A final chapter, "The Spiritual Dimension," is an attempt to make sense of the Long Descent in the context of that realm of ultimate meanings we awkwardly call "spiritual" or, perhaps, "religious." An appendix, more technical in nature, outlines the theory of societal collapse that underlies the argument of this book.

No book is the product of a single mind, and this one in particular has benefited from the help I have received from many other people. Dr. Richard Duncan and the members of the Third Place Society introduced me to the world of peak oil and encouraged the first rough outlines of the ideas presented here. Richard Heinberg offered valuable feedback at several stages of the process; he and Wijnandt de Vries also arranged for online publication of my initial essay "How Societies Fall: A Theory of Catabolic Collapse" when other options fell through. Many people provided valuable feedback on that essay and on subsequent posts on my blog, "The Archdruid Report," where many of the ideas discussed in this book were first aired. All the staff of New Society Publishers, especially publisher Chris Plant and editor Linda Glass, were unfailingly enthusiastic and helpful.

Another series of intellectual debts begins with Corby Ingold, who introduced me to the modern Druid tradition. Philip Carr-Gomm, Chosen Chief of the Order of Bards Ovates and Druids (OBOD), helped me make sense of Druidry and posed cogent questions about the interface between Druid spirituality and the fate of the industrial world. The visit to Caernarfon described at the beginning of this introduction was made possible by OBOD's Mount Haemus award for Druid scholarship, for which I also must thank the Order's Patroness Dwina Murphy-Gibb. Dr. John Gilbert welcomed me into the Ancient Order of Druids in America (AODA), the Druid order I now head. He and many other members of AODA have played crucial roles in shaping my ideas on this and many other subjects. My wife Sara, finally, has had a central part in helping to shape this book, and in the rest of my life. My thanks go to all.

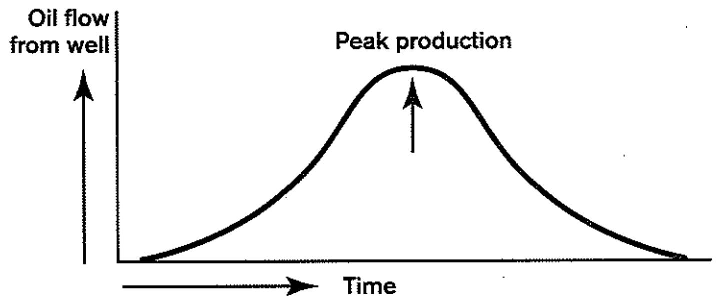
ONE

The End of the Industrial Age

For those of us who grew up during the energy crises of the 1970s, recent headlines have taken on an eerie degree of familiarity. Now as then, soaring energy costs make the news almost daily, part of a wider economic shift that's sending the prices of many raw materials through the roof. The countries that export the oil we in North America waste so casually (OPEC then; Iran, Venezuela, and Russia now) are showing an uncomfortable eagerness to cash in their economic chips for the headier coin of international power. Meanwhile the US balance of trade sinks further into a sea of red ink as imported consumer goods from our largest Asian trading partner (Japan then, China now) overwhelm what's left of American exports, sending the dollar skidding against most foreign currencies. In Yogi Berra's famous words, it's déjà vu all over again.

Then as now, too, the rising cost of oil isn't simply the result of market vagaries or the wickedness of oil companies. It comes out of a disastrous mismatch between our economic system and the hard facts of petroleum geology. In 1970, petroleum production in the

Figure 1.1. The Hubbert Curve



One of the basic tools of petroleum geology, the Hubbert curve predicts the total production of petroleum from an oil well. Peak production comes when about half of total production has already taken place.

United States reached its all-time peak and began the steady decline that continues to this day. This decline forced American society, raised on fantasies of endless supplies of cheap home-grown energy, to retool its foreign policy, its economy, and its culture to deal with the unwelcome new reality of dependence on overseas reserves. Much of the economic and cultural turmoil of the decade after 1970 came out of the wrenching changes demanded by that new reality.

The peak of US oil production came as a surprise only to those who weren't paying attention. Decades before, a petroleum geologist named M. King Hubbert worked out equations that predict in advance how much oil you can get from a well.[1] Oil is viscous stuff, and it takes time to move through pores and crevices in the rock that contains it. When an oil well pierces the rock and starts drawing out oil, the flow starts off slowly, gradually rises to peak production, and dwindles away just as gradually to nothing. Normally this works out to a bell-shaped curve, the Hubbert curve, that ranks today as one of the basic tools of petroleum geology.

Hubbert's discovery, however, had wider implications. The same curve, he found, was just as effective a way of tracking production from oil fields, oil provinces (regions with similar geological

features), and the oil reserves of entire nations. It's worth taking the time to understand how this works, because both the crisis of the 1970s and the larger crisis taking shape around us today both unfold from it. Production from a field, an oil province, or a country starts off slowly, just as with an oil well, because it takes time and investment to find the right places to drill. As the first few wells start producing, more wells are drilled, and total production rises. Eventually, though, the rising curve of production runs into the awkward fact that any given field, oil province, or country only contains so much oil.

This impacts production in two ways. First, as the number of wells rises, it gets harder to find more places where oil can be drilled. Second, old wells start to run dry as each one follows its own Hubbert curve, and so rising production from new wells starts to be offset by dwindling production from older ones. Sooner or later, these two factors overtake the rate of new oil production, and the field, province, or nation tips into decline. On average, this happens when about half the recoverable oil has been pumped out. There's still plenty of oil in the ground when this happens, and much of it may not even be discovered by then, but each new well drilled after the peak simply helps take up some of the slack from older wells that are running dry.

All through the early 1950s, Hubbert tried out his curve on oil field data from around the world and refined his equations. In 1956 he took the next step by predicting publicly that oil production in the United States would peak about 1970, and then enter a permanent decline. Almost everyone in the oil industry dismissed his claim as nonsense. The conventional wisdom insisted that better technology and increased investment would keep US domestic oil production rising into the far future.

As the numbers came in during the early 1970s, though, it became clear that Hubbert was right. Despite immense investment, dramatic new technological advances, and federal tax policies that amounted to a trillion-dollar giveaway to the American oil industry, production peaked and then began to shrink right on schedule. That peak and decline gave the newly founded Organization of Petroleum Exporting Countries (OPEC) the leverage they needed to force the price of oil upward. Then, when the United States sided with Israel in the 1973 Yom Kippur War, OPEC was able to impose an oil embargo that came close to bringing the US economy to its knees.

Hubbert was not finished, though. In 1970, armed with the best current estimates of world oil reserves, he took his curve one step further and applied it to the entire world. His calculations predicted that oil production for the entire planet would crest around 2000, and decline thereafter. This was bad news for a global economy that depended on oil for close to half its energy and nearly all its transportation. How bad the news might be, though, did not become clear until a few years later, when a study sponsored by the Club of Rome put the concepts of limits to growth on the Western world's cognitive map.

