Stephen Schneider

GLOBAL WARMING:
NEGLECTING THE COMPLEXITIES

For three decades, I have been debating alternative solutions for sustainable development with thousands of fellow scientists and policy analysts—exchanges carried out in myriad articles and formal meetings. Despite all that, I readily confess a lingering frustration: uncertainties so infuse the issue of climate change that it is still impossible to rule out either mild or catastrophic outcomes, let alone provide confident probabilities for all the claims and counterclaims made about environmental problems.

Even the most credible international assessment body, the Intergovernmental Panel on Climate Change (IPCC), has refused to attempt subjective probabilistic estimates of future temperatures. This has forced politicians to make their own guesses about the likelihood of various degrees of global warming. Will temperatures in 2100 increase by 1.4 degrees Celsius or by 5.8? The difference means relatively adaptable changes or very damaging ones.

Against this background of frustration, I began increasingly to hear that a young Danish statistician in a political science department, Bjørn Lomborg, had applied his skills in statistics to better determine how serious environmental problems are. Of course, I was anxious to see this highly publicized contribution—*The Skeptical Environmentalist: Measuring the Real State of the World*. A "skeptical environmentalist" is certainly the best kind, I mused, because uncertainties are so endemic in these complex problems that suffer from missing data, incomplete theory and nonlinear interactions. But the "*real* state of the world"—that is a high bar to set, given the large range of plausible outcomes.

And who is Lomborg, I wondered, and why haven't I come across him at any of the meetings where the usual suspects debate costs, benefits, extinction rates, carrying capacity or cloud feedback? I couldn't recall reading any scientific or policy contributions from him either. But there was this massive 515-page tome with a whopping 2,930 endnotes to wade through. On page xx of his preface, Lomborg admits, "I am not myself an expert as regards environmental problems"—truer words are not found in the rest of the book, as I'll soon illustrate. I will report primarily on the thick global warming chapter and its 600-plus endnotes. That kind of deadweight of detail alone conjures at least the trappings of comprehensive and careful scholarship. So how does the reality of the text hold up to the pretense? I'm sure you can already guess, but let me give some examples to make clear what I learned by reading.

The climate chapter makes four basic arguments:

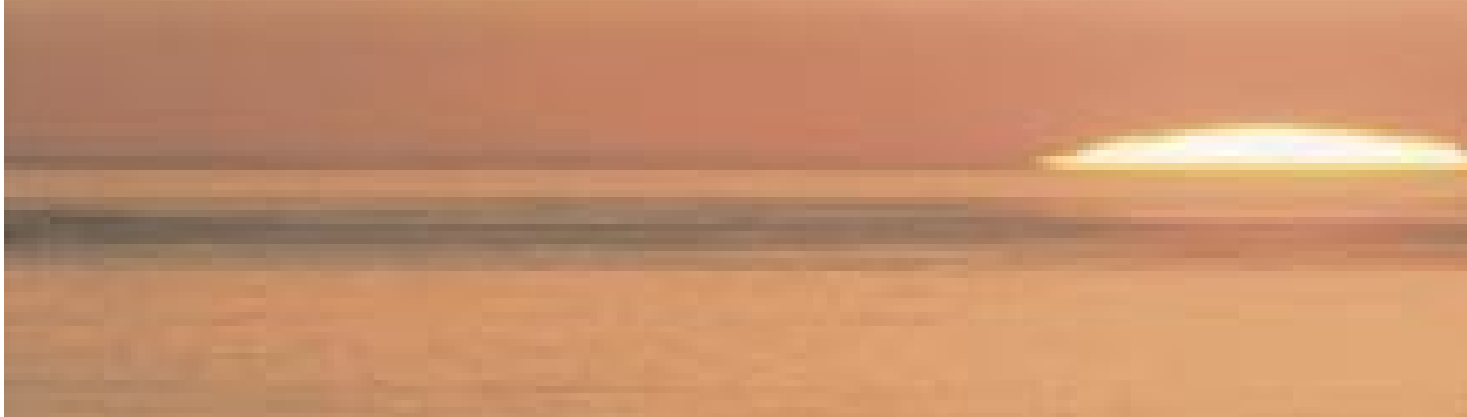
Climate science is very uncertain, but nonetheless the real state of the science is that the sensitivity of the climate to carbon dioxide will turn out to be at the low end of the IPCC uncertainty range—which is for a warming of 1.5 to 4.5 degrees C if carbon dioxide were to double and be held fixed over time.

