



SCEPTICAL QUESTIONS AND SUSTAINABLE ANSWERS



THE DANISH ECOLOGICAL
COUNCIL

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The Danish Ecological Council The Danish Ecological Council is a Danish NGO. The main objective is to promote sustainable patterns of development, where environmental concerns, social justice and human well-being are main focal points. The Danish Ecological Council publishes the magazine "Global Økologi" (in Danish) and promotes public debate by producing information material, analyses, booklets and reports.

The Danish Ecological Council is different from other Danish NGOs in the way that it is an academic organisation dealing with environmental policy on a scientific basis, but at the same time trying to inform and have a dialogue with both politicians and the general public.

The Danish Ecological Council is a member of the European Environmental Bureau (EEB) which is a federation of Environmental Associations.



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PREFACE

In 1999 – compelled by the errors and misrepresentations voiced by Bjørn Lomborg, Associate Professor – the Danish Ecological Council published a book intended as a countermove. To do so, we called upon a broad range of researchers and professionals. Now we are back, occasioned by Lomborg's most recent book, 'The Skeptical Environmentalist'.

Despite his limited knowledge of the environmental field, Lomborg's exceedingly optimistic view of the state of the environment has been given a free ride by the media. However, already when the forerunner of 'The Skeptical Environmentalist' appeared in Denmark in 1998, researchers responded with a maelstrom of criticism. Lomborg presents himself as an impartial scholar, drawing conclusions on a well-founded basis. A scientific basis, rejected by most of those with a knowledge of environmental studies, most recently in the reputable magazines, *Nature*, *Science*, and *Scientific American*.

His book is disputed in terms of his selection and use of figures, and rightly so. Researchers and professionals point out obvious errors and distortions, which Lomborg persistently denies or ignores. The main focus of the critique is Lomborg's subjective use of research findings, misleading citations, and unorthodox statistical approaches.

To the 'uninitiated', this is all quite opaque. The public could easily be left with the impression that experts disagree, and that one party might just as well be right as the other. On top of it, Lomborg offers a message bound to win support: Who would not like to hear that all is well, and that environmental problems will sort themselves out along the road? And then, when Lomborg & confreres tell you that it is possible, based on simple economic calculations, to prioritise environmental problems vs. other social problems, this is indeed a tempting proposition. But perhaps it will appear slightly less alluring to those bound to leave house and home, when global warming causes sea levels to rise. Not to mention farmers worldwide who will have to abandon their lands, once their fields are no longer blessed with rain.

The environment has improved in a number of ways, but we are still facing major environmental challenges requiring our active efforts. These efforts must not be weakened, by Lomborg or by the circles that have been waiting for precisely such an opportunity to shoot down the environmental cause. Lomborg goes to extremes, but the economic line of thought – that basically anything can be broken down into money – is gaining ground in several quarters. According to Lomborg and his like-minded, an effort for e.g. environmental protection is only to be made, if it will demonstrably pay off in terms of money. This argument forces the proponents of the environment to embark upon peculiar calculations, making up the money value of birds' song or human life, and enabling a conversion of our descendants' living conditions to present value.

The present book brings together a forum of professionals to offer their perspectives on the environmental situation, and comprising most of the fields covered by 'The Skeptical Environmentalist', and a critique of the economic mind-set that Lomborg represents. Moreover, the book intends to offer a solidly based overview of the state of the global environment for select areas.

Whenever possible, we have structured the book so as to allow each chapter to be read on its own. This in turn means that those who choose to read the book cover to cover will find a few repetitions. However, Chapters 1 and 11 are survey chapters, offering an overview of Lomborg's methods and the media debate, while in-detail documentation of Lomborg's errors is found in the intervening chapters.

In addition to the contributors to the book, a number of professionals – none mentioned, none forgotten – have offered helpful comments on the chapters. We wish to thank them for their significant contribution.

Christian Ege og Jeanne Lind Christiansen

1. SCIENCE, METHOD, AND ETHICS

LOMBORG'S 'JOURNALISTIC' METHOD

By Jesper Jespersen, professor

Department of Social Sciences, Roskilde University, Denmark

The present article¹ proposes to discuss the methodology applied by Lomborg in his work, 'The skeptical environmentalist – measuring the real state of the world'. This is done as an attempt to evaluate whether the presented findings and conclusions conform to current standards for scientific work in the social sciences.

MAIN CONCLUSIONS

The main conclusion is that Lomborg's approach has selective empiricism as a pervading trait. He uses an edited dataset as a foundation of his discussion of the different assertions that he wishes to verify or disprove. Moreover, Lomborg does so on a largely atheoretical basis, by choosing to 'let his figures speak for themselves'. The overall methodological principle applied is a form of simple falsification, used to dismiss competing theories, and simple verification, used to accept his own hypotheses. The approach inherently tends to yield predetermined – and in this case, largely atheoretical – results. This lends a journalistic-polemical air to Lomborg's conclusions, which lack actual scientific substance (in terms of their foundation in theoretical and critical statistics).

This could in part account for the fact that Lomborg chose to use the mass media² for the initial presentation of his findings. I have no direct knowledge as to how Cambridge University Press entered the picture, or much less, which referee method was applied, if any?

SELECTIVE EMPIRICISM AND LACKING THEORY

Qualified doubt is the finest quality of academia. It is vital that our universities communicate such questioning of pre-existing knowledge. Therefore I noted with considerable interest how an associate professor – then admittedly unknown to me – at the Institute for Social Studies at Århus University, in a matter of four weeks and via four feature articles in Politiken (a Danish daily newspaper), was able to challenge conventional wisdom in the environmental field. A small team of statisticians at Århus University, headed by Lomborg, challenged several well-established environmental positions with a shower of figures, supplemented with references to statistical tabular works. The team raised an extremely relevant question: *How much do we really know about global trends in living conditions, and in particular about extrinsic environmental factors? Let alone: What do we know about their impacts on future living conditions, if our development continues its current trajectory?*

Lomborg would have served a number of environmental NGOs a deserved lecture, had he just stopped to conclude that academic knowledge of the interplay between society, economy, and environment is (still) so limited that, for a number of environmental issues, we cannot present any unambiguous answers. Then his effort would have won great acclaim. And presumably, the debate would then have been concluded with a plea for an extraordinary research effort, not least in order to provide a greater understanding of the complex interplay between society, economics and environment. In other words, a recognition that academia has come nowhere near answering the question, whether the world is approaching sustainable development – in a Brundtlandian sense. Not

least the long time spans and the considerable delays, combined with a number of irreversible processes, make the reply to that question a difficult one. It requires a profound insight into both natural and social sciences.

Yet, Lomborg did not leave it at that. For a number of welfare and environment related fields he selected unrepresentative and extremely pessimistic views given by some development and environmental NGOs. Thus he devised the concept of 'The Litany', soon to become emblematic of not only environmental NGOs, but of all environmental research in Denmark as such (and later to be extended to most of the western world). After delivering this scathing caricature of 'The Litany', he and his graduate students set themselves to dig up figures on the Internet from other environmentalist organizations and researchers that could be used to 'disprove' The Litany. This approach serves the conclusion on a silver platter: 'There you are – things are not anywhere as bad as claimed by 'The Litany'!

From page one, Lomborg refers to mass media, reference works and popular-scientific magazines (including Time Magazine, Young Oxford Books and New Scientist) talking about the 'impending catastrophe', and that 'everyone knows the planet is in bad shape', rather than arguing directly with his academic critics.

Unfortunately, the English edition carries on Lomborg's strongly polemic tone. The massive critique delivered by a number of Danish researchers is brushed aside in the preface: 'I would have thought as the debate [in Denmark] progressed that refusal would give place to reflection on the massive amounts of supportive data I have presented, and lead to a genuine re-evaluation of our approach to the environment (p. xix). In so many words, without even deliberating for a moment if perhaps he could himself have benefited from reflecting just a little over the adduced criticisms. This present book was just one (among several) of the responses to the original Danish edition, which, apparently, Lomborg chose to ignore when reworking his book for the English language. There has only been a minor change to the title of the English edition, with the more mellow title, *'The skeptical environmentalist'*, as opposed to the original title, *'The real state of the world'*.

Even the preface is the same. It tells once again the story of how Lomborg got his inspiration for the book in Los Angeles in February 1997, and only eighteen months later was able to submit the finished manuscript for the Danish edition. It goes without saying that an author who nearly starts from scratch and pretends being able to give an exhaustive account of all major environmental issues in just 18 months, is plunging himself from great heights, risking a hard landing. Not least when choosing to include a pretentious word (in science terms) such as 'real' in the title. For that reason alone, he would have been well advised to be just a little empathetic to his critics.

Yet, his journalistic method leaves no room for doubt in the text. Data are selected to lead the reader on to his cocksure conclusion, 352 pages and 2930 footnotes later: '*... this is the very message of the book: children born today – in both the industrialized world and the developing countries will live longer and be healthier, they will get more food, a better education, a higher standard of living, more leisure time and far more possibilities – without the global environment being destroyed...*'

Such a conclusion cannot be the work of a dedicated scientist. What Lomborg demonstrates with his selective figures is that a number of environment and development data did not show a negative trend in the historical period under study. First, one can easily find contradicting data on important environmental and development issues (CO₂ concentration, the amount of radioactive fallout, the number of species, the ozone hole, and the rainforest). Second, 'history' cannot just be projected uncritically into the future. That requires a solid theoretical basis. Although Lomborg admits on page 273 that '*basically we have to conclude that the present models are complicated, but far from complicated enough to capture all the essential aspects of the global climate. The basic*

uncertainty of climate sensitivity still makes the models more noisy,’ it does not prevent him from drawing this cocksure conclusions. Let’s take just another example. On p. 187, Lomborg says that, *‘unfortunately, asthma still has many unknown factors to it.’* It is hard to disagree; still, Lomborg ventures a conclusion on p. 188: *‘Developing asthma is probably caused by a whole series of changes in our lifestyle. The main thing to point out here, however, is that there is no reason to assume that it is due to a deterioration of our environment.’*

In fact, if Lomborg was truly interested in ‘the real state of the world’, it is already possible today to offer a far more faceted presentation, as found for instance in the reports of the IPCC, which, of course, do not provide simplistic and unconditioned conclusions. Instead, the IPCC presents its results in the form of probability interval for future temperature rises of between 5.8 °C and 1.4 °C. Then Lomborg criticizes this more scientific way of presenting the results because the news media paid more attention to the highest (and most dramatic) figure. The researchers are hardly to blame for this misrepresentation of their results. Contrarily, it does speak volumes that Lomborg uncritically uses a study showing only an increase of 1.92 °C (comp. Figure 157, pp. 302) – or is he just trying to establish an optimistic antidote to ‘The Litany’?

Lomborg has found a great many trend data on developments in environment and living conditions over the 20th century that could be taken to indicate that today more people enjoy better living conditions than ever before in history. However, these data are not systematically selected which would make for *projections of the future*. Here Lomborg forsakes his reader, since failing to select his data on a systematical-theoretical basis, which subsequently could make the basis of an actual scientific discourse. Development trends pointing the ‘wrong’ way are few in Lomborg’s dataset, and when they are presented, a prognosis is ‘tacked’ onto them, showing that if we just let another decade or two pass by, things will (surely) improve, e.g. Figure 35, p. 75 (global income distribution) and below. There plainly lacks a description of the method applied by Lomborg in evaluating trends negative to him, before he dismisses them. Yet, which is worse, Lomborg is prepared to uncritically project largely atheoretical trends that bolster his own viewpoint into an infinite future. He blatantly lacks the theoretical basis needed to account for the development over the last 20-50 years, which, after all, is instrumental in projecting developmental trends another 50 years (or more) into the future (the life expectation of children born today).

LOMBORG’S METHOD

To Lomborg, ‘Truth’ is whatever selection of available data he chooses to present to his reader: *‘I wish to gauge the most important characteristics of our state of the world – the fundamentals ... Hence the real state of the world.’* Basically, it is completely unacceptable for someone in an academic environment to ‘monopolise Truth’. Presumably, this is among the very first things any university teacher will instil in his or her undergraduates: that we shall never get anywhere near ‘The Truth’ – and most certainly not in the realm of social sciences. How can anyone teach statistics and harbour such uncritical belief that one figure can represent ‘The Truth’? Not least when the figure appears atheoretical, and hence ahistorical.

On the other hand, it is both appropriate and praiseworthy of Lomborg to put forth an (often justified) critique of environmentalist NGOs, who liberally peddle data for which they lack sufficient empirical documentation (much less theoretical argument). Here Lomborg is relentless. I just find it hard to comprehend how then his critical sense can thus fail him, when presenting data to prove the truth of his own claims. After all, the demands that can and should be made on an NGO and those to be exacted from a work pretending to have a scientific foundation are things apart.

It is amazing how Lomborg pretends being able to dismiss every critique if only he can

tack a reference onto his figures, and the responsibility is off his shoulders. That makes his method resemble the approach used by the environmentalist NGOs he castigates so severely. Thus, readers are left in the dark, wondering who is actually in the right.

Yet, his uncritical data use is merely the visible top of the methodological iceberg. Far more important issues left unanswered are,

- 1) how Lomborg selects his data,
- 2) on what theoretical basis Lomborg interprets those figures.

This is where Lomborg lets down his readership *and* his own academic credentials, by practicing a selective and largely atheoretical empirism. Take for instance his conclusions, that '*the air is getting less polluted, not more; the developing countries starve less, not more etc.*'). They would, instead, have been the opposite, had he considered some of the mega cities of the developing nations, the CO₂ concentration, or the number of people subsisting below the poverty limit (notably in Africa). Which precisely shows how misleading an argument based on selective empirism can be.

GLOBAL AVERAGES ARE MISLEADING INDICATORS OF THE 'REAL STATE'

In his introductory chapter, Lomborg expounds why he feels that trends in *global* average figures over *long* time spans are best suited for verifying/disproving hypotheses. Such global average figures are presented verbally using the word 'we'. Typical phrasings are that 'we' will not run out of energy or natural resources, that 'we' live longer and longer lives', and that 'we' have reduced poverty. The metaphysical 'we' concept, identified by a single global average, is unusable for the analysis of e.g. regional and local problems of environment or poverty. Only genuinely global phenomena, such as atmospheric content of greenhouse gases and ozone depleting substances, can meaningfully be analysed using a global average.

In addition, averaged developmental trends – even for a region – are informative only if the region is largely homogeneous. What is the sense of a statement such as, 'We have seen a global reduction of people living in poverty', when it covers a dramatic deterioration in Africa, a growing number of street orphans in Brazil, more unemployed people in Indonesia, and heavily reduced old age pensions in Russia, outweighed by fewer hungry people in China?

'We can only elucidate global problems with global figures', which would sound reasonable if all problems were shared equally among countries; but Lomborg proceeds, 'If we hear about Burundi losing 21 percent in its daily per capita caloric intake over the past ten years [that could create] information overload.... The point is that global figures summarize all the good stories as well as all the ugly ones. On average, however, the developing countries have increased their food intake from 2,463 to 2,663 calories per person per day over the last ten years.' (p. 7). Yet, the increased food production in China will never feed the mouths of those starving in Burundi, meaning that such an aggregate figure is irrelevant. Moreover, there are lots and lots of instances of starvation and under nourishment in countries that, on paper (i.e. the national average) could supposedly feed its entire population. Here, Amartya Sen's studies of conditions in India make instructive reading.³ Sustainable development is also about limiting local collapses, which is blurred by global averages.

Figures on global food production (e.g. Figure 2, p. 9) used to evaluate sustainable development are therefore misleading. The only thing that really matters is to clarify whether all people have sufficient purchasing power to guarantee every single individual the necessary calorific intake. Moreover, on the national level, a social safety net has to be spread out to ensure that such minimum purchasing power can be upheld when a region is struck by natural disaster. It is the weakest social segments, both nationally and hence also globally, that determine whether a development is 'sustainable' – not

only today, but in the future. The future purchasing power is determined by the available capital apparatus, and by the access to use it, directly (e.g. land allocation) and indirectly (the social security net). Several of those nations that are already poor are consuming from their scarce capital. Fertile lands shrink, nature capital is sold without adequate investments in new capital apparatus. In other words, their savings are negative. Anyhow, their situation may appear tolerable at first sight, when judged only by the trend in per capita income. In a prospective view, historical trends in gross income and consumption can be deceptive, if they are paid for by negative savings. Thus, the future prospects vary greatly for the individual developing countries even if income trends are positive, which in turn makes global average figures even less relevant. Moreover, the segment of the Earth's population with minimal purchasing power will suffer disproportionately, whenever global problems of environment, resources, and starvation spread in a geographically or socially unbalanced way – even though a global average could indicate a reduced load.

Precisely the same methodological problem emerges for the count of e.g. global air pollution. It is correct and good news that some air nuisances (notably in prosperous countries) have been reduced over the last 20-30 years. Not least, the transition from coal firing to oil and (in particular) gas improved air quality in the cities of industrialised countries. Yet, how is Lomborg's general statement about 'less air pollution' in tune with the rapidly increasing air pollution in most Third World cities? Lomborg concedes that his global average does not stretch this far and therefore adds (p. 175) that particle and SO_2 '*...levels in these cities are at least twice the maximum recommended by the WHO. The World Bank estimates that in Beijing at least 4,000 people lose their lives every year because of SO_2 pollution, and the number is rising.*' If weighed against the number of people in the world's cities, how would the average figure for global air quality have turned out (assuming it makes any sense at all to calculate it)? Which weights did Lomborg use – or should I ask, which weights did Lomborg's sources use – and what is the theoretical basis guiding their choices? Yet another of the many questions to which Lomborg owes us an answer.

Lomborg explains (away) as cocksure as ever: The reason why those environmental nuisances are yet to be reduced is that the prosperous nations have not grown so wealthy that doing something efficient about those problems will pay off. However, his argument is not a valid one, because a number of these processes are irreversible and can only be reversed at extreme costs in the future.

Lomborg does not flinch at such objections: According to his 'model', air pollution in developing countries is just a transient phenomenon. It will evaporate, as these countries grow wealthier, as it has in the industrialized countries. But is this all that obvious? Increasing car traffic will leave ever more smog in the streets, especially in cities with high (summer) temperatures. Thus, several studies made by the Danish Clinic of Occupational Medicine have demonstrated that city traffic in Denmark creates an increasing health hazard for bus drivers.

The mere fact that analyses do not systematically consider the capital basis weakens Lomborg's 'Things are getting better' conclusion. What Lomborg could perhaps have concluded is that some global, regional, and local environmental problems are not as serious as some environmentalist NGOs would have us believe. Yet, he could also – if that was his errand – have built up to a conclusion showing a number of environmental problems to be far worse than claimed by 'anti-alarmist' NGOs.

So what Lomborg has demonstrated is that some lobby organizations might have overstated the overall decline in some areas, which is, of course, a point of interest – though the reader would hardly require such bulk of 'documentation' to be persuaded. To such ends, more efficient approaches exist, not least within political science theory.

But even worse, Lomborg has himself demonstrated how easy it is, in a seemingly academic style, to present equality biased data and projections, which to me is much more worrying.

Lomborg reckons in 'lives saved' and 'money equivalents'. In Lomborg's argument, all phenomena can be broken down into their money equivalents, and thus mitigating environmental problems boils down to a 'mere' matter of priority setting. There are no physical limits here. Decision-makers are free to choose whether they wish to solve the environmental problem today or in the future. The complexity of the environment is thus reduced into one dimension, with money as the only measuring unit. This seduces Lomborg to his conclusion: that environmental problems can invariably be solved, enough money provided. Once the developing countries have grown sufficiently rich, they will have the necessary means to solve their own environmental problems, and to make a substantial contribution to the reduction of the genuine global problems. This is supposed to be *'the real state of the world'*! The book completely fails to discuss the specific analytical problems associated with entirely or even partially irreversible physical and biological processes. Hence, the cited calculations on the money costs of the ozone hole and the greenhouse effect appear less than convincing, because no scientific method to value the costs of such processes has yet been established.

Anyhow, in the Lomborg universe, money is the only relevant yardstick. Only money-convertible phenomena are included in his purportedly 'rational' prioritisation basis. A few examples in point:

- The ozone hole arises above the poles, with tentacles stretching down across the prosperous temperate zones where every change (including an increased number of deaths) has a far greater average money value than in the poor regions around the Equator.
- Lomborg's preferred calculation unit for computing the costs of environmental impacts is human lives, made up in US dollars.

Lomborg's somewhat imprecise rendering of his sources, in terms of costs and benefits in relation to the ozone hole and the greenhouse effect respectively, leaves the reader with a disquieting impression that human lives are included with different weights in the cited calculations. A human life is attributed a value proportionate to expected lifetime income. If this is the case, then it is not to wonder that adverse environmental effects in developing countries carry far less weight than does the cost of changing lifestyles and production modes in industrialised countries. This could in part account for the amazingly small benefit from limiting temperature rises, caused by the greenhouse effect.

In all events, it is a very one-eyed position – and certainly not unproblematic in ethical terms – that environmental prioritisation should be based 'strictly on cost-benefit analyses'. For that will cut off relations that cannot meaningfully be made up in money terms from being part of the decision basis. Lomborg apparently assumes that unless cost-benefit analysis is used, 'every form of rational (well-considered and argued) prioritisation is abandoned, leaving decisions to be random and irrational'. In that case, this method precludes the systematic inclusion of irreversible and uncertain environmental impacts in the prioritisation basis.

Lomborg does not discuss the reliability of his prognosis. As mentioned above, he has a strong inclination for choosing the most optimistic ones. That practice leads him to conclude that there is good 'cost-benefit economy' in limiting CFC gases – as a counter-measure against the ozone hole – not least in the USA where the cost of human life is high and the cost of substitution substances low. But there is a hitch, because of his deliberately chosen optimistic scenario, in which the ozone hole has started to shrink already by the end of the 1990s. That was the projection when the Montreal agreement was signed in the mid-1990s. Today it has been demonstrated that the interplay between greenhouse effect and the cooling of outer stratospheric layers can both

aggravate and perpetuate the ozone hole problem, which is yet another argument favouring an endeavour to reduce the greenhouse effect. Just another case showing that climate policy cannot be based on atheoretical empirism (Figure 144, p. 274). What is Lomborg's criterion for accepting a prognosis on climate effects?

On the other hand, Lomborg leaves out considerations of the potential delayed consequences, when it comes to the relationship between today's use of chemical pest control in agriculture and pesticide residues in groundwater. Despite his statement on p. 245 that '*We possess only extremely limited knowledge from studies involving human beings*', Lomborg still concludes on p. 248 that if all pesticides were removed from food production, '*it would probably also mean that we can avoid some twenty deaths a year*'. A fairly precise number, based on very scant historical substance, which would not be particularly helpful anyway, since there is a considerable delay from the time intensive spraying began in agriculture and until contamination becomes manifest. Alone leaching to the groundwater takes several years, after which many more years will pass before 'deaths' begin to occur, and yet a number of years until science has collected enough data to verify or falsify the hypothesis.

Lomborg's approach would suggest that for all these years politicians would just sit back, arms crossed and an intent gaze into the rear mirror, looking at 'the half annual death' that (according to Lomborg) studies have been able to document so far. Was it not precisely such a rear mirror strategy on part of the British government in the 1980s that made it possible for the mad cow disease to reach thus dramatic dimensions? What is Lomborg's criterion for accepting a prognosis on environmental effects?

LOMBORG ON 'THE PRICE OF OUR FUTURE' AND 'DOUBLE DIVIDENDS'

If Lomborg had trusted his own conclusion, '*Things are getting better*', then he had hardly needed to write another 110 pages on '*Tomorrow's problems*. However, there is a worm nagging: Global warming cannot be dismissed – not even by Bjørn Lomborg. Uncertainties are considerable as to how it will affect our climate (not to mention our economy). But there is this nagging worm of uncertainty and irreversibility, so Lomborg takes several pages to argue that the Kyoto agreement will merely reduce temperature rise very marginally. And then he plays his trump card: The cost of realizing the Kyoto agreement would be better spent on other sectors. The calculated cost is USD 245 billion, five times the amount spent on development aid. Thus, the fact that rich countries donate a minute amount in development aids is now used to justify that we cannot afford a very modest CO₂ reduction. Taken at face value, his argument is that CO₂ reductions are too costly for the participant nations, since potentially reducing their consumption possibilities in 2050 by 0.5 per cent! This should be judged in light of the fact that over the same period consumption will have more than doubled (at least in the rich countries). If anything, this serves to demonstrate that there is ample room for several more Kyoto agreements.

When, all the same, the Kyoto agreement can be represented as 'a poor deal', this is due to the use of so-called cost-benefit analyses, leaving out the benefit of reduced uncertainties in addition to an unjustified high discount rate (which requires a high return on any real investment to be profitable). Lomborg is a graduate of political science. So perhaps this is why things go amiss in his book when he is to expound economic theories – including the use of discount rates (as in the section '*The price of the future*', pp. 313-315) and the, according to him, overstated 'double dividend' related to a greener green tax policy (pp. 308-9).

THE DISCOUNT RATE

I will limit myself to the slightly technical aspects of comparing dollars consumed

today with dollars earned on real environmental investments sometime in the future. From his private economy, Lomborg has probably experienced that the price of the future is charged by the bank as interest payments on the loans he has used to boost his current consumption beyond his current income. The rate of interest is a kind of thermometer, showing the willingness to pay or the impatience of consumers with a 'licence to loan', in terms of bringing forward their consumption in relation to their income (an expression of 'private' time preference). The higher the market rate of interest, the greater the impatience of borrowers must be, if they are willing to pay the price. In other words, the rate of interest reflects the willingness of consumers (the present generation) to pay for accelerating their consumption – which has the consequence of reducing the amount of savings available for future generations. Hence, a high rate of interest reflects a high degree of selfishness in the present generation, at the expense of future generations. If the rate of interest was lowered, people would invest more to the benefit of future development.

Thus, if decision-makers raise their eyes a little from the consumption of the present generation (which can be hard, since the present consumers are also voters), to look at the future society, then there is no obvious reason to give a preferential status to the present generation. Instead our point of departure should be that society would continue to exist forever – from which springs the relevant discussion of sustainable development. In this perspective, the present generation should not be allowed to usurp benefits at the cost of future generations.

Ideally, the discount rate (the intergenerational comparison) should reflect the marginal productivity of capital produced in a situation of equitably distributed per capita welfare, in the present and in an infinite future. In practical terms, it is an exceedingly complex calculation full of theoretical and empirical pitfalls, because the future is uncertain and irreversible. Hence, the major part of the theoretical literature on environmental economics offers good theoretical arguments that sustainability studies should use a lower rate of interest than that of the market, since the latter is determined by the present generation's impatience.⁴

Thus, Lomborg is mistaken in saying, '*... However, this apparently sound assumption [using a low societal interest] leads to a grim surprise. If the welfare of future generations means just as much (or almost as much) to us as our own, then we ought to spend an extremely large share of income on investment in the future, because the dividend payable on investments will be much greater in the future.*' (p. 314) Lomborg says so with reference to the IPCC report⁵, which – in other contexts – he has greatly disputed. (And actually, checking up on his reference, we find nothing whatsoever to support the view advanced by Lomborg!)

Apparently, Lomborg takes the financial market rate of interest to reflect the long-term social dividend of real investment. Obviously, he fails to comprehend that the market rate of interest mirrors the present generation's desire to consume, which is not relevant for the social planner as a measure of how future benefits should be discounted. Which, precisely, is why a lower rate of discount implies that more real investment will be profitable, and hence that a greater capital apparatus and cleaner environment will be available to future generations – not least if investments made are on reducing the consumption of nature capital and on pollution control (that is, less environmental debt). I dare say this would be the opposite of a 'grim surprise'. Matters get even more muddled when Lomborg says that a societal interest of 4-6 per cent '*...actually means that we are making sure we administer our investments sensibly so that future generations can choose for themselves what they do – and do not – want.*' (p. 314) A viewpoint which, once more, Lomborg underpins with a reference to the IPCC report – and another case of 'borrowed plumes', since no such argument is found in the report!

Anyhow, it remains more than unclear whatever it is that future generations can better choose for themselves, once nature capital has been cut back and pollution has increased due to over consumption and failure to invest.

If Lomborg had read and understood the central economic arguments, he would have realised that most environmental economists advocate the use of a discount rate, to be set according to the likely long-term productivity trends, which in most industrialised countries hover around two per cent annually. The IPCC report – which he repeatedly cites (and occasionally misleadingly) – would have told him that a societal interest of that order would more likely balance the relation between present and future generations. For the very poor developing countries, however, allocating resources to be invested in the environment presents some serious difficulties, if the present generations are suffering directly. In that case, a relatively high discount rate could be applied because the present generation is starving. That would be a case for extended global solidarity to mitigate this overt poverty, which will otherwise force these countries to run down their natural capital basis. Lomborg, who only looks at global averages, does not discuss this aspect.

Yet, towards the closing of the chapter on ‘The price of the future’, Lomborg apparently feels himself to be on shaky ground. Despite the plentiful references and footnotes, his argument gets quite muddled, and his conclusion ends up in sheer nothing: ‘A reasonable discount rate will probably in the long run mean a far better utilisation of society’s resources, for our descendants too’ (p. 315) No one would disagree – that is, if the previous analysis had been made on a qualified basis in regards to setting a reasonable discount rate in sustainability analyses. But here Lomborg leaves his reader in the dark and uncritically leans to Nordhaus’ study, which – for its 100-year calculation of the feasibility of CO₂ reductions – uses a real interest of 5 per cent (equalling the market interest over the past 10 to 20 years) as discounting factor (which is more than twice the underlying productivity increase). Not surprisingly, Nordhaus (and Lomborg with him) come to the conclusion that efforts to reduce the irreversible greenhouse effect do not pay off. Moreover, the calculation ignores the uncomfortable fact that in a hundred years nothing can be done about the greenhouse effect to reverse the climate effect.

THE DOUBLE DIVIDEND EFFECT

Lomborg does not fare much better when, on pp. 308-309, he sets out to expound why, after all, there is no ‘double dividend’ attached to green taxes. The rather transparent agenda of his argument is to undermine the broadly agreed economic theory, which belongs to the mainstream of environmental economics.

Actually, the ‘double-dividend’ theory should be easy to grasp: Until now, pollution has been gratuitous for the polluter. Thus, the cost of pollution (apparent as welfare lost) has not been paid for. This amounts to a subsidized economic activity. If a tax were imposed on the polluter, this causes the subsidy to be reduced or even cancelled out. This makes the economic system work better – dividend #1. The green tax means that the fiscal minister cashes more money than he or she spends, which in turn makes it possible to cut back one of the ‘real’ taxes, which distort the economic system as it is. When one of the ‘real’ distorting taxes is cut back – we have dividend #2. Hence the term ‘double dividend’.

So far, there is little disagreement among economists; but then Lomborg produces a hat-trick – a negative ‘tax interaction effect’. He claims that a green tax in any case is a tax – which reduces the real income and welfare. He postulates that this ‘tax interaction effect’ might even outweigh the double dividend effect, leaving society no better off than before the green tax was introduced. However, this ‘tax interaction effect’ has already been calculated for when the original tax was introduced into the economy. Deducting for this effect once again would rather be a ‘double counting effect’. Meaning that economic theory cannot support Lomborg in his attempt to nullify the double dividend effect.

Even if the proposed green tax may not hit fully on target, it would really have to miss the target by a wide margin in order to ‘swallow up’ the entire positive double dividend.

Economic theory is not where Lomborg excels, so in that perspective we should perhaps be grateful that he largely sticks to presenting his figures without supporting it with economic arguments .

CONCLUSIONS

What did we learn from Lomborg's input to the environmental debate? More than anything, that care should be taken in the use of statistical source materials, because they are of extremely varying quality and all of a marked uncertainty. Second that one should scrutinize one's data sources and carefully investigate what methods and theories they rely on.

Unfortunately, Lomborg did base his conclusions on rather selective statistics without any in-depth source criticism, on a non-theoretical basis , and with no intention of heeding the subsequent debate and criticism. Against that backdrop, I cannot evaluate his conclusion, that

'... *the children born today – in both the industrialized world and developing countries ... are sure to get a better life*' in any other way than thinking that I have just read another long-winded and postulating contribution to the environmental debate, which has increased my scepticism of the author's intentions by leaving my academic expectations unfulfilled.

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1 I have greatly benefited from clarifying various theoretical aspects with Anders Chr. Hansen, Morten Højer, and Anne Mette de Visser, who, however, carry no responsibility of the final wording.

2 Politiken, a Danish newspaper, and a debate book released by the publishing section of Jyllands-Posten, another Danish newspaper.

3 Sen (1970).

4 See e.g. Atkinson, G. et al., (1997) and Solow (1992)

5 See IPCC (1996) p.133

2. RESOURCES

THE WORLD'S FUTURE ACCORDING TO DR PANGLOSS

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'We shall never run out of energy or natural resources,' neither shall we run out of unspoilt environment or species diversity, for Mother Earth can easily sustain increasing economic activity, because 'technology makes it possible to achieve growth as well as a better environment'. This is the message of Bjørn Lomborg's book, *The Skeptical Environmentalist* (pp 4, 176, 211),¹ based on two basic assumptions:

- First, that until now 'we have experienced fantastic progress in all important areas of human activity' (pp 4, 87, 351), which is true,² and is substantiated with enormous amounts of informative and comprehensive data,³ which form a considerable part of the book.
- Second, that 'we have no reason to expect that this progress will not continue' (p. 330), which however remains unproven. Actual studies of potential future development scenarios are only found on few pages of the book.

Lomborg concludes directly from the first to the second, simply by claiming that 'when things are improving we know that we are on the right track' (p. 5). One cannot reason that way, though many have before Lomborg, presumably including the passengers onboard the Titanic, and especially those in first class. Yet, Lomborg also provides more elaborate explanations, and the transition from his first basic assumption to the second goes via a series of arguments that fall in six groups:

- 1) price developments for natural resources
- 2) incentives created by the market
- 3) infinite duration of limited resources
- 4) economic growth
- 5) the uncertainty of prognoses
- 6) the lessons of history.

As will be seen in the following, all six arguments are erroneous, because they evade the true issues, which are of a scientific and moral nature.

1. PRICE DEVELOPMENTS FOR NATURAL RESOURCES

Until now no overall increases in raw material prices have occurred, and therefore 'resources are not limited' (which is evidently mistaken, but all the same Bjørn Lomborg's claim),⁴ and especially 'there was – and is – enough oil' (p. 120). For, according to Lomborg⁵, 'if we want to examine whether oil is getting more and more scarce we have to look at whether oil is getting more and more expensive' (p. 122). The argument is based on the economic theory on the market price of a raw material with known deposits; it will equal the extraction costs plus an increment for scarcity that increases over time by an annual percentage, equalling the rate of interest.⁶

But first, the market is a peculiar place to search for information on the magnitude of resources and likely technical advances in the future. The sensible thing to do would be to directly address geologists and engineers. Second, the price will depend on the market players' preferences for present resp. future consumption, which does not necessari-

ly reflect the market players' assessment of our future raw materials supply: A low price could just as well owe to the fact that when it comes to anything remoter than 5-10 years into the future they could not care less. For instance at an interest rate of 5 per cent the market would be very short-sighted, and the scarcity increment would be minute until a few decades before depletion. Moreover, for oil, an appreciation based on calorific value would seem short-sighted, since oil is a combination of chemical compounds with many other and more sophisticated applications than combustion. Third, no market and hence no market price exist for many ecological resources. The most urgent problems are linked up with emissions to the environment caused by resource consumption, and even if certain types of pollution, notably the most concentrated ones, have been successfully eliminated, other and more elusive pollution problems have increased. However, there is no such thing as a market for air with a low CO₂ content, or for seawater not contaminated with nutrients.

Two types of problems determine the adequate supply and optimal use of resources: First the magnitude and nature of reserves and the available technical options, including possible substitutions in consumption and production; these are scientific problems, and naturally must be investigated using scientific methods, and not by scrutinising price trends for some raw materials markets (comp. pp. 137-140). Second, to which extent do we want to allow for the welfare of future generations? Stuck between both these sets of problems there is little leeway left for an economic analysis, the contribution of which is to examine the effects of economic incentives under various institutional arrangements, once the answers to both the above questions are known. Adequate supplies and optimal use of resources is a technical, scientific and political issue, yet not primarily an economic one.

In order for an economic analysis to make sense we need to assume that certain possibilities for substitution exist. It must always be possible to substitute non-renewable resources with greater inputs of labour, manmade capital and renewable resources. As the well-known American economist Robert Solow said in 1992, 'Without this minimal degree of optimism ... there is no point of talking about sustainability'.⁷ That assumption is the backdrop of the particular brand of economic eco-optimism, and the effect of infinite possibilities for substitution – as Robert Solow said in 1974 – is that 'the world can, in effect, get along without natural resources'.⁸ Whether or not the assumption is correct is a scientific problem, and not an economic one.

We cannot trust the market mechanism to allow for generations yet unborn, even though a profiteering owner of an oil well will let the oil remain in the earth, if prospective future price rises are sufficiently high. It is true that in theoretical terms market equilibriums over long spans of time are possible, and that in theory there is no difference between those who will live in a hundred years and e.g. those who live in Denmark. Yet, in practical terms markets only function in the short term, and there is another, rather more fundamental problem. There is always a large number of possible market equilibria. They produce widely different distributions of the final consumption among market players, which is precisely the issue here. Which distribution is realised depends on how resource control is distributed at the opening of the market, that is today, when the present generation owns all natural resources. The problem confronting future generations is that they do not own anything. It is equally decisive for those living in Denmark how many resources they control, in the short term especially labour and capital.

The allocation between generations is an extremely painful problem that cannot be

solved 'with a discount rate of minimum 4-6 per cent', as suggested by Lomborg (p. 314). An interest rate of 5 per cent will require considerable price rises, before the market will save anything for posterity. It is possible that the utility value to us of a barrel of oil is 132 times greater now than in a hundred years and 17,000 times greater than its utility value in 200 years, which would correspond to a 5 per cent discount rate. Still our great-grandchildren are likely to see things differently. Whether a hundred years is a long time obviously depends on one's point of observation. There are several suggestions on how to formulate the optimisation problem over time with a reasonable allocation between generations, i.a. by including the condition that welfare must not decrease over time, or by applying a discount rate approaching zero over time.⁹

2. MARKET-MADE INCENTIVES

Yet, 'if *price* increases this will increase the incentive to find more deposits and develop better techniques' (p. 124). The problem with the effect of those market-generated incentives is that the causation chain has two links that are both weak. First, price rises have to happen early and strongly enough for measures towards substitution and technical development to be taken in due time; however, since the scarcity increment will only make itself felt right before depletion, prices will only rise if geological conditions cause sufficiently rapid increases in the extraction costs.

This first link of the causative chain can be corrected politically by means of administrative regulation, taxation and subsidies, and convertible quota. In all cases, these are incentives for centrally and politically set allocations, i.e. what is normally termed planned economy. Moreover, the difference between those instruments can easily be over-rated, and even administrative regulation can become a purely economic incentive in the form of fines, if the public ignores the fact that infringing laws and regulations is a criminal offence. No doubt, there is good case for using economic and other incentives in environmental politics; yet they should not be mistaken for market economy, which is something entirely different, namely that the market will spontaneously and decentrally determine how resources are to be allocated.

But secondly, those endeavours have to succeed, and that does not happen 'automatically' (p. 176). How can Lomborg let himself believe that 'new oil fields will be continuously added as demand rises' (p. 125)? As Mr Micawber says, 'Something will turn up'. Of course, it cannot be ruled out, and luckily, in Mr Micawber's case, Dickens finally let it happen. But what we do know for certain is that the number of unknown reserves will go down at precisely the same rate as the number of known reserves goes up. It is sublime nonsense that 'we have more and more oil left, not less and less' (p. 125), and that our oil reserves can be compared with a 'refrigerator' which, when near-empty, can simply be replenished 'in the supermarket' (p. 125). According to Bjørn Lomborg, 'fusion energy will be commercially available only after 2030 or perhaps well into the twenty-second century' (p. 129). Or perhaps never.

The magnitude of resources is a scientific problem of an entirely different nature than economic effects reflected as rising prices. If the laws of supply and demand do not provide enough incentives, they can be corrected by state decree. As for the laws of nature, they do not lend themselves to amendment by decree.

3. INFINITE DURABILITY OF LIMITED RESOURCES

The same limitation eliminates the third argument, namely that 'it is *theoretically* possible never to run out of a limited resource, even with continued use ... This is simply because recycling or efficiency improvement - our ingenuity - compensates for both consumption and increases in consumption' (p. 147). Simply!

Infinite durability of limited resources can appear paradoxical, in the same way as Xenon's (c. 490-430 B.C.) famous argument about Achilles, who cannot catch up with the tortoise. Whenever Achilles reaches the place where the tortoise started, the tortoise will have crept a tiny bit further, and when Achilles has run that stretch, the tortoise will once more have crept a bit of way, and so forth. For Achilles to catch up with the tortoise the sum of this infinite number of 'bits of way' has to be finite, which Xenon did not believe. Yet it is indeed possible - that is, provided the individual elements of the sum converge towards zero quickly enough. Archimedes (287-212 B.C.) knew the final sum of an infinite geometric progression, which is what we have here. This mathematical result is the basis of Lomborg's contention, that the consumption of a finite resource can in fact extend over an infinite period of time.

If oil reserves are estimated to last 44 years' of present consumption it will be possible to stretch them forever, provided the consumption declines by 2.3 per cent a year. If the efficiency of oil use increases correspondingly, the utility value can be kept unchanged. That requires a doubling of efficiency in 30 years, and in 100 years the efficiency will have to be approximately increased tenfold. However, there is nothing to indicate that consumption is on the decline, or that efficiency will continue rising infinitely, which latter is moreover impossible in theory, since the laws of thermodynamics set an upper, finite limit to energy efficiency.

Energy efficiency has increased considerably. All the same, the oil consumption of the OECD countries is expected to rise by 1.1 per cent annually until year 2010, gas consumption by 2.6 per cent, and power consumption by 2.1 per cent.¹⁰ In 1987 the Brundtland Report concluded that energy consumption would have to increase by 450 per cent up to the year 2025 if 8.2 billion people were by then to have an energy consumption comparable to the 1980 consumption of the wealthy countries.¹¹

4. ECONOMIC GROWTH

Lomborg blankly dismisses 'our myth of the economy undercutting the environment' (p. 32), one of his key theses being that the impacts of economic activity on the environment are positive, since 'over time, the environment and economic prosperity are not opposing concepts, but rather complementary entities' (p. 210).

Economic growth is seen as the answer to a host of different problems: poverty (p. 72, 100), starvation (p. 109), deforestation (p. 114, 117), shortage of water (p. 153), and pollution of air (p. 176), indoor climate (p. 183) and water (p. 203), and moreover as a contribution to 'handling' the greenhouse effect (p. 289, 323).

His general confidence in the beneficial effects of economic growth (p. 210) relies on extrapolations of developments in discrete areas, which he does not relate to one another. E.g., re agriculture, he says that 'there is no "wall" for maximum yields in sight' (p. 108); yet he fails to mention that increased yields will require increased supplies of other inputs, notably energy, water and chemicals. As for water, 'we are beginning to experience limits' (p. 156), and in developing countries redistribution from irrigation to industry and households 'will probably involve a minor decline in the potential agricultural production' (p. 155). What a drastic increase in energy consumption would mean to the environment remains unclear. The problem remains whether such development is possible, or in other words, whether it is sustainable – characteristically a concept that Lomborg hardly refers to (comp. p. 91).

5. THE UNCERTAINTY OF PROGNOSSES

The better part of Lomborg's book deals with developments over the latest decades. Actual analyses of future possibilities are 'surprisingly'¹² infrequent. There are quite a few approaches,¹³ however the arguments for his optimistic predictions are mostly limited to a statement that 'there are good reasons to believe them',¹⁴ provided a number of anticipated and positive, yet uncertain technical advances occur.

By contrast, Lomborg is quite preoccupied with uncertainties found in the numerous gloomy predictions of future environment and resource-related problems, not least in *Limits to growth* and *Beyond the limits* (p. 120-121). Many of these are not actual forecasts, but much rather projections with no assumptions concerning the beneficial, yet uncertain technical advances in which Lomborg puts his hopes. In Lomborg's opinion they do more harm than good, because 'the Litany' (as he calls them) provokes unnecessary fears, 'The Litany frightens us' (p. 331).

To substantiate his view he contrives ingenious examples of what could have caused us to worry in the past. In a realistic extrapolation of the amount of transport in London in 1870 a population forecast would have predicted a disastrous increase in mortality due to poisoning, as the result of enormous accumulations of horse dung in the streets. As mentioned by Lomborg (p.124) the English economist William S. Jevons in 1865 predicted imminent problems for the English economy due to the increasing cost of coal mining, and in 1907 the Swedish economist Kurt Wicksell cautioned that ruthless exploitation of forests would cause the entire Swedish industry to collapse like a house of cards. Their prophecies did not hold; but after all that is no criterion for a prophecy to be good or not.

Whether those concerns made sense is quite a different matter. That depends on whether available, relevant information was being used, and not on whether the worst imaginable event did eventually occur. If some of the ancient Egyptians were concerned about the depletion of copper reserves in Nubia, the Eastern desert and in the Sinai that was justified, because Egypt was a bronze age economy that relied heavily on copper. Based on the conditions of the past the correct prognosis would have seemed wildly improbable, since people then had no way of knowing that Cyprus had large deposits, or that iron would prove to have far more potential applications than did bronze.¹⁵

Lomborg cites several examples of forecasts that proved wrong,¹⁶ and that uncertainty 'necessitates that the precautionary principle be strictly circumscribed' (p. 348, comp. pp. 227, p. 330), since it is 'unreasonable to spend such large sums of money on such uncertain events' (p. 317) due to the greenhouse effect, or to prevent the extinction of species 'which is claimed to be a catastrophe' (p. 256). Yet, the uncertainty of forecasts is no sufficient reason to ignore them. The best forecast for our future would hardly be the best decision basis. The task is not to find the best forecast for our future, and then act as though that forecast was certain. If there is a certain probability of less positive scenarios with serious consequences, it can be rational to try warding them off, thus acting upon a less probable forecast. After all few people would consider their fire insurance premium to be wasted just because their houses did not burn down during the insurance period.

The marking feature of serious environmental problems is their incalculability. Human activity has proved to have ever more extensive impacts that we had never suspected: environmental impacts of DDT in the 1960s (p. 215, 233), eutrophication in the 1970s (p.

196, 201), the ozone gap (p. 272, 276) and the greenhouse effect in the 1980s (p. 258-324), and the mad cow disease in the 1990s. It is actually true that 'for more than 40 years, earth has been sending out distress signals' (p. 3).

As Lomborg writes 'we simply know too little' (p. 238) of the cumulative effect of man-made compounds released to the environment, e.g. estrogens, which Bjørn Lomborg mentions, and a number of toxic and dangerous waste substance including dioxins and VOCs (Volatile Organic Compounds), which he does not mention. For Bjørn Lomborg this is an argument for ignoring the waste problem that 'far fewer data are available', and it is easy to settle for the view that 'they probably pose less of a danger to humans' (p. 166).

Lomborg tries to get round the problems in part by simple extrapolations and assumptions on possibilities for substitution, and in part by resorting to rash price calculations, most markedly so in his section on the greenhouse effect (p. 258-324), which actually deals with the future. First of all, it is devoted to exposing 'the basic uncertainty of climate sensitivity' (p. 273). Thus 'throughout the past 25 years the basic range of estimates of global warming from CO₂ has *not* improved' (p. 271), and 'present models seriously overestimate CO₂-induced warming' (p. 271).

Curiously, this uncertainty disappears when it comes to the optimum expenditure for controlling global warming: 'economic analyses clearly show that it will be far more expensive to cut CO₂ emissions radically than to pay the costs of adaptation to the increased temperatures', and 'if we go beyond an 11 per cent global CO₂ reduction, the world will lose' (p. 318). Apparently, economic models are more suitable for analyzing global warming than climatological ones.

Optimal carbon reduction "is 4 per cent of current CO₂ emissions, increasing to 11 per cent by 2100, neither more, nor less, according to the DICE-model (Dynamic Integrated model of Climate and the Economy), a stylized model of various economic aspects of global warming (pp. 305-307), which is constructed upon a host of heroic assumptions, including growth rates of total factor productivity (1.5 per cent, and then decreasing) and social discount rates (3 per cent). Here we could truly talk about uncertainty, although Lomborg does not, since the DICE model is based on a number of assumptions that taken individually are quite uncertain. Lomborg's 4 and 11 per cent is the optimum for one out of several very hypothetical scenarios, namely the one assuming at the outset that damages are small and where this is proved true in 2085.¹⁷ According to Lomborg the great problem of the greenhouse effect is that we are spending too much money to keep it at bay, since even the greenhouse effect is a 'limited and manageable problem' (p. 323).

Price calculations are well suited for marginal decisions that allow substitution, e.g. whether you want to have gherkins or beetroots with your roast pork. Breakdowns of total or true savings, i.e. savings adjusted for natural resources spent and environmental deterioration also presuppose possibilities of substitution, namely between human capital, manmade physical capital and natural capital. Many economic calculations show that true savings are positive and hence sustainable, based on the assumption that North Sea oil can be substituted with e.g. education.¹⁸

However price calculations and substitution assumptions become meaningless if critical maximum values are overrun and cases of discontinuity, irreversibility and non-linear effects arise – all of which would favour a precautionary principle, yet which Lomborg evades by ignoring it (p. 316).

6. THE LESSONS TAUGHT BY HISTORY

However, if Lomborg's other arguments are not watertight, then there is the lessons of history. The purpose of presenting ample evidence of improvements of human welfare until now, as well as examples of gloomy and mistaken predictions in the past, is of course to prove that 'one might have thought that history would have made us wiser' (p. 121) and that 'we have no reason to expect that this progress will not continue' (p. 330).

Bjørn Lomborg is following the footsteps of Marx and Engels (without crediting these prophetic forerunners), who also had confidence in technological progress, '... and what is impossible for science?' as Engels wrote back in 1844,¹⁹ at a time when most other economists were concerned about resources, and economy was called *the dismal science*.²⁰ In 1979 the following statement could be read in the Soviet journal *Social Science*²¹: 'There has not been a single case in which science was unable to solve an urgent problem for humanity', and in 1991 Per Stig Møller, then Danish minister of the environment, could second this official Soviet viewpoint: '... after all it can be empirically established that whenever man has a problem, he will also solve it'.

The gist of the historical argument is that things have never been so good as now, so things will continue to get better and better still – thus a direct conclusion from the first to the second basic assumption mentioned in the introduction. Lomborg takes great pains with the correctness of the first argument. However, the second argument is the real trouble. Obviously, such thinking is not very helpful when it comes to environmental problems of the future, since presupposing documentation showing that the key features of historical examples will continue to exist – and no such documentation is present. Lomborg's conception of 'the historical probability'²² is simply devoid of any sense.

Moreover it is far from true that mankind has solved all its environmental problems so far. Our history is rife with environmental disasters - though of a relatively local nature so far - in which cultures perished after depleting their own resource basis. But Lomborg side-steps this issue, despite his declared purpose of providing 'a general impression of what is going on in the world' (p. 40) based on 'long-term and global trends' as described by means of 'figures and trends which are true' (p 12).

The environmental disasters of the past were certainly serious enough for those who suffered them, e.g. the destruction of agricultural areas in Southern Mesopotamia after 3.000 B.C, and the subsequent decline of Sumer empire. Other examples include the crashing of the isolated Easter Island because of exhaustion of the resource base of trees, and also the decline of the Maya culture, and the swamping and desertification in Antiquity, not least in North Africa. Examples from our own time are the repeated over-fishing crises at Newfoundland, soil erosion in Kazakhstan and in the *dust bowl* in the American Midwest, over-exploitation of groundwater in California, in the Middle East and in Central Asia – where in just a few years Lake Aral was transformed into a salty desert after the water level had fallen by 13 metres and the water content had been reduced by two thirds since 1960 as the result of large-scale cotton cultivation and irrigation. The tragedies of the Easter Island and of Lake Aral are mentioned by Bjørn Lomborg (pp. 27, 157), but comfort is easily at hand, as Bjørn Lomborg assures us that 'today, we have learnt the lesson' (p. 157). Really?²³

Lomborg represents the environmental history of mankind as a continuous chain of

advances.²⁴ Yet the true lesson of our environmental history is quite another,²⁵ namely that we have displayed a stunning improvidence and lack of long-term foresight when it comes to the problem that – with varying success – people have wrestled with throughout history, namely to achieve balance between, 1) our desire to live in wealth and increase the supply of commodities, first and foremost by increasing the distance to the starvation limit by increased food production, 2) our desire to proliferate, and finally 3) the capacity of our natural basis to sustain production.²⁶ Yet, the case could also be stated in a more positive vein as our tremendous ability to suppress the insurmountable problems - of which there have been countless -, and instead concentrate on doing something reasonable. Globally that approach has been successful so far, and in Lomborg's advice we should continue freeing ourselves of 'our unproductive worries' (p. 351).

As correctly pointed out by Lomborg wealth has never been greater than today. Yet, the material problems are felt to be increasingly urgent by wide circles in society, not least among the wealthiest. Materialism is strongly rooted in the nature of people and society, and in that sense we are all marxists. Therefore it would require serious readjustment for us to approach the global environment and the global distribution - the big challenges of our times – in a civilised manner, and without falling back on the familiar regulation mechanisms, namely war, famine, migration, and pandemics. Fortunately, efforts are made towards creating political solutions, although more ominous trends are also in evidence. Probably the Gulf War was a matter of Middle East oil, much rather than about Kuwaiti democracy.²⁷ As for the foreseeable future scarcity of oil, the American military interest may be more eloquent than the present low prices on oil.

POSTMODERN ENVIRONMENTAL SCIENCE

None of Lomborg's six reasons for environmental optimism holds water. They are based on the assumption that arguments derived from history, economics and (even) mathematics can be used in predicting our future in terms of biology, geology, technology and climate. However, the interfaces between both groups of disciplines are far too small. The conclusions are all wrong. There is no getting around it: If we wish to know something about the future we will have to ask biologists, geologists, engineers, and climatologists.

Lomborg makes a courageous and impressive attempt to scrutinize the sources and create an overview of the facts, and taking into account that he is nothing but an interested layman in relation to the whole wide range of academic disciplines he embarks upon, he is to some extent successful. Obviously, it is not correct and sufficient to represent man's environmental history as a continued progress, or to focus on the exaggerations, errors, and 'myths' (p. 115) launched by environmentalist organisations, without crediting their 'worries' (p. 351) for a share of the achieved environmental improvements. Nor is it correct and sufficient to say that 'we have more [oil] reserves than ever before' (p. 123), without the addition that finding and exploiting new reserves is becoming increasingly difficult. Or that 'actual extinctions remain low' (p. 255), without the addition that the number of critically threatened species is rapidly increasing. Or that 'fish consumption will increase dramatically' (p. 108) by means of fish farm production, without mentioning the ensuing environmental and biological problems.

However, Lomborg's attempt to span enormous amounts of literature presents a few problems that spring to the eyes of any reader with firsthand knowledge of the literature. To my mind, the gravest example is Lomborg's misconceived and strongly biased

use of the calculation examples of the DICE model (pp. 305-307), comp. above.

Another problematic example from economics is Lomborg's statement, that 'inequality peaked in the 1960s, has been decreasing since then and is likely to continue to decrease' (p 75).

First, because it is questionable whether measures of inequality only 'make sense' if, like the Gini-coefficient²⁸, they are scale invariant, meaning that inequality remains unchanged when all incomes are increased by the same percentage. This is obviously reasonable in cases when e.g. all incomes increase by 10 per cent due to inflation, and perhaps also when comparing income distributions in a single country for a shorter time-span. Yet, that does not imply, as claimed by Lomborg (p. 75), that it is also reasonable when comparing global differences of income in 1960 and 1995. Thus, if real per capita GDP measured by PPP (i.e. Purchasing Power Parity) in a poor country (e.g. India) was to double in the period of 1960-1995, from 700 to 1400 PPP\$, and simultaneously doubled from 10.000 to 20.000 PPP\$ in a wealthy country,²⁹ would we be justified to say that inequality between both countries was unchanged? This issue is not as straightforward as Lomborg would have us believe. And second, the long-term development in global inequality is still a much disputed issue.³⁰

It is incorrect that until 1980 'the Chinese did not experience any noticeable improvement in prosperity' (p 66); in the period of 1950-1973 China's GDP growth was 5.8 per cent a year and 3.7 per cent per capita, while figures for e.g. South Korea were 7.5 resp. 5.2 per cent.³¹ Bjørn Lomborg has very unshakeable views on what generates economic growth (p. 62, 72), including a very firm belief in private property (pp. 67, 107, 113), which may explain his confidence in 1998 that 'Russia is emerging from its crisis' (p. 70, Danish version). However, Russia was hit by the August 1998 crisis, but Bjørn Lomborg concludes, as he did in 1998, that 'real increase in production is now prevalent' (p 76).

Probably it would be more appropriate to say that we know very little about what causes growth, which is reflected by the fact that one of the most robust growth determinants is absolute latitude, i.e. distance from the Equator - with Singapore as one remarkable exception.³² Bringing about a proper overview of the entire literature is a demanding task, not least requiring a sound knowledge foundation.

Yet, such one-sidedness and lack of insight do not detract from the fact that Lomborg has done a great job in compiling vast amounts of interesting and well-documented information that has put right a number of superficial notions, at least in the present author. For that he deserves thanks. For instance, it is interesting that the total pollution from the 1989 Exxon Valdes disaster was less than 2 per cent of the water pollution caused by speed boats in the USA each year (p. 190-193); that estimates for the number of species to go extinct each year vary from 40,000 to 1,000, although Bjørn Lomborg's reasons for preferring the lower estimates rather than the higher ones are not made entirely clear; and that from 1600 till today the extinction rate for mammals and birds went up from one species every four years to one a year (pp. 250). Moreover, it is quite comforting, just for a change, to read an environmental book that is not sheer lament and misery.

The problem lies with the coherence and selection of the selected data. How much faith can a reader have in his assessments, and how qualified are they? Thus, concerning climate change, Bjørn Lomborg is extremely critical towards the predictions of the climate models, but the economic models and their welfare computations are vulnera-

ble to much more serious criticism, since not only do they rely entirely upon assumptions, but they also suffer from inconsistencies concerning basic concepts such as discounting, welfare aggregation, and substitutability. If climatological models amount to 'computer-aided storytelling' (p. 280), even more do economic models.

Lomborg's general praise of economic theory, and especially a laissez-faire interpretation of it - from the power of market prices and economic incentives to the welfare models of the costs of climate change - shows no critical distance, but rather the enthusiasm of the newly initiated. This general problem of judgment permeates the whole book. The real problem is his argument and his conclusion, namely that Planet Earth 'is so incredibly much larger than all our needs'.³³ That is true given a sufficiently short (that is, a very short) time horizon. Yet, with just a minimum of foresight, that conclusion ends up as the opposite of the truth. The very basis of contemporary environmental awareness is that Planet Earth has its limits in relation to our human capabilities and activity, which are now of global dimensions. It is very hard to imagine 11 billion people on earth with the same or maybe twice our present standard of living (p. 46). That would require 'sufficient energy' (p. 143), which is uncertain, sufficient possibilities of substitution and technical advances, which is uncertain, and sufficiently small environmental effects, which is also uncertain. One can only hope for Lomborg's predictions to hold.

In any event it is of course an excellent academic exercise to make a sweeping statement and search out arguments of the type: 'A stone cannot fly – Mum cannot fly – Ergo Mum is a stone.'³⁴ But there is a problem if Mum starts believing it and feels that her legs 'start feeling cold', or when – in a boosting review of Lomborg's book – Tøger Seidenfaden, executive editor-in-chief of Politiken (a Danish broadsheet daily) feels that it will set 'a new agenda on the environmental issue' and declares that 'we are overruling the scope and seriousness of environmental problems'.³⁵ Nor is it good when the over-laudatory reviewer of *The Economist* (8 September 2001) declares 'More power to him' and '“The skeptical environmentalist” is a triumph'. *The Economist* admires this kind of wishful thinking about the environment and repeats it regularly.³⁶ One of these articles, 'Plenty of Gloom' (20 December 1997), gave rise 47 pages of serious comments in the journal *Environment and Development Economics* (1998, pp. 491-537), which could be read as comments to Bjørn Lomborg, too.

Lomborg mostly fastens upon the fact that erroneous and exaggerated claims on the state of the environment have been advanced in the past, which produces his wholesale distrust in scientific expertise³⁷ and makes him caution against 'taking “the expert of the day” to be anything more than the evidence of one party'.³⁸ Environmental analyses lose their objectivity in this derailed representation of the world and are reduced to political instruments. This is analyzed in Chapter 2 (pp. 34-42), the only chapter where Bjørn Lomborg's professional training as a political scientist is relevant. He explains why 'we get primarily negative news' (p. 41) about the environment, from a truly political science point of view, namely struggle for power: the struggle of environmental organizations for political power, the struggle of news media for intellectual power, and the struggle of research institutions for economic power - 'there are many grants at stake' (p. 254). Lomborg represents a very contemporary and extremely dangerous trend, namely the post-modern whose credo is: There is no such thing as truth, and there is no such thing as justice; for they are both subjective. There is only one thing – power – which, admittedly, is also subjective, yet unlike truth and justice is manifest.

With Bjørn Lomborg, Dr Pangloss has had another double, and one just as lifelike as the real one – found in Voltaire’s *Candide* from 1758, who ‘taught metaphysico-theologico-cosmoloogology and showed with irrefutable proof that the was no effect without a cause, and this world was the best of all possible worlds.’

Candide was inspired by the Lisbon earthquake in 1755 and the subsequent auto-da-fe, which deeply shook Voltaire.³⁹ Unfortunately, the target of Voltaire’s persiflaging narrative was the great Leibnitz, which proves that even the very wisest, amongst them Leibnitz, occasionally find themselves capable of reeling off the most pigheaded nonsense.

„Enjoy“, was Bjørn Lomborg’s concluding word in the Danish version (pp. 11, 264). As will be seen, I do not agree with the premises, although I can second his conclusion. There is much to be enjoyed, not least the quest for a true representation of reality, which – like other spiritual joys – is both sustainable and inexhaustible.

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1. Lomborg, 2001. Page numbers in the text refer to Bjørn Lomborg’s book, ‘The skeptical environmentalist’. The first sentence is quoted from the Danish original, since the English translation is inaccurate: ‘We are not running out of energy or natural resources.’
 2. With few exceptions, namely the suicide rate, which has increased from around 1 per 100,000 in traditional communities to 10-25 in modern urban communities (p. 85), and possibly eutrophication (p. 210) and the greenhouse effect (p. 323).
 3. In such a large body of data ‘errors will undoubtedly still have crept in’ (p. xxiii). One of them is that Bjørn Lomborg’s ‘profession’ is ‘statistics’ (p. xx); according to *The Economist* (8 September 2001 p. 97) he is even a ‘professor of statistics’. Bjørn Lomborg has no degree in statistics. He is a Ph.D. in political science and a senior lecturer of politology at the Institute of Political Science, Aarhus. Und das ist ganz was anders.
 4. In the Danish newspaper *Politiken*, 19.1.98.
 5. And many economists, comp. Mankiw, 1997a:244, in which the viewpoint is rendered verbatim. But that apart, this source, like many other recognized economics textbooks show little interest in matters of environment and resources. E.g. Mankiw (1997b) and Burda & Wyplosz (1993) have chapters on economic growth with comprehensive empirical documentation without mentioning ecology, environment, pollution, green taxing, and resources. These entries simply do not exist in the index.
 6. Pearce & Turner, 1990:271-276.
 7. Solow, 1992:9.
 8. Solow, 1974:11, comp. note 5 above.
 9. Pearce & Turner, 1990:211-238.
 10. *The Economist*, 29 May 1999, p 70.
 11. U.N., 1987:170.
 12. Together with ‘amazing’, ‘astounding’ and ‘astonishing’, this is Bjørn Lomborg’s favourite term, used over and over, e.g. pp. 38, 73, 119, 123, 171, 227, 245, 252, 315, 331, 339.
 13. Pp. v (citation from Julian Simon), 5 (General conclusion), 77 (economic growth), 96-98 (grain), 99 (biomass), 106 (soil erosion), 108 (fish), 114 (Amazonas), 127 (coal), 128 (oil shale), 129 (nuclear power and ‘commercial’ fusion energy), 130-132 (cost of renewable energy), 137, 145 (minerals), 155 (water), 207 (waste), 255 (species extinction), 280 et seq. (greenhouse effect).
 14. Pp. 77 (growth in poor third-world countries), 100 (increased harvesting yields), 118, 128, 329 (energy prices), 156, 158 (water saving), 159 (solar cells), 176, 211, 329 (environmental improvements in third-world countries), 330 (major problems of the future).
 15. Aage, 1984:108.
 16. Pp. 60, 983 (grain), 122-124 (oil), 124 (coal), 137 (raw material costs), 141 (iron), 350 (starvation).
 17. Social cost-benefit analyses of the type in which attempts are made to calculate a number of different effects in money, are nearly always sensitive in terms of assumptions, not least regarding the discount rate, and also when the issues to be evaluated are far more transparent.
 18. Interestingly the fronts regarding green amendments to the national accounts have been reversed: Earlier economists were criticised by environmentalists for not including environmental effects; now when attempts have been made to do so, economists are still being criticized, though the criticism has switched sign. Previously economists used to say, ‘Why am I to sit here setting a price for the lark’s song?’ Now the environmentalist organizations are saying, ‘Two pounds of larks, or two French lessons?’.
 19. Cited from Meek, 1953:63, comp. Aage, 1984:109.
 20. Parallelism to ‘the dismal trade’, i.e. undertaker business. Marx did not attribute any importance to nature as a

- production factor, and this has penetrated in many modern textbooks in macroeconomics, comp. note 5 above.
21. Fyodorov, 1979:221.
 22. Launched by Bjørn Lomborg in the Danish newspaper Politiken, 19.1.98.
 23. Ponting, 1991:68-87, 260-265; Bjørn Lomborg mentions the problems of soil erosion as being 'vastly overstated' (p. 105), the ongoing overfishing as a problem to be solved by fish farming and ownership rights to the fish (p. 108), and irrigation as being relatively unproblematic and with 'great potential' (p. 66, 155).
 24. Pp. 50 (life expectancy), 56 (health), 61 (nutrition), 70 (prosperity), 82 (leisure life), 112 (forests), 164 (air quality), 170 (lead), 197 (eutrophication), 250 (species extinction).
 25. Ponting (1991) can be recommended as a corrective, although unfortunately it does not have the excellent degree of documentation of Bjørn Lomborg's book and unfortunately (p. 193) peddles information concerning extinction of species without the criticism reported by Bjørn Lomborg (p. 250).
 26. Ponting, 1991:17.
 27. Bjørn Lomborg touches upon the issue (pp. 121, 129, 151). Yet, neither does it need to give rise to concern, since many of those conflicts are solved, and 'there is nothing unusual in these wars', as we were told in the Danish version (p. 141). According to the English edition there is still nothing to worry about, but now the reason given is that 'waging a war for water simply makes very little strategic sense' (p. 156).
 28. And which, for reasons unknown, Lomborg calls a 'a simple gini coefficient', which has very little in common with the Gini-coefficient (p. 73).
 29. Comp. UNDP, 1998:149.
 30. Comp. e.g. Pritchett, 1997.
 31. Maddison, 1989:35-36.
 32. Sala-i-Martin, 1997.
 33. Bjørn Lomborg in the Danish newspaper Politiken, 19.1.98.
 34. The student, Erasmus Montanus, in a classical Danish comedy from 1722 by Ludvig Holberg, uses a false syllogism to prove that his old peasant mother is a stone.
 35. Politiken, 22.9.98, also quoted as 'advance praise' in the book.
 36. The Economist, 20 December 1997, pp. 21-23; 11 September 1999, survey pp. 29-31; 4 August 2001, pp. 63-65.
 37. Bjørn Lomborg does indicate that 'primary research in the environmental field ... appears to be professionally competent and well balanced' (p. 12); still, his key message is that the driving force of research is to grab more grants (pp. 36, 37, 254, 411, note 2109).
 38. Bjørn Lomborg in the Danish newspaper Politiken, 12.1.98.
 39. This natural disaster is described in *Candide* (Voltaire, 1758). Maybe it was in part created by man since, following the first minor quake, the grateful survivors rushed to the churches where they lit enormous numbers of wax candles. Reportedly these caused the next, extremely forceful quake to set the city afire, all of which caused two-thirds of Lisbon and 30,000 people to perish.

ENERGY, NATURAL RESOURCES, AND WATER

By Henning Schroll, associate professor, Institute for Environment, Technology and Society, Roskilde University, Denmark

It does not seem plausible that economic growth can go on forever in the world that, from an ecological viewpoint, is a closed system in terms of substance. It would require such dramatic improvement of our natural resources utilization that it does not seem realistic. The global population is growing, though the available space does not. Our consumption of natural resources increases, and reserves of oil, coal, iron, chromium, water, etc. are finite. Even assuming that e.g. new oil reserves are found, they remain limited, and some day we will run out of oil. Through the ages such deliberations have caused many to theorise that sooner or later things were bound to go wrong with our supply of natural resources. Lomborg calls those persons doomsday prophets, and proclaims that there is no reason to take them seriously.

WHAT WAS THE MESSAGE OF THE 'DOOMSDAY PROPHETS'?

It is a widespread notion that the book *Limits to Growth* is some kind of a doomsday prophesy. Yet, on reading the book, one finds that it is an attempt to build a global model to assess the possible outcome if there is a parallel growth in global population, industrialisation, pollution, food production, and resource depletion. If that development were to continue unchanged, then the limits to growth would be reached within the next hundred years. The most likely result would be a sudden fall in population figures and industrial capacity. However, the authors state, it is possible to change these growth and development features and create a state of ecological and economic stability that will be sustainable for a long time to come. Such state of global equilibrium can be designed to satisfy the basic material needs of every person on Earth. If the population of the Earth would decide to go straight for that sustainability, then our chances of success would be greatly improved.¹

Global resource depletion was assessed by comparing the consumption with the known reserves of a resource, followed by an extrapolation of how long known reserves could be stretched, if consumption growth developed at the rate seen in previous years. Chromium was used to exemplify the resources with the greatest reserves, and curves were traced, as shown in Figure 1. Where the consumption line intersects the line of a known reserve, there would be no more extractable chromium. Such calculations were made for a number of natural resources. Lomborg sneers at such calculations, for today it is obvious to anyone that there is still enough oil, gold, and zinc, and now, in 2001,² he tries to demonstrate how foolish those predictions were by stating that natural resources are still abundant. However, it is not fair to cite those figures on their own, as though the authors of *Limits to Growth* had claimed that the said metals would have run out in the years predicted. In 1972, the development was not expected to be so sharply defined. Already then, it was possible to foresee advances in chromium extraction technologies, and new chromium reserves were expected to be found. Thus, the authors of *Limits to Growth* assumed that chromium reserves would increase by five times.

