SCIENTIFIC SERVICES DIVISION

REPORT

SYMPOSIUM ON THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON BRITISH COLUMBIA

Scientific Services Division
Atmospheric Environment Service
Pacific Region

Edited by Eric Taylor and Kirk Johnstone

December 14, 1988
Report PAES-89-1

Environment Canada
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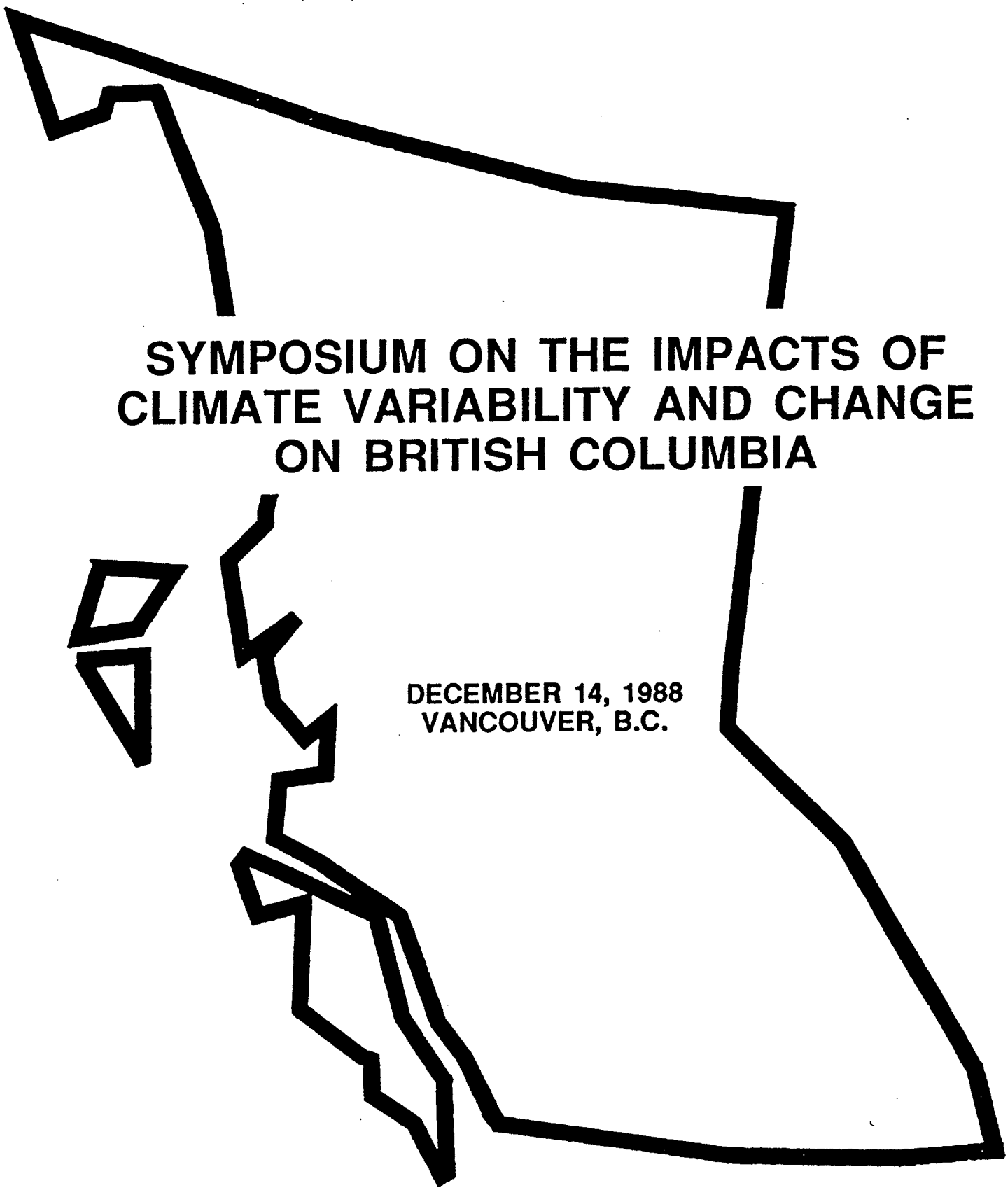
Service de l'environnement atmosphérique



SYMPOSIUM ON THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON BRITISH COLUMBIA

DECEMBER 14, 1988
VANCOUVER, B.C.

Canada

PROCEEDINGS OF THE

SYMPOSIUM ON THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON BRITISH COLUMBIA

DECEMBER 14, 1988
VANCOUVER, B.C.

Sponsored by
Environment Canada

Edited by
Eric M. Taylor
Kirk J. Johnstone

Scientific Services Division Report PAES-89-1
Pacific Region
Atmospheric Environment Service

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Reference:

Taylor, E. and Johnstone, K. (eds) 1989: Proceedings of the Symposium on the Impacts of Climate Variability and Change on British Columbia, December 14, 1988, Vancouver, Scientific Services Division Report PAES-89-1, Atmospheric Environment Service, Environment Canada, Vancouver, B.C., 87 pp.

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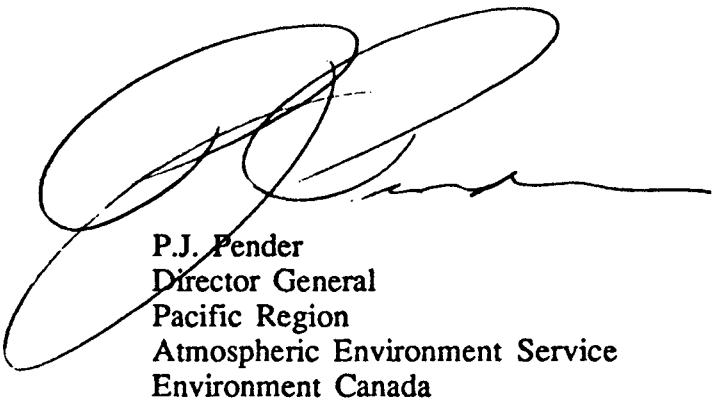
PREFACE

During the past few years an international scientific consensus has been reached that humankind's alteration of the chemical composition of the atmosphere poses a major threat to our global environment. Climate change, acid rain, ozone depletion in the stratosphere, and the long-range transport of toxic chemicals to otherwise pristine environments are some of the serious symptoms of the polluted atmosphere. The final statement of the international conference "The Changing Atmosphere: Implications for Global Security," held in Toronto during June, 1988, indicated that the ultimate consequences could be so serious that they could be second only to a nuclear war.

Nations from around the world have participated in major meetings in Toronto, Montreal, London, The Hague, and Nairobi over the past years to discuss this global threat and means to overcome it. New regulations on the use of chlorofluorocarbons, stemming from the Montreal Protocol on Substances that Deplete the Ozone Layer, are evidence of contemplated and instituted actions.

Climate is an integral and critical part of British Columbia's environment. In addition to its influence on the Province's ecosystem, British Columbians are dependent on climate for their social and economic well-being. The basic stocks for the natural resource sectors of forestry and fishing rely on their surrounding climate. The atmosphere provides the water that we require to drink, grow crops, and generate hydro-electric power. The B.C. climate has a profound influence on tourism, recreation, and lifestyle. It's influence is ubiquitous.

This Symposium was held to promote a greater awareness of an apprehended change in our global climate and the possible impacts of that change on British Columbia. The intention was to foster discussion and study of our changing climate, the potential impacts, and our response to this global threat. This report on the proceedings of the meeting will further that effort.



P.J. Pender
Director General
Pacific Region
Atmospheric Environment Service
Environment Canada

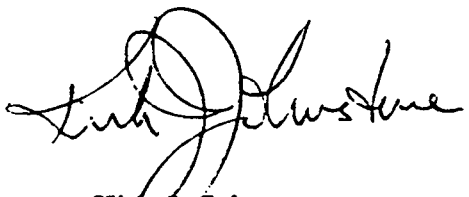
ACKNOWLEDGEMENTS

The success of the Symposium was the result of the many individuals who contributed their thoughts, time, and efforts by attending and participating. I especially thank Messrs. Henry Hengeveld, Dave Phillips, Hal Coulson, Mike Dunn, and Dr. Doug Pollard for preparing stimulating talks and contributing manuscripts for this Proceedings. My gratitude is also extended to the session and workshop chairpersons and recorders for their contributions.

Mr. Pat Duffy made a special contribution with his time and guidance during our preparations for the Symposium. His summary report of the discussion and recommendations is the first paper in this volume.

I am most appreciative of the tremendous organizational support provided by Franca Corbie, Doris Wiebe, Marilyn Issavian, and Terry Chiasson. The Symposium would not have happened without them!

The compilation of these Proceedings is in large measure the result of the successful efforts of Mr. Eric Taylor.



Kirk J. Johnstone
Chief
Scientific Services Division
Pacific Region
Atmospheric Environment Service
Environment Canada

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Impacts of Climate Variability and Change on British Colombia

P. Duffy
Symposium Rapporteur
Vancouver, B.C.

INTRODUCTION

A symposium on "The Impacts of Climatic Variability and Change on British Columbia" was held on December 14, 1988 at the Sheraton Plaza 500 in Vancouver from 9 AM to 5 PM. The objectives were to:

1. Brief participants on the Greenhouse Effect;

2. Report on the international conference on "The Changing Atmosphere: Implications for Global Security", that was held recently in Toronto;

3. Outline the climate change activities of the Canadian Climate Program;

4. Provide a forum to exchange views on climate variability and change issues and activities; and

5. Consider future activities.

The agenda featured an information session on Global Climatic Change and a report on the Toronto Conference, followed by a description of the activities of the Canadian Climate Program, and the implications of climate change to British Columbia water resources, forest resources, and the sea level/coastal zone.

The next section of the symposium consisted of three concurrent workshops on each of water resources, forest resources, and sea level/ coastal zone resources. A plenary session followed with presentations from the workshop leaders, and by the symposium facilitator. The plenary session moderator concluded the day at 5 PM by thanking participants for their efforts.

There were 93 participants representing three levels of government, university and industry. Workshops were attended by 25-30 persons.

MEETING SUMMARY

The symposium delivered views on climate change from global, national, regional and sectoral perspectives. In a global sense, references were made to such quotes as: "Humanity is conducting an unintended, uncontrolled, globally pervasive experiment whose ultimate consequences could be second only to a global nuclear war" (Toronto Conference: Summary)

and to the recommendation of the World Commission on Environment and Development: "Given the complexities and uncertainties surrounding the (climate change) issue, it is urgent that the (international negotiation) process start now. A four-track strategy is needed combining:

- improved monitoring and assessment of the evolving phenomena;
- increased research to improve knowledge about the origins, mechanisms, and effects of the phenomena;
- the development of internationally agreed policies for the reduction of the causative gases; and
- adoption of strategies needed to minimize damage and cope with the climate changes and rising sea level" (p. 176).

Dr. Mostafa Tolba is the Executive Director of the United Nations Environment Programme. His 1988 World Environment Day Message (June 5) was on "Global Warming: Window of Opportunity":

> ... on this issue we cannot afford to wait ten years... We need to start taking countermeasures soon. There are two main priorities. First to devise and apply strategies to restrict the build-up of greenhouse gases and thus delay or limit the temperature increase, and second to prepare to cope with the climate change. The implications of climate change for the social and political stability of our planet are profound. But understanding of the global climate is in its infancy -- it may take another 15 years before scientists can give reliable predictions of what warming will mean in each region. But by then it may be too late to act. ... The dozen years between now and the end of the century form a window of opportunity for these actions".

In the information session Henry Hengeveld described Global Climate Change in a very useful way. Essentially his presentation was a problem statement given in some detail and from different perspectives. Global climate is expected to change at an unprecedented rate but the available information does not give us the means of making accurate predictions of the details of future change and the potential impacts that might arise.

