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## BIG FOOT

*In measuring carbon emissions, it's easy to confuse morality and science.*

by Michael Specter

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An excessive carbon footprint has become the equivalent of wearing a scarlet letter. Photograph by Horacio Salinas.

A little more than a year ago, Sir Terry Leahy, who is the chief executive of the Tesco chain of supermarkets, Britain's largest retailer, delivered a speech to a group called the Forum for the Future, about the implications of climate change. Leahy had never before addressed the issue in public, but his remarks left little doubt that he recognized the magnitude of the problem. "I am not a scientist," he said. "But I listen when the scientists say that, if we fail to mitigate climate change, the environmental, social, and economic consequences will be stark and severe. . . . There comes a moment when it is clear what you must do. I am determined that Tesco should be a leader in helping to create a low-carbon economy. In saying this, I do not underestimate the task. It is to take an economy where human comfort, activity, and growth are inextricably linked with emitting carbon and to transform it into one which can only thrive without depending on carbon. This is a monumental challenge. It requires a revolution in technology and a revolution in thinking. We are going to have to rethink the way we live and work."

Tesco sells nearly a quarter of the groceries bought in the United Kingdom, it possesses a growing share of the markets in Asia and Europe, and late last year the chain opened its first stores in America. Few corporations could have a more visible—or forceful—impact on the lives of their customers. In his speech, Leahy, who is fifty-two, laid out a series of measures that he hoped would ignite "a revolution in green consumption." He announced that Tesco would cut its energy use in half by 2010, drastically limit the number of products it transports by air, and place airplane symbols on the packaging of those which it does. More important, in an effort to help consumers understand the environmental impact of the choices they make every day, he told the forum that Tesco would develop a system of carbon labels and put them on each of its seventy thousand products. "Customers want us to develop ways to take complicated carbon calculations and present them simply," he said. "We will therefore begin the search for a universally accepted and commonly understood measure of the carbon footprint of every product we sell—looking at its complete life cycle, from production through distribution to consumption. It will enable us to label all our products so that customers can compare their carbon footprint

as easily as they can currently compare their price or their nutritional profile.”

Leahy’s sincerity was evident, but so was his need to placate his customers. Studies have consistently demonstrated that, given a choice, people prefer to buy products that are environmentally benign. That choice, however, is almost never easy. “A carbon label will put the power in the hands of consumers to choose how they want to be green,” Tom Delay, the head of the British government’s Carbon Trust, said. “It will empower us all to make informed choices and in turn drive a market for low-carbon products.” Tesco was not alone in telling people what it would do to address the collective burden of our greenhouse-gas emissions. Compelled by economic necessity as much as by ecological awareness, many corporations now seem to compete as vigorously to display their environmental credentials as they do to sell their products.

In Britain, Marks & Spencer has set a goal of recycling all its waste, and intends to become carbon-neutral by 2012—the equivalent, it claims, of taking a hundred thousand cars off the road every year. Kraft Foods recently began to power part of a New York plant with methane produced by adding bacteria to whey, a by-product of cream cheese. Not to be outdone, Sara Lee will deploy solar panels to run one of its bakeries, in New Mexico. Many airlines now sell “offsets,” which offer passengers a way to invest in projects that reduce CO<sub>2</sub> emissions. In theory, that would compensate for the greenhouse gas caused by their flights. This year’s Super Bowl was fuelled by wind turbines. There are carbon-neutral investment banks, carbon-neutral real-estate brokerages, carbon-neutral taxi fleets, and carbon-neutral dental practices. Detroit, arguably America’s most vivid symbol of environmental excess, has also staked its claim. (“Our designers know green is the new black,” Ford declares on its home page. General Motors makes available hundreds of green pictures, green stories, and green videos to anyone who wants them.)

Possessing an excessive carbon footprint is rapidly becoming the modern equivalent of wearing a scarlet letter. Because neither the goals nor acceptable emissions limits are clear, however, morality is often mistaken for science. A recent article in *New Scientist* suggested that the biggest problem arising from the epidemic of obesity is the additional carbon burden that fat people—who tend to eat a lot of meat and travel mostly in cars—place on the environment. Australia briefly debated imposing a carbon tax on families with more than two children; the environmental benefits of abortion have been discussed widely (and simplistically). Bishops of the Church of England have just launched a “carbon fast,” suggesting that during Lent parishioners, rather than giving up chocolate, forgo carbon. (Britons generate an average of a little less than ten tons of carbon per person each year; in the United States, the number is about twice that.)

