GUEST COMMENT

Science, Policy, and International Affairs: How Wrong the Great Can Be*

It is a real question as to how much science is assimilated nowadays into policy decisions both nationally and internationally. Yet it is more relevant today than ever, with grave agreements that have been, or need to be, forged on such threats as global warming due to the 'greenhouse' phenomenon, the diminution of stratospheric ozone, and increased incidence of acidic precipitation. It is not that these are new problems. Acid rain, as a harmful product of an emergent industrial society, was already recognized over a century ago by the British with the passage of the Alkali Act. But it did not become an international problem until the introduction of the tall smoke-stacks that mostly removed the harmful sulphur dioxide from the local region and transported much of it as far as five hundred miles (800 km) away. It has certainly exacerbated relations between otherwise friendly nations such as the UK and Sweden as well as the US and Canada.

Global warming is also a problem that was already enunciated over a century ago — first, perhaps, by J.A. d'Arsonval — and later was even subjected to a fairly good numerical analysis by S.A. Arrhenius. But here again, it did not leave the laboratory coffee-table until about twenty years ago when the precise measurements of Dr C.D. Keeling at my Institution revealed the steady exponential growth of CO_2 in the atmosphere to where it stands at some 30% above the pre-industrial value. The growth is almost certainly due to industrial activity, and the exponential reflects the global population increase as well as the technological expansion which is what supports the population growth in the first instance.

These problems share a characteristic that makes it very difficult for modern society to cope, namely the long time-interval, of the order of one hundred years, for predicted adverse effects to appear. Accordingly the analysts and policymakers have to rely on admittedly imperfect science and complex mathematical models to assess both the extent of the danger and the urgency and cost of remedial action.

In discussing the state of science and technology, there is an overwhelming tendency to depend on the present state of technology and natural sciences and ignore the advances that will occur in the next one-hundred years. We also play down the role of the social sciences — particularly economics. An argument is usually made that economic predictions, over the time-intervals that we mention, are inadequate; but it is not well understood that the climate models, for example, are of the same mathematical genre as the economic models, and are no more reliable.

Views on DDT

In this brief essay, we take up these points, one by one. I deal with the question of how much science finds is way into policy decisions, first by drawing on several historical examples. The most difficult one to discuss is the use of DDT as an antimalarial agent. In January 1979 Dr Lee A. DuBridge, Science Adviser to the President of the United States, gave it as:

> 'My view is that DDT is still an extremely useful agent for many kinds of insects and pests, crop-killers, and disease-bearing insects and so on. Banning it would have serious effects on human life, with the spread of disease and the destruction of crops.'

In September 1971 Dr Jesse L.O. Steinfeld, Surgeon General, United States Public Health Service:

> 'DDT has been instrumental in literally changing the course of history for many nations and continues to do so today. Its use has meant the difference between hunger, despair, and poverty, and food, hope, and the promise of a better life, to billions of people throughout the world. Few drugs can claim to have done so much for mankind in so short a period of time as can DDT.'

In 1971 Dr Phillip Handler, President of the United States National Academy of Sciences:

> 'DDT is the greatest chemical that has ever been discovered. The second generation of pesticides is a darn sight more dangerous than DDT, but, because of the public outcry, the government has needlessly banned DDT for most uses. The predicted death or blinding by parathion of dozens of Americans next summer must rest on the consciences of every car-owner whose bumper sticker urged a total ban on DDT.'

In the 1971 Report of the US National Academy of Sciences:

> 'It is estimated that in little more than two decades DDT has prevented 500 million deaths that would otherwise have been inevitable.'

In a report of the Food and Agricultural Organization of the United Nations:

> 'With no cheap substitutes available, these developing nations will suffer crippling setbacks if they hastily follow the example of the United States in curtailing the use of DDT. ...The case against DDT has not been proved. On the contrary, the case for it in controlling pests, ranging from malaria-carrying mosquitoes to locusts and cotton worms, is well documented.'

On 14 June 1972 the United States Environmental Protection Agency banned the use of DDT for all practical purposes.

*Following the Author's address, entitled 'Environmental Science and International Politics', to the opening Plenary Session of the First Geneva Environment Meeting (GEM), on Environment and Development: Conflict and Convergence — *see Environmental Conservation*, Vol. 19, Nr 4, pp. 371–2, 1992.