Emissions scenarios, according to the IPCC, fall into six "equally sound" alternative paths. These paths span a doubling in carbon dioxide concentrations in 2100 up to more than tripling and well beyond tripling in the 22nd century. Lomborg, however, dismisses all but the lowest of the scenarios: "Temperatures will increase much less than the maximum estimates from IPCC—it is likely that the temperature will be at or below the B1 estimate [the lowest emissions scenario] (less than 2° C in 2100) and the temperature will certainly not increase even further into the twenty-second century."

Cost-benefit calculations show that although the benefits of avoiding climate change could be substantial ($5 trillion is the single figure Lomborg cites), this is not worth the cost to the economy of trying to constrain fossil-fuel emissions (a $3-trillion to $33-trillion range he pulls from the economics literature). Asymmetrically, no range is given for the climate damages.

The Kyoto Protocol, which caps industrialized countries' output of greenhouse gases, is too expensive. It would reduce warming in 2100 by only a few tenths of a degree—"putting off the temperature increase just six years." This number, though, is based on a straw-man policy that nobody has seriously proposed: Lomborg extrapolates the Kyoto Protocol, which is applicable only up to 2012, as the world's sole climate policy for another nine decades.

Before providing specifics of why I believe each of these assertions is fatally



RICHARD HAMILTON SMITH *Corbis*

flawed, I should say something about Lomborg's methods. First, most of his nearly 3,000 citations are to secondary literature and media articles. Moreover, even when cited, the peer-reviewed articles come elliptically from those studies that support his rosy view that only the low end of the uncertainty ranges will be plausible. IPCC authors, in contrast, were subjected to three rounds of review by hundreds of outside experts. They didn't have the luxury of reporting primarily from the part of the community that agrees with their individual views.

Second, it is ironic that in a popular book by a statistician one can't find a clear discussion of the distinction among different types of probabilities, such as frequentist and Bayesian (that is, "objective" and "subjective"). He uses the word "plausible" often, but, curiously for a statistician, he never attaches any probability to what is "plausible." The Third Assessment Report of the IPCC, on the other hand, explicitly confronted the need to quantify all confidence terms. Working Group I, for example, gave the term "likely" a 66 to 90 percent chance of occurring. Although the IPCC gives a wide range for most of its projections, Lomborg generally dismisses these ranges, focusing on the least serious outcomes. Not so much as one probability is offered for the chance of a dangerous outcome, yet he makes a firm assertion that climate "will certainly" not go beyond 2 degrees C warming in the 22nd century—a conclusion at variance with the IPCC, other national climate assessments and most recent studies in the field of climate science.

Now let us look in more detail at the four major arguments he makes in this chapter.

Climate science. A typical example of Lomborg's method is his paraphrase of a secondary source in reporting a 1989 Hadley Center paper in the journal *Nature* in which the researchers make modifications to their climate model: "The programmers then improved the cloud parameterizations in two places, and the model reacted by reducing its temperature estimate from 5.2° C to 1.9° C." Had this been first-rate scholarship, Lomborg would have consulted the original article, in which the concluding sentence of the first paragraph presents the authors' caveat: "Note that although the revised cloud scheme is more detailed it is not necessarily more accurate than the less sophisticated scheme."

In a similar vein, he cites Richard S. Lindzen's controversial stabilizing feedback, or "iris effect," as evidence that the IPCC climate sensitivity range should be reduced by a factor of almost three. He fails either to understand this mechanism or to tell us that it is based on only a few years of data in a small part of one ocean. Extrapolating this small sample of data to the entire globe is like extrapolating the strong destabilizing feedback over midcontinental landmasses as snow melts in the spring—such an inappropriate projection would likely increase estimates of climate sensitivity by a factor of several.

As a final example, he quotes a controversial hypothesis from Danish cloud physicists that solar magnetic events modulate cosmic rays and produce "a clear connection between global low-level cloud cover and incoming cosmic radiation." The Danish researchers use this hypothesis to support an alternative to carbon dioxide for explaining recent climate change. Lomborg fails to discuss—and I haven't seen it treated by the authors of that speculative theory either—what such purported changes to this cloud cover have done to the radiative balance of the earth. Increasing clouds, it has been well known since papers by Syukuro Manabe and Richard T. Wetherald in 1967 and myself in 1972, can warm or cool the atmosphere depending on the height of the cloud tops, the reflectivity of the underlying surface, the season and the latitude. The reason the IPCC discounts this theory is that its advocates have not demonstrated any radiative forcing sufficient to match that of much more parsimonious theories, such as anthropogenic forcing.

Emissions scenarios. Lomborg asserts that over the next several decades new, improved solar machines and other renewable technologies will crowd fossil fuels off the market. This will be done so efficiently that the IPCC scenarios vastly overestimate the chance for major increases in carbon dioxide. How I wish this would turn out to be true!

Lomborg admits, "I am not myself an expert as regards ENVIRONMENTAL PROBLEMS"—truer words are not found in the rest of the book.

