

# Policy Analysis

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## ***Sustainable Development A Dubious Solution in Search of a Problem***

by Jerry Taylor

### **Executive Summary**

From August 26 through September 4, 2002, approximately 100 heads of state and 60,000 delegates will gather in Johannesburg, South Africa, to attend a “World Summit on Sustainable Development.” The conference—convened on the 10th anniversary of the Earth Summit in Rio de Janeiro and expected to be the largest U.N. summit in history—will explore domestic and international policy options to promote the hottest environmental buzzwords to enter the public policy debate in decades.

The concept seems innocuous enough. After all, who would favor “unsustainable development”? A careful review of the data, however, finds that resources are becoming more—not less—abundant with time and that the world is in fact on a quite sustainable path at present.

Moreover, the fundamental premise of the idea—that economic growth, if left unconstrained and unmanaged by the state, threatens

unnecessary harm to the environment and may prove ephemeral—is dubious. First, if economic growth were to be slowed or stopped—and sustainable development is essentially concerned with putting boundaries around economic growth—it would be impossible to improve environmental conditions around the world. Second, the bias toward central planning on the part of those endorsing the concept of sustainable development will serve only to make environmental protection more expensive; hence, society would be able to “purchase” less of it. Finally, strict pursuit of sustainable development, as many environmentalists mean it, would do violence to the welfare of future generations.

The current Western system of free markets, property rights, and the rule of law is in fact the best hope for environmentally sustainable development.

**Both strong and weak definitions of sustainable development pose problems. The narrower the definition, the easier it is to pin down, but the less satisfactory the concept.**

## **What Is Sustainable Development?**

The concept of sustainable development is an important milestone in environmental theory because it posits how society itself should be organized, not simply why certain environmental protections should be adopted or how they can be best implemented. This ambitious interpretation is widely shared by business leaders, policy activists, and academics alike.<sup>1</sup> Of course, just how much social and economic change is necessary to achieve sustainability depends upon how “unsustainable” one believes the present to be. Many advocates of the idea clearly believe the present to be quite unsustainable and thus are prepared for radical change.

Unfortunately, sustainable development is rather difficult to define coherently. The UN Commission on Economic Development in its landmark 1987 report titled *Our Common Future* defines sustainable development as that which “meets the needs of the present without compromising the ability of future generations to meet their own needs.”<sup>2</sup> But that definition is hopelessly problematic. How can we reasonably be expected to know, for instance, what the needs of people in 2100 might be?

Moreover, one way people typically “meet their own needs” is by spending money on food, shelter, education, and whatever else they deem necessary or important. Is the imperative for sustainable development, then, simply a euphemism for the imperative to create wealth (which, after all, is handed down to our children for their subsequent use)? True, some human needs, such as the desire for peace, freedom, and individual contentment, cannot be met simply by material means, but sustainable development advocates seldom dwell on the importance of those nonmaterial, non-resource-based psychological needs when discussing the concept.<sup>3</sup>

Thus, sophisticated proponents of sustainable development are forced to discard as functionally meaningless the

UNCED definition. Otherwise, the UNCED definition can be read as a call for society to maximize human welfare over time. An entire profession has grown up around that proposition. The profession is known as economics, and maximizing human welfare is known not as “sustainable development” but as “optimality.” Was Adam Smith’s *The Wealth of Nations* really the world’s first call for sustainable development?

Since the release of *Our Common Future*, more than 70 competing definitions of sustainable development have been offered by academics and policy analysts.<sup>4</sup> Economists David Pearce and Jeremy Warford, two of the world’s more serious thinkers about sustainable development, argue that these competing definitions largely fall into two categories. Many advocates of sustainable development are defining regimes in which the natural resource base is not allowed to deteriorate.<sup>5</sup> This category is generally known as the “strong” definition of sustainability. Other advocates of sustainable development are describing regimes in which the natural resource base would be allowed to deteriorate as long as biological resources are maintained at a minimum critical level and the wealth generated by the exploitation of natural resources is preserved for future generations, who would otherwise be “robbed” of their rightful inheritance. This category is generally known as the “weak” definition of sustainability. Weak sustainability, then, can be thought of as “the amount of consumption that can be sustained indefinitely without degrading capital stocks,” defined as the sum of both “natural” capital and “man-made” capital.<sup>6</sup>

Unfortunately, both strong and weak definitions of sustainable development pose problems. As Robert Hahn of the American Enterprise Institute points out, the narrower the definition, the easier it is to pin down, but the less satisfactory the concept.<sup>7</sup>

### **Strong Sustainability, Flabby Analytics**

Numerous analytic problems cripple the utility of strong sustainable development theory.

First, advocates of strong sustainability

are implicitly contending that in most cases natural capital is more desirable than the man-made capital created from its exploitation. Natural capital, it is argued, offers future generations multiple possibilities for its use, whereas man-made capital settles the question for future generations. Future generations, argue advocates of strong sustainability, may have different preferences for the ultimate use of natural capital than the present deciding generation.

Nevertheless, the wealth created by exploiting resources is often more beneficial than the wealth preserved by “banking” those resources for future use. Otherwise, there would be little point in exploiting resources for commercial use in the first place. Moreover, wealth created through resource exploitation is far more versatily employed than the rock or mineral might be in its unaltered state.

Subscribers to the concept of strong sustainability are implicitly suggesting that the world is somehow a poorer place because past generations drew down stocks of oil, iron, and various other minerals and metals to make advanced satellites, modern industry, and—through the wealth thereby created—advanced medicines and dozens of other life-enhancing technologies and practices. Geography professor M. J. Harte of the University of Waikato, New Zealand, underscores the analytic problem:

We should accept that it is often impractical and perhaps undesirable to hold natural capital intact in its entirety, but it is also counter to the idea of sustainability to bequeath a stock of natural capital to future generations that is incapable of yielding sufficient resource flows (i.e., “income”) to fulfill their potential needs and aspirations.<sup>8</sup>

Taken at face value, strong sustainability is wholly inconsistent with a modern economy. Whether a project is sustainable forever or just a very long time has nothing to do

with whether it is desirable. If unsustainability were really regarded as a reason for rejecting a project, there would be no mining, no more than subsistence agriculture, and no industry.<sup>9</sup>

A second problem with the concept of strong sustainability is the fact that sustainable resource use can, paradoxically, cause more environmental damage than unsustainable resource use. For instance, economist Richard Rice, ecologist Raymond Gullison, and policy analyst John Reid—a team of scholars who together spent years studying the Amazonian rain forests of Bolivia—concluded recently:

Current logging practice causes considerably less damage than some forms of sustainable management (which require more intensive harvests of a wider variety of species). Indeed, a more sustainable approach could well double the harm inflicted by logging. . . . Sustainability is, in fact, a poor guide to the environmental harm caused by timber operations. Logging that is unsustainable—that is, incapable of maintaining production of the desired species indefinitely—need not be highly damaging (although in some forests it is, especially where a wide range of species have commercial value). Likewise, sustainable logging does not necessarily guarantee a low environmental toll.<sup>10</sup>

The third and final problem with strong sustainability is the implicit suggestion that today’s natural resource base (and the health thereof) will necessarily be of significant interest to future generations. On the contrary, conserving today’s natural resource base does not ensure that tomorrow’s natural resource base is secure. Likewise, drawing down today’s natural resource base does not necessarily mean that tomorrow’s natural resource base will be put in jeopardy.

Resources are simply those assets that can be used profitably for human benefit.

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**Weak sustainability is certainly a more reasonable proposition because it is functionally indistinguishable from the economists' mission of maximizing human welfare.**

“Natural” resources are a subset of the organic and inorganic material we think of as constituting the biological environment, since not all of that material can be used profitably for human benefit. But what can be used productively by man changes with time, technology, and material demand. Ocean waves, for example, are not harnessed for human benefit today and thus cannot really be thought of as a natural resource. But the technology to harness the movement of waves as a means to generate energy certainly exists, and the day when the cost of doing so is lower than the cost of alternative energy sources is the day when waves become a natural resource. Uranium, to cite another example, would not have been considered a resource a century ago but is most certainly thought of as such today. Petroleum was not an important resource 150 years ago but today is thought of as perhaps the most important resource to modern society. And if cold-fusion technology had panned out, coal would be another example of yesterday’s resource but tomorrow’s relatively useless rock.

Thus, the natural resource base is itself relative and its components vary greatly with time due to technology and material demand. The composition of the natural resource base of a century ago is substantially different from the natural resource base of today, not because of depletion but owing to advances in the economy, technology, and industrial society. There’s little reason to think that tomorrow’s resource needs will necessarily match those of today.

### **The Meaninglessness of Weak Sustainability**

What if we embrace the weak definition of sustainable development—allowing natural resources to be depleted as long as they are maintained at a “minimum critical level” and the proceeds of their use are preserved for future generations—rather than the clearly untenable strong definition? Weak sustainability is certainly a more reasonable proposition, but that’s largely because it is functionally indistinguishable from the economists’

mission of maximizing human welfare. As economist David Pearce, a strong proponent of weak sustainability, concedes:

[Sustainable development] implies something about maintaining the level of human well-being so that it might improve but at least never declines (or, not more than temporarily, anyway). Interpreted this way, sustainable development becomes equivalent to some requirement that well-being not decline through time.<sup>11</sup>

The two apparent qualifications of weak sustainability are really no qualifications at all. If, on the one hand, we understand “minimum critical level” as the natural resource base necessary to sustain human life, then one certainly doesn’t maximize human welfare by consuming resources beyond that point. As noted by scholars at the Australia-based Tasman Institute:

Stripped down to its essentials, efficiency means making the best use of resources, including natural resources, capital, labor, knowledge and inherited institutions and cultural values, to ensure that community well-being is maximized. Essential to this are energetic steps to reduce waste and to ensure that valued goods and services are provided with minimal cost. Environmental concerns are a vital part of the notion of economic efficiency and allocations of resources which do not take environmental concerns into account are unlikely to be efficient.<sup>12</sup>

If, on the other hand, we mean that each and every natural resource, regardless of its utility to mankind, should be preserved beyond some minimal critical level—for example, if we construe sustainable development to mean the maintenance of a set of resource “opportunities”<sup>13</sup>—then, without reference to costs and benefits, the concept is simply anti-

human and inimical to the interests of future generations.

As a thought experiment, assume that the only way we could have preserved the American bison beyond a minimum critical level was to leave the Great Plains largely untouched by agriculture. Would the sacrifice of what was to become the world's most productive cropland in order to protect the great buffalo herds have been in either the economic or social interest of future generations? A policy paradigm that refuses to consider the costs or benefits of such decisions is incapable of making a moral argument about the interests of future (human) generations. But to include cost and benefit calculations in such decisions brings us right back to the economic concept of "maximizing welfare."

The admonition that the proceeds of such tradeoffs be preserved for our children is superfluous. Since all wealth is eventually inherited by future generations, there would appear to be no rationale for a special state-supervised "account" to be established for their benefit.

### **The Incoherence of Intergenerational Equity**

Perhaps the strongest rationale for both strong and weak variations of sustainable development is, according to its proponents, the case for "intergenerational equity." Indeed, as economist Matthew Cole points out, "despite the countless definitions, a key characteristic of all versions of sustainable development is the principle of equity. Such a notion of equity includes not only providing for the needs of the least advantaged of today's society (intragenerational equity) but also extends to the needs of the next generation (intergenerational equity)."<sup>14</sup> One of the most articulate proponents of this argument is Georgetown University professor of international law Edith Weiss, who argues that future generations have as much right to today's environmental resources as we do, and that we have no right to decide whether or not they should inherit their share of those rights.<sup>15</sup>

Yet the concept of tangible rights to

resources for those not even conceived is dubious to say the least.<sup>16</sup> First, it is philosophically inconsistent. Those disincorporated beings not yet even a glimmer in someone's eye are said to have rights to oil, tin, copper, trees, or whatever but not, apparently, to life itself (unless, of course, Western societies decide to outlaw abortion). Moreover, once individuals are conceived, we do not maintain that they have a right to all the resources of the parent. If, for example, a retired couple spends \$50,000 on a trip around the world, we do not argue that the couple has violated the resource rights of their children. If intergenerational equity is to be taken seriously, then the claims one generation has on another should not be affected by the distance in time between the two.

The concept of intergenerational equity, moreover, is hopelessly inconsistent. If the choice to draw down resources is held exclusively by future generations, then are we not some previous generation's "future" generation? Why is the present generation bereft of that right? If the answer is that no generation has the right to deplete resources as long as another generation is on the horizon, then the logical implication of the argument is that no generation (save for the very last generation before the extinction of the species) will ever have a right to deplete any resource, no matter how urgent the needs of the present may be. If only *one* generation (out of hundreds or even thousands) has the right to deplete resources, how is that intergenerational equity?

Compounding that problem is the fact that future generations will almost certainly be far, far better off economically than present generations. If we were serious about equality between generations, then, we might take economist Steven Landsburg's advice and "allow the unemployed lumberjacks of Oregon to confiscate your rich grandchildren's view of the giant redwoods."<sup>17</sup>

The math is actually quite simple. If U.S. per capita income manages to grow in real terms by 2 percent a year (a conservative assumption), then in 400 years, the average American family of four will enjoy an income

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of \$2 million a day in 1997 dollars (roughly, Microsoft CEO Bill Gates's current income). If per capita income grew a bit faster—say, at the rate reported by South Korea over the past couple of decades—it would take only 100 years for an average family of four to earn \$2 million daily. “So each time the Sierra Club impedes economic development to preserve some specimen of natural beauty,” writes Landsburg, “it is asking people who live like you and me (the relatively poor) to sacrifice for the enjoyment of future generations that will live like Bill Gates.”<sup>18</sup>

Furthermore, the notion of resource rights for future generations is premised on the argument that one has a right to forcibly take property from someone else in order to satisfy a personal need. Although that is an argument best left unexplored here, suffice it to say that such a claim is expansive and fraught with moral peril.<sup>19</sup>

Finally, the belief that the interests of future generations are more likely to be protected by political than by market agents is dubious. Indeed, any clear-eyed survey of government versus market decisionmaking finds that market agents are far more likely to invest for the future than governmental agents.<sup>20</sup> As noted by economists Peter Hartley from Rice University and Andrew Chisolm and Michael Porter of the Tasman Institute:

Future generations do not take part in elections, but they are represented in the capital market. While many voters are concerned about future generations, democratically elected governments have a tendency to reflect the wishes of the marginal voter in the currently marginal electorate, so it is unreasonable to expect governments to be more conservation-minded than such a voter. Markets, on the other hand, can reflect more extreme views on the future value of a resource. Since the value of an asset hinges on expectations of what others may pay for

access in the future, speculators become the representatives of future generations in today's markets.<sup>21</sup>

Since advocates of sustainable development rely upon governmental action to ensure the success of their agenda, it is unlikely—no matter how well-intentioned their efforts or successful their political campaigns—that their goals will be realized through state intervention in the economy.

## **The Chimera of Resource Scarcity**

The call for sustainable development implicitly posits that robust stocks of natural resources are crucial to economic well-being and that current trends in resource consumption are somehow unsustainable.

As to the former claim, it may certainly be the case that resource sustainability is desirable for subjective cultural reasons, but natural resource scarcity is simply not a binding constraint on economic growth as is commonly asserted. Economist Joseph Stiglitz in a classic study found that exogenous technological advances lead to long-run gains in per capita consumption in less-developed countries under conditions of exponential population growth and limited, exhaustible stocks of natural resources.<sup>22</sup> Economist Edward Barbier found that even in a growing economy, technological change is resource augmenting.<sup>23</sup> As Barbier and colleague Thomas Homer-Dixon of the University of Toronto put it, “sufficient allocation of human capital to innovation will ensure that resource exhaustion can be postponed indefinitely, and the possibility exists of a long-run endogenous steady-state growth rate that allows per capita consumption to be sustained, and perhaps even increased, indefinitely.”<sup>24</sup>

Regardless, the data clearly show that most natural resources are becoming more—not less—abundant with time. In fact, a proper understanding of resource economics suggests that this trend will actually improve greatly over time and that resource depletion

is simply not a significant worry if the correct legal and economic policies are maintained. Accordingly, “sustainable development”—even if we put aside its theoretical difficulties—is a solution in search of a problem.

### Agricultural Sustainability

Let’s start by examining the data regarding the agricultural sustainability. Figure 1 reveals that, since 1950, food production has greatly outpaced population growth. Figure 2 illustrates the practical effects of figure 1—an overall decline in the price of food throughout the world. Figure 3 reveals that this growing abundance of food has led to a marked increase in daily per capita intake of calories in both rich and poor regions of the world. This massive increase in production came primarily from increased productivity, not from increased cultivation of lands. The amount of land devoted to agricultural purposes expanded by only about 9 percent from 1961 to 1999 while population doubled.<sup>25</sup> Paul Waggoner of the Connecticut Agricultural Experiment Station and Jesse Ausubel of Rockefeller University cal-

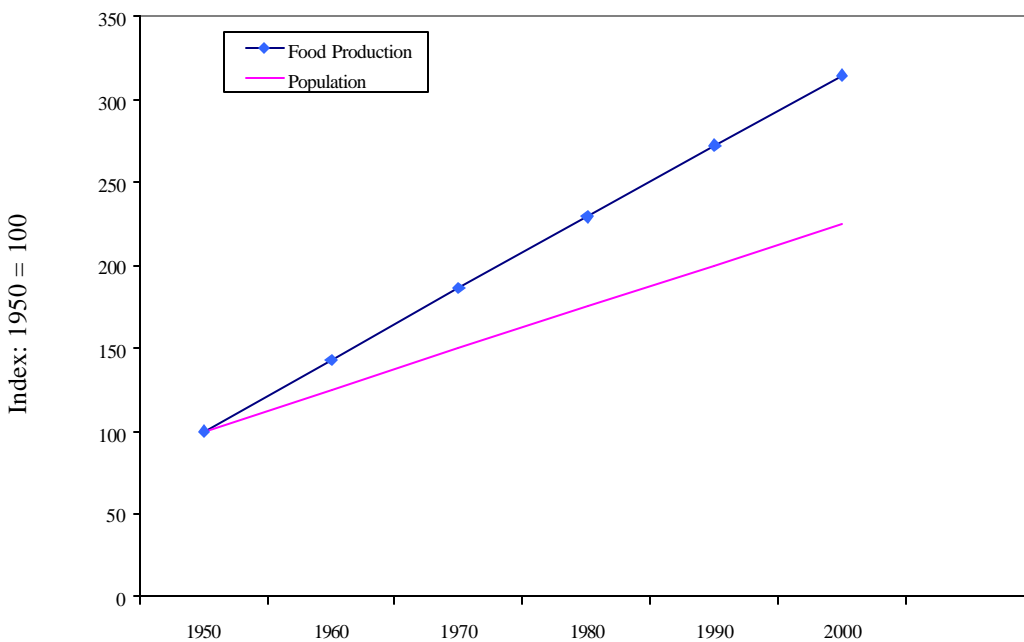
culate that, given likely trends, cropland will shrink globally by about 200 million hectares, or more than three times the land area of France, by 2050.<sup>26</sup> Ausubel believes that development will increase global forest cover by about 10 percent.<sup>27</sup>

The UN’s Food and Agriculture Organization reports that, as a consequence, the percentage of the population subject to famine and starvation declined from 35 percent in 1970 to 18 percent in 1997 and is expected to fall to 12 percent by 2010.<sup>28</sup> Likewise, the percentage of undernourished children in the developing world has fallen from 40 percent to 30 percent over the past 15 years and is expected to fall to 24 percent by 2020.<sup>29</sup> The continuing existence of large and growing farm subsidies in the developed world is testament to the fact that glut—not scarcity—is the prevailing problem in the agricultural sector.

The positive trend in food availability is unlikely to reverse itself for several reasons. First, there are tremendous unrealized opportunities to exponentially expand global food production simply through the applica-

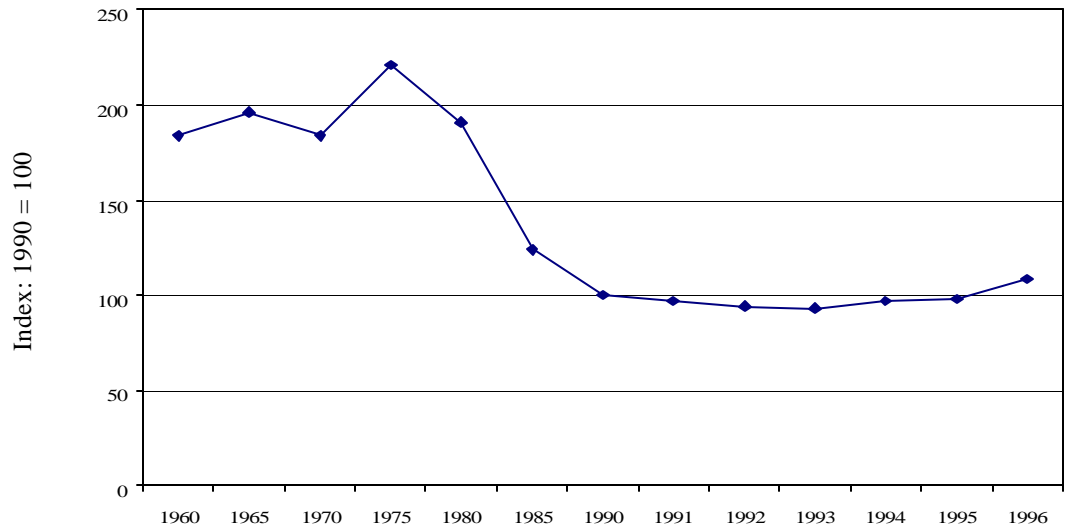
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**Figure 1**  
**World Food Production vs. World Population Growth**



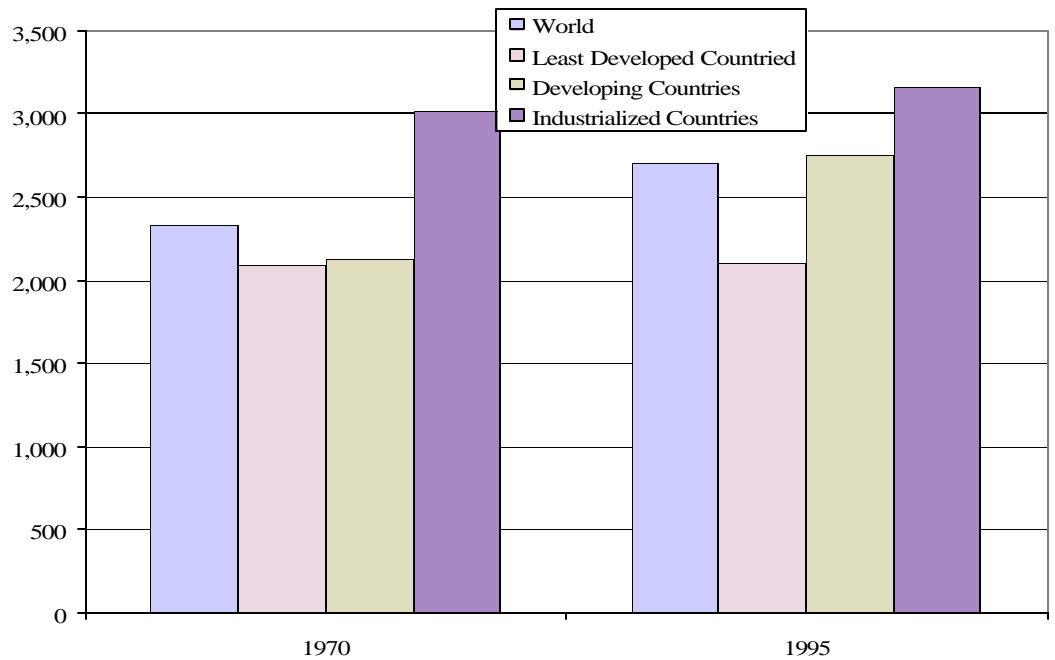
Source: UN Food and Agriculture Organization, data cited in “Loaves and Fishes,” *The Economist*, March 21, 1998.