David Phillips described the organization and results of the Toronto Conference on "The Changing Atmosphere: Implications for Global Security". The investment of time and effort in the meeting resulted in a higher level of understanding of the climate change subject in Canada and abroad. Hosting the conference has improved Canada's position in the international network of agencies, national institutions, scientists, and specialists working on the problem of climate change and on protocols to deal with it. There are several international conferences being planned over the next several years and they will yield up-dated and improved information for our work here. We are now well established and positioned to capitalize on these activities.

Henry Hengeveld outlined the activities of the Canadian Climate Program with its linkages across Canada. Basically, the framework is in place to increase co-operation in the development of regional strategies and programs to address the climate change challenges. A

present priority is for "climate needs to be worked into the mandate of agencies with socio-economic responsibilities..." A federal committee tasked with the development of a national framework to address the changing atmosphere has prepared guiding principles which furnish valuable policy guidance at this stage. These include:

- sustainable development is the ethic of the future;
- decision makers need information now;
- knowledge of the subject must be increased;
- limited and adaptive responses are appropriate as the science progresses;
- the best available science needs to be used and applied;
- a response to the challenge is the responsibility of all sectors of society;
- given the uncertainty surrounding the subject, approaches to international co-operation and partnership are required;
- we need to use existing institutions as much as possible.

In order to reduce uncertainty, research programs are being tailored to focus on models, develop tools for assessing impacts, and understanding the options to respond to the problems of climatic change.

An underlying need is support for the ongoing Canadian Climate Program which will result in better education of the public and decision makers in government and industry.

British Columbia perspectives on climatic change were given by three government officials speaking on water, forestry and sea level/coastal zone respectively. They were H. Coulson, Water Management Branch, B.C. Ministry of the Environment, Dr. D. Pollard, Forestry Canada, Pacific Forestry Centre, Victoria, and Mr. M. Dunn, Environment Canada, West Vancouver.

Three concurrent workshops of 1 1/2 hours duration followed, dealing with implications to water resources, forest resources and the sea level/coastal zone respectively. Each workshop attempted to identify the climate change related issues, current activities in the sector, required action, and what the next steps should be.

WORKSHOP REPORTS

1. CLIMATE CHANGE IMPACTS ON WATER RESOURCES

There is a need to develop and maintain a public information program. Keeping in mind the level of uncertainty on climatic change trends, it will be important to convey an accurate picture to the public-at-large while maintaining scientific credibility. The challenge is to convey an unambiguous message and reflect the uncertainties, in order to avoid contradictions. It is time to begin informing the public about adaptive and preventive measures, i.e. the need to adapt to the inevitable change which is predicted and the need to "restrict the build-up of greenhouse gases." In all of this it will be necessary to target the public and carefully construct the message. This information program should also seek to inform other professional groups (e.g. economists, planners) and should involve

communications specialists in its planning and execution.

Research Needs

In terms of research needs, it was held that general circulation models are not designed for regional impact studies but rather for global sensitivity studies. Therefore it will be necessary to develop methodologies for regional impact studies, while continuing to bring improvement to the general circulation models in the long run.

Research needs to be concentrated on the physical processes and links between meteorological variables and hydrological response. Evapotranspiration is a very important factor here, because there is a critical inability to measure or estimate evapotranspiration at a level of accuracy for use in models of climatic change. There is also a need to develop physical models of responses to climate extremes. As well, it will be necessary to extend the system of benchmark stations at which climatic change data is gathered, over and above the British Columbia stations presently being used.

Next steps

It was recommended that a broadly based representative forum should be held in B.C. to identify and discuss the issues associated with climatic change. Public sectoral workshops should be held with the intention that they report back to a regional climate change coordinating committee.

In terms of communications, there is a need to distribute information to target groups in a timely way. Existing newsletters and the CO_2 Digest are not filling the need. Computer-based bulletin boards are being used by some agencies and could be applied to the distribution of climate change information.

Other action items called for included support for the 1990 Congress of the Canadian Meteorological and Oceanography Society which will deal with climatic change, identification of informed speakers on climatic change, and a workshop on data gathering, collation, and analysis relevant to the subject of climate change.

2. CLIMATE CHANGE IMPACTS ON FOREST RESOURCES

There was general consensus that climatic change is a major issue for the forestry sector in B.C. and that early action is required on a number of fronts. As with other sectors it was emphasized that the scientific data base is not precise enough for predictions of impacts. However, a number of actions can be taken now, at the same time that the data base is being improved. These include energy conservation, conservation of gene pools of living material, enhanced technology transfer using existing knowledge, public information programs on climatic change, and making current information from the federal Atmospheric Environment Service (Climatic Change Program) more available to users interested in climatic change.

The public-at-large needs to be informed on the climate change phenomenon, in order

that politicians and other decision-makers can give priority to related programs. Recently national magazines (Macleans, Time) have underscored the importance of the subject and government publications have done likewise. Such efforts need to be continued and stepped up.

Current Activities

It was found that climate change does not figure prominently in current activities and planning of the agencies represented at the workshop. In fact there was a wide diversity ranging from consideration of climatic change in strategic planning (Forestry Canada., B.C. Ministry of Forests) to increased recognition in research and teaching at the University of B.C. and the University of Victoria, to inclusion in water management planning (B.C. Ministry of Environment), becoming more active in co-operative research (Canadian Wildlife Service), to simply seeking more information (MacMillan Bloedel Ltd.).

Follow-up action was recommended along seven lines:

1. Information on climatic change needs to be dispersed widely through symposia, conferences, meetings, and workshops as a responsibility of all of the end users, both in government and in non-government agencies.

2. The forest industry would probably be very receptive to an information session at the operational level, in the near future.

3. The best available information should be accessible to the public-at-large.

4. Commence dialogue between Environment Canada/AES and other partners on such matters as joint research, student internships with industry and governments, preparation of illustrative and interpretive materials, and a focus on the regional perspective.

5. The development of more comprehensive analysis of terrestrial resources and of the impacts of various climatic change scenarios on them.

6. Where it is necessary to do so, influence the agenda of key regional and national forestry meetings to include climatic change items. Examples include the Association of B.C. Professional Foresters and the Canadian Institute of Forestry.

7. Exert pressure to obtain political leadership, new resources, and the will to make the changes to reduce the generation of greenhouse gases. Climatic change needs to be seen as a non-partisan issue, and a subject to which Canada can make a major contribution through a coordinated response by specialists, decision-makers and publics.

3. CLIMATE CHANGE IMPACTS ON SEA LEVEL AND THE COASTAL ZONE.

Issues

Data credibility is important because there is a range of projections for sea-level change

in the future. The public, the planners. and the decision-makers need to be informed on the range of impacts and the probabilities. A defensible 10-year projection is vital to a credible information program and to political decision-makers.

In a broader context, a policy contradiction has arisen in man's use of hydrocarbons and industrial developments of a kind that contribute to the Greenhouse Effect.

To successfully address changes, it will be necessary to co-ordinate government policy-making and activities at the three levels, together with those of other agencies in the industrial and public interest sectors. This co-ordination needs to be in place at the regional level and to be tied into the global picture, in order to be mutually supportive and not contradictory.

What do we know now?

Projections of sea level rise range from a probable rise of 30 cm. up to a possible rise of as much as 1.5 meters by the middle of the next century. The U.S. Environmental Protection Agency prefers a value of slightly over 1 meter. The challenge is to work with the uncertainty and to seek low cost adaptive solutions such as amending by-laws to prohibit development in coastal flood plains.

What must we find out?

In order to develop a reliable information base we require a baseline measurement technique to monitor changes over time. This should be compatible with international monitoring techniques. With such information, confidence will grow in the projections and it will then be possible to carry out an inventory of coastal areas at risk by land use or habitat categories.

There is a need to understand the amount of error or uncertainty in temperature rise predictions and the statistical validity (confidence levels) of the predictions. As well, there is a need to know if we can be sure that present trends will continue. Policy and decision-makers will be further assisted if the impacts can be quantified and even costed in dollar terms. The subject is a vague one for decision-makers when compared to present-day environmental problems which sometimes require a strong lobby to generate political action.

Adaptive approaches in policy and program planning will be required to minimize costs and preserve future options. Flexibility is required to permit planning and engineering know-how to have full play in dealing with the predicted impacts of sea level rise.

How do we get the message across?

"It may require a few disasters to get the message across."

The severe prairie drought helped to raise the level of awareness of the public and at the 1988 Toronto Conference.

Sea level rise is a creeping problem and needs to be described in a meaningful way

for public information programs.

It was agreed that current information should be furnished to agencies and the public now, and that fresh information should be distributed as it becomes available. In the U.S.A. the Environmental Protection Agency is distributing sea level rise data to public agencies. In Canada such information should be in the context of the overall subject of climatic change.

Precautionary design criteria could be prepared now. They would incorporate probable sea level rise estimates into design criteria for coastal developments. They would give recognition to coastal hazards and the attendant risks in development.

How to keep the momentum going.

Moving ahead from this first regional symposium on climatic change, momentum should be maintained by:

- widely circulating the symposium proceedings;
- developing a climatic change newsletter which covers the subject of sea level rise;
- encouraging the sharing of leadership between the key provincial and federal agencies. Within Environment Canada, the Committee of Regional Executives (CORE) would arrange for co-ordination;
- initiating local studies of impacts from sea level change;
- translation of the scientific information for use by the policy makers and decision makers;
- creating an inter-agency group for the delivery of global/international aspects to the regional setting. Such a group would have representation from the three levels of government, industry, academic and other agencies and should seek to build up a network of interested parties, and review and recommend priorities for action on climatic change, including sea level rise;
- arranging workshops and seminars in the near future. It may be feasible for an institution to handle this on a contract basis (e.g. the Westwater Institute).

RECOMMENDATIONS

In order for B.C. to be informed on the climatic change phenomenon and to reduce or eliminate surprise on the impacts of this change, the following recommendations are made:

1. Ongoing work on the subject of climatic change and its implications to British

Columbia should be coordinated by an inter-agency steering committee with representation from senior management of Environment Canada, the Provincial Government, the regional and municipal government level, industry, and public groups. This would serve to fill the need for a senior policy level steering committee to oversee collaborative work and communication on the subject, including the extension of the network of contacts at the regional, national and international levels. The B.C. Climate Advisory Committee would give support to the Steering Committee.

2. Sectoral workshops should be held, where the level of interest warrants it, to inform interested parties in agriculture, forestry, fisheries, municipal/regional governments, and others. Two or three workshops per year would seem to be warranted. By canvassing sector representatives, the level of interest can be determined.

3. As a public information initiative, the Steering Committee should take early steps to provide information kits to government departments, municipal/regional governments, academia, industry, public groups, and the media. Available information is sufficient to alert interested parties and to begin the education process. As well, efforts should be taken to generate TV coverage in the form of interviews, information clips, and documentaries.

4. A comprehensive bibliography of relevant references on climate change for the range of users in B.C. should be readily accessible to potential users in B.C.

5. It is recommended that high priority be given to the need for industry and the three levels of government to take on more responsibility, action, and accountability to ensure that follow-up on these and other recommendations is urgently pursued and that Environment Canada is very much a participant in this. There is a strong case for a highly collaborative effort here.

The activities described here constitute a start in the process of preparing British Columbia to adapt to climatic change and to participate in the global effort to reduce the generation of greenhouse gases. New priorities will have to be set to generate the in-house support for this work, which for many agencies will be a new initiative. To the extent that bottom-line in-house support can be arranged for in the collaborating agencies, then the results of the research, the responses to the issues, and the public support will be forthcoming earlier than later.

PROGRAM

SYMPOSIUM ON THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON BRITISH COLUMBIA

Wednesday, December 14, 1988
Sheraton Plaza 500
500 West 12th Avenue
Vancouver, B.C.

