CHAPTER 3

Waste Not

Industrial metabolism — The amazing amount of waste — When employment disappears, one billion and counting — Overproductivity — $2 trillion in potential savings — Growth versus progress

CARS ARE A BIG COMPONENT OF THE MODERN INDUSTRIAL ECONOMY BUT only one part. Think of the material flows required to maintain the industrial production of the United States in biological terms as its metabolic flow. Industry ingests energy, metals and minerals, water, and forest, fisheries, and farm products. It excretes liquids and solid waste — variously degradable or persistent toxic pollutants — and exhales gases, which are a form of molecular garbage. The solid waste makes its way into landfills, backyards, junkyards, recyclers, and the ocean. The molecular waste goes into the atmosphere, oceans, rivers, streams, groundwater, soil, plants, and the flesh of wildlife and people. Like the human circulatory system, most industrial flows are invisible or only partly visible. People tend to take them for granted, much as they do their bodily functions. Some of the flow can be seen in Dumpsters, shopping malls, gas stations, truck stops, or in shipping containers stacked up along docks. While its most obvious manifestations are the goods people buy or use every day — soap, food, clothing, cars, et cetera — household items make up only a small fraction of the material required to maintain our standard of living. A greater amount is needed for buildings, roads, and infrastructure. But even these taken together are dwarfed by the greatest contributor to the daily flow of materials: waste in the form of tailings, gangue, fly ash, slurry, sludge, slag, flue gases, construction debris, methane, and the other wastes of the extractive and manufacturing processes.

A critical difference between industrial and biological processes is the nature of production. Living systems are regulated by such limiting factors as seasons, weather, sun, soil, and temperature, all of which are

governed by feedback loops. Feedback in nature is continual. Such elements as carbon, sulfur, and nitrogen are constantly being recycled. If you could trace the history of the carbon, calcium, potassium, phosphorus, and water in your body, you would probably find that you are made up of bits of the Black Sea, extinct fish, eroded mountain ranges, and the exhalations of Jesus and Buddha. Industrial systems, in contrast, although they get feedback from society in the form of bosses, employees, Wall Street, and monitoring machines, have largely ignored environmental feedback. The materials cycle takes high-quality natural capital from nature in the form of oil, wood, minerals, or natural gas and returns them in the form of waste. Twenty centuries from now, our forests and descendants will not be built from pieces of polystyrene cups, Sony Walkmen, and Reebok cross-trainers. The components of these goods do not naturally recycle. This means, of course, that industrial waste is accumulating and it is accumulating in nature.

A striking case study of the complexity of industrial metabolism is provided by James Womack and Daniel Jones in their book *Lean Thinking,* where they trace the origins and pathways of a can of English cola. The can itself is more costly and complicated to manufacture than the beverage. Bauxite is mined in Australia and trucked to a chemical reduction mill where a half-hour process purifies each ton of bauxite into a half ton of aluminum oxide. When enough of that is stockpiled, it is loaded on a giant ore carrier and sent to Sweden or Norway, where hydroelectric dams provide cheap electricity. After a monthlong journey across two oceans, it usually sits at the smelter for as long as two months.

The smelter takes two hours to turn each half ton of aluminum oxide into a quarter ton of aluminum metal, in ingots ten meters long. These are cured for two weeks before being shipped to roller mills in Sweden or Germany. There each ingot is heated to nearly nine hundred degrees Fahrenheit and rolled down to a thickness of an eighth of an inch. The resulting sheets are wrapped in ten-ton coils and transported to a warehouse, and then to a cold rolling mill in the same or another country, where they are rolled tenfold thinner, ready for fabrication. The aluminum is then sent to England, where sheets are punched and formed into cans, which are then washed, dried, painted with a base coat, and then painted again with specific product information. The cans are next lacquered, flanged (they are still topless), sprayed inside

with a protective coating to prevent the cola from corroding the can, and inspected.