**Figure 2**  
**Total Food Commodity Price Index, World**



Sources: World Resources Institute, UN Environmental Programme, UN Development Program, and World Bank, *World Resources 1998–1999: A Guide to the Global Environment* (New York: Oxford University Press, 1998), Table 6.3, as cited in Ronald Bailey, ed., *Earth Report 2000* (New York: McGraw-Hill, 2000), p. 265.

**Figure 3**  
**Daily per Capita Supply of Calories, 1970 and 1995**



Source: World Resources Institute, UN Environmental Programme, UN Development Programme, and World Bank, *World Resources 1998–1999: A Guide to the Global Environment* (New York: Oxford University Press, 1998), p. 161.



tion of existing Western technology and agricultural practices in less-developed countries.<sup>30</sup> Second, advances in nonexotic technology and information services are beginning to radically improve yields as they have in many other industries.<sup>31</sup> Third, agricultural science is progressing in record leaps and bounds, promising even greater expansions in agricultural productivity and nutritional improvements.<sup>32</sup> Fourth, economic growth produces greater food availability (largely by making more capital available for advanced agricultural practices), and few economists expect the global economy to stop growing in real terms in the future.<sup>33</sup> Finally, global population is now projected to level off at around 11 billion by the year 2200,<sup>34</sup> a figure well within the agricultural “carrying capacity” of the planet.<sup>35</sup>

### **Fishery Sustainability**

A perennial concern within the subset of issues pertaining to agricultural sustainability is the concern over the depletion of the world’s fisheries. As noted above, however, land-based crop and food production is more than capable of meeting future needs. This is particularly the case since fish consumption makes up less than 1 percent of total caloric intake and only 6 percent of protein intake across the global population.<sup>36</sup>

Regardless, there is little evidence for the oft-stated assertion that global fisheries are near collapse. Total catches have increased a bit more than fourfold since 1950 while total catches per capita have doubled over that same period (although they’ve held steady by that measure since about 1965).<sup>37</sup> While some commercially valuable species are in decline, high prices, consumer tastes, and public awareness campaigns have shifted consumption to less scarce species. So what is commercially valuable today is often not what is commercially valuable tomorrow and visa versa.

Still, there is legitimate concern over the depletion of some species and species subpopulations. Those problems stem from what ecologist Garrett Hardin famously termed “the tragedy of the commons.”<sup>38</sup> In short, since

everyone is free to harvest fish but no one owns the schools, individual fisherman maximize their revenue by increasing their harvest regardless of what other fishermen might do. Nobody has any incentive to efficiently manage fish populations. Governments are called in to do the job, but the proliferation of massive subsidies to the fishing industry in virtually all countries and excessively generous allotments for fish harvests demonstrate that well-organized special interests will almost always sacrifice the health of fisheries for the economic interests of the fishing industry.

Here, we confront for the first time in our discussion (but not for the last time) a major cause of “unsustainable” resource use—public ownership and extraction subsidies. The remedy can be found in simple economics—privatization of fishing rights. The most popular method of privatization involves state issuance of individual fishing quotas that could be traded in secondary markets. This approach, which has the support of both conservationists and economists, has proven successful in Iceland and elsewhere at stabilizing fish populations while protecting the economic health of the fishing industry.<sup>39</sup>

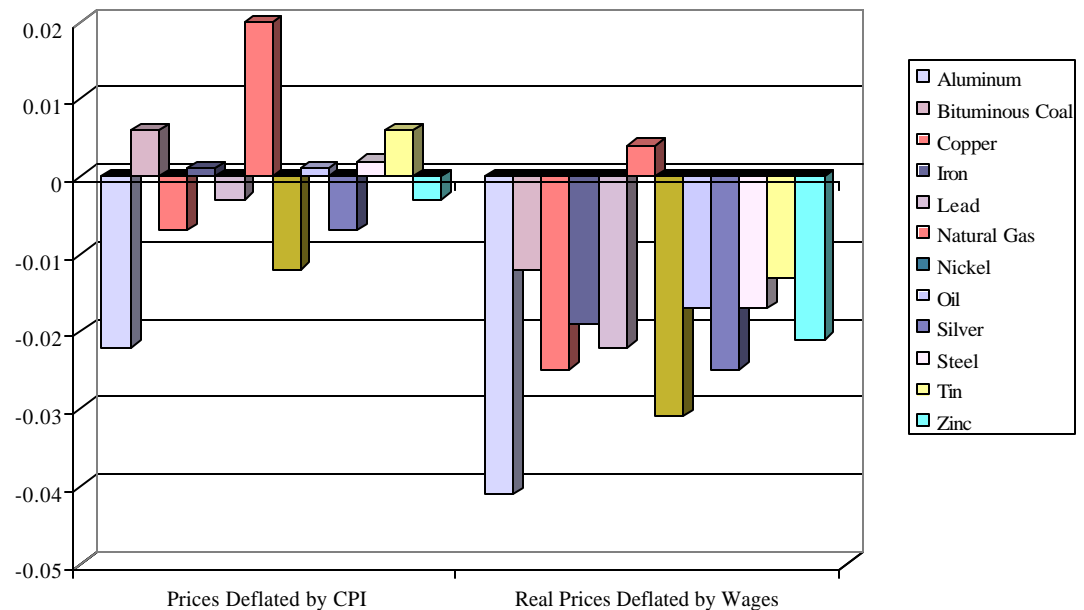
Another method is the emerging practice of “fish farming,” which not only helps to provide resources at minimal ecological cost but also serves to take the pressure off wild fish stocks.<sup>40</sup> Production from such farms has increased fivefold since 1984—now constituting about 25 percent of total catches<sup>41</sup>—and will continue to grow in the future.<sup>42</sup> The production from such farms could grow even more dramatically with the introduction of fertilizers. Oceanographers estimate that 60 percent of ocean life grows in but 2 percent of the ocean’s surface. The limiting factor is primarily the lack of nutrients necessary to sustain phytoplankton. Adding those nutrients—which is conceptually no more difficult than land-based fertilization techniques—could increase fish yields by a factor of hundreds.<sup>43</sup>

### **Mineral Sustainability**

Next, let’s consider trends in the availability of commercially important metals, fuels,

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**Figure 4**  
**Estimated Annual Trends in Mineral and Metal Prices, 1870–1998 (all commodities indexed to 1990 = 100)**



Source: Stephen Brown and Daniel Wolk, “Natural Resource Scarcity and Technological Change,” *Economic & Financial Review*, Federal Reserve Bank of Dallas, Q1, 2000, p. 7.

**Whether you measure the availability of various mineral resources by inflation-adjusted prices or by the amount of effort necessary to produce a unit of consumption, mineral resources are becoming more abundant.**

and minerals. Figure 4 demonstrates that, whether you measure the availability of various mineral resources by inflation-adjusted prices or by the amount of effort necessary to produce a unit of consumption,<sup>44</sup> mineral resources are likewise becoming more abundant—not more scarce—and are on a clearly economically sustainable path.

Perhaps the most provocative suggestion from Figure 4 is that petroleum is becoming more abundant, not more scarce as is popularly believed.<sup>45</sup> This is true even if we examine indicators other than price.<sup>46</sup> The best indicators are development costs and values in-ground. The average cost of finding oil fell from \$12 per barrel in 1980 to just \$7 per barrel in 1998 despite 40 percent inflation in the interim.<sup>47</sup> While data on petroleum asset values are hard to come by, what is known suggests that those asset values are not trending upwards.<sup>48</sup>

Secondary indicators are less useful but likewise reveal positive trends. Proven reserves of petroleum, for instance, are 15 times larger

today than when record keeping began in 1948 and about 40 percent larger than in 1974.<sup>49</sup> Moreover, the amount of those reserves that we use in any given year has remained steady at 2–3 percent since 1950.<sup>50</sup> How much oil can we potentially move from the “unproven” to the “proven” category? One prominent study estimates that 6 trillion barrels of recoverable conventional oil exist today (a reserve of approximately 231 years given present consumption) and another 15 trillion of unconventional oil—such as tar sands, oil shale, and orimulsion) are recoverable (808 years at present levels of consumption) given favorable economics.<sup>51</sup> The argument that we’re running out of new fields to discover and that production will accordingly peak in the near future (the so-called Hubbert’s Curve hypothesis) ignores the potential for unconventional fossil fuel and grossly underestimates the availability of oil in existing fields given technological advance and adequate pricing signals.<sup>52</sup>

Concerns over the finite nature of mineral resources are ill-considered because such con-

cerns ignore the ongoing process of resource creation. As economists Harold Barnett and Chandler Morse explained in their classic work *Scarcity and Growth*, as resources become more scarce, people will anticipate future scarcities, prices will be bid up, incentives will be created for developing new technologies and substitutes, and the resource base will be renewed. Indeed, Barnett and Morse's ideas are now widely accepted in the world of resource economics and are not even particularly controversial among those who specialize in that field within academia.<sup>53</sup>

Is Barnett and Morse's optimism regarding "just in time" delivery of new technologies and resources justified? Well, historical experience—as noted above—would certainly seem to justify their optimism.

Those who find Barnett and Morse's theory impossibly counterintuitive betray a fundamental misunderstanding of the genesis of resources. Natural resources do not exist independent of man and are not materials we simply find and then exploit like buried treasure. Natural resources, on the contrary, are created by mankind. As resource economist Thomas DeGregori points out, "Humans are the active agent, having ideas that they use to transform the environment for human purposes. . . . Resources are not fixed and finite because they are not natural. They are a product of human ingenuity resulting from the creation of technology and science."<sup>54</sup> Political scientist David Osterfeld thus concludes, "since resources are a function of human knowledge and our stock of knowledge has increased over time, it should come as no surprise that the stock of physical resources has also been expanding."<sup>55</sup>

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### **Forest Sustainability**

Next, let's consider the sustainability of various forests, another perennial environmental concern. The longest data series available reveals that global forest cover increased

from 30.04 percent of the planet's surface area in 1950 to 30.89 percent of the planet's surface area in 1994.<sup>56</sup> Moreover, most of the computer models that examine future resource trends predict a constant to slightly increasing rate of forest expansion through 2100.<sup>57</sup> Some of the main reasons for this trend include the emergence of substitutes for timber,<sup>58</sup> increasing reliance on plantation forests for timber, and more efficient logging practices in general.<sup>59</sup> Those trends will likely accelerate in the future, returning a tremendous amount of today's forests harvested for human use back to nature.<sup>60</sup>

Conservationists argue, however, that positive macro-trends in forestland health hide significant micro-problems. But those alleged micro-problems are generally overstated. For instance, it has been alleged that we're sacrificing "original forest cover" for "secondary forest cover" and that these secondary-growth forests are poorer ecologically. But the planet has only lost about 20 percent of its original forest cover since the dawn of agriculture.<sup>61</sup> Moreover, secondary forests are not necessarily ecologically "poorer" than old growth forests.<sup>62</sup>

Another concern is that, while temperature forests are expanding,<sup>63</sup> tropical rainforests are disappearing, so while the overall trends for global forest cover might be slightly positive, they mask the decline of the more ecologically important rainforests. But tropical rainforest deforestation is proceeding at but 0.3 percent a year, a not particularly alarming sum,<sup>64</sup> and only 20 percent of the planet's original tropical rainforest cover (compared to about 50 percent of the forest cover in the developed world)<sup>65</sup> has been effected by man.<sup>66</sup>

Academics who've examined the data conclude that deforestation—where it indeed exists—is less a problem of global demand for timber and croplands outstripping supply than it is a problem of politics. First, the lack of private property rights to forest resources correlates strongly with deforestation problems, suggesting that deforestation is a result of political mismanagement of economic

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**Alarming figures pertaining to species extinctions are based not on observation but on extrapolation from a host of assumptions.**

resources (an old story that could be told about any number of industries in any number of socialist states).<sup>67</sup> Second, deforestation correlates strongly with poverty.<sup>68</sup> Economists have discovered, for instance, that once per capita incomes exceeded \$4,760 in Africa and \$5,420 in Latin America, deforestation rates actually moderated slightly.<sup>69</sup>

That's largely because the main driver for deforestation in the developing world is the need for more agricultural land—land that wouldn't be necessary if modern agricultural practices were available to increase yields from existing agricultural lands.<sup>70</sup> Yet modern agricultural practices require capital inputs that are often beyond the means of poor economies.<sup>71</sup>

Another way poverty contributes to deforestation is the demand for wood fuel that results from the lack of an electricity grid.<sup>72</sup> In West Africa, for instance, 80 percent of domestic energy consumption is met by wood fuel. In sub-Saharan Africa, wood fuel accounts for 63.5 percent of total energy use.<sup>73</sup>

Poverty in the developing world, however, is a legacy of the lack of property rights, the absence of the rule of law, and counterproductive state interventions in the economy.<sup>74</sup>

### **Species Sustainability**

One of the oft-heard alarm bells rung by conservationists is the assertion that the world is in the midst of a biodiversity crisis. Mass extinctions, it is charged, are decimating flora and fauna populations with dangerous implications for ecosystem health throughout the world. It's worth bearing in mind, however, that even if we accept the alarms about current extinction rates, the number of species living on the planet today is far, far greater than at any other period in earth's history, and even the most dramatic projections of species lost will not bring species diversity below the earth's historic norm.<sup>75</sup>

Alarming figures pertaining to species extinctions, however, are based not on observation but on extrapolation from a host of assumptions. The standard method employed is to first guess the absolute num-

ber of species on earth (many of which are yet to be discovered). Biologists then calculate how much habitat from various ecosystems is disappearing a year. From there, biologists calculate how many species thought to live in those habitats go extinct from such habitat losses. The speculative nature of those calculations is illustrated by the fact that only 1,000 identifiable species since 1600 A.D. are known to have gone extinct, which works out to about 2-3 extinctions a year.<sup>76</sup> The above extrapolations, however, suggest that from 17,000 to 100,000 species are going extinct every year.<sup>77</sup>

The assumptions upon which those extrapolations are based, however, are highly uncertain. For instance, biologists have identified 1.6 million species to date, and they are fairly confident that they've accounted for virtually all of the birds and mammals in existence.<sup>78</sup> The great unknown is the number of unidentified insects, fungi, bacteria, and viruses yet to be catalogued. Estimates of the ultimate size of the species pool, therefore, range from 3 million to 100 million,<sup>79</sup> although evidence suggests that the lower-bound estimates are more likely to be correct.<sup>80</sup> The larger the size of the species pool, the greater the number of calculated extinctions, but most of those extinctions will necessarily be among insect, fungi, bacteria, and viruses.

Habitat loss is more easily quantifiable, but even so, the more alarmist projections of extinction rates greatly overestimate losses and deforestation trends.<sup>81</sup> More to the point, however, the alleged relationship between habitat loss and species extinction, which appears intuitive at first glance, does not withstand scrutiny. For instance, biodiversity in Puerto Rico is the clearest and best investigated test case of the habitat-loss-equals-species-extinction model. Fully 99 percent of the primary forests there have been wiped out by human development over the past 400 years, but only 7 of the original 60 species of birds living in those forests have disappeared, while the overall number of avian species in Puerto Rico actually increased over that same period of time.<sup>82</sup> Similarly, primary eastern forestland in the United States lost 98-99 per-

cent of its original coverage in the period since the arrival of European colonialists, but only one species extinction resulted.<sup>83</sup>

Clearly, the most crucial linchpins of the biologists' model of extinction dynamics are seriously flawed. At best, the alarmist projections of species loss are hypotheses still waiting for proof.<sup>84</sup> At worst, they are classic cases of junk science. The best review of the data, undertaken by the International Union for Conservation of Nature and Natural Resources, finds that "actual extinctions remain low" and that close examination of known facts do not back up alarmist claims.<sup>85</sup>

In addition, there is growing doubt within the ecological community whether ecosystems are naturally stable at all.<sup>86</sup> This has important implications. For instance, if ecosystems do not tend toward stabilization, then policies that are intended to promote species preservation through sustainable ecosystems are unnatural and without ecological merit. Furthermore, if ecosystems are not functionally and structurally complete, then "sustainable management" of those stocks will prove suboptimal. Finally, if ecosystems do not tend toward stability, then calculations about the economic or ecological value of natural capital are impossible on a macro level.

Accordingly, conclusions about whether or not certain economic activities are sustainable are more problematic than some would like to think. As economists Robert Costanza of the University of Maryland and Bernard Patten of the University of Georgia concede:

A system can only be known to be sustainable after there has been time to observe if the prediction holds true. Usually there is so much uncertainty in estimating natural rates of renewal, and observing and regulating harvest rates, that a simple prediction at this as Ludwig et al. ("Uncertainty, Resource Exploitation, and Conservation: Lessons from History," *Science*, 260: 17, 36) correctly observe, is always highly suspect, especially if it is erroneously thought of as a definition.<sup>87</sup>

A second implication is that preserving certain ecological states indefinitely is less a matter of ecological necessity than social preference. Geographer M. J. Harte of the University of Waikato, New Zealand, pointedly notes:

Discussions of natural capital must have an anthropocentric component which incorporates human preferences for various ecosystem states. Without this anthropocentric dimension, economists cannot claim that any one ecological state is superior to another because their recommendations are not clearly supported by ecological theory and practice. . . . It is therefore possible to suggest that collective social preferences regarding desirable system attributes and their contribution to human well-being should be given a weighting at least comparable to environmental constraints when describing the ecological-economic dimensions of development.<sup>88</sup>

### **Freshwater Sustainability**

While it's certainly true that some regions of the globe suffer more from water scarcities than others, from a global perspective the supply of freshwater is more than adequate. Only 17 percent of the accessible water available annually from precipitation is withdrawn for extended periods of time for human use and that figure is expected to rise only to 22 percent in 2025.<sup>89</sup> Moreover, desalination technologies, which convert salt water to freshwater, are increasingly affordable and employed throughout the world,<sup>90</sup> ensuring that freshwater resources are indefinitely sustainable.<sup>91</sup>

According to calculations by the World Bank and the World Resources Institute, only 15 countries, containing 3.7 percent of the world's population in 2000 (Algeria, Burundi, Egypt, Israel, Jordan, Kenya, Kuwait, Libya, Oman, Rwanda, Saudi Arabia,

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Singapore, Tunisia, United Arab Emirates, and Yemen) suffered from “chronic water scarcity,” which is defined as lacking the amount of freshwater necessary (2,740 liters of water per person per day) for routine household needs, agriculture, modern industry, and energy production.<sup>92</sup> Even this modest calculation, however, ignores the freshwater delivered through desalination plants (a major source of freshwater for many of those countries) and assumes water needs that are inflated by gross—but unfortunately, common—inefficiencies.<sup>93</sup>

If all this water is available, then why do we experience occasional water shortages? First, many parts of the developing world lack the infrastructure necessary to deliver freshwater resources to users, resulting in unsafe drinking water and poor sanitation. Still, trends are positive. The proportion of people in developing countries with access to safe drinking water increased from 30 percent in 1970 to 80 percent in 2000 while access to sanitation increased from 23 percent in 1970 to 53 percent in 2000.<sup>94</sup> Providing universal access to water in the developing world would cost approximately \$200 billion, suggesting that the problem will soon disappear given even modest economic growth.<sup>95</sup>

Second, governments in both developed and developing nations heavily subsidize water services, promoting excessive consumption and waste.<sup>96</sup> Most countries, for instance, apply flat annual fees for access to irrigation services (which account for 90 percent of water use in the developing world but just 37 percent in developed countries)<sup>97</sup> and don’t charge according to the amount of water consumed.<sup>98</sup> Given such subsidies, it shouldn’t surprise that most irrigation systems waste significant amounts of water through poor maintenance and inefficient application practices.<sup>99</sup>

Municipal water prices are also heavily subsidized. Households in the developing world pay only 35 percent of the actual price of water services on average,<sup>100</sup> while subsidies in the developed world are smaller but not insignificant.<sup>101</sup> Where subsidies for

water services have been eliminated, greater efficiency and conservation have resulted.<sup>102</sup>

Freshwater supplies, in sum, are plentiful and not in danger of running out. What prevents them from reaching users is extreme poverty, poorly designed markets, and counterproductive subsidies.<sup>103</sup>

## **The Sustainability of Pollution**

Another set of resources that environmentalists worry about sustaining is the various local air, water, and land-based “pollution sinks” across the planet. The ability of the planet to assimilate industrial waste products is largely predicated upon the “carrying capacity” of those pollution sinks. Modern environmentalism is if anything more concerned today with the sustainability of natural environmental waste disposal services than it is with the hard environmental resource inputs that once occupied the attention of the conservation movement.<sup>104</sup>

### **Air Shed Sustainability**

Will the carrying capacity of local air sheds be great enough to assimilate industrial pollutants given current trends without endangering human health and the environment? In the developed world, the data unequivocally demonstrate that the answer is “yes.” Consider the pollutants identified by the U.S. Environmental Protection Agency as most worrisome from a human health perspective: particulate matter (smoke, soot, and fine particles in the air), sulfur dioxide, ozone (smog), lead, nitrogen oxides, and carbon monoxide. The concentration of all these contaminants in the air over developed nations has for the most part been trending dramatically downward for as long as data have been available.

Unfortunately, data regarding the concentration of air pollutants are limited. The best data set available pertains to the United States.