Sponsored by
Environment Canada

0800 REGISTRATION (8:00 - 8:45 a.m.) Mezzanine

0900 GLOBAL CHANGE (9:00 - 10:15) Ballroom
Moderator - Mr. K. Johnstone, Atmospheric Environment Service, Environment Canada, Vancouver

0900 **Welcome and Introductory Remarks** - Mr. M. Clark, Acting Director General, Conservation and Protection Service, Environment Canada, West Vancouver

0910 **Global Climate Change** - Mr. H. Hengeveld, Atmospheric Environment Service, Environment Canada, Downsview

0940 **Report on the Toronto Conference: "The Changing Atmosphere: Implications for Global Security"** - Mr. D. Phillips, Atmospheric Environment Service, Environment Canada, Downsview.

1010 **COFFEE** and Visit the Climate Change Display (10:10-10:30)

1030 REGIONAL PERSPECTIVES (10:30-12:00) Granville Room B. Moderator - Mr. B. Beal, Atmospheric Environment Service, Environment Canada, Vancouver

1030 **Canadian Climate Program Climate Change Activities** - Mr. H. Hengeveld, Atmospheric Environment Service, Environment Canada, Downsview

1100 **Water Resources** - Mr. H. Coulson, Water Management Branch, B.C. Ministry of Environment, Victoria

1120 **Forest Resources** - Dr. D. Pollard, Pacific Forestry Research Centre, Forestry Canada, Victoria

1140 **Sea-Level/Coastal Zone** - Mr. M. Dunn, Environmental Protection Service, Environment Canada, West Vancouver

1200 **BUFFET LUNCHEON** (12:00-13:00) Ballroom

1300 **WORKSHOPS** (13:00-14:30)

Water Resources Workshop - Location Ballroom
Chairman - Mr. K. Johnstone, Atmospheric Environment Service, Environment Canada, Vancouver.
Reporter - Mr. L. Welsh, Atmospheric Environment Service, Environment Canada, Saskatoon.

Forest Resources Workshop - Location Oak C
Chairman - Mr. T. Chiasson, Secretary, Committee of Regional Executives, Environment Canada, West Vancouver.
Reporter - Mrs. M. Issavian, Secretariat, Committee of Regional Executives, Environment Canada, West Vancouver.

Sea-Level/Coastal Zone - Location Oak D
Chairman - Mr. B. Thomson, Atmospheric Environment Service, Environment Canada, Vancouver.
Reporter - Mr. B. Beal, Atmospheric Environment Service, Environment Canada, Vancouver.

1430 **COFFEE** and Visit the Climate Change Display (14:30-15:00)

1500 **PLENARY SESSION** (15:00-17:00) Ballroom
Moderator - Mr. P. Pender, Atmospheric Environment Service, Environment Canada, Vancouver

Workshop Presentations

1500 **Sea-Level/Coastal Zone** - Mr. B. Thomson, Workshop Chairman, Atmospheric Environment Service, Environment Canada, Vancouver

1530 **Forest Resources** - Mr. T. Chiasson, Workshop Chairman, Committee of Regional Executives, Environment Canada, West Vancouver

1600 **Water Resources** - Mr. K. Johnstone, Workshop Chairman, Atmospheric Environment Service, Environment Canada, Vancouver

1630 **Summary Remarks** - Dr. P. Duffy, Symposium Rapporteur, P.J.B. Duffy & Associates, West Vancouver

1655 **Closing Remarks** - Mr. P. Pender, Atmospheric Environment Service, Environment Canada, Vancouver

OPENING REMARKS

SYMPOSIUM ON THE IMPACTS OF CLIMATE VARIABILITY AND CHANGE ON BRITISH COLUMBIA.

M. Clark
Chairperson, Committee of Regional Executives
Pacific and Yukon Region
Environment Canada
Vancouver, B.C.

December 14, 1988

Good morning ladies and gentlemen. Welcome to Environment Canada's Symposium on the Impacts of Climate Variability and Change on British Columbia.

We are here today to discuss the potential impacts of our changing climate. A change caused by humanity's alteration of the chemical composition of our atmosphere. The potential impacts are so serious that over 300 world experts in science, the environment, and law; including ministers of government; suggested that the "ultimate consequences could be second only to a global nuclear war." This startling thought is contained in the opening line of the final statement of the international conference "The Changing Atmosphere: Implications for Global Security" that was held last June in Toronto.

The Earth's atmosphere is being changed at an unprecedented rate by the pollutants of human activity. The consequences of this unintended, uncontrolled, global experiment could be devastating.

What will be the impacts of climate change on British Columbia? I am sure that many of your have seen or heard media reports about the global impacts of flooding as sea-levels rise, drought as precipitation patterns change, and migration of forest zones. Or you may have read about them in the background material sent to you. In B.C., that threat of rising sea-levels will increase the risks of flooding for low-lying coastal communities. Coupled with an altered hydrologic regime, it could threaten fish and wildlife habitat crucial to the preservation of salmon species and migratory birds. The social and economic costs incurred as the forest sector is forced to adapt to changing forest productivity, tree species, and the very issue of the global carbon dioxide cycle could be exorbitant.

Today, you will hear a number of speakers talk about the scientific basis for concern, and some of Canada's national and international activities. Later this morning, speakers will discuss their perceptions of what the implications of climate variability and change may mean to British Columbia. These speakers will not identify all of the issues, pose all of the questions or provide very many answers.

I am sure that you have your own views, and questions about climate change and its impacts! I want you to state your views and raise your questions in this afternoon's workshop

sessions. We will not be able to answer all of the questions. But, collectively we should get some sense of the priority issues and concerns. This is the first step in developing some cooperative activities that address this issue in British Columbia. These activities can try to identify, prevent, or adapt to the serious impacts of climate change in this province.

During the course of the day, I want you to think about what you can and should contribute to the resolution, insofar as possible, of this impending, albeit creeping, disaster.

Thank you for coming.

FUTURE CLIMATE SCENARIOS FOR PACIFIC CANADA

H. Hengeveld
Canadian Climate Centre
Atmospheric Environment Service
Environment Canada
Downsview, Ontario

INTRODUCTION

The current decade is likely to go down in history as the decade in which the World finally recognized that economic development and environmental protection are not contradictory objectives, but in fact inextricably linked. Sustained development demands a sustained resource base, particularly with respect to natural resources. One of the most important natural resources is the Earth's atmosphere, a limited resource that belongs to no one, yet touches everyone. The very existence of life on Earth depends upon sustaining the remarkable characteristics of the atmosphere. Yet, after several centuries of relentless and ever increasing emission of effluents into the atmosphere by an industrialized global society, there is now clear evidence that the atmosphere is changing. These changes are unprecedented in human history and may well be irreversible. The many environmental issues related to the atmosphere, particularly that pertaining to climate change, find their root causes in these fundamental changes.

This presentation will summarize how atmospheric change is altering the fundamental processes that determine the characteristics of the earth's climate, what these changes may mean for global climate in the decades to come, and how this may affect the regional climate of the west coast of Canada.

EVIDENCE FOR CHANGE

Regular measurements of atmospheric concentrations of CO_2 were started at Mauna Loa, Hawaii, in 1957. They are now being recorded at numerous stations around the world. The results are irrefutable - the mean concentration of atmospheric CO_2, now at about 350 parts per million by volume (ppmv), has increased by 11% since 1957 (Bodhaine et al, 1988). When compared with information obtained from air bubbles fossilized within the Antarctic ice cap, it appears that current values are about 20-25% higher than the previous highest values during at least the past 160,000 years (Barnola et al, 1987).

The principal source of additional accumulation of CO_2 into the atmosphere appears to be the release of carbon as carbon dioxide during the combustion of fossil fuels. Currently this source causes the emission of about 5.5 billion tonnes of carbon into the atmosphere as CO_2 each year. In addition, the destruction of vast tracts of tropical timberland to make way

for agricultural development appears to be contributing an additional 1-2 billion tonnes each year (Houghton et al, 1989). Although these releases are relatively small compared to the natural annual fluxes of carbon between atmosphere, biosphere and ocean (Trabalka, 1985), they represent a cumulative one-way release of carbon from long-term reservoirs into the atmosphere, causing an imbalance in the natural global carbon cycle.

Fortunately, not all of the unnatural emissions of carbon into the atmosphere remains there. The natural system appears able to accommodate a portion of these additions to the atmosphere by re-absorbing as much as 60% into other carbon reservoirs, primarily the oceans (Bolin et al, 1986). The progressive increase in atmospheric CO_2 concentrations is caused by the approximately 2.5 billion tonnes of carbon that remains in the atmosphere each year.

Other atmospheric constituents important to climate are also changing rapidly. Methane concentrations, monitored since the early 1970's, are increasing at about 1.1% each year and are already more than double those of pre-industrial times (Khalil et al, 1987). Although increased global populations of cattle and acreage of rice paddies are believed to be primary sources, release of methane during coal and gas extraction processes and biomass burning are estimated to account for about 40% of the increase. Nitrous oxide is also increasing at 0.3%/year, with an estimated 50% contributed by fossil fuel combustion. Surface concentrations of ozone are rising in urban areas, largely as a by-product of energy use for transportation. Other gases such as chlorofluorocarbons, although as yet low in concentrations, are in many cases increasing very rapidly (Wuebbles et al, 1988).

The above greenhouse gases have several common features (Table 1). They are all climatically important gases that already have an abundance sufficient to significantly influence the heat radiation balance of the climate system. They are all increasing in concentration due to human activities. Finally, most are increasing in concentration at least partly due to emissions from the extraction and combustion of fossil fuels.

BASIS FOR CONCERN

Greenhouse gases collectively behave as an insulating blanket around the planet. Their effect on the incoming solar heat energy which fuels the earth's climate system is minimal. However, their combined influence on the outgoing heat radiation, emitted from the earth's surface and lower atmosphere towards space to cool off the climate system, is large. By absorbing and returning much of this outgoing radiation, they effectively trap heat within the lower atmosphere. This "greenhouse effect" is naturally occurring and essential to life on earth. Without it, the earth's surface would be more than 30 degrees C colder.

TABLE 1

CONCENTRATIONS AND SOURCES OF PRINCIPAL GREENHOUSE GASES

(Adapted from Bolin et al, 1986)

Principal Greenhouse Gas	Concentrations (Parts per Billion)			Relative Efficiency Compared to CO_2	Man-Made Sources
	Present	Trend (%/Yr)	Projected 2030 AD		
Carbon Dioxide (CO_2)	$345X10^3$	0.4	$450X10^3$	1	Burning of coal, oil and gas; deforestation
Methane (CH_4)	$1.55X10^3$	1.1	$2.34X10^3$	25	Biological activities related to increased human and bovine global population
Nitrous oxide (N_2O)	301	0.3	375	250	Increased use of fertilizers; burning of coal, oil and gas
Chlorofluorocarbons					Industry
i) F11	0.17	5.7	1.1	17500	
ii) F12	0.28	6.0	1.8	20000	
Tropospheric Ozone (O_3)	Variable	~ 1	+ 12.5%		Photochemical reaction of other gases

cc-1-e

Projections of future CO_2 emissions into the atmosphere clearly suggest at minimum an eventual doubling of atmosphere CO_2 concentrations over preindustrial levels. However, the timing of such doubling remains uncertain, since long-term future human behaviour with respect to energy consumption is largely unpredictable. Concentrations of other greenhouse gases are also likely to increase significantly in future decades, adding to the climatic effects of rising CO_2 levels. A combined effect on climate equivalent to a doubling of CO_2 appears possible as early as 2030 AD, and highly probable by 2050 AD (Bolin et al, 1986).