As appears from the curve in Figure 1, the period to pass until consumption has 'swallowed up' the reserves is not quintupled. The increased reserves hardly double the lifetime of chromium. Things look bad, if each natural resource is assessed that way. Neither was it the point of the models in *Limits to Growth* that e.g. chromium would run out after a certain number of years. The authors' message was that taken together increa-

sed resource utilisation, industrialisation and growth in the ensuing pollution would threaten the global ecosystem. The point of those model calculations was to draw attention to the interplay between consumption and pollution, which at the time was a key insight.

What one could with some weight have held against the forecasts made by the authors of *Limits to Growth* was their naïve belief that some reasoning global institution existed, capable of ensuring that resources were equitably allocated between the inhabitants of the Earth. Their forecasts on the urgency of buckling down to address our pollution problems were in fact taken seriously, so in that sense *Limits to Growth* helped to underpin a necessary development in the regulation of untrammelled resource use.

For instance there was a radical shift in the current view of mercury, one of the elements for which few reserves were known in 1972. In 1974 Mogens Boserup, Danish economist, wrote that the most interesting property of mercury was its high specific of toxicity to organisms, which made it useful in controlling bacteria and fungi, notably in agriculture. On the other hand, mercury proved to be a serious environmental toxin for humans, and the poisoning risks mainly owed to the fact that mercury could be accumulated in fish used for human consumption.³ This understanding of pollution risk caused mercury to be almost completely removed from production, so today it has become a metal with a limited use in industrialised countries, and as such it has become uninteresting in relation to a resource scarcity scenario.

Many people died or were disabled from mercury poisoning, and we should learn our lesson - that it is poor strategy to procrastinate action until damage is a fact. History abounds with evidence that there can be a high price to pay if we leave it at tidying up after resource depletion and pollution. Therefore, it is vital to work out scenarios based, among other things, on critical reviews of historical experience. Proposed actions may then rely on optimistic estimates such as Lomborg's, or on the precautionary principle, as preferred by environmentalists.

ENERGY AND MATTER

For a resource context, we need to distinguish between energy and matter. Energy is constant, in the sense that if one unit of solar energy is converted into calorific energy, then its energy content, measured in joule, remains the same. Where solar energy and calorific energy differ is their quality. For instance green plants cannot thrive on heat radiation alone; they need sunlight. Another important property of energy is that light energy can convert itself into calorific energy, while the process cannot be reversed.

The Earth has a continuous influx of solar energy. The energy of sunrays is 'trapped' in wild herbs and cultured crops, and the visible result is what we call organic matter. Green plants can utilise 1-3 per cent of the solar energy; yet the rest is not "lost", as suggested by Lomborg.⁴ The remaining solar irradiation drives the water cycle and stabilises the terrestrial climate. Plants (organic matter containing energy) provide the subsistence basis of wild animals, domestic animals, and humans who utilise the energy of organic matter. Sunrays provide the soil ecosystem with potentials for building up organic matter, and in practice the sun is an infinite source of energy. Once solar energy has been transformed, it leaves the earth as heat radiation.

Over millions of years solar energy was built into plants, and concurrently some organic matter was formed that did not decompose. This organic matter was deposited in the

layers of the earth and transformed into coal, oil, and gas (fossil energy). In practice, fossil energy has a finite volume, and new natural resources have not been formed to any noteworthy extent within the timeframe (a few hundred years) during which we have been extracting and consuming resources. Thus it makes sense to say that energy resources are finite, and that once spent they cannot be recreated or re-extracted.

When energy resources decompose this implies that the solar energy bound within the plants is released as heat. At the same time, the matter used by plants to bind the solar energy is released, so carbon dioxide, nutrients, and minerals can re-enter the ecological cycles.

The earth is a closed circuit, in the sense that only minute amounts of matter will leave the planet. That implies that elements such as iron, chromium, nickel, nitrogen, carbon etc. cannot be removed from the earth, and since elements do not decompose or disappear, it is not possible – at least in theory – for such matter to run out. The elements will continue to exist, after being used for production or consumption. The question then is how dispersed they are, if it is feasible to recover them for further use. However, with today's technology there are several resource applications where reuse is not possible. For one thing, this is true of substances found in small concentrations in industrial and household wastes.

Mineral resources that form part of the societies' production include metals, uranium, coal, oil, gas, oil shale, stone, sand, gypsum, saline, asbestos and many more. Mineral resources can be grouped in several ways. An ecologically based grouping is chosen here, since providing an easier overview of the renewability of resources, in which distinctions are made between natural energy resources (fossil energy), nuclear energy resources, renewable resources, metal resources (elements), and other resources such as minerals, salt, water etc.

Assessing the extent of natural resources reserves is an extremely difficult matter. Both geological, technical and economic issues are involved. Therefore distinctions are made between resource reserves, for which the volume and purity are estimated to allow feasible exploitation with known technology. Other reserves are of such a nature that they are potentially exploitable given an improved technology or higher prices. Finally, some reserves are estimated on the basis of experience from particular geological conditions that would indicate that a given resource could be present. Thus the total natural resources are the sum of reserves and potential reserves.

Prospecting for such reserves is costly, so extractive industries often operate with a limited survey of reserves ensuring that sufficient reserves are surveyed to cover consumption for a number of decades onwards.

In some cases it is in the interest of the industries to publish optimistic estimates of reserves in order to discourage others from investing in prospecting and thus get a share of any price rises. So a statement to the effect that there is enough of a given resource to cover global requirements for so and so many years, is reasonably certain for the next few decades, after which uncertainty increases considerably.

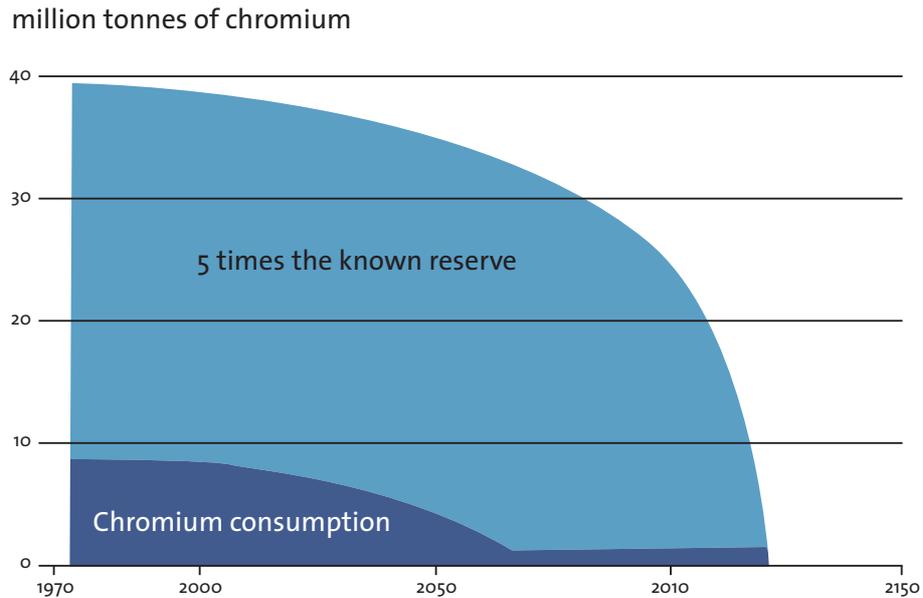


Figure 1. Consumption of chromium reserves shown by the curve starting at nearly 8 million tonnes of chromium in 1972 and ending at zero around the year 2065 (dark area). If chromium reserves are 5 times greater, chromium consumption will have “swallowed up” the reserves around the year 2122.

ENERGY RESOURCES

The known reserves of energy resources have been estimated at some 1.160 billion tonnes of crude oil.⁵ Resource reserves are unevenly distributed in relation to the countries that are major consumers of crude oil. Table 1 shows the global distribution of known oil reserves.

Oil is only found in specific regions, which can cause problems of reliable supply, and several wars, notably in the Middle East, can be ascribed to the wish of control with oil reserves. From the table showing the distribution of oil reserves it is evident that strategically the Middle East is highly important to global oil supply. The USA has oil reserves of 22 billion tonnes.⁶ After using a large proportion of her own reserves the country has to rely heavily on imports, and therefore has a vested interest in keeping world market prices on oil low.

Table 1. Global distribution of known oil reserves. The unit is billion tonnes of crude oil. All reserves (except those of the former Soviet Union, included in the figure for East Europe) have been verified and can be extracted at the 1997 level of technology and prices.⁷

Region	Billion tonnes
North America	76
Central and South America	91
Western Europe	35
East Europe and the former Soviet Union	185
Middle East	636
Africa	76
The Far East and Australia	61
World, total	1160

Table 1

The 1997 world production was about 24 billion tonnes of crude oil, and the OPEC countries (Saudi Arabia, Iran, Kuwait, the United Emirates etc.) accounted for a good 10 billion tonnes.⁸

If we compare the global oil consumption with the reserves, then calculations using our present oil consumption show that the reserves would last us about 43 years. Campbell and Laherrère – two experts with 40 years experience from the oil industries – have investigated the finds and outputs of new oil fields worldwide, and they question whether there is really so much oil left as stated in Table 1. Their arguments are that oil companies and governments alike tend to mark up their oil reserves in order to improve their own credit ratings. In the late 1980s, several OPEC countries suddenly marked up their reserves in hopes of boosting their own export shares in the OPEC agreements. A third indication is that around 80 per cent of the oil extracted today comes from fields found before 1973, most of which have a falling production.

In the 1990s the oil companies discovered on an average new finds equalling 7 billion tonnes of crude oil a year, yet simultaneously drained their sources of some 23 billion tonnes for consumption. By the same token, the total global reserves should have gone down by 16 billion tonnes. That does not transpire in statistics. What happened was a mark-up of total reserves by 11 billion tonnes of crude oil, which appears to be a sheer desk-top exercise, given the already known oil fields. The oil reserves are overrated, and the authors estimate that the world has 850 billion tonnes of crude oil left. Comp. Figure 2.⁹

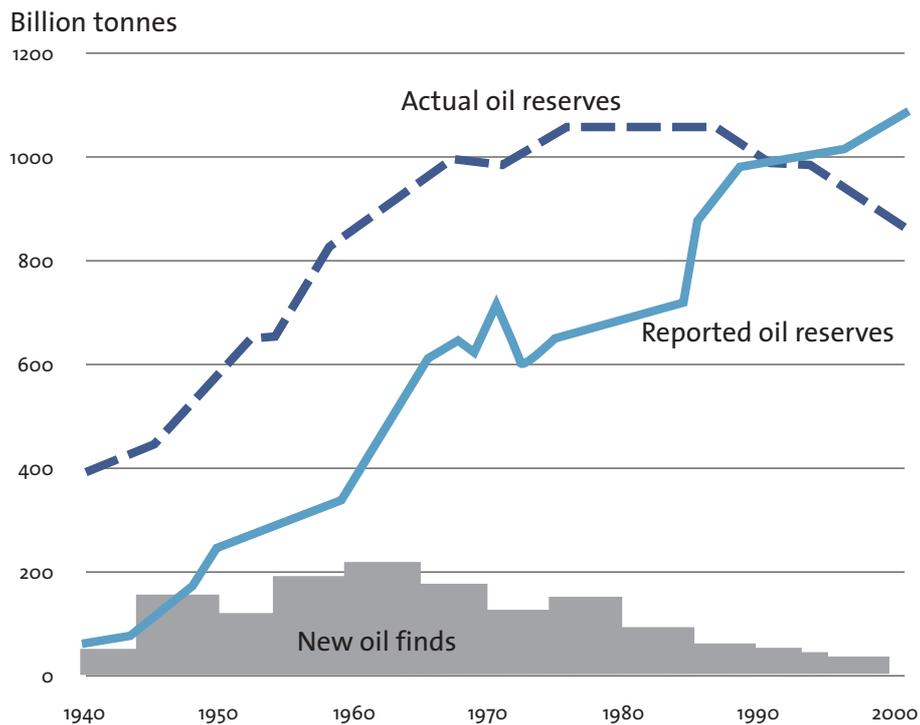


Figure 2. The relationship between reported oil reserves and actual oil reserves. Further new finds in the period from 1940 until today are indicated.

In 1997 the USA had an oil consumption of 6.8 billion tonnes of oil, and each of the 268 million Americans will spend more than 25 tonnes a year.¹⁰ For comparison, a Chinese will spend a good tonne of oil a year.¹¹ Americans have organised their society around a high energy consumption; yet it is not a law of nature that an American has a particular need for the standard of living that requires a high energy consumption. Other inhabitants of our planet might also aspire to a similar energy-based lifestyle. If US oil consumption was to be made the norm for the global population (in 1997 a good 5 billion people), then their oil consumption would amount to 125 billion tonnes of crude oil a year, and in that case our oil resources would last us about 9 years.

The above calculation covers crude oil only. If we include other energy resources, inequalities between the peoples of the earth – though slightly smaller – remain great, and thus there continues to be a potential for growing global energy consumption. As for total energy consumption, each US citizen spent 10 times more energy in 1996 than did a Chinese, and nearly twice as much as a Dane.¹²

Lomborg says that the reduced cost of resources even at increasing consumption serves to indicate that crude oil reserves are huge. However, the price does not necessarily reflect how extraction companies estimate our future resource supply. At least not in a remote future, since they will only take on the large costs associated with surveying crude oil reserves to the extent they expect such investments to pay off. In a capitalist economy, this will rarely amount to much more than 10 years ahead.

In Lomborg's view, we will not be running out of oil in the next few years, even with

increased consumption. Once supplies from conventional oil sources become short, increasing prices will make it feasible to extract oil from large deposits of oil shale, tar sand and oleiferous mud, which occur in many places throughout the world. However, the extraction of oil shale and tar sand will create far more air pollution and waste problems, with potential groundwater pollution as a result. A large part of those deposits has a hydrocarbon component of only 10 per cent, half of which is needed for process energy. That means that for each 1 tonne of oil produced you would have to extract 18 tonnes of shale powder. Presumably very few countries will find such consequences of oil shale extraction acceptable.¹³

The experience gained from Eastern Europe indicates that if we were to increasingly rely on oil shale extraction for energy supply, this would also involve the added cost of landscape rehabilitation measures.

The Northeastern part of Estonia (3,200 square kilometres) has been extracting oil shale for many years, both by open-cast and underground extraction. The oil shale layers have thicknesses of 1.5 to 2.8 metres and are found in depths of 20 to 60 metres. Due to the low energy content (and hence low economic profit) of oil shale there was no money left to spend on filling up the empty pits. Therefore, the ground has become unstable, so it settles, forming landscape trenches that are difficult to use for other purposes.¹⁴

Assessments that go beyond energy reserve breakdowns are fraught with great uncertainties. Once the easily accessible oil reserves are depleted, and we have to start mining the less accessible and less pure reserves, this will make the costs rise and (not least) cause extensive pollution problems, which in many places will reach unacceptable dimensions.

TECHNO-OPTIMISM

Technical advances do not just happen by themselves, and historically it is not true that 'something just turned up' – that a new energy technology emerged, solving our problems. They will appear in specific areas, yet we cannot count on them to solve all our problems.

Nuclear energy was first represented as a CO₂ neutral source of energy; yet the disasters in Chernobyl, the problem of storing radioactive substances for up to 100,000 years, and the risks of nuclear proliferation have stalled the development of new nuclear plants. Nor is nuclear energy economic compared with conventional power plants. In the USA this has been commonly known for years, and all new nuclear power plants planned over the last 25 years have been shelved. By contrast, it has been contended from French quarters that French nuclear plants have a good economy. Yet, that is the case because of public funding. Thus, in a 1998 report, the French National Planning Commission concluded that if investments in nuclear power were to be left to market conditions, the nuclear plants' share of power production would drop from 80 to 13 per cent by the year 2020.¹⁵ In 1992, the World Bank concluded that nuclear plants were a poor bet in Third World countries. They 'would not be economic. They are white elephants'.¹⁶ Thus, few believe that present-day nuclear power technology will provide us with energy in the future, and neither does Lomborg, in fact.¹⁷

The skyrocketing oil prices in 1973 and 1979 spurred initiatives in order to find different and renewable sources of energy, and concerns about our supply options also encoura-

ged savings in energy consumption. Windmills were among those renewable energy sources, and in the few years following they evolved into a sophisticated technology with great capacity. Yet, that does not imply that windmills can compete economically with conventional power plants, which is to do with affordable natural resources for energy. If windmills had not been subsidised, they would not have developed into a technology, which today is practically competitive with power plant based electricity. Presumably, windmills would be competitive if the environmental problems of power plants were included in the costs. Denmark has become a pioneering country in the development of windpower, and without the Danish contribution their development could have lagged 10 or 20 years behind. In Denmark, the utilisation of windpower for electricity has gone from practically nothing in the 1980s to 3.7 per cent in 1996.¹⁸ The evolution history of windpower demonstrates that the market powers per se could not guarantee that an alternative would be available, once scarcity of oil occurred. It took a long time to develop a windpower technology.

Lomborg has a favourable view of wind and solar power and finds them to have great potentials. Yet, he fails to note that these technologies took a long time to develop, and that they sprang directly from the discussions of limited resources that – in Lomborg’s opinion – there is no reason to take seriously. When Lomborg indicates that our reserves of natural resources for energy production are plentiful, and that the greenhouse effect is not to be taken seriously, he is in effect arguing *against* the development of alternatives. If everyone had followed Lomborg’s line of argument back in the 1970s and 1980s there would have been no development of windmills.

Lomborg has a techno-optimistic view of our future, and he presents cases to illustrate how everything has gone well in Denmark. For instance, a great many household appliances have become more energy-efficient.¹⁹ Yet, the benefits of those improvements have not materialised as lower energy consumption in households, although the rate of increase has gone down. From 1980 to 1995, the power consumption of Danish households increased by 20 per cent; comp. Table 2.²⁰ Our homes have simply filled with more power-consuming devices, such as tumble-driers, TV sets, audio equipment, computers, printers, lamps, food processors, hand blenders, electric toothbrushes, potato peelers, and waterbeds. The energy efficiency bonuses are ‘swallowed up’ by the increased number of electrical devices.

Table 2 Energy consumption of households, 1972-1995. Unit TJ (TJ = 10¹² joule)²¹

Energy consumption, TJ	1972	1980	1990	1995
Electricity	23,427	30,670	35,960	37,731
District heating	40,416	37,880	47,838	60,655
Heating, other	173,372	136,522	85,287	89,251
Households, total	237,215	205,072	169,085	187,637

One of the success stories of the 1970s is the decline in energy used for heating, as seen in Table 2. The drop in total consumption from 1972 to 1990 was due to savings in heating. The reduced consumption of energy for heating results from insulation of houses, conversion to cogeneration of heat and electricity, plant renewals, and improved energy control, which were introduced in the wake of the energy crises in the late

1970s. The increase in energy for heating in the 1990s is the result of more living space. Estimates are that there is still a great potential for further reduction of energy spent on heating.²² Probably the easiest cherries have been plucked already, and the increased heat consumption in recent years shows that there are limits to how much more can be gained in the field. At least that would require the introduction of control mechanisms rather more efficient than those used until now.

Neither do other major consumption sectors display any overall positive impacts of technological advances. Over a number of years, new cars have become more energy efficient on average, meaning that they make more mileage per litre. If we calculate the average fuel consumption of new cars and then weight the energy consumption against the number of cars sold in Denmark, then there has been an improvement from a good 13 km/litre in 1985 to a good 14 km/litre in 1992. Since then, there has been a downward trend in fuel economy, since consumers have preferred car types with poorer energy efficiency.²³ There have been several plans to upgrade the energy efficiency of cars, and cars have already been designed that can run from 30 to 60 km/litre,²⁴ yet no mass production of such low-energy cars has begun so far. It is beyond doubt that there are potential energy savings in better household practices and more energy efficient cars; but generally, there appears to be little support for such initiatives among the world's countries.

The natural resources available for biomass production in Denmark are waste, wood, and straw, providing some 7.5 per cent of the Danish energy consumption. In 1995, 900,000 tonnes of straw were used for heat and power production, which amounted to about a quarter of the straw recovered from agriculture.²⁵ Combustion of organic matter such as straw means that farmland is deprived of this carbon source, which may affect soil fertility. If added to the soil, either as a fertilizing agent or directly by ploughing back, some 20 per cent of the carbon added with the straw will remain in the soil as humus and only decompose gradually over 10 to 100 years. A high humus content in soil helps to increase fertility, and will retain considerable amounts of carbon that consequently will not contribute to increasing the carbon dioxide content of the air.²⁶

Renewable energy such as windpower, wavepower, straw and solar energy, combined with energy savings can reduce the use of fossil energy resources. However, if economists are just peddling the message that there are enough fossil energy resources, then there is no driver to push the required technical development and planning.

METAL RESOURCES (ELEMENTS)

Metals as such cannot run out, but deposits of sought-after minerals with an adequate purity can. An adequate purity means that their percentage metal content is high enough to make extraction feasible using available technology. The limits to metal resource reserves are determined by the extraction potentials of technology and economy, which undergo continuous change. Though chromium deposits still exist, they are not unlimited, and if consumption continues to increase our chromium reserves will no longer be sufficient. However all chromium is still here on earth. Obviously, a scenario with fewer good metal deposits would not be the end of the world; instead, advances in extraction methods will be developed, and so long as we have affordable energy a lot of things can be done.

In Denmark, recycling is a significant goal, and for many years recycling has been a major element of our environmental regulation. Most metals have to be imported to

Denmark, so economising with metal resources has macroeconomic benefits. Another even more important aspect is that a number of metals become manifest as pollution problems in air, water and soil. The less we use for production and consumption, the less the extent of such environmental problems.

Another option is to substitute 'problem' substances in production with others, or to carry out tasks using other procedures. For instance, chromium is used as an anti-corrosion metal coating; however, the same effect can be achieved by coating the object with a type of organic paint.

Yet another example of substitution is Denmark's only factory producing radiators for cars, lorries and buses, where lead has successfully been substituted with zinc for anti-corrosion treatment of iron in copper/brass radiators. Thus our environment is saved the load of 6.5 tonnes of lead annually, and the driving force behind this substitution was a public grant from the Danish Council for Recycling and Cleaner Technologies.²⁷

Modern industrial production displays considerable flexibility and innovative skills when it comes to substituting substances of environmental concern, especially where a future ban has been announced and public grants are made available. Yet, things do not always run that smoothly. The production of N-fertilisers for agriculture is quite energy-intensive, and low prices are closely allied with low energy prices. There is little incentive to save on N-fertiliser in agriculture. Mineral fertilizers are affordable, so slurry is not being used optimally, and the level of utilization of its N-content is about 30 per cent. Despite many years of criticism and experiments with reuse, it has proved exceedingly difficult to persuade farmers to cut down on fertiliser use.²⁸ Nitrogen-fixing plants (peas, clover etc.) could be included in the crop rotation plans in agriculture, and could thus substitute chemical N-fertilisers, thereby generating considerable energy savings in agricultural production.

Technology development does not become environmentally friendly or cleaner by itself. Natural resources such as mercury, chromium, cadmium, sulphurous oil, nitrogen (in fertilizers) and many more have been used in production environments that gave rise to a host of environmental problems. Once the problems were understood by environmentalist groups, researchers, population and politicians, measures were introduced in the form of bans and restrictions on specific uses, or cleaner technologies were developed. Over the last 25 years, a number of technologies have been developed in Denmark precisely because there was an active environmentalist movement. Their key arguments were about proper use of resources – because they were directly or indirectly limited, and because their extraction caused primary or secondary pollution (via the associated energy consumption). Such evolution was compelled by the fact that many refused to accept an insular economic technology development, instead of letting justified doubts and uncertainty play a role. A public pressure is needed, in the face of a social development marked by the 'trial and error' of a modest number of industrialists and technicians, with no regard for anything but short-term profit and the requirements laid down in environmental legislation.

THE WATER CYCLE

In nature, water has a continuous cycle, alternating between precipitation, evaporation, and run-off. The cycle is driven by the energy of the sun. Part of the precipitation falling on landmasses evaporates. The remaining part of the precipitation runs off as water-courses or penetrates further into the watershed, forming groundwater. The globally

available freshwater resources are unequally distributed, depending on climate, topography, and geological conditions.

Yet there is no law of nature to determine that a mere 15 per cent of net precipitation can be utilised.

On a global level precipitation falling on landmasses, minus evaporation, is estimated at approx. 41,000 cubic kilometres a year, or some 7,690 cubic metres per year per earth dweller. It is assumed that sustainable utilisation would make up 15 per cent of the net precipitation.

Egypt is a country with a great strain on water resources. In many parts, it will rain once every second or third year, and precipitation can vary greatly. Central regions of Egypt will get less than 80 mm rain a year. The national water supply relies on water from the Nile, and nearly all water flowing in the Nile is being used for irrigation, industry, and households.²⁹

In 1990, 20 countries were classified as a group with scarcity of water, and in 2050, another 26 countries will join them. Estimates are that by 2050 1-2.5 billion people will be living in countries with scarcity of water.³⁰

Even a country like Denmark, with an annual precipitation of 750 mm, has its own water supply problems. By the mid-90s, groundwater pollution had assumed dimensions that posed a risk to our traditional, decentralized water supply system, based on simple water treatment. In 1995, traces of pesticides and breakdown products had been found in 10 per cent of the analysed water supply wells, and in 3 per cent of the analysed wells contents exceeded the threshold values for drinking water.³¹

In some places, water catchment is intensive enough to cause a permanent lowering of the water table, and wetlands and recipients dry out periodically, at the peril of lasting ecological deterioration of watercourses and nature. The impact on the minimum flow amounts to nearly 50 per cent of the water drained. E.g. an annual catchment of 1 million cubic metres would reduce the summer flow by nearly 500,000 cubic metres per year.³²

In Denmark problems of dried-out water courses and polluted groundwater have drawn much public attention. Considerable resources have been put into the regulation of those sectors, and certain improvements have been introduced as political pressure grew loud.

Based on average assessments, Lomborg believes there is enough water for all people on Earth. In his view, the available amount of water would suffice for all necessary purposes, conditional upon proper prioritisation and appreciation. Yet invoking some supreme Reason to ensure the equitable distribution of water is wishful thinking. In part, because the water resources involve potent local interests, and in part, because we cannot just move water around, across long distances and to wherever it is needed. Neither does everyone have the technology and means needed to desalinate seawater. It may well be that on average there is enough freshwater in the world, and that water is being wasted. However, it remains a fact that many parts of the world do have great water supply problems, and it is hard to think of any international forums that could improve the situation.

CONCLUSION

Natural energy resources can be used up, while metals and water basically cannot, although high-purity reserves can run out. The key point in *'Limits to Growth'* was to demonstrate that such limits exist – and not to predict the precise year when we would run out of various resources. Lomborg holds the book to be a ridiculous doomsday prophecy; but the truth is that it actually contributed to changing the ways of the world, so the impacts from pollution became less grave than they would otherwise have been.

In a lomborgesque perspective, there is no reason to do anything until shortage of a natural resource begins to filter through as price increases, or until a pollution problem has been established. 'Everything will be just fine – because it has been, so far.' However, we would be wiser to apply a precautionary principle and a holistic view, in order to ensure that cleaner technology, recycling etc. are developed, even if such efforts are not feasible in a short-term economic perspective. Pollution problems are highly important, and by reducing our use of natural resources in production and consumption we can limit their impacts on people and nature. Moreover experience shows that when it comes to governing a society's resource exploitation there is no such thing as a rational common sense in market economy itself – just a rationale cut out to suit short-term economy. Thus, the driving force in resource protection has to be a public pressure, where criticism and uncertainty must be weighed within the decision-making system and translated into action.

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3. POVERTY

IS PROTECTING CLIMATE STABILITY WORTHWHILE?

By Anders Chr. Hansen, associate professor, Roskilde University, Denmark

HOW DIFFICULT CAN IT BE?

Lomborg has been marketed as a 'sceptical environmentalist'. After reading the book, it is obvious that 'sceptical' must be a humorous understatement while 'environmentalist' must be jocular irony. In fact, he recommends abandoning almost any important environmental protection effort that has entered the international agenda in the 80s and 90s. The global climate policy is no exception.

The aim of the global climate policy is to 'prevent dangerous anthropogenic interference with the climate system.'¹ However, according to Lomborg, preventing it does not pay off. At least it is not worthwhile doing it to the extent intended with the Kyoto Protocol. He acknowledges that a continuing increase in emissions of greenhouse gases will cost the world a total of USD 5 trillion². However, he argues, preventing a temperature rise of more than 2.5 degrees centigrade will cost USD 8 trillion or more.³ The Kyoto Protocol itself is even worse. It will only delay global warming about six years, yet cost 2 per cent of the total income in OECD countries each year.⁴

Now, after the UN-appointed panel of the world's leading scientists and economists have fumbled hopelessly with this simple task for more than a decade, we should be grateful that somebody will cut through and tell us what the question is all about: USD 5 trillion or USD 8 trillion. 2 per cent of GDP for nothing. How difficult can it be?

However, although these figures are extracted from internationally recognized analyses, they are not what they pretend to be. They are presented as if they were figures known with certainty, but in reality, they are definitely not certain and they are not even correctly cited.

THE COSTS OF GLOBAL WARMING

The Kyoto Protocol is the first binding step that the international community (minus USA) has taken to 'prevent dangerous anthropogenic interference with the climate system.'⁵ Obviously, there is no knowing which kind of climate policy this heralds until after a few decades have passed, though different varieties come to mind. However, what can we really say about the damages to be prevented by the climate policy?

Lomborg feels he can say with some degree of certainty that the damage inflicted on world economy by global warming amounts to USD 5 trillion. In order for such figure to be of any practical use one would prefer it to be at least so certain that its uncertainty is no greater than the figure itself. However, no one can assess the economic costs with that kind of precision. Since, in the history of humankind, we have never seen such warming before, we lack the experience needed to make up the calculation with a safety margin of 'just' USD 10 trillion.

How Lomborg arrives at his USD 5 trillion is not apparent from the referenced sources. On the whole, his figures do not tally with those found in the sources given on page 310, where he compares the cost of adopting various climate strategies. The below figure shows the alleged figures of Lomborg's sources, and their actual figures.

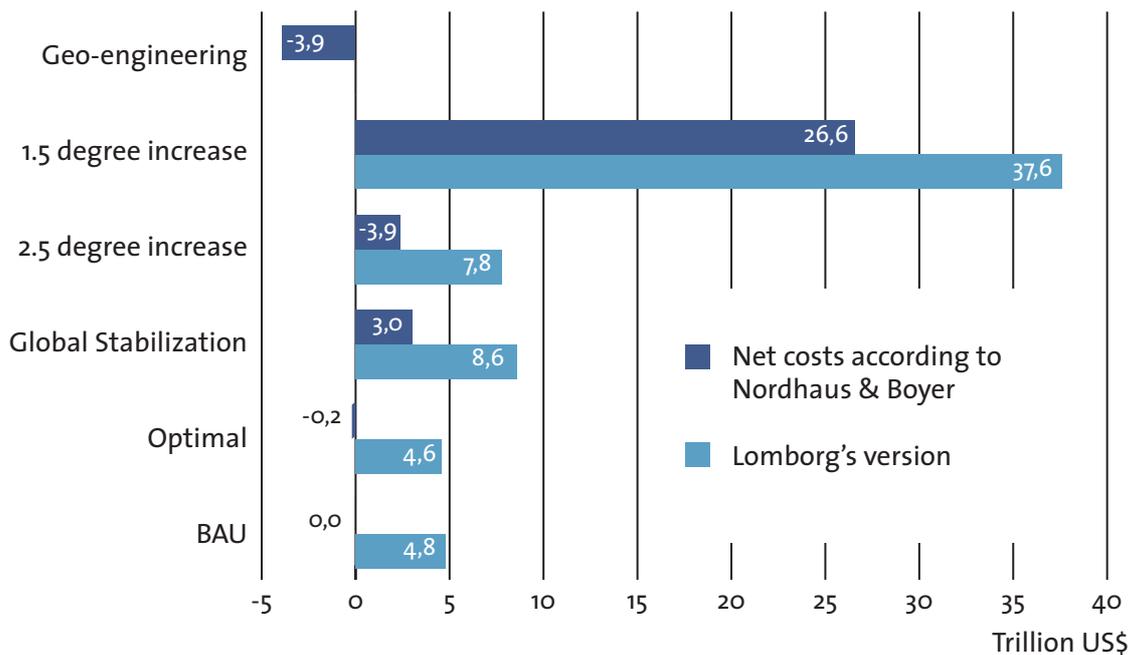


Figure 1. The present value of the net-costs of pursuing alternative climate strategies according to Nordhaus and Boyer and the Lomborg version.

Apparently, the USD 5 trillion are derived from Nordhaus and Boyer. They purportedly calculated the net benefit by following a *geo-engineering strategy*⁶. It implies a continued pollution of the atmosphere with greenhouse gases, combined with injection of a layer of particles to the atmosphere that reflects sunlight, thus reducing the warming. The net benefit of this operation is that the world will save the economic loss that would otherwise occur due to global warming. The thing is that according to Nordhaus and Boyer the cost of geo-engineering is nil and has no adverse effects.⁷ The economic damage from global warming thus saved would amount to USD 3,901 billion. Converted to Year 2000 prices that would be USD 4,820 billion. This is the figure that Lomborg rounds up to USD 5,000 billion or USD 5 trillion. In Lomborg's version, this is the cost of the BAU (Business as Usual) approach. Apparently, these costs are then added to the net costs of the remaining climate policy strategies, aimed at limiting the greenhouse effect. Thus, Lomborg's figures should be understood as the cost of controlling the greenhouse effect instead of using the miraculous geo-engineering. What does Lomborg make of this peculiar number-juggling operation, and why is there no mention of how the figures emerged? A possible explanation is that most readers would find the notion of no-cost geo-engineering more suitable for a computer game than for a serious evaluation of alternative climate strategies. On the whole, it would be quite hard to convince readers that the somewhat academic premises, on which Nordhaus and Boyer based their calculations, are realistic. For instance, they assume that people in the rich temperate countries would stand to benefit considerably from a warmer climate, since enabling them to stay more out-of-doors and thus spend more time on recreational activities such as golfing and swimming. They assume that the rich part of the world would benefit so greatly from such increased opportunities of outdoor recreation that it would outweigh the losses incurred due to destruction of groundwater resources, and general living conditions in the world's coastal zones, due to a rise in mean sea level in the oceans.

Further, they assume that potentially *disastrous* climate changes resulting from a doubling of the atmosphere's CO₂ content would merely result in a 1 per cent loss of the world's total incomes.⁸ In other words, it is assumed that the greenhouse effect will not cause *serious* disasters.

Given such assumptions, we do not really need to carry out the calculations to know the result. They are almost sure to produce a recommendation for a climate policy that merely comprises minor adjustments to the present course of the world. In that case, there is no need for a climate policy that will considerably reduce CO₂ emissions. Economically speaking, such a policy would do more harm than good. If we insist on doing something, we should mitigate the consequences of greenhouse gas concentration rather than its cause. This point is also illustrated in the figures from Nordhaus and Boyer shown in the above figure.

When using current methods to calculate the cost of global warming we can arrive at just about any figure we desire. Lomborg estimates, in another chapter, a figure of USD 480-640 billion a year to be the cost of the damage caused by global warming. Apparently, he is unaware that this would amount to a total present value of USD 20-27 trillion.⁹ The point is not that this figure is 'better' than the USD 5 trillion; it merely serves to demonstrate that using slightly different assumptions (which Lomborg himself accepts in other contexts), the same calculation would produce precisely the opposite conclusion: With these figures it would more than pay to control global warming in Lomborgian calculus.

Purportedly, the USD 480-640 billion figure was gleaned from a tally of the costs of global warming made by the IPCC: 'In assessing the total costs of global warming, the IPCC listed a whole series of consequences of a doubling of atmospheric carbon dioxide.'¹⁰ Lomborg continues: 'The total annual cost of all the considered global warming problems is estimated to be around 1.5-2 percent of the current global GDP, i.e., between 480 and 640 billion dollars.'¹¹

However, IPCC¹² itself points out that the 1.5-2 per cent is *not* the IPCC estimate of the aggregate cost, yet merely refers to the findings of a number of available studies. IPCC made nothing like such an assessment of the aggregate cost of global warming. By contrast, the report includes an overview of the *reference literature* then available on the different economic effects of global warming. The bulk of literature increases year by year, so today the figure would probably be far higher. Yet such a count would still be of limited value in decision-making. For one reason because there are so many consequences of global warming that we cannot possibly foresee since, in the history of mankind, we have never before been experimenting with the global climate.

THE COSTS OF CLIMATE POLICY

It is far easier to calculate the costs of our climate policy than that of the environmental damage it is meant to prevent. The reason is that we have ample experiences on the economic consequences of e.g. introducing energy taxes or building windmills. However, although an international agreement has been acceded, detailing how much each country is to cut down their emissions before 2010, the individual nations are free to decide how they plan to do so. Hence, the costs depend entirely on how each country chooses to carry it into effect. Any figure concerning the costs of the Kyoto Protocol will thus assume the countries to implement the protocol in a specific fashion.

Thus, the economic effects of the climate policy are linked up with a number of other factors, including:

- the extent to which countries will pay other countries for reducing emissions in order to make a cheaper deal for themselves (quota trade),
- the extent to which each country will make use of economic incentives,

- how the proceeds from energy and CO₂ taxes are spent,
- how swiftly the markets of the economy respond to relatively higher fuel prices,
- the number of developed technological options for conversion to renewable energy sources, and much more.

Lomborg uses the long-term costs of the Kyoto Protocol from OECD calculations made four years before the Kyoto agreement was entered: 'The OECD estimates, that the cost in 2050 will be around 2 percent of the OECD countries' GDP.'¹³ In point of fact, this is a working paper describing what the OECD's GREEN model can be used for in this context. Among other things, the calculations assume that no technical advances will occur for renewable sources, and that the overall technological development is insensitive to prices and markets.

However, such advances have already taken place to a considerable extent since the calculations were made, and no one would doubt that more are in the pipeline. This is one reason why calculations, made on the same model right after the Kyoto agreement was entered, show 'that the cost of achieving the Kyoto Protocol emissions target will most likely only have a negligible impact on overall OECD economic growth rates, particularly if a coordinated approach to achieving the targets is implemented.'¹⁴

Later calculations using the GREEN model, also including the other greenhouse gases, show that the Kyoto Protocol could cause a loss of GDP of just 0.13 per cent.¹⁵ That means that if we were to postpone the implementation of the Kyoto agreement till after 2010, we could merely expect our 2010-consumption to add a little more than *one-tenth* per cent to the (perhaps) 14-22 per cent by which our consumption would have increased by then.

However, according to Lomborg, the share of GDP that the Kyoto agreement is going to cost us is 1.5 per cent.¹⁶ This calculation assumes an agreement that completely disallows quota trade. Moreover, it is related to GDP in the year 2000. To be sure, such agreement has not been on the table since the mid-1990s, but of course 1.5 per cent does sound somewhat more forbidding than 0.13 per cent.

NO-REGRET OPTIONS

In many cases, individual countries are able to organize their climate policy in a manner that allows them to concurrently rid themselves of old laws and old production and consumption patterns that cost both money and energy.

For instance, each day, many of us come across several traditional light bulbs that should have been replaced by energy-saving bulbs. Why were they not? Many people make such decisions based on what they usually do – and not on what would be the most economic thing to do. Perhaps because that is what they have done for a lifetime and they cannot be motivated to familiarise themselves with new options – or because it is not their own money that is being wasted, or for a number of other reasons.

Also, a lot of unnecessary energy consumption owes to 'policy failure' and even costs the countries money. For instance, the International Energy Agency (IEA) calculated in 1999 that 8 of the most energy-consuming countries outside the OECD are subsidizing energy consumption to such an extent that average energy prices are cut by 20 per cent. Abolishing those subsidies would reduce the world's total energy consumption by 3.5 per cent, and the world's total CO₂ emissions by 4.6 per cent. However, the gross domestic product of these countries would be *improved* by 1 per cent.¹⁷ Subsidised energy consumption, coal production and more are also found within the OECD, though it is unclear to what extent. OECD estimates are that in 1995 energy subsidies by the OECD countries were at between USD 4.7 and 80 billion, depending on accounting methods. Equally, the OECD countries would be able to achieve both lower CO₂ emissions and a

higher GDP if this expenditure was redirected to purposes useful to society. Both patterns contribute to the efficiency gap found to exist between state-of-the-art technology and technology actually used by households and companies. A climate policy targeting a reduction of this efficiency gap could prove to be no-cost, or even yield an economic surplus.

We could also go a step further and include the economic benefits of using energy sources other than coal and oil, since the latter are known to also cause urban air pollution, and hence respiratory ailments with both human and economic consequences. Such impacts are not caused by CO₂ emissions themselves, but by other contaminants also emitted by oil and coal based fuels.

Finally, we could implicate the issue of how the state uses the proceeds from e.g. energy and CO₂ taxes. In some cases, they can be used to ease other taxes impeding production. In such cases, we will talk of a 'double dividend'.

For generations, economists have pointed to the potential savings in terms of money, time, and resources by improving the information basis of households and companies, reducing distorting taxes and subsidies, and using economic incentives to reduce the harmful effects of air pollution, both to humans and to the economy. Still, with no documentation whatsoever, Lomborg claims that 'Most economists are therefore extremely sceptical towards assertions of such improvements in efficiency which can be implemented at no cost or even produce a profit.'¹⁸

COST-BENEFIT ANALYSIS

According to IPCC, a simple cost-benefit analysis is not suited to uncover the *dangerous interference with the climate system*, which the panel has been entrusted with analysing. Cost-benefit analysis was 'developed originally for project-level decision making with planning horizons typically no more than 20 years'¹⁹. IPCC²⁰ mentions i.a. two more rather more fundamental aspects in which climate policy differs markedly from such projects.

First, there is *not a single, but a wide group of decision-makers*, each with their own values and goals. That implies, among other things, that when economists are to add up costs and benefits across countries, they first have to set up a few general values and goals, relative to which they will then convert each country's losses and benefits. Thus, the outcome of the calculation very much relies on the ethics, according to which the individual countries are weighed.²¹ It is also highly questionable if a reliable system can be organised, to be used for transferring funds from those benefiting from a lax climate policy (mainly the present inhabitants of the rich nations) to those, who are to carry the costs (primarily future generations of inhabitants in the tropics and the sub-tropics).

Second, there are a number of unknowns in climate policy, simply because man has never before experimented with the temperature of Planet Earth.

In the new climate report, IPCC explains that the costs of global warming 'are incompletely characterized and cannot be compared directly to mitigation costs for the purpose of estimating the net economic effects of mitigation.'²² Their being incomplete owes to the fact that first, we do not know how much global average temperature is going to increase as a result of a given concentration of greenhouse gases in the atmosphere, and second, what will be the consequences for the climate of such warming, and third, the adaptability of nature and humans to various climatic changes.

Generally, a simple cost-benefit analysis is only suited to elucidate alternative strategies if we can calculate the odds of specific effects occurring at specific strengths, and the odds of these to have specific effects on people's economy and welfare. Such probabilities cannot be calculated when we lack an experiential basis. How, then can we choose

the optimal strategy, when we do not know and cannot know all major effects of alternative strategies?

MAKING ECONOMIC CHOICES WHERE LITTLE IS KNOWN

Economic theory suggests that rational decision-makers distinguish between different kinds of uncertainty. Uncertainty of the number of eyes you get when rolling a dice is *risk*. Based on the experience of how frequently, e.g., six eyes will turn up, you can calculate your odds of winning. Uncertainty as to what could happen in a case that nobody has ever met before is referred to as *scientific uncertainty* or *ignorance*. In such a situation, there is no prior knowledge of the kind of events that can turn up, the frequency of their occurrence, or their typical strength (and thus their economic value).

The first case is typical when we build a road or a bridge. In human experience, this has been done millions of times. We have a pretty good idea of what can happen when we build a road, the probability of these events occurring, and of their anticipated strength. Thus, we are able to quantify the uncertainties as risks and to a wide extent assign economic values to them.

Climate policy is, however, a prime example of scientific uncertainty. The problem is that a sufficiently great change in the radiation balance of the earth will produce climate changes that could be fatal for people on the earth, at least in some regions. But we do not know how much change of that radiation balance the climate can tolerate. Neither do we know exactly what kind of catastrophes can occur, the probability of their occurrence, how strongly they will affect our lives, or how we can respond to them. Additionally, we know that the damages are likely to be irreversible since we cannot remove the greenhouse gases from the atmosphere once they are there. When facing irreversible losses, we are risk averse or (which amounts to the same in this case), we require a premium equalling the value of the lost option of changing our minds. Scientific uncertainty of potentially catastrophic and irreversible climate changes is the basis for the choices of climate policy. It does not make us much wiser to *assume* that temperature changes and climate changes will happen gradually, leaving us the opportunity to adapt gradually, almost without noticing.

Economic literature on how to make such choices was quite sparse when IPCC completed its second assessment report in 1995. This naturally accounts for the fact that economists have very rarely been asked to analyse this kind of question. In some of the literature²³ published later, as well as in the new Third Assessment Report²⁴, the question was analysed within this framework.

The analysis made use of the judgements given by a panel of climate experts on the possible effects of global warming. Therefore, we do not have to pretend to know about things that we know nothing about. Some of these potential climate changes are of a scope that can truly be considered *catastrophic*, and none of them can be neutralized – they are *irreversible*.

The analysis concludes that the most economic climate policy would be to avoid such potentially catastrophic and irreversible climate change, and instead proceed step by step, re-evaluating the policy as new information becomes available. The Danish Economic Council followed up on this analysis in their review of the climate policy, concluding that 'Precautionary principles, a mainstay of Danish environmental policy, is a rational decision criterion in regulating environmental problems characterized by their uncertainty and irreversibility.'²⁵ This implies that, properly used, the precautionary principle is not an *alternative* to, yet *part of* a rational economic prioritisation. It is not, as clai-

med by Lomborg, 'about making *worse* decisions than we need to'²⁶, but quite the opposite, about making our *actual* knowledge and ignorance the basis of our prioritisation.

IGNORING UNCERTAINTIES MEANS LESS QUALIFIED DECISIONS

In fact, ignoring the huge uncertainties surrounding climate policy, as Lomborg suggests, would be bad economics and lead to suboptimal decisions. One way to ignore uncertainties is, as mentioned above, to *assume* that the costs of global warming are known with certainty, despite the fact that they are as uncertain as can be. Another way to neglect uncertainties is to assume that a problem *does not exist* whenever uncertainties are too great for quantification. Both approaches lead to an uneconomic use of resources, and Lomborg uses both for safety's sake.

Lomborg admits that 'we still do not know the actual cost of a breakdown of the Gulf Stream'.²⁷ He then recommends the opposite of an optimal economic response to such a situation, concluding that it is 'unreasonable to spend such large sums on such uncertain events...'.²⁸ This is because climate policy is only 'a partial insurance (...) against a risk, the extent of which we know very little about'.²⁹

From any point of view, it is very bad advice to take the ostrich-approach in dealing with risks and dangers.

DISCOUNTING OVER GENERATIONS

Lomborg is also convinced that whichever climate policy we choose, it will be cheaper for us to postpone investments to the second half of the century. His argument is that we will then develop carbon-free technologies in the first half of the century, to be used in the second half.

This view of technology policy was typical until the 1960s: First, our government funds research and development until the desired invention emerges. We can then use it to produce at lower costs. Today, the typical view of technology policy is more based on our knowledge of economic realities. Research and development resources are controlled by companies that have to base their expenditure on innovation on actual market potentials. As a result, the technology use and development cannot be separate in time to the extent assumed by the old technology policy paradigm. In other words, renewable energy technologies and energy saving solutions will not be developed unless the firms are positive there is a market for them. This is what we create when implementing the Kyoto Protocol.

A strategy to postpone the heavy investments until the second half of the century is more cost-efficient for yet another reason. The present value of future consumption fifty years from now is negligible at almost any rate of discount. *Present value* literally means: the value for those living at present. Posthumous consumption is of limited value to us.

Obviously, this is at odds with the principle of intergenerational fairness to which literally all governments in the world subscribe – at least officially. According to this principle, the consumption of future generations should weigh in as well. Which approach is wrong, then? Considering the value of future consumption from the point of view of the present, or from the point of view of future generations?

There is not necessarily a contradiction since the two principles are not necessarily mutually exclusive. Recent research has shown that the traditional method of discounting with a constant rate of discount can be replaced with a declining rate of discount.³⁰ This solution to intergenerational discounting, however, will make it less preferable in economic terms to postpone investments to future generations.

POVERTY OR CLIMATE CHANGE?

Despite Lomborg's going to great lengths in representing climate policy (and the Kyoto Protocol in particular) as an extremely costly strategy, he finally has to concede that this is not the case. As he points out, ever so correctly, a climate policy costing one or two per cent annually just means that it could take 51 years instead of 50 years to double our incomes.³¹ Thus, he also explodes his own claim elsewhere, that 'it will also be expensive to cut CO₂.'³²

Moreover, it explodes yet another key message of the anti-Kyoto campaign, also mentioned several times in the book, and used as a selling argument: The money spent on climate policy would be better used on the Third World. For instance, it could provide clean drinking water for all.

Thus, Lomborg presupposes that it is impossible to do both, which is in glaring contrast with Danish experience.

Throughout the 1990s, Denmark has contributed more than 1 per cent of her gross national product (GNP) in development aids. This is more than practically every other rich country in the world.

Concurrently, according to the Danish Ministry of Finance³³, Denmark has increased her overall spending for control of air pollution (greenhouse gases, acidification, ammonia, etc.) from 1.4 per cent of GNI in the early 1990s to around 2 per cent in the late 1990s. These figures are definitely on the large side, yet there is no doubt that there was a considerable increase.

In the same period, an increasing proportion of Denmark's total income was put aside for investments and repayment of foreign debt. The share of GNP grew from 23 per cent in 1992 to 26 per cent in 2000. Exclusive of consumption of existing capital and of our oil and gas assets, it amounted to 6 per cent in 1992 and 9 per cent in 2000.

Finally, Denmark's total consumption increased by 2.2 per cent annually on average – private consumption alone accounting for 2.4 per cent a year.³⁴

The development seen in Denmark serves to prove that one can very well make a strong effort against the emission of greenhouse gases, make a sizeable contribution (by international standards) to developing countries, work off foreign debt, and increase building stocks, road systems and production equipment, and last not least enjoy a massive increase in consumption.

Hence, the problem does not lie in the capacity of the rich world to fund clean water and schooling in developing countries along with an ambitious climate policy. The problem resides in the fact that most rich countries are rather far from meeting the UN target of contributing 0.7 per cent of their national income in development aids. Only a handful of North European countries, including Denmark, are contributing that much. It

is a matter of prioritisation, and both climate and development can be given priority at the same time, without any suffering on the part of the rich countries.

Finally, Lomborg does have to concede that we are ‘actually so rich that we can afford both’³⁵. Which precisely makes it so utterly strange that this very argument is made the key argument in the launching of the book.

CONSPIRACY AGAINST A SOUND POLICY?

Lomborg finds that when IPCC does not want to base its recommendations on cost-benefit analyses, there must be an underlying political conspiracy. He thus claims that ‘a political decision stopped IPCC from looking at the total cost-benefit of global warming’. This is in poor concord with the fact that IPCC itself cautioned against the use of simple cost-benefit analyses in determining the elaboration of climate policy, comp. above.

But then, perhaps, IPCC itself is the problem? In several cases, Lomborg thinks he has caught IPCC attempting to use the Third Assessment Report as a Trojan horse for insinuating irrelevant political messages. According to Lomborg IPCC suggests ‘that we should build cars and trains with lower top speed and extol the qualities of sails on ships, biomass (...) and bicycles.’³⁶ ‘What IPCC suggests – and openly admits – is that we need to change individual lifestyles, and move away from consumption.’³⁷

However, in point of fact, those citations are not IPCC’s own but only distorted versions of citations from the literature, IPCC has been set to review. Out of the things Lomborg claims the panel to have suggested, IPCC has not proposed even one. The mere fact that IPCC cites literature faithfully is certainly no cause for paranoia. On the contrary, Lomborg could learn from that.

USE AND MISUSE OF MODELS

Lomborg’s manhandling of models and model calculations appears less than reassuring. For instance the fundamental scenarios are presented as though they were impact analyses of alternative economic and environmental policies: ‘should we go down a path focusing on the environment, even if we stay within a global setting, humanity will lose some \$107 trillion, or 12 percent of the total, potential income.’ That is a complete misreading of the scenarios based on which the impact analyses were made. When computing the impacts of climate policy we have to relate them to the world as it is without the climate policy. However, such a world can have several aspects. We do not just have one future – global development can follow several trajectories, and the international community can only influence, yet not control which trajectory development is to follow. Countless factors weigh in, including climate change, natural disasters, population growth, technological breakthroughs, collapse of institutions, emerging alliances and conflicts, and a host of other things that evade planning by the global community.

Some of these development trajectories are more energy-intensive than others. This is quite significant when assessing the urgency of our future consumption of fossil fuels. Therefore, IPCC has made step-by-step calculations for a multitude of scenarios, so assumptions on population trends, technology, commerce, production, etc. fit together within each scenario. This means that it is possible, for every single scenario, to extrapolate the future demand for fossil fuels if we do nothing today.

However, the scenarios cannot be used the way Lomborg does. They are not *per se* cal-

culations of the impacts of a specific policy – merely developmental patterns that fit together.

This frivolous use of model calculation is also in evidence when Lomborg carefully picks out the model calculations that will underpin his climate policy viewpoints. He covers his back by stating that they are supposedly representative: 'It is crucially important to point out, that while the presentation below will rely on the Rice model, this model gives the same qualitative conclusions as *all* the other integrated assessment models.'³⁸ Further, he says that 'according to the IPCC they have all produced more or less the same results.'³⁹

However, such an interpretation is wholly unsubstantiated by the IPCC report. IPCC subdivides integrated assessment models into two groups, optimisation models and policy evaluation models. Optimisation models can be further subdivided into cost-benefit-models and uncertainty based models. Researchers using the latter do so precisely due to the lack of knowledge (already mentioned) of potential climate changes resulting from global warming.

IPCC finds that 'similar results are obtained from the CETA, MERGE, and SLICE models when run under similar assumptions'.⁴⁰ Thus, three of the other models yield the same outcomes on the costs of climate policy, when fed the same inputs. This is no surprise to any trained economist or statistician – who will be aware that nothing will come out of an economic model that has not been fed into it. Therefore, models based on identical assumptions will yield the identical outcomes.

Lomborg has taken a fancy to precisely the model calculations, the assumptions of which cause them to yield the result that climate policy does not pay. That means that they cannot be used to determine whether or not a climate policy will pay off. Contrarily, they can be used to determine whether it will pay off *under precisely the assumptions* on which they were based.

One of those key assumptions is that the costs of global warming is an incrementally increasing quadratic function of the Earth's mean temperature. At the selected model specifications no major impacts of climate changes will occur. This, however, is not a result, but an assumption. It is not an output, but an input.

In a certain sense, the assignment of IPCC is to study what will happen in case these assumptions are *not* true. The purpose of a global climate policy is precisely to 'prevent dangerous anthropogenic interference with the climate system.'⁴¹ If we wish to study this anthropogenic interference, it is not particularly helpful to assume that it is not dangerous at all, but just an economic nuisance. Despite Lomborg's reassurance, that it is just a matter of a few scientists who are overstating its risks, climate policy still departs from the assumption that something extremely unpleasant can happen once we begin to experiment with the temperature of our planet.

Therefore, there is every reason to be sceptical. Not only of the model results used by Lomborg in his fight against climate policy, but also of how he manipulates the figures.

THINGS CAN INDEED BE MADE TOO EASY

There could be a point in trying to stay levelheaded when faced with the overstatements and misrepresentations that occasionally turn up in the public discourse on environmental policy. This, validating various assumptions and theories, is actually

what international research environments are engaged in at conferences and in journals. Appraising the resulting policy proposals is what politicians and advisors are doing every day. In several ways that approach is superior to the media strategy that ‘The Skeptical Environmentalist’ stands for. If we were to overstate and misrepresent just as much, only in reverse, then the net outcome would not necessarily be a more informed public discourse, much less a public awareness closer to the truth.

When we have stripped the book of its economic overstatements and misrepresentations, we are left with the message that Lomborg does not believe that climate changes can assume the catastrophic dimensions predicted by many researchers. This, of course, is an entirely legitimate viewpoint, and largely concords with Lomborg’s general thesis: that overall global development is what it should be. But having his message served wrapped up in a lot of dollar signs of unknown provenience is less than informative.

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1 (United Nations 1992), Article 2, Objective.

2 1012, henceforth.

3 (Lomborg 2001a) p. 310. Also comp. figure.

4 (Lomborg 2001a) p. 304.

5 (United Nations 1992), Article 2, Objective.

6 Geo-engineering is a strategy, which – instead of limiting the layer of greenhouse gases that prevent the earth’s heat radiation from escaping – intends to supplement it with another layer that limits the penetration of solar rays. The idea is to inject a large quantity of e.g. aluminum particles into the stratosphere thus to reflect

- solar irradiation. This would be a way to maintain radiation balance, which would not restrict the use of fossil fuel, but only the resulting adverse effects.
- 7 (Nordhaus and Boyer 2000), Ch. 7, p. 26. Also comp. note 7.
 - 8 (Nordhaus and Boyer 2000), Ch. 4, p. 44.
 - 9 Using the same global discounting factor as used by (Nordhaus and Boyer 2000) in the calculations of the RICE model.
 - 10 (Lomborg 2001a) p. 301.
 - 11 (Lomborg 2001a) p. 301.
 - 12 (International Panel of Climate Change 1996) p. 218.
 - 13 (Lomborg 2001a) p. 304.
 - 14 (Mensbrugghe 1998) p. 27.
 - 15 [Burniaux, 2000 #51]
 - 16 (Lomborg 2001a) p. 303.
 - 17 (International Energy Agency 1999).
 - 18 (Lomborg 2001a) p. 313.
 - 19 (International Panel of Climate Change 1996) p. 170.
 - 20 (International Panel of Climate Change 1996) p. 57.
 - 21 (International Panel of Climate Change 1996) p. 206 refers to interpersonal comparison of utility, a familiar problem in economic theory.
 - 22 (International Panel of Climate Change 2001) Q6.12. The costs of global warming and other environmental cost associated with the emission of greenhouse gases roughly correspond to the benefits of climate policy.
 - 23 (Woodward and Bishop 1997).
 - 24 (International Panel of Climate Change 2001) p. 613.
 - 25 (The Danish Economic Council (Det Økonomiske Råd) 1998) p. 249.
 - 26 (Lomborg 2001a) p. 350.
 - 27 (Lomborg 2001a) p. 316.
 - 28 (Lomborg 2001a) p. 317.
 - 29 (Lomborg 2001a) p. 316.
 - 30 Especially (Weitzman 2001) has a promising attempt at a discounting algorithm that can also be applied for very long-term calculation.
 - 31 Actually, at an annual growth of 3 per cent, the world's total production would be doubled already after 23 years and six months. That climate policy will cost us 2 per cent of the world's total GDP means that the economic benefit of letting emissions increase correspondingly would be that production would reach this doubling-level nine months earlier.
 - 32 (Lomborg 2001a) p. 305.
 - 33 (The Danish Ministry of Finance (Finansministeriet) 2001).
 - 34 Own calculations based on the national accounts in (Statistics Denmark (Danmarks Statistik) 2001).
 - 35 (Lomborg 2001a) p. 324.
 - 36 (Lomborg 2001a) p. 320.
 - 37 (Lomborg 2001a) p. 320.
 - 38 (Lomborg 2001a) p. 306.
 - 39 (Lomborg 2001a) p. 305.
 - 40 (Lomborg 2001a) p. 385.
 - 41 (United Nations 1992), Article 2, Objective.

POPULATION, GROWTH AND POVERTY

By Kåre Fog
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The growth in global human population affects largely all other environmental problems on earth. The population figure as such has decisive influence on the food supply situation, on the issue of water resources, on erosion and desertification, rainforest clearing, and the eradication of plant and animal species. Moreover, the number of people with a reasonably high standard of living, i.e. the size of the global middleclass, is crucial to energy consumption, consumption of natural resources, and global pollution.

POPULATION DENSITY

The most densely populated regions on Earth are found in part in some industrialised countries (Japan and parts of Western Europe), and in part in some less prosperous countries in South and East Asia. The Netherlands has more than 300 persons/km², and so far, this has been possible only because of considerable resource imports from outside. The same goes for Japan, with a population density of approx. 340 persons/km². Thus, the present mode of life in such prosperous, densely populated countries can only be upheld by tapping resources elsewhere on Planet Earth. At the present level of technology, it is impossible that their way of life could be extended to all nations.

A similar high population density is also found in some poor Asiatic countries. However, while populations in the prosperous countries have largely ceased to grow, population growth has remained high in the poor countries of Asia. Overall, India 'only' has a good 200 persons/km², yet the number of people is not expected to stabilise until it reaches 4-500 persons/km². If these many Indians are ever to achieve our standard of living, such high population density across an area of that magnitude is bound to create resource and environmental problems far greater than those known in The Netherlands and Japan today. Seen in the long-term perspective the important part is how great the population density is *going to be*, and not its present size.

In other continents, e.g. Africa and Latin America, population density is far lower. Thus, it would lie near to assume that there would continue to be room for considerable population growth here. However, the interesting part is not population density as such, yet the relation between population growth and economic growth – a point I will be getting back to shortly.

HOW MANY PEOPLE CAN THE EARTH SUPPORT ALTOGETHER?

Presently, Planet Earth has a population of about six billion people, and their number is rapidly increasing. Forecasts are that by the mid-21st century the earth population will have reached some 10 billion. Is there enough room for all those people, and will there be room for further growth thereafter?

There is no unambiguous answer to the question. The answer depends on the set conditions. In some kind of sci-fi-like future scenario, where food production with plant crops has been replaced by chemical photosynthesis in plants using huge solar collector antennas, with people closely packed in multi-store-

yed subterranean rooms, there could possibly live far more people on Earth than those 10 billion. The question is rather more what quality of life these people would demand. A world, in which it is still possible to listen to the nightingale in the open, can accommodate far less people than one, in which the song of the nightingale is only available as sound recordings.

Furthermore, it is a matter of justice. The less people on Earth, the easier will it be to create a world community with the same material standard of living everywhere. Contrarily, a continued strong growth in the Third World would make it exceedingly difficult to provide global justice in any near future.

On the one hand, it is widely held that the populations of the industrialised countries should continue having, as a minimum, the material welfare they have now, and on the other hand, it is of course hard to dismiss the notion of global justice. Taken together, these two views would imply that some time in the future the entire world population are to have the standard of living that we have today. The populations of the industrialised countries practically do not grow any more. Thus, one of the most decisive factors in achieving global justice will be how much the populations of the developing countries are going to grow. For instance, the population of India is foreseen to gradually stabilise at around 2 billion people. If all Indians are indeed to achieve the standard of living found in today's industrialised nations, it matters greatly if India's population will sometime stabilise at 1.5 billion or 2.5 billion. Moreover, a strong economic growth in populous countries will aggravate the global pollution problems, and more so, if environmental protection is initially given low priority. E.g., the total release of ozone-depleting gases from China now amounts to more than twice the overall emissions of the EU.¹

On the shorter term, one could ask if there is room for ten billion people at the present level of technology in e.g. food production. That could be possible, yet not without problems, as demonstrated by the situation in China. For decades, agricultural production has been heavily intensified in China, and for instance rice yields have gone up and up. However, one cannot just extrapolate that trend into the future and count on yields to continue rising. This is evident if we compare with other countries that have been further ahead in their development. In Japan, rice yields per hectare reached approximately the present level already about 1975. Since then, the yields have increased by less than 10 %. Yields in South Korea have grown more rapidly, and in 1977-1978 they surpassed the Japanese level. However, they have not increased since then, the yields in 2000-2001 being the same as in 1977-1978. The Chinese yield level has grown steadily from a low level, and finally reached the level of Japan and South Korea around 1995. Since then, the yield has not increased there. So, in each country, whenever the yield has approached the level seen in South Korea since c. 1977, the growth in yield nearly stops². Apparently, the present yields are close to maximum at our present state of technology. At the same time, the farmland area of China can hardly be extended, for in the most recent decades it has actually gone back – soil erosion, desertification etc. have swallowed up greater areas of farmland than the new areas brought under plough. Thus, it is fortunate that population growth in China has practically come to a stop. Had that not been the case, considerable problems with food supply would probably have occurred. Other resources that may become

extremely scarce are water reserves, e.g. in India and China.

Future population growth rates will prove decisive for the extent to which it will be possible to preserve the regions on Earth with a high biodiversity, such as rainforests and coral reefs. Africa will be the continent with the highest continuing population growth. This will be a crucial factor in determining if the rich plant and animal life of Africa can be preserved. However, it is not possible to indicate precisely when we will reach the limit to an acceptable population size. Nor is it the most urgent question at this time. What matters right now is, whether population growth is checked, or risks going out of control. The main part of this chapter will deal with that issue.

RECENT DEVELOPMENTS IN WORLD POPULATION FIGURES

UN published its first comprehensive population prospect in 1957 and has since produced several new projections. Practically at the outset, it was decided to prepare three projections: a low, a medium, and a high variant. The three variants differ in their assumptions on how low levels of birth rates will eventually come. The final number of children per woman is set at 1.6, 2.1 resp. 2.6 for the low, medium, and high variant. Then, for each nation, separate assumptions are made as to how long they will take to reach that endpoint level.

A classic of the environmental cause, 'Population, resources, environment' by Paul and Anne Ehrlich from 1970³, draws upon 1963 UN population prospects. Their book provides a detailed account of all three variants. It is interesting to compare the projections of the medium variant with how the world population has actually developed according to official estimates (Table 1).

Year	1963 UN prospects	Estimate of actual figures
1960	2998 million	3027 million
1970	3592 million	3702 million
1980	4330 million	4447 million
1990	5188 million	5282 million
1995	5648 million	5687 million
2000	6130 million	6057 million

Table 1. Total world population according to the 1963 UN population prospect⁴ and present best available estimates on actual population figures in respective years.^{5,6}

According to the medium variant of the 1963 prospect the Earth population was to number 5648 million people by mid-1995, which practically turned out to hold. In the span up to the year 2000 population growth proved to be slightly slower than foreseen, but still the prognosis has only shot 1 per cent above the target – quite an impressive result. Over the years, numerous other prognoses have been made, several of which shot far more above target than the one shown here. Thus, things have gone better than feared by many. Still, there is no reason to blame Paul Ehrlich in particular for being overly pessimis-

tic, with reference to Table 1. Quite the contrary – he included in his text the medium variant of the prospect that turned out to hold true.

In many places, birth rates have recently seen considerable decline. Yet, such falls have certainly not taken the experts by surprise. Contrarily, prognoses have always been optimistic enough to expect such falls – their uncertainty was merely about when those falls would happen. And the early expert guesses concerning the timing of the falls were more or less to the point. This is the basis why e.g. the 1963 UN prospect was able to hold so precisely.

It must be pointed out that the 'actual figures' of the table are not quite precise. In some countries, 10 or 20 years pass between censuses, and between censuses population figures are calculated based on estimated birth and death rates. For this and a number of other reasons their figures have considerable uncertainties. For instance, different estimates of Nigeria's population in 1997 range from 107 to 118 million.^{7,8}. Given such uncertainties one has to admit that the coincidence between the 1963 prospect and the actual development is as good as it can possibly be.

Even though the first UN prospects, including the one from 1963, prognosticated developments up until Year 2000 rather precisely, the geographical distribution of growth turned out to be somewhat different from the projections. Population growth in Asia has seen a marked decline in the 1990s. Since more than half the total growth takes place in Asia, low birth rates here will have a strong impact on the total world figures. As late as 1995 the annual growth in world population was believed to be some 93 million persons a year, a figure expected to peak right before Year 2000 and only then start going back down. The newest figures available show that actually, growth in the early 1990s was 'only' at 80-90 million people annually, and in Year 2000, it was down to 77 million.

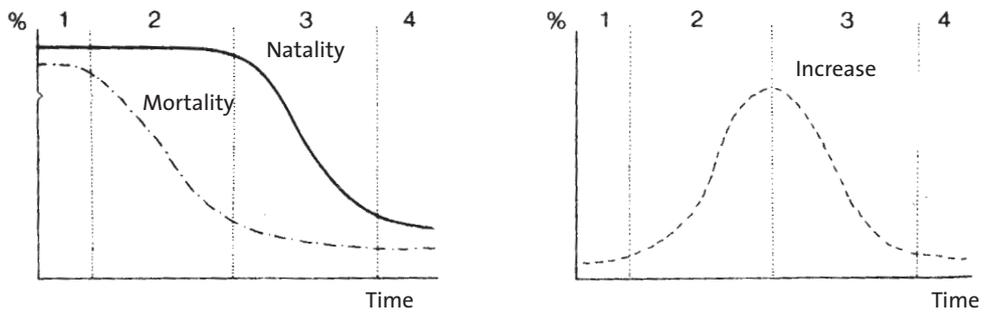
By contrast, growth in Africa did not fall as much as expected. Since Africa's population was still relatively small, that trend does not make itself felt in total world tallies. Yet, with continuing strong growth, the population will eventually expand enough for population growth in Africa to impact ever more on the total account of worldwide population growth.

THE DEMOGRAPHIC TRANSITION

The concept of 'demographic transition' was introduced in 1945 and is the key to understanding and assessing trends in population growth. The concept expresses how the transition from a situation of high birth and death rates to one of lower birth and death rates evolves. It is based notably on experience gained from the prosperous parts of the world, yet also fits with the development taking place in most poor countries.

The process falls into four phases, comp. Figure 4. Phase 1 is characterized by poverty, illness, and insecurity, and both birth rate and death rate are high.

In Phase 2 advances in material welfare, education, hygiene, etc. cause the death rate to decline. Nevertheless, the birth rate remains unchanged at the previous high level. The ever-growing surplus of births vs. deaths causes popu-



Figur 4. Schematic representation of the demographic transition. The figures 1,2,3 and 4 indicate the four phases of the development.

lation to grow, at first slowly, and then faster and faster.

On transition to Phase 3, the death rate has practically reached its lowest possible level. Nearly all newborns survive. This causes parents to change attitude as to how many children they wish to give birth to, and the birth rate decreases, often rather abruptly. The ever-decreasing surplus of births vs. deaths causes population growth to decelerate. This is the situation in Phase 3. Once the birth rate has decreased enough for the number of births and deaths to balance, population growth stops again. This situation is Phase 4, which largely all European countries have reached by now.