Greenhouse-gas emissions have risen rapidly in the past two centuries, and levels today are higher than at any time in at least the past six hundred and fifty thousand years. In 1995, each of the six billion people on earth was responsible, on average, for one ton of carbon emissions. Oceans and forests can absorb about half that amount. Although specific estimates vary, scientists and policy officials increasingly agree that allowing emissions to continue at the current rate would induce dramatic changes in the global climate system. To avoid the most catastrophic effects of those changes, we will have to hold emissions steady in the next decade, then reduce them by at least sixty to eighty per cent by the middle of the century. (A delay of just ten years in stopping the increase would require double the reductions.) Yet, even if all carbon emissions stopped today, the earth would continue to warm for at least another century. Facts like these have transformed carbon dioxide into a strange but powerful new currency, difficult to evaluate yet impossible to ignore.

A person’s carbon footprint is simply a measure of his contribution to global warming. (CO<sub>2</sub> is the best known of the gases that trap heat in the atmosphere, but others—including water vapor, methane, and nitrous oxide—also play a role.) Virtually every human activity—from watching television to buying a quart of milk—has some carbon cost associated with it. We all consume electricity generated by burning fossil fuels; most people rely on petroleum for transportation and heat. Emissions from those activities are not hard to quantify. Watching a plasma television for three hours every day contributes two hundred and fifty kilograms of carbon to the atmosphere each year; an LCD television is responsible for less than half that number. Yet the calculations required to assess the full environmental impact of how we live can be dazzlingly complex. To sum them up on a label will not be easy. Should the carbon label on a jar of peanut butter include the emissions caused by the fertilizer, calcium, and potassium applied to the original crop of peanuts? What about the energy used to boil the peanuts once they have been harvested, or to mold the jar and print the labels? Seen this way, carbon costs multiply rapidly. A few months ago, scientists at the Stockholm Environment Institute reported that the carbon footprint of Christmas—including food, travel, lighting, and gifts—was six hundred and fifty kilograms per person. That is as much, they estimated, as the weight of “one thousand Christmas puddings” for every resident of England.

As a source of global warming, the food we eat—and how we eat it—is no more significant than the way we make clothes or travel or heat our homes and offices. It certainly doesn’t compare to the impact made by tens of thousands of factories scattered throughout the world. Yet food carries enormous symbolic power, so the concept of “food miles”—the distance a product travels from the farm to your home—is often used as a kind of shorthand to talk about climate change in general. “We have to remember our goal: reduce emissions of greenhouse gases,” John Murlis told me not long ago when we met in London. “That should be the world’s biggest priority.” Murlis is the chief scientific adviser to the Carbon Neutral Company, which helps corporations adopt policies to reduce their carbon footprint as well as those of the products they sell. He has also served as the director of strategy and chief scientist for Britain’s Environment Agency. Murlis worries

that in our collective rush to make choices that display personal virtue we may be losing sight of the larger problem. “Would a carbon label on every product help us?” he asked. “I wonder. You can feel very good about the organic potatoes you buy from a farm near your home, but half the emissions—and half the footprint—from those potatoes could come from the energy you use to cook them. If you leave the lid off, boil them at a high heat, and then mash your potatoes, from a carbon standpoint you might as well drive to McDonald’s and spend your money buying an order of French fries.”

One particularly gray morning last December, I visited a Tesco store on Warwick Way, in the Pimlico section of London. Several food companies have promised to label their products with the amount of carbon-dioxide emissions associated with making and transporting them. Last spring, Walkers crisps (potato chips) became the first of them to reach British stores, and they are still the only product on the shelves there with a carbon label. I walked over to the crisp aisle, where a young couple had just tossed three bags of Walkers Prawn Cocktail crisps into their shopping cart. The man was wearing fashionable jeans and sneakers without laces. His wife was toting a huge Armani Exchange bag on one arm and dragging their four-year-old daughter with the other. I asked if they paid attention to labels. “Of course,” the man said, looking a bit insulted. He was aware that Walkers had placed a carbon label on the back of its crisp packages; he thought it was a good idea. He just wasn’t sure what to make of the information.

Few people are. In order to develop the label for Walkers, researchers had to calculate the amount of energy required to plant seeds for the ingredients (sunflower oil and potatoes), as well as to make the fertilizers and pesticides used on those potatoes. Next, they factored in the energy required for diesel tractors to collect the potatoes, then the effects of chopping, cleaning, storing, and bagging them. The packaging and printing processes also emit carbon dioxide and other greenhouse gases, as does the petroleum used to deliver those crisps to stores. Finally, the research team assessed the impact of throwing the empty bags in the trash, collecting the garbage in a truck, driving to a landfill, and burying them. In the end, the researchers—from the Carbon Trust—found that seventy-five grams of greenhouse gases are expended in the production of every individual-size bag of potato chips.

“Crisps are easy,” Murlis had told me. “They have only one important ingredient, and the potatoes are often harvested near the factory.” We were sitting in a deserted hotel lounge in Central London, and Murlis stirred his tea slowly, then frowned. “Let’s just assume every mother cares about the environment—what then?” he asked. “Should the carbon content matter more to her than the fat content or the calories in the products she buys?”

