inhale air contaminated with nearly twenty times the number of fine particles than nearby outdoor air. The U.S. National Academy of Sciences has recognized the importance of this individualized approach for at least a decade, but the EPA has paid little attention.

Perhaps the most egregious defect in federal efforts to control air quality has been neglect of indoor environments, where people spend most of their time. Workplace bans have been most effective, as have protection of environments frequented by children. The most serious remaining oversight of indoor environments remains the home, which is perhaps being avoided due to privacy concerns. Several U.S. statutes—including federal pesticide, tobacco, consumer product, and toxic substance control laws—have attempted to influence indoor air quality. But these national laws have produced only weak regulations that rely on warning labels to educate consumers about dangerous exposures. Like other examples provided earlier, bans are far more effective than pollution limits, or restrictions by place or time that require intensive monitoring.

The EPA has been most effective at reducing emissions from large apparent sources such as mining, utility, chemical, and manufacturing companies, and least effective at managing and reducing emissions from highly decentralized sources such as vehicles. The rapid growth of U.S.

cities has concentrated the areas where energy is used—for transport, heating, and industrial activities—creating localized air pollution problems that often escape government detection. Highways have experienced increasing congestion as the U.S. population has continued its move from the city to the suburbs, and as people now generally drive farther to work each day. Although emissions per vehicle have dropped, the increasing numbers of cars and trucks have intensified our collective exposure to hazardous chemicals in exhaust, especially as we move slowly through traffic jams and construction sites.

The most compelling arguments for more restrictive outdoor federal air pollution stem from the now irrefutable facts that children's lung function decreases as traffic density increases near their residences (with asthma and bronchitis symptoms increasing the closer the home is to a highway), and that hospitalizations for asthma rise along with proximity to heavy traffic and especially, idling or traveling trucks. The growing consensus regarding the dangers of living, working, or playing near highway corridors is troubling for those hoping to reduce urban sprawl by locating new residential developments close to transit routes such as interchanges and hubs. Although such a shift could reduce a community's carbon emissions, it would also likely increase the number of those who breathe the particles and gases produced as they travel, consume electricity, and burn fossil fuels for heat.