Letter to the Editor

Some Comments on a Changing World

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In late June, I attended the Changing Atmosphere Conference held at the Conference Centre in Toronto. As a Quaternary geologist with strong interests in northern ecology and climate change, I was curious to see what would be said by a number of distinguished colleagues and policy makers. This report is a personal record of some thoughts which evolved before, and during the conference.

Like many other geologists, I have to keep reminding myself, and most of my colleagues, that 1988 is part of the Quaternary (the last two million years of geological time), and that all modern processes, man-made or natural, are occurring in Holocene time (the last ten thousand years of the Quaternary). Man is a peculiar animal whose direct modern ancestry is intimately connected with the latest part of the Quaternary. Our "caveman" ancestors of 20,000 years B.P. had to cope with a vastly different world. Survival was a matter of contending with animals who are now part of the geological record; the mammoths of the Siberian permafrost, the huge brown bears which roamed much of North America, and the woolly rhinocerus of the European plains. It was a time when glaciers covered all but a small portion of Canada, and when springtime on Bylot Island was about as good as one could expect in the Canadian summer. But that time changed; for reasons unknown the continental ice sheets receded, sea levels rose dramatically, plant and animal communities struggled to respond to the change, and that most adaptable animal, man, prospered and multiplied. At the end of Pleistocene time, about 10,000 years ago, small groups of Homo sapiens were almost certainly changing from an exclusive hunting and gathering regime to the earliest forms of agrarian life. Battling and living in the environment was slowly changing to living and using the environment. The small, mobile agricultural village economies of the early Holocene flourished; the city states of the Indus Valley, Sumaria, Egypt and China expanded. Modification of the environment was becoming noticable at the local and regional level. Slash and burn clearing techniques are pronounced in changing floras reflected in European pollen diagrams for mid Holocene time, irrigation practises in both the near and far east are evident in the infrastructure needed to support the populations of certain major centres.

Still more sophisticated social structures are revealed in the records of Egypt, Greece, Rome, and southeast Asia, and world population moved to an estimated 200 million. The development of printing techniques, the liberation of scientific ideas from religous dogma, and improved transportation, finally led to the socio-economic phenomenon known as the "Industrial Revolution". The advent of the machine economy, and particularly the steam engine, meant that man could do things which had been previously impossible. The species could now use and manipulate the environment. Huge canals could be dug linking water bodies which had been unconnected until that time. Commerce could move rapidly over the surface of the planet; complete ecosystems could be (and were) exploited. All of these events had an environmental price. More animal and plant species joined the mammoths and the mastodons; the Dodo, the Great Auk, and the Passenger pigeons are some of the best known, but thousands of other species have joined them without being recorded by science. Improvements in communication, and advances in science and medicine meant that many natural controls on human population growth were removed. The human species has prospered; our companion species on the planet have not.

Only recently, and with the exception of a few far-sighted individuals, has there been growing awareness and concern about man's deprivation and alteration of not just regional systems, but of the whole planetary system. We have reached a state where our use of energy is so great, and our numbers have grown so large, as to actually threaten the fabric and life support systems for all species on this planet. How many of us have seen the smoke from factory chimneys blowing away over the horizon, to be lost in the blue haze of the mountains, lakes, plains or seas? How often have you stood at a sea shore, or a lake edge, or a river bank, and watched tar balls, algal mats or oily slicks move away in the currents to be lost in the distance? How many times have you observed aircraft dipping across the fields and forests releasing chemical sprays, or seen the lawn companies promising greener than green gardens with no insect pests? How stupid do we have to be before we realise that we live in a closed system!!!?