I put that question to the next shopper who walked by, Chantal Levi, a Frenchwoman who has lived in London for thirty-two years. I watched her grab a large bag of Doritos and then, shaking her head, return it to the shelf. “Too many carbohydrates,” she said. “I try to watch that, but between the carbs and the fat and the protein it can get to be a bit complicated. I try to buy locally grown, organic food,” she continued. “It tastes better, and it’s far less harmful to the environment.” I asked if she was willing to pay more for products that carried carbon labels. “Of course,” she said. “I care about that. I don’t want my food flown across the world when I can get it close to home. What a waste.”

It is a logical and widely held assumption that the ecological impacts of transporting food—particularly on airplanes over great distances—are far more significant than if that food were grown locally. There are countless books, articles, Web sites, and organizations that promote the idea. There is even a “100-Mile Diet,” which encourages participants to think about “local eating for global change.” Eating locally produced food has become such a phenomenon, in fact, that the word “locavore” was just named the 2007 word of the year by the New Oxford American Dictionary.

Paying attention to the emissions associated with what we eat makes obvious sense. It is certainly hard to justify importing bottled water from France, Finland, or Fiji to a place like New York, which has perhaps the cleanest tap water of any major American city. Yet, according to one recent study, factories throughout the world are burning eighteen million barrels of oil and consuming forty-one billion gallons of fresh water every day, solely to make bottled water that most people in the U.S. don’t need.

“Have a quick rifle through your cupboards and fridge and jot down a note of the countries of origin for each food product,” Mark Lynas wrote in his popular handbook “Carbon Counter,” published last year by HarperCollins. “The further the distance it has travelled, the bigger the carbon penalty. Each glass of orange juice, for example, contains the equivalent of two glasses of petrol once the transport costs are included. Worse still are highly perishable fresh foods that have been flown in from far away—green beans from Kenya or lettuce from the U.S. They may be worth several times their weight in jet fuel once the transport costs are factored in.”

Agricultural researchers at the Iowa State University\* have reported that the food miles attached to items that one buys in a grocery store are twenty-seven times higher than those for goods bought from local sources. American produce travels an average of nearly fifteen hundred miles before we eat it. Roughly forty per cent of our fruit comes from overseas and, even though broccoli is a vigorous plant grown throughout the country, the broccoli we buy in a supermarket is likely to have been shipped eighteen hundred miles in a refrigerated truck. Although there are vast herds of cattle in the U.S., we import ten per cent of our red meat, often from as far away as Australia or New Zealand.

In his speech last year, Sir Terry Leahy promised to limit to less than one per cent the products that Tesco imports by air.

In the United States, many similar efforts are under way. Yet the relationship between food miles and their carbon footprint is not nearly as clear as it might seem. That is often true even when the environmental impact of shipping goods by air is taken into consideration. “People should stop talking about food miles,” Adrian Williams told me. “It’s a foolish concept: provincial, damaging, and simplistic.” Williams is an agricultural researcher in the Natural Resources Department of Cranfield University, in England. He has been commissioned by the British government to analyze the relative environmental impacts of a number of foods. “The idea that a product travels a certain distance and is therefore worse than one you raised nearby—well, it’s just idiotic,” he said. “It doesn’t take into consideration the land use, the type of transportation, the weather, or even the season. Potatoes you buy in winter, of course, have a far higher environmental ticket than if you were to buy them in August.” Williams pointed out that when people talk about global warming they usually speak only about carbon dioxide. Making milk or meat contributes less CO<sub>2</sub> to the atmosphere than building a house or making a washing machine. But the animals produce methane and nitrous oxide, and those are greenhouse gases, too. “This is not an equation like the number of calories or even the cost of a product,” he said. “There is no one number that works.”

Many factors influence the carbon footprint of a product: water use, cultivation and harvesting methods, quantity and type of fertilizer, even the type of fuel used to make the package. Sea-freight emissions are less than a sixtieth of those associated with airplanes, and you don’t have to build highways to berth a ship. Last year, a study of the carbon cost of the global wine trade found that it is actually more “green” for New Yorkers to drink wine from Bordeaux, which is shipped by sea, than wine from California, sent by truck. That is largely because shipping wine is mostly shipping glass. The study found that “the efficiencies of shipping drive a ‘green line’ all the way to Columbus, Ohio, the point where a wine from Bordeaux and Napa has the same carbon intensity.”