The Limits To Growth

The Club of Rome was founded in 1968 by Aurelio Peccei, a former CEO of Italian auto manufacturer Fiat. Its mission was to find constructive responses to what Peccei called "the global problematique" — the spiral of converging crises that he, along with many leading figures in economic and scientific fields, saw closing in on industrial society in the second half of the 20th century. Shortly after its founding, the Club hired a team of MIT scientists and computer engineers for a daring project — an attempt to predict the future course of industrial society. The results of the project saw print in 1972 as the controversial bestseller *The Limits to Growth*, one of the defining books of the decade and the storm center of bitter debates that continue to this day.

What the *Limits to Growth* team found was that, in simplest terms, unlimited growth on a finite planet is a recipe for disaster. As population increases and economic growth unfolds, the world

has to provide ever greater supplies of food, water, energy, and raw materials for industry. The Earth, though, only has so much oil, so much coal, so much topsoil, and so on through the sprawling list of resources used by industrial society, and it can only absorb so much pollution before the natural systems that support the global economy begin to break down. Since these systems include the weather patterns, water and nutrient cycles, and ecological interactions that produce food for people to eat, wood and other raw materials for them to use, and even the oxygen they breathe, this is not a small matter.

None of this is a problem as long as a society stays within what ecologists call the *carrying capacity* of its environment (the level of resource use and pollution the environment can support indefinitely). Once growth outstrips carrying capacity, though, resources become scarcer while demand rises, and so the costs of supplying the economy with what it needs climb steadily. Meanwhile, rising population and economic growth churn out ever greater amounts of pollution and put increasing strains on economically important natural systems. As these natural systems begin coming apart, the global economy either has to pay to do things nature once did for free or it has to fund pollution control measures to keep natural systems operating. Either way, costs go up.

The *Limits to Growth* team found that the twin economic burdens of resource depletion and pollution turn a growth-oriented economy into its own nemesis. The MIT team's computer models showed that once an economy overshoots the carrying capacity of its environment, the costs of resource depletion and pollution rise faster than the rate of economic growth. In the end the economic burden of dealing with the consequences of growth overwhelms growth itself and brings the global economy to its knees.

All this posed a stark contradiction to one of the most widely held beliefs in modern economics — the conviction that economic growth is the answer to all the problems of human society. *The Limits to Growth* demonstrated that you can't grow your way out of a crisis if growth is what's causing the crisis in the first place. The study concluded with the sobering assessment that unless something changed drastically, the limits to economic growth would arrive sometime in the first half of the 21st century and push industrial society over the edge into a long period of catastrophic decline.

From the day of its publication, *The Limits to Growth* became the focus of a firestorm of criticism, much of it politically motivated and not all of it fair or well informed. Economists dismissed it out of hand; conservative politicians denounced it as something close to a Communist plot; and plenty of people from all walks of life found its conclusions impossible to accept. Still, it found receptive audiences all over the world. While the use of sophisticated computer models was new, the risks charted by the MIT team were simply a restatement of problems already discussed in educated circles in Europe and America for most of a century before *Limits to Growth* was published.

By the late 19th century, in fact, perceptive people in Europe and America were already comparing the modern West to ancient Rome and other vanished civilizations and suggesting that industrial civilization was already on the downslope of its history.[2] The crises of the 1970s brought these uncomfortable possibilities to center stage. The industrial world found itself confronted with a succession of economic crises — soaring energy costs driven by depletion at home and the rising power of OPEC overseas, and the American military failure in Vietnam. These troubles drove many people to take a hard second look at their assumptions about the future, kickstarting a flurry of projects aimed at retooling industrial society so that it could survive in an age of resource depletion and ecological limits.

Some of those projects were follies from the start, and others that could have succeeded foundered on the inevitable problems facing any innovative venture. Fingerpointing and scapegoat hunting played as large a part in the collective dialogue then as it does

today, but despite all that, a remarkable amount of effort went into constructive responses to the crisis. The 1970s were a boomtime for the now-forgotten "appropriate technology movement," which developed an impressive toolkit of methods for conserving energy and raw materials. Two other movements — organic agriculture and recycling — moved off the drawing boards and became profitable industries during that decade.

Conservation and energy efficiency in general had a pervasive presence on the cultural radar screens of the time. Most Americans in those years knew about insulation and weatherstripping and at least glanced at the miles-per-gallon numbers when shopping for a car. The result was an unprecedented decline in energy use — for example, petroleum consumption worldwide went down some 15% in the decade after 1973.[3] For a brief moment in the late 1970s, it seemed possible that the industrial world might move forward to a future of sustainable prosperity.

The successes of 1970s conservation, however, represented only the first baby steps toward that goal. By the end of the 1970s most serious students of energy policy saw only two realistic options for going further. The first would have thrown the full weight of government policy and funding into a transition toward a "conserver society," in which stability rather than growth would be the watchword. The second would have launched a transition to nuclear power, gambling the future of the industrial world on the success and safety of untried breeder reactor and fusion technologies. Both options were major challenges with huge financial and political price tags.[4]

The Reagan/Thatcher era saw politicians across the industrial world choose a third option, breathtaking in its simplicity — or rather, in its simple-mindedness. Where the conserver society and the nuclear options accepted severe short-term costs to ensure the long-term survival of industrial society, 1980s political leaders across the industrial world pursued short-term strategies that forced energy prices down in order to keep the electorate and business interests happy; the politicians simply hoped that things would somehow work out in the long term.

The conservation successes of the 1970s helped make this decline in energy costs possible by bringing down the demand for oil. The reckless overproduction of newly discovered oil fields in the North Sea and Alaska's North Slope finished the process by allowing American and British governments to turn the oil spigot all the way on, sending the price of oil crashing to levels that were (in constant dollars or pounds) lower than ever before. As a short-term strategy, it proved overwhelmingly successful: energy prices plummeted; economies shook themselves out of the "stagflation" of the 1970s; and the Soviet Union lurched into bankruptcy and political collapse as oil — its one reliable source of hard currency — no longer propped up the inefficiencies of the Communist system.

The blowback from these successes, though, is only just coming due today. As energy prices plunged, efforts to find a replacement for fossil fuels withered on the vine. Alternative energy companies went bankrupt by the score as the market for their products evaporated. The nuclear industry took just as severe a hit; only massive government subsidies kept nuclear plants functioning as the price of electricity dropped below the cost of producing it by splitting atoms. The 1982 bankruptcy of the Washington Public Power Supply System, a grandiose, and wildly overpriced nuclear power project, convinced investors around the world that the nuclear industry was a sucker's bet.

Some of those who pushed the short-term economic fixes of the 1980s likely did so out of sheer political opportunism — it's almost always a good election strategy to tell voters what they want to hear. Still, it's only fair to say that some of those who supported the energy policies of Reagan, Thatcher, and their equivalents in other industrial nations had more respectable reasons for doing so. Faith in the free market's ability to solve all problems was at an all-time high. Influential conservative intellectuals of the period such as Julian Simon and Herman Kahn argued that the exhaustion of petroleum reserves was a nonproblem. Once government regulations got out of the way (the claim went) entrepreneurs would come up with abundant new energy sources and all would be well.