The cans are palletized, forklifted, and warehoused until needed. They are then shipped to the bottler, where they are washed and cleaned once more, then filled with water mixed with flavored syrup, phosphorus, caffeine, and carbon dioxide gas. The sugar is harvested from beet fields in France and undergoes trucking, milling, refining, and shipping. The phosphorus comes from Idaho, where it is excavated from deep open-pit mines — a process that also unearths cadmium and radioactive thorium. Round-the-clock, the mining company uses the same amount of electricity as a city of 100,000 people in order to reduce the phosphate to food-grade quality. The caffeine is shipped from a chemical manufacturer to the syrup manufacturer in England.

The filled cans are sealed with an aluminum "pop-top" lid at the rate of fifteen hundred cans per minute, then inserted into cardboard cartons printed with matching color and promotional schemes. The cartons are made of forest pulp that may have originated anywhere from Sweden or Siberia to the old-growth, virgin forests of British Columbia that are the home of grizzly, wolverines, otters, and eagles. Palletized again, the cans are shipped to a regional distribution warehouse, and shortly thereafter to a supermarket where a typical can is purchased within three days. The consumer buys twelve ounces of the phosphate-tinged, caffeine-impregnated, caramel-flavored sugar water. Drinking the cola takes a few minutes; throwing the can away takes a second. In England, consumers discard 84 percent of all cans, which means that the overall rate of aluminum waste, after counting production losses, is 88 percent.[1] The United States still gets three-fifths of its aluminum from virgin ore, at twenty times the energy intensity of recycled aluminum, and throws away enough aluminum to replace its entire commercial aircraft fleet every three months.

Every product we consume has a similar hidden history, an unwritten inventory of its materials, resources, and impacts. It also has attendant waste generated by its use and disposition. In Germany, this hidden history is called "ecological rucksack." The amount of waste generated to make a semiconductor chip is over 100,000 times its weight; that of a laptop computer, close to 4,000 times its weight.[2] Two quarts of gasoline and a thousand quarts of water are required to produce a quart of Florida orange juice.[3] One ton of paper requires the use of 98 tons of various resources.[4]

In Canada and other parts of the world, there is growing use of a concept known as "the ecological footprint," put forth by Mathis Wackernagel and William Rees, which examines the ecological capacity required to support the consumption of products, even entire lifestyles. An ecological footprint is calculated by totaling the flows of material and energy required to support any economy or subset of an economy. Those flows are then converted to standard measures of production required from land and water areas. The total land surface required to support a given activity or product is the footprint. Worldwide, productive land available per capita since 1900 has declined from fourteen acres to 3.7 acres of which less than an acre is arable. On the other hand, the amount of land required to support populations in industrialized countries has risen from two and a half acres per person in 1900 to an average of ten acres today. From a surplus of eleven acres in developed countries in 1900, there is now a deficit of seven acres per person. For all the world to live as an American or Canadian, we would need two more earths to satisfy everyone, three more still if population should double, and twelve earths altogether if worldwide standards of living should double over the next forty years.[5]

HOW MUCH WASTE IS THERE?

Fresh Kills — the world's largest dumping ground, located in Staten Island, New York — provides a repository for the daily garbage of the five boroughs of New York City. Visitors to the site are awed by a landfill that receives 26 million pounds of commercial and household waste per day.[6] Covering four square miles and rising more than a hundred feet high, it contains 2.9 billion cubic feet of trash, consisting of 100 million tons of newspaper, paint cans, potato peels, polystyrene clamshells, chicken bones, soggy breakfast cereals, cigarette butts, Coke cans, dryer lint, and an occasional corpse.[7] By the time it is filled to capacity and closed in 2001, it will be the highest mountain on the eastern coastal plain. But as massive as Fresh Kills is, it takes in just 0.018 percent of the waste generated in the United States daily. Americans and American industry create or dispose of an additional 5,500 times as much solid waste elsewhere.