The environmental burden imposed by importing apples from New Zealand to Northern Europe or New York can be lower than if the apples were raised fifty miles away. “In New Zealand, they have more sunshine than in the U.K., which helps productivity,” Williams explained. That means the yield of New Zealand apples far exceeds the yield of those grown in northern climates, so the energy required for farmers to grow the crop is correspondingly lower. It also helps that the electricity in New Zealand is mostly generated by renewable sources, none of which emit large amounts of CO<sub>2</sub>. Researchers at Lincoln University, in Christchurch, found that lamb raised in New Zealand and shipped eleven thousand miles by boat to England produced six hundred and eighty-eight kilograms of carbon-dioxide emissions per ton, about a fourth the amount produced by British lamb. In part, that is because pastures in New Zealand need far less fertilizer than most grazing land in Britain (or in many parts of the United States). Similarly, importing beans from Uganda or Kenya—where the farms are small, tractor use is limited, and the fertilizer is almost always manure—tends to be more efficient than growing beans in Europe, with its reliance on energy-dependent irrigation systems.

Williams and his colleagues recently completed a study that examined the environmental costs of buying roses shipped to England from Holland and of those exported (and sent by air) from Kenya. In each case, the team made a complete life-cycle analysis of twelve thousand rose stems for sale in February—in which all the variables, from seeds to store, were taken into consideration. They even multiplied the CO<sub>2</sub> emissions for the air-freighted Kenyan roses by a factor of nearly three, to account for the increased effect of burning fuel at a high altitude. Nonetheless, the carbon footprint of the roses from Holland—which are almost always grown in a heated greenhouse—was six times the footprint of those shipped from Kenya. Even Williams was surprised by the magnitude of the difference. “Everyone always wants to make ethical choices about the food they eat and the things they buy,” he told me. “And they should. It’s just that what seems obvious often is not. And we need to make sure people understand that before they make decisions on how they ought to live.”

**H**ow do we alter human behavior significantly enough to limit global warming? Personal choices, no matter how virtuous, cannot do enough. It will also take laws and money. For decades, American utilities built tall smokestacks, hoping to keep the pollutants they emitted away from people who lived nearby. As emissions are forced into the atmosphere, however, they react with water molecules and then are often blown great distances by prevailing winds, which in the United States tend to move from west to east. Those emissions—principally sulfur dioxide produced by coal-burning power plants—are the primary source of acid rain, and by the nineteen-seventies it had become clear that they were causing grave damage to the environment, and to the health of many Americans. Adirondack Park, in upstate New York, suffered more than anywhere else: hundreds of streams, ponds, and lakes there became so acidic that they could no longer support plant life or fish. Members of Congress tried repeatedly to introduce legislation to reduce sulfur-dioxide levels, but the Reagan Administration (as well as many elected officials, both Democratic and Republican, from regions where sulfur-rich coal is mined) opposed any controls, fearing that they would harm the economy. When the cost of polluting is negligible, so are the incentives to reducing emissions.

“We had a complete disaster on our hands,” Richard Sandor told me recently, when I met with him at his office at the Chicago Climate Exchange. Sandor, a dapper sixty-six-year-old man in a tan cable-knit cardigan and round, horn-rimmed glasses, is the exchange’s chairman and C.E.O. In most respects, the exchange operates like any other market. Instead of

pork-belly futures or gold, however, CCX members buy and sell the right to pollute. Each makes a voluntary (but legally binding) commitment to reduce emissions of greenhouse gases—including carbon dioxide, methane, and nitrous oxide—and hydrofluorocarbons. Four hundred corporations now belong to the exchange, including a growing percentage of America's largest manufacturers. The members agree to reduce their emissions by a certain amount every year, a system commonly known as cap and trade. A baseline target, or cap, is established, and companies whose emissions fall below that cap receive allowances, which they can sell (or save to use later). Companies whose emissions exceed the limit are essentially fined and forced to buy credits to compensate for their excess.

Sandor led me to the "trading floor," which, like most others these days, is a virtual market populated solely by computers. "John, can you get the carbon futures up on the big screen?" Sandor yelled to one of his colleagues. Suddenly, a string of blue numbers slid across the monitor. "There is our 2008 price," Sandor said. Somebody had just bid two dollars and fifteen cents per ton for carbon futures.

A former Berkeley economics professor and chief economist at the Chicago Board of Trade, Sandor is known as the "father of financial futures." In the nineteen-seventies, he devised a market in interest rates which, when they started to fluctuate, turned into an immense source of previously untapped wealth. His office is just north of the Board of Trade, where he served for two years as vice-chairman. The walls are filled with interest-rate arcana and mortgage memorabilia; his desk is surrounded by monitors that permit him to track everything from catastrophic-risk portfolios to the price of pollution.

Sandor invents markets to create value for investors where none existed before. He sees himself as "a guy from the sixties"—but one who believes that free markets can make inequality disappear. So, he wondered, why not offer people the right to buy and sell shares in the value of reduced emissions? "At first, people laughed when I suggested the whole future idea," he said. "They didn't see the point of hedging on something like interest rates, and when it came to pollution rights many people just thought it was wrong to take a business approach to environmental protection."