But wishes aren't analysis. One study is cited; ignored is the huge body of economics work he later accepts to estimate a range of costs if we were to implement emissions controls. In fact, most of these economists strongly believe high emissions are quite likely: they usually project carbon dioxide doubling to tripling (or more) as "optimal" economic policy. I have attacked this literature for failing to point out that climate policies that raise the price of conventional fuels spur investments in alternative energy systems. But such incentives need policies first—and Lomborg opposes those very policies. No credible analyst can just assert that a fossil-fuel-intensive scenario is not plausible—and, typically, he gives no probability that it might occur.

Cost-benefit calculations. Lomborg's most egregious distortions and poorest analyses are his citations of cost-benefit calculations. First, he chides the governments that modified the penultimate draft of the report from IPCC's Working Group II. These modifications downgraded the significance of economic studies that aggregate climate change damages. Lomborg says: "A political decision stopped IPCC from looking at the total cost-benefit of global warming." (As an aside, I should mention that it is strange he chose to cite the penultimate and *pre-approval* draft report in this case but didn't mention the very first item in the *approved* summary—that recent temperature trends have caused a discernible effect on plants and animals. Even more puzzling is his failure to discuss ecological impacts in general, focusing instead on health and agriculture, sectors he thinks won't be much harmed by climate change of the minuscule amount he predicts.)

The government representatives downgraded aggregate cost-benefit studies for a reason: these studies fail to consider so many categories of damages held to be important by political leaders as to render them just a guideline on market-sector transactions, not the "total cost-benefit" analysis Lomborg wants. A total analysis would have to include the value of species lost, crucial ecosystem services degraded, inequity created by the poor being hurt more than the rich (which Lomborg does acknowledge), quality of life reduced (for example, a rise in sea level driving small-island inhabitants from traditional homelands), and likely changes to climatic extremes and variability. Then again, Lomborg cites only one value for climate damages—$5 trillion—even though the same economics papers he refers to for costs of climate policy generally acknowledge that climate damages can vary from benefits up to catastrophic losses.

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It is precisely because the responsible scientific community cannot rule out such catastrophic outcomes at a high level of confidence that climate mitigation polices are seriously proposed. And to give one number—rather than a broad range—for avoided climate damages defies explanation, especially when he does give a range for climate policy costs. This range, however, is based on the economics literature but ignores the findings of engineers. Engineers dispute the economists' typical estimates because the economists fail to take into account preexisting market imperfections such as energy-inefficient machines, houses and processes. These engineering studies, including a famous one by five U.S. Department of Energy laboratories—hardly environmental radicals—suggest that climate policies that provide incentives to replace inefficient equipment with more efficient state-of-the-art products could actually reduce some emissions at *below-zero costs*.

The Kyoto Protocol. Lomborg's creation of a 100-year regime for a decade-long protocol is a distortion of the climate policy process. Every IPCC report has noted that carbon dioxide emissions need to be cut by more than 50 percent below most baseline projections to avoid large increases in concentration in the late 21st and 22nd centuries. Most analysts know "Kyoto extended" can't make such large cuts and that both developed and developing na-

JIM BRANDENBURG *Minden Pictures*

tions will have to fashion cooperative and cost-effective solutions over time. This will take a great deal of learning-by-doing: international cooperation is not a common experience. Kyoto is a starting point. And yet Lomborg, with his creation of a straw-man 100-year projection, would squash even this first step.

So what then is "the real state of the world"? Clearly, it isn't knowable in traditional statistical terms, even though subjective estimates can be responsibly offered. The ranges presented by the IPCC in its peer-reviewed reports give the best snapshot of the real state of climate change: we could be lucky and see a mild effect or unlucky and get the catastrophic outcomes. The IPCC frames the issue as a risk-management decision about hedging. It is not the everything-will-turn-out-fine affair that Lomborg would have us believe.

For such an interdisciplinary topic, the publisher would have been wise to ask natural scientists as well as social scientists to review the manuscript, which was published by the social science side of the house. It's not surprising that the reviewers failed to spot Lomborg's unbalanced presentation of the natural science, given the complexity of the many intertwining fields. But that the natural scientists weren't asked is a serious omission for a respectable publisher such as Cambridge University Press.

Unfortunately, angry reviews such as this one will be the result. Worse still, many laypeople and policymakers won't see the reviews and could well be tricked into thinking thousands of citations and hundreds of pages constitute balanced scholarship. A better rule of thumb is to see who talks in ranges and subjective probabilities and to beware of the myth busters and "truth tellers."