None of us would take all those that we love and sit in a car, windows rolled up tight, with an engine running, and the exhaust being fed into the trunk; and yet this is exactly what we are doing on the planetary scale. Unfortunately so few of us have seen what our astronauts and cosmonauts have seen, that our world is very beautiful, very small, and so very vulnerable. There are 5 billion of us taking a planetary car ride through space. Perhaps one of the most worthwhile tasks of the shuttle projects would be to take politicians of the different countries of the world into space, to make them realise that this is the only home for mankind, and that the death of the planet is the death of our species. At the Global Atmosphere conference a quotation was given, attributed to one of the Russian cosmonauts, who stated "... I can see the industrial haze over our cities, and the smoke from the factories; I can see the fires of our burning forests, I can see the polluted rivers, and the plumes that extend from them into the oceans of the world, and I realise that there is nowhere for the pollution to go."

Such a global perspective is difficult for individuals to comprehend. The smoke from our factory chimneys does not vanish into some unimaginable distance, it arrives as acid rain in some neighbouring country; the oily streaks and plastic garbage in the oceans are not recycled and cleansed, they wash onto some distant shore; the lawn sprays do not disappear into some cosmic sink, they end up in your drinking water! We are all so busy in our own affairs that we do not recognise, or we chose to ignore, the very clear warning signals that nature is sending us. Natural systems do have the ability to be self-cleansing and self-renewing in a limited way, but not to the levels which we want to push them. Major river systems in North America, Europe and the Soviet Union are dead or dying. We have our Love Canals, in smaller ways, scattered throughout and around our habitations. In recent years we have seen the lakes threatened by acid rain in Europe and North America, we have read of Minamata disease in Japan, heard the cries of outrage about chemical spills in the Rhine Valley echo from Switzerland to Holland. We have seen the death of whales, dolphins and porpoises along the eastern seaboard of this continent. Some are so contaminated that the corpses are designated as toxic wastes! We have read of blood samples, syringes and other medical products washing ashore on the Atlantic coast, and we have heard of the global wanderings of garbage scows from the same area trying to rid themselves of human waste materials. Even away from human habitation in the vastness of the Pacific plastic garbage litters the seas. One billion years or more of evolution has not equipped the micro-organisms of the planet with the ability to breakdown products which have only appeared in the last fifty years of geological time. The animals of the Antarctic are laced with chemical products of a society which they have never seen. The litany could go on and on in a terrible indictment of our species, and particularly of western society, in the potential death of a planet.

Perhaps there are some faint glimmerings of hope. The society which has spawned the

products cited above has moved *Homo sapiens* off the surface of this planet. Our satellites and instruments can see the global changes through cosmic eyes, and these eyes are not limited by human horizons.

However, the remotely sensed images are not encouraging. Incoming solar radiation has been declining during the period that we have been able to directly measure the arrival of the sun's output outside the influence of our atmosphere. Ominously, atmospheric carbon dioxide concentrations (Figure 1) and global temperatures have been rising throughout this same period in the so-called "greenhouse effect".

The four hottest years in 150 years of meteorological readings have been since 1980, with 1987 (the last year for complete records) being one of the two hottest. The global temperature trend for the last 110 years is shown in Figure 2, and although it shows many peaks and troughs, the general trend is always rising. Not shown in the diagram are the implications for future elevated global temperatures. Melting of polar, sea, and continental ice could be responsible for as much as a 1.5 m rise in sea level. While 1.5 m (about 5 feet) does not sound like much to the populace of most places in the continental interiors, it will have devastating effects on residents in low-lying coastal regions or major coastal cities. Storm surges at current sea levels already cause from hundreds to tens of thousands of deaths by drowning, practically on an annual basis, in India, Pakistan and other parts of southeast Asia. The battle of the residents of the Netherlands and other countries of the subsiding southern portion of the North Sea basin is well known to all. Yet, as E. Nijpels, the Minister of the Environment for the Netherlands stated, "... we can build higher dykes, but this does not help the residents of the Third World." Other, far less understood implications of elevated temperatures include changing oceanic and meteorological patterns, changing agricultural lands and practises, the demise of the boreal ecotone in North America, Scandinavia, and Eurasia, changing demands on water supplies, melting of northern permafrost and pack-ice, different scenarios for energy demands, and a total restructuring of socio-economic systems.