- Concentrations of particulate matter decreased by between 40 and 50 per-

cent in 1957–1997, the most recent year for which data are available<sup>105</sup>

- Concentrations of PM-10 (particulate matter less than 10 micrometers in size, which is now thought to be more harmful than larger particulate matter) declined by 25 percent from 1988 to 1997, the most recent year for which data are available.<sup>106</sup>
- Concentrations of lead increased from 1965 to 1971 but plummeted by 95 percent from 1974 to 1997.<sup>107</sup>
- Concentrations of sulfur dioxide fell almost fivefold between 1962 (when data first became available) and 1997, the most recent year for which data are available.<sup>108</sup> The most robust part of that data set, running from 1974 to 1997, reveals a 60 percent decline in sulfur dioxide concentrations over that period.<sup>109</sup>
- Concentrations of ozone (popularly known as summertime smog) are hard to come by because they are measured indirectly. The reigning metric is the concentration of ozone during the second-highest one-hour reading of the year above a given locale.<sup>110</sup> By this imperfect measure, the severity of ozone concentrations declined by 30 percent from 1974 to 1997, the most recent year for which data are available.<sup>111</sup> The number of days in which the second-highest one-hour reading exceeds federal air quality standards declined by about 50 percent nationwide from 1989 to 2000.<sup>112</sup>
- Concentrations of carbon monoxide declined by 75 percent between 1970 and 1997, the most recent date for reasonably comprehensive data.<sup>113</sup> Half of that decline, interestingly enough, occurred within the past 10 years.<sup>114</sup>
- Concentrations of nitrogen oxides declined by about 20 percent from 1974 to 1997, the most recent year for which data are available.<sup>115</sup>
- Concentrations of various other toxic air pollutants are poorly and incompletely monitored, but for every moni-

toring station showing a statistically significant increase in concentrations, more than six monitoring stations show a statistically significant decline in concentrations.<sup>116</sup>

The economic costs imposed by air pollution in the United States from 1977 to 1999 dropped almost two-thirds from \$3,600 per person per year to \$1,300 per person per year.<sup>117</sup>

Empirical examination of the data demonstrates a clear relationship between per capita income growth in the United States and absolute reduction of air emissions.<sup>118</sup> Data from Europe are far more fragmentary but consistent with trends in the United States.<sup>119</sup> Clearly, when economic growth reaches a certain level, air pollution begins to fall rapidly.

Data from the developing world suggest that this same dynamic is already at work. Numerous economists have studied the relationship between economic growth, population, and industrialization, on the one hand, and environmental quality, on the other (known in the economics community as Environmental Kuznets Curves, or EKC<sup>s</sup>)<sup>120</sup> and found that, beyond a certain point, economic development does indeed reduce air pollution burdens.

- Ambient concentrations of sulfur dioxides were found to decline when per capita incomes reach between \$3,670 and \$8,916.<sup>121</sup>
- Ambient concentrations of particulate matter were found to decline when per capita incomes reach between \$3,280 to \$7,300.<sup>122</sup>
- Ambient concentrations of nitrogen oxides were found to decline once per capita incomes reach between \$12,041 and \$14,700.<sup>123</sup>
- Ambient concentrations of carbon monoxide were found to decline when per capita incomes reach between \$6,241 and \$9,900.<sup>124</sup>
- A survey of “megacity” air quality data gathered by the Global Environmental

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Monitoring System of the World Health Organization shows that pollution concentrations stabilize after cities reach a moderate level of development, and air quality then improves as cities become more wealthy.<sup>125</sup>

- Data compiled by the World Bank demonstrate an unmistakable correlation between per capita income and access to safe drinking water and sanitation as well as declining urban concentrations of particulate matter and sulfur dioxide.<sup>126</sup> “Poverty and environmental degradation go hand in hand. . . . Economic development, on the other hand, provides the financial and technical resources needed for the protection of human health and natural ecosystems.”<sup>127</sup>

There are competing explanations for why local air quality improves when per capita income reaches a certain point. Economic growth may increase the demand for environmental quality, which is in many respects a luxury good.<sup>128</sup> The increased demand for environmental quality manifests itself not only in the marketplace (by increased demand for low-polluting technologies and various environmental goods and services) but also in political demands for more aggressive pollution controls.<sup>129</sup> Advanced economies also rely less on heavy manufacturing and more on service industries, which reduces national emissions.<sup>130</sup> Moreover, the manufacturing sector in advanced economies is far more efficient—and thus, less pollution intensive—than in less-developed economies.<sup>131</sup> Advanced economies are also generally characterized by more vigorous enforcement of property rights, contracts, and the rule of law, which may play a significant role in pollution control.<sup>132</sup> Controlling for each of these variables in an attempt to explain the correlation between rising per capita income and declining pollution levels is obviously difficult.

The relationship between growth in per capita income and improvements in local air quality is now widely accepted within academia.<sup>133</sup> Fortunately, per capita income has

grown dramatically in the developing world since 1972—by 13 percent in Africa, 72 percent in Asia and the Pacific, and 35 percent in Latin American and the Caribbean. Only West Asia experienced a decline (6 percent) over that period.<sup>134</sup> Unfortunately, many nations are still for the time being on the “wrong” side of the curve. That is, air pollution may well get temporarily worse with economic growth before it gets better.<sup>135</sup> EKC’s, however, demonstrate that air quality is sustainable in the face of future economic growth.

### **Watershed Sustainability**

Data pertaining to water quality are unfortunately far less comprehensive and robust than data pertaining to air quality. Still, the fragmentary data we have point in a positive direction.

Information on coastal water pollution is quite spotty for each of the three items tracked by scientists: fecal bacteria, dissolved oxygen levels, and toxic contaminants. Since it’s difficult to monitor for the presence of all the possible pathogens and substances of concern, the indicator most commonly used to measure coastal pollution is fecal bacteria.<sup>136</sup> Within the European Union, 21 percent of all beaches were polluted by high levels of fecal bacteria in 1992. By 1999, only 5 percent of EU beaches were so polluted.<sup>137</sup> Similar data are not available for the United States because each local community maintains its own monitoring standards and results are not comparable between communities.<sup>138</sup> Data for the developing world are generally unavailable.

Oxygen depletion is the second problem of concern in coastal waterways.<sup>139</sup> Oxygen depletion, however, has not reduced fish or shrimp catches—it may actually have increased certain fishery stocks—and has had no discernible effect on total coastal biomass.<sup>140</sup>

Moreover, the use of nitrogen-based fertilizers—which significantly contribute to oxygen depletion—has declined in absolute terms in the United States since 1980. Similarly, nitrate concentrations in the northeast Atlantic and Baltic have declined by 25 percent since 1985.<sup>141</sup> Global nitrogen use peaked in 1988 while total



world fertilizer use (which includes phosphates and potash) is 10 percent below the peak reached a decade ago.<sup>142</sup>

Toxic substances are the third contaminants of concern in coastal water bodies.<sup>143</sup> Data from the United States show that toxic metals in coastal fish and shellfish declined dramatically from 1986 to 1995.<sup>144</sup> The only European equivalent to that database measures the concentration of DDT and PCBs in cod. It likewise reveals a massive reduction in concentrations from 1973 to 1992.<sup>145</sup> Data for the developing world are again unavailable.

Somewhat better data are available for freshwater resources, which look very much like the data we examined for air quality. Again, three issues are of primary concern: fecal bacteria, dissolved oxygen levels, and toxic contaminants.

The World Bank examined trends in fecal bacteria concentrations in 52 rivers in 25 countries and found that when per capita incomes reaches about \$1,375, water quality begins to improve. Yet, after per capita incomes reach \$11,500, water quality begins to deteriorate again.<sup>146</sup> Bjorn Lomborg concludes, "The explanation seems to be that we see a general downwards trend in fecal pollution *so long as people are dependent on river water*. However, when countries get rich enough they use groundwater to a much greater extent, which diminishes the urgency and political inclination to push for even lower fecal pollution standards."<sup>147</sup> Even so, the U.S. Geological Survey finds no worsening of U.S. waters as far as fecal contamination is concerned.<sup>148</sup> Moreover, Princeton economists Gene Grossman and Alan Kreuger find that the concentration of fecal coliform bacteria in rivers begins to decline when per capita income reaches \$7,955 (in 1985 dollars).<sup>149</sup>

Levels of dissolved oxygen, however, are considered the most important indicator of water quality.<sup>150</sup> Major rivers in the developed world, such as the Thames and the Rhine, and New York City's harbor have shown rapid increases in dissolved oxygen content over the past 50 years, rendering them fishable and swimmable again and home to an

exploding population of flora and fauna.<sup>151</sup> The European Environment Agency found deterioration in 23 percent of rivers surveyed but improvement for 73 percent of those surveyed.<sup>152</sup> The U.S. Environmental Protection Agency likewise reports that the number of rivers and lakes deemed "fishable and swimmable" has doubled since 1972.<sup>153</sup> Investments in expensive wastewater treatment facilities are the primary factor contributing to improvement.<sup>154</sup> Economists Grossman and Kreuger find that oxygen levels begin to increase in bodies of water when per capita income meets a certain threshold, suggesting that—here again—EKC can be found.<sup>155</sup>

Toxic contaminants in rivers and lakes are also trending downward in the developed world, but data are generally unavailable for the developing world. In the United States, for instance, the number of fish in the Great Lakes contaminated by various toxic substances has declined about fivefold.<sup>156</sup> And although the data are mixed, Grossman and Kreuger again find that trends in toxic water pollution in the developing world conform to the EKC hypothesis.<sup>157</sup>

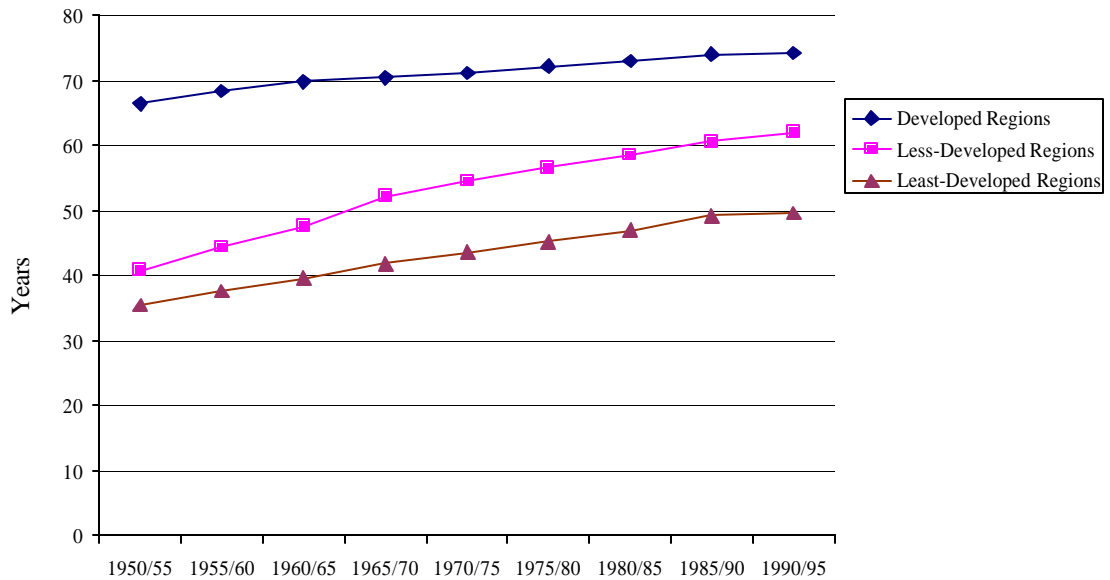
Although the data are incomplete, positive trends in water quality in the developed world, as well as the correlation between per capita income and water pollution, suggest that freshwater quality is sustainable in the face of economic growth. The main cause of water pollution, after all, is insufficiently treated sewage effluent. This is a problem almost completely remediable given sufficient capital investments, but those investments will increase only with improvements in economic growth in the developing world.<sup>158</sup>

### **Human Health Sustainability**

The best measure of whether pollution is or is not sustainable from a human health perspective is trends in life expectancy. If pollution were posing a greater and greater threat to human health, we would expect to find data evidencing increases in early mortality, disease burdens, and the like, particularly when examining populations in those areas where pollution is on the rise. But given

**The main cause of water pollution is insufficiently treated sewage effluent. This is a problem almost completely remediable given sufficient capital investments, but those investments will increase only with improvements in economic growth in the developing world.**

**Figure 5**  
**Estimated Life Expectancy at Birth, 1955–95**



Source: UN Population Division, *World Population Prospects: The 1996 Revision (draft)*, 1997.

**The data clearly demonstrate that human health continues to improve with time, suggesting a sustainable present and future.**

that pollution burdens in most of the world are generally declining, not rising, and given that per capita income in most countries is increasing, not decreasing, it should not surprise us that life expectancy is going up, as illustrated in Figure 5. A child born today can expect to live eight years longer than one born 30 years ago.<sup>159</sup>

If sustainable development pertains largely to the material well-being of both present and future generations, it's hard to identify a better index of material well-being than the index illustrated in Figure 5. In short, the data clearly demonstrate that human health continues to improve with time, suggesting a sustainable present and future.

### **The Sustainability of Urbanization**

There is also general concern about whether the developing world can sustain “megacities” given the widespread belief that human health and the environment are natural resource casualties of rapid Third World urbanization. Although it's certainly true that governmental interventions in the less-developed countries

often indirectly foster the growth of megacities at the expense of the agricultural economy and the efficiency of the economy as a whole,<sup>160</sup> megacities are, as a general matter, an important component of economic growth, particularly in the less-developed world.<sup>161</sup> Their emergence is a sign not of demographic disaster but of economic development.<sup>162</sup> Urban growth is so important to the developing world that scholars believe restricting urbanization to combat pollution will do more economic harm than good.<sup>163</sup> Moreover, there is good reason to believe that restricting city size would actually increase overall national pollution rates by fostering resource-costly inefficiencies and increasing overall transportation costs and attendant fuel-based emissions.<sup>164</sup>

Fortunately, such hard choices are probably unnecessary. Extensive analysis of the data by Vibhooti Shukla at the University of Texas and Kirit Parikh of the Indira Gandhi Institute of Development Research shows that “the positive association between poor air quality and city size is not inevitable and tends to diminish with economic growth and

the capacity for undertaking pollution abatement measures. It follows that restricting urban growth in developing countries may be neither necessary nor sufficient for achieving environmental gains.<sup>165</sup> Moreover, another Environmental Kuznets Curve can be found at work in the population data: ambient concentrations of sulfur dioxide, particulate matter, and smoke increase in cities until population reaches 4–6 million, upon which those concentrations tend to decline as population grows further.<sup>166</sup> Shukla and Parikh ask:

Is there, then, a compelling argument for pollution control through city size restriction in developing countries? Our characterization of the international development experience, which indicates that pollution has fallen without regard to city size, but rather in conjunction with high incomes, suggests not. This is not to minimize the gravity of the pollution problem facing cities of developing countries, but to question the sagacity of policies that would seek to “solve” it without appreciation of the large implicit costs involved in this particular choice of instrument. For, as we have seen, curbing urban growth is fraught with productivity losses, which are higher both in magnitude and relative importance in the LDCs. On the other hand, facilitating higher urban incomes is likely to result in spontaneous dispersal, a stronger public “demand” for abatement and greater societal wherewithal to undertake it as a matter of policy. Nor is it necessarily true that restricting city size would, by itself, guarantee lower pollution levels.<sup>167</sup>

### “Leapfrogging” the Industrial Revolution?

A standard prescription for minimizing environmental damages in the developing world is for preindustrial economies to

“leapfrog” the industrial revolution altogether. Since businesses now have access to advanced pollution control technologies to minimize emissions at their source—technologies not available to the West when it industrialized more than a century ago—why shouldn’t less-developed economies skip the old industrial stage of development altogether and move directly into a 21st-century economy? The Worldwatch Institute’s Megan Ryan and Christopher Flavin, for instance, believe that “China has three energy paths open to it: copy the worst of the West (the nineteenth century coal path), copy the best of the West (an oil-based system similar to the U.S. or German ones), or leap past the West, directly to an efficient, decentralized, twenty-first century system. The third path would involve a portfolio of new energy sources and technologies, including natural gas, solar energy, wind power, and improved energy efficiency.”<sup>168</sup>

To some extent, of course, leapfrogging is exactly what is happening in various industrial sectors today. China’s rapid adoption of cellular phones in lieu of a traditional wire-based telephone system is but one example of this phenomenon.<sup>169</sup> India’s rapid advance in computer software programming is another.<sup>170</sup>

Still, to continue with Ryan and Flavin’s argument, China’s living standard is so low compared to the West that some industrial growth is not only inevitable but also vitally necessary for simple human comfort. For example, the typical Chinese household uses only 0.03 percent of the energy consumed by the typical American household, a shortfall largely owing to a lack of even the most basic modern household appliances.<sup>171</sup> No matter how energy efficient new appliances might prove, per capita energy consumption is bound to rise dramatically along with demand for electricity. An industrial “energy revolution” will be required irrespective of advanced technology.<sup>172</sup>

The decision whether to embrace advanced technological practices or industries, however, must be made by market agents, not government planners. When it makes economic sense

**The decision whether to embrace advanced technological practices or industries must be made by market agents, not government planners. When it makes economic sense to do so, the private sector will adopt leapfrog technologies without government encouragement.**

**In general the argument that global climate change will significantly reduce the availability of resources is spurious.**

to do so, the private sector will adopt leapfrog technologies without government encouragement. It is important to remember that prices largely reflect relative scarcity. If the price of solar-powered electricity, for example, is greater than the price of coal-fired electricity, it means that greater resources are necessary to deliver solar power than coal-fired power.<sup>173</sup>

Unfortunately, many of the enthusiasms of the environmental community—such as renewable energy—are far more expensive than conventional alternatives, the main reason why the West has yet to widely adopt them.<sup>174</sup> Not only could China scarcely afford to embrace what Western economies find prohibitively expensive, but to do so would deplete the very resource base sustainable development is supposed to protect.

A few opportunities to leapfrog old technologies indeed exist. Most cars sold in China, for instance, lack even the most basic emission controls and continue to rely on leaded fuel. Although Beijing has only one-eighth the number of cars on the street as does Tokyo, the two auto fleets emit the same amount of carbon monoxide.<sup>175</sup> The undoubted increase in auto prices that would result from banning leaded gasoline and requiring basic tailpipe pollution controls would help achieve an internalization of the costs of auto emission (the legitimate goal of making the polluter pay for his or her pollution), achieving a relatively large amount of pollution reduction for a minimum public cost.

### **The Sustainability of Atmospheric Temperature and Climate**

A review of the literature pertaining to sustainable development finds that, for many analysts, the ultimate threat to the sustainability of the planet is the advent of global warming. Unfortunately, space does not permit a thorough review of the debate regarding the scientific case (or lack thereof) for alarm.<sup>176</sup> In general, however, the argument that global climate change will significantly reduce the availability of resources is spurious.

First, it's not entirely clear that global warming will prove to be the major event

advertised in the media. In short, the amount of warming over the past 100 years has been moderate (about a degree Fahrenheit) and far less than the computer models suggest should have occurred by now.<sup>177</sup> Since all the computer models rightly predict that warming will occur in a linear fashion (a phenomenon that conforms to atmospheric physics), we can reasonably project future warming based upon an extrapolation of the temperature trends observed in the 20th century. Doing so yields an additional warming of 1.17 to 1.35 degrees Fahrenheit by 2050 and, if we use projections from the UN's International Panel on Climate Change as a point of departure, a rather modest 3.0 to 5.3 inch rise in sea level.<sup>178</sup>

Second, the moderate warming we have experienced has been concentrated over the northern latitudes during the winter night. In other words, nighttime, wintertime lows in the far north have not been quite as cold as usual. The rest of the globe does not show significant long-term warming trends.<sup>179</sup> If warming continues to manifest itself along those lines (and there are good meteorological reasons for it to do so), then the apocalyptic vision of global climate change is wrong.<sup>180</sup> In fact, polar nighttime warming has already begun to show significant economic benefits.<sup>181</sup>

Third, even if a greater degree of warming is spread out evenly across time and space, the world is unlikely to feel much economic or ecological pain. For instance, Ren Zhenqiu, a research fellow of the Chinese Academy of Meteorological Science, notes that a warmer climate would cause the prevailing westerly summer wind to move farther inland, bringing much-needed rainfall to China's drought-plagued areas and, consequently, better crop yields.<sup>182</sup> Both he and professor Zhang Piyuan of the Institute of Geography of the Chinese Academy of Sciences have found through historical research that warmer periods in Chinese history correlate with prosperity.<sup>183</sup> Zhang, for instance, found that agricultural output was higher during the 1750–1790 warm period than during the 1841–1890 cold period.<sup>184</sup>

Ren concluded overall that “warm periods are the economically and culturally prosperous periods of mankind.”<sup>185</sup>

Those findings are representative of what a warmer world would likely mean for resource availability throughout most of the world. Yale forestry professor Robert Mendelsohn, for instance, finds that warming will likely increase resource availability in the United States.<sup>186</sup> A thorough review of both agricultural history and the economic literature by economist Thomas Gale Moore confirms those conclusions on a global scale.<sup>187</sup> Even the UN Environment Programme concedes that, “based on simulation models, the most likely impacts are net favorable effects for the cooler margins of the temperate zone and adverse consequences for the sub-tropical and semi-arid zone.”<sup>188</sup>

Fourth, it’s important to keep in mind that continuing improvements in per capita income will occur regardless of global climate change, improvements that will almost certainly swamp any localized negative effect on resource availability. Even if, for instance, world economic output were reduced by 10 percent annually as a consequence of global warming by the end of the century (a far higher estimate than those offered by even most mainstream alarmists, who postulate a 1 to 2 percent annual reduction in global economic output by 2100), per capita income given recent trends would be only 3.95 times larger than today rather than 4.4 times larger as would be the case absent global climate change.<sup>189</sup> Similarly, global cereal production will likely rise by 83 percent between 1990 and 2060. Given mean estimates of climate change, that figure would only be changed by -1.1 percent to +2.4 percent under an “equivalent doubling” of carbon dioxide concentrations in the atmosphere.<sup>190</sup>

Finally, it should be noted that controlling greenhouse gas emissions would prove less sustainable than a policy that left them unaddressed.<sup>191</sup> Economist Deepak Lal notes that modernization is simply not possible without the substitution of an organic (subsistence) economy by a mineral-based economy, and

that any attempt to block this transition would “leave little hope for the world’s poor.”<sup>192</sup> As Lawrence Summers, former chief economist at the World Bank and former secretary of the treasury, once famously observed, “Poverty is already a worse killer than any foreseeable environmental distress. Nobody should kid themselves that they are doing Bangladesh a favor when they worry about global warming.”<sup>193</sup>

## Sustainability Metrics: Smoke and Mirrors

If resources are growing more abundant while the concentration of pollutants in air sheds and watersheds continues to decline, how can we explain the proliferation of various stylized sustainability indices that point to a deterioration of the planet’s resource base? There are five common weaknesses with such reports. First, they are almost always built upon a selective but fundamentally arbitrary or irrelevant set of indicators. Second, they are often built not upon actual resource data but upon hypotheses or theories about resource health that do not comport with the data or that rest upon highly suspect data fundamentally inconsistent with the larger data sets available to analysts. Third, they ignore the well-documented propensity of capitalist societies to create and invent new resources when old resources become relatively more scarce (that is, they assume that resources are fixed and finite when they are not). Fourth, they are highly aggregated and often subjective calculations of data sets that lack common denominators. Finally, they are frequently heavily biased by ideological assumptions about politics and government action. Accordingly, they provide little help to policy analysts or political leaders.