Those of us who were around in the 1980s may still remember the Laffer Curve, the theory floated by Reagan's economic officials that tax revenues could actually be increased by cutting taxes. The theory was that excessive taxes stifled business activity and lower rates would spur so much economic expansion that they would actually bring in more revenue. Although it looked plausible at the time, it didn't work. Instead, the Reagan tax cuts landed the United States in a cycle of reckless deficit spending that continues today. The energy policy embraced by industrial nations in the 1980s followed a similar logic. It looked just as plausible to many people at the time, and it turned out to be just as misguided in the long run.

For most of the 1980s and 1990s, though, it looked to many as though both the energy shortages and the visions of sustainability seen in the 1970s were an aberration best forgotten. That was where matters stood in the late 1990s, when Hubbert's nearly forgotten 1970 prediction suddenly took on a great deal of new urgency and a new phrase — "peak oil" — started moving in whispers through the intellectual back alleys of the industrial world.

The Coming of Peak Oil

At the time, nothing seemed sillier than concern about the future of the world's energy supply. Oil prices were at historic lows, bumping along just above the $10 a barrel level. Gasoline was so cheap that huge, gas-guzzling SUVs had become America's latest automotive obsession, and they were starting to find a market overseas. Energy had cost so little for so long that most of the conservation programs put in place during the 1970s had long since been scrapped. Hubbert's curve, while it remained a standard tool among working petroleum geologists, had dropped so far out of public awareness that even the best discussions of energy in the 1990s routinely missed the fact that oil production would peak and decline a long time before the last of the world's oil was extracted from the ground.[5]

The only thing wrong with the comfortable picture of abundant oil was the troubling numbers coming from the oil industry. Despite huge investments in exploration and discovery, it was becoming harder and harder to find new oil fields, while existing oil fields all over the world moved closer to their Hubbert peaks and the world's thirst for oil kept climbing. Those who took the time to put the numbers together discovered that the volume of oil pumped out of the ground overshot the volume of new oil discovered in every year since 1964, and the gap was growing — by 2000, for example, new discoveries only equaled a quarter of the oil drawn from existing wells that year. Since oil has to be found before it can be pumped, and it can only be pumped out of the ground once, a slump in the rate of oil field discovery is the proverbial canary in the mine shaft of the petroleum economy.

These unwelcome figures brought belated attention to Hubbert's 1970 prediction of a 2000 peak. During the late 1990s, several teams of independent researchers set out to update Hubbert's figures. This was a challenging task, not least because oil in the ground is an asset that affects stock prices and the value of national currencies. Oil companies and oil-exporting nations alike have strong incentives to inflate their reserves and no reason at all to reveal details that might puncture the bubble of apparent prosperity. As a result, many oil-producing nations keep the size of their oil reserves secret, and the estimates published by various government and industry sources are unreliable, at best. Still, as the teams crunched numbers and found ways to estimate figures they could not locate, it became clear that unless the world had much more oil than the evidence showed, the world's Hubbert peak was much closer than anyone had guessed.

The imminence of the peak was bad news because the entire modern way of life runs on oil. Industrial civilization demands fantastic inputs of energy. Oil, more than anything else, keeps it

running. Oil is nearly the perfect energy source: there was originally a huge amount of it, it contains a huge amount of energy per unit of volume, it can be extracted from the ground very cheaply, it's just as easy to transport and store, it's even easier to use, and it's *fungible* — that is, it can be easily put to work in many different ways; you can burn it to produce heat, power motors, fuel cars or planes, generate electricity, or anything else you want. Oil provides 40% of all energy used by human beings on Earth, and it powers nearly all transportation in the industrial world. It's also the most important raw material for plastics, agricultural and industrial chemicals, lubricants, and asphalt roads.

As the first peak oil researchers and activists began work, two objectives took center stage in their work: figuring out when the worldwide peak of petroleum production would arrive, and communicating the unwelcome news to the rest of the world. The first of these tasks proved to be the easiest. A loose network of retired petroleum geologists and engineers — Colin Campbell, Kenneth Deffeyes, Richard Duncan, Walter Youngquist, and others — took the lead in sorting through the data on oil reserves. Taking advantage of the great strides made in computer technology in the 1990s, they developed analytical models as accurate as the ones used by the major oil companies. As the end of the decade closed in, the results of these new models converged, placing peak between 2005 and 2010. As the imminence of the peak became clearer, the focus shifted steadily toward the second objective — getting the word out to governments and the public that a new round of energy crises might soon be in the offing.

At first, these warnings fell on deaf ears. The same business and government interests that had been fighting tooth and nail against the recognition of global warming quickly turned on peak oil as well. In the resulting debate, official figures on oil reserves too often reflected political expediency rather than accurate science. Thus the Energy Information Agency (EIA), a branch of the US Department of Energy, has long been one of the major sources used by debunkers of the peak oil theory. Its own documents, however, show that the figures it offers for future oil production are generated by estimating future demand for oil and then assuming that the supply will be there when it's needed.[6] To say that this begs the question is to understate matters considerably.

One of the many ironies of these debates is that while the EIA and other government agencies massaged the data, the peak oil message had already found an audience in the highest levels of the American political system. One of the experts who began speaking out about peak oil in the late 1990s was Matthew Simmons, a banker to the energy industry who served as energy advisor to Vice President Cheney in the months immediately before and after the 2000 election. Many astute observers of the American political scene have argued that peak oil has been the hidden subtext behind much of American foreign policy since that time.[7] This would certainly go far to explain the Bush administration's obsession with launching an invasion of Iraq, a country that probably has more untapped oil reserves than any other nation in the world.

If access to oil supplies was the point of America's recent Middle East entanglements, the results have not been worth the cost in money, lives, and international prestige. The Afghanistan and Iraq invasions put American troops in control of the world's last remaining major undeveloped oil fields. In both cases, however, American military power drove a hostile government from power but proved unable to make peace in their absence, much less secure access to oil reserves. Moreover, these military adventures have pushed America into exactly the sort of imperial overstretch that Paul Kennedy warned about in his widely respected book *The Rise and Fall of the Great Powers*.

Meanwhile, the energy, materials, and time expended on these ventures were desperately needed to help make the transition to a post-peak economy. One of the central themes of *The Limits to Growth* was precisely that modern civilization cannot turn on a

dime. Changing from one energy resource to another isn't simply a matter of pouring something different into our gas tanks, because much of today's energy infrastructure is fuel-specific — that is, you can't burn coal in a nuclear reactor or dispense hydrogen through a gasoline pump. It took 150 years and some of the biggest investments in history to build the industrial, economic, and human infrastructure that turns petroleum from black goo in the ground to the key power source of modern society. To replace all that infrastructure with a new system designed to run on some other form of energy would take roughly the same level of investment, as well as a great deal of time.