Industry moves, mines, extracts, shovels, burns, wastes, pumps, and disposes of 4 million pounds of material in order to provide one average middle-class American family's needs for a year. In 1990, the average American's economic and personal activities mobilized a flow of

roughly 123 dry-weight pounds of material per day — equivalent to a quarter of a billion semitrailer loads per year. This amounts to 47 pounds of fuel, 46 of construction materials, 15 of farm and 6 of forest products, 6 of industrial minerals, and 3 of metals of which 90 percent is iron and steel. Net of 6 pounds of recycled materials, that average American's daily activities emitted 130 pounds of gaseous material into the air, created 45 pounds of material artifacts, generated 13 pounds of concentrated wastes, and dissipated 3.5 pounds of nongaseous wastes into the environment in such scattered forms as pesticides, fertilizers, and crumbs of material rubbed off tires. In addition, the person's daily activities required the consumption of about 2,000 pounds of water that after use is sufficiently contaminated that it cannot be reintroduced into marine or riparian systems, and produced 370 pounds of rock, tailings, overburden, and toxic water as a result of extracting oil, gas, coal, and minerals.[8]

In sum, Americans waste or cause to be wasted nearly 1 million pounds of materials per person per year. This figure includes: 3.5 billion pounds (920 million square yards) of carpet landfilled,[9] 3.3 trillion pounds of carbon in CO_2 gas emitted into the atmosphere,[10] 19 billion pounds of polystyrene peanuts, 28 billion pounds of food discarded at home, 360 billion pounds of organic and inorganic chemicals used for manufacturing and processing,[11] 710 billion pounds of hazardous waste generated by chemical production,[12] and 3.7 trillion pounds of construction debris. Furthermore, these are merely domestic figures for material flows, and do not account for wastes generated overseas on our behalf. For example, the Freeport-McMoRan gold mine in Irian Jaya, Indonesia, annually generates 400 pounds of tailings and toxic waste for every man, woman, and child in the United States. Only a tiny fraction of the 130,000 tons of daily material flow comes to the United States as gold; the rest remains behind in the form of toxic tailings from which leachates run off and destroy riparian areas of low-lying rainforest.

Total annual wastes in the United States, excluding wastewater, now exceed 50 trillion pounds a year. (A trillion is a large number: To count to 50 trillion at the rate of one per second would require the entire lifetimes of 24,000 people.) If wastewater is factored in, the total annual flow of waste in the American industrial system is 250 trillion pounds.[13, 14] Less than 2 percent of the total waste stream is actually

recycled — primarily paper, glass, plastic, aluminum, and steel. Over the course of a decade, 500 trillion pounds of American resources will have been transformed into nonproductive solids and gases.

These are all American numbers. Developing nations generally aspire to an economy like America's, but many are growing and industrializing much faster. Britain required more than a century to double its income in the first industrial revolution. Korea took fewer than 25 years. After the United States began its industrialization, 50 years passed before income doubled; in China, it required only nine years. The staggering rate of waste in the United States could therefore be quickly overtaken by the rest of the world, which has 21 times as many people.

WASTING PEOPLE

In society, waste takes a different form: people's lives. According to the International Labor Organization in Geneva, nearly a billion people (about 30 percent of the world's labor force) either cannot work or have such marginal and menial jobs that they cannot support themselves or their families. In China, it is predicted that the number of un- and underemployed will top 200 million by the year 2000, a situation that is already leading to protests, addicted youth, heroin use, drug wars, violence, and rising criminality.[15] In the United States, in 1996, a year when the stock market hit new highs, the Fordham University "index of social health" did not. The index, which tracks problems like child abuse, teen suicide, drug abuse, high-school dropout rates, child poverty, the gap between rich and poor, infant mortality, unemployment, crime, and elder abuse and poverty, had fallen 44 percent below its 1973 high.[16] Globally, rates of unemployment and disemployment have been rising faster than those for employment for more than 25 years. For example, unemployment in Europe in 1960 stood at 2 percent; in 1998 it was nearly 11 percent.[17] In many parts of the world, it has reached between 20 and 40 percent.