Although space does not permit a complete review of the various sustainability indices that have been published,<sup>194</sup> a brief examination of some of the more prominent reports should suffice to demonstrate the problems.

**The moderate warming we have experienced has been concentrated over the northern latitudes during the winter night. The rest of the globe does not show significant long-term warming trends. If warming continues to manifest itself along those lines, then the apocalyptic vision of global climate change is wrong.**

**Although the IPAT formula is widely celebrated within environmental circles, its premises have not held up well over the years.**

### **The “IPAT” Calculation**

Perhaps the longest standing method of calculating environmental sustainability (albeit indirectly) is a formula known as the “IPAT Identity.” Originally forwarded by Barry Commoner, the formula works as follows:

$$\text{Environmental Impact (I)} = \text{Population (P)} \times \text{Affluence (A)} \times \text{Technology (T)}$$

Although the formula is widely celebrated within environmental circles, its premises have not held up well over the years. As noted earlier, affluence can worsen or improve environmental quality depending upon where per capita income falls on the Environmental Kuznets Curve for particular pollutants. Technology likewise can have positive or negative effects, but our discussion earlier finds that the former today is far more prevalent than the latter.

Accordingly, Waggoner and Ausubel have revised the IPAT formula in order to make it more useful.<sup>195</sup> The revisions have produced a far more robust and empirically accurate calculation: the “ImPACT Identity”:

$$\text{Environmental Impact (I)} = \text{Population (P)} \times \text{per capita GDP (A)} \times \text{intensity of use (C)} \times \text{efficiency (T)}$$

The renovated IPAT identity—now the ImPACT formula—comports nicely with the empirical observations forwarded in this paper. Waggoner and Ausubel conclude from that formula that “an annual 2–3 percent progress in consumption and technology over many decades and sectors seems a robust, understandable, and workable benchmark for sustainability.”<sup>196</sup>

Unfortunately, most alternatives to Waggoner and Ausubel’s suggested index—as we shall see below—fall far short of robust, understandable, or workable.

### **Living Planet “Index”**

The World Wildlife Fund offers a Living Planet Index by which it purports to measure the health of the world’s ecosystems. The index is an average of three other indices, which purport to measure the abundance of

various forestland, freshwater, and marine animal species. According to WWF, the Living Planet Index declined by 37 percent between 1970 and 2000.<sup>197</sup>

WWF arbitrarily chose 282 species populations to represent forest ecosystem health, 195 species to represent freshwater ecosystem health, and 217 species to represent coastal ecosystem health. There are many more species than that. Why did WWF choose some species as indicators and not others? The report doesn’t say. Even worse, the report doesn’t say *which* species were chosen as indicators.<sup>198</sup> The opportunity for sleight of hand should be immediately obvious. Choose white-tailed deer as an indicator and American forestlands look robust and healthy. Choose wolves as the species indicator and American forestland looks sickly and diseased.

The report claims that the species population data for whatever species it used as indicators “were gathered from numerous published sources,” but concedes that confidence limits cannot be ascribed to the claims “because of uncertainties within the underlying population data.”<sup>199</sup> Suffice it to say that this doesn’t inspire much confidence.

Moreover, why is the ecological “exchange rate” between forest health and, say, oceanic health presumed to be 1.0? WWF doesn’t say. One could argue that forest health is more important to the human population but that oceanic health is more important to some mythic “Mother Earth” given that 70 percent of the earth is covered by water. It may be analytically convenient to aggregate the results of all three indices but there’s no obvious scientific or ecological reason for doing so.

An even bigger question, however, is why measure environmental health by an arbitrary selection of animal population data? There are, after all, a number of equally plausible alternatives. We could measure the amount of the planet covered by forestland (it’s increasing, as noted previously). We could measure trends in water pollution (it’s decreasing in many parts of the globe, also as noted previously). We could measure ecosystem health by plant populations (there are, after all, far more plants than ani-

mals, and plants are even more fundamental to the food chain). We could measure trends in the diversity of life within these ecosystems (it remains essentially unchanged, as noted previously). We could measure the availability of resources produced by these ecosystems (price data illustrate growing resource abundance, not increasing scarcity, as previously noted).

### Ecological Footprints

Several studies purport to measure the “ecological footprint” of humanity, which entails assessing total human demand on the planet and comparing that demand with the supply of resources the planet has to provide. This exercise is performed by the WWF in the same report that featured the aforementioned Living Planet Index, but it appears to be only a brief summary (without attribution) of a study authored by Mathis Wackernagel and others that was published in a recent edition of the *Proceedings of the National Academy of Sciences*.<sup>200</sup>

Wackernagel et al. conclude that “human demand may well have exceeded the biosphere’s regenerative capacity since the 1980s.”<sup>201</sup> In particular, they suggest that as of 1999 humans were harvesting 20 percent more of the planet’s renewable resources than the planet can regenerate in a year.<sup>202</sup> While this conclusion implies that those renewable resources are becoming more scarce, there is little empirical data to support the claim. As noted earlier, most of the data available regarding trends in renewable resources point in the opposite direction.

As far as resource consumption is concerned, the study reports correctly that the amount of the earth’s surface used for growing crops, grazing animals, harvesting timber, fishing, and supporting various human infrastructure has grown only slightly over the past 40 years (about 35 percent of the planet’s surface, in fact, which is pretty remarkable given that global population exploded over that period as did the size of the global economy and the demand for various resources). But the amount of land that Wackernagel et al. claim is used to produce energy has shot

through the roof, essentially doubling over 40 years. According to the study, we now use twice as much of the planet’s space to produce energy as we use to produce food of all kinds.

Wackernagel et al., however, didn’t simply calculate how much land was being used to produce oil, gas, and coal (which is, in fact, trivial). They calculated how much *forestland* is necessary to absorb the carbon dioxide generated by fossil fuel consumption. By only the wildest stretch of the imagination can one discern a human “footprint” in wild and uninhabited forests sucking up carbon dioxide (which, after all, is plant food). If anything, those emissions are *contributing* to forest health by fertilizing them mightily, an argument made convincingly by Sylvan Wittwer, former chairman of the National Research Council’s Board on Agriculture.<sup>203</sup> Moreover, this human use of forests as carbon sinks does not preclude any other ecological or economic use of forestland resources.

In essence, the Wackernagel study’s actual finding is that the planet’s ability to sequester carbon dioxide from the atmosphere is limited and that greenhouse gases are building up in the atmosphere. But there is not and has never been any dispute about that. The question of whether the buildup of greenhouse gases in the atmosphere is sustainable is really a question about the science of global climate change and the ramifications of global warming, a subject unaddressed by the study. If one dismisses the argument that a “human footprint” is left in the ecosystem by carbon sequestration, the Wackernagel study finds no ecological overshoot at all.<sup>204</sup> In fact, trends in agricultural productivity suggest that, by 2070, an area the size of Amazonia currently being husbanded for human use will likely be returned to nature.<sup>205</sup> Even a conservative scenario—which postulates productivity gains half those experienced since 1960 and dramatic increases in world meat consumption—finds that land about half the size of Amazonia (the equivalent of three areas the size of Spain) would be returned to nature by 2070.<sup>206</sup>

Another reason for optimism is, once again, growing per capita income. The UN

**Trends in agricultural productivity suggest that, by 2070, an area the size of Amazonia currently being husbanded for human use will likely be returned to nature.**

**Only half the indicators are directly relevant to the question of sustainability. The rest are irrelevant, counterproductive, redundant, blatantly ideological, or various combinations of those four.**

Environment Programme, for instance, points out that “land degradation is intricately linked to poverty.”<sup>207</sup> As per capita income grows, land degradation is sure to decline.

### **Environmental Sustainability Indices**

A host of reports purport to rank the sustainability of individual countries by aggregating sets of largely subjective environmental, social, and political indicators. The most prominent such indices include the “2002 Environmental Sustainability Index,” a product of the World Economic Forum in collaboration with the Yale Center for Environmental Law and Policy and the Center for International Earth Science Information Network of Columbia University,<sup>208</sup> the “Well-Being Index” from consultant Robert Prescott-Allen,<sup>209</sup> and the “Dashboard of Sustainable Development Indicators” produced by the Consultative Group on Sustainable Development Indicators in collaboration with the UN Commission on Sustainable Development.<sup>210</sup>

Although space does not permit a complete review of each of those three reports, they are similar enough to one another that a discussion of the strengths and weaknesses of one of them will suffice for our purposes.<sup>211</sup> Consider, then, what is probably the most prominent report of the three, the “2002 Environmental Sustainability Index” issued by the World Economic Forum.

The index calculates the environmental sustainability of nations by using 20 indicators, each of which combines 2 to 8 sets of data for a total of 68 underlying data sets. The index ranks the sustainability of nations relative to one another, and although the authors concede that “scientific knowledge does not permit us to specify precisely what levels of performance are high enough to be truly sustainable,”<sup>212</sup> they nonetheless assert that “no country can be said to be on a sustainable path.”<sup>213</sup>

The study has a host of serious problems. First, only 6 of the 20 indicators used to calculate sustainability pertain to actual data regarding environmental conditions,<sup>214</sup> and

there are severe problems with the data sets used to produce even those findings.<sup>215</sup> Only one of the indicators—“basic human sustenance”—measures resource availability (through calculations of malnourishment and safe drinking water availability).<sup>216</sup> None of them purports to measure resource creation or even net resource consumption. Three indicators are of secondary importance, reflecting expertise in science and technology,<sup>217</sup> the degree of civil and political liberties within each nation, and the extent to which environmental regulations are enforced fairly and environmentally destructive subsidies are kept to a minimum.<sup>218</sup>

Thus, only half the indicators are directly relevant to the question of sustainability. The rest are irrelevant, counterproductive, redundant, blatantly ideological, or various combinations of those four.

Irrelevant variables include the following:

- *Renewable water use*—Without reference to water availability, it’s impossible to know whether water use figures are sustainable or not;
- *Water inflow from other countries*—If domestic water supplies are sufficient, what difference does water inflow make?
- *Air emissions, industrial organic pollutants, coal consumption, and radioactive waste generation*—Without reference to the capacity of local or regional air sheds to assimilate emissions, it’s impossible to know whether or not those emissions are problematic. The question of whether emissions are worrisome is best answered by measurements of ambient concentrations of air pollutants, which the study does elsewhere;
- *Renewable energy production*—Whether renewable energy is worth producing or not is an economic question.<sup>219</sup> Moreover, most renewable energy technologies are extremely land intensive, which poses its own set of environmental problems ignored by this variable.<sup>220</sup>
- *Total marine fish catch*—Whether catches



are sustainable or unsustainable is a function of both total catch and the size of the individual schools in question. Without information about the latter, we can't draw conclusions about the former. Moreover, it would seem that large and growing catches could just as easily be a sign of resource abundance and sustainability as not.

- *Seafood consumption*—Not only does the prior argument apply here, but also one could argue that, given the nutritional value of seafood and the relatively minor contribution of seafood to the average diet, high levels of seafood consumption might well indicate nutritional health.

Counterproductive variables include the following:

- *Population growth and fertility rates*—A growing population would suggest species health and sustainability, but the authors imply exactly the opposite by using it as a negative indicator. Moreover, as discussed previously, there is no correlation between population growth or population density and environmental quality or resource availability.
- *Land “protected” from private use*—The implicit assumption here is that public ownership in whole or in part is a form of ecological stewardship superior to private ownership. The environmental consequences of such ownership patterns or regulatory controls on private use of resources in the socialist world apparently escaped the authors' attention.<sup>221</sup>
- *Vehicle use*—The suggestion that societies built upon animal transport and labor are more sustainable than societies built upon modern transportation technologies and farm equipment is rather bizarre. Even more to the point, the environmental damage and public health problems associated with animal transport dwarf those associated with motorized vehicles.<sup>222</sup>

- *Fertilizer and pesticide use*—Without the green revolution, which was driven by modern agricultural chemicals, the amount of additional land necessary to feed the planet (or the size of the human “ecological footprint,” if you will) would be immense. If agricultural technology were frozen at 1910 levels in the United States, for instance, farmers would have to harvest about 1.2 billion acres of land (or 54 percent of the land mass of the United States including Alaska), rather than the 297 million acres actually harvested, to produce the same amount of foodstuffs produced by American farmers in 1988.<sup>223</sup> Alternatively, if technology were frozen at 1961 levels, land devoted to agriculture would have had to expand by 80 percent from that point through 1993 to meet the world's food needs by that same year (by comparison, croplands increased by only about 8 percent in that period given technological advances). That would have meant converting an additional 3,550 million hectares—27 percent of the world's land area outside of Antarctica—to food production.<sup>224</sup> Ausubel estimates that by 1995, improvements in grain yields due largely to fertilizer and pesticide use since 1960 saved as much land as the Amazon Basin.<sup>225</sup> Accordingly, it's wrong to argue that the world's ecosystems would be healthier or more sustainable without fertilizers, pesticides, or other modern agricultural practices.

Redundant variables include the dubious aforementioned “ecological footprint” calculations from Wackernagel et al.<sup>226</sup> Ideological variables of dubious merit (11 in all) include the number of domestic corporations that are involved in various left-of-center advocacy groups,<sup>227</sup> corporate subscription to various left-of-center business practices and protocols,<sup>228</sup> citizen membership in various left-of-center environmental advocacy groups,<sup>229</sup> and national involvement in, and compliance with, a host of international environmental

**If technology were frozen at 1961 levels, land devoted to agriculture would have had to expand by 80 percent from that point through 1993 to meet the world's food needs (by comparison, croplands increased by only about 8 percent in that period).**

**Economic liberalization is absolutely vital for environmental protection.**

organizations and agreements.<sup>230</sup>

Finally, there are tremendous gaps in the database relied upon by the authors. Fifty countries had to be eliminated from the study because reliable data were not available.<sup>231</sup> Even after they were removed, 22 percent of the 9,656 data points relied upon for the calculations in this study were missing. In those cases, the authors estimated what the data might be “based on a judgment that these variables were significantly correlated with other variables in the data set, and with a small number of external predictive variables.”<sup>232</sup> Even so, the study found significant correlations between a nation’s environmental sustainability and the degree of civil and political liberty maintained by its citizens, per capita gross domestic product, the prevalence of democratic institutions, and the containment of political corruption.<sup>233</sup>

The weakness of the stylized environmental sustainability index (ESI) can be easily demonstrated by the rankings produced. After all, if we posit that a more sustainable country is preferable to a less sustainable country, then it logically follows that citizens of the United States (with an ESI of 53.2) should prefer living in Botswana (with an ESI of 61.8), Slovenia (58.8), Albania (57.9), Paraguay (57.8), Namibia (57.4), Laos (56.2), Gabon (54.9), Armenia (54.8), Moldova (54.5), Congo (54.3), Mongolia (54.2), or even the Central African Republic (54.1).<sup>234</sup>

Does anyone seriously think that Botswana is more sustainable than the United States? Only by concentrating exclusively on resource use while ignoring resource creation could such a dubious assertion even be entertained.

### **An Affirmative Agenda for Sustainable Development**

A review of data concerning resource availability and environmental quality clearly illustrates that the developed world is on an eminently sustainable path: resources are becoming more abundant, environmental quality is improving, and per capita incomes are rising. While the data also strongly sug-

gest that economic growth along its current trajectory is sustainable in the developing world, many of those countries are either on the “wrong side” of the relevant EKC’s for the time being or are experiencing far less economic growth than is necessary to accelerate trends in both human and environmental well-being.

The earlier discussion regarding various resources of concern suggests a number of fruitful policy steps that could be taken to enhance environmental quality and resource abundance. A few broader policies would also prove beneficial.

### **The Necessity of Economic Liberalization**

In order to best advance sustainable growth, the developing world should adopt the lessons learned from a recent World Bank study of 11 developing nations (China, Costa Rica, Ghana, Indonesia, Mexico, Morocco, the Philippines, Poland, Sri Lanka, Tunisia, and Zimbabwe). The study found that national economic policies have a tremendous secondary impact on environmental health and resource conservation.<sup>235</sup> Economic policies that led to the greatest amount of ecological sustainability were “altering the rates of exchange or interest, reducing government budget deficits, promoting market liberalization, fostering international openness, enhancing the role of the private sector, and strengthening government and market institutions, often coupled with pricing and other reforms in key sectors such as industry, agriculture, and energy.”<sup>236</sup> Although this study is but one of many to reach the conclusion that economic liberalization is absolutely vital for environmental protection, a detailed review of its findings is illuminating.<sup>237</sup>

First, the study found that state intervention in the economy creates inefficiencies and that economic inefficiency leads to resource waste and excessive pollution.<sup>238</sup> For instance, “in many developing countries, misplaced efforts to promote specific regional or sectoral growth and general economic development have created complex webs of commodity, sectoral, and macroeconomic price distortions,

resulting in economic inefficiency and stagnation,” which generally “promote resource over-exploitation and pollution.”<sup>239</sup> As an example, it has been estimated that 30 percent or more of all pollution in China is a result of the inefficiencies of its centralized economy.<sup>240</sup> Such ill-advised policies are rife throughout the developing world.<sup>241</sup>

The problem is not just inappropriate subsidies; it is socialism itself. Economist Mikhail Bernstam found overwhelming evidence that free-market economies use energy and other natural resources far more efficiently than planned economies.<sup>242</sup> As Pearce and Warford stress, “Centralization of power precludes an appreciation of the effects of environmental degradation. . . . Central planning poses serious risks for the environment and hence for sustainable industrial and agricultural production. The stress on meeting output quotas and the rewards for exaggerating performance work against environmental concerns.”<sup>243</sup>

Moreover, economic intervention engenders uncertainty about property and contract rights, which also has an unintended adverse effect on resource use.<sup>244</sup> In China, for instance, “one major agricultural input, namely land, is still subject to command and control and, in some communities, arbitrariness in its allocation. In such circumstances, the uncertainty about land allocation tends to encourage short-run profit maximization and exploitation of land at the expense of sustainability in agricultural production.”<sup>245</sup>

Mohamed El-Ashry, the World Bank’s environmental director and the chairman of the Global Environmental Facility, observes similarly that “the security of [people’s] tenure may also make it easier to obtain the credit necessary for such investments. Thus, after slum dwellers in Bandung, Indonesia, were assigned property titles, household investment in sanitation facilities tripled.”<sup>246</sup>

Second, the study found that a mixed reform agenda of liberalization and industrial subsidy can have negative environmental and resource consequences. “The remedy does not generally require reversal of the original reforms,” the authors note, “but rather the

implementation of additional complementary measures (both economic and non-economic) that remove such policy, market, and institutional difficulties.”<sup>247</sup> For example:

- The adoption of export promotion or trade liberalization programs without a corresponding elimination of state subsidies or economic preferences for various natural resources will lead to overexploitation of that resource; and
- Economic liberalization—coupled with poor environmental accountability for state-owned enterprises, inadequately defined property rights, or weak financial intermediation—will tend to undermine incentives for economically efficient resource management.<sup>248</sup>

Third, the study found that “measures aimed at restoring macroeconomic stability will generally yield environmental benefits, since instability undermines sustainable resource use.”<sup>249</sup> For example, “high interest rates associated with economic crises can severely undermine the value of sustainable production, as resource outputs in the future lose most of their expected value. Thus, to the extent that adjustment policies can help restore macroeconomic stability, their impact will be unambiguously beneficial for long-term natural resource management and environmental concerns.”<sup>250</sup>

That finding was echoed by Chisolm, Hartley, and Porter in their paper for the Australian-based Tasman Institute:

Activist monetary and fiscal policy have, in recent decades and in most market-oriented economies, been the most potent and persistent causes of an undervaluation of the interests of future generations by keeping interest rates higher than they would otherwise be. . . . Tax policies also have a significant effect on intergenerational equity. . . . Relative to an expenditure or a consumption tax, an income tax encourages current consumption as opposed

**Economic intervention engenders uncertainty about property and contract rights, which also has an unintended adverse effect on resource use.**

**In 1994 exports provided 12.6 percent of the GDP of developing nations. To the extent that free trade fosters industrialization, it is a good thing from an ecological perspective.**

to saving for future consumption. The income tax results in a double taxation of savings, in that tax is paid on the principle and again on the interest yield. An expenditure tax, on the other hand, taxes current and future consumption by the same amount.<sup>251</sup>

Fourth, the study found that developing countries (and even, in many respects, advanced industrialized countries) rarely have the institutional capacity to provide the kind of command-and-control environmental regulation advocated by much of the environmental community.<sup>252</sup> “Regulating large numbers of potentially environmentally degrading activities is especially difficult, even for industrialized country governments. Substantial reductions in institutional and monitoring needs may be achieved with the use of indirect measures or modified pricing-regulation approaches.”<sup>253</sup>

Decentralized regulatory policies are also important in order to maximize the efficiency of environmental protection. Concerning urban air pollution, for example, the World Resources Institute says, “Given the complexity of the problem, strategies for reducing air pollution must be tailored to a particular city, bearing in mind both the key contributors and the city’s priorities and resources.”<sup>254</sup> Likewise, giving industrial emitters the power to choose how to meet their pollution targets is far more efficient and less economically burdensome than empowering regulators to make those decisions in lieu of plant management.<sup>255</sup>

Fifth, the study found that crash programs for economic liberalization may have unforeseen adverse (but only short-term) effects on various “open access” natural resources by weakening the ability of the state to protect those resources against overuse by the poor.<sup>256</sup> Although the authors concluded that special attention should thus be given to state enforcement efforts under such circumstances, one could just as easily argue that privatizing those environmental commons (where possible) would be a more

efficient, less burdensome, and economically preferable alternative.

And finally, the study found once again that economic liberalization leads to economic growth, which in turn “generate[s] new economic opportunities and sources of livelihood, thereby alleviating poverty and reducing pressures on the environment due to over-exploitation of fragile resources by the unemployed.”<sup>257</sup> The link between economic growth and environmental as well as human health improvement has already been well established above.

### **Expand and Protect Free Trade**

Less-developed nations are frequently told to restrict resource exports in order to protect their ecosystems. Advocates of sustainable development frequently contend that such exports are a sort of international ecological colonialism, a means of despoiling Third World resources to fulfill the excess consumption of developed nations. Moreover, many believe that trade allows developing countries to export their pollution-intensive industries to less-developed countries and thus creates excessive health harms to the world’s poor.<sup>258</sup>

The latter argument can be quickly dismissed. As we saw earlier, industrialization and economic growth are a vital component of—not a terrible obstacle to—environmental progress. In 1994, for instance, exports provided 12.6 percent of the GDP of developing nations.<sup>259</sup> To the extent that free trade fosters industrialization, it is a good thing from an ecological perspective.