In a widely cited 2005 study, a team of researchers headed by Robert Hirsch determined that even given the full resources of the US government, a program to head off the worst consequences of peak oil would have to be launched fully twenty years before peak to keep the inevitable production declines from having severe impacts on economy and society.[8] The problem here is that we don't have twenty years. We probably don't have ten. We may not have five. As I write these words, world petroleum production appears to have peaked in late 2005 and declined since then, despite sky-high prices that make even the most marginal oil wells paying propositions. Several more years will need to pass before it's clear whether those declines are a temporary fluke or the beginning of the end of the Petroleum Age, but it's possible that peak oil has already arrived.

Replacing Petroleum?

The obvious solution to the peak oil problem is to find something to replace oil, and this became a third major topic for discussions within the peak oil community as soon as the scale of the problem became clear. The problem peak oil researchers found, as their equivalents in the 1970s discovered before them, is that replacing oil with anything else is much more difficult than it looks. Sheer volume poses the first of many difficulties. The world burns

84 million barrels of petroleum — more than three and a half billion gallons — every single day, with about a quarter of that going to the United States. Replacing even a small fraction of that vast flood of energy and material from any other source poses staggering challenges.

To start with, the three other fuels that, together with oil, provide most of the world's energy — coal, natural gas, and uranium — are already being exploited at a breakneck pace. Official statements about reserves of these resources suffer from the same distortions as oil, for similar reasons, and statements that there will be plenty of these fuels for many years to come need to be assessed with this in mind. These sanguine estimates also fail to take into account what would happen if production has to be increased in order to make up for dwindling supplies of oil.

As things stand today, uranium reserves are severely depleted worldwide (roughly half of the reactor fuel used today comes from dismantled Russian warheads, not from mines) and prices have soared accordingly in recent years.[9] Unless huge new reserves turn up unexpectedly, the supply of reactor fuel will start to fall short of demand sometime before 2010 — in other words, around the same time oil does. Natural gas is expected to hit its worldwide Hubbert peak around ten years after oil, and North American natural gas production will most likely begin dropping before that. Furthermore, a growing fraction of Canadian gas now gets burned to power the plants that extract oil from Alberta's tar sands, which decreases the amount of gas available for other uses and accelerates the depletion rate.

The one fossil fuel we can expect to have left in large quantities after oil peaks is coal, the most abundant of all the fossil fuels — and also the dirtiest. For many years, claims that the world had virtually endless supplies of coal have been part of conventional wisdom, but recent studies have cast serious doubts on that comforting faith; the National Academy of Sciences, for example, has issued a report warning that current estimates of the amount of coal left in the United States are wildly inflated.[10] Furthermore, unlike oil or natural gas, coal's energy content varies dramatically from one variety to another. Anthracite, the most energy-rich grade of coal, contains about half the energy as the same weight of petroleum, while lignite, the lowest grade, contains as little as a sixth.[11] Sensibly enough, mining firms have concentrated on extracting the best grades of coal first, and so most of what's left is low-grade "brown coal" full of sulfur and other impurities. In recent years the ratio between the amount of energy provided by coal and the amount of energy needed to mine it has been dropping rapidly — so rapidly, according to some studies, that by 2040 coal will take about twice as much energy to mine as it produces when burned.

The problems with coal are a good example of the crucial problem of *net energy*, the least discussed and most challenging part of the energy equation. To get energy out of any resource, you have to put energy in. To access the energy in oil, for example, you have to invest the energy needed to drill and maintain an oil well. The energy you get out minus the energy you put in equals the net energy of the resource. Net energy varies from one fuel to another, and it also varies from one source to another — oil from a newly drilled well producing light sweet crude under natural pressure can have a net energy of 200 or more (that is, burning the oil yields 200 or more times as much energy as it takes to drill and maintain the well). On the other hand, oil from an old well that has to be pumped out of the ground often has net energy down in single digits.

A net energy of 1 is the breakeven point — the resource yields exactly as much energy as went into extracting it — and many of the proposed "solutions" to the energy crisis have lower net energy than that. This makes them energy sinks, not energy sources. Hydrogen, the "wonder fuel" ballyhooed by so many pundits in recent years, could be the poster child for this particular problem because there are no reserves of hydrogen gas lying around waiting for us to tap into them — not this side of the planet Jupiter, anyway. Pure hydrogen must be manufactured from water or natural gas, and you have to put slightly more energy into extracting it from these sources than you will get back from burning it; the result is negative net energy. Trying to run an economy on energy sources with negative net energy is like trying to support yourself by buying $1 bills for $2 each. No matter how you calculate it, it's a losing proposition.

More insidious is the fact that all other fuels and energy resources receive a hidden "energy subsidy" from oil. For example, coal is excavated and transported by machinery powered by petroleum-derived diesel fuel, not by coal. Coal contains much less energy than oil does. As mentioned earlier, it takes about twice as much coal as oil to do the same amount of work, even with anthracite, and if you're burning brown coal it takes much more. If coal has to be mined, processed, and shipped using machinery powered by coal or a coal-derived diesel substitute, costs soar and efficiencies slump by at least a factor of two. Of course, if you have to turn the coal into a liquid fuel, or build new mining machinery to run on coal, the energy needed for either process also has to be factored into the equation. If oil prices itself out of the market, in other words, coal reserves have to be drawn down much faster just to maintain current levels of coal production. Try to replace oil with coal, using coal-powered technology to do the mining, and seemingly huge coal reserves run out rapidly.

If other fossil fuels and conventional nuclear power can't take up the slack, what about exotic technologies such as breeder reactors and nuclear fusion? There has been a great deal of hype about these high-tech methods, but a flotilla of challenges still has to be met before any of them contributes even a single kilowatt to the electricity grid. Most of the handful of breeder reactors built around the world in the last few decades have been shut down due to massive technical problems. Fusion has never even gotten that far despite billions of dollars in research funds. Only Nature has been able to construct a working fusion reactor that actually produces energy in useable amounts.[12] Even if one or more of these technologies could be made to work, retooling the modern energy economy to make use of them would demand immense and increasingly scarce amounts of money, resources, and time. Proponents of these exotic technologies have never addressed — much less answered — the question of how much *net* energy could be produced.

All of this leaves only renewable resources such as solar power, wind, and biofuels to supply our energy. Some of these have net energies in the single figures, others are close to breakeven, and still others fall well below the breakeven point, making them useless once the energy subsidy from oil runs out. Those that yield positive net energy have a valuable part to play in the world's energy future, but crippling problems of scale make it impossible to replace more than a small fraction of fossil fuels with renewable energy. It's worth taking a moment to see how this works.

Let's imagine, for example, that the United States decided to replace its current gasoline consumption (a large sector of its fossil fuel use, though not the largest) with ethanol derived from corn. The United States uses about 146 billion gallons of gasoline a year; since ethanol only yields three-quarters as much energy per gallon as gasoline, it would take a bit over 194 billion gallons of ethanol to keep the present American automobile fleet on the road for a year. According to US government figures, there are about 302 million acres of arable land in the United States; corn yields about 146 bushels an acre on average, and you can get 2.5 gallons of pure ethanol out of a bushel of corn.[13] This means that if every square inch of American farmland were put to work filling our gas tanks — with none left over to grow food or anything else — the total yield of ethanol would only be a little over 110 billion gallons, which is just a bit more than half of our current gasoline consumption.