The United States is proud of its relatively low 4.2 percent unemployment rate (1999), and should be. Yet official U.S. figures mask a more complex picture. According to author Donella Meadows, of the 127 million people working in the United States in 1996, 38 million worked part-time, and another 35 million, though working, weren't paid enough to support a family. The official unemployed rolls of 7.3 million do not count an additional 7 million people who are discouraged,

forcibly retired, or working as temps. Of those counted as employed, 19 million people worked in retail and earned less than $10,000 per year, usually without any type of health or retirement benefits.

Unemployment percentages also mask the truth about the lives of inner-city residents. In *When Work Disappears,* W. Julius Wilson cites fifteen predominantly black neighborhoods in Chicago, with an overall population of 425,000. Only 37 percent of the adults in these areas are employed. While there are many reasons for the high rates of unemployment, the dominant cause is the disappearance of jobs: Between 1967 and 1987 Chicago lost 360,000 manufacturing jobs, and New York over 500,000. When reporting corporate restructuring, the media focuses on jobs lost. When covering the inner city, the emphasis is more on welfare, crime, and drugs; the attrition of meaningful work is rarely mentioned.[18] The irony of urban America is that fifty years after World War II, parts of Detroit, Philadelphia, and Newark look as if they were bombed, while Dresden, London, and Berlin are livable and bustling.

People are often spoken of as being a resource — every large business has a "human resources" department — but apparently they are not a valuable one. The United States has quietly become the world's largest penal colony. (China ranks second — most Americans have probably bought or used something made in a Chinese prison.) Nearly 5 million men in the United States are awaiting trial, in prison, on probation, or on parole.[19] In 1997 alone, the number of inmates in county and city jails increased by 9 percent.[20] One out of every twenty-five men in America is involved with the penal or legal system in some way. Nearly one of every three black men in his twenties is in the correctional system.[21] Is there a connection between the fact that 51 percent of the prison population is black and that 44 percent of young black men grow up in poverty? While crime statistics have been dropping dramatically since 1992 due to a combination of economic growth, changing demographics, and more effective policing, we are still so inured to criminality that rural counties seek new prison construction under the rubric of "economic development." Indeed, despite the drop in crime, during the period 1990–94, the prison industry grew at an annual rate of 34 percent, while crime and crime-related expenses rose to constitute an estimated 7 percent of the United States economy.[22] Is this level of crime really caused by Colombian drug lords, TV violence, and lack of family values? Is there not something more fundamentally amiss in a society that stores so many people in concrete bunkers at astounding

costs to society? (There is no cost difference between incarceration and an Ivy League education; the main difference is curriculum.) While we can reasonably place individual blame on each drug-user, felon, and mugger, or anyone who violates civil and criminal law, we should also ask whether a larger pattern of loss and waste may be affecting our nation. Our right to assign individual responsibility should not make us blind to a wider, more comprehensive social cause and effect.

In a world where a billion workers cannot find a decent job or any employment at all, it bears stating the obvious: We cannot by any means — monetarily, governmentally, or charitably — create a sense of value and dignity in people's lives when we are simultaneously creating a society that clearly has no need for them. If people do not feel valuable, they will act out society's dismissal of them in ways that are manifest and sometimes shocking. Robert Strickland, a pioneer in working with inner-city children, once said, "You can't teach algebra to someone who doesn't want to be here." By this he meant that his kids didn't want to be "here" at all, alive, anywhere on earth. They try to speak, and when we don't hear them, they raise the level of risk in their behavior — turning to unprotected sex, drugs, or violence — until we notice. By then a crime has usually been committed, and we respond by building more jails, and calling it economic growth.

Social wounds cannot be salved nor the environment "saved" as long as people cling to the outdated assumption of classical industrialism that the *summum bonum* of commercial enterprise is to use more natural capital and fewer people. When society lacked material well-being and the population was relatively small, such a strategy made sense. Today, with material conditions and population numbers substantially changed, it is counterproductive. With respect to meeting the needs of the future, contemporary business economics is the equivalent of pre-Copernican in its outlook. The true bottom line is this: A society that wastes its resources wastes its people and vice versa. And both kinds of waste are expensive.