A curve of total population figures will display an S-shaped progression: Starting from a low population figure in Phase 1 population growth will accelerate rapidly through Phase 2, then gradually more slowly in Phase 3, and finally the figure will stabilise at a high level in Phase 4.

The countries to have progressed the farthest are European countries. In all parts of Europe, so few children are born today that the populations no longer replace themselves. Normally, we say that each woman of childbearing age is to have a little more than two children (2.1 child) in her lifetime in order for a population to replace itself. However, in most European countries fertility, i.e. number of children per woman, is now merely between 1.2 and 1.8, and hence too low for replacement of the population. We do not know if this will still be the case in the future.

THE SIGNIFICANCE OF ECONOMY TO DEMOGRAPHIC TRANSITION

Economic development is quite important when it comes to the demographic transition. When comparing different countries we find, as a general rule, that the higher GDP per inhabitant, the farther down the demographic transition has the country moved, from Phase 1 towards Phase 4.⁹ The same applies when comparing different population segments within individual countries.

How economic growth and population growth interact is most easily seen by expressing both as annual growth in per cent increments.

As long as the economic growth of a country exceeds population growth, the average material welfare per capita will increase. This implies that overall the population becomes more prosperous, healthier, better educated, etc., thus driving the evolution on through the demographic transition. As long as we are still in Phase 2 population surplus will go up. If we take the economic growth rate over the same period to be more or less constant, that implies that the population's growth rate will close in on the economic growth rate, and the annual growth in material welfare per capita risks to stall. However, before things go all that wrong, the development will generally reach Phase 3 and the annual birth rate begins to fall. At the point of passing from Phase 2 to Phase 3, a 'good circle' will begin: From then on any extra increase in wealth will cause the birth rate to drop a little further. The surplus of economic growth vs. population growth will grow a little more, material welfare per person will further increase, the birth rate will go down further, etc. Such intrinsic dynamic in a society will then 'automatically' push development through Phase 3 and take the population to Phase 4, in which it has stabilised.

However, in countries with exceedingly high birth rates and low economic growth, there is a risk for the situation to go into deadlock in Phase 2. Here we risk reaching a zero advance situation where the population growth rate has caught up with the economic growth rate. Should that happen, then material welfare per person will cease to rise. All progress made in education, health, nutrition, etc. will be 'cancelled out' by population growth. In that case, it can be feared that population growth will just continue, and that the demographic transition will never get to pass from Phase 2 to Phase 3, or that the development even starts moving backwards, i.e. decreasing material welfare per person, and increasing mortality. In that case, we would have a vicious circle that drives development backwards. We are yet to find out whether this actually occurs.

OTHER FACTORS WITH BEARINGS ON THE DEMOGRAPHIC TRANSITION

As will appear from the phases of the demographic transition, the death rate must be the first to fall, and only then can the birth rate fall. Presumably, the effect of economic growth is very much that it increases living standards enough to cause death rate to go down. However, other factors can have the same effect. In Sri Lanka, for instance, control of malaria mosquitoes in the years after World War II reduced malaria deaths so much that a positive development towards greater material welfare and health was activated. Several other forms of health programmes, immunisations, stationary and mobile health clinics etc. have similar effects.

It matters greatly whether an extra child means a bonus to a family, or an extra impediment. Traditional farming communities often need all the hands they can muster. This is in particular true of regions where manual labour is used to work the soil. In that case, children make welcome extra labour. At the same time offspring also has what is known as 'old-age security value'. In communities where old-age care rests with the offspring, parents feel 'compelled' to bring enough children into the world for at least one or two to be alive, once the parents grow old and need care.

In addition, uncertainty as for the children's survival plays a major role. The more uncertain children are to survive, the more children will parents give birth to. In that sense, good health and well-organized social conditions are prerequisite to low birth rates. Basically, the need for surviving children can cease altogether, if the state assumes the full responsibility of old-age care. This is particularly the case in contemporary Scandinavian societies, yet attempts have also been made in communist countries, notably China.

Experts in family planning schemes occasionally apply the rule of thumb that people cannot be motivated for family planning until the life expectancy of a newborn is minimum 50 years.¹⁰ If average life expectancy is below 50 years parents dare not refrain from producing many children. Thus, a life expectancy in a country of less, resp. more than 50 years is a major indicator in showing if the demographic transition can be expected to pass from Phase 2 to Phase 3.

Education is another major factor. The more widespread it is for children to go to school, the less their value as labour, and the greater the cost of having children. Moreover, school attendance is important for girls in particular. Illiterate

girls will often see it as their prime role in life to produce progeny, while children with schooling have a different attitude and aspire to have fewer children. Certain experts apply the rule of thumb that transition from Phase 2 to Phase 3 will not happen in a country until at least 20 per cent of all girls proceed from primary to secondary school.¹¹

The ratio between rural and urban population is another important factor. In the country, children are considered as useful labour, while urban children make more of an economic burden. If an increasing share of the population is concentrating in towns and cities, this will thus contribute towards lower birth figures.

THE SIGNIFICANCE OF RELIGION

Despite the fact that religion is often associated with sexual constraint, pronounced religiousness mostly implies high birth rates. This lies, among other things, with the fact that religiousness often implies close-knit family units, where the woman's role is to look after the home and bear children. Add the religiously motivated resistance to birth control and induced abortion. At global level, not least Islam and the pope of the Catholic Church have put a brake on trends towards lower birth rates.

Some places religion is an element of a vicious circle. If population growth in a country is so high that economic growth can hardly keep pace, then large groups of poor people emerge whom the government cannot or does not wish to support adequately. Often these poor will then resort to religion instead, especially if religious authorities show more understanding of their plight than does the government. Hence, poverty can lead to increasing religiousness and not least, increasing fundamentalism. This in turn causes families to have more children, still more population growth, and hence still more poverty. More detailed data on the significance of religion to family size exist e.g. in Iran in relation to the Islamic revolution; here, birth rates have fluctuated according to the varying influence of theocracy.¹² Data on the impact of traditional religious beliefs also exist for Sub-Saharan Africa.¹³

THE SIGNIFICANCE OF FAMILY PLANNING

Normally, apart from the Chinese one-child policy, it is not possible to base a country's family planning on compulsion. Thus, there are only two strings on the bow: 1) information campaigns to encourage low birth rates, and 2) making contraception available to any woman or man, who wishes to use it. But even so, birth rates cannot be pressed down any further than what the economic, health-wise and educational situation of a country dictates.

This is the general principle, but exceptions do exist. Family planning campaigns have been able to produce low birth rates in some countries, although their economic conditions would not make this likely to happen. This is the case in Cuba, Costa Rica, Sri Lanka and a southern constituent state of India. Bangladesh has also seen pronounced declines in birth rates recently. In Bangladesh, the number of births per woman has gone down heavily since 1970, from c. 7 to c. 3.8 today.^{14,15,16} Among married women in Bangladesh 42 per cent are now using contraceptives.¹⁷ A similar development, though hardly as marked, has taken place for India as a whole. The sudden drop in the number

of childbirth's per woman in Bangladesh happened in spite of poor economy, low status for women, high infant mortality, high value of children as old age security, and opposition from the Islamic priesthood. In Bangladesh, widespread family planning was successfully introduced, and in a manner that won the consent of the general population. Starting in 1995, the government has begun to launch a one-woman-one child campaign. Concurrently job opportunities for unmarried women have increased.

All of this happened notwithstanding that Bangladesh is one of the world's poorest countries. The likely effect is that the country's economic growth per capita will rise considerably, greater economic investments become possible, and that economic growth in the country will get into its stride. It would thus appear that the generally accepted cause-and-effect chain of demographic transition could be reversed. Where it is normally assumed that economic growth is the motive force of demographic transition, the case of Bangladesh is evidence that by themselves changes in demographic parameters are able to drive on the demographic transition, and in turn lead to more economic growth. Thus, so far Bangladesh is the most eloquent evidence that concerns about the effects of heavy population growth can actually lead to concrete change in a country, giving momentum towards a more positive development.

THE SIGNIFICANCE OF WARS

Wars cannot reduce population figures. In most cases, the effect is just the opposite. In Europe, we have seen, for instance, that birth rates increased considerably during and right after World War II, and normally similar phenomena are seen elsewhere in the world. Wars increase mortality and insecurity, and as we know more insecurity about the survival of children prompt families to give birth to more children. Although wars mean that people of fertile age die, they still cause population growth to increase. Another effect of wars is that infrastructure is destroyed, and economic progress is lost. This, too, will cause development to put back the clock by several years.

THE SIGNIFICANCE OF AIDS

The AIDS epidemic is still spreading.¹⁸ While the 1998 UN population report considered 34 countries to be 'highly affected' by AIDS, the 2000 report now counts 45 countries. 35 of these are in Sub-Saharan Africa. The hardest-hit country is Botswana, where c. 36 per cent of the adult population is HIV positive.

A cynic might say, 'Well, then let the AIDS epidemic blow itself out – that will mean a brake on population growth.' However, AIDS will not be able to stop population growth. WHO has designed an epidemiological model to be used in projecting trends for the numbers of AIDS deaths. This model was applied i.a. for five of the hardest-hit countries (Botswana, Zimbabwe, Zambia, Malawi, and Uganda). Altogether, these countries had 50 million inhabitants in 1995. In the absence of an epidemic, that number would – according to the population projections – increase to 168 million in 2050. When taking account of the effect of AIDS, that figure is reduced to a 'mere' 146 million. Thus, the percentage reduction in population figures is rather modest.¹⁹

Since then the epidemic has spread more vehemently than predicted, but

even with the most recent figures indications are still that AIDS will, in most countries, only check population growth, yet not bring it to a complete halt.²⁰ Another effect of AIDS is to render people's future more uncertain. In Botswana, 'life expectancy at birth' was c. 60 years in the early 1990s. That figure has greatly declined, and is expected to plummet to c. 35 years around 2005. Above, we have seen that a population can be expected to be in favour of birth control only if life expectancy is more than 50 years. In Botswana we are now back below that limit. Moreover, the many AIDS-sufferers will occupy many resources of the health system, thus also increasing the risk associated with suffering from other conditions. Furthermore, the impaired working capacity of the AIDS-sufferers is beginning to cause agricultural production to go down. Thus, on all counts, AIDS causes development to reverse, pushing a country far back into Phase 2. Therefore, the effect of AIDS is negative in every respect – and nor does it directly produce a decrease in population figures.

What was said for Botswana also applies for the other hard-hit African countries. By now, in an increasing number of countries, life expectancy at birth has once more dropped below 50 years, in some cases even below 40 years. Overall, for Sub-Saharan Africa present life expectancy is estimated to be down at 47-49 years now.^{21,22}

THREE PRINCIPAL CATEGORIES OF COUNTRIES

In the past, we used to classify the world's countries into two main groups: industrialised countries and developing countries. This classification is no longer sufficient. Today we are rather to distinguish between three groups of countries, the situations of which are vastly different. We speak about 'more developed regions', i.e. industrialised countries; these countries have made it to Phase 4. 'Less developed regions', i.e. previously developing countries that have now entered Phase 3 with increasing material wealth per capita. Many of these countries have an economic growth rate per capita that is considerably higher than the 'old' industrialised countries, meaning that these countries are rapidly closing in on the standard of living found in industrialised countries, although they still have quite a way to go before catching up. Finally, the 'least developed countries', which are the countries that are yet to leave Phase 2. They have extremely high birth rates, and material welfare per capita is not necessarily increasing. Thus, the former rift between industrialised countries and developing countries is now being superseded by another rift, namely between 'less developed regions' in rapid progress, and 'least developed regions', where progress is slow or non-existent. The group of 'less developed regions' is approaching the industrialised countries, leaving behind the group of 'least developed regions'.

We are now to take a closer look at some countries among the 'less developed regions' where, in the main, development has been more positive than anticipated. This goes especially for East Asia.

THE SITUATION IN CHINA

In its first years, the communist government of China considered high population growth to be an asset, yet from the early 1960s their attitude changed. Following the Cultural Revolution and Mao Zedong's death in 1976, a restrictive one-child policy was introduced. However, in practice there are born more

children than one per woman. In 1998, China had a fertility rate of 1.8 children per woman,²³ and thus less than the 2.1 required in order for a population to stay at replacement level. Presently the powerful deceleration in birth rates provides China with a favourable age distribution, with a very large proportion of working-age population and a small burden of supporting the next generation.

The small burden of supporting the next generation leaves considerable room for economic investment. If a family only has few children, it will still have money to spend after covering the cost of children's clothing, food, and school. Society will accumulate a surplus that can be invested on the improvement of infrastructure, means of production, etc. Thus, a 'good circle' is set in motion in macroeconomics. In China, this effect is more pronounced than perhaps anywhere else. In the years from 1988 to 1997, the GDP of China went up by nearly nine per cent annually.²⁴ From 1985 to 1996, per capita food production in China has increased by 65 per cent.²⁵

The latest ten years' development in China may well be the one single aspect that has most decisively changed the outlooks for the world population. In a matter of very few decades, the situation of more than a billion people has shifted towards low population growth and great economic progress. Yet, I would add that with these comments I have not committed myself on whether the methods used in China are acceptable.

EAST ASIA

In the aftermath of World War II Japan had stronger economic growth than USA, and in terms of GDP Japan reached the world second place in the 1990s. The strong Japanese economy gradually spread to other parts of East Asia. First to the second-strongest economies of the region, namely 'the four small tigers', i.e. South Korea, Taiwan, Hong Kong, and Singapore, and then gradually to other countries in Southeast Asia with lower costs of labour, and where we have now seen the 'tiger economics' emerge. Based on what we know about the demographic transition we would expect the strong economic growth to reduce population growth. That has indeed happened, as shown by the examples in Table 2. In Thailand, fertility has now dropped below 2.1 children per woman. Thus, in the longer term, population growth in Thailand should have ceased by now.

Country	1980 fertility	1998 fertility
Japan	1.8	1.4
South Korea	2.6	1.7
Vietnam	5.0	2.3
Malaysia	4.2	3.2
Thailand	3.5	2.0
Indonesia	4.3	2.7

Table 2. Fertility in some Southeast Asian countries. Figures indicate number of children per woman.^{26,27}

The summer of 1997 marked the onset of an economic crisis in Thailand, later to spread to the remaining Southeast Asia; yet it appears to have blown itself out by now and may perhaps not have any lasting effects on the developments in population figures.

PARTICULARLY POOR COUNTRIES IN ASIA

Certain Asian countries have just barely started moving from Phase 2 to Phase 3. The most important of these is Pakistan, which at present has a population of c. 140 million. Up until 1995 or so birthrates were still exceedingly high in Pakistan, at close to six children per woman.²⁸ At present, some 45 million inhabitants are still living below the poverty limit defined by UN. Yet, notwithstanding the extremely high population growth, Pakistan has succeeded in maintaining economic growth at a still higher level, thus making room for an annual growth in material welfare of 1-2 per cent per capita.²⁹ Birth rates have now dropped to approx. 5.5 children per woman, and further declines are anticipated in the future. However, there is a remaining risk of growing religious fundamentalism to cause birth rates to increase once more and smother the seeds of a positive development.

Also, some other poor Asian countries, such as Laos, have a situation with a very high rate in population growth, yet with a still higher rate of economic growth.

NORTH AFRICA AND THE MIDDLE EAST

North Africa and the Middle East have seen rapid growth in population figures, comp. Table 3. The heavy increases are caused in particular by high birth rates in the past, which accounts for the fact that the populations still have an age distribution with few old and many young. In regards to fertility in North Africa, some remarkable reductions have taken place in more recent times. From the early 1970s until the early 1990s, the number of children per woman in North Africa went down from 6.3 to 4.1.³⁰

	1980	1995	2010
North Africa	88 million	127 million	163 million
Middle East	132 million	215 million	305 million

Table 3. Population figures in 1980, 1995, and 2010 (prospect according to the World Bank) for North Africa (from Morocco to Egypt) and the Middle East (from Turkey and Israel + Palestine to Iran).³¹

Equally, there has been a fall in fertility in the Middle East, though quite modest. For the region in general it appears that increasing wealth and high health standards do not translate into falling birth rates to the extent found for the rest of the world.³² In particular, most of the prosperous oil nations still have exceedingly high birth rates. This may in part be attributable to religious aspects, and in part to social structures with considerable gaps between rich and poor. All presently available information indicates that the populations of North Africa and the Middle East will continue growing far into the 21st century. This owes in part to the present age structure, and in part the present fer-

tility rate, which is way over 2.1 and is only slowly declining. The strongest population growth is found in the Middle East, where the doubling time is less than 30 years, as seen in Table 3.

LATIN AMERICA

In the start of the 20th century South America had relatively well-developed societies, and in economic terms one would have expected South America to remain far ahead of other third world countries through most of the century. However, an exceedingly high population growth has contributed to the retardation of progress. In most countries of South and Central America, the demographic transition from Phase 2 to Phase 3 did not take place until around 1980. So far, economic growth in Latin America is only slightly higher than population growth. Thus, while the demographic transition is well under way and there should be room for increasing per capita prosperity in the next few decades, the situation still appears uncertain.

THE SITUATION IN SUB-SAHARAN AFRICA

While the situation in East Asia is encouraging, the situation in Africa is quite disappointing. All African countries have successfully passed into Phase 2 of demographic transition, meaning that death rates have gone down considerably. Infant mortality has seen a marked decrease since 1950, yet not nearly as pronounced as in Asia and Latin America. In the 1950s, life expectancy at birth in Africa was at around 36 years. Before the AIDS epidemic life expectancy increased to 50 years, which is still far lower than in Asia (64.5 years) and Latin America (68.5 years).^{33,34}

Some 25 years ago the developing countries had overall high birth rates of approx. six children per woman. Since then, there has been a marked fall except for Sub-Saharan Africa, where many countries still have extremely high birth rates of 6.5-7.5 children, in the Niger as high as 8 children. Decline in birth rates, and hence transition to Phase 3, has only been seen with a few countries in eastern and southern Africa – most markedly in Kenya, less so in Tanzania, Zimbabwe, and several other countries in southern Africa (However, these southern countries are now heavily afflicted by AIDS, and as already mentioned, this will probably reverse development here).

Africa's agricultural production cannot keep pace with population growth. It increased by approx. 2.7 per cent annually in the 1960s, but the increase has been as low as approx. 1.4 per cent annually in the period of 1970-90, and thus way below the present rate of population growth of 2.6 per cent annually. The proportion of Africans who are chronically undernourished has gone up from 38 to 43 per cent.³⁵

Apart from southern Africa, only 16 per cent of girls in Africa attend secondary school. In the least prosperous countries, as little as 2 or 3 per cent of the girls and 6 to 9 per cent of the boys will take secondary education. According to a rule of thumb, a drop in birth rate would presuppose a minimum 20 per cent of the girls to take secondary education. Thus, most African countries are below that figure.³⁶ Several African countries have problems keeping up public spending for the present level of education. Especially in those countries that have the highest population growth the number of children to attend

secondary school is falling. The health system has similar problems. As for Nigeria, the largest nation of the region, public health services are directly in a state of dilapidation.³⁷

In several places, no progress can be seen regarding governmental family planning efforts, and in most African countries, less than 10 per cent of the women are using modern methods of birth control. In many places, a family unit with 6-8 children is still considered desirable, in part due to religious beliefs. Another reason is that when it comes to the number of offspring, women have to obey their husbands, while the economic burden of child-rearing does not rest with the men.³⁸

Countries where prospects look definitely bad may be defined, in a first approximation, as those countries where not even a marginal fall in population growth rate is in evidence, or where life expectancy is less than 50 years – meaning that a continuing fall in birth rates cannot be expected. Now, in the whole world 33 countries fit this definition. 31 of these countries are in Africa.

A closer look may reveal if, after all, these countries can be expected to gradually pass from Phase 2 to Phase 3, or if they risk 'getting stuck' in Phase 2 and may never in any foreseeable future have their population figures stabilised. Therefore, let us see if there is still a growth in per capita prosperity in these countries. For that purpose, I have drawn upon World Bank figures.³⁹

I have chosen to evaluate economic development for the period of 1980-2000. We can then see that over this period an upward economic trend is in evidence for 6 out of the 31 countries, regardless of perspective, e.g. if we calculate in USD or in local currency. In those countries, economic growth is high enough to match population growth and even yield a surplus so per capita wealth is increasing. Contrarily, for the remaining 25 countries, per capita wealth has been decreasing over the period, if made up in USD, and in 20 of these countries per capita wealth has fallen even when measured in local currency. Thus, at least 20 countries of Sub-Saharan Africa are stuck in Phase 2, at present with no prospects of moving on, since per capita wealth is falling. It is still possible that a new positive development may take off here within the next decade, but there is at present no clue that this will actually happen.

Thus, the African situation is fraught with a number of adverse features. Some countries, notably in southern Africa, appear to be heading for a favourable development, while for many countries development has practically stalled, and in a few cases it is even reversing. That is, towards economic recession, increasing starvation, health deterioration, and increasing mortality. Birth rates are still of such formidable dimensions that the demographic transition risks getting stuck in Phase 2, and then to reverse.

OTHER COUNTRIES IN PHASE 2

Apart from the countries in Africa, a few other countries of the world still show no indications of moving on from Phase 2 to Phase 3. In contrast to the African countries, the nations in point have a reasonably good health status (life expectancies are at 60 to 70 years). However, they are remote from the world's growth centers and are very much influenced by traditional beliefs

concerning religion and family life. New notions on reducing the size of their households have not truly filtered through here.

In Asia, we have two such countries, namely Yemen and Afghanistan. Both continue to have exceedingly high birth rates of a magnitude of around 7 children per woman. However, the present situation in Afghanistan is of course so uncertain that it defies evaluation.

Latin America has a few countries in which development is not positive. Birth rates are not so extraordinarily high as in Africa, though adverse features are still in evidence. That goes for Paraguay, Bolivia, and more so for Haiti. Here there has been a negative trend in per capita wealth over the period of 1980-2000.

OTHER FACTORS THAT COUNT ON THE DEBIT SIDE

Trends in economic wealth per capita do not necessarily tell us everything worth knowing, if we wish to know if better times are ahead. Recently the World Bank has announced the use of a new index that not only allows for the economic resources of a country, but also includes human and natural resources.⁴⁰ The index is called the 'genuine savings rate'. For instance, a fall in human resources can happen when civil wars or AIDS leaves a country short of well-trained labour. A decline in natural resources can arise due to e.g. ruthless forest exploitation in a country, or when the diamond mines of a country are emptied in order to provide money to buy weaponry. 'Environmental degradation' can cause measurable losses in GDP. Thus, instant economic growth can be 'on borrowed time', possibly jeopardising potential economic options in the future.

If allowing for such aspects, then 30 of the world's countries have a negative 'genuine savings rate', meaning that the total assets of the country are in recession. In another 20 countries, the total assets are growing more slowly than their population figures, such that the per capita amount of assets is decreasing.

CONCLUSIONS ON THE POVERTY ISSUE

There are a number of countries in which development is unfavourable at present. These countries are primarily countries in Sub-Saharan Africa, with the exception of Kenya and possibly Tanzania, and moreover a few countries in Asia and Latin America. By the year 2000, this cluster of countries had a total population of approx. 655 million inhabitants, or what amounts to c. 10 per cent of the global population. The remaining 90 per cent of the world population live either in industrialised countries or in countries where, in spite of all, development is clearly positive.

For the countries, in which the 90 per cent most prosperous of the world population live, we must assume Phase 2 of the demographic transition to be over by now, and that their development will proceed through Phases 3 and 4. This will entail a continuing fall in birth rates, and along with that an increasing per capita wealth. It is by no means certain that those positive trends will continue. Various forms of accidents could stall the development, or more widespread religious fundamentalism could bring the fall in birth rates to a

halt. However, a continuing positive development remains the most likely scenario. (However, when using the term 'positive development', this only goes for the economic aspects. The prospect of the whole of China and the whole of India reaching a standard of living that matches what we have today in the industrialised countries forewarns problems of hitherto unknown dimensions, with regard to environmental problems and draining the earth's resources).

In the countries where the remaining approx. 10 per cent of the world population lives, the economic prospects do not appear to be unambiguously positive. It is possible that a large part of these countries will shortly pass into a positive development reminiscent of the ongoing development in the rest of the world, but it is also a very real possibility that such a positive development does not get started. In any case, the development of these countries will continue lagging behind the others, so they will remain relatively poor.

For the world population as such an increase is expected from presently approx. 6 billion to approx. 10 billion by 2050. However, for the countries with the gloomiest outlook population figures will rise far more than that. A tripling – for some countries even a quadrupling – can be expected to occur up to 2050. Thus, by 2050, the population of these countries will be around 2 billion people. That implies that the least prosperous countries will make up an increasing proportion of the global population – since their share will go up from 10 per cent today to 20 per cent by the year 2050.

This is a matter of relevance whenever we discuss global injustice. A UN organisation has assessed global injustice by comparing the ratio of welfare between the most prosperous 20 per cent and the least prosperous 20 per cent of the world's population. So doing, the statistic would include not just the 10 per cent of the world population living in countries with gloomy prospects, but another 10 per cent of poor people living in countries with good prospects. On these grounds, the 20/20 ratio is not very appropriate. It would be more to the point to consider three groups: the 20 per cent living in industrialised countries, the 70 per cent living in countries 'on their way up', and the last 10 per cent living in countries with less promising prospects.

Until now, the least prosperous countries have made up a rather small proportion of the world population. In later years, their share has been growing. By 2050, they will make up the whole of the bottom 20 per cent. Thus it is very likely that previous trends in the 20/20 ratio will change, and that the next decades will see a worsening of the ratio, no matter whether economy is measured by USD or another economic unit, e.g. PPP dollars (PPP = Purchasing Power Parity).

A COMMENTARY ON LOMBORG'S SECTIONS ON POPULATION GROWTH AND POVERTY

Throughout the better part of the 20th century, there has been widespread concern over the effects of rampant global population growth. Population growth has appeared as one of the biggest threats facing the future of humankind. Yet, in later years the media have broadcast news of an opposite trend, e.g. a feature in New York Times in 1997⁴¹ with downright manipulated figures, aimed at making experts appear to have been mistaken so far and

conveying the impression that things are going a lot better than the alarmists expected. One environmental proponent to be criticized on that occasion was Paul Ehrlich.

Lomborg, too, throws a blow at Paul Ehrlich, blaming him for being overly pessimistic. Such critique is not justified, as is shown in Table 1 of this chapter.

That detail apart, Lomborg's account of population growth is more balanced than most other sections of his book. There are no particular grounds for criticising his data presentation in this respect. He could be blamed for introducing the concept of demographic transition without making use of it afterwards, and without relating it to developments in poverty. On p. 48 he says, '... Such images are real enough but are actually the result of poverty rather than population density. We shall discuss poverty below.' On p. 77 he says, 'We have previously looked into why sub-Saharan Africa has not been able to get into its stride, and again the explanation lies primarily with the political and ethnical struggle'. The citations are evidence that he fails to see the relationship between population growth and poverty. Lomborg has been confronted with this criticism in the Danish version of the present book, but the reply to this criticism⁴² reveals a complete lack of understanding of the fundamental point in the demographic transition. The reply states that population density in itself is of no concern, because we have no problems with the high density in e.g. Holland. He completely ignores my point that what is important is not the density in itself, but the rate of change in density.

Lomborg's presentations of data are not without flaws. Thus, I have compared his Figure 54 on rice yields in Japan and South Korea, based on data from USDA, with the data available from FAO⁴³. Relative to the FAO data, his curve for yields in Japan rises somewhat more steeply, and the rising trend becomes more prominent because the bottom part of the vertical axis has been omitted. In the FAO data, the yield curve for South Korea rises very steeply up to 1978, and rises no more after that. Lomborg's curve, on the other hand, shows a slightly more gradual increase, which would suggest to the reader that the increase might continue in the future – which is just the impression that Lomborg wants to give.

Lomborg writes (p. 6) that 38 % of the people in Africa were starving in 1970, but only 33 % in 1996, suggesting a decrease. However, this impression is obtained by combing two non-comparable data sets, as explained in the chapter on opinion formation. Actually, there has been no significant decrease.

As for Lomborg's mention of the AIDS epidemic, present developments have already caught up with his slightly over-optimistic picture. The now available UN data paint a slightly more negative picture than the 1999 data that Lomborg had access to. He mentions that the positive trend in life expectancy for Sub-Saharan Africa has come to a temporary halt due to the AIDS epidemic, yet has not suffered a direct backlash. This is no longer the case. Calculated on average for the whole of Sub-Saharan Africa, life expectancy has actually gone down from previously 50 years to 47-49 years now, and is expected to drop further. The beginning of a recovery cannot be expected until 2010-2015 at the earliest. His account of prospective trends up to the year 2050 suggest consi-

derable faith in an extremely positive development, with life expectancy surpassing 60 years in 2025. Probably one should not overestimate one's ability to predict how things will be going at this point. Twenty years ago no one had ever heard of AIDS. Today it is a pandemic. How, then, can we ever believe that we are able to predict the situation twenty years from now?

When it comes to his account of global poverty and injustice, Lomborg's presentation is not quite balanced. His argument, that there is a slightly downward trend for global inequality solely rests on the fact that he chooses to make up his figures in the PPP dollars instead of USD. Both pros and cons can be adduced to such calculation. If we choose to look at USD, inequality is on the increase, meaning that in terms of cross-border trade the situation has been further skewed to the detriment of the poorest countries.

Global economic development is a mix of both extremely positive and quite negative trends. My argument in the above chapter was that the best overview is provided by subdividing the global population into three groups of countries, representing the most prosperous 20 per cent, a large intermediate group of 70 per cent, and a small group of 10 per cent with relatively poor prospects. If the available data is analysed in a way allowing the trends in the 70 per cent group to dominate the picture, then we will actually end up with quite a positive picture of the situation. However, if we sort out the poorest 10 per cent to look at them separately, we can also find quite pessimistic assessments to be justified.

Let us take the situation in Somalia. In the year 2000, the population was 8.8 million. Birth rates were at 7.25 children per woman, and major decreases are not expected within the first few decades. The UN assumes that the population will have grown to over 40 million by 2050. Life expectancy is only c. 48 years. 38 per cent of the population is illiterate. No assessment of present GDP is available, yet there are figures indicating a slightly decreasing per capita wealth until 1990, and things have hardly improved since then. It is all well and good that the situation is improving for large population segments in China, India, and Brazil. Still, a presentation should not overemphasise that, so the situation in countries such as Somalia is completely overshadowed. It is important to stress just how diverse such developments are, a mixed bag of good and bad. And Lomborg does not – or not sufficiently so. His choice of citations is extremely selective. On p. 71 he cites a few very positive parts of a UN report⁴⁴, and then continues, 'The UN emphasises that this progress has been general ...'. But actually, the report does not emphasise that the said development has been of a general nature; contrarily it says that development was unevenly distributed. The report chose to reflect the complexities of real life by segmenting the text into sections on positive and negative aspects, respectively. If a person cites only from the positive sections, and then purport them to describe the overall picture, then he is guilty of gross distortion. Citing that selectively without reservation is not compatible with a position as an appointed scientist.

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- 40 The World Bank (2001): Annual environmental review 2001: Environment matters.
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- 42 U. Larsen (1999), pp. 63-66 in "Godhedens Pris" [A reply to the Danish version of the present book; edited on Lomborg's website].
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4. BIODIVERSITY

BIODIVERSITY IS MORE THAN EXTINCTION RATES

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Biodiversity – in a nature and environment context – is a very frequently used concept with positive connotations. If biodiversity declines something is amiss. Most of the time biodiversity is used in a less concise sense, rather denoting ‘as many plant and animal species as possible’, or it is used synonymously with ‘number of species’. This, too, is how Lomborg uses the concept in *The skeptical environmentalist*. In the real world biodiversity is a complex concept encompassing far more than just the number of species¹, namely also how animals and plants fare in nature.

Under the heading of ‘Biodiversity’ Lomborg addresses the issue of how many species become extinct on the global level. He concludes that the extinction rate is so negligible (0.7 per cent per 50 years) that there is no reason for us to worry. He considers it wholly unjustified for biologists and others to ‘bandy’ about species being threatened. The gloomy predictions have been proved not to hold water, so let us just sit back and relax. Incidentally, Lomborg feels that we could easily do with a few species less.

My question is whether a discussion only addressing the global extinction rate is really all that relevant. Thus, I do not propose to argue Lomborg’s figures on the extinction rate directly (for more details, comp. the section on species extinction), but will approach the biodiversity discourse in a more general vein. It is not immaterial how many species exist; yet, the global extinction rate is not a very apt expression of biodiversity. Extinction rate is a grossly oversimplified concept – it can only say something about species that have become extinct and nothing about the situation of all other species. Nor has the global extinction rate anything to tell us as to how animals and plants are thriving in individual continents or countries.

WHY PRESERVE SPECIES?

What indeed is the importance of the world’s species? And does it matter if the number of species declines? Lomborg applies an experiential argument, a medical argument, and a genetic argument, yet dismisses them all as being insufficient grounds for preserving the species. (p.250). He presents his three arguments in a very anthropocentric (human-centred) manner, that is, merely related to the use of those species for mankind. It is of course true that the species are very useful to us, and unlike Lomborg, I find that the proffered arguments in favour of species preservation are excellent. However, I also think that merely considering the possible utility value of biodiversity is a far too narrow perspective. I would augment the three mentioned arguments with another two arguments for preserving the world’s species, a biocentric (not human-centred) argument, and an ecosystem argument. Despite the fact that these arguments in favour of species preservation are frequently put forward, they are not dealt with in Lomborg’s book. Of course it is possible to adduce still more arguments. Thus, it is generally recognised that the species have an existence value and a heritage value. The existence value indicates that merely knowing that the species are there holds a value to us, no matter whether we personally experience them. The heritage value indicates that we wish to pass on biodiversity to posterity.

According to the *biocentric* argument – and unlike Lomborg’s human-centred argument – there must be room for the world’s species, no matter whether people can directly make use of them. Nature and the species have a value beyond the value that we attach to them. For myself I would advocate a moderately biocentric viewpoint, the essence of which is that we should also make room on Earth for other living organisms, yet without leaving people with no possibilities to change their environment, e.g. by cultivating land and controlling any plants and animals that inflict major harm to us, e.g. HIV viruses, malarial insects and other noxious creatures. But we simply cannot allow ourselves not to care if we wipe out some of the world’s species.

The *ecosystem* argument reflects humility in our dealings with nature. We do not know nature inside out, with all its species and processes, and we cannot definitively point out which species and processes are essential, and which are dispensable to the ecosystem. Often the ‘unspectacular’ species form a necessary part of an ecosystem, and are prerequisite in order for the ‘interesting’ species to prosper. If we spray away the insects, the partridges, nightingales and swallows will disappear, since depending on those insects for forage. That our knowledge of ecosystems is limited becomes obvious when we try to draw up models. Even with a fairly limited ecosystem such as a lake, it is quite difficult to piece together a model that, with a minimum of certainty, can predict the impacts of a planned intervention. There is an incredible number of factors interacting in countless ways. The unpredictability with which an ecosystem can respond also becomes blatantly obvious in those places where a foreign species has been introduced, unintentionally is left to take over, and becomes invasive. For instance, this happened with giant hogweed, which is spreading away across many Danish nature areas. Another example is the New Zealand flatworm, now threatening earthworm populations in several countries, including Great Britain. With such poor understanding of ecosystems, it would be too downright narrow-minded, if we were to only preserve the species known to be of direct utility value to mankind. Both because we would have to face the unpleasant consequences of upsetting the ecosystems too much, and because we should preserve the ecosystems and the species in their own right.

As mentioned Lomborg operates with three arguments for preserving the world’s species, all of which he dismisses:

Lomborg acknowledges the *experiential* value of species; however, in his view, this argument would only apply for large, exciting and spectacular species. For instance, he finds that the ‘millions of black beetles, flies and fungus spores’ that exist do not contribute any major experiential value (p.250). It is beyond doubt that nature and species have an experiential value for people, which is also a good reason for us to preserve the world’s species. Enjoying nature with its teeming life makes our own lives fuller. It is not to wonder that the larger animal and plant species draw the most attention. However, that does not mean that smaller, less conspicuous species such as beetles and fungi do not matter.

As for the experiential value of nature, we can distinguish between two types: an entertainment value and a ‘transformative value’. The entertainment value is about satisfying our need for diversion, in line with Tivoli, theme parks, football, etc. Here nature acts as the backdrop or setting of our adventure. By contrast, the essence of the transformative value is that, via our contact with nature, we gain access to experiences that both give us more insight and transform us personally. Our picture of the world, and of ourselves as part of the world, is broadened. If essential parts of nature disappear, e.g. a

whole group of species, we stand to miss the experiences and insights that we no longer have a chance to acquire. We will be losing vital opportunities for deeper insights. For instance, it is a very special experience to visit an area with water so clean that you can drink it directly out of a watercourse. Another great experience is to sit in a shelter one spring morning, watching the deer and the birds. Most nature experiences hold elements of both types of experiential value. Still, while nature's entertainment value could be interchangeable with entertainment's, other types of experience cannot replace its transformative value.

The basis of the *medical* argument is that we do not know the inherent medicinal potentials of utilising species that are yet to be studied. Thus, by wiping out species, we are also depriving ourselves of yet unexplored medicinal uses, e.g. remedies derived from various plant species. We do not know the range of options the species can offer. Ergo we would not be wise to eradicate them. Lomborg refuses this argument, purporting that the value of the last species investigated is low, and that the number of species is so unfathomable that we will never get to analyse them all. So one more or less ... Of course we cannot be sure that investment in the preservation of all the world's species will pay off from a medico-economic viewpoint, instead of staking on other sectors within pharmaceutical research. If the medico-economic argument were our prime argument for preserving the world's species, we would have to calculate where our investments would yield the best returns. But then, are we able to value e.g. an anti-AIDS drug in a credible manner? Still, the medical argument is merely a supplement to the other and more significant arguments for preserving the world's species.

In Lomborg's version, the *genetic* argument is not an argument in favour of preserving all species, but exclusively an argument for preserving our culture plants. Essentially, his argument is that among the individual species of cultivated plants we should preserve stocks of great genetic diversity. However, we should also preserve the wild relatives of culture plants in order to secure genetic material, such that in the future we can add new properties to cultured plants by interbreeding them with their wild relatives. The fact is that genetic variation within each species results in greater adaptability and enhances its survival potential. In Lomborg's view, this need can easily be met by setting up gene libraries for culture plants. But gene libraries will not do. First because not all species are particularly suited for gene libraries. Second because there is no way for us to know if we have included all we need in those gene libraries. Third because genetic variation is not only important in cultured plants. It is vital for all species, both animals and plants, domesticated and wild alike. Setting up gene libraries for each and every of the world's plants and animals would clearly be unrealistic, so we may just as well preserve the species. Genetic variation is also biodiversity, only at gene level instead of species level. If we are to let the 'genetic variation' argument apply, then it has to cover all species and not just plants in culture – and thus it is no longer an anthropocentric argument, but instead a biocentric argument based on humility towards nature.

INBREEDING AND GENETIC VARIATION

It is well-known that problems of inbreeding occur whenever the number of individuals in a population becomes too small. Inbreeding can directly affect the health condition of individual animals in the form of congenital diseases, malformations etc. This type of inbreeding is also familiar in domestic animals, e.g. in dogs where inbreeding causes malformed hip sockets in Alsatians, among others.

Such inherited diseases or malformations are often caused by recessive, disease-carry-

ing genes. In order for the disease to be expressed the gene has to be passed on from both parents, thus in duplicate. Obviously, that risk is greater whenever closely related individuals produce offspring. In a large population that risk would normally be small, meaning that very few individuals will carry doubles of the disease-provoking gene. In a small population, inbreeding may occur when closely related individuals produce progeny. As a result, more individuals will have doubles of the pathogenic gene, and thus have the disease. The greatest risk of inbreeding is found in small isolated populations where no interchange with individuals from other populations takes place. This can go to such an extreme that the remaining individuals suffer from all sorts of defects, and they may even become infertile and unable to reproduce. At that point, it is often too late in the day. Therefore, we have to prevent populations from declining to such low numbers of individuals that inbreeding becomes a problem.

Still other, rather more indirect effects occur if a population grows too small. A small population will not have near the genetic variation of a large population. There will not be nearly as many different variations of the same gene, which can become manifest as a lack of adaptability to changes in the environment. In large populations variations within the gene pool will normally ensure that some individuals have properties enabling them to adapt to changed conditions, at least so long as those changes are merely moderate. A large part of the population may die off with changing conditions, but there will still be individuals left that survive by virtue of their slightly superior adaptation to the new conditions. A small population, with little variation in their gene pool, would be far less likely to have individuals able to cope with the changes in their environment. As a result, the entire population will become extinct.

The lower critical limit to a viable population varies somewhat from species to species. 500 individuals is a good estimate if we only consider the direct health-related effects of inbreeding. However, if we also look at genetic variation in a more general way, considering the species' adaptability to environmental change, we would have to multiply the figure by 100 or perhaps even 1000. Still, small populations may well survive if only they are not isolated, so they are able to swap individuals and genes with other populations.

Ever increasing distance between individual populations increase the risk of genetic isolation, that is, a risk of local inbreeding and poor adaptability to environmental change. Thus genetic variation is of essence globally, yet also at the local level within individual populations. IUCN (The World Conservation Union)² defines a viable population as follows: 'It has a large genetic variation, thus retaining its potentials of developmental adjustments, while its risk of extinction due to fluctuating population levels, changing ranges, disaster, and human exploitation is small.'

THE GLOBAL RATE OF EXTINCTION

A high rate of extinction is the most extreme manifestation of animals and plants in distress. It is too late once the extinction rate has gone too high, and species will perish forever. However, although the extinction rate is probably lower than the pessimistic estimates we have seen, that does not imply that we can just sit back and relax.

Calculating the global extinction rate is a tricky undertaking. For one thing, because it can be difficult to determine what is a species and to find out how many species exist. Furthermore, it is difficult to recognise if a species is extinct; comp. next section.

A focus on the extinction rate naturally amounts to an either-or: Either the species exists, and all is well, or the species is extinct, and all is lost. But as we know this is not how things work. A species will not pass from being numerous, with many viable populations, to being totally extinct shortly after. There is a long prelude prior to the extinction of a species. Typically, the process begins with a large population gradually depleting in numbers, because habitats disappear or their quality deteriorates. The species becomes increasingly scarce; it is found in fewer and fewer populations, which become increasingly isolated from each other – until finally the species dies out. The direct cause may be a dry summer, a cold winter, or another unusual weather situation. When people choose to describe biodiversity as reflected by the extinction rate, they take the most extreme situation and pay no attention to all more ‘ordinary’ situations where species do not thrive, yet do not go extinct.

To illustrate why species extinction at the global level makes a simplistic representation of how animals and plants are thriving – let us do the following intellectual experiment: Imagine that Denmark was laid waste, and all species vanished. Viewed at a global level a number of species would go down by number – some quite substantially. For instance, a number of birds depending on wetlands would decline. Yet, this would hardly be reflected in the global inventory of extinct species. The fact is that Denmark has few endemic species, i.e. species only found in Denmark and nowhere else. Thus, no species or only few species would be wiped out at the global level, even if all living organisms were to disappear from the surface of Denmark. The situation would be similar for several European countries, most of which have few endemic species. Nevertheless (to state the obvious) we would not feel it to be immaterial if all species found e.g. in Denmark or Great Britain were to disappear.

Thus, the global rate of extinction has nothing to say about all the animals and plants that have not become extinct yet, and tells us nothing about how those species thrive locally and regionally. To be sure, most species are found in the rainforest, but the species right here, where we live, in our countries, are also important to *us*. Nor does a total global extinction rate give away precisely which kinds of animals and plants disappear. Are they mainly rainforest species or marine animals? Or are they amphibians or birds of prey?

A DIVERSE NATURE

If, as Lomborg, we confine ourselves to talking about the number of species at a global level, we could basically settle for one zoo and one botanical garden in which all species of the world were present in suitable numbers – an advanced gene library, so to speak. But a zoo is not what we want. A major shortcoming of zoos and botanical gardens is that they can in no way offer the potential experiences found in a natural setting, where animals and plants exist in large viable populations. The experience of watching the lapwing over the meadow on a spring day is worlds apart from looking at birds inside an aviary of a zoo. Nor can a zoo and a botanical garden replace the ecosystems. Far from all birds and plants can thrive in such gardens.

So what *do* we want? The Biodiversity Convention understands biodiversity as follows: “Biological diversity (biodiversity) is understood as the diversity of living organisms in all environments, on land and in water, and the ecological interactions of which those organisms form part. Biodiversity encompasses the variation within and between species as well as the diversity of ecosystems.”³ Thus not a zoo, but a living nature.

Whether a species is rare or more common also has an impact on our chance to experience it. As a case in point, I would mention two Danish orchid species, pyramidal orchid and broad-leaved marsh orchid. Both species have large, impressive flowers and help to make a 'flower meadow' beautiful and fascinating. The fact that such lovely flowers exist in nature is an essential asset. Both species are associated with light-exposed, grazed, unfertilised and unsprayed areas. However, these nature types have declined, and therefore species native to such areas have gone down in numbers⁴, though not to the same extent for both species. The pyramidal orchid grows in commons with calcareous soil, while broad-leaved marsh orchid is found in freshwater wetlands. Both species are still found in Denmark. However, the pyramidal orchid is rare and only found in a single population at Møns Klint, on the island Møn in southeastern Denmark. The population has been ailing, but is now on the increase thanks to a regulation of landscape management at the site. By contrast, broad-leaved marsh orchid is fairly common in grazed meadows that are not being fertilised and sprayed. If we just look at the number of species, regardless of species prevalence, pyramidal orchid and broad-leaved marsh orchid have the same status. However, they fare very differently. In many places in this country we are able to enjoy the sight of the broad-leaved marsh orchid in late spring or early summer, while only few people know precisely where to go at Møns Klint in order to glimpse a pyramidal orchid. Thus, the fact that a species exists does not make the day. It also has to thrive. Otherwise, we will never get a chance to experience it.

Another case in point is the phenomenon known as 'Black Sun', which for instance can be seen in the marshes of southern Jutland and in Sleswig-Holstein in northern Germany. Here hundreds of starlings will gather and 'dance' in the evening sky for a few weeks before migrating south. Even as a second-hand experience, in a film, this is a moving and stunning sight. It takes enormous numbers of starlings to create a 'Black Sun'. If the starling were to go extinct, then the phenomenon would start losing its magic character long before the fact: With only 1000 starlings left 'Black Sun' would not make the same stunning experience, and something of essence would have been lost to us. Therefore, if we merely record whether the starling has gone extinct, we fail to allow for a phenomenon such as 'Black Sun'. A precondition for preserving 'Black Sun' to posterity is that large and viable starling populations are maintained. Starlings need nesting opportunities, foraging opportunities, good conditions at their winter sites, etc. Many conditions have to be met in order for such great numbers of starlings to be found in the marshes.

RED LISTS

The nature conservation discourse of our day is less and less inclined to use the extinction rate as the one measure of the state of plant and animal life. A rather recent approach to describing the state of animal and plant life is the so-called red list. Red lists were introduced by IUCN in the mid-1960s. Today international red lists are prepared, and in several countries national lists, too. The lists group the species, according to how endangered they are. International red lists operate with four categories:

- 1) Ex. Extinct.
- 2) E. Endangered. Species at risk of disappearing in the near future.
- 3) V. Vulnerable. Species expected to be acutely threatened in the near future.
- 4) R. Rare. Species in few or small populations, making them particularly sensitive to accidental events.

The red list focuses on the most well-known groups of plants and animals, and on ind-

igenous species. Some species found on the red list are on the border of their range, where they cannot be expected to form large viable populations. However, most species listed are on the list because their habitats have disappeared or have been destroyed, as in the case of the pyramidal orchid. By observing how many species are redlisted – among the animal and plant groups included on the list – we can have an indication of how animals and plants are thriving. At present approx. 30 per cent of the indigenous Danish species are comprised by the Danish red list.⁵

Obviously many of the objections that can be raised against making up the number of extinct species, also apply to red lists. There are problems defining what is a species, the total number of species is not known, and data on species distribution may be difficult to obtain. There are also considerable uncertainties with red list figures, yet they do provide a better picture of the state of plant and animal life than if we were just to consider the number of species that become extinct.

A major shortcoming of the red list, however, is that its focus is almost exclusively on rare species and does not include population trends for the more common ones. Yet, in some measure this also owes to the fact that we lack sufficiently detailed knowledge of the more common species. Actually we should take a far broader view than is done with the present red lists. For instance, in aesthetical and recreational terms, it is more interesting to look at biotopes and landscapes than at species. Nature conservation is far more comprehensive than species preservation.

MAKING AN EFFORT FOR ENDANGERED SPECIES MAKES A DIFFERENCE

When we see an upward trend for some of the species this is often because a targeted effort has been made to create new habitats. In several cases, we can see that alerting and launching a rescue plan did make a difference, and more so if the aim of the rescue plan was to recreate habitats.

Amphibians are among the species that have been hit the hardest by agro-industrialization and the demolition of water holes. In addition, nutrients leached from fields to waterholes (eutrophication) have had adverse impacts on populations. Amphibians are completely dependent on good breeding ponds with clean water, that is suitable environments for tadpoles. But in addition, they also depend on access to good habitats for fully-grown individuals near their breeding ponds.

A good case story demonstrating that it does help to alert and at the same time intervene is the story of the European tree frog in Bornholm, a Danish island of km² 588 in the Baltic. As everywhere in northwestern Europe, the water holes in Bornholm had seen a heavy decline. They were fewer and fewer, and the quality of the remaining ponds deteriorated. In the 1950s, there were European tree frogs living in more than 1000 water holes in the island, but from then on and until the early 1990s the population shrank, and in 1991 dived to a low, at around 76 water holes with European tree frogs. By then, however, the plight of the European tree frog attracted attention, and Bornholm County authority had launched a rescue plan. The main focus of the plan was to dredge existing water holes. Following the positive outcomes from the first water holes, the work was organized more systematically. With a minimum of red tape, a maximum of water holes were dredged and dug out – over a period of years a total of some 600 water holes. There was nothing like an instant success, yet after some years the trend reversed, and the number of waterholes with European tree frogs in Bornholm is on the increase. At present, their number is on a par with the late 1960s. The curve in Figure 1 shows their progress.

Number of water holes with tree frogs on Bornholm

Number of water holes

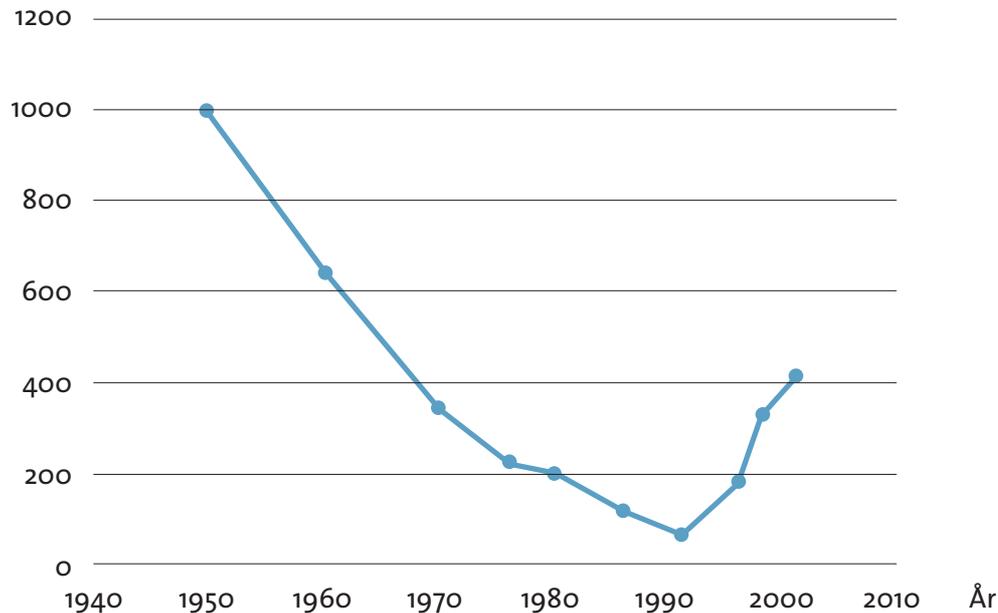


Figure 1. Progress in the number of water holes in Bornholm, in which European tree frogs can be heard. Water holes with a single stray frog are left out. 1950-1980 figures are based on older data and calculations of rate of regression.⁶

Thus, the gloomy predictions of biologists proved to be mistaken. The regression of European tree frogs in Bornholm did not continue, and the frog did not disappear. However, what caused the present increase of the European tree frog population was just precisely the pessimistic forecast that made people feel compelled to intervene in the first place. What would have happened if biologists and others had just sat back and said, 'Oh, they will manage alright.'? The heavy decline of the green frog would certainly have continued, and a fair estimate is that by 1998 there would have been about 40 European tree frog-waterholes left, and in the longer term, the European tree frog would have disappeared from Bornholm altogether. The fact that the European tree frog was saved in Bornholm definitely does not serve as an argument that 'those red-listed species are not all that threatened after all, and they will manage somehow'. In the case of the European tree frog the effort was launched before it was too late. The European tree frog had not yet disappeared, but was acutely threatened.

Thus one of the reasons why the worst scenarios of the 1970s did not come true is that we have made an effort to preserve some of the animals' habitats, and that we tried to remedy some of the problems endangering rare animal and plant species. The key point here is timely intervention, thus preventing the costly emergency actions that have to be launched when species are on the point of extinction. They are not particularly effective, and expensive at that.

CONCLUSION

There is a host of reasons why we should preserve the world's species. First and fore-

most, the species have a right to be there, and we need to show humility towards nature and the ecosystems. Moreover, there is the experiential argument, the medical argument, and the genetic argument. If we want to learn how animals and plants fare, then the extinction rate or the number of species alone is no good measure. People do not just want to look at animals and plants in zoos and botanical gardens. We want to be able to experience many different plant and animal species in large viable populations – both in Denmark and in all countries of the world. Therefore, we need to continue our efforts for the endangered species and for the more common animals and plants as well. It does make a difference. Here the red list is one of the tools available when we are to qualify what should be the targets of our first efforts.

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- 6 Source: Fog (1988): *Løvfrøer – og andre padder på Bornholm*. 79 pp. Bornholms amtsråd, Teknisk Forvaltning. suppleret med data fra J. Chr. Olsen & Gitte Jensen (1991) samt Finn Hansen (1996-2001). [European tree frogs - and other amphibians in Bornholm.]

HOW MANY SPECIES GO EXTINCT ?

By Kåre Fog
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We do not know the number of species of animals and plants living on this planet. And even the number described and named by scientists so far is not known precisely. Estimates range from 1.4 million to 1.8 million.¹ Out of these, some 300,000 are green plants (40,000 algae, 260,000 higher plant species) and approx. 80,000 are viruses, bacteria, and fungi. The rest, over a million species, are animals. The number of described insect species is estimated at at least 900,000 (about 60 per cent of all species on record), and this number increases by around 7,000 a year.

A more precise assessment of the number of described species has now become possible, since a central link for databases, *Global Biodiversity Information Facility*² has recently (Dec. 2000) been set up. Establishing such a database is a costly undertaking. By now, 21 countries take part, and they pay up to USD 700,000 a year. Expectations are that a global overview of the number of described species will be established within a few decades. Thus, if anyone intends to request biologists to produce reasonably precise figures on the number of species, then meeting such a demand will involve extremely high economic costs.

Birds are the only group of organisms studied so extensively that practically all species are known; less than 10 new bird species are described each year. Our knowledge of mammals and plants is somewhat less complete. Most groups have been investigated far more sporadically. For instance, it is assumed that so far only around 60 per cent of all species of freshwater fish in South America have been described.³ Presumably, a large number of species is yet to be described, especially for groups such as bacteria, fungi, nematodes, mites, and insects.

The number of species found in tropical rainforests is huge. E.g., in more recent years, researchers have begun to study insects by spraying entire trees with insecticide; some of the dead insects will then drop to the ground where they can be collected. By spraying small volumes of canopy (a little more than 10 by 10 by 10 metres) it is possible to obtain somewhere between 1,000 and 3,000 beetle species per sample.⁴ Similar numbers of bug species (heteropterans) can be found. Among the species collected in this fashion most are previously unknown to science. Out of a bug sample more than 60 per cent were previously unknown, and some beetle samples had as many as 80 per cent unknown species.⁵

Based on such figures we can try to compute the total number of insect species in the Tropics. Depending on assumptions made results will range from 2 to 100 million species. A reasonable estimate for the most likely number would be around 10 million species, however still an extremely uncertain figure.⁶

Part of the hitch is that it does not suffice to know how many species can occur in a single location. We also have to know to which extent species are replaced by others when we move on to neighbouring locations. Unfortunately very little is known about this. To all appearances small animal species, e.g. spiders are superseded at shorter distances than do bigger animal species such as birds. It also appears that if sticking to precisely the same type of vegetation, you are still able to re-find the same species

across larger distances, while as many as 97 per cent may have been replaced if for instance, in a slightly inclining highland, you move off 100 km to a spot that lies 400 metres higher up.⁷

If we were indeed to specify how many species exist, then we would have to provide more precise data showing at how short distances species are being replaced in tropical rainforests, and in principle we would need that kind of data for all plant and animal groups. In-detail plans for conducting such exhaustive studies have already been prepared (All Taxa Biodiversity Inventory – ATBI), especially for an area of approx. 100,000 hectares in Costa Rica.⁸ More than 200,000 animal species are expected to be found within that area, or what amounts to 10 per cent of the total number of animal species known today globally. However, the cost of such a study would be at least USD 90 million, an amount that has proved impossible to raise. So we cannot count on ever getting such knowledge. All estimates for the total number of species worldwide will necessarily remain quite uncertain.

This leads to the conclusion that while the world's number of plant species is only 'rather' uncertain the number of animal species is extremely uncertain. We cannot even indicate an order of magnitude with any kind of certitude. Especially we should note – since the number of insect species in the tropical rainforests is that uncertain (estimates vary from 2 to 100 million) – that the estimate of how many species go extinct due to rainforest clearing is bound to be equally uncertain. Thus, at the present time, talking about how many per cent of the species are lost is a pretty futile undertaking.

SPECIES EXTINCTION BEFORE MAN

For those types of organisms that are easily identifiable as fossils we can extrapolate how fast species went extinct in prehistoric times, before man. This goes for big animals (larger mammals), for animals with shells (snails, clams, squids), and for certain microscopic organisms (foraminifers, diatoms).

For marine invertebrates estimates are that average species survival was 4 million years, while larger mammal species on average lived for a million years.⁹ However, these figures should be taken with some reservations. First because there is a general tendency for large species to go extinct more quickly than do small species. Second, because species found as fossils are normally those that were widely distributed and common in the past. We do not have nearly the number of fossils of species that used to be infrequent and have a narrow range. This implies that the average extinction rate for all species, common and rare under one heading, could have been somewhat higher than suggested by the above figures, so our knowledge of actual extinction rates is rather imprecise.¹⁰

If we allow for the above reservations, we can generally assume the extinction rate of prehistoric marine invertebrates to have been approx 0.1 per cent per 1,000 years, and somewhat higher for mammals and birds. If such 'natural background rates' were still to apply today, then we would expect for mammals 1-2 extinct species per century, and for birds 2-5 species.

SPECIES EXTINCTION IN PREHISTORIC TIMES

By all appearances, several animal species were eradicated by man already in prehistoric times. In all continents save Africa, the majority of bigger mammals has gone extinct under circumstances indicating that man was the likely cause. In Europe extinct species

included woolly mammoth, straight-tusked elephant, woolly rhinoceros, several species of the rhinoceros genus *Dicerorhinus*, steppe bison, giant deer, sabretooth cats and the cave bear, in addition to extinct subspecies of animals that have survived elsewhere: lion, spotted hyena and dhole.¹¹ Mass extinction of bigger species happened in Australia in the years after 50,000 B.C., and in North America in the years after 11,000 B.C. In both cases extinction coincide with the arrival of man.¹² Circumstances appear to be the same in South America.¹³

So far, studies of fossil birds in the Polynesian islands have not been able to demonstrate that a single bird species went extinct here before the arrival of man. But in the period 1,000-4,000 years ago, when humans came to the islands, many species went extinct. Since each island has had its own species, it is believed that as many as 2,000 bird species were eradicated on the arrival of man, or what amounts to about 15 per cent of all the world's bird species at that time.¹⁴

After man's arrival to Madagascar c. 500 A.D. seven species of elephant birds (ratites) went extinct here – the biggest birds ever. Moreover, close to 20 other bird species went extinct here. Furthermore, two giant tortoise species, 14 prosimian species (mainly rather big species), and the pygmy hippopotamus were lost.¹⁵ We have similar data for e.g. New Zealand and Hawaii. After the Polynesians colonized Hawaii around 400 A.D. around 50 of the original approx. 100 landbird species went extinct. When discussing man's influence on species extinction we thus have to keep in mind that probably mankind eradicated numerous species already in prehistoric times.

SPECIES EXTINCTION IN HISTORIC TIMES

The eradication process has continued in historic times. Among European examples that come to mind are the wild populations of the aurochs, the wild horse (tarpan) and the European bison. Also small mammal species perished, such as Sardinian pika, *Prolagus sardus*, found in Corsica and Sardinia.

At regular intervals IUCN, the World Conservation Union, publishes lists of the world's extinct and threatened animal and plant species. These lists go back to around year 1600, though available data on eradication in the 1600s and 1700s are hardly as precise as those from e.g. the 1800s. Table 1 summarizes how many species have been declared totally extinct until this day. Some are species that hardly anyone would worry about, e.g. special small snail species from isolated islands in the Pacific. However, some species now extinct could have been significant to mankind. For instance, the extinct plant species include a coffee species, a corn species, and five tulip species.

Table 1. Number of species declared extinct.

Group	Global number of species	A. Extinct by 1947 ^{a)}	B. Extinct by now ^{b)}	C. Extinct (Lomborg) ^{c)}
Mammals	4,000	50	88	83
Birds	9,000	95	108	103
Reptiles	6,300	19	21	21
Amphibians	5,000	1	5	5
Fish	19,100	13	93	82
Molluscs ^{d)}	80,000	177	237	235
Insects and other arthropods ^{e)}	> 1.2 million	58	83	107
Other animals	60,000	0	4	-
Plants	260,000	380 ^{f)}	751 ^{g)}	384 ^{h)}
Total	>1.6million	793	1.390	1.033

Notes: a) For animals based on Groombridge (1992), comp. reference 1. b) Includes species only surviving in captivity and species extinct after 1947 according to IUCN; for animals based on ¹⁶. c) Number of species listed as extinct according to Bjørn Lomborg (2001): *The skeptical environmentalist*. d) Only species extinct since the mid-1800s and after. e) The data are practically all from Hawaii and North America. f) IUCN Red List¹⁷, Category Ex. g) IUCN Red List, Categories Ex and Ex/E. Include 'presumed extinct' species. h) Including varieties and sub-species.

When interpreting these data one should keep in mind that a variety of criteria are used to determine the threshold when a species can be considered extinct. In 1979, IUCN decided that in the main a given species can be declared extinct only if searched for in vain for 50 years. In 1994, IUCN once more changed its criteria so the rule of futile search for 50 years was eased. Now species easy to locate may well be declared extinct after less than 50 years. However, when it comes to species that are hard to locate, the 50-year rule still applies as a guideline.

Column A in Table 1 is an attempt to tally the number of species that, by 1997, had been extinct for at least 50 years (since 1947). If we were to compute the rate at which species are lost, these figures should have been used to extrapolate the extinction rate for the period of 1600 to 1947. Column B is the number of extinct species according to the most recent IUCN lists. For organisms relatively easy to locate the figures include species that went extinct less than 50 years ago, while for other organisms (e.g. reptiles), which are often difficult to locate, many species are merely on the 'candidates' list, only to be declared extinct at a later time. Thus, column B does not indicate the total number of species extinct until now, but only species 'rubber-stamped' as extinct. Thus, column B cannot directly be used to compute how fast species are lost. For comparison column C, the last column in the table, shows the number of species extinct since 1600 according to Bjørn Lomborg's book.¹⁸

ESTABLISHED EXTINCTION RATES

The figures in Table 1 should not be taken at face value. Still – as sort of a calculation exercise that does not necessarily reflect reality – let us try some arithmetic on the figures. We can do that by imagining that the difference between Column A and

Column B shows the number of species gone extinct over the past 50 years. This can be done rather reasonably for the groups of mammals, fish, molluscs and plants, though clearly not for e.g. reptiles. We then get the figures indicated in Table 2.

Table 2. Calculated extinction rates over the past 50 years, and for comparison the assumed natural extinction rate (background rate).

	Extinct 1947-1997	% extinct per century	Background rate ¹⁹
Mammals	38	2%	0.04%
Fish	80	0.8%	0.01%
Molluscs	60	0.2%	0.01%
Plants	371	0.3%	< 0.01%

If the figures in the table were correct, then the present extinction rate for the different groups would be at 0.2-2 per cent of a species per century. Obviously, this is several times the background rate. For plants, the natural rate of extinction is taken to be considerably lower than for animals, so here the established extinction rate appears to be at least 100 times the natural rate.

However, as already indicated, the figures in Table 2 have little to do with reality. In the case of fish, 80 extinct species are on record for the past 50 years, mainly in North America and in Lake Victoria. Yet our knowledge of extinct fish elsewhere (e.g. in Malaysia) is so sporadic that data from such regions are left out.

The 'official' extinction figures are most certainly much too low, which is also supported by other circumstances. For instance, the aggregate list of extinct animals (Column B, Table 1) has 92 North American species, yet only 8 South American species. This, of course, does not mean that practically all animal species of South America have survived. It merely implies that South America is way more poorly investigated than is North America. Moreover it does seem rather striking that about 0.3 per cent of the world's molluscs have been declared extinct (mostly snails with easily recognizable shells), while as little as approx. 0.07 per cent of the world's known insect species have been pronounced extinct; that must owe to the fact that insects are more difficult to study. So in point of fact, the figures of the table are not any good for practical purposes.

The question is now: Is it possible to estimate by how much Table 1 underrates the number of extinct species? I will illustrate the issue using amphibians as an example.

AMPHIBIANS – AN EXAMPLE

Based on Table 1 we could have the impression that the animal group with the least extinct species so far is the amphibians. This starkly contrasts with the fact that in later years biologists all over the world have raised great concern over the apparent rapid decline of precisely the amphibians. In 1990, this concern gave rise to a working committee under IUCN, named Declining Amphibian Populations Task Force (DAPTF). Since then DAPTF working committees have been set up all over the world and information from these is co-ordinated by a head office. News is brought in a newsletter published several times a year. Thus, specialists in different parts of the world are now able to share their experience.

The author is a Danish DAPTF representative and has thus been able to keep track of the efforts to record and conserve amphibians all over the world.

WHAT IS THE MEANING OF 'EXTINCT'?

Is it true that only five amphibian species have become extinct so far? In answering, the first problem is: How is the word 'extinct' to be understood? How do we decide which species we want to count in when calculating the number of species gone extinct within less than 50 years? The most recent endangered amphibians inventory from Australia, a comparatively well-surveyed country, reports different frog species as follows:

- First species: *'Endangered. The species has undergone a massive and rapid range contraction with only one adult encountered in the wild since February 1994, despite intensive surveys across the range of the species.'* This species clearly cannot be pronounced extinct as yet, although it actually could be at the time of writing.
- Second species: *'Endangered. An extensive survey in 1991-92 and 1993 failed to locate any individuals.'* Well, well, well ... What is one supposed to think of that species? It has been thoroughly searched for, though in vain. However, is it not possible that biologists were just not shrewd enough to locate it?
- Third species: *'Endangered. The species has not been located since 1979. Previously it was an abundant diurnal species and conspicuous within its geographic range. It is not known whether this species persists anywhere within its former range. Current information indicates that it does not. Regular searches have been conducted unsuccessfully up to December 1995.'* Thus, the said species has been subject to systematic, yet fruitless searches for 16 years, and there is every indication that it is indeed extinct. But experience has shown us that just issuing a 'death certificate' will not do; there is still a very real possibility that an overlooked population could emerge somewhere in the rainforest. Only in 2029, when 50 years have passed, can it eventually be declared extinct. For the time being, we have to think of another description, e.g. 'possibly extinct' or 'can no longer be found'.

I would like to offer a Scandinavian case story, in order to illustrate how difficult it is to ascertain that a species no longer exists in a given area. In 1996, it was found out that a small location in southernmost Norway has a population of the pool frog, *Rana lessonae*. This caused the number of known amphibian species in Norway to increase from five to six. The said species calls quite loudly, so it is audible at quite some distance, unlike the five other species found in Norway. Apparently, these animals are the last survivors of a population that lived in this country for millennia. All the same, it was not until 1996 that biologists realised it was there. My point is: When a species thus easy to spot can go unnoticed in Norway, a thoroughly surveyed and civilised country, how can we ever be absolutely certain that there is not – somewhere in the rainforest of Queensland, Australia – a small surviving population of one of the species mentioned? In reality we have to say that as long as there is any rainforest left in that part of Australia, there is still a hypothetical chance that one of these 'extinct' species is suddenly re-found.

Indeed, in real life, it is impossible to issue a certain death certificate for an amphibian species in a tropical rainforest. Instead, we have to talk of species that are extinct with some degree of probability, thus making the required degree of probability a matter of subjective choice. In the following, I will rather indiscriminately mention the species for

which the probability of extinction is high, yet neither 100 nor 99 per cent. That is, species that in strict terms have not been proven extinct, but which ‘can no longer be found’.

Global overview of probably extinct amphibians

By consulting information from DAPTF and contacting several specialists around the world I have obtained knowledge about a number of species ‘no longer to be found’, comp. Table 3.

Table 3. Overview of amphibian (frog) species which can no longer be found and thus may be completely extinct.²⁰

Country	Number of species disappeared	Last seen, year
Australia	Nearing 9	1979 and later
Vietnam	Minimum 7	1982-1996
Israel	1	1955
South Africa	1-2	
USA (New Mexico)	1	c. 1960
Bermuda	1	1994
Puerto Rico	3	1974, 1981, 1990
Mexico	4	The 3: late 1990s
Honduras	2-3?	(Country poorly surveyed)
Costa Rica	1	1987
Venezuela	Minimum 3	1978, 1986, 1989
Ecuador	Minimum 8	1987
Peru	Minimum 2	1990s

Apart from the species listed in Table 2, some may also have disappeared from the Atlantic rainforest in eastern Brazil. However, since the country is vast and very few people search for these animals, our available knowledge does not permit us to say anything at all about frogs in this region.