Still, this is only the first half of the equation, because oil has more net energy than ethanol. Drilling for oil is relatively cheap in energy terms, and refining it from crude oil uses 5% or less of the energy value of the crude oil it comes from.[14] By contrast, it takes a great deal of energy to produce 146 bushels of corn an acre, and it takes a good deal more to process and ferment the corn on an industrial scale. The exact energy costs to grow corn and turn it into ethanol vary widely depending on details as complex as the terrain of farmland, the sugar content of the variety of corn, and the amount of rainfall in the months prior to harvest. It's possible to provide this additional energy in different ways, too — in terms of growing costs, for example, you can divert a large share of the ethanol to power tractors and combines, or you can divert a large share of the corn to feed horses and farmhands — but one way or another, you have to factor in the extra energy needed to get from seed and soil to ethanol fuel. Even if all the arable land in the United States were devoted to replacing gasoline consumption, the amount of energy produced would fall drastically short of current needs.

The same thing is true of every other form of renewable energy. Today, the world gets much of its energy supply almost free of charge by drilling a hole in the ground and piping the results somewhere. Getting the same amount of energy in any other way requires much more energy to be fed back into the energy production process. Nowhere does the energy subsidy for cheap oil have a greater effect than on renewables. Making a solar cell, for instance, requires large infusions of diesel fuel first to mine the raw materials and then to ship them to the factory. Even larger doses of natural gas or coal are needed to generate the electricity that powers the complex process of turning the raw materials into a cell that will make electricity out of sunlight. The complexity of the process makes net energy calculations challenging, but estimates range from a very optimistic 10:1 yield to more pessimistic, and arguably more realistic, 1:1 net energy yield.[15] Not even the most optimistic calculations show solar cells yielding anything in the same ballpark as the net energy routinely produced by all but the poorest fossil

fuels. The same, as it turns out, is true of every other alternative resource.

Fossil fuels are so much more valuable than other energy resources because they get a double energy subsidy from Nature herself. The first half of the subsidy arrived in the prehistoric past via photosynthesis, the process by which plants absorb and concentrate solar energy. All the fossil fuels, in energy terms, are stored sunlight heaped up over geologic time long before our ancestors strayed out of the shrinking tropical forests of the late Pliocene and launched themselves on the trajectory that led to us. No human being had to put a single day's work or a single gallon of diesel fuel into growing the tree ferns of the Carboniferous period that turned into Pennsylvanian coal beds, nor did they have to raise the Jurassic sea life that became the oil fields of Texas.

The second half of Nature's energy subsidy took the form of extreme temperatures and pressures deep within the Earth. Over millions of years more, these transformed the remains of prehistoric living things into coal, oil, and natural gas and, in the process, concentrated the energy they originally contained into a tiny fraction of their original size. A layer of anthracite coal bed an inch thick, for example, was originally a layer of dead plants several yards thick when it sank below the surface of a swamp 300 million years ago; despite the change in size, it still contains nearly all the flammable carbon of the original biomass. The result is fossil fuel that packs a huge amount of energy into a very small space.

Thus it's important to recognize the crucial distinction between a concentrated energy source and a diffuse one. If you had a handful of burning coal in one cupped palm, and a handful of sunshine in the other, you would certainly notice the difference. In the one hand is a resource that can conceivably support the intensive energy demands of an industrial society, and in the other is a resource that cannot.

All these factors play a part in setting the stage for the energy crisis emerging around us today, making it clear that the predictions of *The Limits to Growth* have stood up to the test of time rather better than the claims circulated by its detractors. Just as the study's authors predicted, industrial civilization finds itself squeezed by resource depletion. Peak oil is the poster child for this unwelcome change, but it's not the only resource likely to be in short supply in the near future. The waves of climate change and freak weather driven by CO_2 emissions from the industrial world's tailpipes and smokestacks provide a sharp reminder that the other side of the Club of Rome's prediction — the menace of rising costs from pollution — is also present and accounted for. Unfortunately the three decades it took to prove the study's thesis were also the three decades in which the first crucial steps in the transition toward sustainability might have been made.

Problems and Predicaments

Plenty of pundits and ordinary people alike insist there still must be some constructive way out of the current situation. First in line are those who insist that replacing the rascals in power with some other set of rascals more to their liking would solve the problems facing industrial civilization. Next come those who argue that if only the right technological fix gets put in place, business as usual can continue. Further down the line are radicals of various stripes who insist that the best solution to the present crisis is to let industrial civilization crash and burn, in the firm belief that it would be replaced by some way of life they consider more appealing. Still others envisage the construction of lifeboat communities that have their own localized sustainable economies, created in an effort to get the basics of an alternative, sustainable economy in place before the existing one falls apart completely. All of these proposals approach the situation as a problem in need of a solution. This may seem like common sense, but it's not. A historical parallel may help point up what's going on here.

Imagine that some ancestor of mine shows up in a prosperous farming village in the English Midlands on a bright autumn

day around 1700. It's a peaceful scene perched on the edge of catastrophic change, courtesy of the imminent arrival of the Industrial Revolution. Within a century, every building in the village will be torn down, its fields turned into pasture for sheep, and the farmers and cottagers driven off their land by enclosure acts passed by a distant Parliament to provide wool for England's cloth industry and profits for a new class of industrial magnates. For the young men of the village, England's transformation into a worldwide empire constantly warring with European rivals and indigenous peoples overseas prophesies a future of press gangs, military service, and death on battlefields around the globe. For a majority of the other residents, the future offers a forced choice between a life of factory labor at starvation wages in bleak urban slums and emigration to an uncertain fate in the American colonies. A lucky few will prosper spectacularly by betting on ways of making a living that nobody present on that autumn day has even imagined yet.

Imagine that, improbably enough, my ancestor figured all this out in advance, and has come to warn the villagers of what is in store for them. There, on the village green in the shade of an old oak, with everyone from the squire and the parson to the swineherds and day laborers gathered around him, he tells them that their way of life will be utterly destroyed, and tries to sketch out for them how the coming of industrial society will impact them, their children, and the land and life they love. Imagine that, even more improbably, they take the warning seriously. As the afternoon passes, the villagers agree that this is a serious problem indeed. What, they ask my imaginary ancestor, does he think they should do about it? What solutions does he have to offer?

What could he say in response? From today's perspective, it's clear that nothing the villagers could have done would have deflected the course of the Industrial Revolution even slightly. Events far beyond their control — geological events millions of years in the past that laid down huge coal deposits in the shallow seas that would someday become England, economic patterns going back most of the way to the fall of Rome, political shifts that had been shaking all of Europe for two centuries — drove England toward its industrial transformation. If by asking for a solution, his listeners hoped to find a way to change the whole situation for the better, my imaginary ancestor would have had to say that there was none. At most, he might have been able to give the villagers some general advice on how to cope with the torrent of changes about to break over their heads.