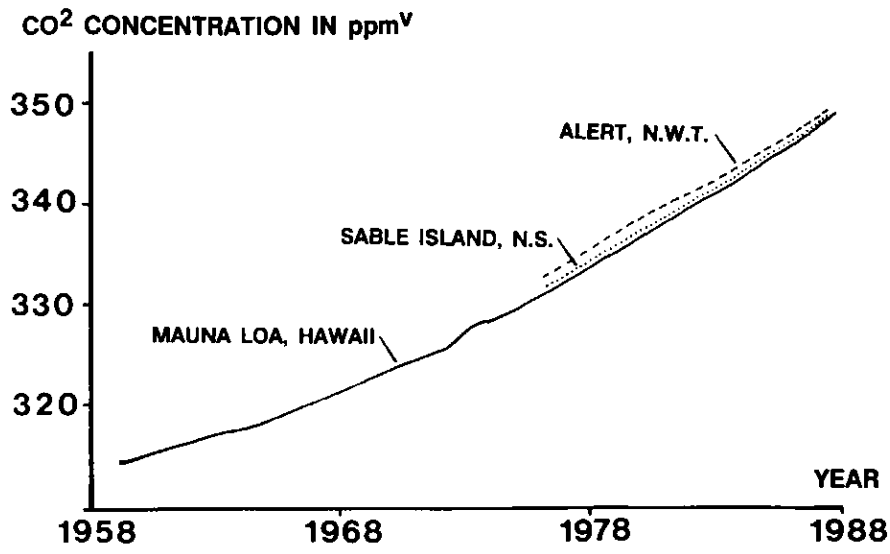

Figure 1 *Increasing atmospheric concentrations of CO_2 measured over the last 30 years are illustrated in curves for Hawaii (Mauna Loa Observatory), and, more recently, for Canadian stations on Sable Island and at Alert. (Source:* The Changing Atmosphere, *Environment Canada).*

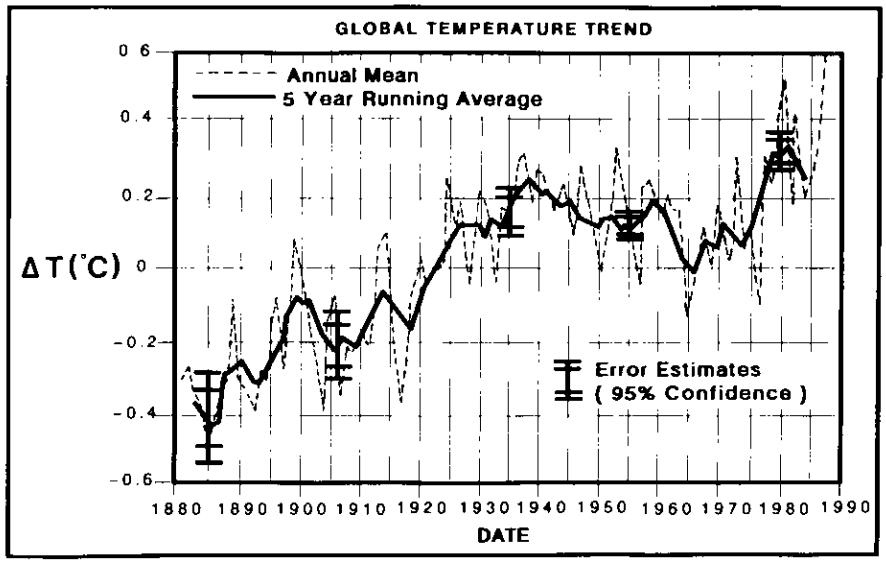

Figure 2 *Global temperature trends have shown increasing values over the last century. Temperatures recorded during the decade of the the 1980s are the highest observed with 1987 as one of the warmest on record. (Source:* The Changing Atmosphere, *Environment Canada).*