Moreover, the argument that free trade promotes the creation of “pollution havens” in developing countries ignores the fact that the costs of complying with environmental regulations are a very small part of the costs of doing business for most industries (especially when compared to the cost of labor). Uncertainties regarding the stability of legal and economic institutions in many developing countries—such as the ability to repatriate profits—and the lack of commercially important infrastructure also mitigate against the migration of indus-

tries to developing countries regardless of differentials in environmental regulation.<sup>260</sup>

The former argument is only slightly less specious. In 1994, for instance, tropical and subtropical nations exported only 1.4 percent and 8.2 percent of their total industrial roundwood production, respectively.<sup>261</sup>

The attack on trade is misplaced. First, restricting trade would in many circumstances force an increased reliance on native natural resources. Government policies that discriminate against export crops (in order to encourage subsistence crops for food security) also generally encourage environmental degradation because those crops (palms, coffee, and cocoa) have typically low erosion factors whereas subsistence crops (maize, sorghum, and millet, for example) have erosion factors of 30 to 90 percent.<sup>262</sup> Likewise, policies to restrict or ban log exports and to steer exports toward finished products tend to depress the price of logs, causing the value of wood itself to decline, which makes forestland more attractive for alternative uses and unattractive for improvement or investments.

Similarly, agricultural imports help reduce the burden on native cropland and marginal lands that might have to be cultivated to meet food needs. Since many of those developing nations most reliant upon agricultural imports are in tropical and subtropical regions, the net effect of trade on global biodiversity (which is richest in the equatorial regions) is almost certainly positive.<sup>263</sup>

This points to a larger issue. Because of trade, an individual family unit, community, or country no longer has to be self-sufficient in basic necessities, so long as it has the ability to obtain them through either direct purchase or exchange. Trade essentially globalizes sustainability, providing consumers with faster, cheaper, and easier access to food. Indur Goklany points out that “Japan’s importation of cereals illustrates how, with trade and affluence, otherwise unsustainable entities become more sustainable, and less vulnerable to fluctuations in production, whatever their cause.”<sup>264</sup>

Second, trade is an important source of

new and more efficient technologies, which not only reduce the amount of resources necessary to produce a unit of goods or services but also reduce emissions. Likewise, the increased economic competition that comes from trade leads to constant improvements in production efficiency.<sup>265</sup>

Third, the competitive pressure exerted by foreign imports helps undermine domestic subsidies, which, as we have seen, are harmful to the cause of environmental protection.

### **The Danger of Western Regulation**

Although less-developed countries might be tempted to consider advanced Western regulatory practices as models for domestic law, that impulse should be rejected. Developing nations simply do not have the economic resources necessary to pay for such policies even if they were more efficient than more market-friendly alternatives. Accordingly, the developing world should explore low-cost environmental protection strategies instead.

An excellent example of the imperative of controlling environmental protection costs relates to water pollution. As Pearce and Warford note, “Wastewater and non-point source pollution can be mitigated in large part through inexpensive, low-technology methods that increase the oxygen of water and improve its self-purification properties (weirs, aeration equipment, and constructed wetlands); the typical high-cost western model for intensive wastewater treatment is not a good example.”<sup>266</sup>

The eastern European experience should be considered instructive before businesses in the developing world (private or publicly owned) are put under the regulatory gun. Pearce and Warford explain:

So far, [Western environmental regulation standards adopted in the East] have not been based on a serious consideration of costs and benefits. Since many of their standards are quite strict but not enforced, the whole system of environmental regulations has not been taken seriously . . . because

**Trade essentially globalizes sustainability, providing consumers with faster, cheaper, and easier access to food.**

**Secure property rights are a prerequisite for optimal investment in various human health and environmental infrastructures. They are also vital to the health of ecological resources.**

enterprises are more concerned about meeting their production targets than about improving their financial performance. Indeed, the price-setting regime allows them to build the cost of fees into the cost base used to determine the prices they charge for domestic sales. These prices are subsidized (by means of a so-called soft budget), and part of the subsidies actually support pollution. Further, the fees and fines are consistently well below the average cost of reducing emissions and are not systematically adjusted for inflation. They are trivial in real terms. . . . Clearly, further efforts to make economic incentives workable are warranted, but major reliance upon them, particularly in systems in which prices in general do not adequately reflect costs and values, will not be possible for some years.<sup>267</sup>

Likewise, advanced regulatory ideas such as emission taxes or tradable permits in lieu of command-and-control regulation require a regulatory infrastructure that is beyond the reach of the developing world.<sup>268</sup>

Again, it must be emphasized that environmental costs in Western economies—given their abundant wealth—have a disproportionately small effect on living standards compared to the developing world. The elimination of poverty and subsistence agriculture must be the paramount concern of environmental policy in the developing world, and Western-style environmental regulation would pose a serious obstacle to that goal. Thus, prioritization is necessary. Particulate emissions from electricity generation and manufacturing, for example, are a major health risk and cost little to solve (1 to 2 percent of capital costs) compared with sulfur dioxide emissions, which cost much more to reduce and cause less health damage.<sup>269</sup>

#### **The Imperative of Private Property Rights**

As noted repeatedly throughout this

study, secure property rights are a prerequisite for optimal investment in various human health and environmental infrastructures. They are also vital to the health of ecological resources. Notes Mohamed El-Ashry:

Where access to natural resources is entirely open, no individual user bears the full cost of environmental degradation and resources are consequently overused. But if open access is replaced with some ordered system of use or ownership rights, then it is likely that individuals—or groups—holding such rights will both suffer the consequences of failing to account for environmental factors in their decisionmaking and reap the benefits of successfully investing in environmental protection.<sup>270</sup>

Indeed, private property rights are an important means by which the public desire for resource conservation and preservation can be realized.<sup>271</sup> Moreover, they can provide an important corrective to seemingly intractable problems related to environmental commons such as ocean fisheries, as discussed earlier. Laws establishing rights are not enough; vigorous enforcement of property rights in the Third World is vital.<sup>272</sup>

Nevertheless, it is important to remember that, although private property rights provide exactly the right incentives to optimize the efficiency of resource use, natural resources might still be more profitably exploited than conserved. As noted by Rice, Guillison, and Reid, secure land tenure “makes investments in regeneration possible for timber companies to consider; it does not, however, make these investments economically worthwhile.”<sup>273</sup> Attempts to reduce the consumption of wood harvested in an environmentally damaging way by labeling the products of environmentally sensitive harvests were similarly found wanting. “Consumers appear to be willing to spend, at most, 10 percent more for certified timber than the price they would pay for uncertified

wood products,” they wrote. “The gap is enormous.”<sup>274</sup>

Resource use per se should not be worrisome. The economy must have access to natural resource inputs in order to produce basic goods and services.<sup>275</sup> Property rights can help ensure that resources are not wasted, but they cannot guarantee that they will not be used at all.

## Conclusion

If sustainable development is the answer, what is the question? Society has managed to “sustain” development now for approximately 3,000 years without the guidance of “green” state planners. The result is not only a society that is both healthier and wealthier than any other in history but also a society with more natural resources at its disposal than ever before.

The overwhelmingly positive trends in environmental quality and resource availability in the developed and developing worlds suggest that the best way to sustain development—or to maximize human welfare—is to

- ensure that productivity continues to improve in both the agriculture and resource extraction industries,
- facilitate continuing improvements in the efficiency of resource use, and
- promote wealth creation and gains in per capita income.

It’s important to remember that conditions in the developing world are similar to those in the West a century ago. As the World Resources Institute observes:

Just a century ago, health conditions in Europe, North America, and Japan were similar to those of the least developed countries today, as was environmental quality. Conditions in London and other major centers were squalid; sewage-filled rivers, garbage-strewn streets,

and overcrowded and dank housing were the norm. Much of the population lacked access to fresh water or adequate sanitation. Epidemics of typhus, cholera, tuberculosis, and measles swept these cities. Indeed, in the world’s most prosperous cities at the time, the infant mortality rate—the number of children who die before their first birthday—was more than 100 per 1,000 live births, and in some places it exceeded 200. Diarrheal and respiratory diseases and other infections were the main cause of death.<sup>276</sup>

The environmental plight of cities such as London might not have been indefinitely “sustainable,” but industrialization was accompanied by an increase in life expectancy and an improved standard of living. Incomes rose so that people were able to afford more environmental amenities, better health care, modern sanitary investments, and an improved diet. Economic growth spawned new manufacturing technologies that were more efficient, less resource intensive, and hence less polluting. Moreover, these gains in human welfare accelerated over time.

Indeed, it is the *lack* of economic growth—not the pollution spawned by growth—that is the root cause of most health-related problems in the less-developed world today. Again, as the World Resources Institute notes:

Of all the factors that combine to degrade health, poverty stands out for its overwhelming role. Indeed, WHO [the World Health Organization] has called poverty the world’s biggest killer [*The World Health Report 1995: Bridging the Gaps* (Geneva: World Health Organization, 1995), p. 1]. Statistically, poverty affects health in its own right: just being poor increases one’s risk of ill health. Poverty also contributes to disease and death through its second-order effects; poor people, for instance, are

**Society has managed to “sustain” development now for approximately 3,000 years. The result is not only a society that is both healthier and wealthier than any other in history but also a society with more natural resources at its disposal than ever before.**

**“Planned intervention to ensure ecological sustainability makes central planning of the economy appear as a comparatively unambitious exercise.”**

more likely to live in an unhealthy environment.<sup>277</sup>

Indeed, the most serious environmental problems today are manifestly the consequence of poverty and lack of development. Approximately 2 million people in developing countries die every year from exposure to high concentrations of particulate matter in indoor environments in rural areas, a direct result of burning primitive biomass fuels.<sup>278</sup> Electrification would save far more lives than any conceivable set of environmental regulatory initiatives, but electrification cannot occur without further economic development. Another 3 million people die every year in Africa due to poor water quality, another problem that could be easily remedied by investment in water treatment facilities.<sup>279</sup> But those investments will not come without economic growth.

Improvements in productivity, efficiency, and per capita income, however, are not preordained. Economists largely agree that they are manifestations of political systems that protect economic liberty and proscribe the boundaries of state authority to protecting life, liberty, and property.<sup>280</sup>

The alternative to allowing the world's less-developed countries to follow the trajectories of the Environmental Kuznets Curve—that is, to facilitate a rise in per capita income in order to improve not only human health but also environmental quality—is to authorize centralized planning of the economy to achieve some vision (or, as Costanza et al. correctly put it, some “highly suspect prediction”) of sustainable development. But state planning has never been able to replicate the gains in productivity, efficiency, and per capita income produced by free market economies. Moreover, environmental planning would impose an incredible informational burden on government that is unlikely to be met in the real world. As Chisholm, Hartley, and Porter note:

Planned intervention to ensure ecological sustainability makes central planning of the economy, as conven-

tionally practiced until recently in Eastern Europe and many other command economies, appear as a comparatively unambitious exercise. Government “ecologically-minded” planners wishing to regulate a range of environmental outcomes would need the vast information on consumer tastes, production techniques, and resource availability required of a conventional central planner, information that is typically not available at any reasonable cost. They would need detailed information on myriad dynamically evolving and interacting ecosystems.<sup>281</sup>

There are other obstacles to ecological centralized planning beyond those related to information gathering. William Mellor III, president of the Institute for Justice, asks several pointed questions that are seldom addressed by the advocates of sustainable development:

Who will decide what is good growth? Who will reconcile competing environmental, social, and economic concerns while anticipating environmental problems rather than reacting to the crisis of the moment? Is it conceivable that the bureaucratic regulatory and enforcement apparatus necessary for such ecologically directed economic policy would be immune from rent-seeking, budget-maximizing, inefficiency, and coercion? If so, it would be a unique experience in all of public choice scholarship.<sup>282</sup>

As an all-encompassing governing philosophy, sustainable development is a dubious pipe dream. Even promoters of the concept are increasingly in agreement that sustainable development must ensure that economic and social considerations are balanced with environmental concerns and are not trumped by them.<sup>283</sup> As a policy admonition, sustainable development is, at best, but one well-under-



stood and unexceptional consideration in the quest to maximize public welfare. At worst, it is inconsistent and dangerous.

## Notes

1. Representative interpretations of the challenge posed by sustainable development include the following:

Our nation's economic system evolved in an era of cheap energy and careless waste disposal, when limits seemed irrelevant. None of us today, whether we're managing a house or running a business, is living in a sustainable way. It's not a question of good guys and bad guys. There is no point in saying "If only those bad guys would go out of business, then the whole world would be fine." The whole system has to change. There is a huge opportunity for reinvention.

Joan Magretta, "Growth through Global Sustainability: An Interview with Monsanto's CEO, Robert Shapiro," *Harvard Business Review* (January/February 1997): 80–81.

Can we move nations and people in the direction of sustainability? Such a move would be a modification of society comparable in scale to only two other changes: the agricultural revolution of the late Neolithic and the Industrial Revolution of the past two centuries. Those revolutions were gradual, spontaneous, and largely unconscious. This one will have to be a fully conscious operation, guided by the best foresight that science can provide—foresight pushed to its limit. If we actually do it, the undertaking will be absolutely unique in humanity's stay on the earth.

Former EPA administrator William Ruckelshaus, "Toward a Sustainable World," *The Environmental Ethics and Policy Book* (Belmont, Calif: Wadsworth Publishing, 1994), p. 348. Lester Brown, former president of Worldwatch Institute, believes that sustainable development would mean a "fundamental restructuring of economies" and "sweeping revisions in regulatory and economic policies. Emily Smith, "Growth vs. Environment," *Business Week*, May 11, 1992, p. 68. Donella Meadows et al. believe a sustainable society would "abandon the social norms, goals, incentives, and costs that cause people to want more than a replacement number of children... that maldistribute income and wealth, that make people see themselves primarily as consumers and producers, that associate social status with material accumulation, and that define human growth in terms of getting more." This

would apparently require "a fundamental revision of human behavior and, by implication, the entire fabric of present-day society." Donella Meadows et al., *The Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind* (New York: New American Library, 1972), p. 9.

2. World Commission on Environment and Development, *Our Common Future* (Oxford: Oxford University Press, 1987), p. 8.

3. For a summary of the various economic, ecological, and sociocultural conceptions of sustainable development, see Mohan Munasinghe, "Environmental Economics and Sustainable Development," World Bank Environmental Paper no. 3, Washington, D.C., 1993, p. 3.

4. J. N. Pretty, *Regenerating Agriculture* (London: Earthscan, 1995), p. 11, cited in Matthew Cole, "Limits to Growth, Sustainable Development, and Environmental Kuznets Curves: An Examination of the Environmental Impact of Economic Development," *Sustainable Development* 7, 1999, p. 90.

5. David Pearce and Jeremy Warford, *World without End: Economics, Environment, and Sustainable Development* (New York: Oxford University Press, 1993), p. 8.

6. Robert Costanza, "Ecological Economics: A Research Agenda," *Structural Change Economics* 2, pp. 335–42, cited in M. J. Harte, "Ecology, Sustainability, and Environment as Capital," *Ecological Economics* 15 (1995): 158.

7. Robert Hahn, "Toward a New Environmental Paradigm," *Yale Law Journal* 102, no. 7 (May 1993): 1750.

8. Harte, p. 160.

9. This interpretation of strong sustainability is no mere straw man. At a planning conference for the World Summit on Sustainable Development held in Bali May 24–27, 2002, four of the six environmental nongovernmental organizations attended a session titled "Mining & Sustainable Development—Two Apparently Contradictory Concepts," which argued for an immediate moratorium on new mining operations across the globe in order to achieve mineral sustainability. "State-statement of the International Mining Workshop," undated (available from the author).

10. Richard Rice, Raymond Guillison, and John Reid, "Can Sustainable Management Save Tropical Forests?" *Scientific American*, April 1997, p. 46.

11. David Pearce, *Economic Values and the Natural World* (London: Earthscan Press, 1993), p. 48.

- cited in Wilfred Beckerman, *Through Green-Colored Glasses: Environmentalism Reconsidered* (Washington: Cato Institute, 1996), p. 147.
12. Andrew Chisholm, Peter Hartley, and Michael Porter, "Slogans or Policies: A Critique of 'Ecologically Sustainable Development,'" Occasional Paper B3, Tasman Institute, October 1990, pp. 6–7.
  13. Munasinghe, p. 3.
  14. Cole, "Limits to Growth," p. 90.
  15. Edith Weiss, *In Fairness to Future Generations* (Dobbs Ferry, N.Y.: Transnational Publishers, 1989). For a summary and a sympathetic critique of Weiss, see Paul Barresi, "Beyond Fairness to Future Generations: An Intragenerational Alternative to Intergenerational Equity in the International Environmental Arena," *Tulane Environmental Law Journal* 11, no. 1 (winter 1997): 59–88.
  16. For a thorough review of the theoretical and practical difficulties in defining and assigning rights to future generations, see A. Baier, "For the Sake of Future Generations," in *Earthbound: New Introductory Essays in Environmental Ethics*, ed. T. Regan (New York: Random House, 1984); B. Barry, "Justice between Generations," in *Law, Morality, and Society: Essays in Honour of H. L. A. Hart*, ed. J. M. S. Hacker and S. Raz (Oxford: Clarendon Press, 1977); and Martin Golding, "Obligations to Future Generations," *The Monist* 56, no. 1, (1972): 85–99.
  17. Steven Landsburg, "Tax the Knickers off Your Grandchildren," *Slate*, March 6, 1997, [www.slate.com/Economics97](http://www.slate.com/Economics97).
  18. *Ibid.*
  19. See Gerald MacCallum Jr., "Negative and Positive Freedom," *Philosophical Review* 76 (July 1967): 312–34; Roger Pilon, "Ordering Rights Consistently: Or What We Do and Do Not Have Rights To," *Georgia Law Review* 13 (1979): 1171–96; and David Kelley, *A Life of One's Own: Individual Rights & The Welfare State* (Washington: Cato Institute, 1998).
  20. Richard Stroup, "Political Control vs. Sustainable Development" (paper submitted for the Cato Institute conference "Global Environmental Crises: Science or Politics?" Washington, D.C., June 5–6, 1991) (available from author); and Fred Smith, "The Market and Nature," *The Freeman*, September 1993, pp. 350–56.
  21. Chisholm, Hartley, and Porter, p. 17.
  22. Joseph Stiglitz, "Growth and Exhaustible Natural Resources: Efficient and Optimal Growth Paths," in *Review of Economic Studies*, Symposium on the Economics of Exhaustible Resources, 1974, pp. 123–38.
  23. Edward Barbier, "Endogenous Growth and Natural Resource Scarcity," EEEM Discussion Paper 9601, Department of Environmental Economics and Environmental Management, University of York (U.K.), 1996.
  24. Edward Barbier and Thomas Homer-Dixon, "Resource Scarcity, Institutional Adaptation, and Technological Innovation: Can Poor Countries Attain Endogenous Growth?" *American Association for the Advancement of Science*, 1996, p. 3.
  25. Land dedicated to agricultural production and grazing grew from 4,490,920,000 hectares in 1961 to 4,961,289,000 hectares in 1999. Food and Agriculture Organization of the United Nations, *Production Yearbooks*, online data query available at [www.apps.fao.org/page/form?collection=Land Use&Domain=Land&servlet=1&language=EN&hostname=apps.fao.org&version=default](http://www.apps.fao.org/page/form?collection=Land Use&Domain=Land&servlet=1&language=EN&hostname=apps.fao.org&version=default).
  26. Paul Waggoner and Jesse Ausubel, "How Much Will Feeding More and Wealthier People Encroach on Forests?" *Population and Development Review* 27:2, June 2001, p. 253.
  27. Jesse Ausubel, "On Sparing Farmland and Spreading Forest," in *Forestry at the Great Divide: Proceedings of the Society of American Foresters 2001 National Convention*, T. Clark and R. Staebler, eds., Society of American Foresters, Bethesda, Md., 2002, p. 127.
  28. World Food Summit: Technical Background Documents, vols. I–VX, p. 1, table 3; Food and Agriculture Organization of the United Nations *The State of Food Insecurity in the World, 1999* (Rome: Food and Agriculture Organization of the United Nations, 1999), p. 29, available at [www.fao.org/FOCUS/E/SOFI/home-e.htm](http://www.fao.org/FOCUS/E/SOFI/home-e.htm); and FAO, *The State of Food Insecurity in the World, 2000* (Rome: Food and Agriculture Organization of the United Nations, 2000), p. 27, available at [www.fao.org/news/2000/001002-e.htm](http://www.fao.org/news/2000/001002-e.htm). All sources cited in Bjorn Lomborg, *The Skeptical Environmentalist* (New York: Cambridge University Press, 2001), p. 61.
  29. Unfortunately, there are no data on actual malnourishment among children ages five years and younger, so international agencies use data on "underweight" children as an indicator of malnourishment, which seems reasonable enough. United Nations Development Programme, *Human Development Report, 1996* (New York: Oxford University Press, 1996), p. 149, cited in Lomborg, p. 61.

30. For a summary of the literature, see David Osterfeld, *Prosperity versus Planning* (New York: Oxford University Press, 1992), pp. 61–83. For a defense of high-yield agriculture in less-developed regions, see Dennis Avery, *Saving the Planet with Pesticides and Plastic* (Indianapolis: Hudson Institute, 2000); and Thomas DeGregori, *Bountiful Harvest: Technology, Food Safety, and the Environment* (Washington: Cato Institute, 2002). For a rebuttal to the claim that trends in soil erosion will reverse or significantly moderate current agricultural productivity trends, see Bruce L. Gardner and Theodore Schultz, “Trends in Soil Erosion and Farmland Quality,” in *The State of Humanity*, ed. Julian Simon (Cambridge, Mass.: Blackwell, 1995), pp. 416–24; and Pierre Crosson, “Cropland and Soils: Past Performances and Policy Challenges,” in *America’s Renewable Resources: Historical Trends and Current Challenges*, ed. Roger Sedjo and Kenneth Frederick (Washington: Resources for the Future, 1991), pp. 169–203.

31. As Jesse Ausubel, the director of the program for human environment at the Rockefeller University observes: “Globally, the future for both lifting means and reducing variability lies with *precision agriculture*. This approach to farming relies on technology and information to help the grower use precise amounts of inputs—fertilizer, pesticides, seed, water—exactly where they are needed. Precision agriculture includes grid soil sampling, field mapping, variable rate application, and yield monitoring—tied to global positioning systems. It helps the grower lower costs and improve yields in an environmentally responsible way. Technology revolutionized agriculture twice in the 20th century. The tractor and other machines caused the first. Nitrogen and other chemicals were responsible for the second. The third agricultural revolution is coming from information.” Jesse Ausubel, “The Great Reversal: Nature’s Chance to Restore Land and Sea,” *Technology in Society* 22, 2000, pp. 289–301, [www.phe.rockefeller.edu/great\\_reversal](http://www.phe.rockefeller.edu/great_reversal).