The consequences of the Industrial Revolution were just as complex as its causes. The destruction of England's traditional rural economy and the society that depended on it drove waves of change that moved out in all directions. Successful responses to it followed the same divergent paths. Some people prospered by abandoning their old lives and making the crossing to a new continent or a new economy, some by digging in their heels and maintaining their old way of life as long as possible, and others by staying flexible and keeping their options open. Still, none of these options offered a guarantee; many who attempted them found that they led only to impoverishment and an early death.

The question itself is the difficulty. What those English villagers faced in the years after 1700 was a predicament, not a problem. The difference is that a *problem* calls for a solution; the only question is whether a solution can be found and made to work and, once this is done, the problem is solved. A *predicament*, by contrast, has no solution. Faced with a predicament, people come up with responses. Those responses may succeed, they may fail, or they may fall somewhere in between, but none of them "solves" the predicament, in the sense that none of them makes it go away.

For human beings, at least, the archetypal predicament is the imminence of death. Facing it, we come up with responses that range from evasion and denial to some of the greatest creations of the human mind. Since it's a predicament, not a problem, the responses don't make it go away; they don't "solve" it, they simply deal with the reality of it. No one response works for everybody, though some do tend to work better than others. The predicament remains, and it conditions every aspect of life in one way or another.

The difference between a problem and a predicament has particular relevance here and now, because the last three hundred years or so have witnessed a curious shift in the way some of the basic factors of human life have been conceptualized. Since the dawn of industrial civilization, the predicaments that define what used to be called "the human condition" have been reframed as a set of problems to be solved. Death itself falls into this category. On the one hand, we've got transhumanists such as Alan Harrington in *The Immortalist* proclaiming that death is "an unacceptable imposition on the human race;"[16] on the other hand we've got a medical industry willing to inflict almost any amount of indignity and pain in order to preserve bare biological life a little longer at all costs. Our culture's mythology of progress envisions the goal of civilization as a utopian state in which poverty, illness, death, and every other aspect of the human predicament has been converted into problems and solved by technology.

The difficulty with all this is that predicaments don't stop being predicaments just because we decide to treat them as problems. There are still plenty of challenges we can't solve and be done with; we have to respond to them and live with them. Death, for example, is not an "imposition;" it's an inescapable part of the human condition. A good case could be made, and indeed has been made, that it's also one of the prime driving forces behind human art, culture, spirituality, and wisdom, and that the confrontation with the inevitability of one's own death is an unavoidable step on the path to human maturity.

The irony of the current crisis is that a civilization that tried to turn all its predicaments into problems has ended up confronted with problems that, after being ignored too long, turned into predicaments. A controlled, creative transition to sustainability might have been possible if the promising beginnings of the 1970s had been followed up in the 1980s and 1990s. That didn't happen, and now we have to live with the consequences. One of the best ways to gauge the shape of those consequences is to look at older civilizations that have encountered the limits to growth, and draw tentative conclusions based on their experiences.

The Lessons of History

It's unpopular these days to suggest that we have anything to learn from the past. Possibly this is because history holds up an unflattering mirror to our follies. Those who recall the 1929 stock market bubble, for example, can find every detail repeated in the tech market frenzy of the late 1990s. The same claims that a "new economy" and new technology made the business cycle obsolete, the same proliferation of investment vehicles (investment trusts then, mutual funds today), the same airy confidence that stock values would go up forever and fundamentals didn't matter: fast forward seventy years and you saw the follies of 1929 replayed in 1999, cheered on by economists who, of all people, should have known better.

The rise and fall of civilizations offer the same embarrassment on a grander scale. We know what happens to societies that outrun their resource base: they go under. Dozens of past cultures ended up in history's wrecking yard for exactly this reason. Civilizations collapse; as Joseph Tainter pointed out in his useful book *The Collapse of Complex Societies*, it's one of the most predictable things about them. From this perspective, our industrial civilization may not be all that different from the scores of earlier civilizations that overshot their natural resource base and crashed to ruin as a result. The collapse of civilizations is a natural process. It doesn't follow exactly the same course in every situation, but like most natural processes, some things about it can be predicted by comparison with past examples.

One highly relevant example is the ancient Maya, who flourished on the Yucatan Peninsula of Central America while Europe struggled through the Dark Ages. Using only a Neolithic stone

technology, the Maya built an extraordinary, literate civilization with fine art, architecture, astronomy, and mathematics, and a calendar more accurate than the one we use today. None of that saved it from the common fate of civilizations. In a "rolling collapse" spanning the years from 750–900 CE, Mayan civilization disintegrated, cities were abandoned to the jungle, and the population of the lowland Maya heartland dropped by 90%.

The causes of the Maya collapse have been debated for well over a century, but the latest archeological research supports the long-held consensus among scholars that agricultural failure was the central cause.[17] Like modern industrial society, the Maya built their civilization on a nonrenewable resource base. In their case it was the fertility of fragile tropical soils, which couldn't support the Mayan version of intensive corn farming indefinitely. All the achievements of Mayan civilization rested on the shaky foundation of swidden agriculture — a system in which fields are allowed to return to jungle after a few years of cultivation, while new fields are cleared and enriched with ashes from burnt vegetation. It's a widely used system in tropical areas around the world, but, like dependence on fossil fuels, it has a hidden vulnerability. Swidden works extremely well at relatively modest population levels, but it breaks down disastrously when population growth takes over and farms can no longer return to jungle long enough to restore soil fertility.

Tropical soils lose most of their fertility after only a few years of farming, and clearing too much jungle too quickly causes topsoil erosion. Dust samples taken from cores of lake sediment from the Yucatan show that both these processes spun out of control during the Maya zenith and collapse. Soil depletion and erosion combined with normal cycles of drought in the Yucatan to cause catastrophic crop failures that sent classic Mayan civilization into a tailspin of political and military chaos from which it never recovered.

Like modern industrial society, the Maya had plenty of options available as they approached what we might as well call "peak corn." They knew about crops that give higher yields than corn but draw less heavily on soil nutrients, such as manioc, sweet potato, or ramon nuts,[18] and they could have switched enough of their farmland to these crops to make a difference. Other ancient peoples managed shifts of this sort easily enough; many of the ancient Greek city-states did exactly that in the eighth century BCE. As a way of dealing with the stark ecological limitations of their rocky peninsula, the Greeks gave up an economy based on grain and cattle in favor of olive and grape farming for export.[19] Among the Maya, though, a switch of this sort was apparently never considered. Archeologists have been able to analyze the ancient Mayan diet by testing skeletons, and they found that corn provided more than 50% of the calories in the Maya diet before, during, and after the collapse.[20]

The reasons behind the failure to switch from corn to other crops is relevant to our own time because corn farming was central to Maya political ideology. The power of the *ahauob*, "divine lords" who ruled the Maya city-states, depended directly on control of the corn crop and indirectly on a religious ideology that made corn farming a core metaphor for government — Maya ceremonial art often showed the ahauob of great cities as farmers planting and cultivating corn fields. Because corn was a central cultural metaphor and a key resource of political power, abandoning it for other crops was unthinkable. Instead, the ahauob responded to the collapse of their agricultural base by going to war to seize fields and food supplies from other city-states, making their decline and fall far more brutal than it had to be.