Atmospheric modellers do not as yet agree on the magnitude of the net climatic changes that would result from an enhanced greenhouse effect. Nor do they agree on the regional characteristics of such changes. However, there is a consensus that such changes will be large, significantly amplified towards polar regions in fall, winter and spring seasons and accompanied by a major adjustment in global rainfall patterns. The range of estimates for the average global surface temperature rise for a CO_2 doubling varies from 1°C to 5°C and higher (Jaeger, 1988). Most model results also suggest a migration of mid-latitude North American storm tracking northward, resulting in a drier mid-continent and a wetter sub-Arctic

(Schlesinger et al, 1988).

Among the most important considerations in assessing the implications of climate change is the rate of such change and the manner in which it affects the pattern of extreme climatic event occurrences. Recent analysis of the possible rates of global climate warming during the next few decades (Figure 1) suggest a 95% probability of values between 0.06°C/decade (low emissions, low climate response scenarios) to 0.8°C/decade (high emissions, high climatic response scenarios). The middle scenario, indicating a rise of 0.3°C/decade, would cause an incremental warming over current global mean temperatures of 0.4°C by 2000 AD, 1.2°C by 2025 AD and close to 2.0°C by 2050 AD (Jaeger, 1988).

Climate trends of the past decade indicate that a global climate warming is already in progress. Global temperatures have warmed by 0.4°C to 0.5°C over the last century (Figure 2). The six warmest years over that time period have occurred in the 1980's. Although this trend is consistent with model predictions of expected response of climate to changes in greenhouse gas concentrations to date, they are also still within the realms of long-term climate variability, and could be explained by combinations of natural causes for change. While some scientists are already prepared to give the credit to the enhanced greenhouse effect, most feel such conclusions are premature (Hansen et al, 1988; Hanson et al, 1989; Wigley et al, 1985).

Numerous studies have attempted to evaluate how the above changes, should they happen, might affect natural global ecosystems and humans (Bolin et al, 1986; Environment Canada, 1987; Jaeger, 1988, Parry et al, 1988; U.S. EPA, 1988). Many of the consequences are potentially positive. Direct effects of higher CO_2 levels on plants, for example, are beneficial for improved growth and drought tolerance. Warmer temperatures will improve growing seasons in cooler climates, while making polar regions more accessible to marine transportation. However there is great cause for concern in other domains. With almost 50% of the world's human population located along the ocean coastlines, the possibility of a 1 metre or more rise in sea levels has very ominous implications, particularly for low-lying countries such as Bangladesh, Egypt, the Maldives and the Netherlands. Redistribution of rainfall will decrease drought stress in some areas and turn others into deserts, dramatically changing the global pattern of food production and distribution. Slow forest response to climate shifts may result in large-scale dieback along the warm margins of current ecosystems. Heat stress, increased disease, poorer water quality and more frequent severe topical storms could have major implications for human health and life. Of greatest concern is that the changes in many cases may be too rapid to make adaptation possible, hence a high risk exists for catastrophic consequences.

IMPLICATIONS FOR THE CLIMATE OF PACIFIC CANADA

Results from general circulation model (GCM) experiments which simulate the possible climatic implications of a CO_2 doubling can be very helpful in illustrating how regional climates might be affected. Figure 3 summarizes the results of three such experiments (involving the GCMs developed by the Geophysical Fluid Dynamics Laboratory, the Goddard Institute for Space Studies, and the Oregon State University) for the Canadian Pacific region bounded by 57°N, 116°W, 45°N and 137°W. The comparison suggests that the models agree

that the associated warming for the region will be large, but disagree substantially with respect to the magnitude of such warming, particularly in winter and spring seasons. The disagreement between the model results is even greater when considering projections for precipitation. Here we find disagreement even as to the direction of change. For each of the summer and autumn seasons, two models project increases of 10-20%, while the third suggests a decrease in precipitation. Water availability, of course, is affected both by changes in precipitation amounts as well as increased evaporation caused by the higher temperatures. Hence a decrease in precipitation would suggest a significant decrease in soil moisture/runoff, while a modest increase in precipitation could leave water resource availability relatively unaffected. The above clearly indicates that the projection of any one of the climate models as to the changes in precipitation and water resources must be taken with considerable caution. Yet such scenarios provide very useful "what if" examples which can be used to evaluate the sensitivity of regional ecosystems and related socio-economic activities to climate change.

Adverse effects of climate fluctuations and/or change are usually associated with extreme events, rather than average shifts in climate conditions. Therefore, an understanding of how the frequencies and severity of extreme climate might be affected by such shifts is important in evaluating regional consequences of climate change. However, the GCM experiment results available today as yet project future climates only as shifts in average values of climate parameters. One method of estimating statistics on the extreme events is to adjust day-to-day historical climate records by the projected mean shift in climate, (assuming the standard deviation of the record remains unchanged), thus simulating a long-term record of day-to-day climate as it might occur under a $2XCO_2$ climate scenario. Figure 4 illustrates how projected changes of the GISS model would affect the frequency and duration of extreme hot and cold events in the Vancouver region under such an analysis. Although heat waves in Vancouver are obviously not as stressful as in other parts of southern Canada, the results suggest that the number of days in July with maximum temperatures exceeding 20°C (which presently occurs about 3 times each July) would increase almost four-fold to 12 events per July. The average duration of such warm events, indicated by the number of consecutive days with temperatures exceeding 20°C, would also double. On the other hand, cold temperature events in January (minimum temperatures less than -2.5°C) would decrease in frequency from 3 times each January to one day every second January. Hence not surprisingly, while cold events would still occur under warmer climates, their frequency and severity would be significantly decreased.

CONCLUSIONS

What can we conclude from the preceeding discussion? First, we are certain that the composition of the atmosphere is changing and are convinced that an equivalent doubling of atmospheric CO_2 concentrations (including the effects of other greenhouse gases) now appears highly probable. The timing of such doubling, however, is still uncertain. Second, there is also a general consensus that such changes in atmospheric composition will cause large and likely unprecedented global climate warming. The rate of such warming, and particularly the related effects on global precipitation and soil moisture patterns still remain uncertain. Finally, the projections for the regional characteristics of such changes are as yet very unreliable and must be used with considerable caution.

Yet the above uncertainties should not suggest that we wait with responsive action until better predictions become available. They clearly suggest that climate can no longer be considered a constant. Where sensitivities are high, we must develop and adopt methodologies which allow us to take into account the uncertainties of the projections when formulating appropriate response strategies.

One appropriate approach is that of risk assessment and risk management - an approach already commonly used in the business community for routine decision-making processes dealing with uncertain inputs. Such studies will help to determine which limitation and anticipatory response strategies are already appropriate today and which may require better scientific input before they become justified.

We need to pursue these studies now! Hence, decisions with respect to systems and activities that are sensitive to climate, particularly those of a long term nature, must allow for the possible implications of climate change. The available climate change scenarios can already help us to identify which systems and activities are particularly sensitive to such change.

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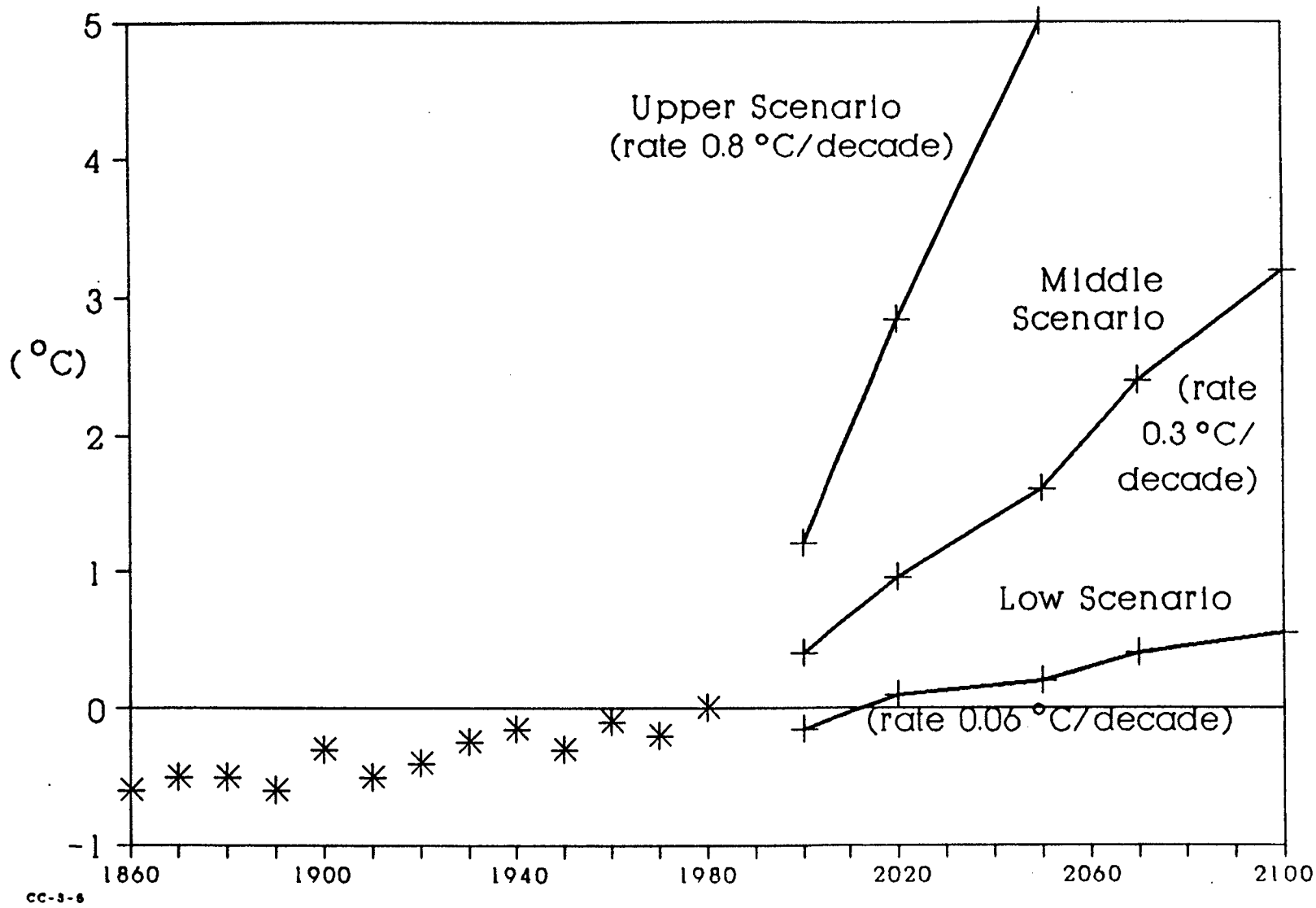


Figure 1. Global temperature scenarios.