North Americans are energy gluttons, and Canadians (on a per capita basis) are the worst offenders in the world. Energy in the form of relatively cheap and easily available power is the substitute slave market of our western society. Our agricultural methods would be astounding to the agrarian economies of the historical past, and our capabilities of moving soil and rock would have been to the absolute amazement of the Pharoahs! Small mining ventures shift millions of tons of overburden to reach the treasures buried in the distant geological past. Our "energy slaves" enable us to dam more rivers, to drill wells kilometres beneath the surface, to scrape away complete mountain ranges, to liberate still more resources for us to use. It is possible that we, at the end of the twentieth century, are living at a mountain peak of energy use. We simply cannot go on squandering energy resources without realising the full environmental and economic costs. Energy will cost more, and we should be thinking of energy conservation in very realistic terms. The reality is in change at the personal and industrial level. Our plastic glitz and yuppie mentalities will have to be modified; lifestyles will have to change. It does not have to be a truly pessimistic scenario, but it will call for a major commitment to conservation of many products, to recycling on an unprecedented scale, to new demands for products which will be far more efficient, and for commodities which will last far longer. There is a tremendous challenge to individuals, industry and government, to ensure that these changes are made in the shortest possible time.

Our satellites, coupled with direct atmospheric measurements by NASA, and by balloons from other countries, have revealed the presence of not one, but two, areas of thinning ("holes") in the ozone layer above polar and sub-polar regions (Figure 3). The ozone horizon is the one responsible

from shielding practically all living things on the planet from the really detrimental effects of solar radiation. Ozone is readily produced by natural processes and by human activity. Production of ozone at low altitude in high concentrations is regarded as a pollutant and is detrimental to health, and agriculture. High altitude ozone is benificial and essential to human well being. The former is produced in industrial smogs; the latter is destroyed by apparently inoffensive activities such as the production and breakdown of certain styrofoams, the creation and release of refrigerator coolants, and the use of many pressurized aerosol sprays.

The ozone above southern Ontario has thinned by 3 percent in 15 years, with a one percent thinning being equated to 4 percent increase in skin cancers. Concern is expressed, not only for humans and land animals under the northern ozone hole, but also for the animals and marine phyto- and zooplankton under the southern hemisphere hole. These minute animals and plants form the basis for one of the richest natural foodchains in the Earth's environment.

Destruction of the tropical rain forests with the associated extinction of hundreds of thousands (if not millions) of animal and plant species which are completely unknown to science, is another matter of documentation and concern. Each satellite image reveals reduction of the tropical forests at a rate of 230 square kilometres every day. Statistics! How can one equate these figures with reality? New York State cleared in eighteen months, the area of the United Kingdom in 3 years, of Ontario in 12 years, of Luxembourg in eleven days! How many potential cures for cancer have been lost? How many pharmeceutical products or new foods have been consumed by the fires of Amazonia? What gene pools and seed sources have vanished in our folly to clear new lands to feed the North American and European populace with plantation foods and hamburgers? Who can blame the farmer of the Amazon Valley for burning the trees, or the forester of Thailand for harvesting the teak for Japan when they have to service huge debt loads to foreign banks? How can one explain to them that their actions will mean soil erosion on an unprecedented scale, flooding in downstream regions, and the inability of that exposed land to support plant growth for thousands of years?

Obviously attitudes will have to change. We are faced with a variety of scenarios, and the hope that we can respond in time to preserve our world for our descendents in some form which would be recognisable to us. Even this simplistic statement is difficult to realise, and we have to follow the route several stages further.