Even so, the Maya decline wasn't a fast process. Maya cities weren't abandoned overnight, as archeologists of two generations ago mistakenly thought; most of them took a century and a half to go under. Outside the Maya heartland, the process took even longer. Chichen Itza far to the north still flourished long after cities such as Tikal and Bonampak had become overgrown ruins. Some small Mayan city-states survived in various corners of the Yucatan right up to the Spanish conquest.

Map the Maya collapse onto human lifespans and the real scale of the process comes through. A Lowland Maya woman born around 730 would have seen the crisis dawn, but the *ahauob* and their cities still flourished when she died of old age seventy years later. Her great-grandson, born around 800, grew up amid a disintegrating society, and the wars and crop failures of his time would have seemed ordinary to him. His great-granddaughter, born around 870, never knew anything but ruins sinking back into the jungle. When she and her family finally set out for a distant village, leaving an empty city behind them, it likely never occurred to her that their quiet footsteps on the dirt path marked the end of a civilization.

This same pattern repeats over and over again in history. Gradual disintegration, not sudden catastrophic collapse, is the way civilizations end. On average, it takes about 250 years for a civilization to complete the process of decline and fall.[21] This casts a startling light on the crises we face as we collide with the limits to growth. It took the Western world more than two centuries of incremental change to transform itself from an agrarian society to its current status. Now, with its resource base failing and the consequences of its maltreatment of nature piling up around it, it faces the common fate of civilizations. Yet if that fate follows its usual timeline, it could easily take two more centuries of incremental change to transform the industrial world to an agrarian society again.

Startling as this seems, it's supported by telling evidence. Consider our dwindling oil resources. The Hubbert curve we examined at the beginning of this chapter tracks production over time for any scale of oil reserve from a single oil well up to a planet. It's a bell shaped curve: oil comes slowly at first, rises to peak production, then falls gradually to zero. The peak arrives when roughly half the oil is gone. The crucial point here is that after the peak, oil production declines at about the same rate it rose before. If peak comes around 2010, production in 2040 will likely equal something not far from production in 1980 (about 20 billion barrels).

The oil produced in 2040 will have to meet the needs of a much larger global population and a world in crisis, but 20 billion barrels is still a lot of oil. In the same way, as reserves are depleted and production continues to slump over the decades that follow, the available oil will fall further and further below the levels needed to maintain a modern industrial society, but for a long time to come there will still be some petroleum available.

To misquote T. S. Eliot: this is the way the oil ends, not with a bang but a trickle. Other fossil fuels and uranium are headed the same way, but all of them can help cushion declining oil production for a while before they hit their own Hubbert peaks. Renewable energy sources can provide only a small fraction of the energy we now get from fossil fuels, but that fraction can also help cushion the decline and stretch dwindling fossil fuel reserves. The dilemma we face isn't having no energy at all. It's having to make do with less and less each year, until finally we get down to levels that can be sustained indefinitely.

The Olduvai Theory

The logic of the Hubbert curve provides the framework for the Olduvai Theory, an uncompromising look at the future in the aftermath of peak oil proposed by Dr. Richard Duncan, a professor emeritus of electrical engineering, who was also one of the most influential voices in the first days of the peak oil community.[22] Duncan's theory (named for the Olduval Gorge, the famous archeological site where Duncan first conceived the theory's central concepts) starts with White's Law, a widely accepted rule in human ecology that takes energy use per capita as the primary measure of economic development. Globally, energy per capita stood at very modest levels until 1800, when fossil fuels sent it skyrocketing to its all-time peak in 1979. At that point, Duncan's figures show, two centuries of explosive progress began to unravel.

After 1979, global energy use per capita declined as rising population outstripped modest increases in energy production. Once

the Hubbert curve reaches its peak and energy production begins to decline, the downward arc of energy per capita will accelerate. Follow the curve, and by 2030 global energy per capita will be where it was in 1930, about a third of its 1979 peak. Duncan argues that the industrial age is a *pulse waveform*, a single, bell-shaped, nonrepeating curve centered on 1979. Since no renewable energy resource can provide more than a small fraction of the immense amounts of fossil fuel energy we've squandered in the recent past, he predicts that the millennia of low tech cultures preceding the industrial pulse — before the fantastic treasure of fossil fuel was discovered and unlocked — will be balanced by millennia of low tech cultures after the industrial pulse — when the treasure will be gone forever.

Such ideas are unthinkable to most people, especially in North America, where the industrial system has arguably achieved more than anywhere else. From the first years of European settlement, the faith that the New World would avoid the mistakes and follies of the old helped drive a dizzying range of social and political experiments. What French president Jacques Chirac mocked as the United States' "almost messianic sense of national mission" has deep roots in our national psyche. Perhaps the most potent of these roots is the rarely expressed but widely held conviction that the United States is exempt from history. The idea that North America's gleaming industrial cities might someday become crumbling ruins no different from the remains of other civilizations is outside the realm of the imaginable for most people today.

A glance at earlier civilizations on the North American continent offers a useful corrective to our delusion of invulnerability. Huge urban centers existed here long before the first European explorers blundered their way to the Atlantic coast. From Copan in the Yucatan jungles to Cahokia on the plains of the Midwest, urban civilizations in America rose, flourished, and fell in the same slow rhythm that defines the history of the Old World. The fact of the matter is that civilizations don't last forever. For all practical purposes, they have a life cycle like that of other living things, and when it's over, they die. That doesn't make the project of civilization pointless, as some people suggest, any more than the fact that every one of us will die someday makes life not worth living. That latter fact does mean, of course, that someone who insists he's going to live forever, and makes plans for his future based on that premise, may not be quite as clever as he thinks he is. The same thing is just as true of civilizations — including our own.

The conviction that history's cycles don't apply to us is especially counterproductive in our present circumstances. Imagine that someone, confronted with a diagnosis of a life-threatening illness, insisted instead that he would live forever. For that reason, he refused either to treat the illness or make sure his family would have some means of support in the event of his death. He would be considered completely irresponsible by most people — and for good reason. This is exactly the collective situation we're in right now. For more than three decades we've known exactly what factors are pushing industrial society toward its own collapse, and it's no secret what has to be done to make the transition to sustainability, but the vast majority of people in the industrial world remain unwilling to embrace the necessary changes — and nothing currently suggests that they are interested in thinking about the generations in the future who will grow up in the ruins of our society.