But it is not only the poor who are being "wasted." In 1994, several hundred senior executives from Fortune 500 companies were asked for a show of hands based on the following questions: Do you want to work harder five years from now than you are today? Do you know anyone who wants to work harder than they are now? Do you know anyone who is or are you yourself spending too much time with your children? No one raised a hand.[23]

Just as overproduction can exhaust topsoil, so can overproductivity exhaust a workforce. The assumption that greater productivity would lead to greater leisure and well-being, while true for many decades, may no longer be valid. In the United States, those who are employed (and presumably becoming more productive) find they are working one hundred to two hundred hours more per year than people did twenty years ago.[24]

From an economist's point of view, labor productivity is a Holy Grail, and it is unthinkable that continued pursuit of taking it to ever greater levels might in fact be making the entire economic system less productive. We *are* working smarter, but carrying a laptop from airport to meeting to a red-eye flight home in an exhausting push for greater performance may now be a problem, not the solution. Between 1979 and 1995, there was no increase in real income for 80 percent of working Americans, yet people are working harder today than at any time since World War II.[25] While income rose 10 percent in the fifteen-year period beginning in 1979, 97 percent of that gain was captured by families in the top 20 percent of income earners. The majority of families, in fact, saw their income decline during that time. They're working more but getting less,[26] in part because a larger portion of our income is paying to remedy such costs of misdirected growth as crime, illiteracy, commuting, and the breakdown of the family. At the same time, we continue to overuse energy and resources — profligacy that will eventually take its toll in the form of even lower standards of living, higher costs, shrinking income, and social anxiety. While increasing human productivity is critical to maintaining income and economic well-being, productivity that corrodes society is tantamount to burning furniture to heat the house.

Resource productivity presents business and governments with an alternative scenario: making radical reductions in resource use but at the same time raising rates of employment. Or, phrased differently: Moving the economy toward resource productivity can increase overall levels and quality of employment, while drastically reducing the impact we have on the environment. Today companies are firing people, perfectly capable people, to add one more percentage point of profit to the bottom line. Some of the restructuring is necessary and overdue. But greater gains can come from firing the wasted kilowatt-hours, barrels of oil, and pulp from old-growth forests, and hiring more people to do so.

In a world that is crying out for environmental restoration, more jobs, universal health care, more educational opportunities, and better and affordable housing, there is no justification for this waste of people.

LOST WEALTH

Finally, in the reckoning of national waste, there is money. The United States, which prides itself on being the richest country in the world, cannot balance its budgets (the present federal budget is *not* balanced using conventional accounting methods), fund properly its educational system, repair its bridges, or take care of its infirm, aged, mentally ill, and homeless. Where, then, is all our wealth going?

The degree to which resources and people are wasted shows up, in fact, in overall gross domestic product. Of the $9 trillion spent every year in the United States, at least $2 trillion annually is wasted. What is meant by "waste" in this context? Simply stated, it represents money spent where the buyer gets no value. An example of waste familiar to everyone is sitting in a traffic jam on a congested freeway. Money is being expended on gas, time, and wear and tear on car and driver, but it produces zero value. Discretionary activities, cruising the streets in low riders or speeding across Lake Mead in a 600 hp cigar boat, aren't counted here as waste. Waste is a built-in feature of an outmoded industrial system and it saps our national strength. Here is a partial list of how money is wasted in the United States:

Highway accidents cost society more than $150 billion per year, including health care costs, lost productivity, lost tax revenue, property damage, and police, judicial, and social services costs. According to the World Resources Institute, highway congestion costs $100 billion per year in lost productivity; that figure does not include gasoline, increased accidents, and maintenance costs. In the United States alone, the total hidden social costs of driving, not paid by the motorist, total nearly $1 trillion, including such expenses as building and repairing roads, economic losses due to congestion, ill health caused by air pollution, and medical costs for the victims of the 2 million accidents each year.[27] We spend $50 billion a year to guard sea lanes bringing oil from sources we would not need if the Reagan administration had not gutted light-vehicle efficiency standards in 1986.[28] Nearly $200 billion a year in energy costs is wasted because we do not employ the same efficiency practices as Japan in businesses and homes.