For Sandor, personal factors like food choices and driving habits are small facets of a far larger issue: making pollution so costly that our only rational choice is to stop. When he started, though, the idea behind a sulfur-dioxide-emissions market was radical. It also seemed distasteful; opponents argued that codifying the right to pollute would only remove the stigma from an unacceptable activity. You can't trade something unless you own it; to grant a company the right to trade in emissions is also to give it a property right over the atmosphere. (This effect was noted most prominently when the Reagan Administration deregulated airport landing rights, in 1986. Airlines that already owned the rights to land got to keep those rights, while others had to buy slots at auction; in many cases, that meant that the country's richest airlines were presented with gifts worth millions of dollars.)

Sandor acknowledges the potential for abuse, but he remains convinced that emissions will never fall unless there is a price tag attached to them. "You are really faced with a couple of possibilities when you want to control something," he told me. "You can say, 'Hey, we will allow you to use only  $x$  amount of these pollutants.' That is the command approach. Or you can make a market."

In the late nineteen-eighties, Sandor was asked by an Ohio public-interest group if he thought it would be possible to turn air into a commodity. He wrote an essay advocating the creation of an exchange for sulfur-dioxide emissions. The idea attracted a surprising number of environmentalists, because it called for large and specific reductions; conservatives who usually oppose regulation approved of the market-driven solution.

When Congress passed the Clean Air Act, in 1990, the law included a section that mandated annual acid-rain reductions of ten million tons below 1980 levels. Each large smokestack was fitted with a device to measure sulfur-dioxide emissions. As a way to help meet the goals, the act enabled the creation of the market. "Industry lobbyists said it would cost ten billion dollars in electricity increases a year. It cost one billion," Sandor told me. It soon became less expensive to reduce emissions than it was to pollute. Consequently, companies throughout the country suddenly discovered the value of investing millions of dollars in scrubbers, which capture and sequester sulfur dioxide before it can reach the atmosphere.

Sandor still enjoys describing his first sulfur trade. Representatives of a small Midwestern town were seeking a loan to build a scrubber. "They were prepared to borrow millions of dollars and leverage the city to do it," he told me. "We said, 'We have a better idea.' " Sandor arranged to have the scrubber installed with no initial cost, and the apparatus helped the city fall rapidly below its required emissions cap. He then calculated the price of thirty years' worth of that municipality's SO<sub>2</sub> emissions and helped arrange a loan for the town. "We gave it to them at a significantly lower rate than any bank would have done," Sandor said. "It was a fifty-million-dollar deal and they saved seven hundred and fifty thousand dollars a year—and never had to pay a balloon mortgage at the end. I mention this because trading that way not only allows you to comply with the law, but it provides creative financing tools to help structure the way investments are made. It encourages people to comply at lower costs, because then they will make money."

The program has been an undisputed success. Medical and environmental savings associated with reduced levels of lung disease and other conditions have been enormous—more than a hundred billion dollars a year, according to the E.P.A. "When is the last time you heard somebody even talking about acid rain?" Sandor asked. "It was going to ravage the world.

Now it is not even mentioned in the popular press. We have reduced emissions from eighteen million tons to nine million, and we are going to halve it again by 2010. That is as good a social policy as you are ever likely to see.”

No effort to control greenhouse-gas emissions or to lower the carbon footprint—of an individual, a nation, or even the planet—can succeed unless those emissions are priced properly. There are several ways to do that: they can be taxed heavily, like cigarettes, or regulated, which is the way many countries have established mileage-per-gallon standards for automobiles. Cap and trade is another major approach—although CO<sub>2</sub> emissions are a far more significant problem for the world than those which cause acid rain, and any genuine solution will have to be global.

Higher prices make conservation appealing—and help spark investment in clean technologies. When it costs money to use carbon, people begin to seek profits from selling fuel-efficient products like long-lasting light bulbs, appliances that save energy, hybrid cars, even factories powered by the sun. One need only look at the passage of the Clean Water Act, in 1972, to see that a strategy that combines legal limits with realistic pricing can succeed. Water had always essentially been free in America, and when something is free people don’t value it. The act established penalties that made it expensive for factories to continue to pollute water. Industry responded at once, and today the United States (and much of the developed world) manufactures more products with less water than it did fifty years ago. Still, whether you buy a plane ticket, an overcoat, a Happy Meal, a bottle of wine imported from Argentina, or a gallon of gasoline, the value of the carbon used to make those products is not reflected by their prices.

In 2006, Sir Nicholas Stern, a former chief economist of the World Bank, who is now the head of Britain’s Economic Service, issued a comprehensive analysis of the implications of global warming, in which he famously referred to climate change as “the greatest market failure the world has ever seen.” Sir Nicholas suggested that the carbon emissions embedded in almost every product ought, if priced realistically, to cost about eighty dollars a ton.