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John P. Holdren

ENERGY: ASKING THE WRONG QUESTION

Lomborg's chapter on energy covers a scant 19 pages. It is devoted almost entirely to attacking the belief that the world is running out of energy, a belief that Lomborg appears to regard as part of the "environmental litany" but that few if any environmentalists actually hold. What environmentalists mainly say on this topic 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. They also argue that we are running out of the ability to manage other risks of energy supply, such as the political and economic dangers of overdependence on Middle East oil and the risk that nuclear energy systems will leak weapons materials and expertise into the hands of proliferation-prone nations or terrorists.

That "the energy problem" is not primarily a matter of depletion of resources in any global sense but rather of environmental impacts and sociopolitical risks—and, potentially, of rising monetary costs for energy when its environmental and sociopolitical hazards are adequately internalized and insured against—has in fact been the mainstream environmentalist position for decades. It was, for example, the position I elucidated in the 1971 Sierra Club "Battlebook" *Energy* (co-authored with Philip Herrera, then the environment editor for *Time*). It was also the position elaborated on by the Energy Policy Project of the Ford Foundation in the pioneering 1974 report *A Time to Choose;* by Amory Lovins in his influential 1976 *Foreign Affairs* article "Energy Strategy: The Road Not Taken"; by Paul R. and Anne H. Ehrlich and me in our 1977 college textbook *Ecoscience;* and so on.

So whom is Lomborg so resoundingly refuting with his treatise on the abundance of world energy resources? It would seem that his targets are pundits (such as the correspondents for *E* magazine and CNN cited at the opening of this chapter) and professional analysts (although only a few of these are cited, and those very selectively) who have argued not that the world is running out of energy altogether but only that it might be running out of cheap oil. Lomborg's dismissive rhetoric notwithstanding, this is not a silly question, nor one with an easy answer.

Oil is the most versatile and currently the most valuable of the conventional fossil fuels that have long provided the bulk of civilization's energy, and it remains today the largest contributor to world energy supply (accounting for nearly the whole of energy used for transport, besides other roles). But the recoverable conventional resources of oil are believed (on substantial evidence) to be far smaller than those of coal and probably also smaller than those of natural gas; the bulk of these resources appears to lie in the politically volatile Middle East; much of the rest lies offshore and in other difficult or environmentally fragile locations; and it is likely that the most abundant potential replacements for conventional oil will be more expensive than oil has been. For all these reasons, concerns about declining availability and rising prices have long been more salient for oil than for the other fossil fuels. There is, accordingly, a serious technical literature (produced mainly by geologists and economists) exploring the questions of when world oil production will peak

and begin to decline and what the price of oil might be in 2010, 2030 or 2050, with considerable disagreement among informed professionals on the answers.

Lomborg gets right the basic point that the dominance of oil in the world energy market will end not because no oil is left in the ground but because other energy sources have become more attractive relative to oil. But he seems not to recognize that the transition from oil to other sources will not necessarily be smooth or occur at prices as low as those enjoyed by oil consumers today. Indeed, while ridiculing the position that the world's heavy oil dependence may again prove problematic in our lifetimes, he shows no sign of understanding (or no interest in communicating) why there is real debate among serious people about this.

Lomborg does not so much as offer his readers a clear explanation of the distinction—crucial to understanding arguments about depletion—between "proved reserves" (referring to material that has already been found and is exploitable at a profit at today's prices, using today's technologies) and "remaining ultimately recoverable resources" (which incorporate estimates of additional material exploitable with today's technology at today's prices but still to be found, as well as material both already found and still to be found that will be exploitable with future technologies at potentially higher future prices). And, while noting that most of the world's oil reserves lie in the Middle East (and failing to note, having not even introduced the concept, that a still larger share of remaining ultimately recoverable resources is thought to lie there), he placidly informs us that it is "imperative for our future energy supply that this region remains reasonably peaceful," as if that observation did not undermine any basis for complacency. (At this juncture, one of his 2,930 footnotes helpfully adds that this peace imperative for the Middle East was "one of the background reasons for the Gulf War"!)

Lomborg's treatment of energy resources other than oil is not much better. He is correct in his basic proposition that resources of coal, oil shale, nuclear fuels and renewable energy are immense (which few environmentalists—and no well-informed ones—dispute). But his handling of the technical, economic and environmental factors that will govern the circumstances and quantities in which these resources might actually be used is superficial, muddled and often plain wrong. His mistakes include apparent misreadings or misunderstandings of statistical data—in other words, just the kinds of errors he claims are pervasive in the writings of environmentalists—as well as other elementary blunders of quantitative manipulation and presentation that no self-respecting statistician ought to commit.