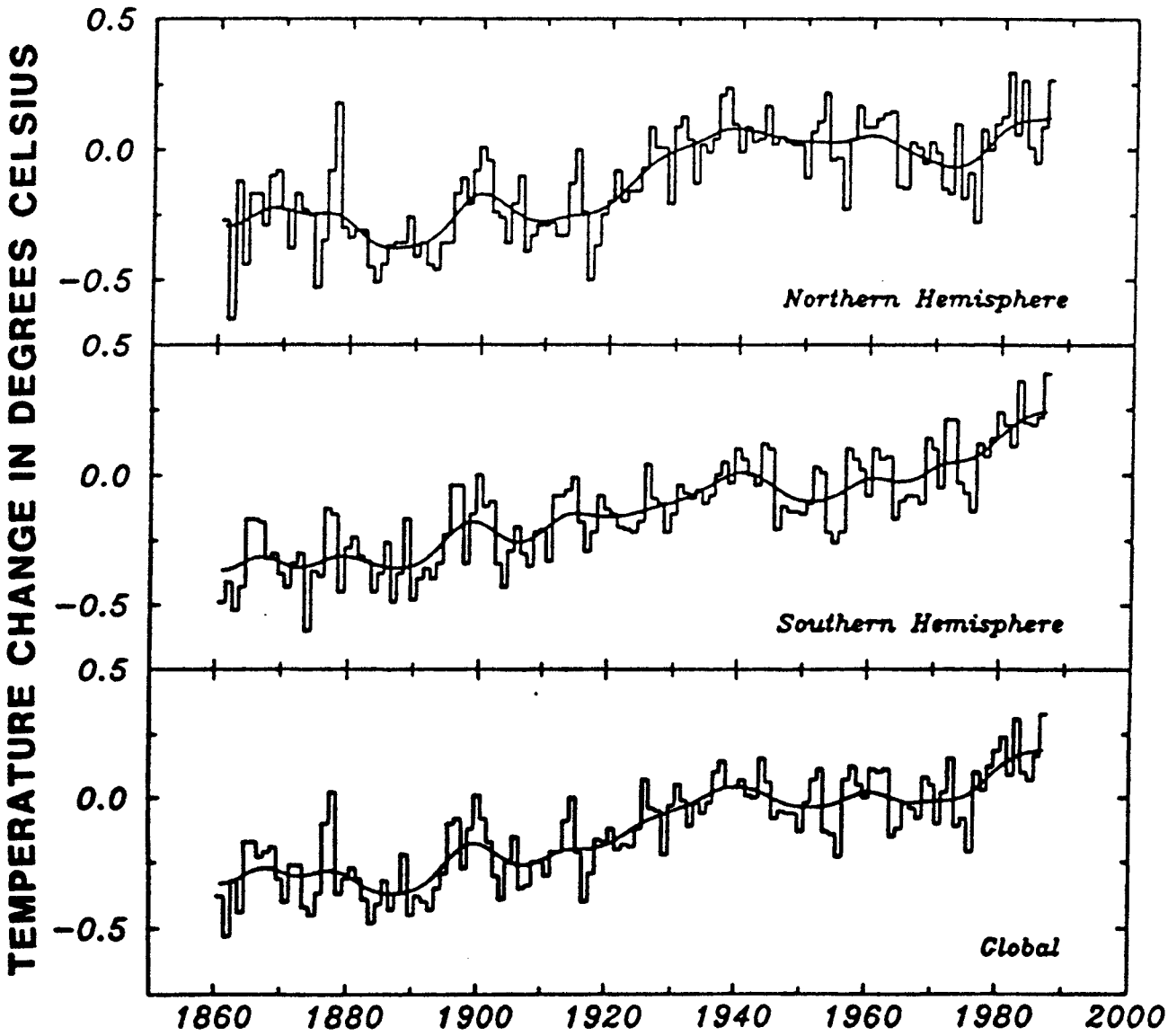
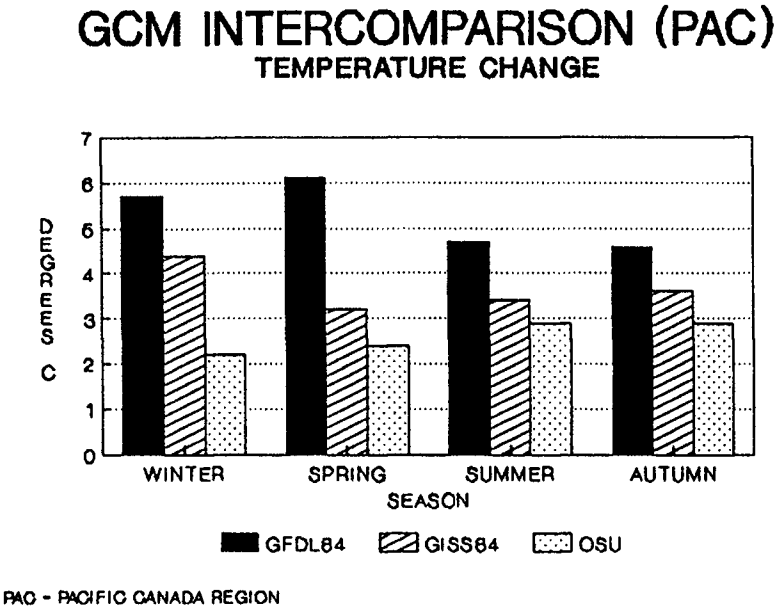


Figure 2. Global temperature trends in the past century.



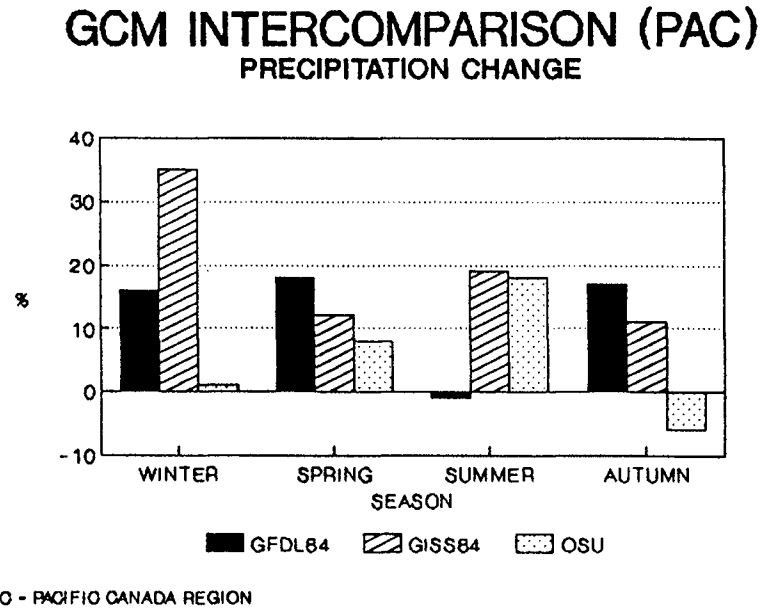


Figure 3. Comparison of the simulated changes in climate for Pacific Canada from three different general circulation models.

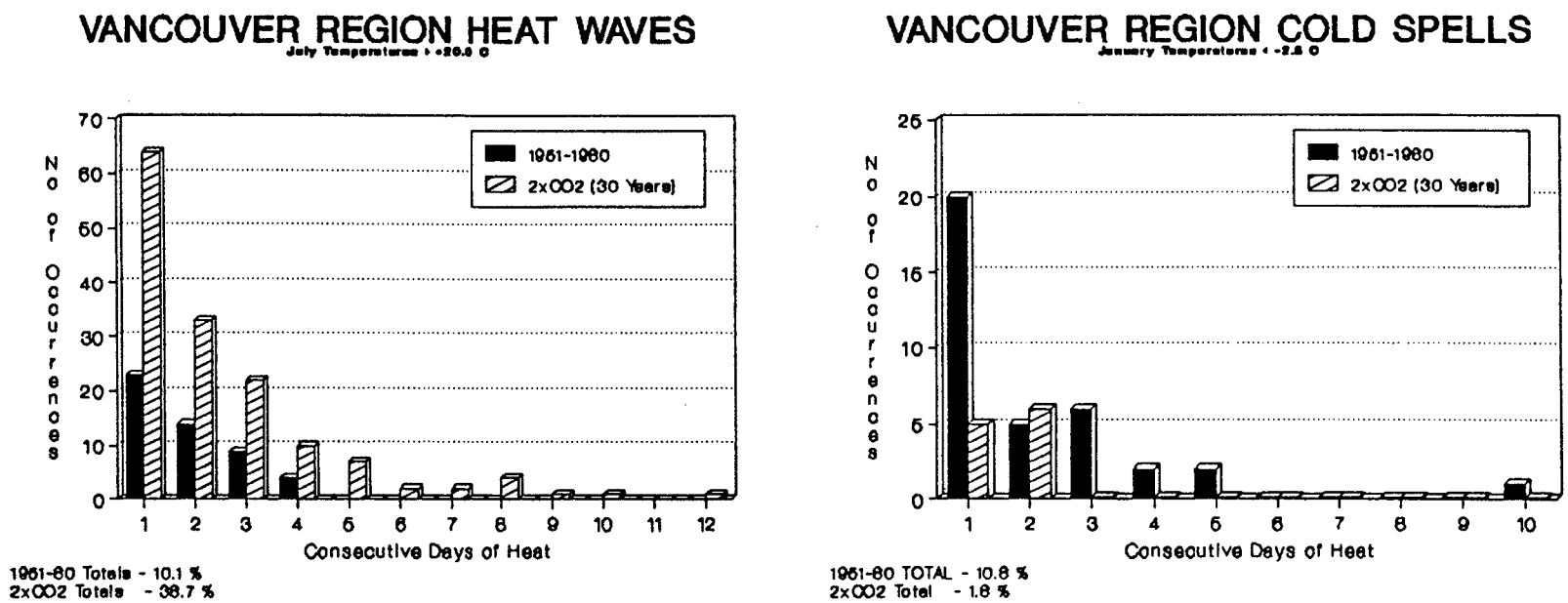


Figure 4. GISS simulated changes in the frequency and duration of heat waves and cold snaps under doubled carbon dioxide scenario.

Report on the Toronto Conference on

THE CHANGING ATMOSPHERE: IMPLICATIONS FOR GLOBAL SECURITY.

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INTRODUCTION

The implications and complexities of the Toronto Conference on The Changing Atmosphere are too vast to cover in 30 minutes. The conference cost over $2,000,000 to stage, took two years to plan and captured the world's attention for almost a week.

In highlighting what took place at Toronto '88, I will confine myself to the Conference beginnings and objectives, outlining the program, mentioning the main Conference achievements and recommendations, and suggesting what might follow the Toronto Conference.

Henry Hengeveld's succinct presentation on global climate change, and humankind's concern with the deterioration of the atmosphere and the disturbing impact this will have on the global biosphere quite effectively describes what led Canada to call world leaders to Toronto in June 1988.

BRUNDTLAND COMMISSION

An important precursor to the World Conference was the publication of the Brundtland Commission Report on "Our Common Future". The world Commission drew attention to the fact that continued economic development in all countries depends on maintaining a sustainable resource base and protecting our shared environment.

When the Brundtland Commissioners visited Canada in May of 1986, for their fifth meeting, Environment Minister Tom McMillan invited them back to Canada to continue the effort:

> "Because Canada agrees with your emphasis an anticipation and prevention, I recommend that the Commission name an existing international agency to take responsibility for developing a multi-disciplinary approach to forecasting and so-called scenario development. As an initial contribution to this important process, Canada would be pleased to host a international conference to identify the current world capacity for forecasting and to consider ways of improving it. We suggest that the first two topics should be climate change and the environmental effects of the chemical society."

The Commission responded favourably to his offer, AES offered to assume the lead role in planning and staging such a Conference. That same year Canada launched its own National Task Force on Environment and Economy. Under the direction of the Canadian Council of Resource and Environment Ministers, the task force developed a series of recommendations to integrate environmental factors into economic decision-making on a national scale.

PRE-TORONTO CONFERENCES

For the past several years, a number of important conferences and meetings were held to assess our scientific understanding of the changing global atmosphere. In 1985 at Villach Austria, senior scientists and policy advisors representing 29 countries and several international organizations produced a consensus statement on the greenhouse gas problem.

Importantly, they suggested that scientists and policy makers should begin to explore the effectiveness of alternative policies and adjustments. This collaboration continued at two workshops organized by the Beijer Institute of Sweden in September 1987 at Villach and in November 1987 at Bellagio. This second Villach meeting confirmed the consensus of Villach I, and produced a range of scenarios depicting the extent of global warming and sea level rise expected. At the Bellagio meeting the scientific findings of Villach I and II were reviewed and policy initiatives were considered for dealing with the greenhouse gas/climate warming problem.