Trading schemes have many opponents, some of whom suggest that attaching an acceptable price to carbon will open the door to a new form of colonialism. After all, since 1850, North America and Europe have accounted for seventy per cent of all greenhouse-gas emissions, a trend that is not improving. Stephen Pacala, the director of Princeton University’s Environmental Institute, recently estimated that half of the world’s carbon-dioxide emissions come from just seven hundred million people, about ten per cent of the population.

If prices were the same for everyone, however, rich countries could adapt more easily than countries in the developing world. “This market driven mechanism subjects the planet’s atmosphere to the *legal* emission of greenhouse gases,” the anthropologist Heidi Bachram has written. “The arrangement parcels up the atmosphere and establishes the routinized buying and selling of ‘permits to pollute’ as though they were like any other international commodity.” She and others have concluded that such an approach would be a recipe for social injustice.

No one I spoke to for this story believes that climate change can be successfully addressed solely by creating a market. Most agreed that many approaches—legal, technological, and financial—will be necessary to lower our carbon emissions by at least sixty per cent over the next fifty years. “We will have to do it all and more,” Simon Thomas told me. He is the chief executive officer of Trucost, a consulting firm that helps gauge the full burden of greenhouse-gas emissions and advises clients on how to address them. Thomas takes a utilitarian approach to the problem, attempting to convince corporations, pension funds, and other investors that the price of continuing to ignore the impact of greenhouse-gas emissions will soon greatly exceed the cost of reducing them.

Thomas thinks that people finally are beginning to get the message. Apple computers certainly has. Two years ago, Greenpeace began a “Green my Apple” campaign, attacking the company for its “iWaste.” Then, last spring, not long before Apple launched the iPhone, Greenpeace issued a guide to electronics which ranked major corporations on their tracking, reporting, and reduction of toxic chemicals and electronic waste. Apple came in last. The group’s findings were widely reported, and stockholders took notice. (A company that sells itself as one of America’s most innovative brands cannot afford to ignore the environmental consequences of its manufacturing processes.) Within a month, Steve Jobs, the company’s C.E.O., posted a letter on the Apple Web site promising a “greener Apple.” He committed the company to ending the use of arsenic and mercury in monitors and said that the company would shift rapidly to more environmentally friendly LCD displays.

“The success of approaches such as ours relies on the idea that even if polluters are not paying properly now there is some reasonable prospect that they will have to pay in the future,” Thomas told me. “If that is true, then we know the likely costs and they are of significant value. If polluters never have to pay, then our approach will fail.

“You have to make it happen, though,” he went on. “And that is the job of government. It has to set a level playing field so that a market economy can deliver what it’s capable of delivering.” Thomas, a former investment banker, started Trucost nearly a decade ago. He mentioned the free-market economist Friedrich von Hayek, who won the Nobel Prize in Economics in 1974. “There is a remarkable essay in which he shows how an explosion, say, in a South American tin mine could work its way through the global supply chain to increase the price of canned goods in Europe,” Thomas said. I wondered what the price of tin could have to do with the cost of global warming.

"It is very much to the point," Thomas answered. "Tin became more expensive and the market responded. In London, people bought fewer canned goods. The information travelled all the way from that mine across the world without any person in that supply chain even knowing the reasons for the increase. But there was less tin available and the market responded as you would have hoped it would." To Thomas, the message was simple: "If something is priced accurately, its value will soon be reflected in every area of the economy."

Without legislation, it is hard to imagine that a pricing plan could succeed. (The next Administration is far more likely to act than the Bush Administration has been. The best-known climate-change bill now before Congress, which would mandate capping carbon limits, was written by Senator Joseph Lieberman. Hillary Clinton, Barack Obama, and John McCain are co-sponsors. Most industrial leaders, whatever their ideological reservations, would prefer a national scheme to a system of rules that vary from state to state.) Even at today's anemic rates, however, the market has begun to function. "We have a price of carbon that ranges from two to five dollars a ton," Sandor told me. "And everyone says that is too cheap. Of course, they are right. But it's not too cheap for people to make money."

"I got a call from a scientist a while ago"—Isaac Berzin, a researcher at M.I.T. "He said, 'Richard, I have a process where I can put an algae farm next to a power plant. I throw some algae in and it becomes a super photosynthesis machine and sucks the carbon dioxide out of the air like a sponge. Then I gather the algae, dry it out, and use it as renewable energy.'" Berzin asked Sandor whether, if he was able to take fifty million tons of carbon dioxide out of the atmosphere in this way, he could make a hundred million dollars.