He tells us correctly, for example, that the world has huge resources of coal, but in observing that "it is presumed that there is sufficient coal for well beyond the next 1,500 years" he says nothing about the rate of coal use for which this conclusion might obtain. Concerning the environmental questions that increased reliance on coal would raise, he writes the following: "Typically, coal pollutes quite a lot, but in developed economies switches to low-sulfur coal, scrubbers and other air-pollution control devices have today removed the vast part of sulfur dioxide and nitrogen dioxide emissions." To the contrary, data readily available on the Web in the Environmental Protection Agency report *National Air Pollutant Emission Trends 1900–1998* reveal that U.S. emissions of nitrogen oxides from coal-burning electric power plants were 6.1 million short tons in 1980 and 5.4 million short tons in 1998. Emissions of sulfur dioxide from U.S. coal-burning power plants were 16.1 million short tons in 1980 and 12.4 million short tons in

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LESTER LEFKOWITZ *FPG International*

1998. These are moderate reductions, welcome but hardly the "vast part" of the emissions.

Concerning nuclear energy, Lomborg tells us that it "constitutes 6 percent of global energy production and 20 percent in the countries that have nuclear power." The first figure is right, the second seriously wrong. Nuclear energy provides a bit less than 10 percent of the primary energy supply in the countries that use this energy source. (It appears that Lomborg has confused contributions to the electricity sector with contributions to primary energy supply.) After a muddled discussion of the relation between uranium-resource estimates and breeding (which omits altogether the potentially decisive issue of the usability of uranium from seawater), he then barely notes in passing that breeder reactors "produce large amounts of plutonium that can be used for nuclear weapons production, thus adding to the security concerns." He should have added that this problem is so significant that it may preclude use of the breeding approach altogether, unless we develop technologies that make breeding much less susceptible to diversion of the plutonium while not making this approach even more uneconomic than it is today.

Lomborg has some generally sensible things to say about the large contributions that are possible from increased energy end-use efficiency and from renewable energy—on these topics he seems, to his credit, to be more a contributor to the "environmental litany" than a critic of it. But on these subjects as on the others, his treatment is superficial, uneven and marred by numerous errors and infelicities. For example, he persistently presents numbers to two- and three-figure precision for quantities that cannot be known to such accuracy: "43 percent of American energy use is wasted"; "the costs of carbon dioxide" emissions are "0.64 cents per kWh"; plant photosynthesis is "1,260 EJ" annually. He makes claims, based on single citations and without elaboration, that are far from representative of the literature: "We know today that it is possible to produce safe cars getting more than 50–100 km per liter (120–240 mpg)." (How big would these cars be, and powered how?) He bungles terminology: "Energy can be stored in hydrogen by catalyzing water." (He must mean "by electrolyzing water" or "by catalytic thermochemical decomposition of water.") And he propagates a variety of conceptual confusions, such as the idea that grid-connected wind power requires "a sizeable excess capacity" in the windmills because these alone "need to be able to meet peak demand."

Of course, much of what is most problematic in the global energy picture is covered by Lomborg not in his energy chapter but in those that deal with air pollution, acid rain, water pollution and global warming. The last is devastatingly critiqued by Stephen Schneider on page 32. There is no space to deal with the other energy-related chapters; suffice it to say that I found their level of superficiality, selectivity and misunderstanding roughly consistent with that of the energy chapter reviewed here. This is a shame. Lomborg is giving skepticism—and statisticians—a bad name.

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John Bongaarts

POPULATION: IGNORING ITS IMPACT

Around the world, countries are experiencing unprecedented demographic change. The best-known example is an enormous expansion in human numbers, but other important demographic trends also affect human welfare. People are living longer and healthier lives, women are bearing fewer children, increasing numbers of migrants are moving to cities and to other countries in search of a better life, and populations are aging. Lomborg's unbalanced presentation of some of these trends and their influences emphasizes the good news and neglects the bad. Environmentalists who predicted widespread famine and blamed rapid population growth for many of the world's environmental, economic and social problems overstated their cases. But Lomborg's view that "the number of people is not the problem" is simply wrong.

His selective use of statistics gives the reader the impression that the population problem is largely behind us. The global population growth rate has indeed declined slowly, but absolute growth remains close to the very high levels observed in recent decades, because the population base keeps expanding. World population today stands at six billion, three billion more than in 1960. According to U.N. projections, another three billion will likely be added by 2050, and population size will eventually reach about 10 billion.

Any discussion of global trends is misleading without taking account of the enormous contrasts among world regions. Today's poorest nations in Africa, Asia and Latin America have rapidly growing and young populations, whereas in the technologically advanced and richer nations in Europe, North America and Japan, growth is near zero (or, in some cases, even negative), and popula-

tions are aging quickly. As a consequence, nearly all future global growth will be concentrated in the developing countries, where four fifths of the world's population lives. The projected rise in population in the developing world between 2000 and 2025 (from 4.87 to 6.72 billion) is actually just as large as the record-breaking increase in the past quarter of a century. The historically unprecedented population expansion in the poorest parts of the world continues largely unabated.