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— and on Acidic Precipitation

Next we take the case of what is most commonly referred to as 'acid rain'. The public discussion on this has latterly abated — partly because of the realization that the German forests seemed to have recovered considerably and had actually increased productivity throughout the crisis period, but also because of the passage last year in the United States of the Clean Air Act which dealt in part with acid precipitation and mandated a reduction of 10 million tons a year of sulphur emissions with respect to a base year.

The US legislation was passed by essentially the same Congress that, almost ten years earlier, had voted for a one-half-billion dollars* decadal programme of measurement, research, and assessment, of the effects of acid precipitation, namely the National Assessment Program on Acid Precipitation (NAPAP). The programme concluded with a massive set of reports whose results can be summarized by saying that the effects on the freshwater systems in the eastern United States were not measurable, and that the forests were in the best condition that they have ever been historically. The only exception to that observation is some damage to high-elevation stands of Red Spruce (*Picea rubens*) in the East that may have been caused by acid precipitation. It might be noted that much the same seems to be true of the forests in western Europe. An article in *Science* put forward the estimate that these forests are accreting carbon at the rate of two gigatons a year, which is a formidable measure of growth, corresponding as it does to about one-third of the annual industrial emission of carbon in the form of CO_2. Nevertheless the Congress ignored the results of its own sponsored research and called for the reductions of sulphur emissions.

Yet we may note that there exists no scientific or economic analysis fixing the number of ten million tons in the Clean Air Act.

'Greenhouse' Gases

Continuingly the world confronts decisions with respect to global warming and the control of the 'greenhouse' gases in which I am afraid the pattern will be repeated. The money that is being spent on research and computer modelling alone is staggering. In the United States it is over one thousand million dollars a year. The not-totally-unexpected result is that the status of the related science is changing with extraordinary rapidity, so that in the last few years these new results have forced a serious rethinking of many aspects of the problem of 'greenhouse' gases and global warming.

The most interesting result is the continually lowering estimate of the rise in sea-level that could be a result of the increase in 'greenhouse' gases in the atmosphere which would have the equivalent effect of the doubling of its CO_2 content. It was only some 17 years ago that serious predictions of a 25 ft (7.62 m) rise in a matter of 'decades' was made by an expert. This estimate has been steadily reduced in the intervening years to the point where it is now 'essentially zero'. In fact, there are some who believe, on the basis of actual measurements of the change in Greenland ice-cap thickness and model predictions, that the average sea-level may even decrease! As a result, the current version of the Intergovernmental Programme on Climate Change (IPCC) barely mentions sea-level rise, although in its 1990 report it spoke of a value of fifteen centimetres (one-half of a foot) as the likely rise — which, while larger, is still almost a negligible factor for most of Humankind and Nature.

Despite this now widely-accepted result among working scientists, agitation still persists in public quarters about the doomsday sea-level change that will drown out Pacific islands — to cite one possible scenario among others that seem equally fearful. Part of this uncertainty in the overall picture is the missing carbon. Originally, the geochemists believed that they could account for the disposition of all the anthropogenic carbon which was emitted annually into the environment. The oceanographers then showed that two gigatons of this carbon (one-third of the total anthropogenic emissions!) were unaccounted for and appeared to be disappearing on land in the Northern Hemisphere. This stimulated the investigations that I mentioned earlier on the growth of the European forests which neatly accounts for this discrepancy — or perhaps too neatly? For along with this discovery came the realization that the fraction of CO_2 which remains in the atmosphere does not last a thousand years or more but, rather, may have a lifetime of sixty years or less. This drastically alters policy implications, as the effects of the CO_2 are nowhere near as 'irreversible' as had been believed.

The other global impact of 'greenhouse' gases which is much discussed is that on agriculture. This is a complex issue because it not only involves changes in rainfall patterns and the photosynthetic 'fertilization' effect of the CO_2, but also because of complex social factors that vary so widely from region to region — such as size of land-holdings, banking, family *versus* collectivized farming, and so on. All the investigations to date, as imperfect as they necessarily are, would seem to indicate that these effects would generally balance one another under any reasonably-assumed changes induced by global warming.