Strong linkages were made between these two meetings and the Toronto Conference. The report of these workshops provided much of the scientific background and conceptual basis for many of the recommendations in the Toronto Conference Statement. Similar linkages will be made between the Toronto Conference and the Second World Climate Conference in 1990 and other international meetings planned in 1989 through 1992.

SPONSORSHIP

The Conference was organized and sponsored by Environment Canada with support, either financial or moral, from several federal departments and agencies. Financial sponsorship towards transportation costs of participants from developing countries and publication of materials, was generously provided by the United Nations Environment Program and the World Meteorological Organization. Endorsement by many other national and international organizations was also obtained.

OBJECTIVES

Getting such a disparate group of individuals, egos and platformseekers to assemble together for four days of difficult discussions in Toronto in early summer was the principle goal of the Conference. Once there and sufficiently wined and dined, it was our aim to inform them, have them recognize roles and responsibilities and then propose and produce actions.

There were 3 broad objectives:

Communication and Cooperation

- communicate to the international political and economic communities the scientific concerns about our changing atmosphere
- sensitize politicians and senior policy makers of the need to act and, to further develop the political will and means to respond to grave environmental concerns
- offer a platform for political leaders to make strong statements and commitments about the need to protect the environment
- enhance global cooperation and response in research programs that attempt to forecast change, reduce harmful emissions and adapt to or mitigate adverse impacts

Plan for Change

- to develop strategies, policies and actions to recognize and deal with protracted changes that are socially and environmentally unacceptable, e.g. adapt to, control and, if possible, prevent undesirable changes in the atmosphere

International Agreements

- consider ways of developing international response through action and policies that address global atmospheric change

- examine the character and means of developing a Law of the Atmosphere. Such international accords take years to achieve and was not a realistic goal for this Conference. Rather, we hoped to launch the process of development of an international Law of the Atmosphere.

Canada's Role

- to enhance Canada's position in the world as an important leader in the environmental matters

Despite enormous challenges, we wanted to foster a mood of optimism. The very fact that an environmental conference of this scope is being held here indicates that the issues are seen as realistic and manageable.

PARTICIPANTS

The Conference was by invitation of the Government of Canada. More than 300 world experts - leaders in science, law, risk management and resources; ministers of government; economists, diplomats and jurists; industrialists; policy analysts; sociologists; environmental activists; urban planners and officials from international agencies.

Contrary to early perceptions it was not a scientific conference nor a political conference but rather a gathering of scientists and politicians; representatives from an incredibly broad range of disciplines; North-South; East-West; developing and developed countries; coming together to exchange ideas and develop consensus on ways of addressing the threat of atmospheric change.

In attendance were first ministers, senior officials of national and international governments, Brundtland Commissioners and ENGOs (Friends of the Earth, Energy Probe, Environment Defense Fund, Native Groups).

Among the headliners were: Brian Mulroney, Gro Brundtland, Tom McMillan - Conference Host, Stephen Lewis - Conference General Chairman who adroitly chaired the final plenary session on approval of the Conference Statement, Marcel Masse, Ministers Nijpels (Netherlands), E. Salim (Indonesia) and U.S. Senator Timothy Wirth.

PROGRAM

The Conference opened on a high note with key-note addresses from Prime Minister Mulroney and Prime Minister Gro Brundtland from Norway.

Mulroney

- Canada would be honoured to host and support a 1992 World Conference on sustainable development under the auspices of the UN
- Safe consumer products in Canada would bear logos labelling them environmentally friendly
- Canada to implement one of the central recommendations of the National Task Force on Environment and Economy, that is, the creation of a multi-sectoral national round table to develop strategies of the integration of economic and environmental decision-making in Canada

Brundtland

- launch immediate international discussions on the feasibility of adopting regional strategies for stabilizing and reducing energy consumption and use by the year 2000
- establish a global convention on the protection of the climate to coordinate scientific activity technology research and transfer to reduce the emissions of harmful substances

MacMillan

- announced that Canada's Environmental Protection Act was given royal assent and proclaimed into law and that Canada was the fourth country to ratify the Ozone Protocol

Next came the scientific presentations on the state of the art understanding of global atmospheric change including greenhouse gases and climate change (Hare), ozone layer depletion (Watson), acid rain (Persson), other radiatively active gases, pollutants and their chemical linkages (McElroy) and energy (Mintzer).

The plenary session on Day 2 saw a further group of specialists consider the socio-economic implications of environmental change including food supply (Sinha), forests (Maini), water (Nemec), health (Grant), and human settlement (Hardoy). Following the scientific sessions on Days 1 and 2, leading world government officials - Obasi from WMO, Salim from Indonesia and Mansfield from UNEP responded with suggestions as to what was needed to begin formulating solutions through research and policy actions.

Canada's Ken Hare stated:

> The level of certainty about the social and economic implications of the global greenhouse is lower than the near - consensus that the global effect will be unmistakable within a few years.

Robert Watson (NASA's Upper Atmosphere Research Program)

> Given what we know about the ozone and trace gas chemistry-climate problem we should recognize that we are conducting a global scale experiment on the Earth's atmosphere without a full understanding of the consequences.

Goran Persson from Sweden's National Environmental Protection Board

> National energy policies are of special importance to the solution of our problems of air pollution and acidification. In the future, environmental protection must be considered as a much more important element than it is at present in the development of national energy, industry and transport policies.

Harvard's Michael McElroy

> It is clear that the composition of the atmosphere is changing at a rate unprecedented in the recent geologic record. The abundance of methane has more than doubled since the industrial revolution. Carbon dioxide has increased by about 25%, and there are detectable rises in nitrous oxide. These changes have implications for global climate, for the distribution of nutrients and for the overall integrity of the global environment.

Irving Mintzar from the World Resources institute in Washington warned that:

> "If current trends continue, the Earth will be committed to a warming of 1.5--4.5°C by the early 2030s. National energy policies that encourage rapid increases in the use of coal, limited investments in technology to improve energy efficiency, and continued increases in the rate of tropical deforestation could accelerate the buildup of greenhouse gases, reaching this level before 2015. By contrast, national policies (which encourage the rapid introduction of efficiency-improving technologies and renewable supplies, stimulate a shift of the fuel mix toward increased less carbon-intensive fuels, and limit tropical deforestation) could postpone this level of buildup until sometime after 2075."

Suresh Sharma from the Indian Agricultural Research Institute warned that:

> If climate changes occur as projected, then several parts of the world which today supply food to other nations might face difficulty in even meeting their food requirements.

The enhanced levels of CO_2 in the atmosphere appear to promote the production

of some crops if adequate input resources are available. However, most of the projections claiming advantageous effects of increased levels of CO_2 are based on studies of vegetative growth. A warming of 2°C promotes sterility in rice and hence reduces the yield by 25% or more.

Jag Maini from Canada said that:

Billions of dollars are currently being invested in forest management and forest industries. Tree seedlings planted today in the middle latitudes will only be half their rotation age by the year 2030 and likely growing in an altered climate regime. Robust and flexible strategies are needed to reduce the levels of risk for these massive financial investments. The anticipated atmospheric changes are beyond the recent evolutionary experience of trees and forests. Consequently, a longer lead-time is likely to be required to address the issues involving gene-environment interaction, which determines the growth and the very survival of species.

Collective international action, or an environmental alliance is required to address this issue of global environmental security.

Jerry Nemec of FAO, but for 20 years at WMC, said:

The most immediate impact of a possible change in climate on society - changing atmosphere - is considered to be through changes in food production. It is proposed that in some respects the impact on the availability and demand of water resources is of an equal, if not a greater, importance.

Lester Grant

Lester Grant from EPA's Environmental Criteria and Assessment Office was widely quoted in the press on the health effects associated with regional and global air pollution problems. These included skin cancers, cataract formation, stress, spread of temperature-dependent disease, sea-level rise, flooding of coastal sewage and hazardous waste facilities.

Jorge Hardoy

Jorge Hardoy from the Human Settlements Program of the International Institute for Environment and Development spoke principally about national disasters and the human costs in urban areas of Latin America.

Politicians and technocrats with the power to decide and implement projects only react to emergencies with partial, short-term measures. Private entrepreneurs and higher income groups assume it is somebody else's problem.

Dr. Obasi

Dr. Obasi, Secretary-General of the World Meteorological Organization, described WMO's role in coordinating global monitoring and scientific efforts in climate change. However, WMO cannot remain a neutral scientific recorder and predictor. We believe that the evidence now available indicates that nations must begin to take steps to preserve and protect this most fundamental resource, the global atmosphere. We associate ourselves vigorously with those calling for a "Law of the Atmosphere" to both protect this thin shield of air on which life itself depends, and to ensure the international exchange of scientific information needed to maintain a continuing watch on our planet's most important and threatened resource.

Emil Salim

Emil Salim, Minister of State for Population and Environment in Indonesia spoke twice - as a featured speaker and as a panellist on the Panel on Economy and Environment. In both addresses, professor Salim said that:

In implementing environmentally-sound technologies, governments in most developing countries are usually constrained by external factors, such as the world economy with declining commodity prices, the appreciation of foreign currencies, leading toward an increased debt burden; the restriction of trade into the developed countries through high import duties or import quotas; changes in the terms of trade in favour of the industrialized countries; and a decline in the foreign investment and foreign aid flowing into the developing countries. This has led to low growth rates, below 5% per annum in most Asian countries.

By the year 2000, we will need intensive agricultural development aid to maintain food self-sufficiency, the movement of industrial development away from a soil-dependent economy towards the service sectors, such as tourism, banking, trade, insurance, and marine resource development.

William Mansfield, Deputy Executive Director of UNEP stated that;

Effective action on global climate change cannot be taken by any individual government or even group of nations. The process by which international action could be agreed on and implemented will raise great economic, political and diplomatic challenges. Global warming is a crucial issue for mankind and requires the urgent attention of everyone.

Beginning the afternoon of Day 2 and carrying on through Day 3 were twelve policy working groups, such as energy, food, integrated programs and investment and trade. Each group identified gaps in knowledge and communications and the institutional and procedural impediments which will need to be overcome in order to realize the goal of long-term sustainable development. Moreover, the groups hammered out policy and specific recommendations that formed the basis of the Conference Statement.

CONFERENCE STATEMENT

The closing statement from the Toronto Conference was very clear, and much more pointed and comprehensive than anyone had expected. Many believe that the Conference's conclusions and recommendations will influence the way that political leaders approach the matter of atmospheric protection and sustainable development.

The participants warned the world that:

> changes in the earth's atmosphere represent a major threat to global security; and that such changes will imperil human health and well-being, diminish global food supplies, disrupt fresh water supplies by altering rainfall patterns, increase the potential for international conflict, jeopardize prospects for sustainable development and increase the extinction of species as well as alterations in forest patterns

Participants agreed to a strong agenda for action to avert the impending crisis. The Conference urged nations and institutions to work urgently towards an Action Plan for the Protection of the Atmosphere with a World Atmosphere Fund financed partly by taxes on fossil fuel use in industrialized countries. The idea of an international fund to assist developing countries to protect the environment, particularly through preserving equatorial forests, was also extremely significant. The other thing that was clearly recognized in the Conference Statement was the need to assist developing countries to move forward with their development. Economic progress must not be equated with atmospheric deterioration and increasing energy use must not be equated with increasing greenhouse gas emissions.

Some of the major recommendations for action include:

1. Reduce the greenhouse effect

- Reduce global CO_2, emissions by 20% of 1988 levels by the year 2005. One-half of these reductions are to come from improved energy efficiency measures and other forms of voluntary conservation. The remaining reductions are to be accomplished by switching to lower CO_2, emitting fuels including renewable energy (biomass conversion technologies), and possibly nuclear power.