Of course, the above bit of information is of a somewhat random nature. It is rather much of a coincidence that we have such information from Vietnam, Costa Rica, and Venezuela, while we do not from Thailand, Nicaragua, and Colombia. If more countries had been surveyed, there would likely be a higher figure of ‘disappeared’ species on record. The largest number of cases has been recorded for areas surveyed by biologists from the most industrialised countries (Australia, USA, Russia). In other words: The most cases of species no longer to be found were recorded for those parts of the Tropics that have been most thoroughly surveyed.

Summing up the said species we arrive at some 40 species that can no longer be found. Most could still be found until around 15 years ago. We have no idea how many will eventually turn up again some time in the future. But that apart, one should not from the official IUCN redbook get the impression that only the five species listed there have gone extinct.

ARE 'INTERESTING' SPECIES ALSO BECOMING EXTINCT?

In Lomborg's eyes, most of the species to become extinct are trivial little creep that no one would bother about anyway. Now, how is the situation with the amphibian species that go extinct? In a small area in the rainforest of Costa Rica, there was the golden toad, *Bufo periglenes*. It is counted amongst the most beautiful amphibians known to man. Many photographs exist of this beautiful creature, yet no living specimens can be conjured up any longer.

Two amphibian species of the rainforest in Queensland, Australia that appear to have vanished were the so-called *gastric brooding frogs*. What made them unique was that the female would place the fertilised eggs in her mouth and let the tadpoles hatch in her stomach. Once the tadpoles had evolved into little frogs, they were spat out through the mouth. These are the only amphibian species known to have this very peculiar brooding biology. Thus, some unique creatures have now apparently disappeared from Planet Earth – eloquent evidence to the effect that the most interesting species are not the ones to survive the longest.

CAN ALL SPECIES BE FOUND?

It does not make sense for someone to sit behind a desk in Denmark, requesting data on the precise number of extinct species. Whoever does so is clueless about the practical difficulties in providing such information. In order to illustrate the amount of time required to survey the amphibians found in a randomly selected piece of rainforest, I would like to mention a study conducted by William Duellman, biologist.²¹ He selected, rather randomly, a location in the westernmost part of the Amazon rainforest, in Ecuador. Around the village of Santa Cecilia, a plot of approx. km² 3 was painstakingly surveyed for amphibians and reptiles, and altogether 173 species were found, which is an unusually high number.

The intensive part of the study started in 1968, and surveys were continued for several years onwards. From the very minute the team of biologists had been 'unleashed' in the area it took them 200 man-hours of fieldwork to find half of the 173 species. Work continued over the following years, and after a total of 1,000 man days on location there were still more species to be found here and there. Undoubtedly the final result of 173 species is not the true total. Yet, it is assumed that around 95 per cent of the species have been found. Thus, if we feel that to be satisfied we have to find 95 per cent of all species in a given area, then this will require us to spend more than 1,000 man days per site, the equivalent of one man for three years, or three men for a full year.

Among the found species, 94 were amphibians, and the rest were reptiles. Out of the 94 species, 59 were already familiar from large parts of the Amazon country, while 15 species were completely new to science. This could suggest that whenever we survey a previously unknown area we will find a whole number of species not present elsewhere. This however proved to be mistaken. Since then, each and every of the 15 previously unknown species have indeed been found on other locations in the neighbouring countries.²² Thus, one may easily be too hasty in drawing conclusions concerning species distribution. Only by studying many locations as meticulously as Santa Cecilia could we have a picture of the number of species with a restricted distribution. At present, however, the general impression is that in the Amazons, all species are quite widely distributed.

When it comes to the mountain forests of South America things are entirely different.

According to the above survey of species no longer to be found at least eight Andean species in Ecuador have not been seen since 1987. When it is possible to claim that some of the species in the mountain forests of Ecuador have disappeared, this is because species up there generally have smaller ranges than in the Amazons. Admittedly the Amazons are heterogeneous, with numerous rivers as natural range delimiters; yet they are indeed also rather flat, uniform, and boundless. It would be impossible to know if a seemingly extinct species could after all be hiding somewhere in the rainforest. In the mountains, however, one can more readily know that a specific species is only found in one particular valley, and has never been seen in the neighbouring valleys. Thus, when it disappears from its single valley, it is certainly extinct. Therefore, one can safely assume that certain mountain species are extinct, while the same is impossible for lowland species.

EXTINCTION IS HARD TO DOCUMENT

A vital concept in relation to extinctions is endemic species. That a species is endemic to a specific area means that in the whole wide world it is only found in this one area. Isolated islands in particular have many endemic species (endemics), yet there are also many in tropical mountain forests that are separated from similar forests on other mountain peaks. The species most at risk for extinction due to destruction of their habitats are of course endemics only found e.g. in a single rainforest. If this one forest is cleared, they will become extinct.

Lomborg says (p. 255) 'One of the few examples of extinction appears in a paper by Gentry, who reported that 90 species [of plants] had become extinct when a ridge in the foothills of the Ecuadorian Andes had been cleared. The biologists often mention this story as a fine example of documented extinctions.' ... 'In two brief return visits six years later, Gentry refound at least 17 of the previously assumed lost species.' My comment is that numerous cases of plant extinction exist, comp. Table 1, and that Lomborg has to some extent misread his source.²³ The case here was that the foothills were totally cleared of forest. Gentry assumed that at least 38 and perhaps nearly 90 plant species of the forest were endemics, thus assuming that these had all been completely wiped out. Shortly after, he examined *other* mountain forests in the neighbourhood and did after all find some of the species there. So the problem consisted in knowing how wide/narrow was their geographical range. It is not possible to know how many of those near 90 species were actually endemic until after meticulously going over every single mountain ridge in the entire Andes chain, so neither can one make preliminary assumptions as to how many of the near 90 species went extinct. However, we cannot rule out that as many as approx. 70 species were indeed eradicated here.

This is a completely normal situation. Time and again, we find that although species have disappeared from their only known location thus far, they are subsequently found to exist elsewhere. In the Atlantic rainforest of Brazil a number of species (including birds and butterflies) only known from a single site were first presumed extinct, and were later refound in other locations, often far from where they were first found.²⁴ Even if we search in vain for a species e.g. within a radius of 50 km from the first locality found, then it may very well turn up somewhere even farther away, maybe 500 km, comp. the pool frog mentioned above, which in 1996 was found in southern Norway, 5-600 km from its nearest known habitat in northern Germany.

Examples of locations exist, also in the Andes, where survey teams of ornithologists have systematically recorded birds for say ten years, and nevertheless when another

specialist visits the same location using different survey methods it is found that several bird species have been overlooked.

In brief: It is practically impossible to prove that an organism has ceased to exist, and hence that a species has become extinct, even if this were indeed the case. In our day, experience has taught biologists to be quite reluctant when it comes to issuing 'death certificates', which is why even the most erudite specialists are extremely disinclined to make definite statements as to which species are extinct.

One of the world's endangered rainforests is the Atlantic rainforest of Brazil, which – unlike the Amazon rainforest – comprises a number of endemic plant and animal species with a narrow distribution range. Estimates are that by 1990 only some 12 per cent of the original rainforest was left. One would thus expect that a number of species had been wiped out, but there is no evidence to support such claim. Lomborg says (p. 255) that '... when members of the Brazilian Society of Zoology analysed all 171 known Atlantic forest animals, the group "could not find a *single known animal species which could be properly declared as extinct, in spite of the massive reduction in area and fragmentation of their habitat.*" ... Similarly, no species of plants was reported to have become extinct. The zoologists allege that "closer examination of the existing data ... supports the affirmation that little or no species extinction has yet occurred (though some may be in very fragile persistence) in the Atlantic forests. Indeed, an appreciable number of species considered extinct 20 years ago, including several birds and six butterflies, have been rediscovered more recently."

When I first read this part I visualised a survey team of international experts on their way through the jungle, busy recording and ticking off as they re-found one species after the other. However reading Lomborg's source²⁵ conveys quite a different impression. These were not extensive field surveys. This was a first attempt to write up a red list of endangered animals and plants in Brazil, by going over the sparing existing data. This red list only counted six animal species, which were listed as possibly extinct. In some cases a field survey had been done, targeting some of the species previously assumed extinct, during which species were refound, including several bird species and six butterfly species.

Once more, the hitch is that it is rarely possible to declare whether or not certain species of the Atlantic rain forests are extinct. For most species, their present status is largely unknown, so when working out red lists we have to confine ourselves to the few relatively familiar species. It goes without saying that usually such familiar species still exist. Those to become extinct will usually be among the poorly surveyed species for which our knowledge is practically nil, so they have never made it to the red lists at all. Moreover, many species are yet to be described by biologists. Altogether, for all animal species, hardly a handful of systematic surveys covering larger areas were carried out across the area in question (measuring 3,000 km from north to south). Such poor efforts make extinction hard to prove.

Yet, new data have become available in later years. The 1989 Brazil red list referenced by Lomborg only had one frog species. Already now, and for one constituent state it includes 11 frog species in the category '*in a state of extinction*'. Also, other locations have several frog species for which no habitats are known at present.²⁶ From this part of Brazil, the most recent official IUCN world red list has several species that are completely extinct by now, namely the so-called mitu, a hen-like rainforest bird²⁷, a club moss spe-

cies, a bamboo species, and eight other plant species.²⁸ Several species have gone extinct in local areas. E.g. in the state of Rio de Janeiro six mammal species have not been sighted in the last 30 years.²⁹ In other words, the situation drawn up by Lomborg – that no species in the region have become extinct – no longer holds, and the more data we collect, the more species are considered to be at a critical low.

Thus, we clearly need better data. But what would that require? As an example let us imagine a frog species that has disappeared from a nature reserve in an East Brazilian rainforest. We set out to prove that it is probably totally extinct (which can never be ascertained). We randomly select some rain forest areas of km² 3 each, scattered across the entire Atlantic rainforest, such that their combined area makes up a sample of 1 per cent of the remaining rainforest (1 per cent is a very low target if we want results to be reliable, but now let's be modest). There is approx. km² 150,000 of rainforest, so we will need 500 sampling sites of km² 3 each. As already mentioned a survey of each field will require about 1,000 man-days of fieldwork, or three man-years. Altogether an input of c. 1,500 man-years is required to prove that one frog species has gone extinct. It is inconceivable that a grant will ever be given for such an effort, and for that one purpose. Thus, it is basically impossible to substantiate that a single frog species of the region has become extinct, even if that were indeed the case.

Lomborg cites a researcher stating that no species from the old, largely endemic fauna of the region can be considered extinct. Even at that time, this citation was somewhat flawed, since for most species we will never be able to consider them extinct, even if they actually are. It would have been more relevant for Lomborg to cite the same author³⁰ from the preceding paragraph of the same book page: 'First, it may well indicate that observed extinctions of the more conspicuous and better studied groups are a poor guide to the seriousness of the problems confronting us; and second, the gap between prediction and observation is a testimony to the need for much more scientific effort in this field.' or from the following page: 'The fact that they [the chapters of the book] do not wholly agree with one another or with other statements in the literature, should be seen as evidence of the need for more work, not as refutation of discordant statements.'

THE COST OF HARD PROOF

Some 75 years ago, on a particular mountain in Kenya, a particular frog species was found. Since then the habitat has greatly changed, and the species may have become extinct – but we do not know, for no one has surveyed the area for the past 75 years.

I asked a Dane familiar with the scene,³¹ what would be the cost of investigating if this species is extinct. The reply was that it would require a couple of weeks' survey or so, on site and in the rainy season. Including transportation etcetera the cost might be EUR 4,000. That kind of money would let us ascertain that the species still exists – if it does, that is. However, in case it was not to be found during that first visit, more surveys would be needed. In fact, if we were to 'prove' the species to be extinct, we would have to count on surveying the region in the rainy season several times at regular intervals right up until 50 years from now. Thus, the cost of proving that a species is extinct is many times greater than the cost of re-finding it alive after many years. Therefore, it is not to wonder that when browsing the available literature with Lomborg's eyes one will come across several cases of re-found species, yet few of the species proved to be extinct.

A Danish botanist is part of a plant survey team investigating Ecuador, including the mountain slopes facing the Pacific, where many endemic species are found. About eight years ago he visited a particular mountain ridge, the world's only known habitat of a specific palm species (*Geonoma tenuissima*). Most of the mountain ridge had been cleared, and all over the remaining tracts of forest chain saws were heard in action. It is possible that the palm has now disappeared from that location. I asked the botanist what it would require to provide proof that this palm species is now extinct. Hard pressed, he ventured to say that it could perhaps be ascertained by six months of fieldwork in the adjacent mountain areas, but that it could easily require a lot more time, or eventually be impossible. The cost of definite proof would thus, at the very least, be about EUR 25,000. And this, presumably, is close to the minimum cost of any proof that could be provided – it takes far more time to search for a tiny seed than for a palm.

SPECIES/AREA CURVES

Faced with such enormous problems in providing manifest documentation biologists have realized long ago that a more sensible route to follow would be to estimate the number of extinct species based on more general considerations. Some of the first estimates to appear some 25 years ago were based on arguments of the order: 'Given the fact that the rainforest is rich on species, it goes without saying that whenever a large piece of rainforest is cleared lots of species are bound to perish, no matter if we actually know them and have described them.' Some of those first estimates relied on extremely simple calculations and were as a matter of course exaggerated. This also goes for estimates made in 1979 by Norman Myers, environmental reporter, according to whom roughly 40,000 species would go extinct each year. Several biologists have criticised that regrettably, such estimates are still being cited in popular literature here and there, and one cannot object to Lomborg's support of such criticisms.

If we are to arrive at better-founded estimates we need to be discriminate about the so-called species/area curves used to compute them. Species/area curves have especially been used to demonstrate that the species count of animals or plants on small islands correlate rather narrowly with island area. If we plot species counts against area, then points will be placed along a bent curve, and the degree of curvature can be expressed by a figure which is the exponent of a so-called potency function.

Now, if instead of studying species on oceanic islands, we survey small 'fragments' of rainforest left in an 'ocean' of forest clearings, then we will find a similar correlation. Again, species count will rather closely follow a bent curve. Let us assume that we do a number of such surveys of forest fragments, based on which we conclude that the curve that most precisely follows the observed species counts equals a potency function with an exponent of 0.3. If that is the case, then implications are that each time the forest area is reduced to a tenth, the species count will be reduced to half (which can easily be computed with a pocket calculator). Then the following assumption lies near: If we clear a large area of rainforest, say nine-tenths of the entire Amazon forest, then we must expect that half of the forest species will go extinct. Based on such calculations quite a number of predictions have been made on the number of species to go extinct. To all appearances these predictions do not hold in real figures – for a number of reasons:

1. We cannot assume that the exponent used for the calculation will hold for areas much bigger than those used to derive the outline of the original curve.
2. We cannot take it for granted that there is really anything like a potency function,

- where a very broad spectrum of areas are being considered. What we have would be much more a function in which the exponent varies with area.
3. It may happen that the species/area curve is displaced when the forest is divided into fragments, so in reality the curve cannot be used for a reasonably precise prediction of species count after clearing. This has been found to be the case e.g. for frogs of the Amazon forest.³²
 4. Species counts depend on the geographical pattern. It makes a difference whether the remaining 10 per cent of rainforest is located as one big 'clump' in one corner of the area, or perhaps is scattered all across the area, as multiple small spots of forests. If there is a lot of small fragments, then we need to know whether those species that have gone extinct are the same in each forest fragment; this is to some extent the case³³, yet we lack more comprehensive knowledge about this.
 5. It is uncertain whether a forest area of a specific size can be 'saturated' with species. Where the Amazon forest is concerned we do know that it consisted of a number of discrete parts until 10,000-20,000 years ago. It is uncertain if the present coherent forest has already now been 'saturated' with a proportionally larger species count.

The species/area curve can change over time. When studying rainforest 'islets' in an 'ocean' of cleared forest, then these islets have just emerged, and we cannot assume that their species count has immediately fallen to a state of equilibrium. Presumably, some species still living in such forest fragments are in reality 'moribund', only they are yet to become extinct. Therefore our task is to predict how many species will either perish at once or be '*committed to go extinct*'.³⁴

Let us imagine a big rainforest where the vast majority of species are very widely distributed. For instance, we study an animal group comprising 100 species, all of which are widely distributed throughout the area. We then reduce the rainforest to a tenth of its original area. Initially all 100 species will still be found to exist within this reduced area. Yet, if the species/area curve applies, the number of species will gradually decline until there are 50 species left. Now the question is, how long will it take? If, after 50 years, we find that there still remain 70 species – would that be because the species/area curve has shifted to a more favourable level, or would it be because a number of the remaining species are 'committed to go extinct' in the longer term? It will be several years before we can have an answer.

Therefore, species/area curves cannot provide any realistic estimates as to how many species will become extinct if the area is reduced. There are far too many elements of uncertainty. Yet, the fact that such curves are useless in predicting what will happen does not imply that they are false. Some sort of species/area curve *will* apply, and the species count *will* decline when the area is reduced. Only it is impossible to say when and how much.

THE IMPORTANCE OF THE RESERVES

When a piece of rainforest is logged for timber it is essential to leave a small portion of the forest as small untouched remains, e.g. along the watercourses of the area. By sparing a mere 5 per cent of the forest nearly all of the species that do not tolerate forest clearing could temporarily survive here, and then return to the rest of the area once new trees grow up. There are other ways to carry out careful logging, so fewer species go extinct than otherwise; unfortunately, however, such consideration is rarely taken.³⁵

Globally the fragments of rainforest designated as nature reserves make up approx. 5

per cent of the rainforest areas.³⁶ By a rough estimate, based on an average species/area curve, one would then expect that those reserves would suffice for the long-term survival of about 40 per cent of all species (uncertainty interval: 20-90 per cent). In addition, there has been some success trying to locate reserves in regions known to have a remarkably high biodiversity or many endemics in particular. This helps to increase the number of protected species.

When listing the proportion of the bird species in various tropical countries that are found within their respective national parks and nature reserves, we often end up with extremely high percentages, around 90 per cent.³⁷ This is heartening information – since it suggests that doing something to protect the animal and plant life of the rain forest helps; thus there are reasons to believe that money spent for rain forest reserves is money well spent. Unfortunately, there is also evidence to the contrary:

First, reserves are not always situated where the most endemic species are found, not by a far cry. With the mentioned inventories, listing such large proportion of all species, we have to keep in mind that most of the species included are widely distributed and common species. If we also want them to include the better part of the rare species with a narrow range, then a lot more strategically situated locations have to be protected. Second, it is a sad fact that the areas with the most endemic species are often precisely the most populous ones, which makes many species hard to salvage.³⁸

Some reserves exist more on paper than outside, or there is little willingness to enforce reserve boundaries and keep out colonisers. E.g. in Ecuador enforcement is quite lacking for many reserves. Yasuni National Park in the Ecuadorian Amazons is at more than km² 9,000. All the same, large parts of the park and the adjoining Huaorani Indian Reserve have been zoned as oil concession areas, i.a. for the multinational companies OXY and YPF. They have constructed a road and various oil processing plants (including two refineries) across part of the park and the adjoining Indian reserve. Moreover, yet another oil-road through the national park is under construction. For the present, the oil crew is keeping most peasants out. But what is more, the state protection of the park is notoriously poor (one hardly ever comes across a state park warden there), and since it is well-known that road construction invariably attracts peasants who clear rainforest along the roads, we can only fear for the worst once the oil crews withdraw from the forest.³⁹

It does look nice on paper that so and so many per cent of all species are found in the protected areas. Yet, in practical terms, this is nothing like a warranty of species survival. Moreover, we have to allow for the fact that although nearly all species now exist within the protected areas the situation is not stable. According to the species/area curves, we have to expect that a number of species living within reserve boundaries at present will not be able to uphold viable populations on the longer term. They are 'committed to go extinct', as mentioned above. Once the reserve is left as a 'green stamp' surrounded by cleared forest, the number of species start declining. Several cases in point are already known.⁴⁰ E.g., there exists a statistic on butterfly populations that became extinct in English nature reserves, even though their habitats were actually protected there. Two species have become totally extinct in England, even though their last habitats were under protection.⁴¹

No theory exists that can describe how fast a species count will drop to a level that fits the size of the area.⁴² In some of the cases where frogs disappeared from rainforest

reserves⁴³, their disappearance was ascribed to e.g. disease epizootics or special weather episodes. Predicting if and when such events will occur is pretty near impossible.

When it comes to the big trees of the rain forest some are extremely long-lived.⁴⁴ For instance, a threatened species can persist as old trees in a reserve; but they do not propagate, so when they finally die off after 500 years or so, the species itself dies with them. Even if a species is 'committed to go extinct', it may take as many as 500 years for this to actually happen. The most recent statistic of extinct plants from 1997 is not to much avail in terms of clarifying this form of extinction.

Often extinction does not owe to a single factor, but instead to a combination of factors. E.g., there may be a combination of forest clearing and climate change. If the rainforest is carved up into discrete fragments that are protected as reserves, then many species are able to survive here in the first phase. However, if a climate change follows – possibly a manmade climate change – then the species cannot spread north or south to more favourable climatic regions, since they are now locked up in confined reserves. That is yet another way that species containment can make them far more susceptible to extinction than previously. This is not purely hypothetical: Natural climate changes happen all the time, and have greatly impinged on the distribution of rain forest species.⁴⁵ Now the entire dynamics by which the species were pushed back and forth, as conditions changed, will no longer exist. Some hold that the extremely high local wealth of tree species found in tropical rainforests results from a process, in which there is a constant local die-off of species, while others immigrate from adjacent areas. If that is the case, then species immigration from neighbouring areas to such isolated forest remains will no longer be possible, and the high species diversity of trees and associated insects will collapse in the end.⁴⁶

Here and now the establishment of reserves is highly important to species preservation, yet only in the sense that problems are staved off to a later time. We are then leaving it for posterity to solve the next problems that crop up – if they can be solved, that is.

A FEW EXTRAPOLATIONS OF EXTINCTION RATES

As we have seen it is largely impossible to provide reliable figures on the number of species that will presumably go extinct. Yet, in conclusion and to counter any incriminations of 'dodging the issue' I will present a few approximate calculations, well aware that they are mere calculating exercises with little relation to real life figures. Let us skip all reservations and try using species/area curves to provide a total estimate of the number of moribund species in the rainforests, that is both forests with many endemics and forests with few endemics, all under one heading. Table 4 gives a few computation results.

Table 4. Examples of computed overall extinction rates for all tropical forests, based on species/area curves, under different assumptions. For more detail, comp. text. Moribund = committed to go extinct.

Ex. no.	Rate of deforestation	Exponent	% mori-bund/ year	Species total	Moribund/ year
1	0,45%/year	0,15	0.07%	2million	1,400
2	0,8%/year	0,35	0.28%	10million	28,000
3	80%/100years	0,35	0.43%	10million	43,000

The first example in Table 4 uses figures yielding a relatively low estimate. It is assumed that approx. 0.45 per cent of all rainforest is cleared each year, and that the exponent of our potency function is 0.15. We then find that 0.07 per cent of all species would be 'committed to go extinct' each year. 'Moribund' implies that they do not necessarily die off immediately, but that they are 'committed to go extinct'. The figure of 0.07 per cent annually for *moribund* species is 3- to 40-fold greater than figures for *documented* extinction, which is often at 0.2–2 per cent per century, as shown in Table 2. Assuming that 2 million species exist in the tropical forests, this would amount to 1,400 moribund species a year.

By contrast, the figures used in the second example of Table 2 yield a fairly high estimate, though they are still realistic. Here we find that 0.28 per cent of all species are declared moribund each year. Assuming that the rain forests have 10 million animal species, this would amount to 28,000 moribund species annually.

Next, let us assume a continuing rate of rainforest clearing over the next century. That would imply that in a hundred years 80 per cent of the rainforest would be cleared (example 3 of the table). Following the same species/area curve approx. 43 per cent of all rainforest species would then be moribund, or on average 0.43 per cent a year, computed for the entire period. The reason why this figure is higher than the one computed in example 2 is of course that the process will accelerate. At an evenly progressing rate of rainforest clearing the species will go moribund at an ever-faster rate – and finally, when there is just a little rainforest left, even at a furious rate. However, as already mentioned, the moribund species will not die off at once, so we cannot say how long they will take to go completely extinct. Not that it really matters, either, knowing they *are* moribund.

If we consider rainforest clearing as an unrelenting, evenly progressive process, then the process will – each year, for the next 100 years – cause 0.43 per cent of (possibly) 10 million species to become moribund, that is 43,000 species annually. By this way of thinking, we arrive at a figure close to Norman Myers' much-disputed figure of 40,000 species a year. Only we have to specify that our figure indicates moribund species, rather than those dying off immediately.

However, such figures are fraught with immense uncertainty. As we have seen already estimates on the number of species to go moribund each year range from 1,400 to 28,000. Setting a definite figure does not make sense with an uncertainty of such order. Norman Myers' figure of 40,000 species a year was a very rough estimate; few biologists are prepared to set the number of vanishing species all that high. Still, while the figure may be too high, as demonstrated above, it is not wildly exaggerated compared to some realistic estimates. If species extinction proves to be an accelerating process, Norman Myers may very well be proved right in a hundred years or so.

COMMENTARY ON LOMBORG'S BIODIVERSITY CHAPTER

Lomborg's biodiversity chapter is difficult to comment upon since it relates in large part to particular persons, referring to whatever various organisations and biologists said on this or that. He practically only cites extremely optimistic and extremely pessimistic individuals, thus misrepresenting the extent of disagreement. Only partially does his chapter deal with the essence of the matter, namely: What do we know of species extinction?

As for this issue, he first brings a table (Table 6, p. 250) with an overview of the number of species officially declared extinct. Lomborg cautions that his figures are definitely lower than the number of species actually extinct. So far, all is well. But still he should also have added a few further comments to the table. Namely first that the estimates were made differently for the individual categories. For some groups, especially plants, he only indicates figures for species that have been extinct for at least 50 years. For other groups he also includes species that went extinct more recently. Second he should have noted that the insects figure practically only applies to North America. This was indicated by Lomborg's source, yet Lomborg fails to note the fact. This causes the number of extinct insects to appear ridiculously small in relation to the far higher current estimates that Lomborg criticises.

In the present chapter, and with amphibians as a showcase, I have argued that the number of species likely to have gone extinct until now is really much higher than the number of species officially declared to be extinct. (In the case of amphibians, the figure is approx. 10-fold greater, not including an unknown proportion of species, for which the status is totally unknown). Presumably, the situation is similar for fish. For instance, all the approx. 250 original cichlid species in Lake Victoria, Africa are endangered (because of the introduction of the Nile perch), although only 50 species have been declared extinct by now. During a survey of freshwater fish of the Malay Peninsula it was found that out of the 266 known species, 55 per cent were no longer to be found.⁴⁷ Yet, these presumably extinct species in Malaysia have not yet been entered to the official red list. Based on these data on fish and amphibians we must assume that also for other groups the number of species already extinct is at least an order of magnitude greater than conveyed by the official red lists.

Lomborg is perfectly aware that extinction is difficult to document, and that the number of extinct species has to be extrapolated by indirect methods. A major topic in his book is the question as to which calculation methods provide the most correct result. In this regard he puts considerable energy into slating one specific (very high) figure on the number of species to go extinct – namely Norman Myers' 40,000 species a year. It should be noted, however, that Myers did not claim this number of species to go extinct annually from now on. Rather, Myers calculated that this number of species might be doomed to extinction some time in the future as a result of the ongoing deforestation. As explained above, such a prediction is warranted, provided that the annual rate of deforestation is close to 0.8 % per year. However, Lomborg wrongly postulates that Myers' figures were merely an unsubstantiated guess, and he fails to recognize that whereas scientists like Myers and Lovejoy have calculated how many species are doomed to go extinct later, journalistic dramatization of their figures in WWF and elsewhere has subsequently given the impression that all these species were going extinct now. Thus, Lomborg does not distinguish between the scientific level of debate and the journalistic level of debate. Myers has actually defended his views in public and countered the criticism directed against him by Julian Simon, American economist and Lomborg's icon, explaining the rationale of his statements. If Lomborg had wished to be fair, he would have cited both parties in the Myers/Simon dispute, as expressed by both opponents in a book on their debate.⁴⁸

When Lomborg says that Myers' figures are not based on any concrete knowledge whatsoever, it is quite grotesque that Lomborg promotes a similarly unfounded figure, only a very low estimate instead of a very high one. For rather incomprehensible reasons Lomborg is bent on a figure saying that 0.7 per cent of all species will go

extinct over the next 50 years. He never gets around to explaining why the figure would be precisely 0.7, and not 0.5 or 0.9. Lomborg's source for that 0.7 per cent is an article by N.E. Stork, in a book published 1997.⁴⁹ Lomborg's reader has no direct access to checking this key calculation, since his list of references is lacking on precisely this count. Therefore, I had better submit his calculation basis here. Stork commences with the fact that England is one of the few countries to have conducted rather exhaustive insect fauna surveys. He then states that on the English red list of endangered species the proportion of threatened bird species is 4- to 10-fold greater than the proportion of threatened insects; the average of these two figures is a ratio of 7. He further states that actually, since the year 1600, the number of birds disappeared from the UK is 7 times the figure for insects. This lets him infer that on a global basis the extinction risk of a bird species could also be 7 times bigger than that of an insect species. So now, if we take the proportion of the world's bird species extinct since the year 1600 and until today, we can figure out how large a percentage of the world's insect species could have gone extinct until this day. Now, if we then take a look into the far future and assume that with progressive manmade effects on nature, the extinction rate would increase 12- to 55-fold within the next 300 years. Lomborg takes the average increase, approx. 33-fold, and uses it to calculate how large a proportion of the world's insect species will go extinct in the future. Since insect species make up the majority of all species, this also amounts to an estimate of the situation for all animal and plant species. Arrived at this final figure Lomborg practically takes it to be Truth incarnate – notwithstanding the fact that the calculation, as will be understood from the above, is extremely uncertain and hypothetical. In his own article, Stork said that, 'Whether the assumptions made ... match reality and whether it is possible to use models from the British fauna and flora to make global predictions is impossible to say...' So according to Lomborg's own source there is no saying if the calculation matches reality. Nonetheless this, and nothing else, is the calculation that Lomborg takes to be the veritable truth. In this case the notion of an extinction rate per decade at 0.208 per cent – a figure with three significant digits – is completely absurd. It runs counter to everything taught within the discipline with which Lomborg is employed – statistics. To the common reader, however, it comes across as being extremely technical and scientific, something to 'impress the crowd'.

Lomborg concludes from the above 'calculation' that the number of species to go extinct is negligible, so there is no reason to do anything about the matter. He ignores the steps actually taken to salvage threatened bird species. Many more would have become extinct, had this not been done. However, similar efforts are not made for all the world's threatened insect species, and for that very reason the above calculation is of no use.

We should add that in his article Stork (i.e. Lomborg's own source) cites 12 different estimates of global extinction rate, all of which are higher than Lomborg's figures. Lomborg leaves out these estimates. This is yet another case in point demonstrating that the key principle used by Lomborg, in his attempt to represent everything in the most positive light possible, is to simply be selective and leave out anything that does not fit in with his own picture of the situation.

Admittedly, compared to Lomborg's original book in Danish, Lomborg has now conceded that the extinction rate is way beyond the natural background rate, and that it is not 'trivial'. Yet, right after (on p. 256) he is quick to add that this probably is merely a transient situation, and once communities grow more prosperous they will have more

money to spend on setting up reserves, and then presumably the problem will blow away. This optimism on his part is rather unfounded. We could just as well or better argue to the contrary: Once species have been 'fenced in' inside reserves with no chances of dispersing from one reserve to the other, then any future climate change will cause many species to go extinct, being now unable to shift their range when the climate changes, as they used to do.

Lomborg brings several examples to illustrate that when a landscape is disturbed this results in far fewer extinctions than predicted by the biologists. However, all of these examples are distorted in ways that make them misleading. The examples dealing with plants in the Ecuadorian Andes and plants and animals in the Brazilian coastal rainforest (Lomborg p. 255) have already been commented upon. On p. 254, there are other distorted examples. Lomborg writes about bird extinctions in North America: "... the eastern forests were reduced over two centuries to fragments totalling just 1-2 percent of their original area, but nonetheless this resulted in the extinction of only one forest bird." First, this is completely wrong concerning the reduction of the forests; the correct percentage is close to 50 % reduction. The figure of 1-2 % concerns old-growth forest, but Lomborg forgets to specify this⁵⁰. Second, it is misleading because actually 4 species have gone extinct, and 2 are seriously wounded⁵¹. But Lomborg is a hairsplitter here. When he writes "forest bird", this means that he does not count those extinct species which were not strictly forest species, and when he writes "resulted in", this means that he excludes those cases where other factors, e.g. hunting, also contributed to the extinction. By using such very restrictive categories he is able to reach the very low figure of one extinction. But, right after this example, he mentions another example from Puerto Rico. Here, he talks about how many extra species of bird have colonized the island after the island was stripped of primary forest. But now, suddenly, he no longer restricts himself to forest birds. He conceals that the landscape changes resulted in the extinction of 7 *endemic* birds – i.e. the total world fauna was reduced by 7 species. The new species colonizing the island occurred elsewhere already and thus did not increase the number of species in the world, and they were not forest species. Considering that the forest area shrank to near 10 % of the area of the island only for a short period, the number of complete extinctions actually agrees with what would be predicted by the biologists' models.

Concluding on these examples, Lomborg manipulates by changing his categories from case to case according to what is favourable to him. In USA, he restricts himself strictly to forest birds. On Puerto Rico, he forgets all about such a restriction to forest species. In both cases, his deforestation figures refer to some kind of primary forest, which makes the percentage cleared extremely high. But when Norman Myers uses figures for clearance of primary forest, Lomborg compares them with lower figures dealing with clearance of primary and secondary forest, and writes on Myers' figures: "Today we know that these estimates [of deforestation] went way over the mark" (Lomborg p. 113). So here again he changes category – when he wants deforestation to look large, he uses figures for primary forest. When he wants deforestation to look small, he uses figures for all kinds of forest, and criticizes those who use figures for primary forest. And he forgets to specify what he is talking about in each case.

The present chapter has gone to some length to explain why, for many species, it is practically impossible to prove them extinct. I mentioned that proving the extinction of just one frog species of Brazil's coastal rainforest would require the input of approx. 1,500 man-years. In real life, it is inconceivable that we would ever commit such enor-

mous resources to such a purpose, which in turn implies that even if a frog has gone extinct here it would not be humanly possible to prove it. For most extinct species, the situation is that we will never be able to prove the fact.

We should consider Lomborg's ardent diatribe against biologists against this backdrop. For instance he says (pp. 254 and 256): 'There are many grants at stake.' ... 'In reality, of course, they are asking society for a blank check to prevent something which is claimed to be a catastrophe ... but which is not supported by data...' The reason why the problem 'is not supported by data' is that providing such data is too costly, and not – as inferred by Lomborg – that the whole show is a sheer delusion. He cites Myers' words, 'we have no way of knowing the actual extinction rate in the tropical forests...', and this is indeed a sober-minded description of our situation.

The situation in the Brazilian coastal rainforest aptly illustrates the dilemma. The citation abused by Lomborg is about the difficulties in formulating the first red list for the region: When it was made there were so few usable data at hand that zoologists 'could not find a single known animal species which could be properly declared as extinct', and that 'Similarly, no species of plants was reported to have become extinct.' Since then better surveys have become available, and now one bird species and 10 of plant species of the region have officially been declared extinct. Lomborg has been informed to the effect and has included this new information in his notes nos. 2066 and 2068. But certainly most of his readership is not going to see these notes, so he should have amended the main text. The text is downright misleading in its present form.

As mentioned, it is often hard to prove that an extinct species has indeed gone extinct. It mostly cannot be done without large grants, which is precisely why biologists have such trouble digging up precise data. Now let us assume that we really wished to provide better documentation. For instance, it is seen from Table 1 that if we could prove about 250 more plant species to have gone extinct, we would arrive at 1,000 extinct plant species out of the world's approx. 270,000 species. What would be the cost? Assuming that the average cost of proving one species extinct is EUR 33,000 this would amount to a good EUR 8,000,000.

If, as a biologist, one really had EUR 8,000,000 available, how could that kind of money be spent to maximum effect? If we used it to prove that some species are extinct, would that particularly impress the anti-environmentalists? Would one wish to spend that kind of money merely to provide documentation – in itself 'barren' knowledge that cannot be put to any use? No, one would try to strike some sort of balance between the necessary preliminary studies and the practical use of the money, e.g. for buying a piece of rainforest, or to pay park wardens, thus making already established national parks more effective. In other words: Satisfying the demand for documentation would appear absurd. Unfortunately it is possible that we will get such proof without stirring a finger, namely if the last remains of tropical forest along the Pacific coast of northern Ecuador is cleared. This could happen before long, and would cause more than 1,000 endemic plant species to go extinct.

Lomborg tries to discredit the grants given to conservation biologists. At the same time he ignores all the efforts to done to save threatened species – for several species enormous efforts are being put in – and he ignores the results obtained thereby. When criticized for this flaw, he replies that all he wants is that we should put the tasks in order of priority – it might turn out that it is better for us to use money for saving human

lives in hospitals than for saving threatened species⁵². Now, to provide the information necessary to set the order of priority, would cost much more than the costs of conservation. But in this case, suddenly, Lomborg does not want a wise use of the money. He creates a double-bind situation: He demands that no money be given to conservation purposes before extensive documentation on extinction rates are provided. And he demands that no money be given for providing such documentation. He demands wise use of money when this speaks against using money for conservation, but he rejects my argumentation for wise use of money when this speaks for putting money into conservation⁵³.

The main part of Lomborg's biodiversity chapter aims to discredit biologists. Apparently, his aim is to give biologists a bad name and thus stop the public from listening to them. In order to achieve his end he frequently resorts to citation-juggling. Most citations on pp. 254-255 are used out of context, so their sense is completely altered. His attack on Wilson and Ehrlich on p. 256 is completely unjustified. I will not go into further detail here, but such cases are dealt with in greater detail in chapter 11.

Lomborg more than hints that biologists are inflating the figures on extinct species in order to grab more grants for themselves. His argument is that biologists are not to get any further funds, until they are able to prove that there is indeed a problem (which then, they cannot). If such a conclusion were really to be drawn, what kind of implications would it have?

The consequence would be that less public funds would be allocated to documenting extinctions, and less money for saving endangered species. That in turn would generate an even greater need for funds from NGOs. These private organisations (WWF, Greenpeace etc. etc.) rely on appealing to private charity, meaning that they have to produce propaganda demonstrating a glaring need. The more need for money, the greater risk of excessive use of propaganda. Thus, if Lomborg and other anti-environmentalists were to obtain the support they vie for, then the result would be an even greater loss of species and more propagandistic environmentalist movements.

Lomborg's attempt to discredit a whole group of people lacks every reasonable justification. Suspecting biologists of being driven by mere pecuniary motives is monstrous, given the fact that many of those working to salvage endangered species are doing a great and selfless task, under difficult conditions and at a miserable pay.

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- 1 B. Groombridge (ed.) (1992): Global biodiversity. Status of the Earth's living resources. World Conservation monitoring Centre. Chapman & Hall. Chapter 2: Systematics and diversity.
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A FEW FIGURES ON THE WORLD'S FORESTS

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WHAT IS MEANT BY 'FOREST'?

If we wish to calculate how large landmasses are covered with forest globally we are faced with a problem – for what, in more precise terms, do we understand as forest? Presumably, we would not count a savannah with sparsely dispersed trees as a forest. Yet, how closely do trees have to stand before we are prepared to think of them as forest? Are we to include the maquis (spiny shrub) of the Mediterranean countries? Are we to include dwarf birch coppice in the border zone of northern coniferous forests? Is a plot of Christmas trees in Denmark to be counted as forest or cropland? Does a rubber plantation count as a forest? Can we rely on the data obtained from satellite images of tropical rainforest areas, or do they have to be supplemented with land surveys to ensure correct data? If all trees in an area are logged, how much time will we allow for a new forest to grow up, without indicating that the forest has been absent for a while?

It is obvious that if individual countries are using different forest definitions, then it is not possible to provide a meaningful inventory of the total global forest area. And if surveys done in the same area, yet at different points of time, have applied different forest definitions, then it is not possible to give a meaningful account of the development in forest area.

However, these problems are not nearly as big as they were in the past. The UN organization FAO now enforces concise definitions of what should be understood as forest, and in the year 2000, the first worldwide registration was carried out using these uniform definitions.

THE FAO DEFINITION OF FOREST:

'Forests are lands of more than 0.5 ha, with a crown cover of more than 10 percent, which are not primarily under agricultural or urban land use.'¹

Thus, the definition includes both the presence of a certain number of trees and the absence of other forms of land use. This precludes the inclusion of e.g. large private gardens with trees, or areas with agroforestry. Moreover, the definition requires that trees must be able to grow to a height of minimum 5 metres (they can still be newly-germinated trees that are yet to acquire such height). Forest area includes forest roads, fire breaks etc. Plantations such as gum trees and cork oaks are counted in, whereas e.g. fruit trees are not.

Formerly different definitions were used for different climatic regions, with a 20 per cent canopy cover as the minimum requirement for temperate regions and in industrialised countries, while only 10 per cent in the tropics. Today a uniform requirement of 10 per cent is applied worldwide, one result being that much greater forest areas are now counted in for Russia and Australia.

FAO's year 2000 Forest Resources Assessment for the whole world is, among other things, based on satellite images of all tropical forest areas. This contributes to the reliability and uniformity of the data. Moreover, trends have been studied in detail across 117 sample sites all over the tropics, while also collating satellite images of these sample sites taken in different years. Hence, it has been possible to provide uniform average

data on how large areas are cleared annually in different parts of the tropics.

However, one should not overlook that interpretation of satellite images is a subjective process which requires experience with the vegetation types of the particular region; this may lead to underestimates of deforestation. Thus, in its latest report, the World Resources Institute states: "Although the FAO estimate of 130,000 km²/year is widely quoted, more recent studies – notably of Indonesia and Brazil – suggest that it underestimates actual forest loss"². Still, the FAO report is the only all-comprehending survey of forest areas and deforestation based on data collected and treated in a standardized way.

In order to determine when an area passes from being a forest to being a non-forest we also need to clarify a few definitions. If a natural forest is cleared and replaced by a plantation, it is still considered a forest, yet only if the newly planted trees actually survive, i.e. if the plantation takes root. This is only fulfilled in 2/3 of cases. Moreover, we need definitions to specify how long time can be allowed to pass before a clearing is overgrown once more by trees through natural succession.

A distinction is made between 'gross deforestation' and 'net deforestation'. The former indicates areas where trees are cleared, regardless of what comes next. The latter indicates areas where trees are cleared, minus the areas returning to forest, either by replanting or by natural regeneration.

PRESENT TOTAL FOREST AREA WORLDWIDE

According to 2000 FAO figures³ Planet Earth has a total of 38.6 million km² of forest. Approx. 28 per cent is tropical lowland-rainforest, and approx. 19 per cent other tropical forest. Thus, overall, some 47 per cent of the world's forest area is found in the tropics.

Altogether, forest makes up a little less than 27 per cent of all landmass (or a good 29 per cent if leaving out Greenland and the Antarctic).^{4,5}

HOW MUCH ORIGINAL FOREST HAS DISAPPEARED WORLDWIDE ?

It is very difficult to estimate how large areas would have been forested today if man had not been here. For instance we know that large forest areas were cleared in the countries around the Mediterranean during antiquity, but we do not know if the areas cleared were originally 100 % covered by forest. Furthermore, the climate has changed since the earliest agricultural civilizations, and some of the areas that were forested then might not be able to sustain forest today.

The uncertainty on this matter is evident from a statement in the latest report from the World Resources Institute⁶: "Using this approach, Matthews (1983 . . .) estimated that as of the early 1980s, humans had reduced global forest cover about 16 percent. Updating this study with more recent deforestation data available from FAO brings the total loss of original forest cover to roughly 20 percent. Historical forest loss could be much higher, however. A 1997 study by WRI, which used a higher resolution map of potential forest than the Matthews study, estimates that original forest cover has been reduced by nearly 50 percent (Bryant et al. 1997 . . .)." Thus we see that estimates range at least from 20 % to 50 %.

The low estimate of 20 % seems unreliable, however. As will appear from the next paragraph, the total deforestation in the tropics may amount to 50 % of the original forest.

Concerning the regions outside the tropics, Russia including Siberia has suffered a forest loss of probably c. 20 %, and most other countries here have suffered forest losses much greater than this. Therefore, it seems difficult to reach at an average value for the whole world of only 20 %, whereas an average of 50 % seems quite possible.

But still, it is very difficult to know what areas might have been forested without the impacts of man and his animal husbandry, and the uncertainty on the figures is so large that anyone is free to choose nearly whatever figure he likes.

CHANGES IN THE TOTAL GLOBAL AREA WITH FOREST COVER

FAO has calculated how the world's total forest area has changed over the decade 1990-2000. The result is shown in Table 1.

Table 1. Changes in area with forest cover. In thousands of km² per year during the period 1990-2000. Source: FAO (2001).⁷ "Natural forest" means all forest that is not plantations.

Domain	Total forest cover		Natural forest cover	
	Gross change	Net change	Gross change	Net change
Non-tropical countries	0	+27	-5	+15
Tropical countries	-135	-117	-145	-135
Global	-135	-90	-150	-120

In the top row, we find that outside the tropics, the annual change in forest area is quite small. When looking at the 'net change' figure, including new plantations and replanting of former cropland with forest, we then find that forest cover outside the tropics is actually on the rise. In addition, the amount of natural forest is increasing – because sizeable areas are re-covered by natural self-sowing of woodland trees (notably in the former Soviet Union).

Contrarily, in the tropics, we find a far greater loss of forest cover, and only a minor fraction of this loss is outweighed by natural regrowth of trees and establishment of plantations (the net change figure is only slightly smaller than the gross change figure).

When looking at the bottom row we find the development in aggregate global forest cover to be negative, because the downward trend in the tropics by far outweighs the positive development outside the tropics.

HOW MUCH ORIGINAL RAINFOREST HAS DISAPPEARED?

From data on precipitation, temperature etc. one may try to estimate which regions on earth were originally covered by rainforest, before man began felling forest for agriculture. This in turn can be compared with present-day rainforest areas.

This type of data has been collected in a report from the World Resources Institute; the data were provided in cooperation with UNEP and IUCN. Table 2 is an aggregation of these figures.⁸ It must be stressed that the figures are not very reliable; estimates for various countries are based on different definitions; in some parts of the tropics, the figures may overestimate the amount of forest remaining, in other parts the figures seem to be underestimates. If we assume that errors to both sides cancel each other,

we arrive at the impression given in the table, viz. that overall approx. 50 per cent of the original rainforest and humid forest has been cleared. Other sources provide somewhat different figures; comp. Thorkil Casse's chapter, 'Forest clearing in third world countries'.

Table 2. Estimate of original and present-day area of tropical rainforest and humid forest. Figures indicate million km² and cover the 1980s.

Domain	Original rainforest	Present-day rainforest	% lost
C. and S. Americas	12.95	9.30	28.2
Africa	12.74	4.89	61.6
S. Asia etc.	6.82	2.35	65.6
Tropics, total	32.5	16.5	49.1

Another way of estimating the total deforestation up to now, is to look at the present forest cover in those countries where the natural vegetation would have been humid forest over nearly 100 % of the area. Such countries are the small countries in Central America, plus e.g. Venezuela, Liberia, Gabon, Bangladesh, Burma, Vietnam and Indonesia. The present extent of forest cover in these countries ranges from 0 % in Nicaragua to 90 % in French Guyana. If one makes a gross average for all such countries, one arrives at a forest cover of 50 %. Considering that countries lying partially outside of the natural range of rain forest would most likely have suffered forest losses greater than those completely within the rain forest zone, this line of evidence likewise points to a total forest loss of at least 50 % in the tropics up to now.

VARIOUS FIGURES ON CURRENT RAINFOREST CLEARING

Over the years, quite different estimates have been given as to how much tropical forest is being cleared annually in our day. In 1980 Norman Myers, environmental journalist, estimated that annual clearings amounted to 0.24 million km², that is 46 hectares each minute.⁹ It must be noted that this estimate concerned the cutting of primary forest, i.e. forest that had never been cut previously. Where such forest is replaced by growth of new trees, there has been no loss of natural forest, but there has been a loss of primary forest.

A book published 1985 has a figure of 0.11 million km² a year¹⁰, and another book from 1988 indicates 0.15 million km².¹¹ These lower figures concern all types of natural forest, i.e. they include secondary forest. The 1987 Brundtland Report reckoned that 0.076 to 0.1 million km² disappeared each year, and furthermore 0.1 million km² was severely damaged. A survey of several estimates made during the 1980s¹² shows that the estimates center around c. 0.12 million km².

The most authoritative estimates are those of FAO. In a 1997 report FAO¹³ estimated that over the years 1980-1990 0.146 million km² of forest was cleared annually in the developing countries in the tropics. The most certain figures are probably those from Southeast Asia, but even these are quite uncertain. For instance an independent inventory produced figures for annual forest clearing in Southeast Asia that were nearly 75 per cent higher than the FAO figures.¹⁴

In the same 1997 FAO report estimates were that in the period of 1990-95 0.129 million km² of forest was cleared annually in the developing tropical countries, which is

somewhat less than for the period of 1980-1990. This could suggest a trend towards slightly slower forest clearing after 1990. However, all figures from the 1980s and the 1990s center around approximately the same values, and there is no reliable indication that differences in the estimates are due to a time trend.

Now the Year 2000 FAO report on the world's forests has been published, as referred to above. In it the total annual loss of the world's tropical forests in the period of 1990-2000 has been calculated as the figures shown in Table 1, that is gross 0.135 million km² and net 0.117 million km². The figure of 0.135 million km² is comparable with the previous estimate at 0.129 million km². Therefore, the earlier estimate more or less holds water. These figures are based on loss accounts calculated individually for each country, after which the figures were summed.

In addition, the most recent FAO report also offers new figures regarding the decline of tropical forest areas. These other figures are based on evaluation of satellite images from the 117 sample sites mentioned above. These figures are somewhat lower. The explanation could be that sample fields may in particular cover outlying areas far from population centres where large and coherent forest areas still exist. Here the percentile annual clearing is bound to happen at a slower rate than in areas with many small forest plots. Or the discrepancy could be due to difficulties in the interpretation of satellite images.

According to information from these sample sites 0.92 million km² of tropical forest area was cleared annually in the period of 1980-90, and in the period 1990-2000 0.86 million km² annually, thus a slightly lower figure. If instead we calculate how large were the large areas of closed forest cleared, then figures are 0.8 million km² in the former period and 0.71 million km² in the latter. All figures thus seem to indicate that clearing slowed down a little over the latter period. Still the report notes that with a standard error for these figures of around 15 percent the uncertainty is too great to allow any conclusions on trend in time. The report also notes that this study is so far the only inventory in which uniform methods have been used to evaluate deforestation rates for two different periods. We can thus conclude that for all we know now there is no positive evidence proving that the forest-clearing rate in the tropics is decreasing.

A FAO report also has a rather detailed overview of the conversions taking place in the tropics from one type of land use to another.¹⁵ We here find that when coherent, closed forest is cleared, this is most often done to make room for agriculture etc. Yet there are also extensive forest areas that, after clearing, are left as more open forest, as shrubs, as short-term 'fallow', or as heavily fragmented forest remains. Part of those areas gradually grow over with forest again, so clearing is a transient situation. However, the proportion of cleared areas that grow over with forest again is but a small part (less than 5 percent). The main part eventually ends up as cropland.

We can also look at the geographical distribution of deforestation. Table 3 provides an overview of forest clearing in various parts of the tropics:

Table 3. Geographical distribution of deforestation in the tropics. The table indicates total forest area and annual deforestation over the period of 1990-2000, according to FAO figures.¹⁶ Areas are specified by 1,000 km².

	Present-day forest area	Annual forest area cleared	Annual clearing, %
South America	8,740	36	0.42
Central America	787	9,6	1,22
Sub-Saharan Africa	6,320	52	0.82
Madagascar	117	1.2	1.00
India and Southeast Asia	1,749	9.8	0.56
Indonesia etc.	1,418	15.2	1.07
Tropics, total	19,135	124	0.65

The deforestation rate varies greatly for various parts of the Tropics. The Amazon forest of South America is so vast that annual clearings only make up a small percentage. By contrast, the small countries of Central America only have rather small forest areas left by now, and annual clearings make up a larger percentage. Figures for Asia conceal very mixed trends. Total forest area is declining for most of Southeast Asia, yet actually on the increase in India, Bangladesh, and Vietnam, according to FAO¹⁷. The upward trend in these countries owes to extensive new plantations; natural forest acreage is heavily declining.

There is no evidence of forest area decreasing at a faster rate in either the most prosperous or the poorest regions. In its 2000 Report FAO analysed if any specific circumstances could account for the variation between countries in terms of forest clearing rates. There is no significant correlation to GDP, that is no certain tendency for the forest-clearing rate to be highest or lowest in the poorest countries. Nor is any statistically significant influence found from population density or population growth. The only factor to have a near-significant influence is how big population density is outside the big cities.

Moreover the report has figures on how clearings are distributed on various forest types, comp. Table 4.

Table 4. Forest area and rate of deforestation for various forest types in the Tropics. FAO data.¹⁸

	Forest (million km ²)	Annual deforestation (%)
Highland and mountain forest	2.04	1.1
Lowland: Rainforest	7.18	0.6
Humid forest	5.87	1.0
Dry and arid forest	2.38	0.9
Tropical forest areas, total	17.6	0.8

By percentage, mountain forest is seen as the forest type most exposed to clearing.

COMMENTS ON LOMBORG'S CHAPTER ON FORESTS

In the above comments I mainly relied on the latest FAO report – not just because it is the newest report, but also because it has the most authoritative and uniform figures, and because it represents the current knowledge of the UN, and thus of the international community. This report was also available to Lomborg, and was cited several places in his forests chapter. Thus, one would expect Lomborg's text to coincide with the information provided by the FAO source. But no, nothing of the sort – actually there are distinct contradictions. And overall, Lomborg's text is greatly at variance with general views.

When it comes to total forest area Lomborg says (p. 112), 'Globally it is estimated that we have lost a total of about 20 percent of the original forest cover since the dawn of agriculture. This figure is far smaller than the one so often bandied about by the various organisations.' Lomborg cites four different sources in support of his claim. And he adds that there is no support for the higher figures given by various others, such as WWF. On this basis, he gives the reader an impression that e.g. WWF cannot be trusted.

To attack the credibility of WWF is not warranted, however. As we saw above, various estimates range from 20 % to 50 % (or more), and one may pick whatever figure one wants. To postulate that the 20 % figure is "true", and to attack WWF on this basis, is not fair.

Next, concerning the total area of tropical forest cleared since the start of human history, Lomborg postulates (p. 114) that 80 % of the original tropical forest cover is still in place, i.e. that only 20 % has been cleared. He gives the reader the false impression that this figure is an official IUCN estimate. It is not. It is a figure from a book edited by IUCN, where the author of one of the chapters¹⁹ makes a very crude calculation. In this calculation, the total area of the remaining tropical forest, dry as well as humid, is shown to make out c. 80 % of the area that must originally have been covered by humid forest. The area that originally had been covered by dry forest is very difficult to estimate and was not included in the calculation. So, the author concludes that the tropical forest remaining must be less than 80 % of the original, since his estimate is a conservative estimate omitting original dry forest. But Lomborg misquotes the text, transforms the "less than 80 %" to "80 %" and calls the figure an official IUCN estimate. He cites no other sources in support of his claim that 80 % of the tropical forest remains. Before he wrote the English version of the book, I drew his attention to the very different estimates that could be extracted from the WRI report from 1994-95. Although he did consult this WRI report, and although he has read the latest WRI report for 2000-2001 stating that probably as much as 50 % of all forest in the world has been cleared, he stubbornly has stuck to the clearly unreliable figure of 20 % also in his English book.

Lomborg runs through one continent after the other, noting for practically all regions that more than 20 percent has disappeared. On this basis, it is very strange that he can believe that the overall average for the world could be only 20 %. However, in one region he records a very low figure for deforestation, viz. Southeast Asia, where according to Lomborg, only 7 percent has been lost over the last 300 years. This incredibly low figure is taken from a table in chapter 10 of the book "The world as transformed by human action"²⁰. However, chapter 11 in the same book, the chapter on forests²¹, which Lomborg has also read, gives data for deforestation in Southeast Asia which clearly demonstrate that the 7 % can impossibly be true or even near the truth. Here it is seen

that even in those countries in the region where deforestation has been relatively moderate, more than a third of all forest has disappeared. It is strange, then, why Lomborg should cite a figure from a less authoritative chapter in the same book, a figure that is unrealistically small.

As for forest clearing in modern history (the 1900s) Lomborg tries to defuse the impression of a negative trend. He writes “Globally, the overall area covered by forest has not changed much since 1950” (p. 110), “Globally, forest cover has remained remarkably stable over the second half of the twentieth century” (p. 111), and “But as we have pointed out, there has not been a fall in global forest area during this period” (p. 115). These repeated statements are clearly contradicted by the latest FAO report on the world’s forests, which Lomborg has read. However, he circumvents the recent FAO data by emphasizing how uncertain they are, and argues that it is preferable to use some series of data based on FAO’s ‘Forests and woodland’ category, because these time series go as far back as to 1948 and 1961 resp. He argues that it is better to use such unreliable data that go back to 1948, because this gives you a long time series, rather than more recent, more reliable data. When using these long time series, he cites data not for the area of forest, but for the area of “forest and woodland”. He explains in his note no. 770 that “forest and woodland” is everything with regular tree trunks. He does not explicitly explain that “woodland” includes e.g. pastures with sparse trees (down to 5 % canopy cover), so that forest cutting and conversion to pasture is not reflected as a change of land use in his statistics, as long as only a few trees are left standing.

In Lomborg’s Figure 60, we can see that in the very period during which curves for ‘closed forest’ and ‘forest’ clearly show a steady decline, the top curve showing the long time series indicates an increase for ‘forests and woodland’. Therefore – for the period in which we can check if the upper curve shows something meaningful – we can see that it does not. Actually, neither of the long curves can be put to any use, since whatever they show is far too imprecise, and because we do not know the extent of data inaccuracy at baseline. The two curves that provide reliable information do not take up much space in Lomborg’s figure, and a reader would not be inclined to consider them important. The figure layout plainly misleads the reader. Right from the beginning in 1998, Lomborg has been heavily criticized for treating the subject in this way. But in spite of this criticism, Lomborg has kept his formulations on this aspect nearly unchanged.

One of Lomborg’s key points is that even if forest area is on the decline in the Tropics, that loss is outweighed by changes elsewhere. He mentions replanting of plantations, and the increase of forest area in temperate zones. During the Danish debate [following the appearance of Lomborg’s book; eds.] this point was heavily criticized, with reference to the absurdity of having tropical rain forest and Siberian spruce included in one and the same calculation. What is more: His point just does not hold good. Out of tropical rainforest lost, only approx. 15 per cent is outweighed by increased forest area in temperate regions²² (figures applying for 1990-1995). New plantations on formerly open land in the tropics make out an area c. 10 % of the annual tropical forest loss. In addition, new plantations in former forest areas likewise make out c. 10 % of the annual tropical forest loss. That is, new plantations do not spare cutting of natural forest; the area of open country converted to trees is not larger than the area of natural forest that is cut in order to have plantations there.

The most recent FAO report is very well-arranged, unambiguous and clearly written. On the basis of this report, Lomborg could have tidied up his text which is messy and con-

fusing in some places. Yet, he opts for just the opposite. He uses the new report for further manipulations with the new figures. The recent report tells that ordinary data yield estimates of the annual forest-clearing rate at 0.8 per cent in the 1980s and 0.7 per cent in the 1990s, and satellite data yield estimates of the forest-clearing rate for these two periods at 0.47 percent during the 1980s and 0.46 percent during the 1990s. In both sets of data, the decline from the 1980s to the 1990s is too negligible to be significant. A fair presentation of this evidence would have been that there is no significant decline in the deforestation rate. Instead, Lomborg utilizes this evidence to create yet another red herring. He writes (p. 113): "The usual FAO estimates put net deforestation in the tropics in the 1980s at 0.8 percent a year, falling to 0.7 percent in the 1990s. With FAO's new 2001-study . . . the estimate of the net tropical deforestation has declined even further to 0.46 percent." From this, practically every reader will understand that the deforestation is steadily declining, completely contrary to the meaning of the cited report. Confronted with this criticism, Lomborg may postulate that he does not write about the change in deforestation rates, but about the change in the *estimates of* the deforestation rates. Such a reply cannot be defended, however: If Lomborg had talked about the changing estimates, he would have mentioned the low estimate of 0.47 % from the 1980s, but he did not. And, by the way, the literature that Lomborg has read does not corroborate that the estimates have been displaced downward²³.

The recent FAO report also disputes Lomborg's views in other respects. For instance, the report points out that there is no clear link between deforestation and economic prosperity, in that the correlation between GNP and deforestation rate is not significant. The same lack of correlation has also been found by another source which Lomborg has read²⁴. So, Lomborg writes against his better judgement when he writes (on p. 117) that the deforestation problem is rooted in poor economic growth. This flaw is very serious, because it is a key point in Lomborg's book that economic growth should not be impeded.

Lomborg uses most of his p. 116 to "document" that 'there is no indication at all that 1997 was an extraordinary fire year for Indonesia or the world at large'. Again, his writing is contrary to what he should have known from sources that he has read, such as the most recent reports from FAO and WRI²⁵. Furthermore, there exists a recent FAO report dealing with the extent of forest fires worldwide²⁶. This is an extensive and authoritative report which in many details contradicts what Lomborg postulates about forest fires. It is especially noteworthy what Johann Goldammer writes in this report about the forest fires in Indonesia. Lomborg postulates that "The independent fire expert, Johann Goldammer, said that there is no indication at all that 1997 was an extraordinary fire year for Indonesia or the world at large." Lomborg cites this statement from a newspaper article and has allegedly corroborated it by personal communication with Goldammer in 1998. How strange, then, that in a scientific paper in *Science* in 1999, and in the FAO report on fires from 2001, Goldammer expresses exactly the opposite. In the report, he clearly writes that 1997-98 was indeed an extraordinary fire year in Indonesia, and that c. 4.9 million ha of forest burned there that year. This is more than twice the figure of 2 million hectares mentioned by WWF in 1997, a figure which Lomborg uses to tell us that WWF exaggerates and cannot be trusted. The strange thing is: When Lomborg updated his book to an English version in 2001, why did he not make inquiries about the most recent figures? Why did he not contact Goldammer personally this time? If he had done that, he would no longer have had a reason to slate the WWF in the way he did.

All in all, I have to conclude that Lomborg's forest chapter is riddled with inaccuracies and misleading and/or manipulated figures to such a degree as to render the text completely useless. It is in direct conflict with the most recent FAO report on forests, which Lomborg has read – yes, it even conflicts with the wording on precisely the pages and tables cited by Lomborg. It is hard to arrive at any other conclusion than Lomborg writes against his better judgement.

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- 1 FAO (March 2001): The global forest resources assessment 2000. Summary report. [Ftp://ftp.fao.org/unfao/bodies/cofo/cofo15/x9835e.pdf](ftp://ftp.fao.org/unfao/bodies/cofo/cofo15/x9835e.pdf).
 - 2 WRI (2000): World resources 2000-2001.
 - 3 FAO (2001), see above.
 - 4 Same source as preceding note.
 - 5 FAO: State of the world's forests 1997.
 - 6 WRI (2000): World resources 2000-2001.
 - 7 FAO (March 2001), comp. previous note.
 - 8 WRI: World Resources 1994-95, Table 20.3 p. 320-321. Estimates of missing data for Central America, Papua, New Guinea, and the Philippines have been added.
 - 9 M. Jacobs (1988): The tropical rain forest. Springer Verlag.
 - 10 World Resources Institute (1985): Tropical forests: A call for action.
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 - 12 M Williams (1990): Forests. Chapter 11, pp. 179-201, in B. L. Turner et al. (eds.): The earth as transformed by human action. Cambridge University Press.
 - 13 FAO: State of the world's forests 1997.
 - 14 R. Steele (1999): Environmental issues of Asia and the Pacific. I: Regional surveys of the world. The Far East and Australasia 1999. 30th ed. Europa publications Ltd.
 - 15 FAO: State of the world's forests 1997.
 - 16 FAO (2001), comp. previous note.
 - 17 Other data indicate that there is still a yearly net decrease in forest area in Vietnam.
 - 18 FAO: State of the world's forests 1997.
 - 19 W. V. Reid (1992): How many species will there be ? Chapter 3 in T. C. Whitmore & J. A. Sayer (eds.): Tropical deforestation and species extinction.
 - 20 J. F. Richards (1990): Land transformation. Chapter 10, pp. 163-180 in B. L. Turner et al. (eds.): The earth as transformed by human action. Cambridge University Press.
 - 21 M Williams (1990): Forests. Chapter 11, pp. 179-201, in B. L. Turner et al. (eds.): The earth as transformed by human action. Cambridge University Press.
 - 22 Computation based on figures from the section: 'Various figures on current rainforest clearing'.
 - 23 Williams (1990), see note above.
 - 24 N. Shafik (1994): Economic development and environmental quality: an econometric analysis. Oxford economic papers 46: 757-773. Cited by Lomborg on his p. 176-177.
 - 25 FAO (2001) and WRI (2000), cited above.
 - 26 J. G. Goldammer & R. W. Munch (2001): Global forest fire assessment 1990-2000. Working paper. FAO forest resources assessment programme, Rome 2001. May be downloaded from www.fao.org:80/forestry/fo/fra/docs/wp55_eng.pdf.

FOREST CLEARING IN THIRD WORLD COUNTRIES

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The following short contribution proposes to set out what we can use macro data of total global forest area for, problems of measurement, and finally try to demonstrate how forests matter to people, as exemplified with three countries. 'The Forest' is a difficult entity to analyse, since – while serving as a vital habitat type to a large part of the world's biodiversity – it can also be exploited by people, either directly by using its resources or indirectly by providing access to forest (recreational purposes). Tourism is the fastest-growing industry worldwide, and is increasingly focused on nature experiences including those associated with forests. Estimating those different services made available by the forest is difficult since certain assets, e.g. forests as biodiversity banks and erosion inhibitors cannot be measured by their market value alone. In making up the significance of the forest one must necessarily keep in mind measurables and immeasurables as well. The focus of this article is on the importance of forest to developing countries and not a pure reply/critique of the chapter (Forest- are we losing them ?) in Lomborg's book. First and foremost, because Lomborg is almost exclusively aiming at refuting the hypothesis that forest cover is decreasing world-wide. In this article we try to go beyond this narrow objective and discuss the more interesting issue about the significance of forests to economic and social development in developing countries.

FOREST AREA IN A GLOBAL PERSPECTIVE

At present no one has a complete overview of the amount of forest vanishing each year. FAO is the only source providing a total picture of how much forest exists and of changes from year to year.

So far, FAO has been the only source to provide a global overview of the existing forest area and of the magnitude of year-to-year changes. WRI (World Resources Institute) has now launched a project, which like FAO (since 2000) applies analyses of satellite images and presents its own deforestation estimates. When comparing the FAO inventory of global forest cover with the WRI figures, we find that they differ by 10 million square kilometres (29 million square kilometres according to WRI and 39 million square kilometres according to FAO)¹. Both organisations also use the same definition of canopy cover, and yet their results differ greatly.

Deforestation is defined as the removal of canopy cover to less than 10 per cent. This is an extremely conservative estimate, and nor is the definition generally accepted by foresters.² A major shortcoming of this approach is that commercial forest utilisation, which can locally greatly influence biodiversity, is not considered as deforestation so long as the remaining forest cover exceeds 10 per cent. However no other available sources provide a comparable global overview.

The figures show trends to differ considerably between industrialised countries as opposed to developing countries. The figure showing the annual loss of 0.2 per cent of the total forest area (1990-2000) conceals a rate of increase in forest cover in the industrialised countries and an annual loss of 0.8 per cent in Africa and 0.4 per cent in Latin America. According to FAO (2001)³ 29 per cent of the earth's area is covered by forests, 60 per cent of which is found in just eight countries: Australia, Brazil, Canada, China, the Democratic Republic of Congo, Indonesia, Russia, and USA.

One of the big problems is that inventory methods are constantly being changed. From the penultimate inventory in 1995 (FAO 1997)⁴ to the latest inventory (FAO 2001) forest area has 'increased' in Australia and Russia due to the very broad forest definition used (canopy cover is at least 10 per cent – previously 20 per cent was the definition used for industrialised countries).⁵ FAO itself notes that the figures of its most recent report are not fully comparable to those found in previous analyses; still the organisation risks the claim that a trend towards a declining deforestation rate seems to be in evidence.

Thus, when FAO concludes that on average the net annual deforestation rate decreased from 13 million hectares in the decade 1980-1990 to 9 million hectares in the decade 1990-2000 we should read such information with some caution. Moreover the increase in plantation forest area has gone up to 3 million hectares annually. So the explanation of the improved situation is completely false, based on a changed forest definition and on increased forest plantation. Finally, it is important to keep in mind that a decline in deforestation rate means less deforestation per year, yet that deforestation has not been brought to a halt. According to the FAO's own figures 13.5 million hectares of natural forest (i.e. excluding plantations) have disappeared in developing countries over the past decade (1990-2000). So even though the forest area outside the Tropics have increased by 1.5 million hectares in the same decade, the FAO data clearly indicate a severe degree of deforestation in the Tropics. Moreover, this is where the greatest concentration of biodiversity exists.

The extremes become still more obvious if we dig further into the details. Less than 5 per cent of the total forest cover in Europe can be classified as primary, pristine forest, while the figure for Tropical America is 69 per cent of the given forest area (the definition is not quite the same here, yet does convey an impression of the variation).⁶

There are various uncertain estimates as to how much forest existed originally ('originally' understood as 'prior to the introduction of agriculture'). Myers (1994)⁷ says that 57 per cent of the original rain forest is left; WRI (World Resources Institute) estimates the total forest cover figure to be 54 per cent of what it was 8,000 years ago.⁸ By contrast Goudie (2000)⁹ arrives at a far more conservative estimate, namely that a mere 20 per cent of the earth's total forest cover is gone since the beginning of agriculture. Yet another source (Matthews) shows a decline of only 15 per cent from the pre-agricultural era to 1970 (here cited from WRI).¹⁰ Goudie (2000: 55) makes an interesting comparison of various author's calculation of forest loss in six Western African states. Estimates of deforestation since 1900 differs from a conservative estimate of 10% to a alarmist viewpoint of 50% ! Regardless we still need to underline the fundamental principle of all research of citing several sources – and even more so where they disagree – instead of sticking to a single calculation just because it precisely suits one's own understanding of life. But then, finally, all three estimates may be so uncertain that it is really not possible to make any statement whatsoever.