Past population growth has led to high population densities in many countries. Lomborg dismisses concerns about this issue based on a simplistic and misleading calculation of density as the ratio of people to all land. Clearly, a more useful and accurate indicator of density would be based on the land that remains after excluding areas unsuited for human habitation or agriculture, such as deserts and inaccessible mountains. For example, according to his simple calculation, the population density of Egypt equals a manageable 68 persons per square kilometer, but if the unirrigated Egyptian deserts are excluded, density is an extraordinary 2,000 per square kilometer. It is therefore not surprising that Egypt needs to import a large proportion of its food supply. Measured properly, population densities have reached extremely high levels, particularly in large countries in Asia and the Middle East.

The unprecedented POPULATION EXPANSION in the poorest parts of the world continues LARGELY UNABATED.

Why does this matter? The effect of population trends on human welfare has been debated for centuries. When the modern expansion of human numbers began in the late 18th century, Thomas Robert Malthus argued that population growth would be limited by food shortages. Lomborg and other technological optimists correctly note that world population has expanded much more rapidly than Malthus envisioned, growing from one billion to six billion over the past two centuries. And diets have improved. Moreover, the technological optimists are probably correct in claiming that overall world food production can be increased substantially over the next few decades. Average current crop yields are still below the levels achieved in the most productive countries, and some countries still have unused potential arable land (although much of this is forested).

Agricultural expansion, however, will be costly, especially if global food production has to rise twofold or even threefold to accommodate the demand for better diets from several billion more people. The land now used for agriculture is generally of better quality than unused, potentially cultivable land. Similarly, existing irrigation systems have been built on the most favorable sites. And water is increasingly in short supply in many countries as the competition for that resource among households, industry and agriculture intensifies. Consequently, each new increase in food production is becoming more expensive to obtain. This is especially true if one considers environmental costs not reflected in the price of agricultural products.

Lomborg's view that the production of more food is a nonissue rests heavily on the fact that world food prices are low and have declined over time. But this evidence is flawed. Massive governmental subsidies to farmers, particularly in the developed countries, keep food prices artificially low. Although technological developments have reduced prices, without these massive subsidies, world food prices would certainly be higher.

The environmental cost of what Paul R. and Anne H. Ehrlich describe as "turning the earth into a giant human feedlot" could be severe. A large expansion of agriculture to provide growing populations with improved diets is likely to lead to further deforestation, loss of species, soil erosion, and pollution

from pesticides and fertilizer runoff as farming intensifies and new land is brought into production. Reducing this environmental impact is possible but costly and would obviously be easier if population growth were slower. Lomborg does not deny this environmental impact but asks unhelpfully, "What alternative do we have, with more than 6 billion people on Earth?"

Lomborg correctly notes that poverty is the main cause of hunger and malnutrition, but he neglects the contribution of population growth to poverty. This effect operates through two distinct mechanisms. First, rapid population growth leads to a young population, one in which as much as half is below the age of entry into the labor force. These young people have to be fed, housed, clothed and educated, but they are not productive, thus constraining the economy. Second, rapid population growth creates a huge demand for new jobs. A large number of applicants for a limited number of jobs exerts downward pressure on wages, contributing to poverty and inequality. Unemployment is widespread, and often workers in poor countries earn wages near the subsistence level. Both of these adverse economic effects are reversible by reducing birth rates. With lower birth rates, schools become less crowded, the ratio of dependents to workers declines as does the growth in the number of job seekers. These beneficial demographic effects contributed to the economic "miracles" of several East Asian countries. Of course, such dramatic results are by no means assured and can be realized only in countries with otherwise sound economic policies.

Lomborg approvingly notes the huge ongoing migration from villages to cities in the developing world. This has been considered a welcome development, because urban dwellers generally have higher standards of living than villagers. Because the flow of migrants is now so large, however, it tends to overwhelm the absorptive capacity of cities, and many migrants end up living in appalling conditions in slums. The traditional urban advantage is eroding in the poorest countries, and the health conditions in slums are often as adverse as in rural areas. This points to another burden of rapid population growth: the inability of governments to cope with large additions of new people. In many developing countries, investments in education, health services and infrastructure are not keeping up with population growth.