- Nuclear power lost credibility because of problems related to nuclear safety, radioactive wastes, and nuclear weapons proliferation. If these problems can be solved, through improved engineering designs and institutional arrangements, nuclear power could be used as one source of energy which does not produce CO_2. Stopping the increase of CO_2 in the atmosphere is an "imperative goal". Even though a 20% cut is seen as a challenging target, scientists currently estimate that a reduction of more than 50% will be required to stop increases in global warming.

- Elimination of certain CFCs.

- Protection of Temperate and Tropical Forests. A trust fund should be established to provide incentives to developing nations to manage their tropical forests on a sustainable basis. Deforestation should be reduced and the planting of new forests encouraged in both temperate and tropical areas. (Forests play an important role in absorbing CO_2, from the atmosphere).

- Set targets for energy efficiency and energy supply improvements.

2. Virtual elimination of the most damaging chlorofluorocarbons

- The Montreal Protocol was signed at a conference in September 1987. Before it can come into effect, the agreement must be ratified to certify that each country can legally enforce the terms of the accord. Nations are strongly urged to ratify the protocol.

- The Montreal Protocol must be revised to ensure the virtual elimination of the most damaging CFCs by the year 2000, including limiting the use of other ozone-destroying substances, such as halons (used in fire extinguishers).

3. Reduction of other pollutants

- Pollutants contributing to ground-level ozone (primarily vehicle exhaust) should be reduced. Reductions in the overuse of nitrogen fertilizers will decrease levels of nitrous oxide in the atmosphere.

- There must be "vigorous application" of existing technologies to reduce pollutants which cause acid rain.

4. Development of Global Protocols (did not mention Laws of Atmosphere)

- A comprehensive global law for the protection of the atmosphere must be developed. It should in no way impede simultaneous national, bilateral and regional actions and agreements to deal with specific environmental problems.

5. Product Labelling

- Manufactured products should be labelled to help consumers identify and select those items which minimize damage to the atmosphere, both in their manufacture and use.

6. Increased scientific research

- Increased funding of research and monitoring programs is required to fill gaps in scientific knowledge and to further technological developments and transfer in areas such as renewable energy and coastal zone protection and management.

7. Education and Awareness

- Funding should be increased to Non-Government Organizations for environmental education and public awareness campaigns, and to related educational programs at primary, secondary and post-secondary levels. Also see to it that the Conference Statement and Working Group reports are made available widely.

ACHIEVEMENTS

In many respects the Conference exceeded all expectations in addressing its basic objectives of improving awareness of the issue and encouraging action. It clearly demonstrated a new, unprecedented willingness of governments and industry to work together with specialists from a broad range of disciplines and backgrounds. Canada received wide recognition for its role in seeking solutions to planetary threats from the changing atmosphere.

Coverage of the Toronto conference was substantial, and achieved a high profile across Canada. During the Conference period 68% of all Canadian media reports on the environment focused on Conference proceedings. This meant some 600 references to the Conference in

Canadian print and electronic media and a grand total of nearly 1.000 world wide. As well the Conference received a moderate profile in the American and international media. There were print, radio and TV journalists from the United States (Boston Globe, San Francisco Chronicle, Washington Post, NBC News, Newsweek, Time), England, France, West Germany, New Zealand, Argentina, Japan, Philippines and Scandinavia and elsewhere. The American media hailed the conference as a landmark conference and used it to demonstrate the seriousness being attached to the issue by other world leaders. They applauded the proceedings and recommendations of the Toronto Conference, and called for immediate global action to address the issue.

Also generally pleased with the outcome of the Conference were the non-governmental organizations. They have a big role to play, in informing the public and focusing attention on the issues.

Also evident was a coming together of participants despite their disparate viewpoints who were nearly unanimous in their praise of the planning and staging of the Toronto Conference and the international coverage it received. As the days wore on, a strong sense of urgency emerged. A strong agenda for action was agreed to, challenging goals were set and nations were urged to develop strategies to meet them.

CONFERENCE OF CONFERENCES

In many ways the World Conference on The Changing Atmosphere was unique. It was not just another scientific conference. It went beyond the scientific discussion to deal with climate change issues on a policy level. The focus was principally on policy and on ways to develop strategies and actions to promote international awareness and to encourage the integration of atmospheric change in socio-economic planning. The view was widespread that Toronto '88 would be a scientific not a policy-oriented conference. That impression was harmful in achieving program support and took considerable effort to remove. Neither did we want it perceived as a political conference but rather a special opportunity for exchanging ideas among various disciplines, between East and West, and between developed and developing countries.

Toronto '88 went further than similar Conferences of the past:

Participants

The conference was a new departure because it brought together not only atmospheric scientists but environmental experts in sectors such as forestry, agriculture and transportation with long-range planners and decision makers some at the political level. It linked East and West, North and South, advanced and developing countries - 46 in all.

A Single Issue

Also a factor in making Toronto '88 different from other conferences was the realization that many changes in the atmosphere (climate change, acid rain, depletion of the

ozone layer and arctic haze) are strongly interrelated. The atmosphere is much more than the sum of its parts. Changes in the ozone layer can affect world climate, while certain "greenhouse gases" can also alter the ozone layer and contribute to urban air pollution.

Since many atmospheric problems have common origins, they may also have common solutions. Clearly, a more integrated approach is needed to solve the problems of our atmosphere. We must strive for wider ranging, more comprehensive laws to protect the atmosphere as a whole. Further the research required to reduce uncertainties, the planning of monitoring and control techniques, and the political aspects of decisionmaking on these various issues require a holistic assessment of the problem and a recognition of linkages among the various issues.

WHAT NEXT

Hopefully Toronto '88 will be the pivotal gathering that will lead to something even more significant in seeking common solutions to the many atmospheric problems facing the Earth.

Howard Ferguson said the Toronto Conference will prove to have been an important step forward in reconciling environmental, societal and development goals. Toronto '88 gave us the right agenda and conviction to act. It also provided an opportunity to share our views with world leaders from many different disciplines.

Many more conferences like Toronto '88 will be necessary in order to move us forward. Early in 1989 a legal conference in Ottawa will attempt to establish a possible comprehensive international framework agreement for the protection of the atmosphere (Ottawa, International Workshop on Law and Policy). The Prime Minister also proposed that Canada host a major international conference on sustainable development in 1992.

Other announced forums for discussing climate change policy considerations include:

Tokyo (1989)- Human Dimensions of Global Change;
Fall 1989 - high-level political conference on Climate Change in the Netherlands;
1989 - World Energy Conference in Canada;
June 1990 - Second World Climate Conference in Geneva;
1992 - Inter-governmental Conference on Sustainable Development.

LAW OF THE ATMOSPHERE/PROTECTION OF THE ATMOSPHERE

Participants at the Toronto Conference urged work to be started at once towards a global law to protect the atmosphere. In response Canada will be hosting a meeting of international experts in 1989 to develop an international framework for a law of the atmosphere.

International environmental laws are usually based on a convention in which nations agree to certain basic general principles, such as cooperation in research, data exchange, and monitoring, sharing of new technology and a commitment to future action to deal with a shared problem.

But the real meat of such a Law would be contained in the protocols, or annexes that would be attached to it over the years. We already have the essence of one annex in the Vienna Convention of 1985 and the Montreal Protocol of 1987, dealing with the stratospheric ozone layer.

Another annex for a Law of the Atmosphere could deal with major environmental accidents having international implications. Fresh in our minds is the Chernobyl disaster of 1986. Such a protocol could obligate nations to promptly inform their neighbours. Another annex could deal with the acidification of the environment such as the ECE Convention and the Helsinki Protocol of 1985, limiting SO_2 emissions. The protocols must deal with more than simply controlling damaging chemicals. Other activities which affect the atmosphere, such as agricultural and forestry practices, should also be addressed.

A new convention for the Law of the Atmosphere might enshrine in law the principle that the atmosphere is a commonly shared resources and is the responsibility of all nations. It might also include a mechanism for settling disputes between nations over air pollution which crosses national boundaries and a threat of trade sanctions for nonsignatories or guilty parties.

A convention would necessitate the establishment of a central agency or secretariat to standardize the collection of scientific data to determine research priorities, and to carry out the global exchange of scientific information. The Law of the Atmosphere will be a major step forward for the protection of the global environment. However, it will also be an extremely complex and difficult law to develop. Global agreement must be reached on both the Convention and its various protocols. All these procedures will take time. It is worth noting that the scientific community began to think about the possible need for an international agreement to protect the ozone layer in the early 70's while the target dates for specific reductions in the protocol are concentrated in the 1990's. Thus, from conceptualization to international limitation will have taken about two decades.

Of course, action by national agencies and international organizations should not be limited to all-embracing international conventions. National programs, bilateral initiatives, treaties and multi-lateral agreements all have their uses and should be pursued.

CANADIAN ACTIONS

The World Conference has sent a challenge to all nations. Canada is now moving on many fronts domestically and internationally to meet the conference recommendations. Some of the major initiatives now underway include the following:

- a program to label manufactured products, so that consumers can choose goods which are less damaging to the environment
- policies to improve the efficiency of energy use in Canada and to encourage the use of alternative forms of energy, e.g. task force to assess implication of the 20% reduction of fossil fuel consumption
- the lead in a legal-experts workshop in February 1989 to consider protocols and conventions for a Law of the Atmosphere (a comprehensive global convention on the Protection of the Atmosphere); advance the agenda of Toronto '88
- promote World Atmosphere Fund based on taxation of CO_2, emissions in developed countries; cancellation of LDC debts to achieve environmental protection
- strive for changes to the Montreal Protocol by 1990
- resourcing of cooperative international research and monitoring programs (climate warming, ozone depletion, acidification, high latitude change)
- public information and education program to promote sustainable development and protection of the global atmosphere
- sustainable development is characterized by a multi-sectoral partnership and shared responsibility
- adopt two kinds of strategies for responding to the changing atmosphere - adaptation and limitation
- development of a cabinet submission on Atmospheric Change and Impacts

THE IMPACT OF CLIMATE VARIABILITY AND CHANGE ON WATER RESOURCES IN BRITISH COLUMBIA

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When you turn on the tap you expect the water to flow - you take it for granted - without any consideration of how an adequate supply of water is always available at the turn of that tap. Should we in British Columbia, with our enormous volume of fresh water resources, continue to take the supply for granted or should we look ahead and plan for future changes in supply and demand?

This note covers the importance of the water resource in British Columbia, how climate and streamflow vary across the province, the impact of the drying trend of the past few years and the potential impact of climatic change on our fresh water resources.

Importance of the Water Resource in British Columbia

Water delivered to our homes and factories costs around 25¢ per cubic metre - that is 25¢ per tonne. Can you imagine any other commodity so necessary in our daily life yet so inexpensive? (There is only one, air.) Water is inexpensive because of its abundance in a usable form, especially here in British Columbia. The extent to which our society depends on fresh water becomes apparent when you consider the variety of ways in which it is used: domestic, industry, agriculture, hydro-power, waste dilution and removal and recreation.

There are, however, times in British Columbia when its quantity is not appreciated - floods. Flooding with accompanying erosion, property damage and loss-of-life is not a frequent occurrence in British Columbia, but it does occur. Considerable expense has gone into the construction of works to control or contain the excess supply - dykes, canals, reservoirs and river channel improvements.

Climate and Streamflow Variation Across the Province

Streamflow integrates the climatic effects of precipitation and temperature over a watershed. In a general sense, the amount of precipitation falling on a watershed less the amount lost to evaporation and transpiration equals the water available for streamflow. This relationship is approximately true on an annual basis.

If we consider annual streamflow in terms of depth on a watershed we find that the annual runoff varies from near zero in the southern Okanagan to 2700 mm in the Queen Charlotte Islands. The Fraser River (the largest river in the province) has a mean annual runoff of some 516 mm at the mouth. The Fraser drains a variety of coastal and interior regions and can be taken as representative of the province as a whole. Figure 1 shows the annual flow at the Hope gauging station. On this we can identify those years that produced flooding (1948, 1972) and the years that brought water shortages (1929, 1970). The striking feature of this graph is the consistency: virtually all annual flows are within 20% of the mean, including flood and drought years. Remember, that the Fraser is representative of the province as a whole.

