STS 160:

TECHNOLOGICAL OPPORTUNITIES FOR HUMANITY

Created: 10:00pm 2/6/96

October 6, 1995 __**PERSPECTIVE**__ London Times Higher Education Supplement 19

The Earth as lab

Scientists are increasingly confident that they can pinpoint the culprits of global warming, says Stephen Schneider

Awareness that pollution can degrade our environment is hardly new. That was dramatically learned centuries ago when uncontrolled coal burning fuelled the infamous London smogs. Modern environmental problems are unique in that the scale is no longer local but global, and potentially irreversible effects are likely - thus it is no longer acceptable to learn by doing. When the laboratory is the earth, we need to anticipate the outcome of our experiments before we perform them.

One of the most potentially serious problems facing the earth is the synergistic effect of changing climate and fragmentation of the environment. People fragment natural habitats for farmland, settlements, mines or other development activities. If climate changes, individual species of plants and animals will be forced to adjust if they can. In the past they typically migrated with changing climate as spruce trees did when the last ice age ended 10,000 years ago. But could all the migrating species that survived the last ice age make it across freeways, agricultural zones and cities of the 21st century?

This problem raises several controversial questions. Should we anticipate this risk and respond by setting up interconnected nature reserves as a hedge against some species going extinct if the climate changes? How much is it worth to protect the survival of a species or a habitat? What is the value of life - of humans or other species?

Good science is necessary to help answer how such biological conservation practices can take place in the most economically efficient way. What policies society should choose to respond to the advent of global change projections, however, is not a scientific question per se, but a political value choice about how to take risks and about who pays the "insurance" premiums to reduce risks or compensate losers.

Policy choice depends on the norms or values of the decision makers - be they consumers, voters, or cabinet ministers. Just because some economists or politicians choose not to value the preservation of biological diversity very highly, for example, does not mean that the majority of the public feels the same way, or would continue to feel the same way if they learned more about the problems.

The problem of global climate change involves a large degree of uncertainty. However, several aspects of the issue are well understood and have brought about consensus in the scientific community. Scientists agree, for example, that approximately six billion tonnes of carbon are emitted as carbon dioxide to the atmosphere every year from industrial activities, mainly the burning of fossil fuels. There is widespread consensus that the build-up of a concentration of carbon dioxide in the atmosphere, combined with build-ups of other greenhouse gases, has trapped in the lower atmosphere roughly an additional two watts per square metre of energy over the entire earth since the industrial revolution. Climatologists also generally agree mat me global surface air temperature has warmed up on average approximately 0.5 +/- 0.2 degrees centigrade in the past century.

Uncertainties become more significant when we move to projections about the future. The combination of increased population and increased energy consumption per capita is expected to contribute to increased carbon dioxide and sulphate emissions over the next century, but the extent of the increase is uncertain. Central estimates of emissions imply a doubling of current carbon dioxide concentrations by the middle of the 21st century, leading to typically projected warming of the earth ranging from one degree to more than 5 degrees centigrade by the end of the 21st century,

Warming at the low end of this uncertainty range could still have significant implications for ecosystem adjustments, whereas warming of 5 degrees centigrade or more in the time frame of a century or less could have catastrophic effects on natural and managed ecosystems and produce serious coastal flooding. The overall cost of these, and other, environmental impacts could run into tens of billions of dollars annually. Since such costs are not included in the price of conventional fuels, they are called "economic externalities." Internalising such externalities is a principal goal of international climate policy advocates.

Analysts from a variety of disciplines have been attempting to gauge the impact of global climate change on agriculture, water supplies, biodiversity and economic growth; others are attempting to get a better sense of the probabilities of the different climate change scenarios. In tandem with this work, many economists have been seeking to estimate the costs in particular countries of strategies designed to reduce carbon dioxide emissions.