At this point it's almost certainly too late to manage a transition to sustainability on a global or national scale, even if the political will to attempt it existed — which it clearly does not. It's not too late, though, for individuals, groups, and communities to make that transition themselves, and to do what they can to preserve essential cultural and practical knowledge for the future. The chance that today's political and business interests will do anything useful in our present situation is small enough that it's probably not worth considering. Oil is to modern industrial nations what corn was to the ancient Maya. The *ahauob* of Washington and Wall Street, "liberal" as well as "conservative," have turned to the suicidal

strategy of war just as their Mayan equivalents did. Fortunately, their participation in the process of transition isn't needed.

Our civilization is in the early stages of the same curve of decline and fall that so many others have followed before it, and the crises of the present — peak oil, global warming and the like — are the current versions of the historical patterns of ecological dysfunction. To judge by prior examples, we can't count on the future to bring us a better and brighter world — or even a continuation of the status quo. Instead, what most likely lies in wait for us is a long, uneven decline into a new Dark Age from which, centuries from now, the civilizations of the future will gradually emerge.

The Long Descent

Map the likely results of current trends onto a scale of human lifespans and a compelling image of the future emerges. Imagine an American woman born in 1960. She sees the gas lines of the 1970s, the short-term political gimmicks that papered over the crisis in the 1980s and 1990s, and the renewed trouble in the following decades. Periods of economic and political crisis, broken by intervals of partial recovery, shape the rest of her life. By the time she turns 70, she lives in a beleaguered, malfunctioning city where nearly half the population has no reliable access to clean water, electricity, or health care. Shantytowns spread in the shadow of skyscrapers while political and economic leaders keep insisting that things are getting better.

Her great-grandson, born in 2040, manages to avoid the smorgasbord of diseases, the pervasive violence, and the pandemic alcohol and drug abuse that claim a quarter of his generation before age 30. A lucky break gets him into a technical career, safe from military service in endless overseas wars or "pacification actions" against separatist guerrillas at home. His technical knowledge consists mostly of rules of thumb for effective scavenging. Cars and refrigerators are luxury items he will never own, his home lacks electricity and central heating, and his health care comes from an old woman whose grandmother was a doctor and who knows something about wound care and herbs. By the time his hair turns gray the squabbling regions that were once the United States have split apart. All remaining fuel and electrical power have been commandeered by new regional governments, and coastal cities have been abandoned to the rising oceans.

For his great-granddaughter, born in 2120, the great crises are mostly things of the past. She grows up amid a ring of villages that were once suburbs, but now they surround an abandoned core of rusting skyscrapers that are visited only by salvage crews who mine them for raw materials. Local wars sputter, the oceans are still rising, and famines and epidemics come through every decade or so, but with global population less than half what it was in 2000 and still declining, humanity and nature are moving toward balance. The great-granddaughter learns to read and write, a skill most of her neighbors don't have, and a few old books are among her prized possessions, but the days when men walked on the moon are fading into legend. When she and her family finally set out for a village in the countryside, leaving the husk of the old city to the salvage crews, it likely never occurs to her that her quiet footsteps on a crumbling asphalt road mark the end of a civilization.

This is the process I've named the Long Descent — the declining arc of industrial civilization's trajectory through time. Like the vanished civilizations of the past, ours will likely face a gradual decline, punctuated by sudden crises and periods of partial recovery. The fall of a civilization is like tumbling down a slope, not like falling off a cliff. It's not a single massive catastrophe, or even a series of lesser disasters, but a gradual slide down statistical curves that will ease modern industrial civilization into history's dumpster.

Track the impact of decline on public health and you have a model that can be applied to many other dimensions of the process. As domestic heating and air conditioning become too expensive for most, for example, deaths from pneumonia and influenza

on the one hand, and heat stroke and insect-borne tropical diseases on the other, will steadily climb. So will infant mortality, while rates of live birth per capita will plunge. Russia is a good model here; since the collapse of Communism, it's seen rising death rates and falling birth rates to such an extent that the population will be cut in half by 2100, and yet there hasn't been any massive catastrophe to account for this — simply shifts in statistics driven by economic and political failure.[23] Those same statistical shifts become inevitable when the ecological basis for a civilization crumbles away as a result of its own mismanagement.

The last few decades have already seen substantial decline in the real standard of living for most Americans and many people elsewhere in the industrialized world. We will likely see quite a bit more in the next few years, especially if the economic juggling act that props up trillions of dollars of paper debt in America and elsewhere gives way. Declining standards of living equate to declining public health. Declining public health impacts population levels. As people become poorer, they become sicker; childhood mortality goes up — the United States is already approaching parity with the nonindustrial world in that department[24] — and other vulnerable groups suffer as well.

There will be crises and disasters in economic, political, social, and military spheres. At certain points along the curve of disintegration, systems become unstable and sudden breakdowns happen. These are the things people will remember afterwards: the day the electric power grid finally went down for good, the winter that the big epidemic took a third of the people in their town, the year that civil war broke out down south, and the decade in which the last shreds of national government dissolved. Ordinary disasters such as hurricanes and massive floods will take on a new role as the resources to rebuild will be less and less available. The lessons of Hurricane Katrina in 2005 are likely to be repeated many times over in the years to come. These sudden events will punctuate the decline, not cause it, and attempts to respond to them without dealing with the broader issues will simply transfer stresses to other aspects of a society in decline.

Sooner or later in the process, we'll see the breakdown of existing social, political, and economic forms and the rise of transitional structures. At some point, continental governments such as the United States and Canada will come apart, in fact if not in name, to be replaced by regional and local governments cobbled together on an ad hoc basis; the global corporate economy will be replaced by jerry-built local exchange systems, and so on. The more sustainable, stable, and effective these transitional structures are, the more people, technology, knowledge, and culture will make it through the couple of centuries that this whole process will take.

That last is the detail that has to be remembered. Nobody now alive will see the end of the process that's now under way. The challenge we face in the short term is how to weather the next round of crises when it arrives. In the long term, the challenge is to get through the Long Descent with as much useful information and resources as possible, and to transmit them to the successor cultures that, to judge by past models, will begin coalescing sometime in the 23rd and 24th centuries. That means making sure that people right now have the information and connections they need to adapt constructively to the changes brought by the decline of our civilization, rather than backing themselves into one blind alley or another. It also means taking a hard look at some of the most fundamental ways people in today's industrial societies think about the world.

TWO

The Stories We Tell Ourselves

By this point even those of my readers who haven't yet thrown this book at the nearest wall will likely be appalled by the image of the future presented in the last few pages. What I find most interesting about this very common reaction is that it can have its roots in two completely different, and in fact opposite, sets of assumptions and beliefs about the future. On the one hand, many people insist that no matter what problems crop up before us, modern science, technology, and raw human ingenuity will inevitably win out and make the world of the future better than the world of today. On the other hand, some people insist that no matter what we do, some overwhelming catastrophe will soon bring civilization suddenly crashing down into mass death and a Road Warrior future.

Discussions about peak oil and the predicament of industrial society constantly revolve around these two alternatives, as though they were the only possibilities. Many believers in either option don't seem to be able to wrap their minds around the possibility of a third alternative. It's a remarkable situation. If two