32. Regarding the agricultural promise of biotechnology, see *Biotechnology, Poverty Reduction, and Food Security* (Manila: Asian Development Bank Publications, 2001); Gabrielle Persley and M. M. Lantin, eds., *Agricultural Biotechnology and the Poor* (Washington: Consultative Group on International Agricultural Research and the U.S. National Academy of Sciences, 1999); Gabrielle Persley, ed., *Biotechnology for Developing-Country Agriculture: Problems and Opportunities* (Washington: International Food Policy Research Institute, 1999); House Committee on Science, *Seeds of Opportunity: An Assessment of the Benefits, Safety, and Oversight of Plant Genomics and Agricultural Biotechnology*, April 13, 2000; and National Research Council, Board on Agriculture and

Natural Sciences, *Genetically Modified Pest-Protected Plants: Science and Regulation* (Washington: National Academy Press, 2000). For a survey of the scientific literature regarding the environmental consequences of biotechnology—which are found to be positive—see Council for Agricultural Science and Technology, “Comparative Environmental Impacts of Biotechnology-derived and Traditional Soybean, Corn, and Cotton Crops,” Ames, Iowa, June 2002, [www.cast-science.org/pubs/biotechcropsbenefit.pdf](http://www.cast-science.org/pubs/biotechcropsbenefit.pdf). For an argument about how to properly apply the “precautionary principle” to the uncertainties surrounding the environmental consequences of biotechnology, see Indur Goklany, *The Precautionary Principle: A Critical Appraisal of Environmental Risk Assessment* (Washington: Cato Institute, 2001), pp. 29–55.

33. Food supplies per capita increase with per capita GDP until they level off at approximately 3,500 calories a day once per capita income reaches about \$7,000 in 1985 dollars. The converse is also true. Declines in per capita income lead to declines in agricultural productivity. T. Poleman and L. T. Thomas, “Report: Income and Dietary Change,” *Food Policy* 20, 1995, pp. 149–59. Cited in Indur Goklany, “Saving Habitat and Conserving Biodiversity on a Crowded Planet,” *BioScience* 48:11, November 1998, p. 942.30. United Nations Development Programme, *Human Development Report, 1999* (New York: Oxford University Press, 1999), cited in Lomborg, p. 47.

34. United Nations Development Programme, *Human Development Report, 1999*.

35. Roger Revelle of Harvard University suggests, for instance, that simply increasing the efficiency of water use in the arable lands of the tropics in less-developed parts of the world could produce yields capable of feeding 35–40 billion people a year with 2,500 calories a day. Calculation performed by Osterfeld, p. 83, based on data in Roger Revelle, “The World Supply of Agricultural Land,” in *The Resourceful Earth*, ed. Julian Simon and Herman Kahn (New York: Basil Blackwell, 1984), pp. 184–201.

36. Brian Berry, Edgar Conkling, and D. Michael Ray, *The Global Economy: Resource Use, Locational Choice, and International Trade* (Englewood Cliffs, N.J.: Prentice Hall, 1993), p. 126; and Food and Agriculture Organization of the United Nations, *The Sixth World Food Survey* (Rome: FAO, 1996), p. 101. All cites from Lomborg, p. 106.

37. Lester Brown et al., *Vital Signs 1998* (New York: W.W. Norton); U.S. Bureau of the Census, *International Data Base*, [www.census.gov/ipc/www/idbnew.html](http://www.census.gov/ipc/www/idbnew.html); Food and Agriculture Organization of the UN, “Fisheries Update,” [www.fao.org/fi/statist/](http://www.fao.org/fi/statist/)

summtab/default.asp; and *The State of the World Fisheries and Aquaculture 2000* (Rome: FAO, 2001), available at Food and Agriculture Organization of the UN, [www.fao.org/docrep/003/x8002e/x8002e00.htm](http://www.fao.org/docrep/003/x8002e/x8002e00.htm). All cites from Lomborg, p. 107.

38. Garrett Hardin, "The Tragedy of the Commons," *Science* 162, no. 1 (1968): 243–48.

39. See Birgir Runolfsson, "Fencing the Oceans: A Rights-Based Approach to Privatizing Fisheries," *Regulation* 20:3 (Summer 1997); Peter Emerson, senior economist, Environmental Defense Fund, Testimony before the Subcommittee on Fisheries Conservation, Wildlife, and Resources, of the House Committee on Resources, U.S. House of Representatives, February 13, 2002, [www.environmentaldefense.org/documents/1447\\_PeteEmersonITQtestimony.pdf](http://www.environmentaldefense.org/documents/1447_PeteEmersonITQtestimony.pdf); and National Research Council, *Sharing the Fish: Toward a National Policy on Individual Fishing Quotas* (Washington, D.C.: National Academy Press, 1999). See also Michael De Alessi, "Sustainable Development and Marine Fisheries," in *Sustainable Development: Promoting Progress or Perpetuating Poverty?* ed. Julian Morris (London: Profile, Books, 2002), pp. 194–221.

40. See Per Heggelund and Thomas Trzyna, "Ocean Farming: An Emerging Aquabusiness?" *Regulation* 18, no. 4 (Fall 1995); Michael Markels Jr., "Fishing for Markets: Regulation and Ocean Farming," *Regulation* 18, no. 3, (Summer 1995); and Michael Markels, "Farming the Oceans: An Update," *Regulation* 21, no. 2 (Spring 1998).

41. Jesse Ausubel, "Maglevs and the Vision of St. Hubert," in *Challenges of a Changing Earth*, W. Steffen, J. Jaeger, and D. Carson, eds. (Hiedelberg: Springer, 2002), [www.phe.rockefeller.edu/sthubert](http://www.phe.rockefeller.edu/sthubert).

42. Brown et al., *Vital Signs 1998*; and FAO, "Fisheries Update." All cites from Lomborg, p. 108.

43 "Fertilizing 250,000 square kilometers of barren tropical ocean, the size of the USA state of Colorado, in principle might produce a catch matching today's fish market of 100 million tons. Colorado spreads less than 1/10th of 1 percent as wide as the world ocean," Ausubel, "Maglevs and the Vision of St. Hubert." See also Ausubel, "The Great Reversal."

44. An analytic method is championed as the superior approach in William Nordhaus, "World Dynamics: Measurement without Data," *Economic Journal* 83, December 1973, pp. 1156–83.

45. For an excellent review of the literature pertaining to the ongoing debate about petroleum scarcity, see Robert Arnott, "Supply Side Aspects of Depletion," *Journal of Energy Literature* 8, no. 1 (June 2002): 3–21.

46. It's also true for other fossil fuels such as coal

and natural gas. For a summary of the increasing abundance of those fuels, see Robert L. Bradley Jr., *Julian Simon and the Triumph of Energy Sustainability* (Washington: American Legislative Exchange Council, 2000). The weakness of price data, however, is that prices can be distorted by government interventions—such as the exercise of monopoly power by OPEC—which results in false signals to consumers and analysts regarding scarcity. Government intervention in oil markets in the United States, for instance, has had the net effect of distorting oil prices in an upward direction. See Jerry Taylor and Peter VanDoren, "The Soft Case for Soft Energy," *Journal of International Affairs* 53, no. 1 (Fall 1999): 222–26. The OPEC cartel has also served to keep world oil prices about three times higher than they would otherwise be without producer collusion and more volatile to boot. See Morris Adelman, *Genie out of the Bottle: World Oil Since 1970* (Cambridge, Mass.: MIT Press, 1996), pp. 11–39.

47. Robert L. Bradley, "The Increasing Sustainability of Conventional Energy," *Cato Institute Policy Analysis* no. 341, April 22, 1999, p. 6.

48. Adelman, pp. 22–24.

49 Data are compiled from various sources by Bradley, *Julian Simon*, figure 2, p. 29, with sources detailed in appendix B, p. 150. The weakness of reserve data is that reserve estimates reflect only resources that can be recovered under present and expected local economic conditions with existing available technology. Thus, data about oil reserves are akin to data about what is presently in your kitchen cupboard. Many exploitable fields are not "proven reserves" because they have yet to be developed (usually because of the lack of profit opportunities in the current market). Moreover, projections based on such data presume no further advances in extraction or energy efficiency technology (more than offsetting the presumed lack of increasing annual consumption). This set of assumptions, of course, is a wildly unrealistic. For a good discussion of the real economic meaning of "proven reserves," see Paul Ballonoff, *Energy: Ending the Never-Ending Crisis* (Washington: Cato Institute, 1997), pp. 7–8, 17–22.

50. Adelman, p. 27; and BP/Amoco "Statistical Review of World Energy," 2000, pp. 4–7.

51. Michael Lynch, *Facing the Elephant: Oil Market Evolution and Future Oil Crises* (Boulder, Colo.: IRCEED, 1998), p. 2, cited in Bradley, "Increasing Sustainability of Conventional Energy," p. 13. The UN's Intergovernmental Panel on Climate Change (IPCC) accepts such estimates by and large. That organization estimated recently that the total consumption of hydrocarbons from

1850 to 1995 represents just 1.1 percent of what remains in the ground. IPCC, *Climate Change 2001: Mitigation* (Cambridge, U.K.: Cambridge University Press, 2001), p. 236. The weakness of such data, however, is that it is thoroughly speculative and ultimately not particularly useful. We can't with any authority estimate the amount of oil we have yet to discover. Moreover, the important thing is not how much oil exists but how much profitably exploitable oil exists. And the question of "profitable exploitation" is connected to the issue of price and technology, which will surely shift over time as it always has.

52. See, for instance, a critical review of Kenneth Deffeyes's *Hubbert's Peak: The Impending World Oil Shortage* (Princeton, N.J.: Princeton University Press, 2001), by Thomas Ahlbrandt in *The Journal of Energy Literature* 8, no. 1 (June 2002): 47–49. See also Arnott.

53. Harold Barnett and Chandler Morse, *Scarcity and Growth: The Economics of Natural Resource Availability* (Baltimore: Johns Hopkins University Press, 1963). For additional texts that have built upon Barnett and Morse's work, see V. Kerry Smith, ed., *Scarcity and Growth Reconsidered* (Baltimore: Johns Hopkins University Press, 1979); Orris Herfindahl, in *Resource Economics: Selected Works*, ed. David Brooks (Baltimore: Johns Hopkins University Press, 1974); Richard Gordon, "Conservation and the Theory of Exhaustible Resources," *Canadian Journal of Economics and Political Science* 32, no. 3 (August 1966): 319–26; Richard Gordon, "A Reinterpretation of the Pure Theory of Exhaustion," *Journal of Political Economy*, 75, no. 3 (June 1967): 274–86; and Adelman, pp. 11–39.

54. Thomas DeGregori, "Resources Are Not; They Become: An Institutional Theory," *Journal of Economic Issues* 21, no. 3 (September 1987): 1243, 1247.

55. Osterfeld, p. 99.

56. Food and Agriculture Organization of the United Nations, *Production Yearbooks 1949–1995*, cited in Lomborg, p. 111. Estimates of forest cover, however, may vary depending upon how one defines forested land. See, for instance, United Nations Environment Programme, *Global Environment 3: Past, Present, and Future Perspectives* (London: Earthscan, 2002), pp. 91–92.

57. Intergovernmental Panel on Climate Change, *Climate Change 2001: Impacts, Adaptation, and Vulnerability*, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel et al., on Climate Change, ed. J. J. McCarthy et al. (Cambridge: Cambridge University Press), cited in Lomborg, p. 283.

58. For instance, the average American today annually consumes only half the lumber for all uses that the average American consumed in the year 1900. Ausubel, "The Great Reversal."

59. Roger Sedjo, "The Role of Forest Plantations in the World's Future Timber Markets," *Forestry Chronicle* 77, no. 2 (March/April 2001): 221–25; Roger Sedjo and Daniel Botkin, "Using Forest Plantations to Spare Natural Forests," *Environment* 39, no. 10 (December 1997): 15–20, 30; and Brent Sohngen et al., "An Analysis of Global Timber Markets," Discussion Paper 97-37, Resources for the Future, Washington, D.C., May 1997.

60. "At likely planting rates, at least one billion cubic meters of wood—half the world's supply—could come from plantations by the year 2050 . . . an industry that draws from planted forests rather than cutting from the wild will disturb only one-fifth or less of the area for the same volume of wood. Instead of logging half the world's forests, humanity can leave almost 90 percent of them minimally disturbed. And nearly all new tree plantations are established on abandoned croplands, which are already abundant and accessible." Ausubel, "Maglevs and the Vision of St. Hubert."

61. See Andrew Goudie, *The Human Impact on the Natural Environment* (Oxford: Blackwell, 1993), p. 43; John Richards, "Land Transformation," in B. L. Turner et al., *The Earth as Transformed by Human Action* (Cambridge: Cambridge University Press, 1990), pp. 163–80; and Intergovernmental Panel on Climate Change, *Special Report on Emission Scenarios*, Special Report on Working Group III of the Intergovernmental Panel on Climate Change, 2001, p. 3.2.2.2, [www.grida.no/climate/ipcc/emission](http://www.grida.no/climate/ipcc/emission). Michael Williams, however, estimates only a 7.5 percent loss of original forests since the dawn of man. See Michael Williams, "Forests," in Turner et al., p. 164. All cites from Lomborg, p. 112.

62. See Roger Sedjo, "Marion Clawson's Contributions to Forestry," Discussion Paper 99-33, Resources for the Future, Washington, D.C., April 1999. Even plantation forests contribute a great deal to the ecological health of global forestlands generally. "The Role of Forest Plantation in the World's Future Timber Supply," *Forest Chronicle* 77, no. 2 (March–April 2001): 221–226; and Sedjo and Botkin, pp. 15–20, 30. The UN Environment Programme likewise reports that, "while plantation forests are usually a poor substitute for natural forests in terms of maintaining biodiversity, they can supplement and substitute wood and other supplies from natural forests, thereby reducing pressure on and disruption to the latter. They also perform many of the environmental services of natural forests, including carbon sequestration, watershed protection, and land rehabilitation." United Nations Environment

- Programme, *Global Environment Outlook 3: Past, Present, and Future Perspectives* (London: Earthscan, 2002), p. 103. See also Mark Lacey, "Learning to Live with Logging and (Gasp!) Even Liking It," *New York Times*, August 20, 2002, p. D3.
63. For more on the subject, see Roger Sedjo, Alberto Goetzl, and Steverson Moffat, *Sustainability of Temperate Forests* (Washington: Resources for the Future, 1998).
64. Frederic Achard et al., "Determination of Deforestation Rates of the World's Humid Tropical Forests," *Science* 297, August 9, 2002, p. 999; and Jocelyn Kaiser, "Satellites Spy More Forest Than Expected," *ibid.*, p. 919.
65. Lomborg, p. 114.
66. W. V. Reid, "How Many Species Will There Be?" in T. C. Whitmore and J. A. Sayer, *Tropical Deforestation and Species Extinction* (London: Chapman & Hall, 1992), p. 60, cited in Lomborg, p. 114.
67. Peter Morrisette, "Political Structure and Global Resource Use: A Typology," ENR92-04, Resources for the Future, Washington, D.C., 1992, p. 20; M. Edelman, "Rethinking the Hamburger Thesis: Deforestation and the Crisis of Central American Beef Exports," in *The Social Causes of Environmental Destruction in Latin America*, M. Painter and W. H. Durham, eds. (Ann Arbor: University of Michigan Press, 1995), pp. 25-62; S. Schwartzman and M. Kingston, "Global Deforestation, Timber, and the Struggle for Sustainability: Making the Label Stick," Environmental Defense Fund, Washington, D.C., 1997; and *The State of the World's Forests, 1997* (Rome: Food & Agriculture Organization of the United Nations, 1997). Government policies that deny land tenure rights unless forestland is cleared have also been indicted as a major cause of Third World deforestation. See Douglas Southgate, Rodrigo Sierra, and Lawrence Brown, "The Causes of Tropical Deforestation in Ecuador: A Statistical Analysis," Paper 89-09, London Environmental Economics Centre, 1989. The UN Environment Programme, for instance, reports that deforestation of the Brazilian Amazon "could not have been successful without the strong support of governments through the provision of tax incentives (the 'Legal Amazon' in Brazil), the construction of roads, and the availability of skilled and cheap labor." *Global Environment* 3, p. 79. Also see *ibid.*, p. 108; and Douglas Southgate, "Forest Conservation and Development: The Role of Institutions," in *Sustainable Development: Promoting Progress or Perpetuating Poverty?* pp. 194-205.
68. As per capita income rises, deforestation rates tend to decline. See T. Panayotou, "Environmental Degradation at Different Stages of Economic Development," in *Beyond Rio: The Environmental Crisis and Sustainable Livelihoods in the Third World*, ed. I. Ahmed and J. A. Doeleman (London: Macmillan Press, 1995); J. M. Antle and G. Heidebrink, "Environment and Development: Theory and International Evidence," *Economic Development and Cultural Change* 43, no. 3 (1995): 603-25; and M. Cropper and C. Griffiths, "The Interaction of Population Growth and Environmental Quality," *American Economic Review* 84, no. 2 (1994): 250-54. All cites from Edward Barbier, "Introduction to the Environmental Kuznets Curve Special Issue," *Environment and Development Economics* 2, no. 4 (1997): 373. See also Pearce and Warford, pp. 184, 188; C. H. Murray, "Joint Action Is Path to Rescue of Forests," *Forum for Applied Research and Public Policy* 7, no. 4 (Winter 1992): 13-15; and Malcom Gillis, "Tropical Deforestation: Poverty, Population, and Public Policy" (speech delivered to the Rice Environmental Conference, Rice University, Houston, Texas, February 1, 1996), reprinted in *Vital Speeches*, April 1996, p. 374.
69. Maureen Cropper and Charles Griffith, "The Interaction of Population and Growth and Environmental Quality," *American Economic Review* 82, no. 2, (1994): 250-54.
70. "Livestock expansion and mechanized agriculture account for more loss of forest cover than wood production, which is concentrated in relatively few countries." *Global Environment Outlook 3*, p. 108. During the 1990s, for instance, 70 percent of the forestland that disappeared was converted to agricultural production. *Ibid.*, pp. 70, 92. Moreover, "the expansion of permanent arable land on soils previously covered by forests is still the main cause of deforestation in the Brazilian Amazon." *Ibid.*, p. 79.
71. *The State of the World's Forests, 1997*; and Indur Goklany and Merritt Sprague, "Sustaining Development and Biodiversity," *Cato Institute Policy Analysis* no. 175, August 6, 1992; and Avery, pp. 315-332.
72. "Many countries are highly dependent on wood to meet national energy needs and this use accounts for some three-quarters of total roundwood production." *Global Environment Outlook 3*, p. 102.
73. "Rural electrification is being promoted in some countries but the rural poor often cannot afford the tariffs or the costs of electrical appliances." *Ibid.*, p. 100.
74. See, for instance, Peter Bauer, *Dissent on Development* (Cambridge, Mass.: Harvard University Press, 1972); James Gwartney and Robert Lawson, *Economic Freedom of the World: 2002 Annual Report*

(Vancouver: Fraser Institute, 2002); and William Easterly, *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics* (Cambridge, Mass.: MIT Press, 2001).

75. United Nations Environmental Programme, *Global Biodiversity Assessment*, ed. V. H. Heywood (Cambridge: Cambridge University Press, 1995), pp. 204, 206, 207, cited in Lomborg, p. 249.

76. "Only about 1,000 species are recorded as having become extinct in recent years (since 1600)." Nigel Stork, "Measuring Global Biodiversity and Its Decline," in *Biodiversity II*, ed. Edward Wilson and Frances Peter (Washington: National Academy of Sciences, 1997), pp. 45, 60. Dividing that figure by 400 (the number of years between 1600 and 2000) results in an average of 2.5 extinctions a year.

77. Estimates typically range from 17,000 to 100,000 species extinctions a year. See, for instance, Edward Wilson, *The Diversity of Life* (New York: W.W. Norton, 1993), p. 255; and Richard Leakey and Robert Lewin, *The Sixth Extinction* (New York: Anchor Books, Doubleday, 1995), p. 236.

78. Jonathan Ballie and Brian Groombridge, eds., *1996 IUCN Red List of Threatened Animals*, compiled by World Conservation Monitoring Centre (Gland, Switzerland: IUCN—World Conservation Union, 1997) (searchable database available online at [www.wcmc.org.uk/species/animals/animal\\_redlist.html](http://www.wcmc.org.uk/species/animals/animal_redlist.html)); K. S. Walter and H. J. Gillet, eds., *1997 IUCN Red List of Threatened Plants*, compiled by World Conservation Monitoring Centre (Gland, Switzerland: IUCN—World Conservation Union, 1998); Robert May, John Lawton, and Nigel Stork, "Assessing Extinction Rates," in John Lawton and Robert May, *Extinction Rates* (Oxford: Oxford University Press, 1995), pp. 1–24; and Reid in Whitmore and Sayer, p. 56. All cites from Lomborg, table 6, p. 250.

79. Stork, "Measuring Global Biodiversity," p. 47; Virginia Morell, "The Variety of Life," *National Geographic*, February 1999, p. 16; and Laura Tangley, "How Many Species Are There?" *U.S. News & World Report*, August 18–25, 1997, p. 79.

80. W. Wayt Gibbs, "On the Termination of Species," *Scientific American*, November 2001, pp. 40–49.

81. Biologist Thomas Lovejoy, for instance, came to his widely referenced 40,000 extinctions a year figure by assuming that tropical deforestation is in the process of eliminating 50 to 67 percent of all rain forests on the planet. Habitat loss on that scale, he calculated, would reduce the overall number of species by 20 percent. But as noted earlier, tropical deforestation is progressing far more modestly than Lovejoy postulates. Thomas Lovejoy, "A Projection of Species Extinctions," in *The Global 2000 Report to*

*the President of the United States: Entering the 21st Century*, 3 vols., ed. Gerald Barney (New York: Pergamon Press, 1980) pp. 328–31.

82. Ariel Lugo, "Estimating Reductions in the Diversity of Tropical Forest Species," in *Biodiversity*, ed. Edward O. Wilson and Frances Peter (Washington: National Academy Press, 1988), pp. 58–70.

83. D. Simberloff, "Do Species-Area Curves Predict Extinction in Fragmented Forest?" in Whitmore and Sayer, p. 85, cited in Lomborg, p. 254.