It is true that life has improved for many people in recent decades, but Lomborg does not acknowledge that this favorable trend has been brought about in part by intensive efforts by governments and the international community. Investments in developing and distributing "green revolution" technology have reduced hunger, public health campaigns have cut death rates, and family-planning programs have lowered birth rates. Despite this progress, some 800 million people are still malnourished, and 1.2 billion live in abject poverty. This very serious situation calls for more effective remedial action. Lomborg asks the developed nations to fulfill their U.N. pledge to donate 0.7 percent of their GNPs to assist the developing world, but few countries have met this goal, and the richest nation on earth, the U.S., is one of the stingiest, giving just 0.1 percent of its GNP. The trend in overseas development assistance from the developed to the developing world is down, not up. Unfortunately, the unrelenting we-are-doing-fine tone that pervades Lomborg's book encourages complacency rather than urgency.

Population is not the main cause of the world's social, economic and environmental problems, but it contributes substantially to many of them. If population had grown less rapidly in the past, we would be better off now. And if future growth can be slowed, future generations will be better off.

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Thomas Lovejoy

BIODIVERSITY: DISMISSING SCIENTIFIC PROCESS

Biologists are trained to have a healthy respect for statistics and statisticians. It was disconcerting, therefore, to find that before even examining the extinction problem—and the numbers invoked to demonstrate that it is or is not a problem—Lomborg begins the chapter on biodiversity with a section questioning whether biodiversity is important. In less than a page, he discounts its value both as the library for the life sciences and as provider of ecosystem services (in part because of a general absence of markets for these services).

When he finally gets to extinction, he totally confounds the *process* by which a species is judged to be extinct with the estimates and projections of extinction *rates*. Highly conservative rules hold that to be declared officially extinct, not only does a species have to be known to science, it has to be observed going to extinction (as in the case of the passenger pigeon, the last one of which perished in the Cincinnati Zoo in 1914). Or, in the absence of direct observation, it must not have been seen in nature for 50 years.

Projections of extinction rates, on the other hand, are generally based on the long-established relation between species number and area (which dates to 1921, not to the 1960s, as Lomborg

maintains, and which demonstrates the rate at which species number increases with increase in area). Researchers then project what the reduction in a natural habitat will mean in terms of species loss. The disappearance of a species is not necessarily instantaneous, and thus some species that survive the initial reduction of the habitat are essentially "living dead"—they are not able to survive over the long term. The loss of species from habitat remnants is a widely documented phenomenon—in contrast to Lomborg's inclusion of an out-of-date assertion that no credible attempt has been made to pin down the underlying scientific assumptions.

As a consequence, a seemingly major contradiction that Lomborg then offers is no contradiction at all: the reduction of the Brazilian Atlantic Forest formation to something on the order of 10 percent of its original extent and the lack of large numbers of recorded extinctions. First of all, this is a region with very few field biologists to record either species or their extinction. Second, there is abundant evidence that if the Atlantic forest remains as reduced and fragmented as it is, it will lose a sizable fraction of the species that at the moment are able to hang on.

In another supposed example of species surviving habitat loss, he notes that few species went extinct when the eastern forests of the U.S. were reduced to 1 to 2 percent of their original area. But only the old-growth forests shrank that much; total forest cover never fell below roughly 50 percent—allowing much biodiversity to survive as forest returned to an even greater area. Consequently, the small number of bird extinctions does not contradict what species-area considerations predict but instead confirms them.

In presenting an analysis for Puerto Rico, Lomborg again cites apparently contradictory evidence that although 99 percent of the primary forest was lost, the island ended up with more birds than it supported before deforestation. First of all, total forest cover was never so dramatically reduced. More significant, he ignores that seven of the 60 species unique to Puerto Rico were lost, and the additional species are not only invasives from other parts of the world but live in a wide variety of habitats. He completely misses the point that the world's bird fauna was reduced by seven species.

Lomborg takes particular exception to projections of massive extinction that started with Norman Myers's 1979 estimate that 40,000 species are being lost from the globe every year. There is some justification for this objection: Myers did not specify the method of arriving at his estimate. Nevertheless, he deserves credit for being the first to say that the number was large and for doing so at a time when it was difficult to make more accurate calculations. Current estimates are usually given in terms of the increases over normal extinction rates, which is preferable in that it is not necessary to assume a figure for the total number of species on the earth. That science does not know the total number of species does not prevent an estimation of extinction *rates*. Lomborg cynically dismisses the use of multiples of normal rates as being done because it sounds more "ominous" rather than recognizing the altered approach as an improvement in the science.

Estimates of present extinction rates range from 100 to 1,000 times normal, with most estimates at 1,000. The percent of bird (12), mammal (18), fish (5) and flowering plant (8) species threatened with extinction is consistent with that estimate. And the rates are certain to rise—and to do so exponentially—as natural habitats continue to dwindle.