But critics charge, isn't talk of abatement costs I or climatic damage to nature or society premature, until we have demonstrated more confidently that climate change is indeed happening (what we call the "signal detection" problem) and, if so, what caused it to happen (the so-called "attribution" question). Data and modelling results over the past few years have, I believe, led to a sharp rise in the confidence that many climatologists worldwide now express (e.g. in drafts of the report from the Intergovernmental Panel on Climate Change circulating to national governments) that both real climate change has taken place and that humans are at least part of the cause. Although few would say they're certain, what has led to this recent jump in concern?

First of all, the 1980s was the warmest decade in the instrumental record of surface thermometers, and there has been a 0.5 (plus or minus 0.2) degrees centigrade century-long warming trend. But this was known in 1991, the previous record warm year (until 1995, now on an even warmer record pace). The years 1992 and 1993 were substantially cooler, and ironically, this actually increased most scientists confidence that human induced global warming was being detected. The reason is that the explosive eruption of Mount Pinatubo in the Philippines in 1991 spread a layer of sulphate dust particles in the stratosphere that filtered out a per cent or two of the sun's heat. This, our computer models predicted, would for a few years cool the surface about a quarter of a degree centigrade - very close to exactly what happened. Since the predicted cooling was made by the very same models that forecast global warming from enhancing the greenhouse effect, the credibility of the models increased as they fared well on this natural experimental test.

Sulphate particles are not only a natural phenomena, but are generated by people all over the industrialised and industrialising world where high sulphur coal and oil are burned. Up to 1991, computer models primarily considered only the effects of increased greenhouse gases in their predictions. Except for global scale temperature rise, the results did not match up well with the patterns of climate change observed over the past 30 years. Critics charged that the models could not produce a "fingerprint" of climate change that looked like the observed changes of the past few decades and that the models were thus presumed suspect. I published an article m the journal Science in January 1994 responding that until the models are driven by the same factors that the earth is -both the global warming from greenhouse gas increases and the regional cooling patterns from sulphate dust - no "fingerprint" matching exercise between model-predicted patterns of change and observed changes proves anything. Since then, three such model calculations have been performed - at the Hadley Centre, the German Max Planck Institute and the Lawrence Livermore National Laboratory. All three studies produced patterns of change (i.e. fingerprints) that are a much closer match to observed changes. So, perhaps ironically, it is the cooling effects of both natural and human produced sulfate dust that has substantially increased scientists confidence in the reality and likely cause of observed climate changes known popularly as global warming

All of this will mobilise considerable pressure from environmental groups for world leaders to rekindle the political climate of concern over human-induced climate change that marked the Earth Summit in Rio in 1992. Controversy is sure to pick up given both the new scientific results and the entrenched economic and political interests aimed at preventing curbs on carbon-emitting fossil fuels.

Investigators assessing the economic costs of reducing greenhouse gas emissions typically have considered the costs of reaching given targets for emissions reductions, or alternatively, the costs of given taxes on fuels that contribute to greenhouse gas emissions. In my view virtually all of the models suffer from an important omission - the neglect of price-induced technological change. This omission biases upward the estimation of the costs of policies to avoid climate change by reducing greenhouse gas emissions. Climate change policies, by raising me prices of conventional fuels, can stimulate more rapid development of alternative, non-fossil fuel technologies and lower the prices at which these technologies break even. Such induced technological change mitigates, perhaps substantially, the cost of climate policies. Larry Goulder, associate professor in economics at Stanford, and I have made preliminary calculations which show the possibility of a cut in the cost of policies to reduce carbon dioxide emissions as a result of possible induced innovations.

I am not suggesting that induced technological change should become the principal basis for introducing policies such as carbon taxes that reduce greenhouse gas emissions through higher prices of carbon-based fuels. The main reason to introduce a carbon tax, for example, is its potential to internalise the carbon dioxide-related economic externalities associated with fossil fuel combustion and thus to help avert significant levels of global climate change and its potential consequences. By recognising induced technological change, however, we lower the minimal environmental benefits necessary to justify a given carbon dioxide reduction policy on overall cost-benefit grounds. Stay tuned, the climate change debate is coming back centre stage.

Stephen M Schneider is a professor of biological sciences, senior fellow at the Institute for International Studies, Stanford University and the author of a forthcoming book entitled Laboratory Earth: the Global Change.