In health care, $65 billion is spent annually on nonessential or even fraudulent tests and procedures (including 420,000 unneeded caesareans).[29, 30] By some estimates, $250 billion of inflated and unnecessary medical overhead is generated by the current insurance system.[31] We spend $50 billion a year in health costs because of our dietary choices, and as much as $100 billion on costs related to the effects of polluted air.[32, 33] We spend $69 billion on obesity, $274 billion on heart disease and strokes,[34] and $52 billion on substance abuse. Health-care budgets are being increasingly burdened by such "old" diseases as staphylococcus and tuberculosis, now appearing in new drug-resistant forms thanks to shortcuts taken to save money in public health, prisons, homeless shelters, and medical treatment.

Legal, accounting, audit, bookkeeping, and recordkeeping expenditures that are required to comply with an unnecessarily complex and unenforceable tax code cost citizens at least $250 billion a year. What Americans fail to pay the IRS adds up to another $150 billion.

We pay criminals $40 billion a year for illegal drugs.[35] Crime costs $450 billion a year.[36] Another $300 billion is spent on lawsuits (how much of that amount is necessary can be gauged by the fact that the United States has 70 percent of the world's lawyers).

This inventory doesn't account for costs to clean or contain Superfund sites. It doesn't count cleanup of nuclear weapons facilities (estimated as high as $500 billion) or the annual expense of disposing of 25 billion tons of material waste. Also ignored are subsidies to such environmentally damaging industries as mining, nuclear utilities, unsound agriculture, and forestry. In various ways topsoil loss, loss of fisheries, damage from poor land management, water pollution, and potential losses due to climate change are all subsidized. Then there is government waste, consumer fraud, legal and illegal gambling, costs related to replacing shoddy products, and the social costs of unemployment. It is conceivable that as much as one-half of the entire GDP is attributable to some form of waste. If even a portion of these expenditures could be shifted to more productive uses, money would be available to balance the budget, raise superbly educated children, restore degraded environments, and help the less fortunate. If that seems an overly optimistic projection, consider that, had we adopted in 1974 the efficient energy practices of some other advanced industrial countries, and applied the savings to the national debt, we would not today have a national debt.

WASTE AS A SYSTEM

Because of the profligate nature of current industrial processes, the world thus faces three crises that threaten to cripple civilization in the twenty-first century: the deterioration of the natural environment; the ongoing dissolution of civil societies into lawlessness, despair, and apathy; and the lack of public will needed to address human suffering and social welfare. All three problems share waste as a common cause. Learning to deal responsibly with that waste is a common solution, one that is seldom acknowledged yet increasingly clear.

There is nothing original in this record of national waste; what is novel is that each of the three types of waste is presented as interlocking symptoms of one problem: using too many resources to make too few people more productive. This increasingly expensive industrial formula is a relic of a past that no longer serves a present or a future.

At this point, it is worth asking, do we have any reasons to be hopeful about the future? History has demonstrated that societies may act stupidly for periods of time, but eventually they move to the path of least economic resistance. The loss of natural capital services is already imposing severe costs. Despite the convoluted economic theories and accounting systems that have been devised to persuade ourselves that they aren't a significant problem, those costs are starting to become apparent, undeniable, and unavoidable, as evidenced above in the cost of waste.