What can all these macro data be used for? That very much depends on whatever we want to prove.

Moreover it would require us to trust the figures used in the FAO statistics. Most forest experts would hold that satellite images are not sufficient, but that further on-site verification of figures is required. At the same time, the clear difference between FAO and WRI, in their respective inventories of global forest cover, show that aggregate methods are not yet sophisticated enough to provide a final answer as to how much of Planet

Earth is covered by forest. Hence, quite understandably, there is bound to be considerable uncertainties regarding the deforestation rate.

The two sources are not entirely compatible, though definitions are similar and they both make use of satellite imagery. FAO relied on 117 sample units covering 10% of 87% of the world's tropical forests. This is what the organisation named a pan-tropical remote sensing survey. In a footnote the organisation admits that an expert team advised FAO to consider a sampling of 350 units¹¹. WRI refers to an International Geosphere-Biosphere-Programme, which is also based on satellite imageries¹².

In the case of FAO, it is not yet clear how country specific forest inventories shaped the final figures given of global forest cover. Over half of the developing countries had only one forest inventory, and more than one-fourth of them had never carried out an inventory¹³. But national data from these biased forest inventories were harmonized with satellite pictures to derive the final estimated regional and country specific forest cover figures. Satellite imageries were probably based on regional photos only, so a misinterpretation highly likely without the mean to collaborate them with country specific forest inventories. The end result, using two types of biased data sources (very aggregate satellite photos and few forest inventories), is not satisfactory.

In the case of WRI, the main problem is that data are not provided by country but only by region. Then we can only compare regional data. Normally, one would have expected discordance being higher in developing countries due to low reliability of country forest inventory figures. Nevertheless, the two sources definitely disagree even so to the estimated forest cover in both Europe and North America. FAO has the highest figure for Europe (a difference of more than 3.5 million km² of forest), but surprisingly WRI has the highest figure for North America (a difference of 1.6 million km² of forest). The single most contested country is Russia, where FAO publishes an estimate of 8.5 million km² and WRI (only in this case a specific country figure is released) announces an estimate of 5.8 million km².

According to the FAO definition a little less than a third of the world's total area is still covered by forests, and there is a tendency for the deforestation rate in tropical developing countries to stagnate or decrease slightly from the 1980s to the 1990s. One could take the view that everything looks bright, then. The viewpoint of this article is not that optimistic. In 15 years (1980-1995) the world has lost a total forest area the equivalent of Indonesia's or Mexico's total area.¹⁴ All the so-called megadiversity countries (those holding 60 per cent of the world's total biodiversity) display medium high to high annual deforestation rates: Brazil (0.4%), Colombia (0.4%), the Democratic Republic of Congo (0.4%), Indonesia (1.2%), Madagascar (0.9%), and Mexico (1.1%).¹⁵ Only Australia falls beyond this pattern, due to change in forest cover definition.

Deforestation at a disaggregated level, in selected countries, can thus easily endanger the environment and possibly also the unimpeded continuation of our present model of economic growth. We shall try to illustrate the point with three specimen countries: Malaysia, Madagascar, and Brazil. This choice is by no means coincidental.

Malaysia is amongst the most prosperous developing countries. For years and years her economic development model was based on the exploitation of not least the forest resources. At the same time Malaysia is a country that environmental NGOs have reproached for not considering natural values. Around 15 per cent of the forest in eastern

Malaysia disappeared from 1966 to 1981, or what amounts to an annual deforestation rate of 2.6 per cent.¹⁶ Less than 25 per cent of the then existing forest area could be classified as good forest. Yet, the present crisis in Asia apart, it is beyond doubt that this country belongs to the small circle of successful countries among the developing countries. Then how are we to evaluate economic success vis-à-vis a visible deterioration of nature not under conservation?

Madagascar is one of the world's poorest countries. At the same time her biodiversity is completely unique: 85 per cent of all plant species are endemic; 93 per cent of the lemurs (mammals) are endemic; 58 per cent of the chameleons are endemic, and a similar rate of endemism is found for birds, namely 53 per cent.¹⁷ Some places in Madagascar deforestation is progressing rapidly, and in terms of economics – unlike Malaysia – the country has reaped very few benefits from the exploitation of her forest reserves. So should we plainly call Madagascar a 'loser country'?

Brazil has the world's largest coherent forest area. The country has seen limited economic growth, but still Brazil belongs to the so-called newly industrialized countries. Based on her practically infinite forest resources in the Amazons, would a strategy based on exploiting those resources be conceivable that could perhaps in time gradually replicate the economic model of Malaysia?

MALAYSIA AND CAPITAL SUBSTITUTION

For years and years politicians and economists alike have used annual growth in GDP as an expression of a country's development. Of course that approach has been much criticized for not including the distribution aspect and for leaving out social aspects such as education and average life expectancy. Since 1991 UNDP has tried to make up for these shortfalls by publishing an annual index of human development (Human Development Index).¹⁸

Increasing preoccupation with environmental issues has now led to wider focus, also addressing the depreciation of natural assets (including forest resources). The approach of conventional economics did not include the depreciation of natural resources in the calculation of GDP. Instead we should now compute the degradation of natural assets and thus arrive at a revised and reduced expression of the increase in economic growth. It goes without saying that this is not done just like that. In order to enable such a calculation we need to have a measuring unit for e.g. forest stocks (say, in m³ per hectare), to be multiplied by a timber price. Moreover we must have figures at our disposal showing precisely how much wood leaves the forest. Obviously such calculations are marred with great uncertainty.

It would go beyond the scope of the present article to discuss the inherent problems of techniques applied. Yet it is interesting that a few authors have buckled down to this immense task and offered their estimate of the implications in the case of Malaysia. Vincent and Ali (1997)¹⁹ computed the loss of natural capital in Malaysia and arrived at the interesting conclusion that despite a heavy toll on forest cover the strategy adopted by that country must be characterized as sustainable. The argument is that depreciation of nature capital is offset by an increase in investments in manmade capital. Evidently that is a conclusion that can be challenged. Is it really possible to substitute birds and animals with freeways and machinery?

The case of Malaysia demonstrates clearly that it is difficult to make comparisons wit-

hout also making some qualitative and extremely subjective choices. It is time to finally silence the misrepresentation of the international forest debate as being an objective analysis field in which it is possible for someone to reference a number of macro data, thus closing the debate. Are we trying to bury our heads in the sand, by claiming that all is well? Or are we prepared to join a concerted debate in order to determine which range of subjective indicators should be made part of an interdisciplinary analysis? If, all the same, we were to try to compare those incommensurables – biodiversity versus economic growth – then we could perhaps tentatively compare regional deforestation figures with data on areas selected as priority zones for biodiversity conservation.

According to BirdLife one of the global biodiversity priority zones is Borneo, which comprises parts of Malaysia and Indonesia.²⁰ Around 130 species of mammals, birds and reptiles, along with 3,500 plant species cannot be found anywhere else on Planet Earth.²¹ To the extent that several of these species are found in Sabah there is reason for concern. According to Vincent and Ali (1997)²² the annual deforestation rate in Sabah was estimated to be as high as 8 per cent from 1969 to 1972. Again the figures are unreliable and only available for a short sequence of years. Yet a guarded conclusion could be that economic growth in Malaysia will have to shift towards the prioritisation of other sectors if economic growth is to continue alongside biodiversity conservation in this country.

MADAGASCAR: BIODIVERSITY AND POVERTY

Out of the 48 lemur species originally found in Madagascar 1623 and at least 13 bird species have suffered the same fate (204 known bird species still exist in the island).²⁴ For the other animal and plant species data are sparser (however a pygmy hippopotamus has also become extinct). There is nothing resembling agreement about what caused those species to disappear. Climatic changes may have had just as much of a role to play as human factors. Yet, based on observations of existing bird species and differences in forest cover Langrand and Wilmé (1997)²⁵ have demonstrated an unambiguous link between deforestation and biodiversity. Therefore we must assume even more animal and bird species are going to disappear as deforestation runs its course.

Right here, however, the angle is a slightly different one. What is presently taking place in Madagascar appears to be the worst imaginable combination of adverse factors. The forest is vanishing in a country, which also fails to get economic growth up and running. The annual deforestation rate is not known, save for select areas. Sussman and Green (1996)²⁶ estimated the annual loss of forest cover in eastern Madagascar at 1.5 per cent for the period of 1950-85. At some east coast locations the rate is nearing 10 per cent for the period of 1957 to 1994²⁷, and in southwestern Madagascar forest losses between 1973 and 1996 are estimated at 3 per cent annually.²⁸ Today the country is left with a meagre 23 per cent of her original forest, and what is more, the forest is extremely fragmented.²⁹

The forest is owned by state. Yet illegal forest devastation does not carry any sanctions on the part of the authorities. The result is practically a no-win situation. If it is not possible to save the region's biodiversity, then it should at least be possible to create a basis for economic development. This is not even sure to happen. Even if attempts were made to convey to the farmers of the forest-rich area how the development could turn out in the long term, by comparing with the situation in the forest-poor area, this would hardly help. The farmers would still envisage a short-term profit, and as long as there is a spot of forest left they will still be able to find a few roots in the forest so they

can make it through the dry season. In one of the selected zones in southern Madagascar the population has actually taken steps to salvage some of their forest. Perhaps the key aspect is to appreciate the amount of forest that villagers do chose to salvage, given the potential economic profit to be gained from corn growing. Thus, in many areas of the developing countries, the management of nature resources is in the hands of the local population, and only by understanding, supporting and improving that management can the forest be salvaged in the longer term. In many regions of Madagascar state intervention practically never takes place, including the southwestern part of the country. Everything is left to the market forces, and the study area only has a single national park (Zombitze), which is actually under constant pressure of being transformed into farmland. Only one more national park and a protected forest area exist, the latter conserved for religious reasons.³⁰ If that development continues, then the forest in the southwestern corner of Madagascar will disappear altogether over the next 20 or 25 years, apart from those two minor forest areas.

The scenario outlined for Madagascar is by no means unique to developing countries. Forests are occasionally exploited inappropriately, and often an unintended effect of e.g. price deregulation starts the snowball rolling. In this case it was a depreciation of the local currency that rendered corn export to the French island Réunion profitable. Commercial exploitation of forests is by and large totally absent, despite the presence of several species of rosewood in the region. Village peasants will only resort to charcoal production in the three months of a year (at most) when farming is impossible. Moreover wood for charcoal production is not obtained in the primary forest, since that would be too laborious. On all these grounds we should be extremely wary of proffering sweeping generalized conclusions when it comes to causes of deforestation in developing countries, charcoal production, and commercial logging, even though such rash cause-and-effect arguments are still being canvassed ... even by eco-optimists.³¹ Extremely few analyses have demonstrated any effect at all between deforestation in developing countries and commercial logging, or deforestation and charcoal production.³² The typical reason is conversion to farmland.³³ Often what happens in Latin America and Asia is that logging tracks or roads open up former inaccessible areas, people move in and convert forests to agriculture. In Africa, including Madagascar, commercial logging is quite absent (apart from some countries in central Africa), and it is small scale farmers who burn off the forest.

The international argument for salvaging the forest in Madagascar is the desire to save as much biodiversity as possible, since the country is unique in a global perspective. Yet all efforts are wasted so long as no good alternatives to slash-and-burn are available. People in Madagascar end up in a 'no-win' situation, because the soil will only remain fertile for a few years after the forest has been felled. The forest has an environmental and economic value (via sale of non-wood products), but there are barriers to the commercial use of medicinal plants and root crops. Problems of transportation and harder labour explain why (in the humid part of Madagascar) it is easier to clear the forest and grow corn or rice. Once the forest is gone only an economically productive investment of profits can lend a certain economic legitimacy – however dubious – to clearing forests (as in the case of Malaysia). As for Madagascar the returns are not invested productively, and after a few years the poor peasants are back to square one in terms of income.

BRAZIL AND SUSTAINABLE DEVELOPMENT

Until now we have evaded touching upon the concept of sustainable development. Per-

haps the concept is too difficult to make operational, and thus does not make sense. For the present context we would rather analyse the concept by its negation – that is: any overexploitation of resources, e.g. forests, risks jeopardizing the very basis of an economy. Whenever a community overexploits a resource (e.g. forests) it risks jeopardizing its own economic basis. That is what we would call a non-sustainable development. Ecological sustainability would be an ideal concept to use, though regrettably not workable in practice. Several economists have tried their hand with definitions of ecosystem capacity and ecosystem resilience,³⁴ though with miserable results. Indicators have been reduced into a measure of charcoal use and agricultural productivity. Both do little to illuminate the capacity of ecosystems for absorbing heavy impacts from the outside, and we stand to gain nothing in terms of deepening our understanding of ecological sustainability.

We have not yet arrived at a stage where we are able to produce a more precise definition of the key concept of ecological sustainability. As in many other fields of environmental research our knowledge is incomplete, and perhaps we are yet to fully comprehend the all-important relations between on the one hand economic and social development and on the other hand ecological capacity and the resilience of ecosystems. As a result of these quite momentous limitations to our present knowledge the objective we wish to pursue here must, for obvious reasons, be of a rather more modest scope.

Given the fact that nearly 90 per cent of the Amazon rainforest is still forested (though some of it may be secondary forest) one would assume that analysing forest utilization in these parts would be completely straightforward: 'Just go ahead – there is more where it came from!' would seem the obvious conclusion. In order to verify or disprove this thesis we carried out an analysis of Paragominas, a municipality in the northeastern state Pará in the Amazons. The municipality covers an area of km² 25.000. Economic development of the region has been made possible since the motorway from Belém to Brasília, funded by the World Bank, was opened in the 1960s. Throughout the 1970s and 1980s Paragominas became Brazil's testing site regarding the impacts of large subsidies for the big cattle farms. Since then wood processing has become the big industrial sector. Today the municipality derives some 80 per cent of its gross product from the timber industry.

Our wish was to measure Paragominas' forest utilisation in quantitative terms. For the purpose we selected a so-called 'user-cost' method, which indicates how fast or slow the natural resource is reduced. The formula is relatively simple and is calculated by relating the resource stock to annual revenues from forest/wood utilization, and then allow for the number of years until the forest is completely gone. Finally we wished to estimate what the share of that resource use would amount to against the total municipal gross product. The calculations were time-consuming, not least because we also had to compute the clean municipal gross product as a baseline.³⁵ Our results showed that the whole economic development model of Paragominas is at risk. Half the gross product has to be viewed as sheer consumption, and in less than 20 years the resource will be spent, and then the very foundations of the development model will have disappeared in the paper mill. From 1994 to 1996 (last year of analysis) the gross municipal product certainly went down, since lack of resources was already noticeable. Over the same period all sectors but the wood processing industry were on the rise, so there was nothing like a general falling-off of the economy. It is just that the wood processing industry carries such weight in the Paragominas economy that the aggregate figure for

the gross product ends up being negative. Unlike Malaysia, the Brazilians in Paragominas have not done much in the way of reinvesting in other forms of economic development. There has been no capital substitution, and time is running out for Paragominas' chances to convert to a different model of economic development.

We draw upon this finding for two conclusions. First, a development model can very well be self-destructive even in a large forestal area. Of course these people are all free to move to a neighbouring municipality. However people will not do so just like that, and in the longer term such a strategy, if copied in the entire Amazon, would be altogether non-sustainable. Second, it is significant for those who take the deforestation threat seriously to develop methods that can warn against non-sustainable development. Computing 'user-costs' is a time-consuming task, and the problem with cost-benefit analyses, though an easier tool, is their absent link to the resource basis. Cost-benefit methods do nothing to demonstrate if perhaps a given development model is non-sustainable. There is a need for developing new and less time-consuming approaches to analysing economic sustainability, while waiting for the day when we will be able to define the concept of ecological sustainability in more operational terms.

CONCLUSION

Our understanding of the forest and its services is extremely limited. At present no one is able to specify any such thing as the minimum forest area that a country must have at its disposal in order to survive in terms of economy. We can say, however, that it would be unduly optimistic for someone to claim that our forests are not at risk. We can also conclude that there is a link between forest exploitation and economic development in many countries, not least developing countries. However good examples of win-win situations – where both environment and economy benefit – are few and far between.

In a historical perspective, opinions differ as to how much of Planet Earth was originally forest-clad. Based on three concrete case studies we are able to conclude that more often than not the real world is rather more complex than first appearance would let us believe. Economically, Malaysia has clearly benefited the most, yet the country may have hit the upper limit to continuing growth based on the exploitation of nature resources. Madagascar has lost on all counts, while Brazil should go for new development models in order to ensure long-term sustainability.

Unlike Lomborg we do not second a view that uncertainty regarding precise figures should preclude us from letting a precautionary principle apply. This does not imply a stop to all deforestation, but that we should continue giving priority to forest and species conservation. For if we stand by, waiting for the eco-optimists to believe some manifest 'proof' while letting loss processes accelerate, then many of the damages will prove to be irreparable. We should start with a serious debate on developing methods for analysing the relations between ecology and socio-economic development. Under certain assumptions logging – occasionally amounting to ruthless exploitation – can prove itself to be feasible according to some forms of economic calculation. Yet the case of Madagascar (and possibly that of Brazil) seems to indicate that we must be extremely guarded in concluding more generally that deforestation is feasible in the long term.

One could choose to base a forest analysis exclusively on a quite generalized global perspective. In that case one would have to caution against the immense uncertainty that prevails for more than half of the developing countries. The notion that we know any-

hing much when it comes to the amount of existing forest in pre-historic ages is almost tantamount to guesswork. If notwithstanding one insists on referencing such uncertain figures, one should as a minimum make it clear that several mutually conflicting estimates exist – and not just a single figure.

The perspective advocated by the present article is a different one. Considering these matters from a local or national perspective will greatly increase our chances of reaching workable solutions, and could perhaps, over a number of years, contribute to a better understanding of the significance of the forest in a global perspective. Meanwhile there is every reason to make it clear that it is extremely difficult to produce any hard evidence in support of the optimistic 'things will work out' outlook. What use is it for lemurs of Madagascar – where all species are more or less endangered – to know that forest areas are increasing in Denmark, or that the global deforestation rate may be stagnant?

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5. MARINE RESOURCES

FISHERIES

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Once we used to believe that the fish resources of the sea were so abundant that we would never be able to deplete them. Today most of us are wiser than that. We know that over-fishing is possible and is actually taking place. But still it may come as a surprise to some that the vast oceans are actually not big enough to satisfy the fish requirements of a growing global population. Misconceived economic points of view can do more harm than good in the fisheries. Current economic mechanisms do not produce a balanced utilisation of fish resources. The same may be true of several other natural resources.

CATCH PER INPUT

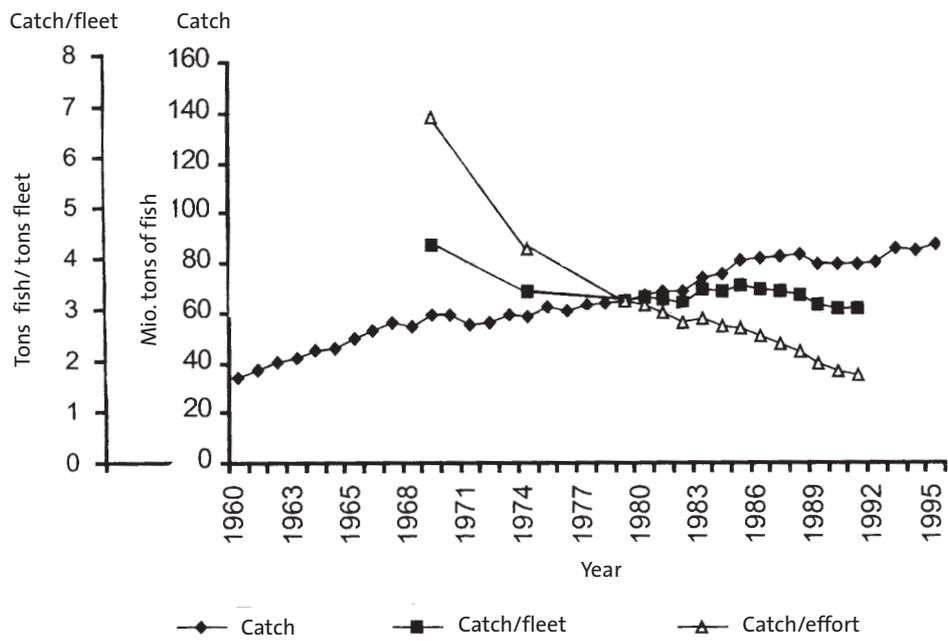
Let us imagine a fishing fleet of ten ships pulling their trawls along a sea area and catching a lot of fish. When they are done there are fewer fish in the sea than before. A few weeks later yet another fishing fleet of ten arrives, to pull equally great trawls through the same sea area. These fishermen are likely to catch fewer fish than the first fishing fleet, though with the same inputs because the number of fish per m³ of seawater is less than before.

Now, if those trawls were pulled through the sea in a rather random fashion, making the catches a representative sample of whatever is found in the sea, then the catch achieved at a given input would be directly proportional to the density of the fish stock in the sea. If for instance the first fishing fleet reduced the stock to 90 per cent its previous size, then we would presume that the next fishing fleet, at the same input, would catch 90 per cent of what the first fishing fleet did.

Although in real life trawls are not used randomly (since sonar etc. are used to localise shoals), one can still make a rough estimate of fish stocks by calculating the total catches / total inputs ratio. Input may for instance be measured by the total weight of all fishing vessels used, multiplied by the average number of days spent at sea.

Well, let us now have a look at the reported total yields of marine fisheries. In Figure 1 the "Catch" trace shows total yields of all marine fisheries globally, computed in million tons of wet weight landed to ports.¹ In the period of 1960-1970 yields increased on average by 5-6 per cent a year. However the increase plateaued around 1970 for reasons to be detailed later. In the 1970-1988 period the average increase was a mere 2 per cent a year, and since 1988 yields have fluctuated around a practically constant mean value, though with a slight upward trend of less than one per cent annually. Thus the spontaneous impression is a continuing increase over a long span of time, though with some trend towards stagnation. However the increase has especially been for the less valuable fish in terms of money.

Then how did fishery inputs develop? Figures are available for the world's total commercial fishing fleet in gross register tonnage¹, though unfortunately only for certain years. If dividing the total yield of global marine fisheries year by year by the total size



of the fishing fleet in the same years we find the points indicated as “Catch/fleet” in Figure 1. An initial decline is seen from 1970 to 1975, followed by a constant or slightly downward trend. This means that the annual amount of fish caught by a fishing vessel of a specified size has been constant or slightly falling.

However the size of the fishing fleet is not a fully valid expression of fishing inputs. Tremendous technical advances have been made both in terms of fishing tackle and equipment used to localise the fish, which means that a vessel of a given size is able to fish a lot more intensely than before. Estimates are that technical advances have contributed with nearly a factor of two to the fishing inputs from 1965 to 1980, and with another factor of two from 1980 to 1995.² If allowing for this, then catches related to fishing inputs have evolved as indicated in Figure 1 with the “Catches/inputs” symbol. Both that trace and the “Catches/fleet” trace are adjusted versions of the “Catches” trace with 1980 as baseline. (The unit of these traces is an arbitrary index). It is seen that if catches are indicated relative to the estimated fishing inputs, then we have a trace that has been declining rapidly since 1970 and continues to do so.

Thus total yields from marine fisheries are practically stagnant whilst fishing inputs are ever-increasing. More and more effort has to be put into maintaining the yield level. This serves to show that there must have been a heavy decline in marine fish stocks. Based on Figure 1 we can estimate that the total stocks of species fished in the oceans could possibly have dropped to approx. a quarter from 1970 to 1992. This is hardly surprising. Increasing yields from fishing will inevitably be linked up with a decline in fish stocks.

But along with that it also tells us that the situation is unstable. Certainly, by the yields from 1988 and after, one would be tempted to believe that a stable situation has been achieved, with more or less constant yields year by year. Yet the figures do not give away a trend for fish stocks to be steadily declining in the same period. This cannot go on forever, so we know for certain that at continuously increasing fishing inputs the yields-trace will peak and then fall back again. It is hard to say when that will happen; but there is much to indicate that we are close to the limit, in terms of how long increased inputs can increase the yields.

HOW BIG CAN FISHING YIELDS BE?

Though of huge dimensions, the oceans are not huge enough to cover a continued increase in our demand for fish. In 1969 a marine biologist published an estimate of the global production of fish in the oceans, and how large a share of that production would be available to man conditional upon a target of constant and sustainable yields.³ He based his estimate on the amounts of food available for fish in different parts of the oceans. The conclusion was that we cannot expect yields to go beyond approx. 100 million tons a year.

Present-day estimates, based on an assessment of the 200 major fish stocks in the oceans, arrive at the same conclusion.⁴ Out of the 200 fish stocks about 35 per cent were over-fished in 1994 (i.e. yields had gone down), 25 per cent were fully exploited, and 40 per cent were hardly fully exploited as yet. For all over-fished stocks, that is especially fisheries off the coast of Peru and fisheries in the Atlantic, we can compute how much greater yields were in the past. The result is approx. 9 million tons total. If fishing inputs were reduced, allowing stocks to recuperate, then the total fishing yields could perhaps be increased by approximately that quantity. Moreover the fishing resources of

the Indian Ocean are yet to be fully exploited. Here obviously the total yields can be increased by at least two million tons or so.

In 1994 total yields worldwide were at 83 million tons. When adding the nine plus two million tons we have an estimate of 94 million tons as the total amount that marine fisheries will be able to yield in the longer term. Further exploitable resources may exist in the Pacific and the Indian Ocean. If we include the most hypothetical ones we could make it to another 30 million tons or so, making the total global yields approx. 125 million tons a year. But presumably the round figure of 100 million tons is a more sober guess. It should be noted that such a figure cannot be achieved by globally increasing the total fishing inputs, but instead by redistributing inputs with cut-downs in some areas and slight increases in others. All in all the total global fishing fleet will have to face a considerable cut-back of its present size in order to achieve maximal returns.

THE BIOLOGICAL AND ECONOMIC OPTIMUM

It might make good sense to adjust the world's total fishing inputs to precisely the peak level of the aggregate yields curve. If we could do that, we would have found "The biological optimum" – which however is not identical with "The economic optimum". The economic optimum is always found at a lower input level than is the biological optimum. The economic optimum is the point where total net returns from fisheries are maximal. Once you have found that point an increase of fishing inputs beyond that point would indeed continue to yield more, by the amount of fish, but the increased running costs would exceed the rise in yields.

In a total view, for a rough average of all fish stocks, the world's fisheries are hardly far from their biological optimum. But has the economic optimum been exceeded? It has indeed. In 1989 FAO worked out inclusive estimates on the aggregate economy of the total fleet of large commercial vessels. The figures were as follows:

Economic gross returns	c. 70,000 million USD
Running costs	÷ c. 92,200 million USD
Profit and loss account, net	÷ c. 22,200 million USD
Interest and repayments	÷ c. 32,000 million USD
Deficit, total	÷ c. 54,200 million USD

Thus, as early as 1989 fishing inputs were big enough to not merely exceed the economic optimum, but to even produce a huge deficit in the accounts. When fishing is continued and even increased notwithstanding, this owes to state subsidies, compensation schemes and a range of other direct and indirect subventions². So whatever is going on is not rational from an economic viewpoint. How is that possible?

HOW DO INPUTS GET TOO BIG?

Things go wrong in the fisheries for a number of reasons:

1. A phenomenon known as "The tragedy of the commons"⁵ This situation can arise with a natural resource that is free for all to use. The more people using the resource, the less to be gained by each person. At the point when the use of the shared natural resource ('the common') has reached its economic optimum it will still be attractive for more persons to join in its use. They do reap some benefit from joining in; but at the same time they are reducing the total benefits available to all the others. Whenever an individual acts solely in his or her own interest, and not in

that of a community, the trend will be towards an ever-greater overrun of the economic optimum. At sea this can be taken so far that total fishing yields will actually decline (over-fishing). Obviously this is not the whole story since on its own such a mechanism would never drive the fisheries to the extreme of downright economic deficit.

2. Technology is an accessory to over-fishing. This is in part a technicality. E.g. in the early 1960s it was technology that made it possible to surround and catch a complete shoal of herring at a time (using a purse seine), which strongly contributed to over-fishing. Yet it is also a matter of economy. It is easy to see that if technical improvements take place and pull in the direction of more large-scale operations, then costs per fish caught will initially go down – thus creating an economic incentive that will push on towards developing a “tragedy of the commons” and get too many to join the fisheries.⁶
3. Speculative investment: The trend is headed towards ever bigger, more sophisticated and more expensive fishing vessels. In a period of increasing profits in the fisheries, optimism runs high and many fishermen will take high-interest loans to acquire new expensive vessels. There is a general trend for industries to make overoptimistic and foolhardy investments whenever they are riding on a surge of progress. This also goes for the fisheries. And they can only repay those loans provided the high fishing yields can be upheld for several decades. So whenever a fisherman wants his bank to grant him a loan, that bank should act in an economically responsible manner and contact biological expertise to inquire about the fisheries forecasts. However it does not, with a bad investment as the result. A few years later the fishery ‘peaks’ or ‘fails’, and experts say that fishing inputs must be reduced or discontinued altogether. But fishermen still have to pay their interest and repayments. So over-fishing goes on long after it has been identified.
4. As a rule more parties will take part in the same fisheries – several nations share a marine area, and the individual fishermen of each nation will compete. If one party holds back in order to save the fishing stock, then other parties may prey on the situation to increase their own share of the whole cake. As a result no one dares hold back voluntarily. The desired reduction to inputs can happen only if there is a superior authority with enough power to issue fiats. Where fishery commissions do exist it is often a matter of choice whether or not the individual parties comply with a commission’s recommendations. But the international fishery commissions suffer because individual national politicians vie for their voters by getting the others to make more concessions than they do themselves. The necessary reductions can only materialise if commission recommendations enjoy enough respect to be met, or if a supranational body (e.g. EU) has the power to punish violations with fines etc.
5. Fishermen cheat to some extent, landing larger quantities of fish than the quota would permit.
6. Occupational concerns: What are fishermen to do if they lose their jobs? Then the state will incur expenditure for unemployment benefits or to retrain those extra people made redundant.

OVER-FISHING EXEMPLIFIED

Certain environmental zealots tend to paint the situation in gloomy detail and talk about an imminent total collapse of fisheries worldwide. Lomborg ridicules such exaggerations (p. 95). But who is in the right?

By volume the most significant fisheries of the world may be those off the South American coast (Peru etc.) where in 1970 catches of anchovies rose to nearly 14 million tons – which is more than 20 per cent of the aggregate marine fisheries yields globally that year.⁷ But 1972 marked the onset of collapse, with stocks and catches plummeting to a mere tenth (approx.), followed by further slides a few years later. 20 years were to pass, until 1993, before catches were back to the pre-1970 level.⁸ This is the single most important reason why global yields from fisheries came to a sudden halt around 1970. Simultaneously however, collapses were seen elsewhere.

Spring herring off the coast of Norway provided rather constant yields of a good million tons a year up to 1967. It was the largest herring stock worldwide. But purse seining caused a collapse. Catches had to be discontinued altogether for a long while, and only in 1995 did they return to the previous level.⁹ Before the Norwegian herring was eradicated fishermen also embarked on the North Sea herring. Over-fishing started with a vengeance in 1965, which caused stocks to fall so low that all North Sea fishery for herring had to be banned in the period of 1975-1978. When fishing was resumed it once more led to over-fishing (though more moderate); from 1992 onwards the stocks have again been considered below the “minimal acceptable biological level”, and since 1995 “outside safe biological limits”¹⁰ Around 1970 the North Sea mackerel was fished so heavily that the stock plunged. This fish strain never fully recuperated.¹²

There are numerous other examples: Capelin in the Barents Sea; collapse in 1985.¹² Cod off the east coast of Canada; total stop to fishing in 1992.⁹ Haddock at Georges Bank off the US east coast; 1965 and later again¹¹. Herring, same location; total collapse in 1977.¹⁰ In 1994 parts of Georges Bank were closed permanently to fisheries². All fisheries in the Black Sea collapsed around 1989.⁶ Fisheries in the East China Sea and the Yellow Sea have been reduced to one-tenth of what they used to be.⁹ Add to these examples of actual collapses the many instances of heavy over-fishing, both in the Tropics, around the Antarctic, and in the deep sea. Moreover this does not go for fish only. The whelks at the coasts of USA and the Caribbean are being so heavily overexploited that temporary, and in some places permanent bans on their exploitation have been introduced.¹⁰ Shrimping in the Mexican Gulf is three times as heavy as it ought to be.²

THE IMPACTS OF OVER-FISHING

A collapse due to over-fishing may thus cause a stock to go so low that it cannot be fished for decades. In some cases there are indications that fish stocks will remain permanently at a low level. The total extermination of a marine fish stock would seem like an unlikely event. Yet there are in fact a few instances where entire stocks have been wiped out: The Californian stock of the giant bass, *Stereolepis gigas*, weighing about 400 kgs, the Irish Sea stock of common skate, *Raja batis*, and certain coral bass species in the Tropics.¹³

Furthermore such collapses can entail permanent ecological consequences. In the Black Sea, around 1989, there was an upheaval of the ecosystem in relation to the collapse of fisheries. So far the change appears to be permanent.⁶

There may also be widespread ecological consequences that are hardly of a lasting nature. Around 1980 the Barents Sea capelin would yield about two million tons annually. But by 1985 that was over. At the same time the Norwegian herring strains had also been fished to the extreme. As a result cod, seals, and sea birds of the Barents Sea did not have enough to eat and starved. This in turn caused reduced yields of the world's largest cod stocks. Cod and seals began eating shrimps instead, which caused shrimping to go down. Moreover many seals migrated to other regions. They took to the fiords of western Norway where they caused trouble, e.g. by ruining fishing tackle. A number of sea birds died. Thus the total impacts were quite widespread.

Collapse in the fisheries can also have economic impacts. A case in point is over-fishing cod in the Baltic. From 1981 to 1987 cod fishery was extensive in the Baltic, for one thing because during that period it was impossible to even strike an international agreement on quota. Moreover the reported catch volumes were unreliable, which made it difficult for biologists to offer any well-founded recommendations. Cod fisheries failed heavily, due in part to over-fishing, in part to environmental degradation of the Baltic Sea. It reached the bottom in 1992-93, at a yield of only some 10 per cent of the yield a decade before. The island Bornholm had benefited from the fisheries from 1981 and on: Investments were made, the fishing fleet nearly doubled its capacity, employment in the fleet rose with 14 per cent, and on-shore employment (fish processing industries) were up with 82 per cent. But then things went wrong. Many went bankrupt, which also caused Bornholmerbanken (a local bank) to fail. Looking at the 1981 launch of the cod adventure compared to the 1995 bottom line, the results were a nearly 50 per cent cut-back on the fishing fleet, employment at sea was down by 55 per cent, on-shore employment was more or less back to the old level, though the number of companies had been reduced. The social impacts on the island's community as such were vast.⁷

Fisheries for various cod species in the waters around the Faroe Islands suffered, in part because of over-fishing, in part due to changing sea currents. This caused a financial debacle in the Faeroes, followed by a banking crisis and the subsequent 'Færøbank scandal', which did much to compromise Danish-Faroese relations.

Perhaps the most far-reaching economic damage from over-fishing happened at the east coast of Canada, especially New Foundland, as a result of over-fishing cod stocks.⁹ In 1992 the Canadian government had to close down the entire cod fisheries. As a consequence 40,000 jobs in New Foundland fisheries and fish processing industries had to be closed down. Over a 5-year period the government had to allocate social benefits at 1.5 billion Canadian dollars.²

Lomborg cites environmentalist Lester Brown for saying that "oceanic fisheries have collapsed not just off the coast of developing countries ... but also off those of industrial countries".⁸ Lomborg demurs to such statement; but still it has indeed happened several places, as we have seen.

FRESHWATER FISHERIES AND OTHER FISH PRODUCTION

Total yields from the world's lakes and rivers are a lot less than those from the sea. The somewhat uncertain figures indicate that yields have gone from about 5 million tons in 1970 to 7.5 million tons in 1996 (also comp. Table 1). This includes various crustaceans and mussels. Thus there has been a continuous increase, though estimates are that all major stocks of freshwater fish are being fully exploited.¹² Moreover production is affected by pollution, fish introductions, etc.

A major contribution comes from aquaculture, i.e. fish-farming in net cages, pens, and basins, partly in saltwater and partly in freshwater. The FAO aquaculture statistics also include breeding of shrimp, mussels and other 'shellfish'. As shown in Table 1 fish-farming in saltwater is rapidly increasing, and so is freshwater fish-farming.

	1988	1992	1996
Catch of marine fish	82,3	79,4	87,1
Catch of freshwater fish ¹⁴	6,2	6,7	7,5
Yield of marine aquaculture ¹³	3,8	5,4	10,8
Yield of freshwater aquaculture ¹⁴	10,8	15,1	23,3
World, total	103	107	129

Table 1. Overview of the world's total fish and 'shellfish' production. Figures indicate million tons of live weight. For shellfish the non-edible shells are thus counted in. The 1996 contribution from shells was around 4 million tons.

A very large part of the world's total aquaculture production takes place in China (approx. 18 million tons in 1995).¹⁶ Their production is in large part carp that feed on waste from agricultural production, thus made useful as food for people. This form of fish production increases at the same pace as China's remaining agricultural production, so foreseeably production will gradually plateau at some point when agricultural yields stop increasing. Potentials for a similar production of carp allied with farming exist elsewhere in the warm regions of the earth, and production is in fact on the rise several places in the Tropics.

One of the biggest contributions to marine aquaculture is shrimp farming in the Indochinese and Indonesian region. Large coastal expanses, previously mangrove, are converted into shrimp basins. This implies a host of different environmental problems, and since the mangrove is vital as the reproductive area for fish fry one might fear that shrimp-farming is to some extent to the detriment of free-swimming fish that could be caught.

Present restrictions to the Danish production of fish from fish farms reflect two concerns, first to prevent fish diseases and second to limit pollution. Similar restrictions can be foreseen in a lot of other places worldwide.

FISH PRODUCTION IN RELATION TO WORLD POPULATION

In 1996 oceanic fisheries yielded approx. 87 million tons (Table 1), and as mentioned above we cannot expect yields to ever go beyond around 100 million tons. That would even require a considerable reduction of the fishing fleet to avoid over-fishing. Even adding yields from freshwater fisheries would not allow us to keep pace with global population growth in the future. In 1987 total fishery yield per person in the world reached c. 17.5 kg, and has since fallen to 16.4 kg in 1996. It will surely continue falling from now on.

We can also have a look at the total yield of marine fish, by adding the 'catch' and 'aquaculture' figures. We then find that during the last ten years total production has fluctuated between 15 and 17 kg per world citizen, without any obvious long-term trend. Only

by considering the entire fish production worldwide, including the large aquaculture production in Chinese farmlands can we arrive at an increasing per capita production of fish etc.

HOW CAN FISHERIES BE REGULATED?

It is a problem that in many parts of the world people are free to exploit the marine resources. There are various positions as to what should be done about it. One possibility is the introduction of national quota: Once a given nation has spent its quota it will have to suspend the relevant fishery operations for the rest of the year. It is also possible to introduce individual quota for individual fishermen, each of whom are entitled to utilise a specific proportion of the total national quota. Finally it is possible to grant exclusive rights to specific fishing populations, which are then assumed capable of managing their base of subsistence soundly. Moreover more general restrictions can be imposed, including provisions regarding mesh aperture and closure of specific marine areas to fishery.²

In practical terms, however, such measures have proved unable to prevent over-fishing – for a number of reasons. The most important part is that often no workable methods exist to define quota size. A quota system is useless in the absence of the necessary biological data, or if politicians fail to follow the advice of biologists. Moreover it is a problem that quota are being transgressed and/or that no effective compliance control is in place.

So far part of the problem lies with the fact that social aspects are not drawn into the decision-making process. The procedure should include calculations on the cost of scrapping fishing vessels, paying unemployment benefits to those left redundant, etc. Such costs will then be collated with the potential revenues from the fisheries, both in a situation of over-fishing and with a rather more long-term sustainable fishery. Thus, after weighing all the merits and demerits, chances are that politicians are better equipped to make decisions that are rational from a more overall perspective. All of this will require more grants for the bodies that are to provide the basic data.

Since 1995 or so the decision-making procedure has been tightened according to more general guidelines regarding the waters in the north-west European area. Quotas proposed by the biologists are now set so there is less than a 10 per cent probability of their being too high. What is more, in later years politicians have actually been seen to follow the recommendations of biologists.

In some cases it may make sense to leave decisions with local communities or authorities, and in a way that gives political leverage to both fishermen, local politicians and environmentalists, while accountable to the national governments in terms of complying with general provisions. In the many cases where it is obvious that fishing fleets are already oversized the relative governments can start buying up fishing vessels for scrapping. Globally a 50 per cent reduction of the total fishing fleet is required.²

THE BEST ADVICE POSSIBLE

No matter how we set up our economic and political systems, the plight of the fisheries cannot be solved without competent advice from biologists. In that regard Denmark is (to put it a bit proudly) one of the world's leading nations. It was a great advance when in the 1970s researchers of Danmarks Fiskeri- og Havundersøgelse (Danish Institute for Fisheries Research, DIFRES) prepared the so-called North Sea Model¹⁵, a data model of

the North Sea fishery. The general idea of the model was that the different fish species in the North Sea impinge on one another. E.g. if we 'sweep clean' some predatory fish species, then the smaller fish species they prey on will survive more easily. Instead we may then have a larger yield of those. Among other things the model served to counter the criticism of fishermen, who accused biologists of underrating the marked progress seen with some fish species when others had declined. The more certain forecasts were intended to lend more weight and authority to the biologists' opinions.

Unfortunately the North Sea Model proved to be of little service the first time around, for one thing because it lent itself to justifying Danish thrash fishery in the North Sea, which was abhorred by the British. As a result England was politically disinclined to recognise the Danish calculations. This in turn caused Danish researchers to enlarge the model's underlying data material with extensive biological mappings of feeding preferences of the individual fish species. This and several other adjustments improved the model's international credibility and its precision and predictive powers, so now it is increasingly used for practical purposes. Since then an equivalent Baltic Sea model has been set up.

Concurrently marine biologists in North Sea countries have also been reaping new experience in calculating and forecasting fishery trends, and on which basis warranted cautions can be issued. The big problem is that the size of individual fish cohorts vary greatly, depending on weather conditions, sea currents etc. E.g. there is no way of predicting if next year's herring or cod cohort will be big or small, because basically just one spring gale more or less can be all-important. This makes for some very large statistical uncertainties that will blur the picture. Only after decades of experience and data collection, forecasts have now evolved that are certain enough to give them a certain political power of persuasion.

The increased responsiveness to the forecasts of biologists also owes to the fact that a few things happening in recent years are repeats of previous events. For instance the North Sea herring has already been over-fished once, and in the 1990s that was about to happen once more. Yet this time around biologists could point out what happened last time when their warnings were ignored. Moreover the present situation is comparable to a previous situation, so and so many years before the fisheries collapsed the last time.

In addition new analytical methods are now available that more unequivocally indicate the risks. A case in point is the North Sea cod fishery, for which it was demonstrated in 1997 that if catches equalling 50 per cent of the stocks are made in the beginning of the year, yields will be maximal also in the long term; but if you go up to 55 per cent the stock will collapse over a rather brief span of years.¹⁶ Thus we have a much narrower margin for errors than previously presumed. A mere ten per cent increase of catches, from 50 to 55 per cent of the stock, could take us right from an optimal to a disastrous scenario.

As long as fishery prognoses are marred by major uncertainties in terms of statistics and methods there is considerable leeway for adducing all kinds of pretexts for ignoring the advice of biologists. If fishery yields go down, people may for instance blame it on adverse climatic conditions in specific years, instead of over-fishing. If biologists overtly present findings with a large margin error, then politicians will mostly trade upon that margin error and argue in favour of easing the quotas. But as a result of

investment in robust biological advice the forecasts obtained today are so good that fishermen and politicians can hardly oppose them.

The fishing waters off north-western Europe are among the world's most plentiful, and at the same time we have a more comprehensive data collection and advisory system than other regions of the world. We can and should take advantage of that situation to create the largest possible sustainable fish yields on the longer term. And also, there is no alternative to using that knowledge. No matter what kind of political or economic management system one may favour, it will be lost without good fishery prognoses to tell us how big next year's quota should be. In most other places of the world – especially in the Tropics – the situation is less fortunate, so they will have to make do with far less sophisticated regulatory measures.

THE PRECAUTIONARY APPROACH

An analysis of North Sea cod fishery (comp. above) showed that the gap between optimal and disastrous utilisation is only some ten per cent. That implies that things can go all wrong if politicians choose to raise the quotas recommended by biologists by a mere 10 per cent. In this case the margin of error is uncannily small.

Such circumstances should invite the greatest circumspection. It was therefore an obvious thing for FAO to prepare guidelines for a measured behaviour. These include the principle of the precautionary approach.¹⁷ We could also call it the precautionary principle. But since the notion of a “precautionary principle” is quite controversial, i.a. in relation to social and economic costs, it is preferably known as the principle of precautionary approach – a term suggesting that social and economic considerations are included.¹

The principle implies the use of “due foresight”, even where very limited knowledge is available. More specifically it means

- showing regard for the requirements of future generations, and avoiding irreparable changes
- launching necessary corrections to previous practice without hesitation
- drawing upon the best scientific knowledge available
- only using resources in harmony with the estimated sustainable level.

A particular issue is the burden of proof. The principle implies that in the event of incomplete information and high risk the burden of proof will rest upon whichever person(s) plan to exploit a natural resource for purposes of personal profit.¹ Thus whoever wants to make money e.g. on fishing, will have to prove that the fishery will not carry irreparable damage in the longer term.

HOW FISHERIES CANNOT BE REGULATED

It is a widespread conception that a combination of private property rights and liberal economy make for the best possible use of available resources. Fishery is an interesting case since perhaps it is the industry where such a view is most blatantly a misconception.

Part of the idea of private property rights is to subdivide resources into “territories”, and then let the individual agents exploit their territories at their possible best. When it comes to fisheries this implies that each agent – e.g. each nation – is allocated the stewardship of a specific marine territory. However there is a hitch, namely that fish tend

to cross territorial boundaries. A still greater problem is that even within each "territory" a liberalist economy, alien to state intervention with quota, control, fines etc., will lead to over-fishing. As already mentioned North America has been relatively poor at regulating fisheries, notably in the Atlantic, with total collapse of several fisheries as the result. The profounder reason of their failure could be precisely their reluctance to effective intervention by state governance.

One of the problems with liberal economics is the great weight attached to calculations utilising a certain predefined rate of interest. The most common of these is the calculation of net present value, in which investments of different life-spans are compared by calculating the value today of future incomes, also known as discounting. If trying to analyse fisheries by discounting calculations we risk ending up with absurd results. An illustrative example is a calculation example in which we consider two options for an imaginary fish stock: We can either exploit it sustainably, so we sustain constant yields year after year forever. Or we can over-fish it heavily for ten years, after which it will be totally wiped out. We are now to select the rate of interest to be used in our example. An interest rate of 3 per cent is selected, since this is close to the average real rate of return in Denmark, considered over a period of almost 200 years. If we selected a higher rate of interest, e.g. 5 per cent, considerations for future resources would carry even less weight, and the outcomes would be even more absurd than those below.

In our example the level of sustainable economic returns could be set at, say EUR 4,000 per km² of marine area. Using that figure the net present value of the said stable yield, year after year into an infinite future, would sum up to a total of approx. EUR 133,000 per km².¹⁸ With heavy over-fishing of the stock yields can realistically be forced up four-fold, that is to approx. EUR 16,000 per km² for ten years. The net present value of those high yields over ten years will amount to approx. EUR 136,000 per km² and thus only just exceed the first figure. So the result, even at an interest rate as low as 3 per cent, is that there is more profit to be gained from ten years of four-fold increased fishing yields than from normal yields in an infinite future.

Obviously the above figures are hypothetical, though quite realistic. They are just to illustrate the point that the said calculation method can produce absurd results. Thus, if uncritically using their conceptions on the prioritisation of society's monetary resources, economists can easily 'prove' that forever wiping out all fish of the sea would actually pay. In such a mindset the idea is that the money earned during those ten years of fishing can just be invested in something else afterwards (e.g. fish farms), and then we will just be producing our food in a different way. In terms of economics one way is no better than the other.

The flaw in those economists' perspective is that money is made the mother of all prioritisation, and that money is seen as the sole limited resource. In Lomborg's words: We have a limited amount to spend, so the question is how to invest it the best way possible.

However there exists a different perspective based on conceptions such as area or natural resource. Under that perspective one would say: We have a marine area of say one million km². Now the question is: How to best husband that marine area in order to feed as many as possible in the long term? This approach basically stipulates yields to be the same each year, so the point is how to maximise each annual yield.

Both angles are familiar in economics. For instance forest management can be analysed based on either angle. Both are appropriate in specific situations, in forestry and in fishery as well. If we have a practically infinitely great marine area at our disposal, though little money to invest, then it makes sense asking how to best invest that money. By contrast, if we just have a single marine area that will only provide a limited fishing yield in relation to requirements, and if we also have plenty of money, then the sea – and not the money – is the most limited resource, and in that case our question should be: How can we manage the sea in the best possible way?

In today's world, with limited natural resources and a large population, the latter angle is the most relevant. As said already there are not sufficient fish in the sea to meet the requirements of a constantly growing global population, which makes the entire global sea a limited resource. Therefore, before anything, we have to make the area or resources angle our starting point, and not the money perspective.

In fisheries the road to maximal yields rests on ever better and more certain forecasts, based on ever more sophisticated field studies and data models, combined with strict observance of the recommendations set forth by experts. Would it not be reasonable to assume that the same goes for other natural resources, which are renewable if only we manage them with due foresight? Perhaps the principles that have been thoroughly studied in the fisheries should also serve as a general model on how to use other natural resources.

COMMENTARY ON LOMBORG'S FISHERIES SECTION

Lomborg acknowledges that a large part of the world's fish stocks are actually over-fished, that yields could be increased if we could avoid over-fishing, and that the fisheries are hard to regulate. Consistent with our present knowledge he says that "Right now we only catch about 90 million tons, the missing 10 million tons being the price we pay for over-fishing the seas."

His comments are that 1) missing out on 10 million tons of food is not a problem, because production is strongly increasing in other respects, and 2) that the total production of fish for human consumption is on the increase because of a marked increase in fish-farm production, which more than outweighs the fall caused by over-fishing. His view is that it does not matter to us if the fish we eat has been swimming in the sea or in a fish farm.

But then, is there anything like a basic difference between the fish provided in one or the other way? Yes, there is. Above anything fish are valuable to us as sources of protein. The fish caught free-swimming constitute a source of proteins that we would otherwise not be having, proteins extracted from the sea and the lakes. By contrast, most pond-farms rely on fish feed containing protein, thus drawing upon proteins that are already 'there' and are then fed to fish in order to "improve" them, with a certain loss during the process. Thus fish caught in the wild will increase the amount of proteins available to man, while pond-fish will rather consume proteins.

More specifically, regarding Chinese fish-farms, it is of course a good thing that waste products are being put to use by letting fish take up residual nutrients. Otherwise such wastes would be lost. But those waste products come, directly or otherwise, from farm production, so the fish farms are only feasible by virtue of agriculture. In principle it is of no consequence whether agricultural wastes are fed to chickens, ducks, or fish. Basi-

cally it all amounts to agriculture and is irrelevant to the fish resources of seas and lakes.

When it comes to regulating fisheries Lomborg's knowledge is evidently very scant. He mentions the potential regulation of extending fishing territories, and otherwise all he has to suggest is that "the state can (through permits, for example) make sure only the optimal amount of fish is caught." But, as shown in this chapter, the state cannot "make sure" just like that. This is an extremely difficult exercise, both professionally and politically. It requires the intensive work of marine and freshwater biologists, it requires developing complicated data models as means of control, it requires politicians to listen to biologists and take their advice, and it requires using the precautionary principle. This runs completely contrary to everything else that Lomborg advocates, namely to plainly ignore pessimistic biologists and under no circumstance follow the precautionary principle. If politicians in northern Europe had taken Lomborg's advice, things would have gone at least as bad with our fisheries as with the fishery off the east coast of North America.

It is a pity that Lomborg has such shallow understanding of the problems of fisheries, for if he had delved somewhat more into the subject he might have come to realise that there are fields where his economic lines of thought will not make the day.

Lomborg's final conclusion reads, "We have become richer and richer primarily because of our fundamental organization in a market economy and not because we have worried." ... "More food is available in the world not because we have worried but..." These citations obviously do not fit the situation in the fisheries. Quite the contrary. If we are thinking of the cod yields in the North Sea or the Baltic the situation is that the fundamental organisation of our market economy is driving a 'devolution' towards lower yields, i.e. less food – while 'worrying' about the future, by trying to prognosticate with data modelling and introducing restrictive quotas, lead to higher yields, and in the end more food. When it comes to fishery things are diametrically opposed to the views held by Lomborg.

- 1 FAO (1995): The state of world fisheries and aquaculture. 57 pp. FAO, Rom. Augmented with 1994-1996 FAO data.
- 2 P.M. Mace (1997): Developing and sustaining world fisheries resources: The state of the science and management. Pp. 1-20 in D.A. Hancock, D.C. Smith, A. Grant & J.P. Breumer (eds.): Developing and sustaining world fisheries resources: the state of science and management. 2nd world fisheries congress. Proceedings. CSIRO Publishing, Australia.
- 3 J.H. Ryther (1969): Photosynthesis and fish production in the sea. *Science* 166: 72-76.
- 4 FAO (1997): Review of the state of world fishery resources: marine fisheries. FAO fisheries circular no. 920 FIRM/C920. www.fao.org/WAICENT/FAOINFO/FISHERY/FISHERY/publ/circular/c920/intro.htm.
Comp. also R.J.R. Grainger & S.M.Garcia (1996), *Chronicles of marine fishery landings (1950-1994): trend analysis and fisheries potential*. FAO fisheries technical paper no. 359.
- 5 G. Hardin (1968): The tragedy of the commons. *Science* 162: 1243-1248.
- 6 K. Fog (1997): Økologi – en grundbog. 423 pp. Gads Forlag. Kapitel 12. [Ecology basics; in Danish]

- 7 FAO (1994): Review of the state of world marine fishery resources. 136 pp. FAO fisheries technical paper no. 335.
- 8 R. Grainger (1997): FAO fisheries department. Recent trends in global fishery production. www.fao.org/WAICENT/FAOINFO/FISHERY/trends/catch/catchf.htm.
- 9 Data from DFU [Danish Fisheries Investigations].
- 10 F. M. Serchuk, E. Kirkegaard & N. Daan (1996): Status and trends of the major roundfish, flatfish and pelagic fish stocks in the North Sea: Thirty-year overview. *ICES journal of marine science* 53: 1130-1145.
- 11 S. Jennings & M.J. Kaiser (1998): The effects of fishing on marine ecosystems. *Advances in marine biology* 34: 201-352.
- 12 FAO (1995). Review of the state of world fishery resources: inland capture fisheries. FAO fisheries circular no. 885. 63 pp. Comp. also notes 2 and 4. Figures in Table 1 are in part interpolations.
- 13 FAO (1997): Review of the state of world fishery resources: Marine fisheries. FAO fisheries circular no. 920 FIRM/C920. www.fao.org/WAICENTFAOINFO/FISHERY/FISHERY/publ/circular/c920/C920-1f.htm.
And FAO (1998): China's underestimated national aquaculture production and global contribution addressed and rectified by FAO. www.fao.org/WAICENT/FAOINFO/FISHERY/trends/china/chinaef.htm.
- 14 FAO (1997): Review of the state of world aquaculture. FAO fisheries circular no. 886 FIRI/C886. www.fao.org/WAICENT/FAOINFO/FISHERY/publ/circular/c886.1/C886-1f.htm.
- 15 K.P. Andersen & E. Ursin (1977): A multispecies extension to the Beverton and Holt theory of fishing. *Meddelelser fra Danmarks Fiskeri- og Havundersøgelser* 7: 319-435.
- 16 R.M. Cook et al. (1997): Potential collapse of North Sea cod stocks. *Nature* 385 (6616): 521-522. I have converted the figures on fishery mortality (F) given in the paper to percentage catch of the stock at the beginning of the year. The paper predicts a collapse of the cod stock. This did not happen for the very reason that the forceful warning caused decision-makers to take the biologists' advice, and the cod stock in the North Sea is once more increasing. If progress continues we can anticipate a two-fold rise in fishing yields.
- 17 FAO (1995): Precautionary approach to fisheries. Part I: Guidelines on the precautionary approach to capture fisheries and species introductions. FAO fisheries technical paper 350/1. 52 pp. Here cited from note 2.
- 18 Despite an infinite period this ends up a final figure, because when discounting back the yields in a remote future will in practice be zero, computed as net present worth.

6. CLIMATE CHANGES

DISCOURSE IN THE GREENHOUSE

By Jesper Gundermann, M.Sc.¹

CONTENTIONS OF THE CLIMATE DISCOURSE

Denmark has been favoured by a relatively balanced discourse on the climate issue. Changing governments have largely carried on the policy set out in 1990, and other main stakeholders, such as industry, power companies, political parties, interest groups, and the media have by and large backed the aims and legitimacy of the policy, though not always its instruments. This has not been the case in every country.

Particularly in the USA, a rather more implacable debate has raged, during which lobby organisations via so-called think-tanks have pulled the strings to shake the basis of a serious effort. Has this state of affairs finally reached Denmark? There are signs that it has. At least, it is striking that a considerable 'recycling' of arguments is in evidence. Practically all arguments presented by Bjørn Lomborg and his undergraduate students have already been advanced on the websites of American greenhouse sceptics.

Since this 'recycling' practice is presumably far from over, I would – as a preventative measure – go through and comment on a few of the most frequent arguments.

- 1) **CO₂ concentrations are not at all on the rise – faults at the Hawaiian measuring stations produced systematical errors!** This argument can be refuted fairly easily, since available data from many other places on Earth follow the Hawaii measurements (apart from the magnitude of seasonal swings being different). Moreover, measurements from ice core drills demonstrate an increase for more than a century before the start of the Hawaii measurements.
- 2) **Increased concentrations were not necessarily caused by manmade/fossil emissions!** This argument is rather special in that, for quite a while, the problem posed to science has been the reverse, namely accounting for what actually became of the carbon emissions – a problem referred to as 'the missing sink'. Obviously, this problem will increase, and not decrease if completely different sources of increased atmospheric carbon exist. However, more recent studies show that the missing amounts were likely absorbed by forests in the northern hemisphere, such that emissions are presently absorbed at approx. 20 per cent to the land-based biosphere, 25 per cent to the oceanic biosphere, and 50 per cent to the atmosphere. Incidentally, it appears from the isotope composition of carbon dioxide in the atmosphere and the sea that the increase in the atmosphere owes to manmade emissions, and not to an altogether different mechanism. It is correct that some uncertainty still prevails regarding the individual items of the carbon balance, of a magnitude of +/- 0.5 to 1.0 billion tonnes. All the same, a claim that manmade emissions (presently amounting to approx. 7 billion tonnes of Carbon annually) are not the main contributors to the increasing atmospheric content plainly conflicts with a great number of independent data and methods used to establish the items of the carbon accounts.
- 3) **Natural carbon flows are so much bigger than manmade flows – so presumably a**

small change must be immaterial! In support of this view it is often adduced that the annual ocean/atmosphere carbon interchange amounts to some 100 billion tonnes, while manmade emissions are a mere 7 billion tonnes annually. However, the hitch of the 100 billion is that they take into account that carbon dioxide in the top layer of the sea is constantly changing places with the carbon dioxide of the air, simply because there is a near-perfect equilibrium between the two reservoirs. (If the content increases for one, it will only take a year for the increase to distribute to both reservoirs.) By contrast, the net interchange between atmosphere and sea is just 1-2 million tonnes, and thus far less than manmade emissions. The reason is that the transport to the deep-water, and not the interchange with the surface layer, is the bottleneck of marine uptake.²

- 4) **Plant growth increases with increasing CO₂ concentration, and thus increased emissions will be absorbed!** The IPCC³ projections include the increased plant uptake, and are moreover extrapolated into a remote future. This implies that the carbon content of the terrestrial biosphere would increase by 20-25 per cent over the next hundred years! Really, this is somewhat optimistic, since there is a real risk of large-scale carbon release from forests (once existing forests – given the foreseen climate changes – will suddenly find themselves outside their proper climatic ranges), and more generally from the accelerated turnover of dead biomass caused by increasing temperatures. However, in conclusion: There is a considerable uptake today, which is taken into account by projections, yet which will far from neutralise the manmade emissions, and the uptake could very well decline over time, or turn into a source of net emissions.
- 5) **Manmade greenhouse gases merely account for a negligible part of the atmosphere's aggregate content of greenhouse gases, the principal greenhouse gas being water vapour.** Therefore, the additional warming caused by CO₂ and other greenhouse gases would rather compare to topping an eiderdown with a thin sheet! The argument uses a familiar stratagem: invoking common sense that would let anyone understand that probably the unnecessarily complicated explanations of researchers cannot be trusted. Yet the argument is flawed since water vapour content is largely determined by temperature, and will thus follow suit with the warming caused by other greenhouse gases: Increased warming from CO₂ and other greenhouse gases produces higher temperatures, which in turn produce more water vapour and hence more warming, etcetera.
- 6) **If the emission of greenhouse gases was to blame for the observed temperature rise, it is indeed strange that a large part of the temperature rise happened before emissions arising from the combustion of fossil fuels gathered momentum around 1940!** It is rather transparent how the argument was originally thought out, its main point apparently being a blanket acquittal of emissions from fossil fuels. Yet, the argument is flawed in more than one sense: First, it ignores the fact that to the best of our knowledge, the greenhouse gas content of the atmosphere has actually been on the rise since the 1700s, as a result of increased logging, farming, and animal husbandry. Indeed, using typical climate models, it has been calculated that around half the temperature rise attributed to greenhouse gases had already happened by 1940. Moreover, the argument postulates that there is a problem for the greenhouse theory, if actual temperature developments do not narrowly coincide with the predictions based on the global warming theory. However, no climatologists would dispute the existence of other origins of temperature swings, such as

volcanoes, solar influence, internal swings caused by sea-and-atmosphere couplings, or just an intrinsic variability due to the chaotic behaviour of weather systems. Precisely because manmade impacts are only just beginning to have the same magnitude as natural variability (which, incidentally, is difficult to determine based on observation across very long time spans), we have to resort to other methods to conclusively demonstrate a man-made global warming. *Thus, the argument of the lacking precise coincidence between temperature and emission just serves to showcase a familiar argumentative strategy: First you put forward a caricature of the issues at hand, after which you try to explode the caricature.*

7) Researchers agree that there will eventually be another glacial period, and by then, we will sure be glad of a global warming! The next glacial period is expected to begin within the next 5-10,000 years^{4,5}, whilst the manmade greenhouse effect will appear over the next few centuries. *This renders a comparison completely irrelevant.*

1. It is seen that the above array of pseudo-arguments builds up to a 'flexible retreat'. If you lose an argument somewhere, you will just proceed to the next one. Presumably, this is what management scions call *damage control* - which is precisely what it is: None of the proffered arguments would ever stand a chance if put forth in science literature! Yet, the fact that such arguments are advanced notwithstanding leaves a serious suspicion that superficial *second-hand knowledge* is being peddled *under the misleading label of research.*

2. As part of the 'flexible retreat' many arguments today centre on showing that the future greenhouse effect, although real enough, is overstated. This also goes for the representation of *The skeptical environmentalist.*

SCIENCE MEDIATION VERSUS JOURNALISM

Compared to the Danish first version of Lomborg's book ('The true state of the world'), the presentation of the greenhouse issue has been improved in *The skeptical environmentalist*, and the author chose, with impressive assiduousness, to quote more extensively on the many complex scientific issues, apparently using much energy sifting out the reports of the IPCC.

But be it said anyhow: It remains a second-hand representation that does not appear to be based on first-hand knowledge of research – neither that of others nor the author's own – and one that uncritically persists in retailing familiar pseudo-arguments. Therefore, anyone wishing to obtain a deeper knowledge of the issues involved is advised to proceed with the reports of the climate panel, instead of taking a detour with Bjørn Lomborg.

For instance, he relates the story that greenhouse warming does not 'align with' the temperature curve (a modified version of the above argument #6), because the global mean temperature increased mainly in two periods, from 1910 to 1945 and from 1975 until today. This is by no means a problem for the greenhouse theory, which does not pretend being the only source of temperature variations. Already the fact that the climate system is a chaotic system means that it can easily vary on several time scales, also in the absence of influence from manmade changes or extrinsic variations, such as volcano eruptions or changes in solar activity⁶. Actually, climate swings that are hardly distinguishable from those found when we subtract a greenhouse warming from the observed temperature series occur already in current climate models, both exceedingly

simple ones⁷, and the more complex GCM models⁸. Thus models including greenhouse gases, sulphate aerosols and an (uncertain, yet modest) influence from volcanoes and solar variations today appear to be able to represent the historic data almost as closely as they go, if considering internal variability⁹. A complete coincidence will never be possible, since the observed curve represents only one possible development of the climate system (and one also subject to some uncertainty, notably for older measurements).¹⁰ Today's climatology research is aware of the presence of slower internal swings, e.g. the familiar El Niño phenomenon, the North-Atlantic oscillation and more, ascribed to non-linear couplings in the ocean-atmosphere system. Some of these are reproducible, while others are not as yet.

However, being able to reproduce a single temperature curve for the observed global mean temperature is not where the greenhouse theory will stand its test.

The greenhouse theory is not an isolated theory, but a puzzle of a multitude of pieces, each of which can be subjected to independent tests, in which each climatological variable is collated with observations, and including temporal and spatial variations, with the purpose of perfecting the realism of each piece, and adding on new pieces wherever required.

By the lay person, the word "theory" is sometimes interpreted as synonymous with "hypothesis" or even "speculation", a fact cleverly exploited by many greenhouse lobbyists, but to scientists, the greenhouse theory is rather more analogous to the physicist's "standard model" of how the world works, i.e. the best synthesis of all present knowledge of the climate system. As such, an incredible body of science should be all wrong for the greenhouse theory to be fundamentally false. Nevertheless, the complexity of the system is so immense that considerable uncertainty remains concerning many details, such as modelling of cloud processes, which are unfolding on too small a scale to be explicitly resolved in present models.

Lomborg describes the great uncertainty, how fraught with difficulty climate modelling is, etcetera. But the same things can be read in the IPCC reports, in which detailed accounts are given on all research findings, including conflicting results that call for clarification.

In this context, it is odd that apparently Bjørn Lomborg (*the statistician*) can resolve many of the moot issues that are in focus for climate research. However, disappointingly, our sceptical environmentalist does so by picking a few research results, then to elevate them to The Penultimate Truth.

For instance, for the sun, our sceptic is absolutely positive that the theory on impacts via cosmic radiation 'can account for temperature developments from 1860 to 1960'. However, his source is not wholly undisputed. For myself (unlike the sceptic), I have co-authored a scientific paper showing that the likely solar contribution would rather be of a magnitude of 0.2 Deg C, which is the result when we consider both a hypothetical solar impact and the greenhouse effect, which accounts far better for temperature developments. By contrast, the greenhouse (minus sulphur aerosols) stands for the lion's share of the rest, that is around 0.4 to 0.6 Deg C today – estimated from the raw data referenced by Bjørn Lomborg, but given that a balanced analysis is worked out. This result narrowly coincides with the conclusion of the Climate Panel. Moreover, the sceptical environmentalist relates that, judged by satellite and radio pro-

be data, tropospheric temperatures do not increase at the rate of the surface temperature, when considering the 1979-2000 period. However, he fails to note that trends in radio probe data and surface temperatures appear to go together nicely (as predicted by most models) over the longer time span from 1958 to 1993. He also fails to cite that apparently volcano eruptions and El Niño impacts can account for the discrepancy in the shown period (which is very short in terms of determining long-term trends), which in addition is only seen for certain marine areas. Hence the stage is set for our sceptic's pronouncement: To all appearances, CO₂ warming is overstated, since without rising temperatures there is less water vapour feedback. This is a truly wonderful specimen of a contrarian pseudo-argument. Appealing to common sense and feigning respect of the science it builds on, the mental model is that 1) increasing temperature gives increasing water vapour, 2) water vapour enhances the greenhouse through positive feedback, and hence: that slower increasing temperatures in the troposphere over time implies a weaker greenhouse effect! Unfortunately, this is all wrong! Climatologists say that if models underestimate the drop in temperature with height (as would be implied if models underpredict tropospheric temperature increases), they would underestimate the greenhouse effect.^{11,12} Obviously, any climate scientists will be quite wary of a possible discrepancy, and consider its implications – while Lomborg already knows the answer!

I will spare the reader any further exposé of an inadequate and misleading representation and proceed to commenting on a more fundamental shortcoming:

THE GREENHOUSE EXPERIMENT

The fact is that Lomborg's ignorance of climatology transpires most blatantly in his poor understanding of the fact that we are facing an unprecedented phenomenon, namely 'a global experiment', with humanity as such as its guinea pig. This clearly owes to his surmised thesis of 'the Litany' being overstated, which of course blocks him from discussing what we are to do if the experiment eventually takes a worse turn than we hope.

However, with our present knowledge, the climate change we might risk to face – especially if the world were to go along with Lomborg's recommendations – could well be of a magnitude completely unheard of since mankind invented agriculture.

Lomborg relies exclusively on projections in which climate changes progress linearly, i.e. in which a doubling of climate influences from greenhouse gases causes a doubling of climate impacts.

In such scenarios, it could be that agricultural production will not suffer from a few degrees of temperature change. But unfortunately, it is not a foregone conclusion that this is the development we will see.

We cannot preclude, on a scientific basis, that we may be facing temperature rises of a magnitude that compares to the rise in mean temperature since the last Glacial Age, which was approx. 5 Deg C. This completely transformed Planet Earth, from a state with kilometre-thick ice across Northern Europe, and an unpleasantly dry, cold, and windy climate in most places on earth. Even if we cannot compare directly, because future climate changes will go the other way, this tells us that such changes would be immense.

When considering the CO₂ concentration we can foresee a hundred years from now, we

actually have to go 20 million years back to find anything of a similar order. How ecosystems will adapt, should we see such immense changes over just a hundred years, is in fact a question that researchers today cannot answer with any degree of certainty.