The public has to realise that scientists are individuals working on a series of (usually) small projects. There are academic scientists who, providing that funding is available, are free to roam in almost any area of endeavour, and there are industrial scientists who are paid to resolve specific, and usually applied, tasks. Most scientists are moderately well read, but their work (and rewards) often leads them to learn more and more about less and less. An analogy is a tree. The visible tree extends from the main trunk to its branches, but there is an invisible and inverted branch form (the root system) underground. A research problem is like a tap root. The scientist following a specific research area find that it forks and forks again and again. One basic problem may turn up five areas worth investigating in more detail. Any one of these sub-problems may turn up five or ten more. Often the scientist will spend many years, perhaps a whole lifetime, trying to reach a particular growing tip of that root system. Frequently he or she has become so engrossed in the problem that adjacent roots may cease to have any real interface with the work on hand. To turn outward, to try to grasp at the big picture, is often anathema to the scientist who might be sneered at for being a dilettante by his peers, and who would be rejected in promotion in academia.

Many scientists are brilliant researchers, but perhaps are poor communicators. There is a scientific jargon which usually excludes the general public from a general comprehension of what is happening in a specific field of science. Equally the jargon also serves to keep a group of scientists from one discipline from communicating easily with scientists from a different discipline. The jargon is not contrived, it is a matter of expediency; it is a form of verbal scientific shorthand. It is far easier to explain a concept or observation in "jargonese" than it is to go through a protracted normal English explanation. Unfortunately, many scientists don't remember that if you are lecturing to a lay audience you simply don't use Swahili (because that is what the scientific explanation sounds like to the audience).

The problem for scientists is twofold. The first is to try to accurately understand the overall picture which is often difficult if you are disciplinary-based, and the second is to communicate this to the public at large, and the policy makers (the politicians) in a way which is as graphic as being hit in the face with a wet fish. The majority of the general public too often are left uninformed and unaware of emerging environmental concerns. There is a common attitude that politicians (and scientists) are being paid to resolve potential problems or disasters.

Another problem is that despite all of the most expensive instrumentation money can buy, and the most sophisticated computers available, scientists are not yet on close speaking terms with God. A favourite comment from the public is "Well, how do you know that this will happen?" The simple answer from an honest scientist is "We don't." The scientific community is then perceived as alarmist, which in turn leads to a further reluctance to communicate. This state of affairs will persist until the problem can be shown (in observable and documented form) in which case the opportunity for an "easy fix" is long gone.

This brings us to the methods of an easy fix and what the constraints are working against the scientist and public alike. Initial observations of many scientific problems are not always in the domain of the scientist. The command structure is often from a concerned

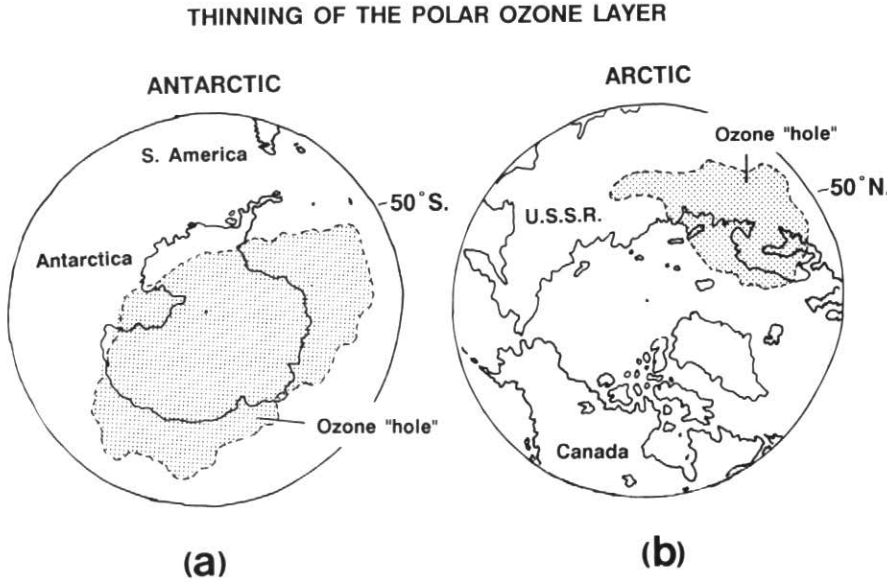

Figure 3 *Satellite images observed in* **(a)** *October 1986, and* **(b)** *March 1986 indicate the extent of ozone depletion at high latitudes for the southern and northern hemispheres. High altitude ozone depletion is likely to cause increased incidence of skin cancers, and deleterious effects on marine phyto- and zooplankton. (Source: Hansen, J. and Lebedeff, S., 1988, Geophysical Research Letters).*