"I said, 'Sure,' " Sandor recalled, laughing. "Two dollars a ton, why not? So he sends me a term paper. Not a prospectus, even." Sandor was skeptical, but it didn't take Berzin long to raise twenty million dollars from investors, and he is now working with the Arizona Public Service utility to turn the algae into fuel. Sandor shook his head. "This is at two dollars a ton," he said. "The lesson is important: price stimulates inventive activity. Even if you think the price is too low or ridiculous. Carbon has to be rationed, like water and clean air. But I absolutely promise that if you design a law and a trading scheme properly you are going to find everyone from professors at M.I.T. to the guys in Silicon Valley coming out of the woodwork. That is what we need, and we need it now."

In 1977, Jimmy Carter told the American people that they would have to balance the nation's demand for energy with its "rapidly shrinking resources" or the result "may be a national catastrophe." It was a problem, the President said, "that we will not solve in the next few years, and it is likely to get progressively worse through the rest of this century. We must not be selfish or timid if we hope to have a decent world for our children and grandchildren." Carter referred to the difficult effort as the "moral equivalent of war," a phrase that was widely ridiculed (along with Carter himself, who wore a cardigan while delivering his speech, to underscore the need to turn down the thermostat).

Carter was prescient. We are going to have to reduce our carbon footprint rapidly, and we can do that only by limiting the amount of fossil fuels released into the atmosphere. But what is the most effective—and least painful—way to achieve that goal? Each time we drive a car, use electricity generated by a coal-fired plant, or heat our homes with gas or oil, carbon dioxide and other heat-trapping gases escape into the air. We can use longer-lasting light bulbs, lower the thermostat (and the air-conditioning), drive less, and buy more fuel-efficient cars. That will help, and so will switching to cleaner sources of energy. Flying has also emerged as a major carbon don't—with some reason, since airplanes at high altitudes release at least ten times as many greenhouse gases per mile as trains do. Yet neither transportation—which accounts for fifteen per cent of greenhouse gases—nor industrial activity (another fifteen per cent) presents the most efficient way to shrink the carbon footprint of the globe.

Just two countries—Indonesia and Brazil—account for about ten per cent of the greenhouse gases released into the atmosphere. Neither possesses the type of heavy industry that can be found in the West, or for that matter in Russia or India. Still, only the United States and China are responsible for greater levels of emissions. That is because tropical forests in Indonesia and Brazil are disappearing with incredible speed. "It's really very simple," John O. Niles told me. Niles, the chief science and policy officer for the environmental group Carbon Conservation, argues that spending five billion dollars a year to prevent deforestation in countries like Indonesia would be one of the best investments the world could ever make. "The value of that land is seen as consisting only of the value of its lumber," he said. "A logging company comes along and offers to strip the forest to make some trivial wooden product, or a palm-oil plantation. The governments in these places have no cash. They are sitting on this resource that is doing nothing for their economy. So when a guy says, 'I will give you a few hundred dollars if you let me cut down these trees,' it's not easy to turn your nose up at that. Those are dollars people can spend on schools and hospitals."

The ecological impact of decisions like that are devastating. Decaying trees contribute greatly to increases in the levels of greenhouse gases. Plant life absorbs CO<sub>2</sub>. But when forests disappear, the earth loses one of its two essential carbon sponges (the other is the ocean). The results are visible even from space. Satellite photographs taken over Indonesia and Brazil show thick plumes of smoke rising from the forest. According to the latest figures, deforestation pushes nearly six billion tons of CO<sub>2</sub> into the atmosphere every year. That amounts to thirty million acres—an area half the size of the United

Kingdom—chopped down each year. Put another way, according to one recent calculation, during the next twenty-four hours the effect of losing forests in Brazil and Indonesia will be the same as if eight million people boarded airplanes at Heathrow Airport and flew en masse to New York.

“This is the greatest remaining opportunity we have to help address global warming,” Niles told me. “It’s a no-brainer. People are paying money to go in and destroy those forests. We just have to pay more to prevent that from happening.” Niles’s group has proposed a trade: “If you save your forest and we can independently audit and verify it, we will calculate the emissions you have saved and pay you for that.” The easiest way to finance such a plan, he is convinced, would be to use carbon-trading allowances. Anything that prevents carbon dioxide from entering the atmosphere would have value that could be quantified and traded. Since undisturbed farmland has the same effect as not emitting carbon dioxide at all, people could create allowances by leaving their forests untouched or by planting new trees. (Rain forests are essential to planetary vitality in other ways, too, of course. More than a third of all terrestrial species live in forest canopies. Rising levels of CO<sub>2</sub> there alter the way that forests function, threatening to increase flooding and droughts and epidemics of plant disease. Elevated CO<sub>2</sub> in the forest atmosphere also reduces the quality of the wood in the trees, and that in turn has an impact on the reproduction of flowers, as well as that of birds, bees, and anything else that relies on that ecosystem.)