Alone the CO₂ change may turn out a problem: In large parts of the tropics, plant growth (including many grasses) is based on the so-called C₄ plants that evolved as a response to a gradual fall in CO₂ concentration on Earth. These are plants that utilize CO₂ better than C₃ plants, yet only at low concentrations. Given the envisaged temperatures and CO₂ concentrations, we must expect a gradual replacement of large parts of the tropical ecosystems. What is more, precisely the ecosystems (including the savannah) that would thus be undermined are those that were once 'the Cradle of Mankind', which serves to illustrate the scale of the experiment.

Another example is the calcareous organisms, both corals and the many plankton species that form calcareous skeletons. These organisms are pivotal to the global carbon metabolism, as well as the functioning of many marine ecosystems. However, it has been demonstrated¹³ that many of these species cease to produce calcium at elevated CO₂ concentrations, possibly because – in terms of thermodynamics – forming a calcareous skeleton becomes an increasingly 'uphill' task in an increasingly acidic environment. Grotesquely, this may be one of our planet's mechanisms to remove the problem of manmade CO₂, in that reduced calcification rates causes the alkalinity in the sea surface to rise, thus causing the CO₂ to drop. It is possible to calculate that this will let us emit a few more billion tonnes of carbon, equalling a few years' emissions, for the same increase in concentration. However, the implications for marine ecosystems remain largely unresearched! And unfortunately, this regulatory mechanism is far from geared to removing an abrupt disturbance such as created by manmade emissions. Research rather seems to indicate that this will require something in the order of 100,000 years.¹⁴ It generally applies that the reactions of the biosphere to climate change are poorly understood. Certainly models are beginning to emerge that can study how equilibrium vegetation will change with changed climate zones. However, from where we stand and to describing how the transition will be there is a very long step, yet to be taken. When the northern range of the beech will be far up in Scandinavia, how then will pines fare? Will we see sudden bursts of tree diseases and infestations, rampant forest fires, or...?

In the context, it is worth noting that Lomborg understates future climate changes by indicating that after all, the coldest temperatures (nightly and in the winter) will rise the most, and everyone likes warmth, so what is the problem? The problem is that this does not necessarily hold for all species, and that changes in the natural ecosystems cannot be predicted. In illustration of the potential scenario we should mention that the Hadley Centre, in a new combined biosphere-cum-climate model, has predicted that, due to drought in e.g. the Amazons, the latter half of our century will see an increase in forest fires, actually implying that global uptake, presently at approx. 2.5 Gt (about a third of the manmade emissions), will change to being a net emission. We will not have to extrapolate this emission curve into a very remote future before ending up with a situation that could go beyond control – or, to put it differently, a point when mankind can no longer compensate just by cutting emissions further – simply because the natural emissions have taken over. We would have sent the snowball rolling, and be left with no other option than to wait and see where it goes. Other models arrive at less dramatic, yet similar trends.

However, it stands that temperature rises, e.g. from the time the last Glacial Age ended,

were accompanied by increasing concentrations of both CO₂ and methane.¹⁵ It also stands that researchers have a long way to go before they will have a detailed understanding of these mechanisms despite a number of contestants (emissions from melting tundra areas, increased decomposition of soil carbon at elevated temperatures, ecological drifts in marine systems). If coming climate changes are going to produce similar effects, we will have a positive feedback to be added on top of the scenarios presented by the climate panel. For it is a fact that only very recently are attempts being made to include such mechanisms, comp. the model of the Hadley Centre mentioned above.

The sceptical environmentalist is positive that future emissions will be in the low range of the possible global scenarios assessed by the IPCC, despite the fact that the panel precisely states that they are spanning the entire, immense outcome space of the future state of Planet Earth, given the difficulty of forecasting a hundred years from now. But on this basis, Lomborg then elects to have blind faith in his preferred -scenario calculations and in impact assessments quoted by the climate panel, regardless of the panel's *caveats* – practically on every second page – of how little control we really have of those connections, and notwithstanding that many possible feedback mechanisms are yet to be included.

Over the years, the panel has persistently downplayed vivid detail in their descriptions of potential risks, for one thing to avoid incriminations of horror-making. And government representatives on the panel have been equally persistent in requesting more information on the risks of unpleasant surprises, simply because the purpose of the Climate Convention is to prevent dangerous manmade climate changes.

However, the latest statement of the IPCC had considerably extended the sections on potential surprises. In addition, the US National Academy of Science (NAS) has published an elaborate report, dealing exclusively with the potentiality of abrupt climate change.

The backdrop is in part that over the last ten years, research has obtained a far better overview of paleoclimatology, i.e. our knowledge of pre-historical climate. What leaps to the eye is that apparently the climate system can undergo sudden rebeddings in which a small or very gradual change will suddenly trigger a rapid transition to a new state. The triggering factor may be a coincidental natural variation, but the true reason is that the system can have several stable states, so a shift can be triggered whenever extrinsic impacts reach a certain threshold. Further, it is found that the climate system has displayed hysteretic behaviour, which means that a far greater change in extrinsic influences is required to make a system rebound to its previous state. In practical terms, this implies that changes are irreversible.

The most well-known example is that deep-water formation in the Northern Atlantic can apparently come to a sudden stop, which happened countless times in the past. This led to colder climates in large parts of the world, yet most markedly in the areas around the Atlantic, at 5 to 10 Deg C – a condition lasting 1,500 years when it last happened.

Oceanic models and coupled climate-oceanic models have shown that a collapse can be caused by a 4 Deg C increase in global mean temperature, which among other things was the background why, running up to the Kyoto Convention, EU ministers of the envi-

ronment recommended that the world should seek to avoid a global increase of more than 2 Deg C. Still, another fact is that oceanic models are far from good enough, and small changes can cause a drastic change in sensitivity. Practically all existing models find there will be an impairment in deep-water formation, rather than a collapse, but the truth is that we do not know if a collapse is possible, or if so, where the threshold lies.

The NAS report deals with this issue in detail, but also reviews many other examples of possible abrupt climate change.

Examples include a catastrophe that happened 55 million years ago when widespread deposits of methane hydrates on the sea-bed of the continental slopes were destabilised and gave off a 'whiff' of greenhouse gases, roughly the equivalent of the experiment we will have concluded in a hundred years time. It is also mentioned that the cause may have been a rebedding (or restructuring) of ocean currents, changing bottom temperatures. When the former Danish minister of the environment adduced this example, Lomborg launched an all-out press campaign against him. He might think fit to do the same to the NAS now.

Contemporary research is aware of the fact that the climate system has undergone sudden, abrupt change in the past. For instance, it is a near-established fact that deep water formation in the Atlantic has come to a halt in the past, with immense and abrupt changes as a result.

There is a host of possible 'surprises in the greenhouse'. A large-scale American study on the possible impacts of climate change for the USA puts it thus: There is every probability that we will be caught unawares, one way or the other, because of our limited understanding. As we were with the ozone hole, when researchers had not foreseen that specific ozone-depleting processes could evolve high up in the polar atmosphere, at a rate far exceeding that seen in the stratosphere.

Therefore, we are left with a risk management problem, instead of a situation where we are to optimise, fully knowing the consequences.

When constructing a bridge, a structure, or an aeroplane, engineers will take into account that their calculations cannot include every possible influence, and will therefore operate with considerable safety margins. Faced with the potential risks of climate change, the world's governments opted for a similar approach.¹⁶ If this is a waste of money, because the money would have been better spent on other problems, then it is about time to also rebuke bridge and aeroplane builders!

Lomborg does not relate to uncertainties. For instance, he finds himself able to state with certainty that the West Arctic will not collapse – despite the fact that researchers are known to have a fairly incomplete understanding of the dynamics of glacial currents, and neither do they know if the incipient collapse of ice-shelves will impinge on deep water formation etc. – and despite the fact that a European team of researchers recently estimated the probability of a collapse to be around 5 per cent. He just knows that the Gulf Stream will not collapse – though researchers find that minute changes in oceanic models (in parameters regarding convective mixing) suffice to totally change their behaviour, and can observe that a stop happens in some of the models. He just knows that climate sensitivity is not very high – although, at present, researchers are

unable to narrow down the uncertainty interval from 1.5 Deg C to the 4.5 Deg C they have been announcing for the last ten years. And ... well, we could go on forever...

Lomborg and consorts have chosen the climate panel as one of their favourite targets, simply because the panel's style is a factual, balanced and uncensored review of all research, also where unresolved discrepancies are in evidence. Instead of championing their views in the scientific arena, where they could stand their test, those folks have chosen to wage their discourse in the public media and in inadequately reviewed books and pamphlets, with pretence of scholarliness, thus hoodwinking the general public.

SCEPTICAL CITATIONS

Lomborg is a frequent misuser of citations. For instance, in a discussion with Lomborg on Nordhaus' model calculation, I referred to a paper¹⁷ criticising Nordhaus. Among other things, the authors wrote that the carbon model applied by Nordhaus is all wrong, and that essentially different findings will result from using a 'state-of-the-art model'. Moreover, they note that a discount rate well above zero does not make sense when optimising across very long time spans, since it produces absurd outcomes. They state in the paper:

'... the choice of r essentially dictates the results. In the $r=3\%$ case, for example, even major changes that we made to the DICE carbon cycle model had virtually no effect on the predicted values of μ ' [μ being the resultant reduction rate of emissions; JG]. And in their summary:

'...This method [using a state-of-art carbon model; JG] is utilized in conjunction with the DICE model (Nordhaus, 1994) to estimate optimal reductions in CO₂ emissions. The results are shown to be extremely sensitive to the pure rate of time preference, r . For $r=3\%$ (Nordhaus' preferred value), our model predicts an optimal reduction of 13% by the year 2045, as compared to 11% in the original DICE model. However, for $r=0\%$ the optimal emissions reductions rises to 79% in the year 2045 and to 97% by the year 2200. We argue that energy policy should be guided by the $r=0\%$ results for both economic and ethical reasons. A steady state analysis performed using the DICE model supports the argument that large fractional reductions in CO₂ emissions should be undertaken.'

Lomborg's reply only cited the subordinate clause: *'even major changes that we made to the DICE carbon cycle model had virtually no effect on the predicted [reduction level; JG]'*, to leave the impression that these authors' findings support Nordhaus' results. But the gist of the matter is that the paper severely criticises Nordhaus. And it demonstrates that the emission path recommended by Nordhaus would produce CO₂ concentrations exceeding the 1,500 ppmv cited below by the year 2250.

In his new book, Lomborg cites a paper I co-authored with Peter Laut, in which we looked at the theory of sun spot cycle length (as a measure of solar activity) as a determinant of observed temperature developments. The idea of the paper was to look at the same data as the two originators of the solar cycle theory, yet also including a possible greenhouse warming to see if there was any basis for concluding (as many have) that the two researchers' analysis shows our climate to be determined by the sun, and nothing like the greenhouse effect. We actually found a better correlation when including a solar influence and a greenhouse warming as well. This would apply for a very broad range of climate sensitivities, with 1.7 as the marginally best fit. This allows a scientific conclusion that, for a start, we cannot preclude a greenhouse effect on the basis of the

applied temperature data, and one with the magnitude of climate sensitivity cited by the Climate Panel. In Lomborg's representation, this is cited as though we ('inadvertently') showed climate sensitivity to be a 'mere' 1.7 (and not 2.5, the panel's central estimate). However, this can no way be deduced from our analysis, which we made explicit in the paper. This demonstrates that basically, Lomborg is unable to familiarise himself with a scientific paper. Further, we wrote that inclusion of greenhouse warming caused deviations (variance) between the measured temperatures used and calculated temperatures to be reduced to a value of 43 per cent the variance found in a calculation only using only a solar influence. This statement tells us nothing about how large a part of the temperatures each factor accounts for, but merely how much the residual, unaccounted for temperature variation is reduced. Bjørn Lomborg, the *statistician*, misrepresents this, stating that our analysis showed the sun to account for 57 per cent of temperature deviations. It is easy to see how the 57 per cent came up, but since greenhouse warming explains by far the greater part of the temperature increase seen in the best fit, this serves to show Lomborg's remiss reading of his sources. You may well ask if Lomborg masters his own subject?

ECONOMICS AND SCIENCE

In all fields of the environment, the sceptical environmentalist is a convinced believer in the notion of 'the optimal pollution'. Hence, he sides with the school of economists advocating the so-called cost-benefit analyses. The idea is fairly unsophisticated: The more money spent to prevent pollution or degradation of the environment, the costlier will it be. Since they want to launch the most affordable initiatives 'first', it is natural to expect 'unit cost per improvement' to rise along with an increasing level of ambition.¹⁸ Conversely, it is conceivable (though nothing like a law of nature) that utility in form of marginal environmental improvement will decrease with the reduction efforts.¹⁹ Then it is just a matter of summing up costs and benefits, and choosing the intervention that will maximise benefits minus costs, which means, minimising costs minus benefits. If we are at a maximum/minimum, the marginal costs needed to achieve an (environmentally) better outcome will be equal to the marginal utility of an environmental improvement, since otherwise there would be a net benefit to be gained from increasing or decreasing the stake. In this outlook, any environmental problem can be boiled down to choosing the 'the optimal mess'. If higher or lower, this will amount to wasteful use of societal resources. It is just a matter of lining up all costs and benefits. That is what we have economists for, so really there is no need for politicians, or a democratic public participation, for that matter. In the prisms of cost-benefit economists, no (genuine) priority-setting discussions exist. The fact is that whoever disagrees with their own prioritisations is just not smart enough with figures!

Characteristically, *The sceptical environmentalist* completely fails to grapple with the fundamentals of cost-benefit analysis, for what is actually (to be) maximised in such calculations is not all that simple. If, for instance, I want to travel faster by car up to the city, the question could be if my time-saving 'benefit' is greater than increased morbidity and mortality, the noise etcetera that I generate for those living along my route. But to me, and to the residents, the net outcome will hardly be the only thing to count, but also *who* will share in the benefits and inconveniences. Practically every decision will create both winners and losers. Therefore, the picture needs to include the vital discussion of problems of distribution and equity.

The mindset of a so-called welfare economist is to attempt optimising a societal utility function, depending on the utility of all citizens. One could imagine that every project

would have to be scrutinized along with the entire spectrum of redistribution options. The optimal alternative would then be whatever produced the greatest value of such societal utility function after the optimal redistribution. However, if a sub-optimal distribution of benefits prevails at the outset, the criterion demonstrably will not yield unambiguous outcomes.

This scientific insight is imparted to freshman students of economics – that generally, no such utility function can be found with other obvious properties that anyone would reasonably demand. As a result, a sound dose of scepticism is always warranted whenever someone purports to practice societal optimisation.

A closer analysis will almost invariably unveil that behind the cost-benefit calculation there is a number of implicit assumptions on the redistribution to be made (or rather, not to be made) from the winners to the losers. Which, of course, is one source of political disagreement?

Most of the time we will find that economic optimisation will presuppose a community of some sort allowing a debate on different priorities and the impacts of different choices, as the basis of a common choice. This can be in a family setting, or in a democracy.

Perhaps a concept such as solidarity is prerequisite to any discussion about societal economy. A confidence that those who stand to lose will not be the same each time. That all problems will be taken in hand, including those arising from common decisions.

Yet, how are we to discuss serving the common good of those living in the industrialised world versus developing nations? Or the common good of present versus future generations?

Our sceptical environmentalist is a die-hard believer in the redistribution or compensation method. Although the benefits of greenhouse emissions fall to the most prosperous today, while probably harming the poorest – or precisely therefore, one might say – the solution is close at hand. The poor are so poor that they will not need much of a compensation for e.g. a briefer life span. Not nearly so much as we would demand for ourselves. The result of such reasoning is for example people in the developing countries living with one kidney or without other organs. We will not have to carry this notion very far to realise that there is an ethical problem.

Precisely this discourse unfolded between climate panel researchers from industrialised and developing countries, respectively, yet without reaching an agreement, and this was the direct cause of the panel's rather tepid support to using cost-benefit analyses on the climate problem. However, the sceptical environmentalist's angle on the issue is that every deal (including our kidney case) is a fair deal, so long as it is voluntary. The notion of poverty as *de facto* compulsion is remote from the author. Instead of seeing the phenomenon as a double injustice, with a crying need for appropriate action, he capitalises on our inability to bring about international relations securing global welfare, as a pretext for adding insult to injury. And advises us to consider ourselves lucky that developing countries will be content with a modest compensation for any climate damages, and to unruffledly continue our lives, pleased that 'we have thrown off so many of humanity's yokes and made possible fantastic progress in terms of prosperity'.²⁰

All the same, we did chose to intervene against international human organs trade. How utterly stupid, in the eyes of a *sceptic*.

Sadly, the forces most doggedly resisting restrictions on greenhouse emissions will likely adopt the arguments of the book, while hardly implementing even the most rudimentary compensations.

The same applies where future generations are concerned: According to the sceptical environmentalist, we would be far better advised saving the money that was to be spent for emissions cuts (i.e. by investing it with a high return). Though I'd be fooled if that argument will not be proffered mostly by those who would rather spend resources on the present generation's consumption than put them into a reduction in greenhouse gas emissions. Interestingly, none of the nations that go along with the author – that we should save up for future compensations to be paid for climate damage, rather than take action while this is still an option – have made blueprints for a mechanism to ensure that such compensation would actually be made payable.²¹

THE NORDHAUS MODEL

In his book, Bjørn Lomborg uses several pages to enlarge upon uncertainties in our present knowledge of the climate system. All the same, his scepticism where scientific work is concerned oddly contrasts with his indiscriminate use of some unsophisticated economic growth models bolstering his view: that mitigating climate change does not pay. Both in his recent book and in previous books and articles published in Danish, Lomborg has professed one type of model to be a veritable crystal ball. The model in point is Nordhaus' so-called DICE model, prepared in view of analysing the issue of 'optimal mess' in terms of climate policy. The model is extremely simple – so simple that I once, during a debate, dubbed it a toy model. Actually, it is of a type one would call a conceptual model, aiming to show – as simplified as possible, and primarily qualitatively – how the logic of economics will progress from assumptions to outcomes.

The model describes the entire global economy as a single production process, with two primary inputs: capital and labour. Production is used either for consumption or to augment the capital apparatus. Moreover, there is a third production factor, greenhouse gas emissions, which – economically speaking – contributes to making the production output cheaper than without that input. The global economy is described as a so-called Cobb-Douglass production function, meaning that equal proportions of a production's money value are used to pay for both production factors. Moreover, production will increase over time, for given inputs, as a result of assumed technological advances. This development, as well as population growth, will eventually saturate, causing the production to approach a stable steady state. To study the climate issue Nordhaus made assumptions on what CO₂ emissions could conceivably be. Without reduced emissions, the necessary CO₂ emissions are assumed proportional with the production. With reduced emissions a fall is assumed to occur at a specified fraction of the production, to cover a specified percentage emissions reduction, following a convex curve (since percentage cuts grow more and more costly). At a 10 per cent emissions reduction, the cost will be 2 per cent of the production. Now, and in 500 years. Parallely, he assumes that a fixed fraction of the production value is lost due to damage caused by climate change (warming). This is 2 per cent for a global increase in temperature of 3 Deg C. Moreover, it is assumed to increase quadratically with temperature, so an increase to 6 Deg C (twice as much as three degrees) will cost four times as much, i.e. 8 per cent of the production value.

In economics terms, climate damage outputted from the production of the economy competes with production output for consumption and investment. If we look at the structure of the entire integrated climate-economy model, it is worth noting that (today's) emission options are 'produced' by the climate system by consuming the input of (future) climate damage. When solving the model, as any other general equilibrium (economic) model, it becomes very clear that the 'price' of today's emissions is determined directly by the future cost of inputted climate damage, through the climate system. This very aptly illustrates that it is a case of direct theft when the countries of the world meet under the Climate Convention to divide the product (emission possibilities), produced on the basis of future climate damage (imposed on others), and mark my words: without paying for that input. This would amount to using slaves in order to save the wages for labour input.

Regarding the production process of the climate system, Nordhaus (wrongly!) assumes that emitted CO₂ will remain in the atmosphere for 120 years, and that the temperature will increase by 2.5 Deg C with each doubling of atmospheric CO₂.

These assumptions set the stage for allowing the model to maximise the entire utility function, which only depends on consumption (production minus investment minus the costs of emission restrictions and climate damage). Nordhaus assumes a logarithmic relation (in the future, people will care less and less about an increased consumption, as their wealth is increasing), which will further boost the effect of discounting back (i.e. down) to the present value.

The thing is that it is the total discounted value of utility for each year that is optimised. Thus a loss in a hundred years or more, e.g. due to climate damage, will carry minimal weight in the accounts. Actually so marginal that we would have to disregard e.g. a climate damage of USD 1,000 (in current prices) in 200 years, if we could save USD 0.60 on it today.²² If by then climate change is considered to be more serious than today – e.g. because lack of remaining natural resources could lead to a higher estimate of losses – the result becomes even more glaring, since damage effects are (disingenuously) set using current estimates of welfare lost.

Not surprisingly, the model arrives at the conclusion that there is no hurry cutting down emissions. As lucidly described by the researchers of the climate panel, the end-level in the atmosphere in a hundred years (or in several centuries) depends on total emissions accumulated, rather than on the course of specific emissions. Indeed, in Nordhaus' model, it is worse still, because the CO₂ will disappear exponentially, while according to the standard carbon model it will take thousands of years to disappear completely. Therefore, the model also chooses to defer spending on emissions cuts. Admittedly, the model has to be run for 600 years or more in order for limit conditions to stabilise, and equally the economic logic will prevail in a hundred years. Here, too, it would be more profitable to defer expenditure, and thus it goes on and on. At all times practically nothing is devoted to emission reductions, while the entire climate spending goes on damages. These continue rising, in per cent of GDP. So does CO₂ concentrations and temperatures. To my mind, this looks more like 'the optimal mess' than the maximal rationality.

Mankind has at all times had an exceedingly short time horizon, which is mirrored by the rate of interest we (implicitly) use: If I am to desist from consumption today, I will demand more, e.g. 5 per cent annually, at a later time. We are well aware that this is the

true reason why people for instance let shrimp farms in South-East Asia destroy mangrove areas, fell the rainforest in South America, and leave the vegetable supply of the USA to an uncertain future by gradual salination of the soil in California. And we could go on forever. For all these cases, it is very likely that short-term profits on non-sustainable resource utilisation make sense in economic terms.

Nordhaus' merit is that he has illustrated that, using the same logic, we must also disregard future climate changes. In my view, this leads to the conclusion that the economic logic is not the answer to global mismanagement, but part of the problem.

The international sustainability discourse is precisely a reaction to this set of problems – one of the key paradigms being that we are allowed to exploit our natural basis, yet not in a manner compromising the possibilities of future generations. At the core of this discourse lies the issue of substitutability, for if we believe – as does Lomborg – that everything can be made up in economic terms, the concept of sustainability will become completely void.²³ Although this discourse is a central one, this is nothing that our 'sceptical environmentalist' cares to relate. The thing is that in this discussion, he has sworn his allegiances beforehand. All losses can be replaced. Even in the remote case that our climate impacts were to trigger an unforeseen development, e.g. the onset of another glacial age, this could possibly pay off. But Lomborg has not been specially appointed to speak on behalf of future generations. The fact is that they could very well disagree with the valuation of future losses assumed by these global cost-benefit calculations.

The Nordhaus model can actually make the point graphic: Physical impacts always evolve from the present towards the future. Conversely, for prices in economics, it is always the future (i.e. its prices and values) that determines those of the present, in 'the optimal solution'.²⁴ If economists conclude that the future is not worth considering, this could in part owe to the fact that the beliefs of the very same economists make supreme rulings concerning the valuation of e.g. climate damage in several hundred years time in relation to, say, consumer durables. And here, they will often chose present-day valuations. Is it conceivable that in a future, with increasing losses of nature and pressure on ecology, yet with increasing wealth, people would value the limited natural benefits more highly? As is for instance the case today, when we are prepared to go to far greater lengths to avoid air pollution in the cities than people were before. Unlike this example, when it comes to the global climate, we cannot turn the ship about as values change. It would be past remedy. If the same had been the case for air pollution in the cities, London would still be tormented by insufferable smog. We could also compare with the situation of the 1960s, when chemical wastes were recklessly buried in the ground, without considering that in 30 or 40 years time people would value clean groundwater far higher than anyone could imagine then.

These points made, Nordhaus' model is so simplistic, and many of its assumptions so dubious that it only lends itself to clarifying the purely qualitative issues, as already said.

All the same, the sceptical environmentalist proclaims it to be the supreme expert knowledge on our future. This is where the hollowness of the book's host of references becomes apparent: Has the author understood the mass of literature he is referencing?

Amenability to critique is not this author's forte, for during the Danish discourse, where

he first vented his views, he was explicitly informed of the limitations of the model. Including that substantial criticism had been put forward (which he only refers to once).

For instance, one researcher pointed to the fact (mentioned above) that entirely different figures for CO₂ concentration and temperature will emerge if state-of-the-art models are applied, instead of the Nordhaus' simplified relations. Using Nordhaus' recommended 'optimal' CO₂ emission, these will not yield a stabilisation at around 1100 ppmv, as believed by Nordhaus, but instead a run-up towards still higher values (1500 ppmv), and without a tendency to weakening. Similarly, there is an explosive increase of temperature and harmful effects. The truth of the matter is that Nordhaus (and Bjørn Lomborg) did not acquaint themselves with how atmospheric contents are inter-related with CO₂ emissions. I would like to linger a little on this error, which is fatal in someone undertaking to act the part of guide to the world, but can be excused in an ordinary layperson, since presumably the very few have entirely understood the implications of the researchers' picture of the carbon cycle.

CARBON CYCLE

Fulfilling the climate convention target of stabilising the carbon dioxide concentration will require not a reduction, but much rather a phase-out of emissions. This applies regardless of the level on which the concentration is to be stabilised.

We can more or less specify a budget for the aggregate carbon emissions, summed up from today into an infinite future, which would be compatible with a given concentration level. This owes to the fact that the two principal drains, the biosphere and the ocean, are expected to decline towards zero, as the concentration stabilises.

The total amount of emissible carbon is large enough for us to combust all oil and gas in estimated reserves (including those yet to be discovered), yet far from all the coal. If we wish a stabilisation at a level that would merely produce a temperature rise of two or three Deg C, there would hardly be any room left for using coal. This means that each time we were to consume coal, we would later have to leave some oil or gas unused (or implicitly accept higher end concentrations).

If, for just a few more years, the industrialised countries continue emissions at largely unchanged levels (e.g. by following the Kyoto Protocol till 2012 and from then comparable minor reductions until 2030 or 2040), the developing countries will never stand a chance of attaining more than a fraction of our present emissions, by a per capita calculation. Nonetheless, it is necessary for the emissions also of developing countries to start declining sometime around 2030-2050, in order to prevent exceeding the concentrations mentioned above.²⁵

The key issue is that if copied by the developing countries, the present production and consumption patterns of the industrialised countries are not sustainable, viewed globally.

Nevertheless, the developing countries are in full swing copying our lifestyle. In a way, the true problem is actually the propagation of the global middle-class, evolving far more quickly than e.g. population growth, since this lifestyle would require

several more planets to take place without risk of serious climate changes.

Hence, the name of the game is, are we able to effect timely changes in technologies and lifestyle before being copied by the developing countries. And here every analysis seems to indicate that we are short on time, having just a few decades.

Actually, an analysis of this nature lies behind the official long-term scenarios of Danish energy policy, as presented in 'Danmarks Energi-Fremtider' ('Denmark's Energy Futures') and in 'Energi 21' ('Energy 21')²⁶, later spelled out in the order of the Danish Folketing (Parliament) to the government, directing it to target a halving of emissions by industrialised nations by the year 2030.²⁷

Therefore, the claim of Lomborg and others – that we can abide developments for, say, ten years before taking serious action towards change – is a complete misrepresentation of the challenge at hand. Our experience regarding the lead-time of various processes is scary: The international community has negotiated climate convention for ten years, without this materialising in the emissions of most countries. Add the incredible time it takes to convert energy supply systems and infrastructure. (For instance, the introduction of wind power began about 25 years ago, and today some 13 per cent of our electricity consumption is covered). Well-suited web sites are available to any reader wishing to study these connections.²⁸

As mentioned, another researcher has proved the recommendations extremely sensitive to the rate of interest chosen.

And a third²⁹ noted that the problem of the Nordhaus model is its lack of inertia, in terms of how quickly restrictive measures can subsequently be stepped up (especially for low rates of interest). Thus, if model conditions were to include that an abrupt change of course is costly, then fairly high mitigation levels would be found to be optimal at an earlier stage.

Are Nordhaus' assumptions likely to hold true – that the global economy will grow (as implied by his assumptions on technological advances and growth in the capital apparatus), that emission reduction and the costs of climate effects, in per cent of the aggregate production, only depend on how many per cent cuts are needed compared to business-as-usual? In reality, these are mere ad hoc assumptions, providing a simpler model to calculate on. They only make sense combined with the dubious assumption that emissions in the basic scenario will follow economic growth as seen in the past, and that the costs of reduction technologies will remain the same forever after.

This is where, scientifically, the sceptical environmentalist is short-changing his reader by failing to mention the implicit 'subjectivity gaps' of these models, by using them authoritatively instead of looking into their inherent properties: 'One of the most prominent model-builders in this field is the professor of economics...' etc. In the same vein, he claims that the built-in damage assessments are based on best available knowledge. However, he fails to note that these assessments are very sporadic, are fraught with considerable problems of methodology, and that e.g. the UN Climate Panel has chosen to make very strong reservations whenever referencing them. Most assessments are sheer spot assessments (e.g. for a situation with a doubled CO₂ concentration), and Nordhaus' assumptions regarding the harmful effects of other scenarios (e.g.

those above 5 Deg C derived from his model as 'the optimal scenario') are sheer conjecture. Moreover, it is not correct, as claimed by *The skeptical environmentalist*, that models include unforeseen events.

When – as claimed by Lomborg – other and comparable models arrive at largely the same results³⁰, this mainly owes to the fact that they are models of the same type, based on the extrapolation of current economic relationships into a remote future. This verges on a travesty of economic modelling: Give an economist two figures. You then have a natural constant, expressed by the ratio between them. The assumptions of natural scientists – the fact that they have to simplify in order to embrace processes on all temporal and spatial scales – are infinitely more reliable, since the system under study will not change fundamentally. The laws of nature will remain as they are, and natural constants are truly constant. Still tomorrow, someone could discover an operational cold fusion process, and the economy inside our greenhouse would be radically changed.

In the universe of Nordhaus and confreres, the world's options have been laid down definitively, from now on and till kingdom come. Subsequently, in their dreamt-up universe and under idealised assumptions of a perfect-functioning global economy (i.e. the absence of monopolies, trade barriers, etcetera), they are able to prove that without the disturbing influence of environmental problems, the world would opt for whatever development trajectory would maximise total welfare. Hence, it is clear that any narrowing of the outcome space of our planet's potential development, in the form of an environmental restriction, would result in fewer options to choose between, and hence less welfare. Hence, what was inputted into the models when they were constructed is outputted as a predictable consequence: Reducing emissions will cost us, compared to what the cost would have been without environmental concerns. No matter for surprise: What comes in comes out!

OUR CHOICES MATTER!

However, other economists hold that the real world is different: Anything done today will impinge on tomorrow's world in countless ways not included in the economists' frozen image:

A case in point: In the past, parking and traffic restrictions in city hubs were considered negative since 'any intervention will yield a poorer economy'. Today we would have to search for a municipal government and a trade association that would not warmly agree that car-free zones are beneficial to both economy and welfare. Thus, the models are best suited for propping up an ultra-liberalist line of argument, since inherently assuming that any regulation of common conditions will reduce welfare.

A more important aspect yet, not taken realistically into account by these models, is technological development. For instance, a statutory requirement laid down by a government can potentially lead to a technological advance that we would not have seen without it. Possible examples could be in the field of hearing aids, the Internet... proceed at your leisure. Another fact is that many countries' long-standing policies to promote various environmentally friendly energy technologies have helped produce several technologies that are now close to being viable on completely normal commercial terms.

A very intriguing phenomenon in this context is 'technological learning' or 'learning by doing'. It is a well-established fact that marketable technologies will gradually improve

– in terms of affordability or efficiency. This relates to the fact that the experience gained during a production process can only be built into a product gradually, parallel with the manufacturer's write down of development costs. By contrast, large-scale government-funded research and development programmes, not yielding sales are not nearly as functional. Following the 1973 oil embargo, a number of countries launched development programmes for mega wind turbines, intended to capitalise on economies of scale, with one stroke and a tiger-leap effort. The resulting prototypes were all x-fold more expensive than the small wind turbines already on the market then. And gradually, those small turbines have grown bigger, and have now completely 'unhitched' the government crash schemes. These micro-enterprises based in small engineering works or workshops for agricultural machinery are now producing the big and affordable wind turbines that the state schemes never came near. What we have seen is an object lesson of 'technological learning'. However, this familiar phenomenon also applies for several other technologies that we profit by. Lomborg's recommendation is that we should abstain from an effort that could create a market for the new technologies, instead staking on government research and development. This serves to demonstrate an abysmal ignorance of what propels technological development.

Brilliant economists on the IIASA and on the IEAS ETSAP project³¹ have studied this phenomenon for years on end, and have included it into economic theories, also such optimising the future development. Unlike the models of mainstream economists, the technologies of these models do not improve as a result of the march of time, but as a result of sales. When inputted into optimisation models, this turns out to have major impacts. The models choose to use new, yet still comparatively costly technologies far earlier than dictated by time-honoured economics reasoning, simply because the models 'see' that when they do, such technologies will improve over time, thus opening up to completely new 'least cost' development trajectories, resulting in a better societal economy. In these models, we can have radically different development trajectories, in terms of emissions, yet with largely identical levels of welfare. They are a little more costly on the short term, but offer considerable long-term savings, once the new technologies have become affordable. So overall, a little extra spending to begin with could come out as the cheaper option. When looking at the discounted costs, there is no inherent relation as to whether the costs are lower or higher than with the traditional business-as-usual approach. It is rather a matter of choosing track: We can take a conventional course, placing all development funds in 'clean coal' investments and nuclear power, or we can choose a course focusing on energy efficiency and renewable energy. In both events, we can have development trajectories with comparable welfare. However, the technologies that will evolve and contribute to the welfare are entirely different for the different scenarios.³²

If, for instance a government puts in a 30 per cent subsidy for a technology for a number of years, it will enter the market far sooner than it would otherwise have. Thereby it will fairly soon reach a commercial level when it begins to yield large-scale benefits. However, the cost of state support for the early phase, when sales are still moderate, is negligible compared to the savings offered to future users of the technology. Thus, in terms of societal economics it is a good bargain (and an example of a 'reverse Lomborg'), in which the present generation invests on benefits for future generations.

When computing how large subsidies can be justified from an economics viewpoint, using typical data for developing technologies – in terms of technological learning curves and penetration rates on the market – we arrive at absolutely eye-opening figures. For instance, we find that the benefits for future generations can justify from 30 to 50

per cent subsidies, only to be incrementally stepped down over the next hundred years³³.

This notion in part is the rationale behind the European position in the climate negotiations: that industrialised countries are to impose restrictions on themselves, sufficiently stiff to set a technological learning process going, rather than target the same reductions in developing countries by substituting outdated technologies with marginally better ones. From a short-term cost-benefit viewpoint, this would appear to be nonsense, since purportedly cheaper emission reduction options exist in developing countries than in industrialised ones.³⁴ However – in a more sophisticated analysis, explicitly implicating technological learning – the European strategy could come out the cheaper option.

A last aspect deserves discussion: There is a fundamental uncertainty regarding the scope and nature of potential climate damages, and regarding the longer-term development of society. Thus, using a long-term cost-benefit calculation, very much depends on whether we will accept without reservation the projections of economic models, and their uncertain assumptions. Given how miserable a 12-month economic projection often proves to be, it would require considerable orthodoxy to accept projections spanning a century or more. Moreover, the calculation also assumes a smooth climate development, with no surprises in the greenhouse. As we know, researchers tell us that our knowledge of long-term mechanisms in the climate system is fairly incomplete, and that something could happen unexpectedly or out of the blue, e.g. a shut-down of ocean currents. However, the fact remains that we are nowhere near an understanding of the system. (For instance, we do not really know why greenhouse gases in the atmosphere rose strongly at the transition from the last Glacial Age.) Thus, what *the skeptical environmentalist* is asking of us is to accept a mystery tour that will take us right to the brink of the precipice, which basically amounts to issuing unsecured warranties for what could result from the global climate experiment.

By contrast, we can fairly easily estimate the short-term cost of intervention against emissions, meaning that we can consider on an ongoing basis whether we want to make the effort. If, by democratic decision, we can agree that an effort to get a better control of climate development is worth a stake, this is OK. It is possible that many would be willing to pay a little bit more for energy in return for bringing the unpredictable global experiment with our climate to an end. In this light, our sceptical environmentalist and Nordhaus' calculations appear immensely disingenuous.

Neither are economic calculations impressive, when it comes to the short term: For instance a comparative study of the different American calculations – of the costs of the prescribed reductions in greenhouse gas emissions – showed those calculations to rely far more on assumptions on economic policy (e.g. if CO₂ taxes were imposed or not, if they were recycled, if existing taxes were distorting, etcetera) than on the actual cost of the reduction initiatives in point. This demonstrates that a reduction policy can be carried through more or less shrewdly. However, it also suggests that occasionally economic model results reflect the general outlook of the 'modeller' rather than manifest differences.

In addition, economic models have problems grappling with the more dynamic aspects of social development, e.g. the processes evolving at a political level and inside the general societal palaver, and which are all-important in enabling a society to respond adequately to new challenges. That process takes time, and would hardly ever get started

unless steps were taken to begin solving the problem. In a way, each step constitutes the basis of the next. Perhaps this is why we often see a progressive tightening up of international conventions, or a kind of salami approach. Even presuming that an economic model might show another route to be more optimal, the forces at play are altogether different from the one-dimensional rationale of the models.

NEW RESEARCH – THE EFFECTS OF THE SUN

Another approach among greenhouse sceptics is to draw attention to new research without reporting the ensuing discourse in scientific magazines. This is used by Lomborg when pointing to Lindzen's 2001 paper, yet failing to mention other results suggesting directly opposite conclusions.

Another clear case is his reference to the findings of our domestic sun spot researchers. Actually, two researchers from the Danish Meteorological Office, Lassen & Friis Christensen, presented findings³⁵ suggesting a certain correlation between various climate data and the cycle length of the sun spot cycle. Looking at the cycle length was a bit of a brain wave, since previous sun spot research focusing on the actual number of sun spots indeed also suggested a connection, though with certain problems (for one, effect preceding causation!). A simple graph illustrating the co-variation of a specific temperature series with sun spot cycle length has now become a fixture on the websites of all greenhouse sceptics, where it is used to demonstrate that 'it is the sun that causes temperature variations', and hence that 'the greenhouse effect means nothing'. Obviously, this graph is also found in *The skeptical environmentalist*.

Only, the hitch with this conclusion is that it is not covered by Lassen & Friis Christensen's own data!

There is indeed a certain co-variation (in the figure enhanced optically by filtering out all variations in the curves but for the slowest). However, a co-variation can also be established if a contribution, the size of the greenhouse effect, is added to or subtracted from the temperature curve. In other words: The cited does *not* allow any inference regarding the size of a possible global warming! This was largely the point of a paper³⁶ by Peter Laut and myself, accepted in the very magazine that published Lassen & Friis Christensen's findings. Equally, other researchers have applied a slightly different angle to the connection and shown the conclusion to be nowhere as unambiguous as alleged from the side of the more politically motivated anti-greenhouse lobbyists.^{37, 38}

In a later paper³⁹, Lassen & Friis Christensen extended their analysis to include temperature data as far back as 1579. Here, too, they find co-variation, but as in their first paper, they did not include greenhouse warming into their analysis. Peter Laut and I therefore addressed the issue in a new paper⁴⁰, and this time around the conclusion is even more thought-provoking than in our first paper: We get a *better* explanation of the applied temperature data by assuming *both* a solar influence and a greenhouse effect, largely of the same magnitudes as those used for the standard case of the greenhouse theory. If the sun spot theory proves to be solid, it would practically imply that it further underpins the greenhouse theory!

We made this analysis – not because we believe that a comparison with a single temperature series can be used as definite proof for anything, but rather more because the findings of the sun spot researchers have been proclaimed to virtually explode the greenhouse theory, and therefore deserve scrutiny. However, our analysis shows the sun spot connection to actually corroborate the greenhouse theory.

The data quality of the temperatures back to 1579 used by Lassen & Friis Christensen is nothing that a climatologist would want to write home about. They are so-called proxy-data, i.e. temperature reconstructions based on other data, e.g. annual rings from trees, since complete temperature measurements that far back are far from available.

The researcher Mann⁴¹ has used a more comprehensive set of proxy-data, and concludes (more or less as Peter Laut and I) that the sun had a certain influence, which dominated in previous centuries, yet that the predominant influence today is greenhouse warming.

Scientifically speaking, the sun spot theory remains rather a working hypothesis, since lacking a proper physical explanation that would let us calculate the magnitude of solar influence based on other data than the ones we seek to clarify (namely the temperature data). Here the work of Henrik Svensmark⁴² is significant: If it holds water that solar influence evolves via a modulation of cosmic radiation, which in turn influences cloud formation, then an understanding of some possible mechanisms could be within sight, allowing a more precise forecast – with the promise of enabling us to better distinguish greenhouse warming from natural climate variations. However, it is a long way yet – especially for extended time spans – before we will have anything more than hints regarding a possible solar influence. By the way things look now, greenhouse warming is a far more potent influence on climate than the possible solar influence.

However, we are left with the problem of eliminating all the other factors that also influence temperature development. Whether this will ever succeed is, I believe, doubtful, since we simply lack reliable data that go sufficiently far back in time. For instance, we know volcano eruptions to be a major influence, and actually we do not need to go back a great many years to find researchers who purported themselves able to explain practically the entire temperature development based on volcanoes and greenhouse effect alone. Still our knowledge of the cooling effect of actual volcano eruptions a long time ago is extremely incomplete and hard to reconstruct with sufficient precision. Similar uncertainties apply for the effect of aerosols, believed to have a cooling effect. However, it remains a major task for science to narrow down the present uncertainty interval for the magnitude of greenhouse warming (1.5 to 4.5 Deg C global warming at a doubled CO₂ concentration).

For myself, I believe such narrowing-down is more likely to emerge from a comparison of the aggregate projections (geographical and in altitude, and involving a spectrum of climate data), than from a comparison of individual series, e.g. global mean temperature. But also for such analyses a verified solar theory could be of major significance.

However, one could also nearly consider it a blessing that projections are not too precise, since otherwise they could make pretence to a certainty that may not ever be truly established. There is every indication that the entire climate system, including oceans, cryosphere, and biosphere, is an extremely complex and probably chaotic system, and that we have a long way to go before understanding all mechanisms and couplings. For one thing, significant questions remain open regarding the true mechanisms behind the growth in greenhouse gas concentrations at the transition from the Glacial Age to historical times, or what caused the abrupt climate swings, evidence of which is found in e.g. Greenland. Therefore, to my own mind, the most worrying part is what science (perhaps) does not know, and that the different predictions of climate changes could easily be toppled by a sequence of unpleasant surprises. A case in point: the predictions

on the depletion of the ozone layer, the tempo of which took researchers by surprise, because they had only calculated on chemical processes evolving in the free atmosphere, but had missed some catalytic processes on the surface of special ice crystals formed high up in the polar atmosphere.

Some of the most worrying are the announcements that the areas of sea ice at the Antarctic and (more recently) the Arctic appear to have shrunk considerably. The rub-off could cause a self-increasing process, because ice and snow reflect incoming sunlight far better than the open sea, so any warming will generate further warming. Moreover, strong warming in the northerly tundra regions and melting permafrost are reported, with the known risk of this causing increased greenhouse gas emission.

DOES EQUITY MATTER?

Lomborg promotes the use of some type of cost-benefit perspective in order to find out 'the optimal mess', between 'reductions today and damages in the future' ... But he fails to note that we can only undertake such a comparison, if we dare to rely completely on someone to provide an overview of what will happen in the future. This recalls the nuclear debate: Should we go for the sophisticated technology, which would require the command philosophy to be carried to its extreme consequence and a blind faith in something we really cannot visualise, or should we choose what we can cope with in small, manageable steps? At least, I doubt that our grandchildren would be able to reclaim their compensation from Lomborg, should his prediction not hold water, and damages will be greater than claimed by Lomborg today!

Rightly considered Lomborg pulls off a bit of intellectual conjuring by first arguing that the greenhouse effect is doubtful, and the next moment advising us to rely on a few projections, as though they were firm as a rock.

There is also an ethical dimension, because we will come to reap the benefits of doing nothing, while the damages will fall to another generation, possibly in another continent. Can we make cost-benefit based on sacrificing a little of our own convenience, against killing fewer people in Bangladesh in a hundred years? Presumably, as a minimum, this would require us to actually shoulder the responsibility of our actions, so we could compensate those suffering damage. (Lomborg would then claim that we could help more people in Bangladesh today, but the ensuing counter-question is: Is the world up to placing such a choice on the agenda?⁴³ And in every circumstances the ethical foundation of such a choice appears doubtful, to put it mildly: You'll get a little help today, and in return I will have no qualms threatening the lives of your offspring tomorrow.

Single-minded economic rationality seems to lead us into serious mistakes, unless we allow for fundamentals, such as equity and responsibility.

MANKIND IS IN CONTROL OF SPACESHIP EARTH

The greenhouse issue is an environmental problem of an entirely different order than the many other issues on the agenda. For the first time ever, mankind is facing a genuinely shared problem that can only be solved by a concerted action. The problem visualises a fundamental matter: By now, human impacts on our physical environment have reached such dimensions that we cannot leave it at considering the unintentional effects of our activity on a local basis. Mankind has become a force of nature on a par with geological processes, a determinant of global bio-geochemical composition that

will have to be taken into account in line with volcanoes, glacial ages, etcetera. While in the past, justly or not, we assumed that the natural ecosystems would somehow deal with the problems we generated, we are now forced to reckon with the impacts. Thus man as a species has, like it or not, been handed the control column of Spaceship Earth. However, the question is: Do we possess the required insight (not to say, will we ever have it!) to take the pilot's seat, and are our thinking, mechanisms and organisation at all geared to this role?⁴⁴

Personally, I tend to think that it still is an unresolved question, whether the western-type civilisation, based on controlling nature, will be viable unless we acquire some humility vis-à-vis the limitations of own powers of control. I thus consider it a blessing in disguise that we were 'given' the greenhouse problem as a chance to come to our senses. Otherwise, we would eventually risk a confrontation with nature's own corrective to our megalomania, which could take less than enjoyable form (for us).

Defining traits in our present outlook on the man-nature relationship is alienation (we hardly feel ourselves to be part of nature) and an anthropocentrism only admitting the entire global ecosystem a *raison d'être* as a vehicle to instant gratification of our human needs. Thus, we may fail to realise that the global ecosystem probably plays a crucial role in sustaining the environment that we are adapted to. Recent years have increasingly brought into focus the large-scale impacts of human activities on the entire interlocking system of processes on this planet, and man's possibilities of steering clear of grave mistakes. The exceedingly long time horizons involved in such steering require us to deliberate what precisely a 'geo-cybernetics' system " should look like. First suggestions on the issue have been offered by e.g. the international GeosphereBiosphere programme, and by the completely new 'Earth System Science'. Equally, the international co-operation under the IPCC and the UNFCCC⁴⁵ can be considered as such a beginning. Like a ship, we need a navigator who, based on charts and projections, is able to draw the course for our destination, and a lookout to warn us against striking the rocks. Likewise, we need a manual for the first helmsman, who has to make decisions based on (often conflicting) signals received from navigator, lookout, and the motley crew (all with agendas of their own), and further allow for the inertia of the vessel and the impacts of waves and currents, and for possible computational errors in the navigator's calculations.

To my mind, it is obvious that to ensure such 'safe navigation' we need to bring about a reliable communication and quality management, and a reliable coupling between science and governance. Since such a system must necessarily be implemented by a democratic procedure, including the international democracy, this will pose immense demands on a qualified and well-informed public debate.

Whether this is feasible – in an environment where scientific discourse is increasingly carried on in the media, in competition with and perceived as 'entertainment', and where appeals are made for mass-votes on profoundly scientific matters – remains an open question. But the fate of future generations may be in the balance.

- 1 Jesper Gundermann is a physicist working with climate change in the Danish Energy Agency.
- 2 This pseudo argument was even aired by one of the former White House science advisors.
- 3 Intergovernmental Panel on Climate Change.
- 4 This is expected if the duration of the present interglacial period will be as the three previous ones. However, more recent research indicates that 50,000 years are likely to pass before the next glacial age.
- 5 M.F. Loutre and A. Berger, Future climatic changes: Are we entering an exceptionally long interglacial?, *Climatic Change*, 46, p 61-90, 2000.
- 6 A topic to be dealt with later in this chapter.
- 7 Comp. Wigley.
- 8 Comp. TAR.
- 9 Comp. TAR.
- 10 We need to understand that 'the climate' is not the same as 'the weather'. Observed temperature data, as well as output from a GCM, are basically 'weather data'. We can study climate predictions resulting from the models by doing a large number of runs using the same boundary conditions, but we can only do a single run with the ultimate weather computer: the real climate system. If we are to talk about 'climate' we can only do so by observing a number of successive years, typically 30 years. However, that, too, is not long enough to exclude natural variations, even in the absence of extrinsic influences. The chaotic development of the weather implies that each tiny change in the initial condition will produce a markedly different process over time. Therefore, for the time being, we can only predetermine the weather across a maximum of 14 days. This, however, does not preclude forecasting the climate – understood as anticipated mean values and probability distributions of weather data. Yet it cannot be excluded that 'the Climate' can have chaotic features, e.g. expressed in the future climate perhaps being able to end up in two or more states, between which sudden transitions are possible. I will go into the issue later, when dealing with the risk of 'surprises in the greenhouse'.
- 11 TAR, p. 428 and p. 714.
- 12 Without being an expert on climate modelling, I offer, as a physicist, the following explanation: Essentially, the atmosphere is very opaque to heat radiation. Only 10 per cent of the radiation emitted from the ground escapes to space. Hence, most of the long wave energy is radiated to space from a position quite high in the troposphere. To increase this radiation, we need an increase in temperature up there. So if temperatures here react slower to warming than expected, the problem of getting rid of the heat gets worse, and the greenhouse warming at the surface will be underestimated.
- 13 Ingrid Zondervan, Björn Rost, Richard Zeebe, Ulf Riebesell: Elevated CO₂ concentrations slow down carbonate production in calcifying marine phytoplankton http://www-user.uni-bremen.de/~micropal/abstr_zo4.html.
- 14 See e.g.: D. Archer, H. Kheshgi, and E. Maier-Reimer: Dynamics of fossil fuel neutralization by Marine CaCO₃. *Global Biogeochemical Cycles* 12: 259-276, 1998.
- 15 The understanding of climatologists has long been that these increases come after the increase in temperature, not that the increase in greenhouse gases was causing the warming. This has recently been confirmed beyond doubt, by measurements of isotopes of the air in bubbles from the Vostok ice core at Antarctica. Do I need to say that also this confirmation of scientific thinking has been misused in the media, as an argument that then the green house theory is wrong?
- 16 Meaning that they have chosen to act despite uncertainty. For in fact the extremely modest level of ambition of the Kyoto Protocol is an expression that we are putting off, or are tacitly accepting rather high end-concentration levels of greenhouse gases, unless one is a believer in a drastic acceleration of reduction efforts at a later time.
- 17 Peter A. Schultz and James Kasting (1997): Optimal reductions in CO₂ emissions, in: *Energy Policy*, vol. 25, no 5, pp 491-500.
- 18 However, the hitch of this approach is that already at baseline something rather in the nature of an assumption has been smuggled into the theory. For instance, there is ample evidence that over time – or more importantly, as a result of experience gained – things become cheaper and cheaper with a rising level of ambition. Such lines of thought lie behind many strategic stakes on environmental improvement, new energy technologies, etcetera – that by getting started you will set a process going that will prove this standard assumption wrong. It is very much their lacking grasp of the more dynamic aspects that let many economists come across as advocates of *laissez-faire* in matters of the environment.
- 19 Actually, this is not the case for the CO₂ greenhouse gas. Since the greenhouse effect will increase by the logarithm of concentration, we will actually find that the *marginal* damage caused by yet another tonne emitted – in a future situation, when the concentration has been stabilised – will be less, the more damage we have already cashed in. It is easy to see that this can lead to a conclusion that no level of stabilisation will be optimal, if only high enough! Thus, logic would invite us to let the problem come out of hand!
- 20 *The skeptical environmentalist*, p. 330.
- 21 A pity, though – since it is actually cheap: We just need to invest some 60 cent, then – at compound interest – we could compensate a loss of welfare of USD 1,000 at current prices in 200 years, if else we dare believe it. See also next note..
- 22 The outcome is both influenced by the discounting rate and by the assumption that the utility of consumption is proportional to the logarithm of the wealth.

- 23 In the words of Lomborg's detractors, the question of where we can 'buy the most environment with our money' tends to switch over to another question: Where do we get the most money (for surrendering) the environment.
- 24 Let me point out that this paradox – that in economics, *the present invariably depends on the future* – creates an unsolvable problem, known as the 'terminal value problem', i.e. that no time horizon is really long enough to determine the optimality.
- 25 We can have an idea of the reduction demands, in relation to projected growth, by experimenting with a series of simple models used by the IPCC, available on the climate web pages of the Danish Energy Agency: <http://www.dea-ccat.dk>
- 26 Comp. <http://www.ens.dk/e21/e21dk/>
- 27 Similar studies have been made in The Netherlands. Regrettably however, practically no other governments of the industrialised world have tried to form a picture of the world, as an indication of whether their own present path reconciles with one of the global reduction profiles pointed out by the IPCC as being requisite to stabilising the level of greenhouse gases in the atmosphere.
- 28 It is possible to explore the connections using the models of the Norwegian UNEP Centre: <http://climate-change.unep.net/jcm/> and on <http://www.dea-ccat.dk>
- 29 M. Ha-Duong, M.J. Grubb, and J.-C. Hourcade (1997): The influence of Socioeconomic Inertia on Optimal CO₂ Abatement. *Nature*, 390 (20 November).
- 30 Including later versions of the Nordhaus model that have become more detailed.
- 31 See: *Down the learning curve with emerging technologies*, http://www.ecn.nl/unit_bs/etsap/newslet/issue5/page1.html
- 32 In this connection, the joke is that *The skeptical environmentalist* predicts that global emissions in the scenarios of the climate panel are greatly exaggerated, since affordable low-emission technologies will come on the market later in the century. While we could hope for this to hold true, it remains highly doubtful if this would happen, if we were to follow his second recommendation of not launching a major effort now that could develop a market for such technologies.
- 33 Critics of this angle object that, after all, there is no way we can ever know how far the improvement of technologies will go. The answer is that a bulk of experiential material has demonstrated the phenomenon for countless technologies. Moreover, we have ample opportunities for evaluating on a current basis, whether technology enhancements proceed as expected. However, investment is never without a risk, nor in this case. However, we can be fairly certain that in the absence of state support, private enterprises will not be able to overcome the barrier of technologies being too costly initially, when the learning effect is not valued. In a sense, this owes to a market imperfection, since a manufacturer cannot for years and years sell a product at a price below the production cost, hoping for later profits once the technology has thus become more affordable. By then, he would have to compete with other manufacturers, and therefore could not sell above the production cost. It is possible that patenting could overcome this obstacle in some cases, but very few private investors are willing to work with the time scales involved here. For instance, wind turbines took 20 years to reach the present stage, where they are indeed competitive, counting in their environmental benefits.
- 34 However, this claim is yet to be verified. Experience from projects in East Europe seem to indicate that the main issue is poorly functioning economies implying that not even no-regrets options can be realised. In this context, it is not a foregone conclusion that the possibility of including a minor CO₂ benefit will change the picture in a major way. Similarly, much of the experience gained from energy projects in developing countries indicate that even simple projects can be associated with very sizeable transaction costs. Altogether, we have to say that the economists' 'birds in the bush' may prove to be just that ... – hence no real possibilities of more affordable reductions than can be achieved 'at home' in the developed countries.
- 35 K. Lassen and E. Friis-Christensen (1991): Length of the solar cycle: an indicator of solar activity closely associated with climate. *Science* 254, 698-700.
- 36 P. Laut and J. Gundermann (1998): Does the correlation between solar cycle lengths and Northern Hemisphere land temperatures rule out any significant global warming from greenhouse gases? *Journal of Atmospheric and Solar-Terrestrial Physics* 60(1), 1-3.
- 37 M.E. Schlesinger and N. Ramankutty (1992): Implications for global warming of intercycle solar irradiance variations. *Nature* 360, 330-333.
- 38 P.M. Kelly and T.M.L. Wigley (1992): Solar cycle length, greenhouse forcing and global climate. *Nature* 360, 328-330.
- 39 K. Lassen and E. Friis-Christensen (1995): Variability of the solar cycle length during the past five centuries and the apparent association with terrestrial climate. *Journal of Atmospheric and Terrestrial Physics* 57(8), 835-845.
- 40 P. Laut and J. Gundermann (1999) Solar cycle length hypothesis appears to support the IPCC on global warming. *Journal of Atmospheric and Solar-Terrestrial Physics* (forthcoming).
- 41 Michael E. Mann (1998). Global-scale temperature patterns and climate forcing over the past six centuries. *Nature* 392, 779-787.
- 42 H. Svensmark and E. Friis-Christensen (1997) Variation of cosmic ray flux and global cloud coverage - a missing link in solar-climate relationships. *Journal of Atmospheric and Solar-Terrestrial Physics* 59(11), 1225-1232.
- 43 The recently elected Danish government seems to be adhering strongly to the cost-benefit ideas advocated by *The skeptical environmentalist*, but has, as one of its first actions in office, announced a huge cut in official

development aids.

- 44 I have often wondered why we insist on trained pilots to fly our planes, but do nothing of the sort when it comes to the steering of Spaceship Earth.
- 45 United Nations Framework Convention on Climate Change.

7. TRANSPORTATION AND ENVIRONMENT

TRANSPORTATION AND ENVIRONMENT – COST-BENEFIT ANALYSES AS SUPREME JUSTICE

By Kaj Jørgensen

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COST-BENEFIT ANALYSES USED FOR THE ASSESSMENT OF ENVIRONMENTAL MEASURES

Bjørn Lomborg stands out as one of the most tenacious and least sceptical proponents of cost-benefit analyses for use in assessing the opportuneness of environmental measures, e.g. if doing something about climate issues ‘pays off’. However, this type of analyses are also spreading among several other – and more influential – circles, and within a number of other fields. For several years cost-benefit analyses have been gaining ground in the transportation sector, as a method of prioritising among environmental measures, and to set targets for the field.

The present section will review examples of such use of cost-benefit analyses. The cases relate to Danish agents; yet their work is completely parallel to what is seen in other EU and OECD countries. Among other things, cost-benefit calculations were implicated in assessing whether the targets adopted for the CO₂ emissions of the Danish transportation sector are “optimal”, i.e. that 2005 emissions would be stabilised at the 1988 level, and that by 2030 reduced by 25 per cent. According to their proponents, cost-benefit assessments are not one approach among others towards such ends, but simply the one and only way to relate to prioritisation issues.

Proponents of the method do acknowledge its shortcomings; yet this is mostly seen as a matter of improving the basis by carrying out still more analyses – not questioning at all whether this is the right approach.

Generally, these other proponents’ hopes for applications of the method are hardly as high as Lomborg’s. Still, most of them do not cast doubt on its fundamental principles. Equally, they tolerate no doubts as to its position as prime justice in decision-making processes. Since they think of cost-benefit prioritisations as the canon of prioritisation methods, they often consider a refusal of these methods as tantamount to refusing prioritisation as such – which is also a cornerstone in Bjørn Lomborg’s argument.

THE MINISTRY OF FINANCE

A case of a very simple cost-benefit analyse is a calculation of environmental measures found in the environmental assessment of the 1999 budget, carried out by the Danish Ministry of Finance.¹ In it, individual energy taxes have simply been related to the CO₂ emissions they are associated with, and it is found that the transportation sector is paying far heavier taxes per tonne of CO₂ than do the other sectors. The analysis is of a praiseworthy simplicity, yet not very exhaustive, given the fact that such taxes have a host of beneficial effects other than their impact on CO₂ emissions. E.g., a restricted amount of traffic would make for better road safety and urban environment. The Ministry of Finance does mention the point, yet does not allow for it. Others have moved their analytic devices into position to work up aggregate quantified weightings (in economic terms) of the different effects, with the argument that otherwise individual preferences would risk skewing the picture, and equally there is a tendency of giving less

weight to non-quantified parameters.

The Danish Ministry of Transportation has worked for several years to provide a basis enabling the use of economic assessments, both in setting CO₂ reduction targets for the transportation sector and in prioritising between different interventions.² The work was not launched until several years after the reduction targets for CO₂ emissions from the transportation sector had been set, and they never arrived at a conclusive result of the analyses.

Indeed, COWI Consultants, who carried out this analytical task for the Ministry of Transportation, has given up valuating the CO₂ emission. They indicate that 'at the present time it is not possible to give a barely reliable estimate of the cost of damage per tonne, incurred with continuing CO₂ emissions at the present level'.³ On that background it is striking to note the weight that Bjørn Lomborg attaches to cost-benefit assessments of climate intervention.

THE DANISH ECONOMIC COUNCIL⁴

The Danish Economic Council also contributed to the above exercises, with a chapter on 'Transportation. Economy and environment' in their biannual statements on Danish finances – the so-called Sage Report of Spring 1996.⁵ A key topic of their work is the valuation of externalities, meaning a value is attributed to side effects that do not normally carry money value in a market economy. The objective is to visualize,

- how different effects weigh in on the total picture, and hence which of these should be targeted individually (compared to other interventions addressing the transportation sector, e.g. those related to road safety or other emissions).
- the costs of the CO₂ emissions in the transportation sector in relation to other parts of the energy sector, hence if reduction targets are "optimal" (compared to actions in other parts of the energy sector).

Even advocates of these analytic tools concede that the present basis is extremely uncertain, however, in their view, it is primarily a matter of providing more data, and not a question of more fundamental problems. To the extent that market prices are available, these are used to calculate costs and benefits associated with the interventions. If not, they are determined based on interviews concerning people's preferences as expressed in purchasing power – also known as *willingness-to-pay*.

The Economic Council computes the transportation sector's annual externalities costs of emissions, accidents, noise, and wear and tear of the roads to be at 4.5 billion ECU. The overriding cost is air pollution (at 43 per cent) and accidents (at c. 40 per cent). CO₂ emissions merely account for c. 6 per cent of the externalities costs. However we have great uncertainties here – a factor of 10 is not unheard of – and it is not just a matter of providing more data in order to eliminate those uncertainties.

For example, the great weight attached to traffic accidents as compared to CO₂ costs is closely linked up with the fact that preferences are expressed in purchasing power. The thing is that those killed in traffic accidents in Denmark and other prosperous countries (with high purchasing power) weigh in more heavily than those who die from climate effects, since these deaths mainly occur in third-world countries. Moreover, for their calculation of accident costs, the Danish Economic Council takes the value of a life lost in the Danish traffic, a figure several times greater than the one normally used by the Danish Road Directorate socio-economic analyses of new road projects.⁶ The explana-

tion of the higher rate used is that it reflects the aggregate loss of welfare caused by those accidents, based on a study of people's willingness to pay for accident prevention. Without this write-up the accidents and CO₂ costs would account for approximately the same share of the aggregate costs in this analysis.

Given the great uncertainties associated with the calculation of externality costs, they may well be illustrative in terms of effects not reflected in prices; but they cannot reasonably be used in prioritising between different considerations, and thus it makes little sense to use them in calculating 'socioeconomically adjusted prices' of petrol and diesel fuel.

MARKET AND FREEDOM OF CHOICE

Since cost-benefit proponents think of the free market as the ideal state, any deviation from the market price is by definition considered a loss. Furthermore, market-based choices are unquestioningly taken to express human preferences, meaning that deviations from these are considered as 'loss of welfare' and are included as a cost factor. It is also normal for transportation to be viewed as a benefit in its own right, while drawbacks are merely seen as regrettable impacts from the traffic environment (external effects such as traffic deaths) or from the motorist proper (e.g. loss of time) – meaning that we just need to have such losses valued. The growth in transportation in itself is not made an issue – since, according to theory, it would not exist if it were not a benefit.

What is ignored is that it is also transportation itself that generates problems: greater mobility creates more opportunities, while also restricting opportunity via its impacts on existing physical and social structures – mostly with a pronounced social bias in terms of distribution of opportunities. Less than half the Danish population has access to a car for day-to-day transportation. It would be impossible to provide car transport for everyone matching the level of those with the greatest mobility (space would simply not allow that). Thus, we have to restrict transportation in order to secure a certain necessary mobility for everyone. By such restriction CO₂ savings would come into the bargain.

The assumption that choices invariably express human preferences does not hold, for one thing because the market does not work 'by the book' – which is described as the so-called market imperfections, i.e. circumstances that the market is unable to allow for or remedy. It is implicit in the term that if the market is unable to meet the population's requirements, this is an exceptional case. There is a problem if the number and extent of market imperfections is so pervading and insurmountable that using the ideal state as a basis does not make sense. In that case, those 'imperfections' become the rule rather than the exception. The functioning of a market is, among other things, limited by the fact that the supply side is focused on relatively few lucrative options, while cutting away the remaining options. As we know, it is not just generated by demand, but also by whichever demand can be made the basis of a remunerative enterprise.

SHOPPING AND TRANSPORT

As a case in point, we could take the history of the convenience goods sector.⁷ In the late 1950s, when the car became more widespread, it enabled some customers to choose shops farther away from their homes. Even if they were a minority – in the beginning maybe even a very small minority – the impacts were significant: The turnover of neighbourhood shops dropped, with subsequent closures. Even minor reductions in

turnover – e.g. 10 or 20 per cent – can potentially consume the profits of such shops and thus cause them to close down. As a result people typically had to do their shopping at a longer distance – also because shopping centres were often located at traffic junctions and not close to people’s homes. This in turn reinforced their need for a car in order to manage their shopping. What is more, the new generation of shops (supermarkets etc.) had inherent demands for expansion, also in order to ensure good returns on their investments in modern technology, and they made a determined effort to smother the neighbourhood shops. The result was a vicious circle, in which structural change (shop closures and re-location of trade) intensifies people’s dependency on owning cars, while car ownership intensifies the centralisation of shopping facilities. A similar phenomenon is seen for the distribution of goods to the shops. Transport lorries have enabled shops to choose their suppliers and distribution systems more freely. But by now national (and multinational) networks have outcompeted local shops, one result being that today many shops have few choices when it comes to selling fruit and vegetables produced locally.

The lesson to be taken from this example is:

- that the ‘preferences’ issue is rather ill-defined. Preferences – to the extent we can talk about preferences at all – is not something we are born with. They are created, and may be linked up with system’s compulsion and conditional choices. Hence a given trend cannot be chalked up on people’s needs;
- more transportation does not necessarily represent a welfare benefit;
- the transport choices of the individual cannot be evaluated in isolation, since impinging on that of others;
- cost-benefit analyses cannot disclose fundamental issues of a qualitative nature. Even though the qualitative discourse is difficult, and risks coming off the rails, there is no point in dropping it and trying to quantify everything in money.

CONCLUSION

Really, the greatest concern associated with cost-benefit analyses is not necessarily the risk of erroneous conclusions, but instead that cost-benefit analyses could stall the debate by swamping it with discussions on the theory and methods of economics. On the other hand, one would need more than average confidence in economic theories in order to entrust them with one’s destiny – a confidence, which is not warranted. This is seen from the extremely great variations in their calculations of the costs of externalities, which becomes even clearer with the issue of transport growth: as being singularly positive (by definition), negative, or somewhere in between. Therefore, what we need is not to put in a lot of energy, trying to find the ‘right’ price of human life, but to understand that there is no such thing as a right price. The question as to how much effort we want to invest in preventing lost human lives is a question of a value-related and political nature. It is not possible to calculate this mathematically.

Economic science needs to take up its proper place – not as judge superior, but as a tool to be used for defined purposes. Of course, the cost of things – and how to prioritise them – is not altogether immaterial, but still we cannot evade weighing qualitatively in those situations.

In this respect, Bjørn Lomborg uses cost-benefit calculations to the extremity. Lomborg will reduce incredibly complex systems, e.g. climate change of both global dimensions and over a very wide time span, into matters subject to decisions on money terms only. However, other and more influential agencies are doing similar calculations, albeit of a

slightly more limited nature, but fraught with the same great uncertainties and fundamental methodological problems. They are given more and more weight in decision-making processes, and considerable resources are being spent on research to sophisticate the methods, although this is hardly the road out of the quagmire around these calculations. This is why the Lomborg debate is not just about Lomborg.

- 1 Finansministeriet: "Miljøvurdering af finanslovsforslaget for 1999". København, 1998. [The Danish Ministry of Finance; Environmental Assessment of the 1999 Financial Bill]
- 2 Trafikministeriet: "CO₂-reduktioner i transportsektoren. Hovedrapport". København, 1996. [The Danish Ministry of Transportation; Co₂ reductions in the transportation sector].
- 3 COWI: "CO₂-reduktioner i transportsektoren. Samfundsøkonomisk omkostningseffektivitet i transportsektoren. Arbejdsrapport nr. 1". Lyngby, 1997, p. 11. [COWI consultants: "CO₂ reductions in the transportation sector. Socioeconomic cost-effectiveness in the transport sector].
- 4 The Danish Economic Council is an advisory board, consisting of three university professors as a chairmanship, a council representing employers, trade unions, government etc., and a secretariat financed by the state (the general budget).
- 5 Det Økonomiske Råd, Formandskabet, København, 1996. "Dansk økonomi for år 1996". [The Danish Economic Council; Danish Economy, Spring 1996].
- 6 Vejdirektoratet: "Trafikøkonomiske enhedspriser. Prisniveau 1997" (Rapport 186). København, 1999. [The Danish Road Directorate]; Transport economy unit prices. Price levels 1997].
- 7 Kaj Jørgensen: "Energy Efficiency in Grocery Distribution - 1960 to the Present". ECEEE 1997 Summer Study, Spindleruv Mlyn, Czech Republic, 9.-14. juni 1997.

8. AIR POLLUTION AND ACID RAIN

Air pollution and acid rain – myth and reality

*By Per Gundersen, senior scientist,
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In *The Skeptical Environmentalist* (178 pp.) Bjørn Lomborg argued that environmental problems caused by air pollution are overrated, and that acid rain is a 'myth' of the 1980s. He puts in a special effort to disprove fears of forest decline. It is vital to discuss myths on environmental problems – in view of either having them put to sleep or confirmed by new knowledge. We did not get the rampant forest decline that many people at that time envisaged would sweep Europe - fortunately. So does that mean the problems have been solved, and all is well in the forests? No, unfortunately not. Environmental problems are complex, and invariably more complex than believed at first sight. The European media ran a wide-screen horror version of the story. In order to help understand why I will offer my interpretation of the historical background of acid rain. The intricate realities about acid rain (and those with somewhat less media 'appeal') will be described, as they appear today from the viewpoint and perspective of an environmental researcher.