84. Even biologist Norman Myers concedes, "We have no way of knowing the actual extinction rate in the tropical forests [where most of the extinctions are allegedly taking place], let alone an approximate guess." Norman Myers, *The Sinking Ark: A New Look at the Problem of Disappearing Species* (Oxford: Pergamon Press, 1979), p. 43, cited in Lomborg, p. 254.

85. V. H. Heywood and S. N. Stuart, "Species Extinctions in Tropical Rainforests," in Whitmore and Sayer, p. 102, cited in Lomborg, p. 255.

86. See generally J. J. Kay, "The Concept of Ecological Integrity, Alternative Theories of Ecology and Implications for Decision-Support Indicators," in *Economic, Ecological, and Decision Theories: Indicators of Ecological Sustainable Development*, ed. P. A. Victor, J. J. Kay, and H. J. Ruitenback (Ottawa: Canadian Environmental Advisory Council, 1991), pp. 23–58; S. T. A. Pickett, V. T. Parker, and P. L. Fiedler, "The New Paradigm in Ecology: Implications for Conservation Biology above the Species Level," in *Conservation Biology: The Theory and Practice of Nature Conservation Preservation and Management*, ed. P. L. Fiedler and S. K. Jain (London: Chapman and Hall, 1992), pp. 66–88; B. H. Walker, "Biodiversity and Ecological Redundancy," *Conservation Biology* 6 (1992): 19–23; and R. F. Noss, "Indicators for Monitoring Biodiversity: A Hierarchical Approach," *Conservation Biology* 4 (1990): 355–64, all cited in Harte, p. 161.

87. Robert Costanza and Bernard Patten, "Defining and Predicting Sustainability," *Ecological Economics* 15 (1995): 194.

88. Harte, p. 162.

89. Igor Shiklomanov, "Appraisal and Assessment of World Water Resources," *Water International* 25; no. 1 (2000): 22; William Cosgrove and Frank Rijsberman, eds. *World Water Vision: Making Water Everybody's Business* (London: Earthscan Publications, 2000), p. 26, cited in Lomborg, p. 150. Approximately 30 percent of the annual amount of "accessible" water provided by nature is harnessed for human purposes, but almost half that amount is returned quickly to the natural water cycle,

which makes use of water withdrawal figures less indicative of the actual burden being placed on water resources. See Lomborg, p. 150.

90. Raphael Semiat, "Desalination: Present and Future," *Water International* 25, no. 1 (2000): 54, 62, cited in Lomborg, p. 153.

91. In principle, the earth's entire present water consumption could be met with a single desalination plant located on the coast of the Sahara Desert. Moreover, that plant could be run by solar cells taking up less than 0.3 percent of the Sahara's expanse. Calculation done by Lomborg in footnote 1095 (p. 384) based on data from John Hille, *Sustainable Norway: Probing the Limits and Equity of Environmental Space* (Oslo: Project for an Alternative Future, 1995), p. 242; Peter Gleick, *Water in Crisis: A Guide to the World's Fresh Water Resources* (New York: Oxford University Press, 1993), p. 372; and S. E. Aly, "Gas Turbine Total Energy Vapour Compression Desalination System," *Energy Conversion & Management* 40, no. 7 (1999): 729-41. Providing desalination services for total municipal water withdrawal across the globe would cost about 0.5 percent of GDP. Calculation performed by Lomborg in footnote 1097 (p. 384) based on data from International Monetary Fund, *International Statistical Yearbook* (Washington: IMF, 2000), p. 113 (updates available online at [www.imf.org/external/np/res/commod/index.htm](http://www.imf.org/external/np/res/commod/index.htm)).

92. World Resources Institute et al., *World Resources 1998-99: A Guide to the Global Environment* (New York: Oxford University Press, 1998), cited in Lomborg, table 4, p. 152.

93. For a summary of the problems with the definition, see Lomborg, pp. 153-54. One of the authors of a UN background report on water needs in 1997 confessed that the benchmark for what constitutes "chronic water scarcity" is "misguidedly considered by some authorities as a critical minimum amount of water for the survival of a modern society." Hille Shuval, "Israel: National Water Resources Conservation Planning and Policies for Rapid Economic Development and Conditions of Severe Scarcity," in J. Lundqvist and Peter Gleick, "Sustaining Our Waters into the 21st Century," background document for UN Commission for Sustainable Development, *Comprehensive Assessment of the Freshwater Resources of the World* (Stockholm: Stockholm Environment Institute, 1997), p. 37, cited in Lomborg, p. 153.

94. World Bank, *World Development Report 1994: Infrastructure for Development* (Oxford: Oxford University Press, 1994), p. 26; World Health Organization, *The International Drinking Water Supply and Sanitation Decade: Review of Regional & Global Data as of 31 December, 1983*, Geneva: World Health

Organization 1986), pp. 15-18; Peter Gleick, *The World's Water 1998-1999: The Biennial Report on Freshwater Resources* (Washington: Island Press, 1998), pp. 262, 264; and Kofi Annan, "Progress Made in Providing Safe Water Supply and Sanitation for All During the 1990s: Report of the Secretary-General," Economic and Social Council, Commission on Sustainable Development, 8th Session, 2000, p. 5 (available online at [www.un.org/esa/sustdev/csd8/wss4rep.pdf](http://www.un.org/esa/sustdev/csd8/wss4rep.pdf)). Calculations performed by Lomborg in figure 5, p. 22.

95. Calculations performed by Lomborg in footnote 154, p. 357, based on data from Annan, p. 5, and World Bank, *World Development Report 1994*, p. 11.

96. David Pimentel et al., "Water Resources: Agriculture, the Environment, and Society," *BioScience* 47, 1997, pp. 97-106.

97. World Bank, *World Development Report 1992: Development and the Environment* (Oxford: Oxford University Press, 1992), p. 16, cited in Lomborg, p. 155.

98. Ariel Dinar, Mark Rosegrant, and Ruth Meinzen-Dick, "Water Allocation Mechanisms: Principles and Examples," World Bank and International Food Policy Research Institute, 1997, p. 12, cited in Lomborg, p. 155.

99. For case studies, see World Resources Institute et al., *World Resources 1996-97* (New York: Oxford University Press, 1996), p. 303; Malin Falkenmark and Carl Widstrand, "Population and Water Resources: A Delicate Balance," *Population Bulletin* 47, no. 3 (1992): 15; Sandra Postel, *Pillar of Sand: Can the Irrigation Miracle Last?* (New York: Norton, 1999), p. 174; Lester Brown et al., eds. *State of the World 1993* (New York: W.W. Norton, 1993), p. 34; and European Environmental Agency, *Environment in the European Union at the Turn of the Century* (Copenhagen: European Environmental Agency, 1999), p. 160. All cites from Lomborg, p. 154.

100. World Bank, *World Development Report 1992*, p. 16, and *World Development Report*, 1994, p. 47. Cited in Lomborg, p. 155.

101. Water subsidies to cities across the developed world are estimated at \$22 billion annually. World Bank, *World Development Report 1994*, pp. 121-22, and A. P. G. de Moor, "Perverse Incentives: Subsidies and Sustainable Development," 1998, chapter 5, [www.ecouncil.ac.cr/rio/focus/report/english/subsidies](http://www.ecouncil.ac.cr/rio/focus/report/english/subsidies). All cites from Lomborg, p. 156.

102. M. W. Rosegrant, R. G. Schleyer, and S. N. Yadav, "Water Policy for Efficient Agricultural Diversification: Market-Based Approaches," *Food Policy* 20, 1995, pp. 203-23; and I. Serageldin, "Toward Sustainable Management of Water Resources," World Bank,



Washington, D.C., 1995. Both citations from Goklany, "Saving Habitat," p. 949.

103. This is, in fact, the prevailing view among experts. For instance, the most recent UN report on the subject finds that water shortages occur "largely as a result of poor water allocation, wasteful use of the resource, and lack of adequate management action." UN Commission for Sustainable Development, *Comprehensive Assessment of the Freshwater Resources of the World*, p. 1. The World Water Council argues: "There is a water crisis today. But the crisis is not about having too little water to satisfy our needs. It is a crisis of managing water so badly that billions of people—and the environment—suffer badly." Cosgrove and Rijsberman, *World Water Vision: Making Water Everybody's Business*, p. xix. All cites from Lomborg, p. 157.

104. "What environmentalists mainly say on this topic [of resource scarcity] is not that we are running out of energy but that we are running out of environment—that is, running out of the capacity of air, water, soil and biota to absorb, without intolerable consequences for human well-being, the effects of energy extraction, transport, transformation and use" Joe Holdren, "Energy: Asking the Wrong Question," *Scientific American*, January 2, 2002, p. 65, [www.sciam.com/article.cfm?articleID=000F3D47-C6D2-1CEB-93F6809EC5880000&pageNumber=5&catID=2](http://www.sciam.com/article.cfm?articleID=000F3D47-C6D2-1CEB-93F6809EC5880000&pageNumber=5&catID=2)

105. Calculation performed by Indur Goklany, *Clearing the Air: The Real Story of America's War on Air Pollution* (Washington: Cato Institute, 1999), based on data published by the U.S. Council on Environmental Quality and the U.S. Environmental Protection Agency, various sources (see footnote 10, p. 168), p. 54.

106. Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, *National Air Quality and Emission Trends Report, 1994, Data Appendix*, EPA 454/R-95-XXX, cited in Goklany, *Clearing the Air*, p. 55.

107. Calculation performed by Goklany based on data from the U.S. Council on Environmental Quality, U.S. Department of Commerce, and the U.S. Environmental Protection Agency (various sources). See Goklany, *Clearing the Air*, figure 3-6, p. 64.

108. Calculation performed by Goklany based on data from the U.S. Council on Environmental Quality, U.S. Department of Commerce, and the U.S. Environmental Protection Agency (various sources). *Ibid.*, figure 3-2, p. 57.

109. *Ibid.*, pp. 56–57.

110. The metric is not particularly helpful

because it provides no information about ozone concentrations during the majority of time spent outdoors and is highly subject to meteorological factors. *Ibid.*, pp. 58–59.

111. Calculation performed by Goklany based on data from the U.S. Council on Environmental Quality and the U.S. Environmental Protection Agency (various sources). *Ibid.*, figure 3-4, p. 61.

112. EPA data cited in Steven Hayward and Julie Majeres, *Index of Leading Environmental Indicators*, 7th ed. (San Francisco: Pacific Research Institute, 2002), figure 6, p. 20.

113. Calculation performed by Goklany based on data from the U.S. Council on Environmental Quality, U.S. Department of Commerce, and the U.S. Environmental Protection Agency (various sources). See Goklany, *Clearing the Air*, figure 3-3, p. 59.

114. *Ibid.*

115. Calculation performed by Goklany based on data from the U.S. Council on Environmental Quality, the U.S. Department of Commerce, and the U.S. Environmental Protection Agency (various sources). *Ibid.*, figure 3-5, p. 63.

116. U.S. Environmental Protection Agency, *National Air Quality and Emission Trends Report 1998, 2000*, p. 77, [www.epa.gov/oar/aqtrnd98](http://www.epa.gov/oar/aqtrnd98), cited in Lomborg, p. 166.

117. Calculation by Lomborg in figure 87, p. 166, based on data from the U.S. Environmental Protection Agency, U.S. Department of Labor, and economists Alan Krupnick and Dallas Butraw of Resources for the Future. For methodological qualifications, see Lomborg, footnote 1166, p. 386.

118. For a regression analysis demonstrating the relationship, see Richard Carson, Yongil Jeon, and Donald McCubbin, "The Relationship between Air Pollution Emissions and Income: U.S. Data," Working Paper 97/08, Department of Economics, University of California, San Diego, February 1997.

119. For a review of the data, see OECD, "Key Environmental Indicators," OECD Environment Directorate, May 2001, pp. 16–17.

120. Environmental Kuznets Curves are so named because the inverted U-shaped relationships discovered when per capita income and environmental indicators are put in graph form bear a striking resemblance to the relationship between income inequality and economic development discovered by economist Simon Kuznets in 1955.

121. Mathew Cole, A. J. Rayner, and J. M. Bates,

- “The Environmental Kuznets Curve: An Empirical Analysis,” *Environment and Development Economics* 2, no. 4 (1997): 401–16; Thomas Seldon and Daqing Song, “Environmental Quality and Development: Is There a Kuznets Curve for Air Pollution?” *Journal of Environmental Economics and Management* 27, no. 2 (1994): 147–62; N. Shafik, “Economic Development and Environmental Quality: An Econometric Analysis,” *Oxford Energy Papers* 46 (1994): 757–73; and Gene Grossman and Alan Krueger, “Economic Growth and the Environment,” *Quarterly Journal of Economics* (May 1995): 353–77. All cites from Cole, “Limits to Growth,” table 1, p. 92. See also T. Panayotou, “Environmental Degradation,” and T. Panayotou, “Demystifying the Environmental Kuznets Curve: Turning a Black Box into a Policy Tool,” *Environment and Development Economics* 2, no. 4 (1997): 465–79.
122. Shafik; Seldon and Song; Panayotou, “Environmental Degradation”; Cole, Rayner, and Bates; and Grossman and Krueger.
123. Cole, Rayner, and Bates; Seldon and Song; and Panayotou, “Environmental Degradation.”
124. Seldon and Song; and Cole, Rayner, and Bates.
125. “Air Pollution in the World’s Megacities,” *Environment* 36, no. 2 (March 1994): figure 5, p. 33.
126. Mohamed T. El-Ashry, “Balancing Economic Development with Environmental Protection in Developing and Lesser Developed Countries,” *Journal of the Air & Waste Management Association* 43 (January 1993): 18.
127. *Ibid.*, p. 23.
128. Wilfred Beckerman, “Economic Growth and the Environment: Whose Growth? Whose Environment?” *World Development* 20 (1992): 481–96, cited in Barbier, “Introduction to the EKC Special Issue,” p. 370; and Goklany, *Clearing the Air*, pp. 87–109. The contention that environmental quality is a “luxury” good, however, is somewhat difficult to substantiate. For a critique, see K. E. McConnell, “Income and the Demand for Environmental Quality,” *Environment and Development Economics* 2, no. 4 (1997): 383–99.
129. M. Komen, S. Gerking, and H. Folmer, “Income and Environmental R&D: Empirical Evidence from OECD Countries,” *Environment and Development Economics* 2, no. 4 (1997): 505–515; and Carson, Jeon, and McCubbin.
130. Beckerman, “Economic Growth and the Environment”; and Panayotou, “Demystifying the EKC.”
131. Beckerman, “Economic Growth and the Environment;” and S. M. DeBruyn, “Explaining the Environmental Kuznets Curve: Structural Change and International Agreements in Reducing Sulphur Emissions,” *Environment and Development Economics* 2, no. 4 (1997): 485–503.
132. Panayotou, “Demystifying the EKC.”
133. The only study that did not find a relationship between per capita income and pollution pertained to an analysis of Malaysia. See J. R. Vincent, “Testing for Environmental Kuznets Curves within a Developing Country,” *Environment and Development Economics* 2, no. 4 (1997): 417–31. All others have confirmed the relationship. Analysts, however, find no relationship between per capita income growth and carbon dioxide emission reductions, suggesting that income growth will not slow emissions of those greenhouse gases. See Douglas Holtz-Eaken and Thomas Selden, “Stoking the Fires? CO<sub>2</sub> Emissions and Economic Growth,” Working Paper 4248, National Bureau of Economic Research, December 1992; and Cole, Rayner, and Bates, pp. 401–16 (which otherwise finds support for the EKC hypothesis).
134. *Global Environment Outlook* 3, p. 32.
135. Barbier, “Introduction to EKC Special Issue,” p. 374.
136. Fecal bacteria primarily enter coastal waters from sewage treatment centers, stormwater runoff, and sewage overflows.
137. European Union, *Bathing Water Quality: Annual Report, 1999 Bathing Season, 2000* (available online at [www.europa.eu.int/water/water-bathing/report.html](http://www.europa.eu.int/water/water-bathing/report.html)). Cited by Lomborg in figure 104, p. 194.
138. Lomborg, p. 195. A national database is compiled by the Natural Resources Defense Council, but given the great differences between the number of communities monitored by that organization from year to year, NRDC itself concedes that “it is impossible to make direct comparisons between states or to assess trends over time based on this closure data.” Natural Resources Defense Council, “Testing the Waters—1999: A Guide to Water Quality at Vacation Beaches,” 1999, [www.nrdc.org/water/oceans/ttw/titinx.asp](http://www.nrdc.org/water/oceans/ttw/titinx.asp), cited in Lomborg, p. 195. The U.S. Environmental Protection Agency also maintains a database on coastal water quality and beach closings, but it, too, is hobbled by changes in the number of beaches monitored from year to year, disparate standards, and a limited data set. “EPA’s BEACH Watch Program: 2001 Swimming Season,” EPA 823-F-02-008, Office of Water (4305), May 2002, [www.epa.gov/waterscience/](http://www.epa.gov/waterscience/)

beaches/2001surveyfs.pdf.

139. Oxygen depletion occurs when excessive amounts of nutrients run off from farmland into coastal waters, causing algae blooms that “suffocate” large flora and fauna. This condition, referred to as “eutrophication,” is decried by the United Nations as the main threat to coastal ecosystems. European Environmental Agency, *Europe’s Environment: The Second Assessment* (Copenhagen: European Environmental Agency, 1998), p. 210, cited in Lomborg, p. 196.

140. “The economic assessment based on fisheries data, however, failed to detect effects attributable to hypoxia. Overall, fisheries landings statistics for at least the last few decades have been relatively constant. The failure to identify clear hypoxic effects in the fisheries statistics does not necessarily mean that they are absent.” Robert Diaz and Andrew Solow, “Gulf of Mexico Hypoxia Assessment: Topic #2. Ecological and Economic Consequences of Hypoxia,” Hypoxia Work Group, White House Office of Science and Technology Policy, Committee on Environment and Natural Resources for the EPA Mississippi River/Gulf of Mexico Watershed Nutrient Task Force, NOAA Coastal Ocean Program, 1999, pp. 8-9, cited in Lomborg, p. 198.

141. *Global Environment Outlook 3*, p. 195.

142. Ausubel, “The Great Reversal.”

143. The UN Environment Programme, however, cautions against excessive concern. “High levels of mercury in tuna and swordfish, for example, have been shown to have natural sources; the most dramatic effects of oil spills have proved to be localized and relatively transient; and heavy metal contamination, except for lead and mercury, has been found to be highly localized and has relatively minor impacts except at high concentrations.” *Global Environment Outlook 3*, p. 183.

144. Tom O’Connor, “1998 State of the Coastal Environment: Chemical Contaminants in Oysters and Mussels,” National Oceanic and Atmospheric Administration, 1998, cited in Lomborg, figure 105, p. 195.

145. Danish Veterinary and Food Administration, “Pesticide Residues in Danish Food 1993,” 1994, p. 78, cited in Lomborg, p. 195.

146. World Bank, *World Development Report 1992*; and Shafik, p. 764; both sources cited in Lomborg, figure 109, p. 202.

147. Lomborg, p. 203. Emphasis in original.

148. F. Smith et al., “Estimating Extinction Rates,”

*Nature* 364 (1993): 494–96, cited in Lomborg, p. 204.

149. Grossman and Kreuger, cited in Cole, “Limits to Growth,” table 1, p. 92.

150. Smith et al.; and Department of Environmental Protection, Bureau of Wastewater Pollution Control, Marine Sciences Section, “1998 New York Harbor Water Quality Survey,” New York City, 1998, p. 5, cited in Lomborg, p. 204.

151. Goudie, p. 224; Peter Kristensen and Hans Ole Hansen, eds., *European Rivers and Lakes: Assessment of Their Environmental State* (Copenhagen: European Environmental Agency, 1994), p. 49; Organization for Economic Cooperation and Development, *OECD Environmental Data Compendium 1999* (Paris: OECD 1999), p. 85; Department of Environmental Protection, Bureau of Wastewater Pollution Control, Marine Sciences Section, “1997 New York Harbor Water Quality Survey,” New York City, 1997, pp. 38, 57; and “1998 New York Harbor Water Quality Survey,” p. 7. All cites from Lomborg, figure 110, p. 203.

152. David Stanners and Philippe Bourdeau, eds., *Europe’s Environment: The Dobris Assessment* (Copenhagen: European Environment Agency, 1995), pp. 82, 87. For a report on the strong improvements in U.K. water quality, see United Kingdom Environment Agency, 2000, cited in Lomborg, p. 204.

153. U.S. Environmental Protection Agency, Office of Wastewater Management, “Water Pollution Control: 25 Years of Progress and Challenges for the New Millennium,” EPA 833-F-98-003, June 1998, p. 1. For an excellent snapshot of overall freshwater quality in the United States, see U.S. Environmental Protection Agency, “National Water Quality Inventory: 1998 Report to Congress,” 1998, [www.epa.gov/305b/98report](http://www.epa.gov/305b/98report).

154. *Ibid.*

155. Grossman and Kreuger, cited in Barbier, “Introduction to EKC Special Issue,” table 1, p. 373.

156. National Containment Biomonitoring Program, “NCBP Fish Database,” 2000, [www.cerc.usgs.gov/data/ncbp/fish.htm](http://www.cerc.usgs.gov/data/ncbp/fish.htm); National Containment Biomonitoring Program, “NCBP Starling Database,” 2000, [www.cerc.usgs.gov/data/ncbp/starling/starling.htm](http://www.cerc.usgs.gov/data/ncbp/starling/starling.htm); President’s Council on Environmental Quality, *Environmental Quality 1996* (1997): 334–38; and “State of the Great Lakes 1995,” State of the Great Lakes Ecosystem Conference, 1995. All cites from Lomborg, figure 112, p. 205.