From both a political and an economic perspective, it would be easier and cheaper to reduce the rate of deforestation than to cut back significantly on air travel. It would also have a far greater impact on climate change and on social welfare in the developing world. Possessing rights to carbon would grant new power to farmers who, for the first time, would be paid to preserve their forests rather than destroy them. Unfortunately, such plans are seen by many people as morally unattractive. “The whole issue is tied up with the misconceived notion of ‘carbon colonialism,’ ” Niles told me. “Some activists do not want the Third World to have to alter their behavior, because the problem was largely caused by us in the West.”

Environmental organizations like Carbon Trade Watch say that reducing our carbon footprint will require restructuring our lives, and that before we in the West start urging the developing world to do that we ought to make some sacrifices; anything else would be the modern equivalent of the medieval practice of buying indulgences as a way of expiating one’s sins. “You have to realize that, in the end, people are trying to buy their way out of bad behavior,” Tony Juniper, the director of Friends of the Earth, told me. “Are we really a society that wants to pay rich people not to fly on private jets or countries not to cut down their trees? Is that what, ultimately, is morally right and equitable?”

Sandor dismisses the question. “Frankly, this debate just makes me want to scream,” he told me. “The clock is moving. They are slashing and burning and cutting the forests of the world. It may be a quarter of global warming and we can get the rate to two per cent simply by inventing a preservation credit and making that forest have value in other ways. Who loses when we do that?”

“People tell me, well, these are bad guys, and corporate guys who just want to buy the right to pollute are bad, too, and we should not be giving them incentives to stop. But we need to address the problems that exist, not drown in fear or lose ourselves in morality. Behavior changes when you offer incentives. If you want to punish people for being bad corporate citizens, you should go to your local church or synagogue and tell God to punish them. Because that is not our problem. Our problem is global warming, and my job is to reduce greenhouse gases at the lowest possible cost. I say solve the problem and deal with the bad guys somewhere else.”

The Tesco corporate headquarters are spread across two low-slung, featureless buildings in an unusually dismal part of Hertfordshire, about half an hour north of London. Having inspired many of the discussions about the meaning of our carbon footprint, the company has been criticized by those who question the emphasis on food. As Adrian Williams, the Cranfield agricultural researcher, put it, the company has been “a little bit shocked” by the discovery that its original goal, to label everything, was naïve.

The process has indeed been arduous. Tesco has undertaken a vast—and at times lonely—attempt to think about global warming in an entirely new way, and the company shows little sign of pulling back. “We are spending more than a hundred million pounds a year trying to increase our energy efficiency and reduce CO<sub>2</sub> emissions,” Katherine Symonds told me. A charismatic woman with an abiding belief that global warming can be addressed rationally, Symonds is the corporation’s climate-change manager. “We are trying to find a way to help consumers make choices they really want to make—choices that mean something to them. This is not all about food. We just happen to be in the food business.

“One of our real responsibilities is to say to our customers, ‘The most important thing you can do to effect climate change is insulate your house properly,’ ” she went on. “ ‘Next would be to get double-glazed windows,’ ” which prevent heat from escaping in the winter. “Third, everyone should get a new boiler.’ We are trying to put this into context, not to say, ‘Buy English potatoes.’ ” Consumers are unlikely to stop shopping. Economies won’t stand still, either; those of China and India are expanding so speedily that people often ask whether sacrifices anywhere else can even matter.

“We have to be careful not to rush from denial to despair,” John Elkington told me, when I visited him not long ago at his offices at SustainAbility, the London-based environmental consulting firm he helped found more than two decades ago.

He believes there is a danger that people will feel engulfed by the challenge, and ultimately helpless to address it.

“We are in an era of creative destruction,” he said. A thin, easygoing man with the look of an Oxford don, Elkington has long been one of the most articulate of those who seek to marry economic prosperity with environmental protection. “What happens when you go into one of these periods is that before you get to the point of reconstruction things have to fall apart. Detroit will fall apart. I think Ford”—a company that Elkington has advised for years—“will fall apart. They have just made too many bets on the wrong things. A bunch of the institutions that we rely on currently will, to some degree, decompose. I believe that much of what we count as democratic politics today will fall apart, because we are simply not going to be able to deal with the scale of change that we are about to face. It will profoundly disable much of the current political class.”

He sat back and smiled softly. He didn’t look worried. “I wrote my first report on climate change in 1978, for Herman Kahn, at the Hudson Institute,” he explained. “He did not at all like what I was saying, and he told me, ‘The trouble with you environmentalists is that you see a problem coming and you slam your foot on the brakes and try and steer away from the chasm. The problem is that it often doesn’t work. Maybe the thing to do is jam your foot on the pedal and see if you can just jump across.’ At the time, I thought he was crazy, but as I get older I realize what he was talking about. The whole green movement in technology is in that space. It is an attempt to jump across the chasm.” ♦

\*Correction, May 19, 2008: The researchers who reported on food miles are at Iowa State University, not at the University of Iowa, as originally stated.

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