THE TALL SMOKE STACKS

In a chapter on air pollution (pp.165-177) Lomborg outlines how air quality in the cities of the western world has greatly improved over the 20th century. Such improvements in urban living conditions were not brought about by a reduction in emissions, but by centralising energy supply and building taller smoke stacks. Until 1980 or so air pollution control was about calculating the appropriate height of smoke stacks. The 'tall smoke stacks policy' implied an increased load on nature areas with sulphur dioxide, nitric oxides, heavy metals, etc. It was established that particles could be carried off several thousand kilometres and result in acid rain in outlying nature areas.

In Europe air pollution will move northeasterly where especially Norway and Sweden have been and still are hit the hardest¹. Acidification of rain was first documented in 1967 by Svante Odén, a Swedish researcher, who also described its impacts on Swedish watercourses and lakes². The problem proved to be a comprehensive one. In an area of 18,000 square kilometres in Southern Norway fish are no longer to be found in watercourses and lakes. In Sweden 14,000 lakes are acidified, and another 3,600 lakes are kept alive by liming. Sweden's annual expenditure for liming of lakes is at SEK 200 million [approx. EUR 22 million; eds.].³ During the 1970s Sweden and Norway tried to stir up international attention to these problems, created by pollution from abroad, but with little success. Moves towards a reduction of emissions only became truly successful when the media became boosted with images of dead trees.

THE DISASTER

Alone in the Erzgebirge, a mountainous Czech region, around 100,000 hectares of forest had died in the early 80s.⁴ Despite extra logging of about 500,000 cubic metres annually,⁹ clearing was unable to keep pace. Large areas with dead trees therefore remained and toured the world media. The disaster was a real one. In adjacent areas in former East Germany and Poland the trees had also died. The region had established a heavy industry relying on lignite with a high proportion of sulphur. A single power plant could potentially have a sulphur emission on a par with Denmark's entire emission. The population of the region had/has a marked excess mortality from several

diseases.⁶ Therefore the region was named 'The Black Triangle'.

In the late 70s West German foresters discovered damage to forest trees, especially silver firs, that could not be accounted for by known diseases. In 1982 an assessment of damage extent was conducted, which showed damage to 8 per cent of the forest area. By 1983 damages had increased to 34 per cent, and by 1984 to 50 per cent.⁷ The hitch with these figures was that they were not based on completely identical assessment methods and therefore left an impression of the progression as being more extreme than was indeed the fact. The figures gave rise to a sense of panic among foresters in West Germany. Newspapers abounded with features on 'Forest Decline'. The debate was emotional, and in those days phrases such as 'ecological Hiroshima' and 'invisible plague' as cited by Lomborg were probably widespread in the media. Yet can we hold such a response against people who believe their world is coming apart? And the experience of driving mile after mile through Czech or Polish ghost forests is bound to leave a profound impression in anyone – and one you would never again hope to see anywhere else.

With the wisdom of hindsight we can see that our worst fears did not come true. Nevertheless the notion of 'forest decline' has become ingrained, and any deterioration in forests will be construed as such by press, dead trees or not. On several occasions, including a major 'acid rain' conference at Gothenburg, Sweden, researchers have cautioned that forest damages have been far less than predicted during the disaster phobia of the early 1980s⁸, yet their message had no penetration power in the media.

CAUSES OF FOREST DAMAGE

Back then the damage seen in the German forests was inexplicable, and several theories were advanced during the 1980s. They had to practically start from scratch, which paved the ground for disaster scenarios. An interlinking between air pollution and 'forest decline' as in the Erzgebirge lay close at hand. Today, after 15-20 years of research there is a widespread agreement among researchers that causes are extremely complex. They can largely be described as follows: As for the extreme 'forest decline' in The Black Triangle *direct* impacts of air pollution on the leaves and needles of trees played a major role. With remote pollution sources the impacts are *indirect* and soil-borne. Strong acids will wash essential nutrients out of the soil and increase concentrations of potentially toxic aluminium in the soil. This will seldom kill the trees, yet impair their resilience to climatic stress (drought, frost) and pests (e.g. insects). Actual damage may then be triggered by extreme weather conditions. This can be compared with the fact that people will also be more prone to illness when their general level of resistance is low. Thus the damages found in Germany during the 1980s were probably brought on by climatic conditions. Yet would they have occurred to such an extent in the absence of air pollution?

It is immensely difficult to substantiate the indirect impacts of air pollution when actual damage occurs in relation to climatic extremes etc. At most we can substantiate our case by looking at various chemical indicators, e.g.: that many forest soils have been acidified over the latest two or three decades; that significant nutrients are being washed out more quickly than they are being supplied; that the result is an imbalanced supply of nutrients in the trees. The case is further complicated by the fact that basically biomass exploitation (logging which removes trees from the forest ecosystem) has the same effect as air pollution (Figure 1). One could say that air pollution taps the nutrient resource that used to be available for forestry purposes only.

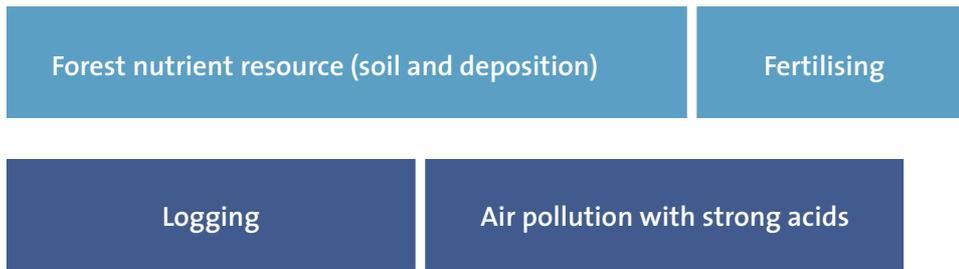


Figure 1: Simple model of nutrient resource. The available nutrient resource in a forest has a finite extent (which can obviously be increased by fertilising). ‘We’ can consume those nutrients either by removing biomass from the forest (logging), or by using the forest as a recipient of air pollution. Strong nitric and sulphuric acids wash nutrients out of the forest soil. In many places logging and air pollution are consuming more than the available resources.

Researchers agree that in the longer term the present pollution levels will impair forest productivity and stability.⁹ Where researchers disagree is in terms of the uncertainty as to how long it will take for adverse impacts to arise, and to what extent it is possible to reduce problems by liming and fertilising. Here we need to keep in mind that forests have only been exposed to the extreme pollution load for the last 30 or 40 years, while we need to secure forest health and productivity for several centuries.

A recent study from Norway based on increment measurements from more than 31000 spruce trees has for the first time demonstrated long-term decline in forest growth due to acid deposition.¹⁰ A complicated statistical analysis was used to compare areas with low acid deposition against areas of high acid deposition (Figure 2). The results show that spruce trees in Norway grew better in high deposition areas in the 1960s and 1970s - the period of major pollution increase - (points ‘b’ and ‘c’), probably as an effect of fertilisation by the increasing nitrogen deposition and an initial release of other nutrients by acidification. Initial beneficial effects from acidification have been demonstrated in many short-term experiments. As acidification from acid rain persisted over decades the increment decreased below that of low deposition areas in the 1980s and 1990s (the two ‘d’ points).

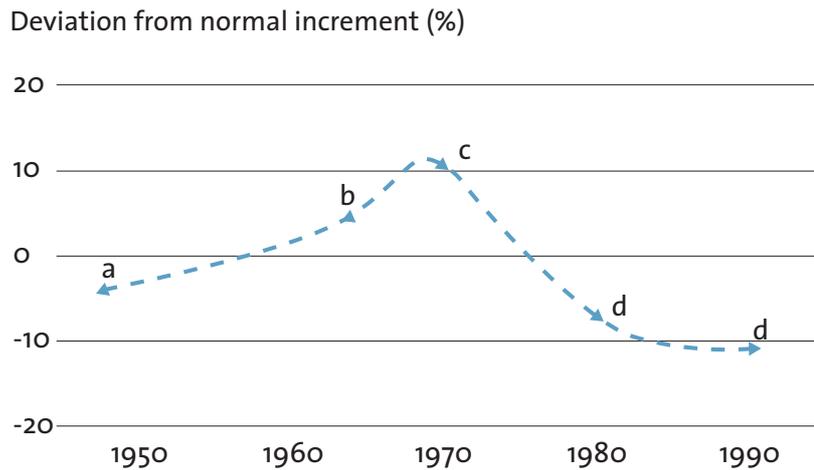


Figure 2: The difference in radial increment of Norway spruce between areas of medium to high deposition and areas with low deposition in Norway. Measuring points with different letters (a-d) are significantly different (Nellemann and Thomsen, 2001; note 10). The authors have excluded effects of age, soil and climate differences through an advanced statistical analysis.

WHY 'FOREST DECLINE' NEVER HAPPENED

Based on fears of massive 'forest decline' measures were taken, which have reduced the risk of damage: From 1980 to 1994 sulphur emissions in Europe were cut by 50 per cent. In Saxony, a former state of East Germany (in The Black Triangle) SO₂ emissions dropped from 4 million metric tons to about 100,000 tons from 1989 to 1992.¹¹ Following the 1989 reunification lignite-fired works were closed down or equipped with purification plants, which considerably reduced the load on parts of the German forest areas. A million hectares of European forests have been limed and/or fertilised¹² in order to counteract nutrient problems. In some German regions researchers have quite a hard time trying to find stands for experiments or monitoring that have not been limed already. Yet the problem of using liming as a remedy is that natural plant and animal life are affected, and in some cases there may be a risk of stimulating nitrate leaching from forests.

Recent research findings seem to indicate that via their interplay (symbiosis) with various root fungi, trees are able to draw nutrients from soil minerals, meaning that trees may be less sensitive to acidification than believed previously. Still this vital interplay between tree and fungus can be compromised by the increased nitrogen deposition brought on by precipitation.

An inventory of damage to European forests says that 'air pollution has only in few cases been identified as the cause of damage'¹³. This does not imply – as read by Lomborg – that there is no damage. It implies that few cases of direct damage were found. As already mentioned the impacts of indirect damage are hard to quantify. Still it is disquieting that the health condition has deteriorated for practically all tree species over the ten years for which Europe-wide studies have been conducted.¹⁴ In later years an intensive large-scale European forest-monitoring scheme¹⁵ has collected large amounts of data, which presumably in the next few years will enable us to better filter the significance of air pollution and acid precipitation from other factors influencing forest health and growth.

INCREASED GROWTH – A PARADOX?

Lomborg points out that acid rain cannot have a negative impact on forests, given the fact that productivity has increased in some European forests.¹⁶ It certainly does sound like a paradox. It is important to note that increased growth is not a general European phenomenon, and that increments have clearly gone down in some areas.¹⁷ Increased growth can happen for a number of reasons, including better forest management, more carbon dioxide in the air, a warmer climate, increased nitrogen deposition, and the fact that initially acidification will actually make a little more nutrients available to the trees. Another possible reason is that in the past forests were over-exploited due to collection of firewood and the use of foliage for animal feed and bedding. The soil was exhausted, so in some forests increments were lower in the ‘good old days’.

The incremental increase at many localities cannot continue in the long term, as shown by the results in Figure 2. Nutrients will be spent and the forest will start having problems maintaining stability. Growth may well be strong for a while, yet the trees often will have to be felled before time, so the forest owner does not reap the anticipated profit.

In his argument Lomborg placed much emphasis on the findings of a single 3-year experiment from the USA. It has not been possible to find the original publication from the experiment.¹⁸ Three tree species were exposed to rain with increasing acidity (decreasing pH) without this showing any growth impacts. First, three years do not count for much in a forest setting, where the perspective is 50-200 years. Moreover the trees must have been small and presumably pot-grown. Second, the acidity (pH) of the rain is only a minor part of the problem. For instance in several European regions rain is not all that acidic, and often neutral (pH 7) because the ammonia released from agriculture farms neutralise the rain. Still, when it comes to the forests, this is not to much avail, since it is the amount of sulphur and nitrogen compounds that usually causes problems, by stripping the soil of vital nutrients like calcium and magnesium. With his focus on pH in rain Lomborg demonstrates his superficial understanding of the acid rain problem. He may not have understood that ‘acid rain’ is an expression covering a broad complex of air pollution-related problems in the environment, all leading to deterioration of soils through loss of nutrients and weakening of vegetation.

When Lomborg in his book plays down the problems arising from acid rain, he largely underpins his argument with citations from the executive summary of a major research and investigation work from the USA (NAPAP - National Acid Precipitation Assessment Program), concluded in 1990. Lomborg points to NAPAP as the world’s longest, largest, and most expensive study. This is apparently meant to be a positive quality; however US scientists and sources in the US-EPA say that the report was influenced by political judgements, and much emphasis was placed on the uncertainties. Furthermore, a range of important results from NAPAP studies was published at a later stage.

According to US-EPA¹⁹ there are major problems with acid rain in the USA, especially regarding lakes and surface water. Moreover pollutants from the USA are carried on to Eastern Canada, where i.a. 14,000 lakes have been acidified. In addition one of the most thoroughly documented examples of manifest forest decline caused by the indirect effects of acidic precipitation is found in the plateaus in Eastern USA (e.g. Great Smokey National Park).²⁰ Heavily increased sensitivity to frosts is an important element among several indirect impacts of acid precipitation, causing spruce decline.

The NAPAP has continued to work on integrated assessments of acid rain for the US Congress, and the executive summary on forests of 1998 report²¹ reads: 'Sulphur and nitrogen deposition have caused adverse impacts on certain highly sensitive forest ecosystems in the United States.... if deposition levels are not reduced in areas where they are presently high, adverse effects may develop in more forests due to chronic, multiple-decade exposure.'

Air pollution levels in Europe are considerably higher than in the USA. Consequently Europe has also spent vast resources for 'acid rain' and air pollution research. Over the last 10 or 15 years the process from scientific insight to environmental policy intervention has been linked by the notion of 'critical levels and loads'. Based on available knowledge researchers are trying to determine the amount of pollution that various types of nature can endure before suffering damage, or their future stability and productivity are compromised. Tolerance limits are entered into geographical maps and collated with emission and deposition data. The environmental policy goal is a step-by-step reduction of the difference between deposition and tolerance limits (*gap closure*).²² Using environmental economy models attempts are made to optimise the reduction targets of the individual countries, enabling us to get the most environmental benefits for the money spent.

ENVIRONMENT AND ECONOMICS

Lomborg does not really discuss cost and benefit related to pollution control of 'acid rain', although this is his field of profession. However on page 179 he tries to make the case that damages to buildings and materials are of no importance (again based on the 1990 NAPAP report), yet without mentioning the actual cost of such damages. For the 1994 international agreement on reduction of sulphur emissions the benefits on buildings alone were estimated at 7 billion EUR per year for a total spending on cleaning of 13 billion EUR annually.²³

If we look at all types of adverse effects (health, nature, materials, reduced visibility, etc.) benefits are obviously greater. The EU Commission is preparing an 'Acidification Strategy', which towards the year 2010 will further reduce emissions in the EU.²⁴ According to Commission calculations the societal costs incurred from implementing the strategy will by a wide margin be outweighed by its benefits for society. Their annual cost on EU level for the year 2010 will be 7,5 billion EUR/year, while the benefit is estimated at somewhere between 17 and 32 billion EUR/year.²⁵ The 1998 NAPAP report reaches the same conclusion for the legislation implemented in the USA, and states that the mere benefits in the fields of human health and visibility will exceed the costs of pollution control.²⁶

AIR POLLUTION WITH NITROGEN

Sulphur emission has declined and will drop further over the next few years. By contrast there has been no such drop in nitrogen releases, making it the single largest air pollution problem in today's Europe. It is caused especially by a large nitrogen release to the air from agriculture (mainly animal husbandry), in the form of ammonia. In 1990 the agricultural release of nitrogen for Europe was estimated at 3,5 million metric tons. On top of this 2,9 million metric tons of nitrogen is emitted from traffic and energy production as nitric oxides.²⁷ From the 1950s and to this day the nitrogen content of rain-water has practically quadrupled.

Forests are particularly good at filtering air and in Central and North-western Europe

forests thus receive from 10 to 60 kg of nitrogen per hectare each year. Woods and forest edges will receive as much as 100 kg per hectare. Trees need less than 10 kg per hectare to cover their annual growth. The rest will accumulate in the soil or be washed out. Surplus nitrogen in forests can potentially harm the trees, especially because it creates an unfavourable balance between the essential nutrients. Plants indigenous to nutrient-poor nature areas (forests, dune heaths, high moors) can no longer compete with more nitrogen-loving plants.

Many European forests are still able to retain the supplied nitrogen, but about 40 per cent display elevated nitrate leaching.²⁸ At 14 per cent of the forest area, nitrate limit values for drinking water have been exceeded. The proportion of forests with elevated nitrate leaching will gradually increase as the nitrogen-binding capability of the soil is exhausted. Today we think of forest as a benefit for water quality. In the future, if the big nitrogen inputs from the air continue, our forests may fall short of our expectations in this regard.

Many large cities in Germany and elsewhere depend on clean surface water from forest areas. The same is for instance true for New York City where water is supplied from the Catskill Mountains.

THE MEDIA AND THE DEBATE

The dissemination part is a key issue with the environmental debate. Problems of environment are complex, and probably there is no getting around the fact that occasionally we need to simplify them in a public debate. But still, do such simplifications necessarily have to become clichés, to be mindlessly repeated over and over? We could certainly do with some investigative journalism, capable of looking beyond images of dead trees. On the one hand I consider part of Lomborg's work a positive contribution towards reinvigorating the environmental debate, let us be critical, and 'get a few stones turned that were about to dig themselves in'. On the other hand he has adopted a canvassing approach that is already beginning to make this a black-and-white debate once more. What we need is people and media who are able to challenge know-it-all researchers, one-eyed environmentalist NGOs and economists who feel entitled to monopolise Truth.

Acid rain is not a myth. Acid rain causes a number of thoroughly documented environmental problems. Forest damage is one aspect that has been overrated by the media under the 'forest decline' heading. But all the same acid rain does harm the long-term stability and productivity of forests. Especially in Europe problems caused by acid rain have decreased over the years because – based on knowledge – international agreements to reduce emissions have been reached. Intensive studies of forests and nature have demonstrated that, although those problems are complex ones, our moves to reduce air pollution have been necessary. In Asia and South America emissions are on a rapid increase, and first reports on acidification damage in China have begun to emerge in the literature.

In 1999 yet another international air pollution agreement was endorsed, this time including the release of nitric oxides and ammonia.²⁹ And an agreement not based on a myth, but instead based on a process integrating environmental knowledge, economy, and environmental policies. It is quite likely the most well-founded environmental policy agreement ever entered.

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- 2 Svante Odén, Nederbördens försurning. Dagens Nyheter, 24. October 1967. [Acidified precipitation].
- 3 Acidification and Air Pollution. Naturvårdsverket, Sweden.
- 4 Europe's Environment. The Dobris Assessment. EEA, Copenhagen.
- 5 Cerny & Paces. Acidification in the Black Triangle Region. Acid Reign '95? - Excursion guide, Prague, 1995.
- 6 B. Rohde (ed.). Air Pollution in Europe, Vol. 2: Socialist countries, Vienna Centre.
- 7 Allgemeine Forst Zeitschrift, 22/12-1984, p. 1265.
- 8 H. Rohde et al. Acid Reign '95? - Conference summary statement. Water, Air and Soil Pollution 85:1-14, 1995. Conclusions to 1000 researcher conference on acid rain in Gothenburg, Sweden.
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- 10 C. Nellemann. and M.G. Thomsen (2001): Long-term changes in forest growth: potential effects of nitrogen deposition and acidification. Water, Air and Soil Pollution, 128:197-205.
- 11 E. Brueggemann & G. Spindler (1999): Wet deposition of sulphur at the site Melpitz in East Germany. Water Air and Soil Pollution, 109: 81-99.
- 12 H. Rohde et al., Note 8.
- 13 Lomborg *The Skeptical Environmentalist* page 180, top, 1st column.
- 14 Ten years of monitoring forest condition in Europe. UN-ECE & European Commission, 1997.
- 15 Level II övervakningen i ICP-Forest (International Cooperative Programme on assessment and monitoring of air pollution effects on forests) under UN-ECE and EU.
- 16 Science, vol. 256 (1992).
- 17 H. Spieker (1999). Overview of recent growth trends in European forests. Water, Air and Soil Pollution 116: 33-46.
- 18 I asked Lomborg for a copy, but he did not have the original paper. He merely referred to a secondary publication.
- 19 EPA-Acid Rain Environmental Effects Factsheet, <http://www.epa.gov>; Acid Deposition Standard Feasibility Study Report to Congress, EPA 430-R-95-001a, Oct. 1995.
- 20 Acid Deposition Standard Feasibility Study Report to Congress, EPA 430-R-95-001a, Oct. 1995, page A-6.
- 21 NAPAP Biennial Report to Congress: An Integrated Assessment, National Acid Precipitation Assessment Program, National Science and Technology Council, Silver Spring, Maryland, USA, May 1998.
- 22 Communication to the Council and the European Parliament on a Community Strategy to Combat Acidification COM (97)88 (<http://europa.eu.int/comm/environment/docum>).
- 23 H. Rohde et al. Note 8.
- 24 National Emission Ceilings Directive COM(1999) 125 (<http://europa.eu.int/comm/environment/docum>) and the document in note 22.
- 25 National Emission Ceilings Directive COM(1999) 125, pages 33 and 37.
- 26 NAPAP 1998 report (Note 21), page 4.
- 27 Recalculated from page 8 in note 24.
- 28 W. De Vries, G.J. Reinds, H.D. Deelstra, J.M. Klap and E.M. Vel (1999). Intensive Monitoring of Forest Ecosystems in Europe. Technical Report. EC-UN/ECE 1999, Brussels, Geneva, 160 pp.
- 29 The 1999 Gothenburg Protocol to Abate Acidification, Eutrophication and Ground-level Ozone www.unece.org/env/lrtap/

9. CHEMICAL SUBSTANCES

By Christian Ege, director, The Danish Ecological Council

The uncertainties of scientific evidence are considerable when it comes to chemicals that are ecotoxic and hazardous to human health. However, their impacts can be quite considerable, too. Human history is riddled with disastrous mistakes that we would not want to ever repeat. Up until the early 1980s large quantities of DDT and PCB were used, two of the most dangerous ecotoxins known so far. Back in the 1960s, several experts swore that they were safe. Yet, although the industrialised countries gave up their use 15 to 20 years ago, those substances are still found, dispersed throughout the global environment. The thing is that they are extremely persistent. The people who are suffering the highest exposure to those substances are precisely those who never used them, namely Arctic Inuit populations, who subsist on fish and marine mammals, where concentrations are the highest. A case in point: Today Canadian Inuit women are only reluctantly recommended to breast-feed their infants¹ – which would otherwise be considered essential to a person's quality of life.

Swedish and US authorities advise women of childbearing age to limit their consumption of certain fish species from certain locations, since they would otherwise risk contaminating their breast milk with e.g. DDT and PCB. For the time being, Danish authorities have not issued a similar recommendation, in part for fear of deterring some women from breast-feeding altogether – and not without a reason, since it would be disastrous if many mothers were to give up breast-feeding. Norwegian consumers are directly advised against eating fish caught in a number of polluted fiords, due to their high ecotoxin content.

Some of the substances still in use closely resemble PCB in terms of persistence and toxicity, namely the so-called brominated flame retardants. They are used in large amounts notably in electronic devices. Increasing concentrations are now detected in breast milk – though still in far lower concentrations than PCB. However, they will reach the same level if the present trend continues.² In addition, brominated flame retardants have been proved to cause brain damage in newborn mice.³ The National Danish Institute for Food Safety and Toxicology in 1999 agreed that such persistent and ecotoxic substances should be phased out without awaiting further risk assessment. Still, those substances do not appear to be quite as toxic (potent) as PCB so far.⁴

How are we to prevent the problems associated with dangerous chemicals? The answer is closely linked up with the extent of scientific evidence required before steps are taken to ban or limit the use of certain chemicals. Previously, in most fields, restrictions on the use of a given chemical would be introduced only once actual damage in humans had been proved. Nowadays we will try to take action before things come to such extremes. However, this can only be done under certain assumptions, e.g. that in some cases findings from animal studies can be applied to humans, or from cell-level studies to complete organisms. A great many chemical substances are already known to be ecotoxic – i.e. harmful to animals and plants. Several have been shown to be toxic in animal experiments.

For far less of those substances do we positively know them to have harmed humans. What we do know is that thousands of people worldwide – in later years notably in developing countries – have died or contracted serious illness due to accidents or poor

working environments related to hazardous chemical substances. For instance, thousands have died as a result of working with asbestos. By contrast it remains non-proven that a very large number of people have died or been harmed by ordinary, non-occupational exposure to hazardous chemicals. Lomborg is right in pointing out that occasionally we come across statements that are probably exaggerated, e.g. that a very large proportion of total cancer deaths can be attributed to our exposure to industrial chemicals. Yet, Lomborg completely ignores the uncertainties of the full-scale experiment that we are exposing ourselves to by using thousands of chemical substances, without prior studies on their impacts on humans and the environment. What is more, he disregards the fact that we see extensive effects on organisms found in our environment – snails with gender disturbances (so called imposex), polar bears that turn hermaphroditic, male alligators with grossly reduced penises, etc.

A possible approach to substantiating that damage does occur in humans is the so-called epidemiological population studies, in which a population segment that has been exposed to the relevant substance is collated with a control group that has not. However, such studies present considerable difficulties, since it is quite hard to find groups that were exposed to the substance in question, yet without concurrent exposure to other hazardous substances. Moreover the control group has to closely resemble the study group in terms of age and occupational composition, smoking habits, urban/rural distribution and other circumstances that could potentially skew the relationship under study. The name of the game is checking for *confounders*. Fortunately, epidemiologists are constantly honing their skills in doing such studies. But they are comprehensive and time-consuming, and often produce less than conclusive findings.

Apart from the known potential hazards of such chemicals, we also find an increasing incidence of several conditions in the population, even given the improvements in general living standards, preventative medicine, and hygiene. They include asthma and allergy, and breast and testicular cancer, and there is much to indicate that infertility (involuntary childlessness) has increased, and that male semen quality has deteriorated, a point I will get back to.

We are often left without definite proof of a precise link between the individual hazardous chemical and specific damage in humans. Estimates are that somewhere between 20,000 and 70,000 different chemical substances are currently in use, the majority of which has not been assessed for relevant ecotoxic and hazardous properties. That is, we have let ourselves be enrolled in a gigantic full-scale experiment, investigating if these substances will sometime turn out to be ecotoxic or hazardous to health. If we stand by, waiting for science to produce conclusive evidence of the dangerous properties of each substance, then damages could reach monstrous proportions before we intervene to get them under control. For that very reason a political decision has been made to let the precautionary principle apply, comp. relevant section [Alex Dubgaard].

Lomborg's general conclusion is that environmental problems are overstated. As for chemicals, he purports to demonstrate that there is hardly a correlation between man-made chemicals and declining semen quality, and only a negligible cancer-causing effect of pesticide residues in food. He has thus touched on two corners of the issue, damage to the environment and to human health associated with chemical substances, while side-stepping all the remaining potential risks. Hence, as far as chemical substances go, his general conclusion – that environmental problems are of a very limited nature – is unfounded. All the same, Lomborg is right in pointing out that present-day

life style factors account for more – probably *far* more – lives lost than does pollution, e.g. by chemical substances. Still it is questionable if the allocation of societal resources for prevention should always be strictly proportional to the number of illnesses and deaths caused by individual factors. After all, smoking, alcohol and inappropriate diets are all self-inflicted evils (if, for the time being, we focus on the industrialised countries), while an individual citizen's exposure to chemical pollution is mostly undeserved. Therefore, although lifestyle factors take a heavier toll of human lives, it still makes sense to spend resources on preventing both types of problems. Add the fact that there is considerable uncertainty as to the number of deaths and illnesses caused by pollution. This definitely should not be read as an argument against spending resources on preventing lifestyle-related problems – since this is actually of major importance. However, my point is that resources should not be allocated perfunctorily – as Lomborg seems to hold – in proportion to the cause-of-death distribution we know today.

Lomborg feels he can demonstrate that pesticide residues in food and drinking water do not present a major problem, since a number of studies have shown that pesticide residues only account for few cases of cancer, and since a number of researchers consider the issue of estrogen-mimicking effect to be of minimal significance. He does mention that some researchers think there *are* problems of both cancer and estrogenic effects, but since more researchers do *not* attach importance to those effects, he feels justified in concluding that the such effects are of negligible significance. However, that approach is rarely appropriate. For one thing because the industries have far more funds to put into research than both public agencies and independent institutions. Thus, a very large proportion of research on a given substance will be funded, directly or indirectly, by the industries. Yet another problem, as already mentioned, is that it is hard to positively demonstrate such causalities in humans in a manner that allows for *confounders* etc. Therefore, it is not to wonder that it is possible to conduct several studies *not* showing a causal relationship, even when the final conclusion has to be that a causality *does* exist.

Yet, another problem with Lomborg's argument is that although one might second his view – that cancer problems from pesticides are negligible – that still would not warrant a blanket acquittal of pesticides, as does Lomborg. There could be *other* health-related problems – and there are indisputably environmental problems. Finally, it is possible that currently available scientific methods are not sufficiently good/sensitive to document the relevant impacts. In that case, we will not be able to demonstrate such causalities until some time in the future, once adequate methods have been developed.

DOCUMENTATION AND CONFLICTING STUDIES

For comparison, let us look at e.g. lead. In the 1930s, the American oil and automobile industries decided to use lead as a petrol additive. Already then, some researchers cautioned about the health hazards involved. However, they were stifled by researchers funded by the automobile and oil industries. During the 1980s better test methods were developed: First, the conventional methods used to test lead content in blood, which merely provide an instantaneous snapshot, were gradually supplemented with dental tests showing a cumulative load, and second, more sensitive psychological tests were developed that could demonstrate effects on children's emotional and mental development at lead levels previously thought to be harmless. Today it is a widely held by American and Canadian experts that it is even possible to measure how a slight increase in children's lead exposure will impair their intelligence, which for instance materialises as an increased number of school children requiring remedial instruction.⁵

And mind you, these are lead levels detected today, *after* the use of leaded petrol has been discontinued. Moreover, a Danish study demonstrated learning problems caused by lead, but this covered the situation of the 1980s, when leaded petrol was only just being phased out.⁶ Present-day lead-loads come from soil residues – deposited by cars while they were still running on leaded petrol – and in some countries, e.g. USA, from old house-paint etcetera. In other words, lead showcases a substance where warnings should have been heeded far earlier, even if the relevant testing methods were less sophisticated or less certain in the past.

Another case in point concerns two closely related substances, zinc- and lead chromate. Both belong to the so-called Chromium-6-compounds, and both have been proved carcinogenic in animal experiments. Still, for years, the EU did not acknowledge that once correctly conducted animal experiments had proved a substance to be carcinogenic it would also have to be considered carcinogenic in humans. What is more, zinc chromate has also been proved carcinogenic in human epidemiological studies. By contrast, lead chromate has not – apparently mostly because it was impossible to find a group of miners, who had been exposed to lead chromate without concurrently being exposed to zinc chromate. As we all know, it is not possible to run cancer experiments with humans, exposing them to one substance at a time in a laboratory setting. As a result, zinc chromate was acknowledged as a carcinogenic by the EU, while lead chromate was not (and still today lead chromate is only acknowledged as a class III (suspected) carcinogen) – despite the fact that to all appearances the carcinogenic property is found in the chromate-fraction, which is identical for both substances.

Finally, as a third example, let us look at asbestos. Today few researchers would dispute that (apart from causing asbestosis) asbestos can cause cancer in humans. A very decisive argument is that asbestos causes an exceedingly rare type of cancer, namely pleural mesothelioma carcinoma. Hence, it is relatively easy to demonstrate if an increasing number of persons develop mesothelioma after exposure to asbestos. Contrarily, the task would have been far more demanding if asbestos had caused lung cancer, which many people get for other reasons, e.g. smoking. If we look at a specific group of people, then 50 surplus cases of mesothelioma would make a 100 per cent increase, while 50 surplus cases of lung cancer would make an increase of e.g. 2 per cent. The former would be highly statistically significant – meaning there is sufficient certainty that the correlation is not purely incidental – while the latter would not. Or to put it differently, it is far harder to demonstrate an increase of *frequently* occurring symptoms.

This may also be true of chemical substances potentially causing allergy. Allergy has grown to be a widespread scourge that can be triggered by dust mites, certain foods, allergenic chemical substances and more. Some 20 per cent of the population suffers from some kind of allergy, so an increase brought on by a specific chemical can be minute by percentage, yet substantial in absolute figures. Statistically it would be extremely difficult to demonstrate. And another parallel: There is a considerable number of miscarriages. If a minor *proportion* – though possibly a large *number* – of those miscarriages were caused by chemical substances, this would be extremely difficult to demonstrate.

Moreover, it is a marked tendency that the causes of such widespread ailments are considered *in relative terms*, in relation to one another. For instance, researchers and civil servants tend to play down the chemicals, if they consider allergenic chemicals to be less important than dust mites in relative terms.

Something similar goes for substances that can provoke *frequent* forms of cancer. A statement to the effect that pesticide residues in foods merely account for 0.1 or 0.5 per cent of all cancer deaths would appear reassuring, even though this would amount to approx. 15 resp. 75 annual cancer deaths in Denmark in absolute figures. For comparison, there has been a great stir over the dreaded DT-104 salmonella found in meat, which caused two deaths and some cases of illness in 1998.

Thus, we need to keep in mind that present scientific constraints could make it difficult (nay impossible today) to demonstrate harmful effects in humans. Yet, to conclude on that basis that the impacts are negligible in practice – as does Lomborg – is not scientifically defensible.

PESTICIDES AND CANCER

Lomborg finds that abandoning pesticides in American food production would spare 20 cancer deaths, but would lead to thousands of additional cancer deaths because fruit and vegetables would become more expensive, so people would eat less of them and hence lose part of their cancer-protective effects. Lomborg mentions that e.g. a 10 per cent reduction of a population's fruit and vegetable intake would cause the total number of cancer deaths to increase by 4.6 per cent, or 26,000 more annual cancer deaths.

I will return to those 20 cancer deaths. The underlying rationale of Lomborg's reasoning is a belief that all potentially harmful effects of pesticide use can be expressed in cancer terms, while disregarding other health impacts, e.g. allergy. He equally dismisses the issue of impaired fertility, which I will also get back to.

Lomborg's contention, that people would eat less fruit and vegetables if pesticides were to be abandoned, is based on a study⁷ showing that the lowest income segments eat less fruit and vegetables. But that is an entirely different matter. It is a well-known fact that the population segments with the highest levels of education are those most inclined to eat healthy food and follow dietary recommendations. That does not warrant a conclusion that if food prices go up we will all move a step down the ladder and eat more junk-food. Moreover, pesticide bans and conversion to ecological farming are gradual processes that will evolve over a great many years. It has to go along with a general debate on food quality and diet composition.

In most industrialised countries, we are spending a very small portion of our available incomes on food, and the share has gone down over the last few decades. We have been hit by the discount culture. However, the trend is being reversed these years. This is evident in the eco-wave, but there are other indications that more people are prepared to pay a little more for quality foods, produced with consideration for the environment and animal welfare, and for food quality in its own right. Yet, since such a development is bound to be slow, there will still - for many years to come - be conventionally grown fruit and vegetables to buy for those who only demand the lowest-priced commodities.

Moreover, Lomborg's argument is lopsided because the price of meat products will increase at least as much as fruit and vegetables, should pesticides be abandoned. As will be known, animals feed on vegetable fodder, and there is a great loss of energy during feeding. Therefore, a price rise due to pesticide-free farming would, other things being equal, penetrate more forcibly in meat prices than in vegetable foods. If consu-

mers are to buy dearer foods with the same household money, they will have to cut down on meat and eat more basic foods – that is, bread and vegetables. Lomborg dismisses this argument with reference to the Danish Bichel Committee, comp. below. Here he refers to a specific scenario in which pesticide use is discontinued completely in Denmark, though without a conversion to ecological production.⁸ The scenario set-up is that no restrictions are set for pesticide use in imported animal feed, and that domestically produced animal feed is widely replaced by imported fodder grown with pesticides. Precisely such a scenario would be considered undesirable by any standards – and thus unrealistic – since it would not provide a more environmentally friendly production and would merely move production out of Denmark. But Lomborg picks precisely that scenario to bolster his own line of reasoning, since it allows the argument that fruit and vegetables will become more expensive here, while meat will not, simply because production is based on imported animal feed grown with pesticides. On the other hand, when calculating the cost of banning pesticides⁹, Lomborg paradoxically leaves out precisely the scenarios that permit import of conventionally grown goods (food and feed), because he needs to make the price appear as high as possible. Lomborg is thus juggling the scenarios to pick whichever will optimally buttress the bottom-line he wants.

Lomborg arrived at the 20 annual cancer deaths in the USA by selecting, out of a long series of studies, one of the lowest estimates. He also mentioned that US EPA (The US Environmental Protection Agency) has set up a worst-case scenario that arrives at the finding that at most 0.5-1 per cent of all cancer deaths can be ascribed to pesticide residues in food, equalling 3-6,000 cancer deaths a year.¹⁰ Lomborg chose the very low estimate with reference to reports from the US National Research Council¹¹ and World Cancer Research Fund.¹² He added some estimates by Ames & Gold¹³ indicating that for instance coffee has a far greater carcinogenic effect than pesticides. Researchers are in really deep water here – both when it comes to comparing the potency of the carcinogenic effects of various sources/products, and when trying to assess the number of cancer deaths with specific causalities. As of now, no one has the right figure.

It is not fair to place the potentially harmful effects of pesticides on a par with the number of cancer deaths. The issue at hand is far more complex. Today agents such as the so-called mini-sprays are used, which can kill off living organisms – animals or plants – at concentrations so minute that the agents cannot be detected by standard measuring methods. Thus, yet another experiment has been launched, which in a few years time may prove to have undesired effects.

Further Lomborg claims that neither does the rather more massive exposure to pesticides in the working environment of those occupied in agriculture and market gardens cause cancer incidence to rise. However, Lomborg's argument does not hold water, namely that farmers generally have a lower cancer rate than the average population. Lomborg refers to Acquavella et al¹⁴, who conclude that lip cancer is the only cancer found to be more frequent among farmers than in other population segments, and that such excess incidence must owe to their increased exposure to sunlight. Yet, since a presumably more healthy lifestyle among farmers would let us expect a *lower* cancer rate than in the average population, we cannot just deduce from the fact that the rate is not higher. In addition, Lomborg does himself, in a note, caution that Acquavella is associated with the agrochemicals industry, and that his study by Aron Blair, The National Cancer Institute's own statistician has being criticized for disguising a slightly elevated risk of certain other cancers in farmers.

Lomborg also mentions that several studies concluded that those who are occupied in agriculture, and are more exposed to pesticides than others, have a higher cancer incidence. For instance, French winegrowers were seen to have a 25 per cent higher incidence of brain cancer.¹⁵ Yet Lomborg dismisses the results with a blanket reference to the so-called 'file drawer problem', i.e. the fact that a large number of cancer types may have been investigated, while only the one cancer showing an excess incidence is reported.

CHILDREN PARTICULARLY SENSITIVE

Children take in more food and more water per kg of body weight than do adults. Moreover, children have a different diet composition and can also have a considerable over-intake of specific foods that may contain pesticides, e.g. fruit and juice. This has especially been investigated in the USA where National Research Council¹⁶ concluded that children can be up to 10 times more sensitive to the ingestion of pesticide residues than adults. Therefore USA added, for particular cases, an extra uncertainty factor of 10 to the normal 100. The extra factor will be applied in cases, for which the standard risk assessment based on animal experiments is not considered to allow for the particular sensitivity of children. Such an extra uncertainty factor in relation to children is not in use in Denmark or the EU. In 1999, however, EU adopted a marked reduction of maximum permissible values for pesticide residues in baby foods based on the same argument. The new directive comes fully into force by 1 July 2002.

PESTICIDES AND BREAST CANCER

The last 30 years have seen a heavy increase in breast cancer incidence. The increase can in part be explained by lifestyle changes – fewer and later childbirths, and dietary changes – and intensified diagnostic efforts (mammography), meaning that the condition is identified more frequently. Yet, this only accounts for about 1/3 of the increase.¹⁷ Moreover, Lomborg discusses trends in breast cancer, though preoccupied with the trends in breast cancer *deaths*. His conclusion is that until 1990, there was only a moderate increase in the age-adjusted death rate for breast cancer, and that since then the rate has fallen. He further concludes that the pre-1990 increase was caused by lifestyle factors only – fewer and later childbirths and more cases of obesity.¹⁸ How was it possible for Lomborg to arrive at a conclusion so unlike the one above? Well, he did so by focusing on the death rate instead of the incidence rate of breast cancer. Thus, Lomborg ignores the fact that treatment options, and hence survival rates have increased. Admittedly, Lomborg also mentions that the increase in breast cancer *incidence* has been far more drastic than the increase reflected by the death rate. However, he downplays the increased incidence by ascribing it to mammography screenings that have enabled us to diagnose far earlier and benign forms of breast cancer. Thus, Lomborg bases his main conclusion on death rate trends. So doing, he underplays the increasing incidence of breast cancer, drawing his optimistic conclusion from a circumstance that is irrelevant to the issue at hand, namely the improved treatment options and the resulting increased survival rate.

It is correct that a non-smoker's risk of dying from cancer has gone down, which of course is fortunate. Yet, this does nothing to change the fact that death rates for breast cancer and several other cancers could have declined *more* as a result of improved treatment options, if not, for reasons unknown, there had been a concurrent increase in cancer *incidence*. Thus, it remains relevant to search for those causes.

In 1998, a scientific paper by three Danish researchers – Hoeyer, Joergensen and Grandjean - demonstrated a clear excess incidence (two-fold) of breast cancer in women with the highest pesticide concentrations in their blood. The study was made possible by the fact that 17-year old frozen blood samples from 7,700 Danish women had been stored. Researchers were then able to measure pesticide content in the individual samples and check how many of those women were later to get breast cancer, which 268 women did.¹⁹ The pesticide in point was dieldrin, which has meanwhile been banned in Denmark. It should be added, however, that several studies failed to demonstrate a link between dieldrin and breast cancer. Moreover, this study tells us nothing about the pesticides approved at present. Yet, so Grandjean's comment, authorities did find dieldrin to be fully safe back in the 1970s, and compared to the latency period of cancer the substitution frequency of pesticides in use is so high that we will hardly ever be able to demonstrate the carcinogenic effects of a pesticide until it *has been* withdrawn from use already.²⁰

Lomborg fails to mention the above study, despite the fact that he was familiarised with it in the Danish version of the present book. Instead Lomborg cites National Research Council (NRC)²¹ for stating that breast cancer incidence is on the increase, while concentrations of major estrogen mimics such as DDT, DDE, and PCB show a downward trend: 'it seems unlikely that a declining exposure would be responsible for an increasing incidence of cancer'. His objection would be relevant if the contention was that estrogen mimics were the *only* cause of breast cancer, but not against a hypothesis of estrogen mimics as a *contributing* cause. By the way, it is seen from Lomborg's notes²² that the NRC statement was based exclusively on studies published before 1995. Actually, the most recent studies showed that although DDE does only have a slight estrogen-mimicking effect, yet it has an *anti-androgen effect*, meaning that it will inhibit the male sexual hormone.^{23,24}

The only paper to comment on dieldrin studies is a report by the British Advisory Committee on Carcinogenicity of Chemicals. It assumes that the demonstrated dieldrin-breast cancer link is a Type I error (i.e. an incidental error) arisen from the fact that possible causal relations vis-à-vis 46 chemical substances were studied, one of which (dieldrin) was found to be positive.

Against that backdrop, Lomborg adamantly concludes that 'we now have the data, and they supply no evidence as to synthetic chemicals causing breast cancer'.

NATURAL AND SYNTHETIC PESTICIDES

There has also been an ongoing debate in USA on the significance of pesticides versus the natural defence substances of plants. Lomborg contends (p. 233) that pesticide residues in foods must be insignificant, since they make up a mere 0.01 per cent of the load of 'natural pesticides'. What he has in mind are natural plant constituents that e.g. serve to repel insects. There is no doubt that we consume quite an amount of those substances, and that they constitute a far larger quantity than the pesticide residues. Yet, when Lomborg – or Bruce Ames, his source – contends that a plain quantitative comparison can be made, that is a simplification. For instance, a large part of those natural 'pesticides' are tanning agents (tannins) and resins (terpenes). Others are e.g. mustard oils of which we consume larger amounts with our food. Placing those substances on a par with pesticides does not make sense.

Thus, in a reply to one of Lomborg's Danish confreres, Lars Dragsted²⁵ says that this is a

misrepresentation of Bruce Ames, since a mere quantitative comparison *cannot* be made. 'Generally the most frequent natural pesticides in our food, plant phenols and terpenes are not very toxic. And it is certainly very questionable whether they can be carcinogenic to humans. By contrast, they are under serious consideration as cancer-protective agents. I have been doing research on such substances for the past three years. My findings precisely indicate that some toxic effects of the substances are prerequisites to their cancer-protective effect.' Moreover, Lars Dragsted indicates that he also considers pesticide residues in food to be a negligible problem in a cancer context.

No doubt there are problems with certain natural substances found in fruit and vegetables. More recent studies suggest that mushrooms and certain spices involve cancer risks.²⁶ If this turns out to hold, it will be possible to issue recommendations on avoiding or limiting these food ingredients. However, there is nothing to support a *general* statement that vegetables contain larger amounts of such carcinogenic substances. If they did, then it would also be a gross contradiction in terms for Lomborg to contend that we would have 26,000 more deaths if people were to eat fewer vegetables.

To all appearances, eating fruit and vegetables does in fact have a cancer-protective effect, even those containing what Lomborg calls natural pesticides. Thus, apart from special crops such as mushrooms and certain spices, there is nothing to support his claim, that so-called natural pesticides cause far more cases of cancer than do man-made pesticides.

On the other hand, nor is there anything to support a claim that the pesticides now in use entail a major cancer problem. But then, what we do know is that there is a considerable delay when it comes to detecting a *potentially* carcinogenic effect, compare above re breast cancer.

NATURAL AND MAN-MADE ESTROGENS

In a similar way, we have natural substances with a quasi-estrogenic effect. Lomborg cites the conclusions of some sources²⁷, that 'our overall intake of synthetic estrogens' ... 'is more than 40 million times lower than the average intake of natural plant estrogens'. Natural estrogens have been found in foods such as soy, rye, wheat, cabbage, spinach, barley, rice, potatoes, beans, peas, apples, plums, and garlic. However, some studies point out that these phytoestrogens are far more biodegradable than manmade estrogen-mimics, so the artificial (antropogenous) substances, which bioaccumulate and remain in our bodies for a long time, appear to have the greatest endocrine effect.²⁸ There are no indications that eating a normal vegetarian diet affects fertility in any way. For instance, there is a study showing that Asians have had a large intake of natural estrogens (phytoestrogens) for many years, yet that this did not impair their fertility. A likely reason is that man has been eating those substances for so many years that their possible harmful effects have been eliminated as part of the evolutionary process. Contrarily, there are indications that precisely a diet containing phytoestrogens has cancer-protective effects, also with estrogen-related cancers such as breast and testicular cancer.²⁹

Thus, Lomborg is unfounded in talking of 'similar plant estrogens' and making a quantitative comparison. But still much research remains to be done in the field of endocrine disrupters, and we are yet to see proof to a link between the ingestion of endocrine disrupters and impaired fertility, or an increase in breast and testicular cancer.

DECLINING SEMEN QUALITY

In the last few years substantial research has been done regarding impaired sperm quality and diseases related to male reproduction, including the work of Prof. Niels Erik Skakkebaek and colleagues from Rigshospitalet (the Danish National Hospital). Their studies seem to indicate a considerable impairment in male reproductive capacity, including a decline in sperm counts and a marked increase in the incidence of testicular cancer. E.g. the Danish testicular cancer frequency increased three- to fourfold from 1943 to 1982, and the increase *cannot* be ascribed to a better reporting of the disease. Moreover, there appears to be a concurrent increase in the prevalence of malformed male genitalia, including so-called cryptorchidism (undescended testes). Finally, in some instances exposure to hormone-mimics have been seen to reduce the proportion of male newborns. During the 1976 Seveso disaster in Italy there was a release of TCDD, a dangerous dioxin. In the aftermath, from 1977 to 1984, there was a 35.1 per cent decline in the number of boys born to couples living in the most polluted area. As for sperm quality, available findings are not quite unequivocal. There has been a general decline in most of Europe and USA, whilst Finnish men have retained a high semen quality.³⁰

Skakkebaek attaches much importance to the fact that these different aspects of male productive capacity are closely related. Thus, patients with testicular cancer have been found to have reduced fertility. The study confirms the hypothesis that testicular cancer and impaired male fertility have a shared causality, and could both be attributable to influences in pre-natal life. These may be certain chemicals – pesticides, solvents – though also smoking during pregnancy, microwaves and exposure to heat can apparently harm the reproductive organs of male fetuses.³¹

In a recent paper, a research team have pointed out that damage inflicted in pre-natal life can cause irreversible change to the reproductive system, while effects influencing the adult reproductive organs will normally be reversible (transient).³²

Lomborg claims that he can repudiate the above explanation. In his view, there has been no real decline in semen quality: Lower counts are accounted for by shorter abstinence periods, i.e. more frequent ejaculations (intercourse or masturbation), since it is known that the number of living sperm cells in a male is lower for the first few days after ejaculation. Further Lomborg finds that the underlying statistical material of Skakkebaek's statistical studies, and hence his conclusions, to be skewed, since the older material includes too many men from New York compared to the more recent data.

Lomborg's interpretation runs counter to the fact that there has always been an abstinence requirement of minimum 2-3 days prior to delivering a sperm sample. In reply, Lomborg says that there is no way of overseeing whether or not donors actually comply with the abstinence requirement. Moreover, Lomborg's argument regarding the New York figures would assume that men were more abstinent in New York than, say in Los Angeles.³³

Another Danish study from 1998 concludes that men born in the 1940s have better semen quality than those born in the 1960s and the first half of the 1970s.³⁴ This is confirmed by a new study showing a further decline of semen quality in men born 1976-79.^{35,36} In addition, the latter study reviews literature on the frequency of sexual activity. It is concluded that the number of comparable studies is too small to allow the conclusion that there has been a major increase in sexual activity from the 1960s to the

1990s, yet that it seems unlikely for such an increase to be large enough to explain the considerable decline in semen quality. The main part of Lomborg's sources on this topic are from the 1970s and the 1980s³⁷ and report an increasing sexual activity from the 1930s or 1940s up to the 1970s. Thus, this cannot account for a declining semen quality the period from the 1960s to the 1990s.

Based on the above hypothesis of pre-natal effects, the study indicates that the younger males could have been exposed to harmful effects in the womb (i.e. 20-25 years ago), which did not exist 50 years ago. The poor semen quality in young Danish males today appears along with an increasing prevalence of testicular cancer, which naturally leads to the question of a possible common cause.

Lomborg did not include the most recent research in the field. For instance, Shanna H. Swan et al.³⁸ have re-evaluated i.a. the findings of the Skakkebaek team and found a significant drop in semen quality, both in USA and in Europe/Australia, *after* checking for confounders, such as changes in abstinence periods. Moreover, Swan et al. analysed 101 studies of declining semen quality in the period of 1934-96³⁹. Swan notes that it is a shortcoming of many studies, that they fail to report abstinence periods, yet was still able to demonstrate that an adjustment for abstinence periods did not essentially change the general picture of declining semen quality. Thus, adjustment for changes in abstinence periods reduced the demonstrated decline by 10.6 per cent, but the decline remained significant. Swan even found the decline to be greater – 1.5 per cent / year in the USA and 3 per cent in Europe/Australia, against the 1 per cent found by the Skakkebaek team. Again, there is a significant fall in western countries, while no clear-cut tendency in non-western countries. On average, the decline is found to be of the same magnitude as first demonstrated by the Skakkebaek team. Lomborg also cites Swan, though only an older paper from 1997.⁴⁰

Finally, Lomborg leaves out the increase in testicular cancer and damage to the sexual organs of newborn boys, since only focusing on sperm quality.

PESTICIDES AND FERTILITY

Lomborg cites the two Danish studies demonstrating that ecological farmers have better semen quality than other occupations. True, both studies are disputed, since comparisons were made with entirely different occupations from urban trades where sperm quality could be lower due to urban life and possibly higher stress levels. Among other things, he underpins his argument with another study showing that conventional greenhouse gardeners also have higher sperm counts than a number of other occupations.⁴¹ But still, on reading Lomborg's note, we also find that conventional greenhouse gardeners had 20 per cent lower semen quality than did their ecological counterparts. Contrarily Lomborg fails to cite from the same study that the superior semen quality in greenhouse gardeners (compared to completely different occupations) only applied in winter, since their semen quality would fall in the summer, that is in the spraying season. The semen quality of ecological farmers did *not* go down in the summer⁴².

Yet, the study also mentions that the two groups were not entirely comparable in terms of other parameters, so it cannot be concluded that the difference could be ascribed to pesticide use⁴³. The leading author of the study, Anette Abell, GP, assumes that the relatively high winter figures for semen quality found in greenhouse gardeners owe to a very high response rate. It is a common experience that the lower response rate, the

poorer average semen quality, since those men who have fertility problems will invariably participate in such studies. Along with that she points out that the study was done in a period when the now banned organochlorine compounds were still in use, so presumably they caused the impaired semen quality.⁴⁴

Moreover, the report demonstrates that gardeners who worked in greenhouses for more than 10 years have approx. 35 per cent fewer spermatozoa than those who had worked there for less than 5 years. In addition, variations were seen according to their actual job functions. Those with the lowest pesticide exposure had twice the spermatozoon concentrations and more normal sperm cells, compared to those with high pesticide exposure. Finally it was possible to demonstrate an increased number of so-called gaps – sperm cell injuries – in the workers who had the poorest work hygiene, i.e. did not wear gloves and washed their hands less than four times a day.

Generally, the report indicates that pesticides used until a few years back had impacts on semen quality. But still we cannot say anything about those approved for use today.

THE BICHEL COMMITTEE

The Danish Bichel Committee worked for 18 months on investigations regarding the impacts of pesticide use and their potential phase-out from agriculture. The Committee submitted their recommendations in March 1999.⁴⁵ The sub-committee on environment and health concluded that ‘the average load from foods at single-substance level is typically around 1 per cent or less of present ADI (Acceptable Daily Intake) value’, and that ‘based on epidemiological studies it is not possible to produce evidence that pesticides, in the amounts the general population is exposed to, e.g. via food, constitute a health hazard. Equally it will never be possible to provide definite scientific proof that a pesticide could not entail a health risk ... Epidemiological studies on the effects of metabolites [degradation products; eds.] and inert substances [ancillary substances; eds.], which often make up a substantial part of the products, are largely non-existing.’ The Committee recommended, ‘that the circumstance that a number of different chemical substances are ingested simultaneously should to a greater extent be considered in the assessment of health-related aspects of pesticides, especially for groups at special risk.’⁴⁶

The Committee cites several studies of cancer risks in agricultural workers who are exposed to pesticides. General mortality is found to be *lower* than that of the average population, which however is ascribed to the generally healthier rural lifestyle. On the other hand, especially farmers appear to have a higher frequency of special cancers, including leukaemia and cancers of the brain, stomach, and prostate. Other studies point to an excess incidence of certain cancers, leukaemia and notably brain cancer, in the children of occupational groups exposed to pesticides. The link could be attributed to affection of sperm and egg cells, of the foetus, or of the child directly, at home or in the home environment. The identified excess incidences are greater in children than in adults exposed to pesticides, which suggests that children are more sensitive to pesticides. However, the studies cover rather few persons, and are thus subject to uncertainty. Moreover, many of those studies have methodological errors.

The fewest studies are able to pin down specific types of pesticides, yet do point to groups such as organochlorine compounds, organophosphates, and triazines. The two former substance groups have now been banned in Denmark, but some triazines are still in use: simazine and terbutylazine. It is unknown if some of these may be carcino-

genic.

A large Norwegian study done in 1997 found an excess incidence of malformed sexual organs and a moderately elevated risk of certain developmental handicaps in the children of farmers, especially in relation to market gardens and greenhouses with relatively high pesticide exposure. Yet other studies exist that indicate *no* such links, and the Committee concludes that for the present a possible link between pesticides and malformations can neither be verified nor disproved. The Committee also comments on the above study of pesticide sprayers in market gardens (Annette Abell). The Committee attaches much attention to certain findings that appear to be conflicting, yet also to the fact that the prevalence of chromosomal damage and impaired semen quality was related to *present* pesticide exposure, and that it was found with contact with sprayed plants rather than direct spraying. The Committee does find, however, that the findings of the study would prompt 'a strengthened effort towards reducing the exposure of greenhouse gardeners during handling of sprayed plants'.⁴⁷

Thus, what we have is a rather jumbled picture of studies with contradictory findings, so at present we cannot draw any conclusions regarding the possible carcinogenic effect of pesticides. What we can say is that the substances that are highly probable to cause cancer – dieldrin and organophosphates – have now been banned in Denmark. But still these were considered safe relatively few years ago.

The Bichel Committee draws up a number of scenarios with varying degrees of reduced pesticide use - approx. 30 per cent, approx. 80 per cent, plus total phase-out of pesticides, and finally a total conversion to ecological farming. The two first scenarios both embodied a three-string strategy, consisting of partial conversion to ecological agriculture, a general reduction of pesticide consumption in conventional agriculture, and increased establishment of non-spray zones, e.g. riparian zones and borders along nature areas. Moreover, the costs of implementing each scenario were computed. The green organizations have especially pointed to the scenario featuring an 80 per cent reduction, which seemed to be feasible at a cost equalling 0.4 per cent of GDP.

Lomborg comments on the costs of a total phase-out of pesticides and of conversion to ecological farming in Denmark, calculated to 1 resp. 3.5 billion USD. Lomborg translates this interval to a US estimate of USD 20 to 300 billion. He then collates that estimate with another estimate according to which pesticide use in the US will, at most, cause 20 extra cancer deaths a year. Finally, Lomborg concludes that each cancer death avoided would cost upwards of a billion USD. As if cancer avoidance were the only, or even the most important ground for converting to ecological farming.

SHOULD WE USE PESTICIDES?

Lomborg sums up his pesticide overview with a calculation. On the one hand putting an end to pesticide use would prevent up to 20 annual cancer deaths in the US. On the other hand, there would be up to 26,000 additional cancer deaths because people would be eating less fruit and vegetables, since these would become more expensive. Moreover, the cost would be minimum USD 20 billion a year, and more land would have to be put under plough due to lower yields per hectare.

Lomborg reduces the harmful effects of pesticides to a single factor, namely cancer – which may even be one of the factors that are hardest to demonstrate. He never mentions the other disease impacts and environmental impacts, including the well-studied

damage seen in farmland bird life and the many drinking water wells closed due to pesticide contamination. I have clarified already how there is nothing to prove that a certain gradual and *general* increase in food prices would cause us to cut our consumption of fruit and vegetables.

The question, whether or not we would have to put more land under plough if we were to stop using pesticides is rather more complex than Lomborg would have it. Today the industrialised countries have a marked overproduction of foodstuffs. The surplus production is exported with state aid, also to developing countries where it helps to out-compete their own national agricultural produce. Thus, some reduction of the food production in the industrialised countries would only be beneficial. In addition, our large and increasing consumption of animal produce is not sustainable. It implies that we tie up far more land for farming than our population figure would justify – including farmland in other countries used for growing our animal feed. Thus, there is a need for us to reduce our overconsumption of animal products, which would also reduce our need for arable land. What is more, this would also improve our health, since the amounts of meat we are eating now do not benefit our health.

SYNERGY AND ADDITIVE EFFECT

One of the shortcomings of chemicals regulation until now is that by and large each substance has been considered on its own, notwithstanding numerous discussions over the last 30 years on the potential combined effects of the many substances we are exposed to simultaneously. Such effects can be caused by either a synergistic or an additive effect. An additive effect implies that if we have two substances with the same mechanism of action, e.g. provoking testicular cancer, then the effect of 1 mg of each substance will equal the effect of 2 mg of either substance. By contrast, a synergistic effect implies that each substance will potentiate the other's effect, meaning that 1 mg of both would be *worse* than 2 mg of either substance. Finally, an antagonistic effect could be imagined, i.e. two substances inhibiting each other's effects, though this is more seldom.

Lomborg contends that synergy (the cocktail effect) has plainly been disproved.⁴⁸ He bases his assertion on the fact that a single paper demonstrating synergy between two estrogen mimics – in the form of a 160- to 1600-fold increased risk from the combined action of the substances – was withdrawn.⁴⁹ Lomborg himself points out in a note⁵⁰ that many studies have demonstrated synergy of a magnitude of a 2- to 10-fold increase, yet holds that the synergy effect is only of interest if it is far greater. This spotlights Lomborg's conclusion, that the potential of synergy has been disproved. Moreover, current limit values for e.g. pesticide residues in food completely fail to consider synergy, not even additive effect, comp. below.

It is correct that the available documentation regarding synergy effects is rather scant. However, the main reason is that comparatively few substance combinations have been studied. The effect has been found with e.g. asbestos and tobacco smoke, and with radon and tobacco smoke, which are known to potentiate each other's effect.⁵¹

As for synergy in terms of an estrogen-mimicking effect Ana Soto et al. were able to demonstrate the following: '*...The E-screen test also revealed that estrogenic chemicals may act cumulative; when mixed together they induced estrogenic responses at concentrations lower than those required when each compound is administered alone ... The pesticides Endosulfan, toxaphene, and dieldrin have estrogenic effects on human estro-*

*gen-sensitive cells.*⁵² Too few studies have been made in this field. Yet, it is certainly not generally agreed that synergy can be excluded, although a number of studies have pointed to a very limited synergy effect or none. Thus, researchers at the University of Liverpool conducted a study, to be published in early 2002, of synergy effects found for residues of several pesticides that occur simultaneously in fruit and vegetables. Preliminary reports indicate that there is a considerable synergetic effect.

The additive effect is at least as important as the synergy issue. People often confound the two effects, and apparently, so does Lomborg. He uses the term 'cocktail effect', which could refer to both. Researchers generally agree that if two substances have the same target organ, we should count on an additive effect.

As already mentioned documentation of synergy effects is slender. Today most people would probably consider additive effect trivial, but actually this has only just begun to filter through when it comes to the administrative setting of limit values for foods. Thus, as a general rule, the only thing considered is whether every single pesticide residue in a food item exceeds its specific limit value.⁵³ In principle you might have 5 different pesticide residues, all just below the limit. In other words, the applicable safety factors may to some extent be undermined when several residues are found in the same food item. The safety factor means that the limit value is set by a factor of e.g. 100 below the concentration for which animal experiments have demonstrated health damage. The factor must allow for the fact that sensitivity may differ in humans resp. the animal species used, and that some humans are particularly sensitive, e.g. foetuses, children, and old people.

In Denmark, the Danish Ecological Council and others have proposed the introduction of a *summation formula* that would allow for the additive effect. Such formula is known from occupational health, where a series of fractions are drawn up using the concentration and limit value of each substance as numerator and denominator respectively. Next, we say that the sum of those fractions is not to exceed 1. In 1999, the Danish Ministry of Food, Agriculture, and Fisheries launched a project on drawing up such a summation formula for pesticide residues. The project is yet to be concluded.

STRATEGY FOR NON-ASSESSED SUBSTANCES

Whatever can be done to solve the problem of the thousands of non-assessed chemicals? The precautionary principle does not lend itself directly in its most extreme form, namely a ban on all non-assessed substances – plus the hazardous ones. Nor can we just hurry up to have all non-assessed substances investigated. The task of assessing those substances is too huge. In the EU, estimates are that in a few years' time it will be possible to have 25 substances assessed annually – out of a backlog of 25,000-70,000 substances. So far, a meagre 10 substances or so have been assessed since the start in 1993.⁵⁴ According to the EU-Commission another app. 60 substances will soon be finished, but even if they should succeed in this it is very few substances compared to the number of unassessed substances on the market. Therefore, a different strategy is called for. The most realistic option seems to be *group classification*. This implies that a group of chemically closely related substances are classified under a single heading. All substances are classified as the most hazardous among the investigated substances within the group. If the manufacturer or others wish to have a specific substance downgraded, they will have to produce appropriate documentation showing that it is less hazardous. This is a workable way of implementing the precautionary principle for chemical substances. A working committee under the Danish Technology Council first

recommended the method⁵⁵ in 1995. It has been an integrated part of the chemicals strategy of the Danish Environmental Agency since 1999.

A crux of group classification is how to define a group. Here a few ancillary tools are at hand, more specifically the so-called QSAR, which classifies chemical substances according to their chemical structure and activity. The Danish Environmental Agency has assessed 47,000 chemical substances using QSAR and found that 20,624 of them should be classified as hazardous. Based on this, the Danish Environmental Agency has published a list with recommended classifications of those many substances⁵⁶.

However, QSAR does not allow a 100 per cent correct classification of substances. The method can be used for a number of environmental and health effects, but is less suited for other effects. In all events, it does involve a certain error rate. In these cases substances can both be under- and overclassified. Yet the method is, by a wide margin, preferable to the continued use of substances that have not been assessed, and are thus being used with no knowledge of their hazardous effects. However, the use of group classification should not lead to a downgrading of the substance-by-substance testing that is already taking place. Instead, it should be used to provide us, in a matter of a few years, with a preliminary classification of all substances that are non-assessed at present, and that classification will then make the basis of future regulations.

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10. ENVIRONMENT, PRECAUTION AND PRIORITIES

SUSTAINABILITY, DISCOUNTING, AND THE PRECAUTIONARY PRINCIPLE

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Economic theory is based on the fact that we have to prioritise, both as individuals and as a society. We can choose to spend resources on improving hospital treatment, yet the same resources could alternatively be used to improve traffic safety – and thus perhaps save more human lives. The essence of Bjørn Lomborg’s critique of environmental policy is that we should also accept social priority setting in the environmental sector. Even when we *choose* not to rank alternatives, an allocation of resources will eventually take place, though not necessarily in a manner that will optimise welfare, in Lomborg’s argument. As a general principle, his demand is in line with the reasoning found in the theory of environmental economics. Canonizing *all* environmental assets to assets that cannot be weighted against other considerations would be unduly costly. Yet, most environmental economists still acknowledge that the validity of economic rationality is constrained by ethical considerations and by lacking knowledge of the possible consequences of environmental change. In his critique of the environmental discourse and environmental policy, Lomborg leaves out these constraints. E.g. Lomborg claims that it is irrational to let the so-called *precautionary principle* apply in environmental policy. Equally, Lomborg disregards the fact that ethical and allocational limitations could exist regarding the possibilities of substituting environmental assets with produced assets – e.g. within climate policy. Here Lomborg’s economic reasoning clearly departs from what is today considered as mainstream in the field of environmental economics theory. In the following, Lomborg’s dismissal of the precautionary principle is discussed, and exemplified by the precautionary principle an outline is given of the ethical and allocational problems experienced by discounting over very long spans of time.

COST-BENEFIT ANALYSIS AND ENVIRONMENTAL POLICY

Cost-benefit analysis is the method of choice whenever economists are prioritising the resource utilisation of a society. This also goes for environmental economics, in which the preservation of environmental assets is weighted against the cost incurred by an environmental project under an environmental policy. The basic notion is that the social benefits of an environmental policy must be at least as great as the social cost of this policy. If that condition is not met, the money or resources could have been better spent for other social purposes. However, when it comes to environment-related projects, we have the problem that benefits typically consist in various environmental assets and benefits that do not have a market price. For instance, a water protection scheme can yield benefits in the form of clean drinking water, better recreational facilities, and greater biodiversity. Summing up the benefits and collating them with the costs would require us to have a common measuring unit – i.e. money.

In the field of environmental economics a number of methods have been developed, for use in the economic valuation of environmental assets and benefits.¹ When all relevant environmental impacts are expressed in money units, we can compare benefits vs. costs of various environmental schemes or environmental policy alternatives. Thus, in principle, economic valuation and cost-benefit analyse provide the answers to what ‘pays

off' in a social perspective. However, the applied methods rely on ethical and political assumptions that are far from indisputable. One of the crucial issues is: To what extent it is ethically acceptable to reduce the multitudinous functions and facets of the environment to a single one-dimensional measure of value: monetary units.

ETHICAL LIMITATIONS IN COST-BENEFIT ANALYSIS

In order to enable value estimates in monetary units, political decision-makers are required to substitute between all relevant benefits, in an effort to maximise the total welfare of society as such. Yet, precisely which benefits individuals and society are prepared to incorporate in their deliberations on substitution and trade-offs is a matter of ethics. For instance, but few would accept trade in human organs, although benefits could be considerable from a sheer utility calculation. Here, the consequential or utilitarian ethics, upon which economic valuation and cost-benefit analysis are based, collide with deontological ethics such as rights-based imperatives and commitment. In such cases, what matters is not whether the initiative could have beneficial consequences, but whether – according to an ethical principle – we *should* or *should not* do it.

Not only in the environmental field does economic rationality encounter ethical limitations. This is also the case in health policy. Otherwise, the obligation of decision makers would be to distribute available resources such that the implicit price of a human life is identical for all fields of intervention. However, health economic studies have shown that the amount spent to save a statistical human life is widely different in the hospital sector. For instance, far more resources are used on treating the very old than the principle of equalisation would 'allow'. Still, few would hold the efforts to extend the lives of the said patient group to be an expression of irrationality. In other words, ethical norms exist that set a limit to economic rationality in the health sector.

In the environmental field something similar applies, when it comes to the loss of essential environmental assets, species, national and other 'assets' with an emblematic value. We cannot just assume these assets to be interchangeable with produced assets. On the other hand, it would be problematic to consider such assets to be infinitely valuable, and hence beyond social allocation deliberations. If an endangered environmental asset is evaluated to be infinitely valuable, every other consideration will have to cede in order to preserve the asset. If this principle is extended to a larger number of environmental assets, this could generate considerable social costs. Ultimately, a principle of the inviolability of *all* natural assets leads on to a deep ecology ethics allowing no specific regards for humans. The issue here must be: How do we draw the line between more or less substitutable environmental assets, while implicating both ethical and economic considerations? As we are to see later, this issue plays a considerable role in the mainstream of environmental economics – unlike the 'older' school of thought of the 1970s that Lomborg leans on.