157. Grossman and Kreuger, cited in Barbier,

- "Introduction to EKC Special Issue," table 1, p. 373.
158. *Global Environment Outlook 3*, p. 181.
159. *Ibid.*, p. 32.
160. See generally John Powelson and Richard Stock, *The Peasant Betrayed: Agricultural and Land Reform in the Third World* (Washington: Cato Institute, 1990); and Romeo Bautista and Alberto Valdes, eds., *The Bias against Agriculture: Trade and Macroeconomic Policies in Developing Countries* (San Francisco: Institute for Contemporary Studies Press, 1993).
161. M. Montgomery, "How Large Is Too Large? Implications of the City Size Literature for Population Policy and Research," *Economic Development and Cultural Change* 36 (1988): 691–720; and A. C. Kelly and J. G. Williamson, *What Drives Third World City Growth?* (Princeton, N.J.: Princeton University Press, 1984).
162. H. Chenery, S. Robinson, and M. Syrquin, *Industrialization and Growth: A Comparative Study* (New York: Oxford University Press, 1986); and E. S. Mills and C. M. Becker, *Studies in Indian Urban Development* (New York: Oxford University Press, 1986). Environmental quality is also frequently better in "megacities" than in the rural regions of the developing world. For instance, 84 percent of Africans in urban areas have access to reasonably good sanitation compared to only 45 percent of those Africans living in rural areas. *Global Environment Outlook 3*, p. 159.
163. Vibhooti Shukla and Kirit Parikh, "The Environmental Consequences of Urban Growth: Cross-National Perspectives on Economic Development, Air Pollution, and City Size," *Urban Geography* 13, no. 5 (1992): 425.
164. E. S. Mills and P. E. Graves, *The Economics of Environmental Quality* (New York: W.W. Norton, 1986).
165. Shukla and Parikh, p. 422. Analysis of the data also led Pearce and Warford to conclude that "trends in air pollution are determined as much by policy measures and the nature of the urban economy as by population density." Pearce and Warford, p. 170.
166. *Ibid.*, pp. 429–40.
167. *Ibid.*, p. 442.
168. Ryan and Flavin, p. 125.
169. Magretta, p. 87.
170. *Ibid.*
171. William Chandler, Alexei Makarov, and Zhou Dadi, "Energy for the Soviet Union, Eastern Europe, and China," *Scientific American* 263, no. 3 (September 1990): 121.
172. Even if the world market share of nonfossil fuels doubled by the year 2020 (about all that is technically feasible even if economic considerations were discarded), coal and oil were the fossil fuels that were the primary market "losers," and energy efficiency investments were maximized, fossil fuel consumption would still increase substantially as would world carbon dioxide emissions. See William Leffler and Renata Karlin, "Energy and the Environment: Is a Sustainable Energy Path Possible?" written remarks delivered at the Global Tomorrow Coalition: 21st Century Dialogue, February 25, 1993, pp. 11–12.
173. The traditional answer to this observation is that certain commodities impose external costs—such as pollution—that must be internalized in that commodity's price if economic efficiency is to be served. Given the extreme difficulty of pricing nonmarket goods, however, most economists believe prices should be left unmolested by government. On this point, see generally James Buchanan, "Introduction: LSE Cost Theory in Retrospect," in *LSE Essays on Cost*, ed. Buchanan and Thirlby (New York: New York University Press, 1981); Roy Cordato, *Welfare Economics and Externalities in an Open-Ended Universe* (Boston: Kluwer Academic Publishers, 1992); and Israel Kirzner, *Market Theory and the Price System* (Princeton: D. Van Nostrand, 1963). Instead, ex post regulation of potential external harms would be easier and indirectly affect commodity prices so that the same end—internalization of environmental externalities—is achieved.
174. Jerry Taylor and Peter VanDoren, "Evaluating the Case for Renewable Energy: Is Government Support Warranted?" Cato Institute Policy Analysis no. 422, January 10, 2002.
175. Ian Johnson, "Beijing Ends Roast Mutton Smog," *Baltimore Sun*, January 7, 1997, p. A2.
176. For a review of the arguments against scientific alarmism, see Patrick J. Michaels and Robert Balling, *The Satanic Gases: Clearing the Air about Global Warming* (Washington: Cato Institute, 2000).
177. John Christy et al., "Differential Trends in Tropical Sea Surface and Atmospheric Temperatures since 1979," *Geophysical Research Letters* 28 (2001): 183–86; Intergovernmental Panel on Climate Change, "Summary for Policymakers: International Panel on Climate Change Working Group I Third Assessment Report," 2001, pp. 1–2; and Michaels and Balling.

178. Michaels and Balling, pp. 104–7, 210–11.
179. *Ibid.*, pp. 88–90
180. *Ibid.*, pp. 50–54, 111–157.
181. John Fialka, “Global Warming Bad? Not to Some Farmers in Alaska’s Far North,” *Wall Street Journal*, June 10, 1998, p. A1.
182. “The Benefits of Climate Change? China’s Take on Global Warming,” article appearing in “Weathervane,” a website maintained by Resources for the Future ([www.weathervane.rff.org/](http://www.weathervane.rff.org/)), reported in “China May Benefit from Climate Change,” *May Cooler Heads Prevail; A Bi-Weekly Newsletter Covering Climate Change Issues* (Washington: Competitive Enterprise Institute), September 3, 1997, pp. 2–3.
183. *Ibid.*
184. *Ibid.*
185. *Ibid.*
186. Robert Mendelsohn, ed. *Global Warming and the American Economy: A Regional Assessment of Climate Change Impacts* (Northampton, Mass: Edward Elgar, 2001).
187. Thomas Gale Moore, *Climate of Fear: Why We Shouldn’t Worry about Global Warming* (Washington: Cato Institute, 1998).
188. *Global Environment Outlook 3*, pp. 65–66.
189. Beckerman, p. 112.
190. C. Rosenzweig and M. L. Perry, “Potential Impact of Climate Change on World Food Supply,” *Nature* 367, January 13, 1994, pp. 133–138; *Through Green-Colored Glasses*; and International Panel on Climate Change, *Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific and Technical Analyses* (New York: Cambridge University Press, 1996). Both citations from Goklany, “Saving Habitat,” p. 950.
191. For a thorough review of the argument, see Goklany, *The Precautionary Principle*, pp. 57–88.
192. Deepak Lal, “Ecological Imperialism: The Prospective Costs of Kyoto for the Third World,” in *The Costs of Kyoto*, ed. Jonathan Adler (Washington: Competitive Enterprise Institute, 1997), pp. 83–84.
193. Sylvia Nasar, “Cooling the Globe Would Be Nice, but Saving Lives Now May Cost Less,” *New York Times*, May 31, 1992, p. E6.
194. Other sustainability indicators not examined here include the OECD’s “Key Environmental Indicators”; “Sustainable Development in the United States: An Experimental Set of Indicators,” September 2001 Final Report, U.S. Interagency Working Group on Sustainable Development Indicators, Washington, D.C., July 2002; “Draft 2002 Sustainability Reporting Guidelines,” Global Reporting Initiative, April 1, 2002; “Indicators of Sustainable Development: Guidelines and Methodologies,” United Nations Commission on Sustainable Development (undated); and *The Little Green Data Book 2001*, International Bank for Reconstruction and Development (Washington, D.C.: World Bank, 2001).
195. Paul Waggoner and Jesse Ausubel, “A Framework for Sustainability Science: A Renovated IPAT Identity,” *Proceedings of the National Academy of Sciences* 99:12, June 11, 2002, pp. 7860–65.
196. *Ibid.*, p. 7865.
197. World Wildlife Federation International, “Living Planet Report 2002,” 2002, p. 3.
198. *Ibid.*
199. *Ibid.*
200. Mathis Wackernagel et al., “Tracking the Ecological Overshoot of the Human Economy,” *Proceedings of the National Academy of Sciences* 99, no. 44, (July 9, 2002): 9266–71.
201. *Ibid.*, p. 9266.
202. *Ibid.*
203. Sylvan Wittwer, *Food, Climate, and Carbon Dioxide* (Boca Raton, Fla.: CRC Press, 1995). See also Michaels and Balling, pp. 177–90.
204. See figure 2 in Wackernagel et al., p. 9270.
205. “If the world farmer reaches the average yield of today’s U.S. corn grower during the next 70 years, ten billion people eating as people now on average do will need only half of today’s cropland. The land spared exceeds Amazonia. This will happen if farmers sustain the yearly 2 percent world-wide yield growth of grains achieved since 1960, in other words, if social learning continues as usual. If the rate falls by one half, an area the size of India, globally, can still revert from agriculture to woodland or other uses. If the ten billion in 2070 prefer a meaty diet of 6,000 primary calories/day for food and fuel (twice today’s average primary calories), they roughly halve the land spared. A cautious global scenario of sustained yield growth and more calories still offers more

than 10 percent of present world farmland, more than 10 Iowas or 3 Spains, for the Great Restoration." Ausubel, "The Great Reversal."

206. *Ibid.*

207. *Global Environment Outlook 3*, p. 71.

208. Global Leaders of Tomorrow Environment Task Force et al., "2002 Environmental Sustainability Index," 2002, [www.ciesin.columbia.edu/indicators/ESI](http://www.ciesin.columbia.edu/indicators/ESI).

209. Robert Prescott-Allen, *The Well-being of Nations* (Washington: Island Press, 2001).

210. Cited in "2002 Environmental Sustainability Index," pp. 18–19.

211. For a comparison of the indices used in each study and the strong correlations between the findings of these reports, see *ibid.*, pp. 18–21.

212. *Ibid.*, p. 6.

213. *Ibid.*, p. 1.

214. Those include air quality (determined by concentrations of sulfur dioxide, nitrogen dioxide, and total suspended particulates); water quality (determined by dissolved oxygen concentrations, phosphorus concentrations, suspended solids, and electrical conductivity); biodiversity (the percentage of mammals and birds currently threatened); land use (the percentage of land being used by man); "ecosystem stress" (defined by the percentage of change in forest cover from 1990 to 2000 and the percentage of the country experiencing significant acidification), and "environmental health" (defined as the child death rate from respiratory diseases, the death rate from intestinal infectious diseases, and the under-five mortality rate). *Ibid.*, table 3, pp. 7–8.

215. The problems are legion. A brief review of the most important issues follows.

Although the air and water quality indicators are reasonable, the data from specific monitoring stations are not selected by any consistent criteria. Moreover, because monitoring stations are most likely to be sited where pollution problems exist (and to be absent from those areas where environmental quality is not an important concern for whatever reason), the data are almost certainly unrepresentative of mean pollution concentrations. *Ibid.*, p. 32. Moreover, data about concentrations of air and water pollution are sparse. The report, for instance, acknowledges that 101 countries lacked data regarding the concentration of suspended solids in water, 100 countries lacked data regarding the electrical conductivity of

water, 94 countries lacked data regarding the concentration of phosphorus in water, 93 countries lacked data regarding urban concentrations of particulate matter, 91 countries lacked data regarding concentrations of sulfur dioxide and nitrogen dioxide, and 90 countries lacked data regarding the concentration of dissolved oxygen in water bodies. Yet the authors estimated values for those indicators anyway. *Ibid.*, table A3.1, p. 51. For a discussion of regression analysis used to generate the missing numbers crucial to the report, see *ibid.*, pp. 52–55. Unfortunately, those calculations are highly speculative.

The calculations regarding biodiversity are hobbled by the fact that the overwhelming majority of species are neither mammalian or avian, and the health of the species monitored does not necessarily imply anything about the health of the far more numerous insect or plant species of concern (for instance, the wolf population in the eastern United States is low despite the fact that other species are doing quite well in those same ecosystems). Furthermore, the authors concede that the "biodiversity indicator is vulnerable to distortion among countries that have very small number of species (Haiti has only four mammals, for example). In these countries, a small difference in the number of endangered species makes a big difference in the percentage." *Ibid.*, p. 33.

The consideration of "land use" as an indicator (defined as "combining layers of information on land cover, population density, stable 'lights at night' and human infrastructure in a geographic information system," *ibid.*, p. 34) is dubious because it reveals nothing about the health of surrounding ecosystems or pollution sheds, implies that development beyond primitive hunter-gatherer societies is undesirable, and disregards the resources created by such infrastructures.

The use of child death rates from respiratory diseases, the death rate from intestinal infectious diseases, and the under-five mortality rate is problematic because, as the authors concede, "not all of those deaths are attributable to environmental conditions." *Ibid.*, p. 39.

216. Unfortunately, the authors measure drinking water supply by assuming a correlation between certain technologies—such as boreholes and water pumps—and safe drinking water (*ibid.*, p. 38). Yet relying upon open water sources such as lakes and streams is not necessarily unsafe or suboptimal. After all, northern Virginia and Washington, D.C., rely almost exclusively on the Potomac River for drinking water supply with no ill effect. Another indicator—"reducing water stress"—relies on four variables, one of which is water stress. While that variable is a reasonable reflection of resource availability, it's offset by three other variables (fertilizer consumption, pesticide use, and industrial organic pollutants per

unit of available freshwater) that are generally correlated with increased—not decreased—resource availability. Accordingly, that indicator is worthless as a reflection of resource availability.

217. The variables for this index include a stylized “technology achievement index,” a “technology innovation index,” and mean years of education. This index is only marginally useful because a nation does not have to invent its own technologies to take advantage of advances or innovations in other, more scientifically advanced nations.

218. Eight variables go into this “environmental governance” index: data from surveys regarding regulatory enforcement practices, land under “protected status,” the number of state guidelines issued to private industries, the amount of forestland being protected from “unsustainable” uses, the control of corruption, the ratio of gasoline prices to the international average, subsidies for energy and materials use, and subsidies to the commercial fishing sector. *Ibid.*, table 3, p. 8. Although such an index would be useful, contaminating it with assumptions about the relative ecological value of public versus private lands, fuel taxes, and biases toward certain kinds of regulatory approaches rather than others renders it not particularly helpful.

219. See Taylor and VanDoren, “Evaluating the Case for Renewable Energy.”

220. See for instance Robert L. Bradley Jr., “Renewable Energy: Not Cheap, Not ‘Green,’” *Cato Institute Policy Analysis* no. 280, August 27, 1997; and Howard Hayden, *The Solar Fraud: Why Solar Energy Won't Run the World* (Pueblo West, Colo.: Vales Lake Publishing, 2001).

221. Murray Feshbach and Alfred Friendly Jr., *Ecocide in the USSR: Health and Nature under Siege* (New York: Basic Books, 1992).

222. For a review of the health and environmental problems posed by horse transport, see Joel Tarr, “The Horse: Polluter of the City,” in *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective* (Akron, Ohio: University of Akron Press, 1996); Martin Milosi, *Garbage in the Cities: Refuse, Reform, and the Environment 1880–1980* (Chicago: Dorsey Press, 1988); Edwin Burrows and Mike Wallace, *Gotham: A History of New York City to 1898* (Oxford: Oxford University Press: 1999), p. 787; Thomas DeGregori, *A Theory of Technology* (Ames: Iowa State University Press, 1985), pp. 182–83; M. G. Lay and James Vance Jr., *Ways of the World: A History of the World's Roads and of the Vehicles That Used Them* (New Brunswick, N.J.: Rutgers University Press, 1992), pp. 131–32; and “America's Highways, 1776 to 1976: Pollution in the Horse

and Buggy Era,” Federal Highway Administration, U.S. Department of Transportation, 1976.

An excerpt from the FHWA report (p. 366) is indicative: “As the number of horses multiplied they began to be denounced as polluters of the environment in harsh terms similar to those applied to automobiles today. Nineteenth century urban life generally moved at the pace of horse-drawn transportation. Evidence of the horse could not be missed. It was seen in the piles of manure littering the streets, attracting swarms of flies and creating a stench, and in the numerous livery stables that let loose an odor that could only mean ‘horse.’ . . . Carcasses added another dimension to the smells and swarms of flies. In 1880 New York City removed some 15,000 dead horses from its streets, and Chicago carted away 10,000 horses as late as 1912. Because of this problem the cities constantly feared epidemics of cholera, smallpox, yellow fever, or typhoid. Medical authorities blamed the spread of these diseases on filth in the atmosphere and believed that the horse was the chief offender. . . . Even in 1908 *Appleton's Magazine* in an article “The Horse v. Health” blamed most of the sanitary and economic problems of cities on the horse. The article calculated that the horse problem cost New York City some \$100 million each year. . . . The solution to these problems, critics agreed, was the horseless carriage. As the motor car and the truck began to replace the horse, benefits were clearly seen. Streets were cleaner, pollution from manure was diminished, the number of flies dropped, goods were transported more cheaply and more efficiently, and traffic moved faster. By the early part of this century, the advantages of the motor vehicle over the horse were accepted in nearly every quarter.”

223. Goklany and Sprague, pp. 4–5.

224. The calculation is actually quite conservative. It assumes that productivity on pre-1961 lands could have been maintained without additional technological improvements and that new agricultural lands would have been, on average, as productive as pre-1961 lands. Both assumptions are improbable. Goklany, “Saving Habitat,” p. 941.

225. Jesse Ausubel, “Can Technology Spare the Earth?” *American Scientist* 84, 1996, pp. 166–178, cited in *ibid.*

226. Beside the fact that the findings produced by Wackernagel et al. poorly reflect the phenomenon they purport to measure, their use by the authors of the 2002 “Environmental Sustainability Index” double counts the CO<sub>2</sub> emissions and land-use data already incorporated in their index.

227. Membership in the World Business Council for Sustainable Development, for instance,

- denotes support for a policy agenda generally at odds with the conclusions of this study. "2002 Environmental Sustainability Index," table 3, p. 8.
228. Variables that fall under this category include the number of domestic firms that are certified in compliance with "ISO 14001" standards, the number of domestic firms that are a part of the "Dow Jones Sustainability Group Index," and the average "EcoValue" rating of domestic companies. *Ibid.*
229. The variable used is IUCN (the World Conservation Union, a coalition of various non-governmental organizations active on environmental issues) member organizations per million population. *Ibid.*
230. Variables include the number of memberships in intergovernmental environmental organizations; the percentage of CITES (the Convention on International Trade in Endangered Species of Wild Fauna and Flora) reporting requirements met; the level of participation in the UN Climate Change Convention, the Montreal Protocol multilateral fund (which pertains to the use and release of ozone-depleting chemicals), and the UN Global Environmental Facility; and compliance with miscellaneous international environmental agreements. *Ibid.*
231. *Ibid.*, p. 5.
232. *Ibid.*, p. 6. For a summary of the methodology used, see *ibid.*, pp. 52–55.
233. *Ibid.*, p. 18.
234. *Ibid.*, table 1, p. 3.
235. Mohan Munasinghe and Wilfredo Cruz, "Economywide Policies and the Environment: Lessons from Experience," World Bank Environment Paper no. 10 Washington, D.C., 1995.
236. *Ibid.*
237. For a good review of the literature underscoring the importance of economic liberalization for sustainable development, see Pearce and Warford, pp. 173–93, 217–32, 235–58.
238. Munasinghe and Cruz, p. 2.
239. *Ibid.*, p. 15.
240. World Resources Institute et al., *World Resources 1994–95* (New York: Oxford University Press, 1994) p. 74.
241. Environmentally destructive subsidies are estimated at between \$700 billion and \$2 trillion worldwide. Vijay Vaitheeswaran, "How Many Planets? A Survey of the Global Environment," *The Economist*, July 6, 2002, Special Insert, p. 16.
242. Mikhail Bernstam, *The Wealth of Nations and the Environment* (London: Institute of Economic Affairs, 1991).
243. Pearce and Warford, p. 219.
244. See, for example, Yongyuth Chalamwong and Gershon Feder, "Land Ownership Security and Land Values in Rural Thailand," World Bank, Working Paper 790, 1986; Gershon Feder and Raymond Noronha, "Land Rights Systems and Agricultural Development in Sub-Sahara Africa," *World Bank Research Observer* 2, no. 2 (1987): 143–69; and Pearce and Warford, pp. 30–31.
245. *Ibid.*, p. 24.
246. El-Ashry, p. 20.
247. *Ibid.*, p. 2.
248. *Ibid.*, pp. 2–3.
249. *Ibid.*, p. 3
250. *Ibid.*, p. 27.
251. Chisholm, Hartley, and Porter, pp. 32–33.
252. For a review of common administrative and political problems facing environmental regulators in the developing world, see J. Eugene Gibson and Faith Halther, "Strengthening Environmental Law in Developing Countries," *Environment* 36, no. 1 (January/February 1994): 40–43.
253. Munasinghe and Cruz, p. 26.
254. World Resources Institute, *World Resources 1998–99*, p. 91.
255. Keith Schneider, "Unbending Regulations Incite Move to Alter Pollution Laws," *New York Times*, November 29, 1993, p. A1; Tom Tietenberg, *Environmental and Resource Economics*, 3d ed. (New York: Harper Collins, 1992), pp. 360–421; and Thomas Schelling, *Incentives for Environmental Protection* (Cambridge, Mass.: MIT Press, 1983).
256. *Ibid.*
257. *Ibid.*
258. For a brief summary of the environmental arguments against free trade, see Hilary French, "Reconciling Trade and the Environment," in *State of the World 1993*, ed. Lester Brown (New York: W.W. Norton, November 1993), pp. 158–79; and Herman Daly, "The Perils of Free Trade," *Scientific*



- American* 269, no. 5 (November 1993): 50–57.
259. Goklany, “Saving Habitat,” p. 946.
260. *Ibid.*
261. FAO, *The State of the World's Forests, 1997*, cited in *ibid.*
262. Pearce and Warford, p. 191.
263. Goklany, “Saving Habitat,” p. 943.
264. Indur Goklany, “Strategies to Enhance Adaptability: Technological Change, Sustainable Growth, and Free Trade,” in *Climate Change* (Netherlands: Kluwer Academic Publishers, 1995), vol. 30, p. 441.
265. For example, overseas competition is widely thought to have speeded up the introduction of automobile tailpipe controls and more fuel-efficient vehicles in the United States. E. P. Seskin, “Automobile Air Pollution Policy,” in *Current Issues in U.S. Environmental Policy*, ed. Paul Portney (Baltimore: Johns Hopkins University Press, 1978), pp. 68–104; and I. G. Barbour, *Technology, Environment, and Human Values* (New York: Praeger, 1980), cited in Goklany “Strategies to Enhance Adapt-ability,” p. 442.
266. Pearce and Warford, p. 227.
267. *Ibid.*, pp. 228–29.
268. *Ibid.*, p. 213.
269. *Ibid.*
270. El-Ashry, p. 20.
271. See generally the publications of the Competitive Enterprise Institute documenting the success of private conservation and its superiority to command-and-control approaches, [www.cei.org/sections/section35.cfm](http://www.cei.org/sections/section35.cfm).
272. “A major policy failure leading to land degradation is insecure land title.” *Global Environment Outlook 3*, p. 74. See also Pearce and Warford, p. 279.
273. Rice, Guillison, and Reid, p. 47.
274. *Ibid.*
275. For a discussion of the implications of that observation, see Shmuel Amir, “The Environmental Cost of Sustainable Welfare,” Discussion Paper QE92-17-REV, Resources for the Future, Washington, D.C., September 1992.
276. *World Resources 1998–99*, data table 8.2, p. 259.
277. *Ibid.*, p. 8.
278. *Global Environment Outlook 3*, p. 211.
279. *Ibid.*, p. 159.
280. See generally Osterfeld as well as David Landes, *The Wealth and Poverty of Nations: Why Some Are So Rich and Some Are So Poor* (New York: W.W. Norton, 1998); Nathan Rosenberg and L. E. Birdzell Jr., *How the West Grew Rich: The Transformation of the Industrial World* (New York: Basic Books, 1986); and *The Revolution in Development Economics*, James Dorn, Steve Hanke, and Alan Walters, eds. (Washington: Cato Institute, 1998).
281. Chisholm, Hartley, and Porter, p. 19.
282. William Mellor III, letter to the editor, *Policy Review* (Winter 1990): 7.
283. Munasinghe and Cruz, p. 7.

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