But that is not the whole story: this sort of analysis (as is typical of that employed in the other instances of climate change) totally ignores what is possibly the most potent factor, and that is the advance of technology. In the agricultural case the advances made by the agronomists have been, and continue to be, quite extraordinary. Thus in the last eighty years or so the annual yield of Corn (*Zea mais*) per unit area has steadily increased at a rate of *c.* 2% per year. The reasons are many but the fact is that, given the tools which make this increase

* US $500,000,000. — Ed.

possible, and newer techniques that are emerging, any climate change which can override these improvements seems very unlikely. A particularly interesting discussion has emerged about the possible effect of global warming on the northern boundary of growing Corn. Between the time that the above concerns were first expressed and today, due mainly to hybridization, the northern boundary of growing Corn has crossed the border from the United States and advanced well into Canada.

Widespread Discounting of Advancing Technology

This element of advancing or new technology is almost always omitted in dealing with models of predicted happenings fifty to one hundred years into the future. It is not only the non-scientists who commit this error but often the very discoverers of the basic phenomena that ultimately have the revolutionary impacts. Of this I have compiled a long list of examples from which I draw on a few.

Theodore von Karman, the Americanized Hungarian engineer and applied mathematician, is quoted as saying that the United States would never orbit a satellite. Yet he was the originator of the Jet Propulsion Laboratory at the California Institute of Technology, and one of the most important contributors to the development of the modern airplane and jet-propelled vehicles.

A more potentially damaging pronouncement was that of Dr Vannevar Bush, the Nobel Physics Laureate from the Massachusetts Institute of Technology and a leading post-war planner of science. He ridiculed the possibility of a transatlantic ballistic missile, and is quoted as saying, 'In my opinion such a thing is impossible — we can leave it out of our thinking.'

Lee de Forest, the American radio pioneer, firmly believed that television would never be a success. Lord Rutherford, the great English nuclear physicist, felt he could prove that the energy of the atomic nucleus could not be tapped. Robert Millikan, another Nobel Laureate in physics, felt the same way. Thomas Edison believed that talking pictures were a hopeless novelty that the public would not buy. Even as late as 1956 the British Astronomer Royal felt that space travel was 'utter bilge'. An even more famous astronomer, F.R. Moulton, held that Man would never be able to escape the influence of Earth's gravity.

In the early part of World War I, Field-Marshal Douglas Haig is cited as saying 'The idea that cavalry will be replaced by these iron coaches is absurd.' He can be forgiven, for he was not a scientist; so can be Franklin D. Roosevelt, Winston S. Churchill, and Napoleon Bonaparte, for similar errors of judgment.

— and Changes with Time

This observation of the seemingly chronic inability of outstanding scientists to foresee the impact of their discoveries is a malady which adversely afflicts our reasoning in policy planning when dealing with problems as potentially serious as climate change. What is missing in most attacks on these problems is the element of time — time to learn more, and time to allow for the development of favourable technology — and especially time to permit the introduction of countervailing technology.

In climate change due to global warming, the average annual rise in surface temperature has been used as a surrogate of the multitude of effects of the climate change such as sea-level rise, changes in extremes of regional winds, precipitation, and other weather parameters. But this measured rise has been much less than that predicted by the models whose results are used by the IPCC. In fact, almost all climatologists agree that they cannot relate the observed temperature rise to the 'greenhouse effect', and some even feel that the observed rise* is part of a normal expression of natural variability. In further fact, satellite measurements of surface temperatures over the last 14 years show no rise, in contradiction to the century-old series derived from ground-based weather stations. Using empirical results on both the temperature measurements to date and by extrapolating the exponential growth of CO_2 in the atmosphere, we can predict a rise of no more than one-tenth of a degree Centigrade in the next ten years — a result with which theoretical calculations agree. This suggests that crisis actions can wait for at least another decade, and great benefit be derived from the new information and results that are pouring in as we observed earlier. This reasoning, coupled with the much shorter lifetimes than were formerly expected of the excess CO_2 in the atmosphere, strongly suggests that the time will be safely used.

We can contrast this approach with what would have ensued if the world had taken seriously the prediction of a sea-level rise of more than 7 metres in a matter of decades. Unneeded engineering investments would have been made at great cost, resulting in nothing of value. This is strikingly parallel to the situation with regard to world forests as a whole. Published claims of fifteen years ago were that the forests were disappearing at the equivalent weight of fourteen gigatons of carbon a year. We contrast this with today's value of net increase of two gigatons a year, or a swing of sixteen gigatons — which is nearly three times the estimated total of anthropogenic emissions!

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*Of about 0.5°C we recall from the Second World Climate Conference, held in Geneva in 1990. — Ed.