public to the scientist, to the politician (at any level) and then (via legislation) to the resolution of the problem. The process can be short-circuited at any point up the command structure starting with the public. Example: different perceptions by neighbours; "Pouring insecticide and herbicides on my lawn does not create a problem", or, "Wow, Sally's feet have developed blisters and a rash from running around on the lawn." The difference here is a three-year-old with sensitive skin on the lawn 15 minutes after the spray truck has left. Example: the scientific community stating that groundwater reserves in the Kitchener-Waterloo region will not support a large population, especially when that population insists on lawn watering through most dry summers and washing their Mercedes or Pintos twice a day through a prolonged summer drought. In this case the scientists alert the politicians who decide to take no further action to limit city expansion or water usuage until they are forced to consider groundwater recharge schemes or pipelines from the Great Lakes. Example: Company X which is storing leaking toxic wastes in landfill areas. The public is concerned, the scientists document the facts, the politicians decide not to act until Company X (a large multi-national) decides to close the plant and throws 500 workers on the unemployment line. The politicians reconsider and decide two possible courses of action. Fine the plant at a nominal rate and ask them to clean up, or to consider mass regional unemployment and the wrath of the electorate.

The problem here is that the lifetime of a politician is often regarded by many as a term of office (3 to 5 years). It has been obvious to most Canadians, and I am sure to most thinking Americans, that this continent has a serious problem with acid rain. The scientific documentation of acid rain is not a new phenomenon. Long before the shouting heated up in the Great Lakes - St. Lawrence Valley region, the Scandinavians (Norway and Sweden) were screaming about acid rain from Britain and the Ruhr. Like the United States (and to a lesser extent internally in Canada) the politicians of the countries of western Europe approached their scientists and businesses. "Yes" said the scientists, "there is a problem, but it can be resolved by massive capital expenditures, by emission controls, and by changing the types and sources of fuels." "Now wait a minute" said big business, "This is going to be really expensive. If we have to do this then we will close down our older plants. We will cut back on staff, which will increase regional unemployment. We will import our sulphur-reduced natural gas from country X, or uranium from country Y, which will cause layoffs in the coal mining regions of our own country." The net result is that nothing happens because the country producing the pollution does not have the fiscal incentive to halt the pollution. It doesn't matter to the politicians of Britain or Germany that Norwegian forests are dying, or Swedish lakes are acidifying, any more than it does to the Congressmen and Senators from Ohio and Pennsylvania that the maple trees of southern Ontario are dying and some lakes on the Canadian Shield are approximating dilute vinegar. It might be a lousy moral attitude to take, but the realities of lack of support by industry in campaign contributions, or lack of support by an unemployed electorate in the next election is enough for most politicians to turn a Nelsonian eye and say "Acid Rain? Fiddlesticks, these scientists can't agree on it anyway."

We have reached a time in the growth of society when politicians must be aware of, and be responsible for, concerns which are beyond those of their constituents. Local, regional or national interests are no longer enough. As Marshall McLuhan clearly recognized we live in a "global village". Concerns for the planet have to over-ride corporate and personal economic interests and creature comforts.

Now that we have reached the phase that some politicians are (at least) paying lip service to environmental degradation; when some scientists are raising their eyes from the tap roots of academia, and that some economists are becoming aware that economic systems won't operate in a world without people, we need to examine some of the potential scenes from the very near future. Malthus may well have been right about his predictions of world population growth and the ability of the planet to sustain the predicted numbers. His problem was that his time frame was off, and that he didn't allow for technological change in the future. When I was a schoolboy, I can remember my geography teacher telling us that the population of India was about 300 to 325 million. Today that figure is close to one billion, with the increase taking place in about 35 years. The current world population is about 5 billion, and increasing by some 87 million each year! Thirty-five years will take us to about 2025 when the world population is forecast to be close to 10 billion.