DECISION-MAKING UNDER RISK

Economic theory distinguishes between *risk* and *uncertainty*.² In an economics context, 'risk' is defined as the statistical probability of a specific event to happen, multiplied by the economic impacts of such an event. The economic concept of risk thus implies that it is possible to set up a statistical probability distribution showing the possible outcomes of a decision-maker's choices. 'Uncertainty' denotes situations in which we have no experimental basis for assessing the probability of different outcomes. Economic theory has predominantly focused on decision-making under *risk*, with a known statistical probability distribution of possible outcomes of the decision maker's choices. This leads

on to an *expected utility theory*, in which the decision-maker is assumed to choose the alternative that will maximise expected utility. From this theory, it is possible to justify a dismissal of the precautionary principle. E.g. the widespread opposition against nuclear power or genetic engineering, for which expert assessments indicate the risk of major accidents to be exceedingly small, must – according to expected utility – be considered as irrational.

DECISION-MAKING UNDER UNCERTAINTY

If the issue is *uncertainty* rather than risk, the expected utility theory cannot be applied, since probabilities for the different outcomes are not known. In this case, we have to resort to subjective probabilities, i.e. the probability of an uncertain outcome that decision-makers will form, implicitly or explicitly. Controlled experiments have shown the behaviour of many people to be inconsistent with the fundamental axioms of expected utility theory.³ This has spurred a number of new attempts towards modelling actual decision-making behaviour. A groundbreaking contribution is Viscusi's *Prospective Reference Theory* for risk behaviour.⁴ It was developed as a tool especially for modelling attitudes to life and health risks.

Viscusi applies *information-based, reference-dependent* probabilities. With an example from current political life, we could say that – based on the theory of expected utility maximisation – the widespread opposition against genetically modified foods is difficult to explain, since expert opinions indicate the risk of major damage to be exceedingly small. The opposition could be due to the fact that people perceive scientific estimates indicating the probability of damage as incomplete information. This can be based on previous adverse experience of surprises with technologies and substances otherwise considered safe. As a result, we form our own subjective probabilities for the possible consequences. The situation is not perceived as a choice under *risk*, but as a choice under *uncertainty*. Gradually, as more information/experience on genetically modified organisms becomes available, people will – if everything turns out well – update their subjective probability estimates, towards a less negative attitude to this technology.

However, it is also possible that a so-called *safety premium* exists, that is, a willingness to pay a rather large amount for the total removal of even small probabilities of *disaster-like* outcomes.⁵ The probability of a disastrous accident at an atomic plant can only be removed completely by closing down the plant, and similarly, absolute safeguarding against accidents in relation to genetic engineering can only be achieved by standing back entirely from using and experimenting with that technology. In relation to this, Viscusi talks of the existence of a *safety premium*. This implies that the benefits of the last unit of risk reduction can be markedly greater than benefits of the second-last one, since the last unit (i.e. close-down of a nuclear plant or a ban on a specific technology) will remove any *uncertainty*. Such complete removal of uncertainty can thus be preferable to e.g. a 99 per cent risk reduction – even if the marginal cost will increase steeply when passing from a 99 per cent to a 100 per cent risk reduction. Thus, when it comes to the outcome of a cost-benefit analysis based on expert estimates of risk compared to people's own subjective probabilities, the safety premium can make a decisive difference.

THE ECONOMIC JUSTIFICATION OF THE PRECAUTIONARY PRINCIPLE

Lomborg claims that 'the precautionary principle is actually all about making *worse* decisions than we need to'.⁶ Thus, what he says is that the prioritisation of social

resources is biased towards environmental protection. This would amount to claiming that risk, risk aversion, and uncertainty have no economic relevance.⁷ However, such view is unfounded in the welfare economics theory, upon which environmental economics is based. This can be seen in the contributions to climate policy provided by a number of the world's leading (environmental) economists.⁸ The purpose of economic valuation and cost-benefit analysis is to provide a decision basis, enabling the allocation of social resources in accordance with citizens' *individual preferences*. Thus, it is basically assumed that individual willingness to pay is relevant to environmental decision making by political bodies and administrative agencies. The reduced or eliminated probability of irreversible – possibly disastrous – environmental damage must therefore be considered an economic benefit, insofar the individuals of a society are willing to pay for such initiatives. Indeed, both Europe and USA have introduced principles and procedures on the inclusion of risk and uncertainty into their decision-making processes on environmental policy.⁹

SUSTAINABLE DEVELOPMENT AND THE PRECAUTIONARY PRINCIPLE

The starting point of the economic sustainability discourse is an ethical assumption: that present generations have obligations towards future generations. Society's resources must be managed in a manner that will let all generations achieve the same level of welfare over time. Although the different contributions to the economic sustainability discourse are based on the same distributional presumptions, different economic sustainability concepts have gradually evolved. Divergences owe primarily to different expectations concerning the extent to which technological progress will enable us to replace natural resources/environmental services with produced capital goods. The economic sustainability theories of the 1970s¹⁰ are based on the assumption that produced goods can always replace natural resources and environmental services – and that substitution will be fairly easy. Nowadays, this view is termed Solow-sustainability or *very weak* sustainability.¹¹ Under these assumptions, society can maintain a constant level of consumption over time, provided that the aggregate amount of capital is not reduced.

Exhaustion of non-renewable resources, depletion of the ozone layer and increased greenhouse effect all exemplify the present generation's consumption of nature capital. According to the very weak sustainability definition, future generations can be compensated with produced capital goods for this reduction of available nature capital. The conclusion is that we do not owe a specific amount of natural resources to future generations, but a constant aggregate amount of capital.¹²

As already mentioned, these substitution assumptions are questionable. Today, many mainstream environment economists, including the so-called *London School*¹³, favour the stronger sustainability assumptions, which deny that issues of the environment and natural resources can be left to technological and economic forces alone. According to this school, sustainability requires a certain minimum of natural resources to be maintained – typically key species and ecological key processes – thus securing the stability and self-regenerating capacity of ecosystems. Thus, if we speak of critical nature capital, the conventional economic optimisation principle has to give way to a *precautionary principle* in the form of *safe-minimum standards of conservation*. However, most mainstream economists would hold that simultaneously a *proportionality principle* should be applied, to ensure that the costs imposed on society do not become 'unduly' large.¹⁴ Then, the conclusion is not that we have to give up economic considerations in relation to sustainability issues. But mainstream environmental economists no longer

support the happy-go-lucky attitude evident in Lomborg's book, when he dismisses the precautionary principle.

COST-BENEFIT ANALYSIS AND DISCOUNTING

Discounting means that a given benefit (or cost) in the future is given less weight than the same benefit (or cost) here and now. Thus, the discount rate expresses a trade-off relation where one refrains from present consumption to achieve a greater future consumption. In cost-benefit analyses, the discount rate is often all-important to the outcome of the analysis. This is in particular true of projects, for which the flow of benefits is deferred into the far future relative to the costs.

In regards to discounting in cost-benefit analyses, it is significant to distinguish between *intra*-generational discounting and inter-generational discounting. *Intra*-generational discounting is merely a matter of the present generation's prioritisations of their present vs. future consumption. Thus, those involved are basically able to express their own preferences regarding the future. Contrarily, *inter*-generational discounting also involves the welfare of future generations – possibly several hundred years from now. As mentioned, this applies for cost-benefit analyses used to assess the benefits of climate policy.

Both utilitarian and efficiency related arguments are used to justify discounting in social priority setting.¹⁵ The utilitarian argument is based on the assumption of progressing economic growth. Thus, future generations are expected to be considerably wealthier than we are. On that basis, it is possible to argue in favour of giving more weight to increased here-and-now consumption than to greater consumption possibilities for our better-off descendants. Thus, growth-related discounting of goods alone cannot be said to be unfair to future generations – if the implied growth expectations prove to hold water. The ethical problem lies with the empirical uncertainty inherent when determining the expectations for future growth.

The *economic-efficiency related* argument for discounting claims that we should demand the same social returns from investments made e.g. in control of the greenhouse effect as society could obtain choosing the best possible investment alternative. The argument is that otherwise environmental investment would crowd out other investments with higher returns – which is not in agreement with a welfare-maximising resource allocation. This is the discounting principle used by Nordhaus' cost-benefit analysis of the greenhouse effect¹⁶, and the principle Lomborg leans on in his critique of climate policy (comp. also Anders Christian Hansen's contribution in Chapter 4). It is argued that the interest of future generations should be provided for by other types of reallocation than long-term, low-yielding investments in the environment. Precisely the compensation assumption raises ethical problems. No national or international reallocation mechanisms exist to ensure that those suffering damage in the future will indeed be compensated. The following example serves to illustrate the problems associated with discounting across very long time spans.

CLOSE DOWN DENMARK!

Assume that cost-benefit calculations show the global costs of stabilising greenhouse gases to exceed the benefits by a wide margin. It is therefore decided to continue without major restrictions, yet under the clause that those to gain will compensate those to lose. Now, let us assume that over a few hundred years, large lowland areas in Europe will gradually come below sea level. The problem is solved by dike construction, whe-

re cost-effective. However, due to Denmark's specific geography, a dike solution is not cost-efficient in this country. Instead, future Danes will be compensated in full for their loss of property, and be given an offer to settle down elsewhere in Europe.

If we assume that moving-out only truly accelerates in a hundred years time, then the loss of Denmark will not add any particular weight in a traditional cost-benefit calculation, in which future losses are discounted to present value. The value of real estate in Denmark is estimated at a good USD 238 billion. If we apply a standard discount rate of 5 per cent, the loss of these assets in a hundred years would equal a good USD 1.8 billion in present value. If 200 years pass before the assets are lost, the loss in present value will amount to USD 13.8 million. If most Danes can stay resident until 500 years have gone by, then future generations can be compensated at a present-day investment of USD 6! Or, to put it differently: If they do not enlarge their property in the meantime, the loss of all real estate in Denmark would be compensated if, today, we make a saving equivalent to half a barbecued chicken with potato fritters.

As presented here, the example seems absurd. Yet, the economic cost-benefit analyses of the greenhouse effect that Lomborg relies on are based on these principles. The case demonstrates that we need to use cost-benefit analyses with due caution.

CHOOSING A DISCOUNT RATE

Given the problems associated with setting the social discount rate, it would seem tempting to leave out discounting in cost-benefit analyses related to environmental issues. However, completely disregarding economic efficiency in terms of resource allocation over time would also cause problems. This goes in particular for environmental projects, in which the flow of benefits is presumably infinite. At a discount rate of zero, the cumulated value would therefore move towards the infinite – regardless how small the annual benefits, if only they are positive. Thus, it makes no sense comparing here-and-now costs with the size of the projected benefits without discounting. The question then is which discount rate should be chosen for long-term environmental investments.

Chichilnisky has proposed an intergenerational welfare function, which is sensitive to the utility of both present and future generations – thus avoiding what Chichilnisky has dubbed 'dictatorship of the present' and 'dictatorship of the future'.¹⁷ In order to avoid 'dictatorship of the present' in relation to future generations she recommends a declining discount rate for long time spans. This is in good agreement with the recommendations of the EPA (the US Environmental Protection Agency). For *intra*-generational discounting (i.e. the short to medium term) EPA suggests a social discount rate of 2-3 per cent – with reference to the consumers' time preference rate, estimated as the (after tax) market interest rate.¹⁸ In the case of *inter*-generational discounting (i.e. the very long term) EPA recommends sensitivity analyses at discount rates as low as 0.5 per cent. A discount rate at this level is far less than found in Nordhaus' cost-benefit analysis of the greenhouse effect, in which the discount rates are 6 per cent initially, declining to 3 per cent.

CONCLUSION

Evidently, Lomborg is positive that he has economic theory on his side, when criticising environmental policy for being irrational. This is only true if confining economic theory to what was universally accepted in environmental economics two or three decades back. For use in environmental and development policy, Lomborg invokes economic effi-

ciency considerations that disregard the precautionary principle and the difficulties associated with substitution and compensation over time. This sort of gambling could be acceptable, if the stake in future generations matched the amounts that people are prepared to stake on their weekly football-pools coupon. The hitch is the very long time horizons, combined with the risk that environmental changes can prove to be irreversible and have disastrous consequences. Most environmental economists today recognize the constraints thus placed on environmental economics analyses. Therefore, on the economic arena, Lomborg resembles a voice from the past, much rather than the invigorating contribution to the environmental debate he was proclaimed to be.

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 - 2 C. Gollier (2001): Should we beware of the Precautionary Principle, *Economic Policy* (33): 303-327.
 - 3 D. Kahneman & A. Tversky (1979): Prospect Theory: An Analysis of Decision Under Risk, *Econometrica* 47: 263-91.
 - 4 W.K. Viscusi (1989): Prospective Reference Theory: Toward an Explanation of the Paradoxes, *Journal of Risk and Uncertainty*
 - 5 V.K. Viscusi (1989): Prospective Reference Theory: Toward an Explanation of the Paradoxes, *Journal of Risk and Uncertainty*
 - 6 The skeptical environmentalist, page 350.
 - 7 Lomborg mentions risk aversion as a theoretical argument in favour of a more than 'optimal' effort against the greenhouse effect, yet dismisses its practical relevance. (The skeptical environmentalist, pp. 316-317).
 - 8 Comp. contributions in:
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Especially by: Munasinghe, M., Meier, P., Hoel, M., Hong, S.W. & Aaheim, A.: *Applicability of Techniques of Cost-Benefit Analysis to Climate Change*. Arrow, K.J., Parikh, J. & Pillet, G.: *Decision-Making Framework for Addressing Climate Change*.
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11. OPINION FORMATION

LOMBORG AND THE OPINION FORMATION

*By Kåre Fog
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FIELDS WHERE DATA ARE UNCERTAIN

All what Bjørn Lomborg has written about environmental problems, in Danish newspaper articles, in his Danish book, and the updated English version of the book, deals with issues where our knowledge is associated with great uncertainty.

How can one be sure e.g. how many percent of Africa's population are starving? Can we define starving precisely? FAO estimates starving by calculating the average daily energy supply in calories for a country; then the distribution of calorie intakes around this average is estimated from household level surveys; and finally this is compared with an average cut-off value for food requirements based on the age and sex composition of the population. All these calculations involve great uncertainties. In some African nations like Nigeria, even the size of the population is known only with an accuracy of up to 10%. The number of those who are starving must be even less accurate. FAO has two data sets concerning this matter. One set tells that 38% of Africa's population were starving in 1970, changing to 43% in 1991¹. The other set has the figures that 37% were starving in 1980, 35% in 1991, 33% in 1996², and 34% in 1998³. Confronted with these data, we must start to ask if this variation is larger than the uncertainty in the figures. It is stated that the uncertainty on the figures is $\pm 5\%$ ⁴, and in addition to this comes the great discrepancy between figures calculated in various ways, so that the figure for 1991 becomes 43% in the first set, but only 35% in the second set. Therefore, the whole matter is fraught with so great uncertainties that any statement on trends can only be made with great caution and many reservations.

So, we are dealing with a field of great uncertainty. In such fields, only estimates can be given, and of course different experts will come up with different estimates. All Lomborg's subjects are of this type. This means that he deals exclusively with subjects where there may be a great temptation to manipulate the figures in such a way that they show the trend that one wants them to show.

In his book, Lomborg combines the two data sets referred to above to give us the impression that the proportion of starving in Sub-Saharan Africa has shown the following trend: 1970: 38%, 1980: 37%, 1991: 35%, and 1996: 33%, i.e. that the situation is improving slowly but steadily⁵. Thus, the reader observes a clear statement about seemingly exact figures, and will be misled to think that there is a decline, when in fact the trend is not known. He will not detect that the apparent decline may probably have arisen by the combination of older data that are relatively high with newer data which give lower estimates at the same points of time.

Lomborg usually takes just those figures that fit with his overall thesis of optimism, wherever this is possible. This results in a bias, sometimes even in direct flaws or errors. This leaves to others a need to advance criticism and correct the bias and errors. And, indeed, Lomborg has been heavily criticised^{6,7,8,9}.

THE NEED FOR CRITICISM

When making such criticism, it is necessary to go into detail about the actual facts, about the precise conclusions, about figures, about use and misuse of statistics, about misleading quotations etc. Lomborg's book is constructed in such a way that one has to check his thousands of notes, one by one, in order to reveal the flaws. This task is so enormous that the ordinary reader will never have a chance to realise the extent of the bias. Only experts or people willing to spend a lot of time on this can do that.

But even this type of criticism is not enough. One must also realise that the theme of Lomborg's writings is not so much the actual state of the environment; rather, the theme is the environmentalists, and what they *say* about the state of the environment. Lomborg has a clue, a story, and that story is that we have a host of experts who have conspired to tell the public that we stand before severe problems, as a method to obtain still larger grants. This is the story that gives him a large audience.

Therefore, to fully criticise Lomborg, one has to consider what the news media designate "the personal angle". This will be a main theme of the present chapter. But first some words about the actual data.

WAYS IN WHICH THE TEXT IS BIASED

The bias in Lomborg's book is obtained by various methods. One method is to leave out parts of a clause. In the proceedings of an IUCN conference on extinctions¹⁰, one of the contributions has a text saying: "... it is clear that the number of bird species that are being added to the list of critically endangered species, is increasing rapidly. Although actual extinction has remained at a low level, the number of species requiring very great efforts to be saved is becoming very large."¹¹ Lomborg's version of this passage is: "Despite the fact that IUCN predicts higher extinction rates it is concluded that "actual extinctions remain low""¹². The last part of the last clause has been excluded.

Another kind of manipulation is to cite selectively, i.e. to cite only those parts of a text which support one's argument. Thus, a UN report on poverty and inequality¹³ is cited like this by Lomborg¹⁴: "In the past 50 years poverty has fallen more than in the previous 500. And it has been reduced in some respects in almost all countries." This sentence can indeed be found in the report. It is taken from a chapter which lists all the positive trends. In the report, however, there is another chapter which lists all the negative trends. From this, one might cite many depressing facts, e.g. "During the last 15-20 years, more than 100 developing countries, and several East European countries, have suffered from disastrous growth failures. The reductions in the standard of living have been deeper and more long-lasting than what was seen in the industrialised countries during the depression in the 1930's. As a result, the income for more than one billion people has fallen below the level that was reached 10, 20 or 30 years ago."¹⁵

In his text, Lomborg goes on to cite more details from the positive chapters of the report, and omits a whole series of negative trends that are dealt with in the negative chapters. Of course, to be so selective is not to lie, but it certainly is to give the reader a distorted impression, so that the effect is the same as if one lies.

A cornerstone of Lomborg's argumentation is that when we give priority to economic growth, we will better be able to afford doing something for the environment. In support of this idea, he writes about the so-called Kuznets curves which tell that when economic welfare has reached a certain level, the environment starts to improve¹⁶. He cites

a study where BNP has been studied in relation to 10 indicators of the environment¹⁷. He tells us that two of these indicators did show a Kuznets curve. But he omits to tell his readers that in the 8 other indicators such a relationship could not be demonstrated.

The trend for declining semen quality may be a warning signal that something in the environment affects human reproduction. A range of papers exist ranging from those that find a large decline in semen quality to those that find no decline. Lomborg discusses this subject in a way which might give the reader the impression that he had over time accumulated great knowledge of the field and pays due attention to the variability of the results. However, his English text is practically identical to the earlier Danish text, and we happen to know that his Danish text was written within very short time on no other basis than literature sent to him on a single occasion by a Danish expert. Lomborg chose to focus on the most optimistic paper available, a paper¹⁸ that claims that there is no decline in semen quality. On the basis of this paper, he criticises all the others¹⁹. So, in this case we know what evidence was available to him, and what he has selected. We also know that although the relationship between increasing incidence of testicular cancer and decreasing semen quality has been pointed out to Lomborg, he has refused to write about this. He claims that the apparent decline in semen quality may be explained by the increased frequency of semen ejaculation, stating that if one considers the effect of increased ejaculation frequency, the decline is no longer significant. He does that with reference to a paper from 1997²⁰, which however does not support this explanation. Lomborg has talked with the author of the paper²¹, but strangely he has failed to notice that this author has recently published an updated meta-analysis which clearly demonstrates that the declining trend in semen quality persists even if one considers the changes in ejaculation frequency.²² Lomborg emphasizes data from Sweden telling that the ejaculation frequency has nearly doubled, but has not included the source for this in his reference list. If one reads this source, however, one will find convincing evidence that the decline in semen quality cannot be explained by changes in ejaculation frequency²³.

Lomborg criticises those who postulate a connection between synthetic chemicals and breast cancer²⁴ and states that virtually no one dies of cancer caused by organochlorine pesticides such as DDT, lindane or dieldrin²⁵. However, there are papers that find a relationship between these pesticides and breast cancer²⁶ as well as others that do not find a relationship. One of the papers cited by Lomborg²⁷ lists 11 investigations, of which about half find a significant relationship between organochlorine pesticides, mainly DDT, and breast cancer. But Lomborg does not mention that the paper contains this list. To be unbiased, Lomborg would have had to cite studies of both kinds to the same extent, but he did not. Concerning lindane, there is a clear conflict between reality and Lomborg's text²⁸: "Of the three studies that have examined . . . lindane, none has found evidence for an association with increased risk of breast cancer". Actually, a Finnish investigation from 1990 showed a tenfold higher risk for breast cancer in persons who had elevated levels of a lindane residue²⁹. And, most remarkably, Lomborg cites a Danish investigation as a reference that DDT is of no influence, but refuses to mention that the same investigation found a significant relationship between the pesticide dieldrin and breast cancer³⁰. This conflicts with Lomborg's optimistic view that there is probably no relationship between breast cancer and the pesticide dieldrin.

In the criticism published in 1999 of Lomborg's Danish book, it was pointed out to him that his chapter on acid rain was biased, and that he should consult a conference sum-

mary statement from 1995³¹ giving a state-of-the-art overview of existing knowledge. We know that Lomborg did consult this summary statement³², but he has chosen to keep his misleading text on the subject in the English version of his book, and not to cite the authoritative source pointed out to him.

Lomborg uses a whole page to stress that single examples can often be misleading; everybody can pick a single bad or a single good example if he wants to. So, as he states, “we can only elucidate global problems with global figures”³³. But then, a few pages later, when writing about tuberculosis and malaria³⁴, he has problems with his own recommendation. In trying to downplay the severity of tuberculosis, he mentions that the global trend in deaths from tuberculosis is approximately constant, and then quickly goes on to talk about that the rate in USA is decreasing, not increasing, as has been postulated by others. But he should focus on the global situation, which, according to WHO, is that “Tuberculosis is spreading globally at an alarming rate. There were nearly 2 million deaths in 2000 . . .”³⁵. Also, WHO writes that: “Marked upward trends in case notification rates from 1980 to 1997 variously reflect failing TB control (eastern Europe), the impact of HIV (sub-Saharan Africa) and better case finding (China); marked downward trends (western Europe) represent the impact of TB control . . .”³⁶. As to malaria, Lomborg also tries to tell that the incidence has been “approximately stable”. However, to get this impression, he wants us to focus on Asia, which has only a minority of the malaria cases, and especially on China, where malaria has declined. Why shall we not deal with China concerning tuberculosis, where China is reporting more cases than previously? Why shall we not hear about malaria in Bangladesh, where malaria is increasing? And why should we just in this case not deal with the global situation? The global figures up to 1994 are very uncertain, but do not imply any decrease³⁷. The problem of antimalarial drug resistance continues to intensify. In 2001 it was stated that: “Over the last two decades, morbidity and mortality from malaria have been increasing due to deteriorating health systems, growing drug and insecticide resistance, periodic changes in weather patterns, civil unrest, human migration, and population displacement.”³⁸ Instead of telling us this, Lomborg wants to tell us that the situation is stable, and in China excellent.

Lomborg is also selective when it comes to actual statistical figures. Thus, when talking about the proportion of all tropical forest that has been cleared by man, most figures for the proportion cleared up to now are around 50%. However, Lomborg has found one single paper which gives a figure of 20% forest cleared³⁹, which is vastly different from other figures in the literature and actually is due to a miscalculation as explained in the present chapter on forests. This paper is published in the proceedings of an IUCN conference, and on this basis Lomborg gives us the false impression that it is an official IUCN estimate. So, without proper argumentation, he quotes this figure as a fact. Now, the crucial question is if the marked distortion of the evidence in Lomborg’s text was intended. Has Lomborg happened to be so unlucky that in his literature search he found only the aberrant figure, and not those figures which represent the mainstream opinion? No. In the criticism raised against his Danish book by me in 1999, this bias was pointed out to him. But he has refused to change his text on this point. Instead, he made a futile attempt to demonstrate that data reported by WRI were not trustworthy⁴⁰.

Predictions about what will happen in the future are of course even more uncertain than actual data. The range of possible values is even greater, and therefore the scope for selectivity is even greater here. For instance, the range of estimates of how many

species will go extinct in the future, is very wide. A book chapter which Lomborg has read⁴¹, presents a table containing 12 widely diverging estimates. However, in the text of the same chapter, there is an estimate lower than any of the others. Lomborg takes this low estimate for the absolute truth, and criticises all estimates higher than that⁴².

Similar criticisms of selectivity could be relevant when it comes to predictions of temperature rises in 100 years from now due to the greenhouse effect. The list of examples of selectivity could be prolonged nearly ad libitum, whereas it is more difficult to find parts of the book that are *not* biased.

MIXING DATA SETS

Another way of manipulation is to compare data sets that are not comparable. This problem was referred to already in the introduction to this chapter. Another example is the following: In 1997, FAO estimated that the rate of loss of tropical forest was 0.8 % per year in the 1980's, and 0.7 % per year in the 1990's. In 2001, another set of data, based on satellite imagery, gave smaller estimates, viz. 0.47 % in the 1980's and 0.46 % in the 1990's. It is not known if one set of data is more correct than the other. FAO concludes that the rate of deforestation has not changed significantly over the span of years covered here.

These were FAO's data. Now comes Lomborg's text: "The usual FAO estimates put net deforestation in the tropics in the 1980s at 0.8 percent a year, falling to 0.7 percent in the 1990s. With FAO's new 2001-study, based on accurate satellite imagery, the estimate of the net tropical deforestation has declined even further to 0.46 percent."

Every person reading this would understand that the deforestation rate has declined, being first 0.8 %, then 0.7 %, and now 0.46 %. That is, we get an impression of a steadily declining clearance rate. This impression is given by adding the figure of 0.46 % at the end of the paragraph, without explaining that it is not comparable to the two previous figures. This is a serious manipulation, because the source from which Lomborg has taken the last mentioned figure, very clearly states that there is no proof of any reduction in the clearance rate.

CONCEALING WEAK STATEMENTS BY PROVOKING MEANINGLESS DISCUSSIONS.

One of Lomborg's provocative statements is that the clearance of tropical rain forest is not so important, because the total amount of forest in the world is approximately constant. When Lomborg first published this statement in an article in a Danish newspaper, some of his opponents engaged in a debate about the absurdity of such a point of view. They stressed that those species that become homeless when the rain forest is cleared cannot just move to Eucalyptus plantations or Siberian taiga and live there instead.

However, to engage in such a discussion is to fall into a pitfall where one discusses on Lomborg's premises. Lomborg's claim of the constant forest area is based on dubious data and is not correct. But if he can make his opponents discuss rain forest versus temperate forest, he induces his opponents to start out with an accept of the false claim of a constant forest area in total. In this way, he may lead the discussion away from the weak foundation of the claim of a constant forest area.

A similar example deals with the number of starving people in Africa, referred to above. Lomborg presents data on the percentage of the people in various parts of the world

that are starving, and concludes that this percentage is declining in all parts of the world, even in Africa. However, if he had also given the absolute number of people starving, these figures would have shown only a very modest decrease in the third world as a whole, and a marked increase in Africa. Lomborg knows very well that some opponents would prefer the absolute figures, and he uses more than half a page in his book to argue that it is most correct to use the percentages⁴³. Thus, the scene is prepared for a discussion of whether absolute figures or percentages would be most correct – a discussion which is in a way absurd and can never lead anywhere. And already there are opponents who have taken the bait and fallen into this pitfall (Pimm & Harvey in their book review in *Nature*⁴⁴). If opponents engage in such a discussion, the public will understand that at least the two parties agree that the percentage of starving people in Africa is declining. And then Lomborg will have spread the impression that he wants to give. (A proper conclusion might be that if the two types of figures give diverging impressions, one should include both, as was actually the case in the source reference. If one considers the scope for food aid from the rich countries to Africa, it is certainly relevant to know the rise in absolute figures – viz. about 100 mio. people starving in Africa in 1970 and 200 mio. people now).

MISLEADING USE OF CONCEPTS

In his chapter on acid rain, Lomborg states that “`Acid rain´ has typically been used as a collective term for damage to forests, lakes and buildings believed to be caused by emissions of NO_x or SO₂”⁴⁵. But soon after, Lomborg uses about one page to dismantle the conception that such pollution may damage forests⁴⁶. He states that the actual forest death in Central Europe was due to smoke directly from the sources of pollution, i.e. the reader will understand that it was not due to air pollution with sulphur compounds. This is an erroneous interpretation of his source⁴⁷. He then goes on to say that an eventual effect of acid rain on trees is indirect, e.g. via changes in the soil, not direct “as was assumed by the acid rain theory”. So in Lomborg’s text, when pollution with S is so bad that the trees die directly, this is not damage due to acid rain. And when trees are damaged by weaker effects further from the source, this too is not due to acid rain. The term “acid rain” is used in such a narrow sense that only if it had, far from the source, damaged the trees by direct impact on the leaves, would Lomborg had accepted it. But Lomborg started out his chapter with a wide definition of the term. So, Lomborg’s hocus-pocus is that he changes the meaning of the concept from one page to the next.

Lomborg could have known that effects of acidic rain on parts of trees, especially the roots, are documented⁴⁸. Actually, there is much evidence that acid rain is still an increasing problem in Europe, that soil conditions have changed markedly within a few decades due to acid rain, that on average trees in large parts of Europe are becoming less and less healthy, that the problems would have been worse than now if the S pollution had not been reduced, and that further reductions would be necessary to reverse the present adverse effects^{49,50}. But he who reads Lomborg gets the impression that it was unnecessary to reduce S pollution, except for cases where human health were directly threatened.

Concerning the effect of regulations on air pollution, Lomborg writes⁵¹: “Generally it is probably fair to say that regulation is one of the reasons for the reduction of pollution but that other, technological forces also play a major role”. Except for this caveat, he greatly downplays the effect of regulations. He does this by referring to the improved air quality in London. After the smog catastrophe in 1952 with an estimated 4,000 premature deaths, great public concern led to the Clean Air Act of 1956, and subsequently,

the situation improved. Lomborg cites a paper which documents that the improvement was slow, had started before 1956, and continued long after 1956⁵². We get an impression that the improvement was little better than if people in London had voluntarily reduced combustion of raw coal because it was common sense to do so, rather than because they had been forced to do it by law. The point is, however, that the change in heating systems was indeed, to a great extent, voluntary. The authors of the paper cited by Lomborg were not British residents and probably did not understand that in British culture, you rely very much on voluntary agreement. The Clean Air Act was not a compulsory regulation⁵³. Each district council in London was free to decide if they would engage in smoke control, and as late as 1966, some councils had not yet done so. So, it is natural that improvement was only gradual. You cannot use this example in a debate on compulsory regulations, because the Clean Air Act was not a compulsory regulation in the usual sense of the word.

CONCEALING WEAK STATEMENTS IN THE NOTES AND MISREPORTING CONCLUSIONS

In the chapter on biodiversity, Lomborg tells us that the biologists have difficulties to document actual cases of rain forest species that go extinct. Thus, concerning the Atlantic rain forest in Brazil, the text in the chapter has the following sentence⁵⁴: “Similarly no species of plants was reported to have become extinct.²⁰⁶⁸ “. The reader, who has of course stopped to check all notes long before he reaches note no. 2068, will assume that this note simply contains the literature reference to this statement, and only that. Actually, however, the note includes the following statement: “Fog reports that since then, 10 plant species have been declared extinct (1999: 133).” Thus, when the main text tells that no plant species have been reported to have gone extinct, the word “reported” is crucial. Lomborg knows that actually, some species are extinct, but this was not *reported* by that source which he has chosen to cite. The true situation, that extinctions have occurred, is written only in a note that few people read, and which is of no use to English readers. Lomborg should have cited the primary source of the information – viz. the official IUCN red list. By citing instead a Danish source, no English reader can trace the information given and judge if it is relevant. In this way he conceals opposition to his distorted statement.

Another example: In the chapter on chemical fears, he has a box dealing with the heading: “Organic farmers”⁵⁵. Here, Lomborg refers to a Danish investigation which showed that organic farmers and ecologists have better semen quality than other groups of workers. He then goes on to devaluate this result by declaring that traditional greenhouse gardeners, who use pesticides in their work, “also had better quality sperm than numerous other professional groups.¹⁸⁹⁷.” Again, the reader will assume that note no. 1897 simply gives the literature reference. But the note also contains the following remarkable information: “Greenhouse gardeners did, however, have a sperm count 20 percent inferior to that of the ecologists.” Thus, if this difference is significant (we are not told whether that is the case), then we have the remarkable information that the relatively healthy semen of organic farmers cannot be explained simply by the difference between people living in towns and people living in the countryside, as there is an additional effect of working with or without the use of pesticides; but this very relevant information is seen only by those very few readers who read note no. 1897. All others will get the impression that the story about the healthy sperm of organic farmers did not hold water after all.

Lomborg’s text goes on with the statement: “Finally, in 1999, a large study of 171 traditional and 85 organic farmers settled the issue. Of 15 different sperm quality parameters, 14 were indistinguishable.” In reality, however, the reference⁵⁶ tells us that out of 9

sperm quality parameters, 8 showed the best values in the organic farmers; in one of these parameters (percent normal spermatozoa), the difference between the types of farmers was very significant. So, the paper does not disprove the better semen of organic farmers, as Lomborg's language use would indicate. On the contrary, we see that the phenomenon – better semen in organic farmers – is reproducible, even when the pesticide load of Danish traditional farmers is already very low. So the conclusion is misreported.

GIVING THE IMPRESSION OF A VERY SCIENTIFIC TEXT

To the layman, Lomborg's book may appear to be of an impressive scientific standard. The bibliography contains more than 1,800 titles, and in addition there is a list of nearly 3,000 notes. Also, the text gives the impression of an author who has read a lot, knows a lot about many subjects, and goes through many complicated evaluations of conflicting data sets.

The bibliography is not unproblematic, however. One may note that in addition to texts that are parts of the public debate and even working programs of political parties, the bibliography contains many so-called secondary sources relative to the number of primary sources. And, unfortunately, certain of these secondary sources are considered by most experts as flawed or biased.

The reference list is not as useful as it appears at first sight. Thus it is written in a review of the book⁵⁷: "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." Such a *fata morgana* could for instance be a reference to a text written in Danish (there are remarkably many of these). There are also cases of sloppy work, such as when most references on cancer statistics are to something called NCR, which suggests something like National Cancer . . . However, this is an error. One must find out that it should have been NRC, i.e. National Research Council. It is peculiar that references that do not work appear in some places that are central for judging Lomborg's argumentation. For instance, Lomborg stresses very much his estimate that 0.7 % of all species will go extinct within the next 50 years. In note 2075, he refers to Stork (1997). When one tries to find Stork (1997), it refers to "In Wilson et al. 1997". And then, when one tries to find Wilson et al. 1997, this reference does not figure in the book, so the track ends blindly. The correct reference is Reaka-Kudla, Marjorie, Don E. Wilson and Edward O. Wilson (eds.) 1997 . . ., which is in the reference list. But how should the reader find out that ?

Another example: It is crucial for following Lomborg's argumentation on the number of starving in Africa that one consults FAOs report on food insecurity from 2000. This is entered in the reference list as FAO 2000c, referring to the net address <http://www.fao.org/news/2000>. But the cited net page with "news" does not exist any longer, and thus one cannot at first find the report. The present net address is <http://www.fao.org/sof/sofi>. The text about declining poverty on pp. 71-72 is very much based on biased citations of a UN report from 1997. Unfortunately, this report can no longer be downloaded from the internet, so the reader cannot check the source and find the bias. Also, when Lomborg claims that there is no proof that acid rain damages trees, the crucial source for this claim is an EEA report on a website from which it can no longer be downloaded (it also exists in printed version, but this is not easily available). These examples illustrate the worrying in basing so large a part of the references on net addresses.

In many places, Lomborg's text is formulated in a very technical way which may impress some laymen. As an example, I will cite note no 2081, dealing with species extinction rates: "Using the invertebrate species lifespan of 11e6 years (May *et al.* 1995:3) and interpreting the quote to be from 200 to 2,000 times the natural background (the "if not thousands" means it could be thousands, not all the way up to 9,999): $200 * (1/11e6) * 50 = 0.09\%$ and $2000 * (1/11e6) * 50 = 0.9\%$. The authors are not quite consistent, using a somewhat lower lifespan when comparing 1,000 times the background rate to 2 percent per 50 years (UNDP 1995:235), making the conclusion 0.4-4 percent over the next 50 years." To the layman, this is completely impossible to understand; he can only see that it is something very technical, and it sounds as if Lomborg in a balanced way evaluates the reliability of different estimates. Actually, however, the text is nearly meaningless, because the figures involved are so uncertain that they are only guesses about the size order.

LOMBORG'S USE OF STATISTICS

Considering that Lomborg's discipline is statistics, it is strange that statistical aspects are treated so poorly in his books. Thus, Lomborg hardly mentions the concept "significance", and it is rarely evident in his books whether the trends described are significant. Thus, concerning the world's forests, the latest FAO report⁵⁸ explicitly states that the difference in rates of forest clearance between the 1980's and the 1990's is not significant, and that there is no significant relationship between GNP/capita and forest clearance rate. This, however, does not prevent Lomborg from giving the reader the impression that the deforestation rate in the tropics is declining, or from arguing that to reduce deforestation, it is necessary to promote economic growth⁵⁹. Elsewhere in the book he writes⁶⁰: "... the rate of deforestation was 0.346 percent in the 1980s and just 0.32 percent in the period 1990-5 – not a dramatic increase in pace, but a *decrease*." But Lomborg gives no evidence whatsoever that the difference between 0.346 and 0.32 is significant.

It should also be elementary to a statistician that one should not picture trends by combining time series of incongruent data. And, indeed, in his introduction, Lomborg refers to how fallacious it is to do so⁶¹. Therefore, it is strange that Lomborg himself has repeatedly made this fallacy. Two examples concern the deforestation rate in the tropics and the proportion of Africa's population that starve. This may sow a suspicion that he knows about his own fallacies, but does not care.

One would expect that a statistician paid due regard to the enormous uncertainties on figures of the type that are dealt with in Lomborg's books. When the uncertainty is very large, one must of course not indicate a figure with three- or four-figure precision. Thus, it is absurd to write that the total plant photosynthesis on Earth is 1,260 EJ annually. Another example out of many: Out of all cases of tuberculosis worldwide, only a fraction, varying from country to country, is reported. The actual totals are not known⁶². But Lomborg writes⁶³ that "in 1999, the actual death toll from tuberculosis was 1.669 million." In note 767 we read the total forest cover on the globe in 1961 was 4.3750869 ha. Such absurd precision is used every time Lomborg wants to convince his reader that this is "the true figure", apparently in an attempt to impress lay readers. To a scientist, however, such figures appear inappropriate and witness about lack of seriousness.

A particularly absurd example concerns the question of how great a proportion of all species will go extinct in the future. On this matter, Lomborg writes⁶⁴ that the proportion will be less than 0.208 % per decade, and probably 0.729 % every 50 years, rounded

off to 0.7 %. Through all his scriptures, Lomborg stresses that the *true* figure is 0.7 % extinct in 50 years. He gives no reasons why it is not 0.5 % or 1 %. This precision is peculiar, considering that the uncertainty on the figure is more than a factor 10.

Others have criticised Lomborg's approach to statistics on other points⁶⁵. For instance there are remarks on the strange in that he does not distinguish between different kinds of probability (frequentist and Bayesian), and that he nowhere defines what he understands by "plausible". Concerning temperature rises due to the greenhouse effect, Lomborg does not offer a single probability for the chance of a dangerous outcome, yet he makes a firm assertion that climate "will certainly" not go beyond 2° C warming in 100 years, without defining what he means by "certainly".

Instead of seeking certainty in statistical tests, Lomborg goes in the opposite direction. In many of his illustrations, he extends the curves into the future, using projected values, i.e. extremely uncertain figures. This is also so in cases where the present trends are in a negative direction, and where an optimistic view can be based only on optimistic prognoses. In discussing the effect of the AIDS epidemic on life expectancy, Lomborg writes: "The effect on the developing world as a whole is in 2010 a loss of about 2.8 years and in 2025 a bit more than a year lost." To be so precise on figures that can only be measured in 25 years from now, is hardly to be scientific.

IS LOMBORG SCIENTIFIC ?

In science, some unwritten, but obvious ethical rules apply. You must not disregard data which contradict your own theses. You must judge data equally critically no matter if they support your own theses or your opponent's. You must not refer to insignificant trends as if they were real. You must not mislead deliberately. You must not base conclusions on subjective premises. And you must not lie.

However, it seems that Lomborg violates all these rules, the latter one only rarely, the others more often. We do not expect journalists, media advisers etc. to live up to these rules. For some reason, society accepts that what journalists say, is not always true. But we certainly expect scientists to adhere strictly to these rules. If they do not, then our trust in science is in danger, and if people no longer trust scientific results, science has become of no use. So confidence in scientists is crucial. Lomborg reports on a few cases where scientists publish biased evidence, but we cannot accept such cases as an excuse for him to be biased to the opposite side.

Considering the extreme quantity of flaws in Lomborg's writings, and the nearly systematic selective bias, one cannot read anything Lomborg writes and be confident that this is approximately the truth. And a text that cannot be trusted cannot be considered of any scientific value.

MAY SCIENTIFIC CONSENSUS BE REACHED ?

When a manuscript for a scientific paper is submitted to a scientific journal, it is subjected to a so-called peer review, which means that it cannot be published before one or several anonymous colleagues have pronounced on the quality of the manuscript. And the scientists that make written contributions to the Intergovernmental Panel of Climate Change, a politically charged subject, are scrutinised extra carefully. They are subjected to three rounds of review by hundreds of outside experts.

But to our knowledge, Lomborg has produced no scientific text on environmental pro-

blems which has passed a peer review. Also, “The sceptical Environmentalist” has received no evaluation by peers in the natural sciences. It is very strange that Cambridge University Press, a company editing scientific books, has suspended its usual procedures and omitted such an evaluation.

Ultimately, science exists in order to serve the public. Here, instead of making the detour around the forum of scientific peers, Lomborg takes the shortcut and takes direct contact with the public. He displaces the approval of his text to a public forum – the news media. Unfortunately, as will be shown presently, the conditions for debate in the public media is such that a clarification of what is the scientific truth, is not possible here.

Although the debate on Lomborg’s writings in the Danish public fora has been long and heavy, there has been only one attempt at making some sort of peer review. This was arranged in connection with the publishing of the Danish version of the present book. In collaboration between the authors and one newspaper, two public meetings were held. Before a large audience, a panel of experts delivered criticisms of Lomborg’s text in various subject areas, after which Lomborg delivered his defensive replies. Such a procedure might have led towards a general consensus of certain facts, but this did not happen. The parties hardly moved towards each other on any point. As to Lomborg, he did not on any single item give any concession, just as he has given very few concessions in any other part of the debate in the Danish news media.

The Danish version of the present book constituted a serious criticism of many of Lomborg’s so-called facts. This criticism is formulated by specialists independent of environmentalist organisations; several of them are top experts in their fields, and the criticism is based on scientific ways of thinking. Therefore, Lomborg should be obliged to correct those cases of inaccuracies, bias and selectivity which we have pointed out. In the English version of his book, he has actually corrected many small details pointed out by us, but he has refused to correct many others, and he has not been willing to change the overall impression that he gives to his readers. In conclusion, there is still a very long way to go before any consensus can be reached between Lomborg and his critics.

THE DANISH DEBATE ON LOMBORG’S POSTULATES

Lomborg entered the scene in the Danish media in January 1998 when he published a series of articles in one of the largest newspapers. At once, an intense debate started in several newspapers and other media. When we look back today on the outcome of this debate, the conclusions are frustrating. The conditions for the debate were not always fair.

A general trend in the newspaper that brought most articles by Lomborg was that those letters which were most precise in their criticism, most authoritative, most professional and most efficiently “hit their target”, were rejected by the editors. We know that, because it has been possible afterwards to trace and read many of the rejected articles. We also know that the debate did not proceed according to the wishes of the debate editor. He was overruled by the editor-in-chief.

The editor-in-chief did not want any of his journalists to interview people who disagreed with Lomborg. Only one such interview was made, and that was a double-interview with Lomborg and an opponent. The interview focused more on the fight situation, the body language of the combatants etc. than on the actual facts and arguments. The reader got the impression of a situation where “the doctors disagree”, that is a situation

where nobody could know who was right and who was wrong. A few other “cockfights” of similar type were reported in other newspapers.

A person who engaged in an intense debate with Lomborg in another large newspaper, realised how strange it was that although he took much care to express himself understandably and correctly and right to the point, his letters were either rejected or trimmed even more than required by the guidelines for readers’ letters. This was frustrating, because to oppose Lomborg’s arguments and prevent irrelevant counterattacks, it was often necessary to go into some detail and remember to include the relevant reservations, which would always require more space than was allowed. It was also strange, because Lomborg had always extraordinary space put at his disposition, and had any letter accepted, even when it was polemic, aggressive and not to the point. Finally, however, this person learned that if he wrote in the same style as Lomborg – that is in an overly aggressive way – he could always have his letters accepted, and was allowed more space than he was entitled to from the guidelines. Clearly, the criteria that guided the editors’ selection of contributions in this newspaper were not whether they contributed to a clarification of false and wrong, but their entertainment value. The editors want a cockfight, not boring consensus on what is the truth.

One might expect that if Lomborg published very controversial articles in one newspaper, then there would be journalists at other newspapers who contacted various experts and interviewed them about the actual knowledge in the field. Only one newspaper did this, and only to a very moderate extent. For instance, when Lomborg and one of his students wrote that “forest death” is invented by environmentalists and has never existed, no experts were ever consulted by journalists.

In conclusion, the Danish media have not aimed at clarification of the truth, and our experience is that such a clarification of complicated, scientific questions is simply not possible in the news media. But these are exactly the media that Lomborg utilises to promote his points of view. Presumably, the experience in other countries will be the same.

MAKING HIMSELF IMMUNE TO ATTACKS

In many cases, Lomborg’s points do not stand on the lines, but between them. Thereby, it becomes impossible to criticise Lomborg for what he says. A clear example is when he criticises biologists in general. He writes that they have a clear opinion about what the mathematical models should tell. “There are many grants at stake.”⁶⁶ What he tells his readers is that the biologists are not honest. But you cannot criticise him for this, because he has not written it directly. And you cannot criticise the sentence “There are many grants at stake”, because it is obviously true (like it is in practically every other profession).

ATTEMPTS TO MAKE THE OPPONENTS REACT EMOTIONALLY

In many other cases, Lomborg insults his opponents with directly derogatory terms widely out of proportion, e.g. terms such as „it is nonsense“, “he cannot read”, or he is “arrogant”. Unfortunately, those who choose to ignore this by keeping out of the discussion, are not spared by Lomborg. They are slated for being unable to defend their statements, and accused of treating Lomborg as a kind of pariah.

To exemplify the level in the debate, I will briefly mention the dispute with Jon Fjeldså, who administers one of the World’s largest databases on tropical species diversity. In

the newspaper, Fjeldså wrote that Lomborg's estimates of species extinction rates seem to be too low. When Lomborg denied this, Fjeldså replied that even if Lomborg's estimates were correct, they still would mean that the extinction rates were about a factor 1,000 higher than the natural background rate. Then, Lomborg utilised this statement to conclude that Fjeldså had acknowledged his estimate as "the correct figure". When Fjeldså protested, Lomborg answered in a final reply that although his opponent had not agreed to his estimate in what he had written, he had privately, in the telephone, agreed that Lomborg was right – a statement, which was absolutely not true, but hard to disprove.

This was not an isolated episode. Other examples could be given.

Thus, the atmosphere of discussion in Denmark was seriously "poisoned" by Lomborg. And it now seems that this trend continues in the English-speaking countries. Thus, in a radio debate in Australia in October 2001, Lomborg had the following remark to an opponent (Tom Burke) that denied to accept Lomborg's figures as the "truth": "Tom, it actually seems a little bit to me that you would like not to have this figure out in the open." And it was said in such a way that Tom Burke could not reply. Again the same method: Lomborg tries to imply that his opponent is not honest, in a way that prevents the attacked person from defending himself.

If one of Lomborg's opponents commits any small error or overlooks some small detail, he is immediately subjected to scornful derogations by Lomborg. But Lomborg himself stubbornly denies to have been criticised even when confronted with very serious accusations. Under such unequal conditions it may be very difficult for an opponent to avoid becoming frustrated or angry, i.e. to avoid showing emotions.

Many examples may be cited to illustrate that Lomborg tries to frustrate his opponents maximally. He obtains this i. a. by attacking opponents under conditions where they cannot reply in defense, i.a. by including insinuations of named persons in his books. For instance, there are many such cases in the biodiversity chapter. Another method is to cite persons in favour of an opinion opposite to the one they have. As an example, in relation to human sperm quality, a paper by S. H. Swan et al. is cited as part of the argumentation that changes in the frequency of ejaculation may explain the apparent decline in semen quality⁶⁷. But Swan's paper gives documentation of the opposite. In the chapter on forest death in the Danish version of the book, there is a reference to a newspaper article, written by leading experts in the field who opposed Lomborg's views, but which was rejected by the newspaper. This article is cited in a very misleading way, but the authors cannot protest, because their article was never printed, so the readers cannot check it. Thus there is a maximal chance that the authors will turn frustrated and angry. Remarkably, the notes referring to this article are kept unchanged in the English book⁶⁸. This makes the manipulation even greater – English readers have absolutely no chance to check an unprinted Danish text; they will have to rely on that the Danish experts actually said what Lomborg claims. But they said approximately the opposite.

Lomborg seems to have a special talent for formulating provocations in such a way that they are not noticed by the layman, but felt very strongly by the scientists that he aims at. When he succeeds, the layman will observe that the scientist gets angry without any apparent reason. There may be a wish to create situations where the opponents are angry. The heading of a whole-page newspaper article in Denmark in 2002, written by one of Lomborg's supporters, was "When scientists become aggressive". The point was

that the slating reviews of Lomborg's book in international scientific journals were "aggressive".

WHY ALL THIS "MUD" ?

One may think that to write about all this is to stir up mud which one had better leave where it is. One should not do this in a text dealing soberly with the state of the environment. Such a point of view, however, overlooks that all this "mud" may be a crucial element in Lomborg's strategy. The "flinging of mud" appears to serve several purposes. One could be to scare the opponents to such a degree that they keep out of the debate forever after. Clearly, if this was the intention, it was often successful.

Another purpose could be to derogate the opponents in public. Most readers do not understand the scientific arguments, or, at least, are unable to judge from the arguments who is right and who is not. Instead, they try to judge from the tone and/or the "body language". The way that scientists discuss, especially in the natural sciences, is different from the way that laymen discuss. A good scientist understates the strength of his own arguments and is always ready to admit that the opponent might be right. When something has been demonstrated with 90 % certainty, the good scientist will say that we do not know anything for sure, because there remains a 10 % chance that things might be different from what we think. Such attitudes are an important part of the professional ethics. Laymen, on the other hand, are used to trust that person who expresses himself with the greatest self-confidence; this is one of the reasons why prudent scientists are often not understood properly when they are interviewed in the news media or by politicians. (It should be added that if the data point to a risk of e. g. 10 % that some kind of disaster is underway, people who live up to the ethics of their profession would be obliged to focus on the 10 % – that is the precautionary principle).

By acting cocksure Lomborg will not win any victories on the scientific scene, but he can win all the tricks on the public scene. If the situation is evaluated in a social way, rather than in a scientific way, Lomborg will be considered the winner. And, apparently, that is his goal. He has made practically no attempts to win in any kind of scientific forum. He has used all his energy to win on the public scene, in the news media.

In the case with Jon Fjeldså and many other cases, the layman will recognise that at least one of the parties must have manipulated and been dishonest. He cannot know who. But considering that Lomborg demonstrates a lot of indignation, whereas his opponent either remains silent or speaks in a relatively muted tone, many persons – those that mainly judge from the so-called body language rather than from the arguments – will be misled to believe that Lomborg is right in his indignation.

DIFFERENT KINDS OF TRUTH

The word "truth" may be used to designate different concepts. One kind of truth is what could be called the personal truth. Here, a statement made by a person is true if it is in accordance with what this person actually knows, thinks and feels.

Another kind of truth may be called the social truth. Here, a statement is true if it agrees with the opinions of the general public or with any acknowledged social group. It is true if it agrees e.g. with the experts, or the prime minister, or what famous people say, or with the news media, or with the head of the political party that you have joined.

A third kind of truth concerns those statements that do not depend on who makes them. It deals with what might be called "objective facts". To this category belongs the

concept of “scientific truth” as it is conceived in the natural sciences. Here, the truth is that which can be affirmed by observations or experiments, irrespectively of who makes the observations.

Many scientists working in the natural sciences or with technical matters are not very aware of social issues, but are very aware of what is “the scientific truth”. They tend to disregard the importance of the social truth, although it is the social truth that determines the political decisions and the guidelines of the ruling ideology.

When a rebel like Lomborg attacks the prevailing concept of what are the “facts”, sober scientists will act on what may be called the scientific playing ground. They will defend the goal on this ground, trying to avoid that the opponent manages to shoot the ball into this goal. But, if the opponent is Bjørn Lomborg, he acts on another playing ground, the social one. Here, he is completely free to shoot the ball into the goal as many times as he wants, to the applause of the spectators – because the scientists, according to the ethics of their profession, are very careful not to act on the social playing ground. So, in a way, Lomborg’s opponents defend the wrong goal.

Other scientists do not keep sober but become emotionally involved, and, as claimed above, may be provoked by Lomborg’s lack of fairness and become angry. If that happens, they will enter the social scene in a way where they are doomed to lose, because the public does not respect anger in scientists.

Of course, it is important for Lomborg that no scientists interfere in a more clever way that blocks his access to the social goal. His strategy will be hampered if his scientific arguments do not hold water. Therefore, it is important for him to render the experts harmless. The most impressive authorities can be accused of manipulations and dishonesty in such a way that the general public does not know who to trust and who to distrust. They are attacked with means that are efficient socially, whereas they defend their positions with means that are efficient only in the scientific world. The more they stick to the ethics of their profession, i.e. the more they keep away from the social playing ground with its subjectivity, the more defenceless do they become vis-à-vis a person like Lomborg.

Thus, prudent scientists are caught in a “catch-22”⁶⁹ situation. If they choose to keep away from the social playing ground, they lose. If they choose to enter the social playing ground, the sequel will be that their subject area will become tightly intermingled with subjective aspects, and thereby the very basis for the trust in science will have disappeared.

I see no other way out of this dilemma than to bring the matter before some kind of scientific forum, national or international, that has the purpose of revealing scientific humbug. The ideal solution in the case of Lomborg would be that a panel of neutral experts, paid by the public, would check his reference notes, one by one, and draw conclusions on whether the sources have been utilised correctly or not.

METHODS USED ON THE SOCIAL SCENE

Lomborg is not the only person who understands to act on the social scene with the help of data taken from the scientific world. When it comes to environmental issues, various private organisations have acted in this way for a long time. To these belong green organisations, e.g. Greenpeace. And, first of all, to these belong polluting industries which try to defend their economic interests.

In the early 1970's, I had the opportunity to deal with the subject of lead pollution, including the effects of lead additives in fuel. Here, I learned a little about how chemical corporations worked to affect the public opinion in USA. If a corporation wants to give the impression that lead pollution is no matter of concern, it will not succeed simply by stating that lead pollution is harmless. Such direct statements will too easily become falsified by experts. Instead, they may aim at a situation where the social truth is that "we have no certain knowledge of this". First, they launch some investigations which indicate that lead is probably no problem. Then, of course, they are opposed by people who claim the opposite. Then, they engage in discussions with such opponents in a way where they point to statistical uncertainties, the variability of results, unexplained inconsistencies etc. They utilise a weak point in the scientific ethics, viz. the attitude that one should be very cautious not to consider any fact as 100 % proven. As long as they can agree with their opponent that we have no 100 % certain knowledge, the layman will conclude that the scientists have not yet finished their investigations, and we will have to wait until better investigations have been carried out. The layman does not understand that in such complicated matters as the effects of pollution, 100 % certainty is rarely obtainable. Furthermore, the corporations will try to provoke a situation where scientists have opposing views – typically a situation where one is dependent on the firm, whereas the other is independent. As long as these two criticise each other, the layman will conclude that "the doctors disagree", i.e. the time is not yet ripe for well-informed action. If that happens, the firm has obtained what it wants – viz. that no action to reduce pollution is taken. A kind of paralysis is induced. The firm has not won on the scientific playing ground, but that does not matter. It has got a ball into the goal on the social playing ground.

Concerning the case of Bjørn Lomborg, one may make a list of methods that have been used by him on "the social scene". The list may contain the following items:

- 1) Deliberate use of aggressive or polemic tone. This increases the chance that the news media will bring the message, and hampers the esteem of the opponents.
- 2) Throwing suspicion on the opponents' motives. This is for instance when he insinuates that the biologists are not honest, and a similar suspicion is directed towards the scientists of the international climate panel⁷⁰.
- 3) Scaring the most authoritative opponents out of the scene.
- 4) Inducing paralysis, i.e. creating a situation where people can say "the doctors disagree" and where people get confused about right and wrong.
- 5) Creating a picture of the opponents as emotional romantics. Lomborg does this mainly by direct accusations, but he is also supported by the fact that editors of important press media have rejected or neglected the most professional opponents, and created access for less authoritative persons instead. Or he can provoke an opponent so strongly that he leaves an urbane level of discussion and becomes emotional, whereupon he can concentrate on the most emotional parts of his contribution.
- 6) Appealing to the feelings of his followers by depicting his opponents as a conspiring fraternity of selfish experts who look down on laymen. At the same time, he presents himself as a brave opponent against the establishment, as a victim of unjust accusations, or even as a "Galileo" who is not understood by his contemporaries. Thereby, his opponents are indirectly characterised as reactionary defendants of their privileges.
- 7) Accusing (unjustified) his opponents of just those types of manipulations which he uses himself. Thereby, it becomes difficult to accuse him, because he has already said the same about others.

- 8) Lomborg has been clever at cooperating with socially powerful forces. In Denmark he started by obtaining firm support from the editor-in-chief of a leading newspaper. Later, he has been supported by the prime minister, who took over in November 2001. In England, Lomborg's success in obtaining support from Cambridge University Press is surprising, in as much as they published his book without any relevant peer review. And he has been very professional in his P.R. campaign in USA.

OMITTING THE MERITS OF THE ENVIRONMENTALISTS

If we consider the social scene as more important to Lomborg than the scientific scene, we can conclude that the most important message in his book is not that the environment is doing fine. Rather, the most important message is that the environmentalists cannot be trusted.

To get this message clear, Lomborg systematically focuses on prominent environmentalists that can be pictured as radical, and tries to make them stand out as representatives for all environmentalists. He makes these persons more radical than they actually are. One of the persons criticised is Paul Ehrlich, known e.g. from the book *Population/Resources/Environment*. Although Ehrlich has been overly pessimistic in some respects, he has not been so in all respects. He has not overestimated the severity of the growth in world population, and he has not postulated that the oil resources will be used up in the foreseeable future. But Lomborg is so eager to slate him that he postulates that Ed Wilson and Paul Ehrlich are “the enthusiastic supporters of an ambitious plan, the Wildlands Project, to move the entire population of the U.S. so as to recreate a natural wilderness in most of the North American continent. The people would then live in small, enclosed city islands, as an archipelago surrounded by wilderness . . .”⁷¹ This dramatic claim is based on the misreading of an article written by persons in an organisation that is critical of environmentalists, and has apparently been accepted by Lomborg without any scepticism. Lomborg has failed to check this claim by reading any of the editions of the Wildlands Project or speak with project staff members. And he has even neglected evidence to the contrary sent to him in 2001 by the founder of the Wildlands project, Michael Soulé⁷².

All the way through the book, environmentalists are presented as persons who try to withhold information or are suspect in other ways. The merits of these persons, on the other hand, are simply completely neglected. Lomborg never admits directly that concern for the environment has led to results that would not have been obtained in any case. Instead he focuses on a few cases where improvements, according to some but not others, have not been influenced by legislation, cf. what was said about the British Clean Air Act.

Actually, however, one may list a vast series of success histories about cases where concern for the environment has led to improvement of the situation. A few cases in point are reduction of infective bacteria in bathing water, the reduction in acidification of Scandinavian lakes via air pollution, and the efforts to avoid decomposition of the ozone layer. Actually, these and many other positive stories presented by Lomborg could have been used to illustrate that concern for the environment leads to results. But instead, Lomborg uses the same stories to tell that concern for the environment was unwarranted. As Michael Grubb says in his review of the book in the journal *Science*: Lomborg relies on “manna from heaven”. All the good things just happen, as if they were sent from heaven. Ordinary concepts of cause and effect are nearly suspended.

If governments make incentives to reduce consumption of conventional fuels by putting green taxes on such fuels, this incentive may stimulate investments in alternative energy systems. Lomborg approves of the development of alternative energy sources, but strangely, he is against the very type of policy that could stimulate such a development. In his universe, nothing good can come from environmental policy. He can not or will not see the cases where improvements are caused by concerned effort.

This strange “blind spot” in Lomborg’s book is not due to lack of knowledge. Thus, when it comes to extinctions of threatened species, we have seen an examples of his selective citations: When an author says that extinctions have been fewer than expected because of the strong efforts made to save many species, Lomborg omits the latter part of the argumentation and only cites the part saying that extinctions have been fewer than expected. It is so important to Lomborg to eradicate the impression that concern can lead to anything good, that he is willing to manipulate his citations to do this.

It seems that if Lomborg could have his way, all public efforts to prevent species extinctions and degradation of natural habitats would be abolished. In that case, there would be an even greater need than now for NGO’s such as Greenpeace, WWF, Friends of the Earth and conservation unions. Such organisations would use even greater efforts to obtain money, and we would get even more dramatic statements of the type that nature is in peril and we need to act NOW. Thus, Lomborg’s (lack of) policy would lead to even more of that type of statements, that “litany”, which he fights.

THE LATEST DEVELOPMENT IN DENMARK

For years, Lomborg has had contact with Anders Fogh Rasmussen, the leader of the largest right-wing party. He had suggested to Mr. Fogh Rasmussen that a new institute for evaluation of the environment should be established, in order that the type of analysis performed by Lomborg could be promoted. In November 2001, the majority in the Danish parliament switched, and Mr. Fogh Rasmussen became the new prime minister. Already in January 2002, money for such a new institute was granted, and money for competing institutions was cut down. On February 26th, Lomborg was appointed as director. He got what he had asked the prime minister to give him. The new institute will have an “independent advisory” function vis-à-vis the government.

At the same time, criticism against Lomborg intensified in the media. I was contacted by persons who suggested that I lodge a complaint about Lomborg to a committee called “The Danish Committees on Scientific Dishonesty” (“Udvalgene vedrørende Videnskabelig Uredelighed”, U.V.V.U.). These are administered by the Danish Research Agency. The chairman is a High Court judge, and the ordinary members are scientists. I accepted to submit such a complaint to the UVVU, and a copy was given to the board that was about to appoint the director. However the government ignored the complaint and appointed Lomborg in spite of it. Meanwhile, as of March 2002, the UVVU has continued to treat the case against Lomborg, and it is expected that conducting the case will last ± 1 year. Also, a group of American scientists, led by professor Stuart Pimm of the Center for Environmental Research and Conservation, Columbia University, New York, have submitted a complaint to the UVVU as a substantial addition to the Danish complaint.

According to the statutes of the UVVU, scientific dishonesty encompasses acts or omissions, whereby there will in research be forgery or distortion of the scientific message.

In order that an act can be designated as scientific dishonesty, it must be possible to document that the person has acted on purpose or shown gross negligence in connection with the count. The complainers allege that Lomborg has done so.

It is not known, however, what the consequences will be if the decision of the UVVU goes against Lomborg. For instance, there is no demand that he should be fired from the director's chair if he were claimed dishonest. But, of course, most persons would no longer have any trust in statements advanced by the institute.

WHAT CAN WE LEARN FROM THIS ?

The Lomborg case is important because it shows us some of the vulnerable points of natural science – points where science as an institution has difficulties to defend itself against attacks on its integrity. Firstly, it is evident that an agreement on what is the truth, and what is not, cannot be reached in the public news media. The conditions for debate in the media are such that they further confusion rather than clarification. Fair, sober and balanced points of view are not allowed the space that they warrant. It is precisely because of this that we found it necessary to publish a whole book as a response to Lomborg. It simply was the sole possibility to have the relevant objections presented to the public.

We have also seen that science may be vulnerable to “cheap imitations” – that is to something that is presented as science, with impressive statistical calculations or impressive interminable reference lists, but which on close examination turns out to be only superficially similar to science. Laymen will have difficulties in telling the “cheap imitation” from the genuine thing. Ordinarily, people expect that scientists aim at the truth, and, to begin with, you are simply not believed if you claim that somebody is manipulating, lying or trying to break down the esteem of you or your colleagues.

And finally, another conclusion is that there may be forces in our society – including economic forces – which have an interest in throwing doubt on the scientific consensus. There may be forces that seek to bring about a “the doctors disagree”-situation. The long-term effect of such a strategy will be that laymen become confused, no longer know what they can believe, and lose their trust in the authorities and in science.

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 - 3 FAO (2001): The state of food insecurity in the world 2001. www.fao.org/sof/sofi/
 - 4 FAO (1999), see note 2.
 - 5 The Skeptical Environmentalist (TSE), p. 6 and fig. 24 p. 61.
 - 6 S. Pimm & J. Harvey (2001): No need to worry about the future. *Nature* 414 / 8. November 2001 / pp. 149-150.
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 - 9 Articles by members of the union of concerned scientists (2001): P. H. Gleick,, E. O. Wilson, T.E. Lovejoy, N. Myers, J. A. Harvey, S. L. Pimm and J. D. Mahlman, www.ucsusa.org/environment/lomborg.html.
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 - 13 UNDP Human Development Report 1997. www.undp.org/hdro/97. This report can no longer be downloaded from the net, however.

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- 21 Lomborg's note 1889.
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- 27 S. Güttes et al. (1998): Chlororganic pesticides and polychlorinated biphenyls in breast tissue of women with benign and malignant breast disease. *Archives of environmental contamination and toxicology* 35 (1): 140-147.
- 28 TSE p. 244.
- 29 Cited in Wolff et al. (1996), see above.
- 30 A. P. Høyer et al. (1998): Organochlorine exposure and risk of breast cancer. *The Lancet* 352: 1816-1820. Lomborg's argument for omitting the information on dieldrin is that he considers the relationship found to be accidental. His argument for this is that if the relationship between cancer and chemicals is studied, one out of 20 correlations will reach significance at the 5 % level. He counts the many different PCB isomers analysed as different chemicals, and therefore argues that more than 20 chemicals were analysed. This argumentation is not valid, however, because it would require that the quantities of the PCB isomers varied independently.
- 31 H. Rohde et al. (1995): Acid reign '95 ? Conference summary statement. *Water, air, and soil pollution* 85 (1): 1-14.
- 32 Lomborg (1999), pp. 117-119 in "Godhedens Pris" [A reply to the Danish version of the present book, published on Lomborg's website].
- 33 TSE p. 7.
- 34 TSE pp. 22-23.
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- 36 *Weekly epidemiological record* 74 (27) 9. July 1999, pp. 217-227: Tuberculosis control. Progress in 1995-1997. www.who.int/wer/
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- 42 TSE p. 255.
- 43 TSE p. 64.
- 44 See note 5.
- 45 TSE p. 178.
- 46 TSE p. 181.
- 47 Lomborg's note 1306, an unpublished Danish manuscript by Gundersen et al., states in translation "The heavy forest death in the "Black Triangle" was mainly caused by direct impact from the air pollution . . .", thus there is no mention of "smoke", and actually scientific consensus is that SO₂ is a main factor in this direct impact.
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- 59 TSE p. 117.
- 60 TSE p. 16.
- 61 TSE p. 24.
- 62 Weekly epidemiological record 74 (27) 9. July 1999, pp. 217-227: Tuberculosis control. Progress in 1995-1997.
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- 63 TSE p. 23.
- 64 TSE p. 255 and note 2075.
- 65 S. Schneider (2002): Global warming: Neglecting the complexities. Scientific American, january 2002, pp. 66-69.
- 66 TSE p. 254.
- 67 TSE p. 240 note 1890.
- 68 TSE p. 180, notes 1306, 1311 and 1313.
- 69 Cf. Joseph Heller (1961): Catch-22.
- 70 TSE p. 37.
- 71 TSE p. 257.
- 72 According to M. Soulé in the Danish newspaper Information 9./1. 2002.

SCEPTICAL QUESTIONS AND SUSTAINABLE ANSWERS

Twelve Danish scientists – with backgrounds in natural as well as social sciences and economics – go over the many subjects covered by “The Skeptical Environmentalist”. The state of the world is assessed in terms of resources of energy and raw materials, population growth, biodiversity, forests, fisheries and fish stocks, greenhouse effect and climate change, acid rain and chemicals. En route, they expose the methods used by Bjoern Lomborg. In his book, Lomborg concludes that the state of the environment is improving on most counts and also that many actions taken to improve the environment, including the Kyoto protocol, are waste of money. However, Lomborg often reaches his conclusions by excluding statistical uncertainty and by comparing figures calculated on different assumptions. For example, he states that the clearing of tropical forest has been reduced, a conclusion allegedly based on official data from the FAO. However, the reduction he shows relies on figures that are in part incommensurable and in part within the range of uncertainty.

Lomborg claims that instead of trying to reduce carbon dioxide emissions, it is more economically efficient to wait and see the climate change and repair the damage. However, this conclusion is based on several assumptions, e.g. a discounting rate of 3-6%, which makes costs in the future insignificant compared to costs today, and on the assumption that – due to the low ability of payment in developing countries – the costs here are not important compared to costs in industrialised countries.

The many pages and notes in “The Skeptical Environmentalist” successfully convinced the editors of several journals and newspapers. However, no one should conclude on the basis of Lomborg’s book without also reading “Sceptical questions and sustainable answers”.

THE DANISH ECOLOGICAL COUNCIL