Further, if the growth in human-made capital is genuinely being affected by the loss of natural capital, there should be economic and social indices of that fact, measures that can be recognized and acknowledged by businesspeople and policymakers alike. As it happens, the signs are there for us to see. Economic growth in the United States may not be as robust as we have been led to believe; in fact, the economy may not be growing at all. That assertion may sound preposterous, but more and more economists are taking this possibility seriously. Obviously, "growth" in this context does not refer to dollar-denominated GDP, which has increased at 2.5 percent per year since 1973. It is *net* growth that has come to a standstill: the growth in the quality of life, in leisure and family time, in higher real wages, in a better infrastructure, and in greater economic security. We can't say with any confidence that America is growing because the index relied upon, the GDP, only measures money spent, not value received. But there is a world of difference

between the exchange of dollars and the creation of well-being. By current economic definitions, most industrial, environmental, and social waste is counted as gross domestic product right alongside TVs, bananas, cars, and Barbie dolls. The definition of economic growth includes *all* expenditures, regardless of whether society benefits or loses. Growth includes crime, emergency room charges, prison maintenance, dump fees, environmental cleanups, the costs of lung disease, oil spills, cancer treatment, divorce, shelters for battered women, every throwaway object along every highway, and liquor sold to the homeless. When accepted economic indices so wildly diverge from reality, we are witnessing the tottering end of a belief system. These beliefs become even more tenuous as the experts reassure us that more of this type of growth will save us from the very ills this type of growth creates.[37] In fact, an alternate term for what the country is now experiencing has been suggested: uneconomic growth.[38]

According to Jonathan Rowe of Redefining Progress, a public-policy think tank that is analyzing and reframing measures of progress: "The GDP is simply a gross measure of market activity, of money changing hands. It makes no distinction whatsoever between the desirable and the undesirable, or costs and gain. On top of that, it looks only at the portion of reality that economists choose to acknowledge — the part involved in monetary transactions. The crucial economic functions performed in the household and volunteer sectors go entirely unreckoned. As a result the GDP not only masks the breakdown of the social structure and the natural habitats upon which the economy — and life itself — ultimately depend; worse, it portrays such breakdown as economic gain."[39] Since growth as conventionally defined encompasses both decay and improvements, an honest accounting would subtract decline from revenue to determine if the result is a net credit or debit. Those calculations can't be done as long as the government is using a calculator with no minus signs. Then again, if you consider the fact that natural capital isn't even valued, and is theoretically worth as much as all the economic activity shown on the books, it almost doesn't matter what signs are on the calculator.

By masking impoverishment in society, the GDP sends signals to commerce that are as specious as those it conveys to the government and to citizens. While it is not business's responsibility to recalculate government indicators, business may have to get more involved in such debates to enable it to get the sort of feedback it will need to plan strate-

gically for a viable future in which it has a role to play. Ironically, most economists don't like the GDP standard either. In 1972, economists William Nordhaus and James Tobin wrote, "Maximization of GNP is not a proper objective of policy." Economist Robert Repetto goes further: "Under the current system of national accounting, a country could exhaust its mineral resources, cut down its forests, erode its soils, pollute its aquifers, and hunt its wildlife and fisheries to extinction, but measured income would not be affected as these assets disappeared. . . . The result can be illusory gains in income and permanent losses in wealth."[40] Given the pressures that are being placed upon living systems, it is critical for companies to look at their own industrial metabolism and begin to change course. Early adopters and forward-looking competitors will soon stake out the high ground of how a corporation can profitably deliver what people will need yet with radical reductions in throughput.

By any measure, we are destroying the most productive systems ever seen on earth while statistically blinding ourselves to the problem. Economics cannot function as a reliable guide until natural capital is placed on the balance sheets of companies, countries, and the world. As it stands, the capitalist system is based on accounting principles that would bankrupt any company. A healthy economy needs, as any accounting student understands, an accurate balance sheet. In the meantime, acting as though natural and human capital *were* properly valued is critically important. When natural capital is no longer treated as free, unlimited, and inconsequential, but as an integral and indispensable part of the production process, our entire system of accounting will change. Prices, costs, and how we calculate value will alter dramatically.

The next four chapters show what can happen when biological and material limits are seen as an opportunity rather than a problem. In industry, the "waste" problem is being approached with ingenious methods and technologies. The advances in radical resource productivity that have been achieved in a relatively short time are more than surprising; they are revolutionary. Within these techniques and processes resides a whole new set of business and design principles.