Of course most of the change will take place in what we call the Third World, (often termed the "underdeveloped countries") a region whose politicians insist on calling themselves "the developing nations". They are developing nations, they do aspire to all the material goodies which we in the western world have grown used to in the last 50 years or so. The problem is can we afford it? By "we" I do not mean the western world, but rather mankind as a whole. What happens if the southeastern Asian countries, or South America, wish to expend the same amount of energy per capita as we do in North America or Europe? We already have a crisis with CO_2 production from our own industrialised world. We would have to consider the grave consequences if China increased consumption of its vast reserves of coal.

One of the recommendations of the Global Atmosphere Conference was that "we" (mankind; but largely the western world) cut back on carbon dioxide emissions by an initial 20 percent of the 1988 base by 2005, with further cutbacks implied for early in the next century. This led to protests from Third World delegates who (rightly) stated that it was the western world which had largely created the mess, and it was not fair for the delegates of the western world to dictate that other countries could not expand to their full potential.

The interesting question which was not followed up in open discussion, because of time limitations, was what might be used as an alternative energy resource? Coal is obviously out, oil (conventional, oil sands, and heavy oils) is probably out as well. This leaves (excluding solar power and an hydrogen economy which are not practical on a large scale as yet) water, natural gas and uranium (fission and fusion) as the main untapped power resources. Where does that put us as Canadians? Our rivers (Nelson, James Bay, Labrador) have been, and are being, built on to provide electricity largely to the United States. Our western Canadian natural gas is being piped across the border into the United States as fast as the pipelines can handle it, and our uranium resources are tangled in the nuclear controversy. I have little doubt that they too will be shipped south of the border (either converted to electricity, or as concentrated natural uranium) as soon as the environmental problems of waste disposal are resolved.

Water shortages have been severe in southern Ontario, and other regions of Canada, through the remarkable summer drought of 1988. We have seen demands for water release through the Chicago canal from the south end of Lake Michigan to alleviate low water levels down the Mississippi Valley. Those of us with extremely long memories will realise that this is the way that the Glacial Great Lakes drained well over 10,000 years ago, until the Chicago outlet hit bedrock and the Sarnia outlet fortunately took over. Those with moderately long memories, will recall the NAWAPA scheme of the fifties, by the Bechtel Corporation, to dam James Bay, to pump water over the northern Ontario divide, to build new canal systems west from the Great Lakes to the states of the American midwest, and to divert Alaskan river southward (through British Columbia) to the arid American southwest. What new "incentives" will be forced upon the Canadian government (or to key individuals in policy making positions) to agree in providing water supplies to our colleagues south of the border? Will rational environmental concerns be enough to persuade politicians and big industry not to meddle in continental-scale water switching in the potentially drier summers of 2050?

The Global Change scenario is frightening in its scope. It will tax the will of students,

teachers, scientists, politicians, and all sorts of policy makers for decades and centuries to come. Scientists in general, and the academic university community in particular, will have to improve communications with the public. Global change is not yet an "applied" item. It is still in the role of one of those superb basic scientific tasks which governments hate to fund, because there is no tangible "hands on, industry manipulated" end result. This is the role that real universities were made for! One thing that the global change scenario should do is to remind politicians that they ignore basic research at the risk of the future of mankind. The databases necessary to comprehend many of the predicted changes will come from basic and not applied research. Our observations of natural system both in the present, and in the most recent geological past provide our only glimmerings of what might happen in the very near future.

Of course applied tasks in the form of new technologies and applications will be needed. Changes in technology must come in much more efficient, and alternate, energy resources; in our understanding of the ramifications of change to all natural systems. The cost to mankind will be staggering if we succeed: it will be unthinkable if we fail!

We live in exciting times!

Accepted 28 November 1988.

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