The consideration of acid rain in a separate chapter is equally poorly researched and presented. Indeed, the research is so shallow that almost no citation from the peer-reviewed literature appears. Lomborg asserts that big-city pollution has nothing to do with acid rain, when it is fact that nitrogen compounds (NO_x) from traffic are a major source. His reference to a study showing that acid rain had no effect on the seedlings of three tree species neglects to mention that the study did not include conifer species such as red spruce, which *are* very sensitive. There is no acknowledgment of the delayed effects from acid rain leaching soil nutrients, particularly key cations. He confounds tree damage from air pollution 30 to 60 years ago with subsequent acid rain damage and makes an Alice-in-Wonderland statement that the only reason we worry about foliage loss is "because we have started monitoring this loss." It is simply untrue that "there is no case of forest decline in

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which acidic deposition is known to be a predominant cause." Two clear-cut examples are red spruce in the Adirondacks and sugar maple in Pennsylvania.

The chapter on forests also suffers from superficial research and selective use of numbers. Lomborg starts by displaying Food and Agriculture Organization (FAO) data from 1948 to 2000. The FAO began by just reporting sums of "official data" furnished by governments (such data are notoriously uneven in quality and frequently overestimate forest stocks). Subsequently, the FAO adopted so many different definitions and methods that any statistician should know they could not be used for a valid time series.

Lomborg's discussion of the great fire in Indonesia in 1997 is still another instance of misleading readers with selective information. Yes, the WWF (World Wide Fund for Nature) first estimated the amount of forest burned at two million hectares, and Indonesia countered with official estimates of 165,000 to 219,000 hectares. But Lomborg fails to mention that the latter were not in the least credible and that in 1999 the Indonesian government and donor agencies, including the World Bank, signed off on a report that the real number was 4.6 million hectares.

From the very outset—his introductory chapter—Lomborg confuses forests and tree plantations. In criticizing a WWF estimate of loss of "natural wealth," he implies that the only value of forests is harvestable trees. That is analogous to valuing computer chips only for their silicon content. In fact, the metric the WWF used includes natural forests (because of their biodiversity) and omits plantations (because of their general lack thereof).

The central question of the book—Are things getting better?—is an important one. The reality is that significant progress has been made in abating acid rain, although much still needs to be done. And major efforts are under way to stem deforestation and to address the tsunami of extinction. But it is crucial to remember that whereas deforestation and acid rain are theoretically reversible (although there may be a threshold past which remedy is impossible), extinction is not. A dispassionate analysis, which Lomborg pretends to offer, of how far we have come and how far we have yet to go would have been a great contribution. Instead we see a pattern of denial.

The pattern is evident in the selective quoting. In trying to show that it is impossible to establish the extinction rate, he states: "Colinvaux admits in *Scientific American* that the rate is 'incalculable,'" when Paul A. Colinvaux's text, published in May 1989, is: "As human beings lay waste to massive tracts of vegetation, an incalculable and unprecedented number of species are rapidly becoming extinct." Why not show that Colinvaux thought the number is large? Biased language, such as "admits" in this instance, permeates the book.

In addition to errors of bias, the text is rife with careless mistakes. Time and again I sought to track references from the text to the footnotes to the bibliography to find but a mirage in the desert.

Far worse, Lomborg seems quite ignorant of how environmental science proceeds: researchers identify a potential problem, scientific examination tests the various hypotheses, understanding of the problem often becomes more complex, researchers suggest remedial policies—and *then* the situation improves. By choosing to highlight the initial step and skip to the outcome, he implies incorrectly that all environmentalists do is exaggerate. The point is that things improve *because* of the efforts of environmentalists to flag a particular problem, investigate it and suggest policies to remedy it. Sadly, the author seems not to reciprocate the respect biologists have for statisticians.

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MORE TO EXPLORE

The Diversity of Life. E. O. Wilson. Belknap Press of Harvard University Press, 1992.

Global Biodiversity Assessment. Edited by V. H. Heywood. Cambridge University Press, 1996.

Our Common Journey: A Transition toward Sustainability. National Research Council Board on Sustainable Development, Policy Division. National Academy Press, 1999.

Beyond Six Billion: Forecasting the World's Population. Edited by John Bongaarts and Rodolfo A. Bulatao. National Research Council, 2000.

Climate of Uncertainty. George Musser in *Scientific American,* Vol. 285, No. 4, pages 14–15; October 2001.

Grand Challenges in Environmental Sciences, 2001. National Research Council. Available at **www.nap.edu/catalog/9975.html**

World Energy Assessment: Energy and the Challenge of Sustainability. United Nations Development Program, United Nations Department of Economic and Social Affairs, and World Energy Council, 2001. Available at **www.undp.org/seed/eap/activities/wea/drafts-frame.html**

The Intergovernmental Panel on Climate Change Web site is available at **www.ipcc.ch/**