Now consider the dry region of the province - the Okanagan. Figure 2 illustrates inflow to Okanagan Lake in terms of depth over the whole watershed. The mean annual inflow here is 76 mm (as compared to the Fraser's 516 mm). Here there is much greater fluctuation around the mean with most years within the band of 60%. In the Okanagan, water supply is a limiting factor to development, and it is the dry years, especially the consecutive dry years, that give the most problem.

Impact of Climatic Fluctuation During the 1980's

During the period 1980 to the present year we have been experiencing a trend to lower streamflow. This is especially true for the dry months, May to September. Our water supply during these dry months is dependent on the melting of the winter snowpack - the greater the snowpack, the better the summer water supply (although summer rainfall can also be important). During the past eight years the following has been observed. First, Figure 3 shows observed winter temperature deviation from normal - although there is some variation, winter temperatures have averaged 1°C above normal since 1980. Winter snowpacks in the interior have been on the decline as shown in Figure 4 showing Columbia, Kootenay and Okanagan. The reduced water supply has led to declining groundwater levels as shown in Figure 5. Summer water supply itself has been low and inadequate in many areas as shown for May to September inflow to Okanagan Lake, Figure 6.

The Water Management Branch has been able to provide adequate warning for those areas with low seasonal snowpack allowing planning of water use, early storage, development of alternate sources and application use restrictions. As a result problems have generally not been serious. But there has been an economic impact with reduced crops, sale of cattle, and dry groundwater wells.

Effects tend to be cumulative with storage reservoirs being drawn down and groundwater levels declining. We cannot conclude that a 1°C winter warming has brought about a 10% or 20% decline in water supply because both Winter warming and low snowpacks are likely both results of some external driving mechanism. However, we cannot entirely discount the casual relationship between winter temperature and summer water supply. It would be tempting to relate this to the expected global warming due to the greenhouse effect but this would be not correct.

Potential Impact of Climatic Change

It is certain that global warming will impact on the province's water resource. But how will the 1.5 to 4.5°C warming affect water? On an annual basis, will it mean more or less water (more floods or more droughts)? Will it produce the same average but much greater year-to-year variation (more floods and more droughts)? Perhaps the seasonal distribution will be significantly altered with more runoff in the fall and winter and less in the summer. It is not that we just don't know the magnitude of the change on the water resource - we don't even know the direction the change will take.

Referring again to Figure 1, the annual streamflow on the Fraser River, if we increase the mean annual runoff a modest 10%, the number of flood or flood-threat years rises from 5 or 6 to 17 or 18 in the 75 year historical comparison. (That is three times the number of flood-threat years.)

At the other end of the potential, let's consider what would happen in the Okanagan if annual precipitation decreases. As shown in the Table, mean annual runoff is approximately 75 mm - this is the result of approximately 675 mm annual precipitation and an evapo-transpiration loss of 600 mm. If global warming increases evapo-transpiration by 10% and decreases basin precipitation by a modest 10% - what would happen to mean annual runoff?

	Present	With Climatic Change
Precipitation	675	610 mm
Evaporation	600	660 mm
Runoff	75	-50 mm

This would suggest that on an average year, Okanagan Lake would loose more water to evaporation than would enter from the tributaries. The magnitude of change is certainly speculative but the implications are serious.

If the 1980's are any indication, the impact of climatic change on our water resources will be large in economic terms. Impacts in the following areas need to be examined:

Snow:	Snowmelt water supply and winter recreation
Runoff:	Flood potential, drought, groundwater levels
Water Quality:	Dilution of waste
Water Management Structures:	Dams, reservoirs, water supply systems, hydro-power generation, canals, locks and dykes (design and operation).

But how can we examine impacts in these areas if we don't know the magnitude or direction of the change?

What Has to be Done?

A step-wise examination of the impact of global warming on the water resources of British Columbia must be accomplished. It might take some years for this but a start must be made - the sooner the better. First, we must identify how the temperature and precipitation patterns across the province will change direction, amount and timing. This is a job for research climatology - applying the changed global circulation patterns to the coast and interior, south to north, of the province. With this most important step accomplished, the second step for hydrologic research will be to identify the effects on our freshwater resource - the change in distribution and seasonal variability. As a third step, existing and planned water management structures - both design and operation - would be modified. This will take time to accomplish, in the meantime we must set up data collection networks (precipitation, snow, streamflow) to monitor effects of climate change. Secondly, scenario-type studies based on reasonable projections of climatic change should be carried out to identify the possible extent of impact of the climatic change on the water resources of the province.

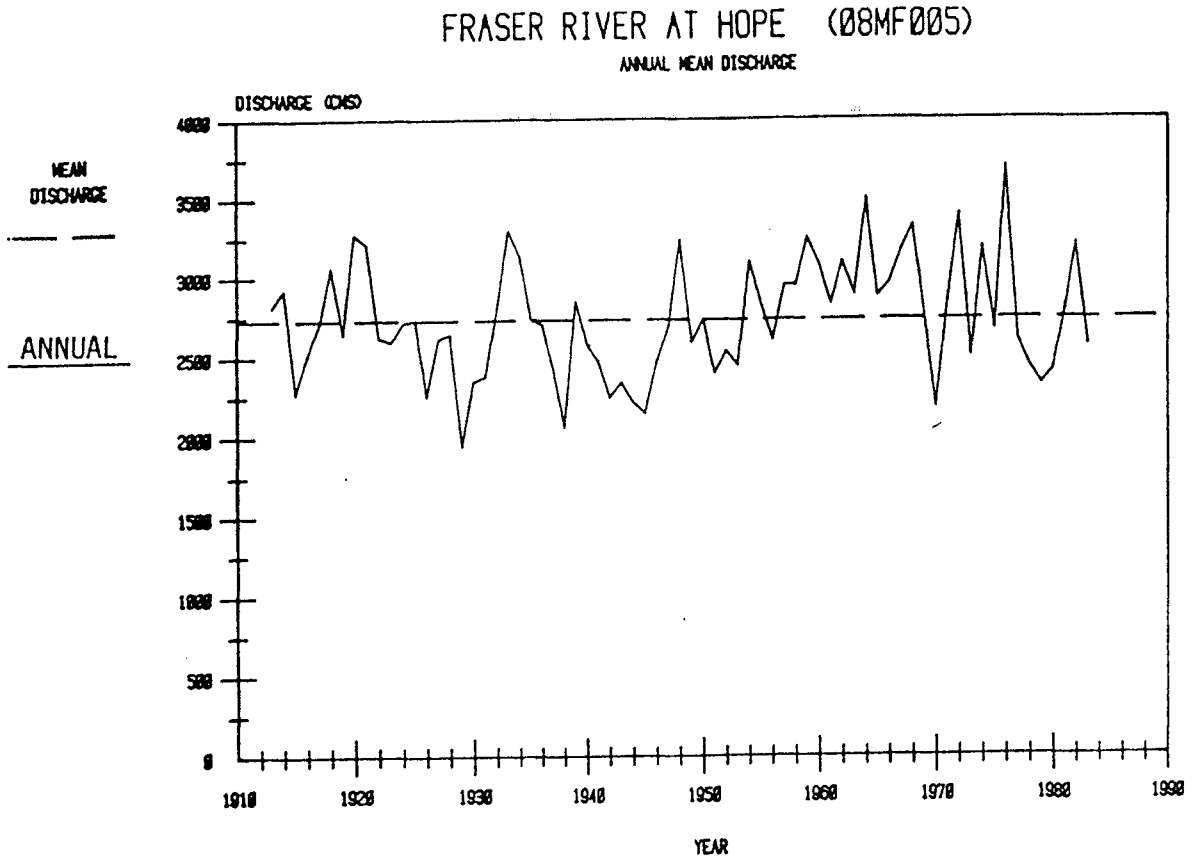

Figure 1. Annual mean discharge of the Fraser River at Hope.

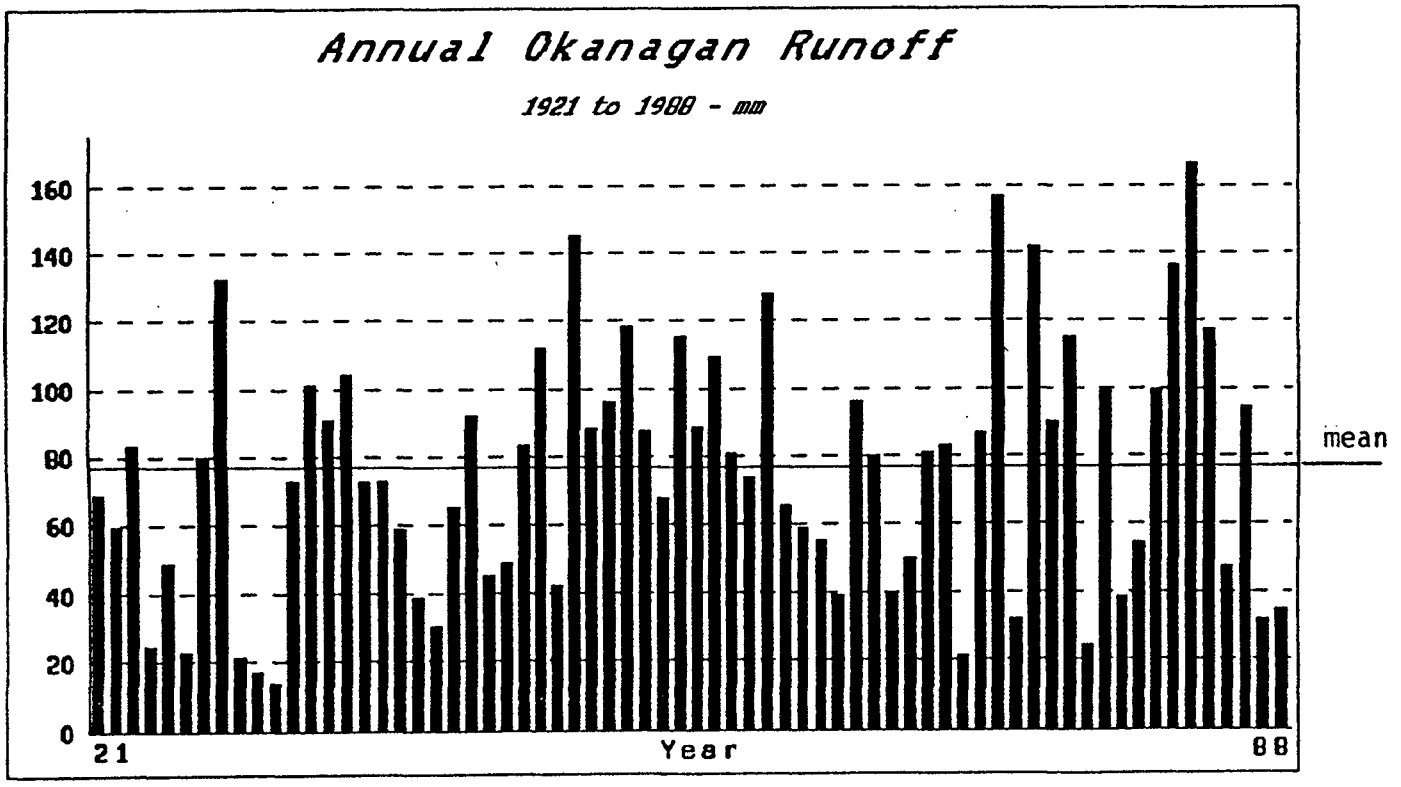

Figure 2. Annual Okanagan runoff.

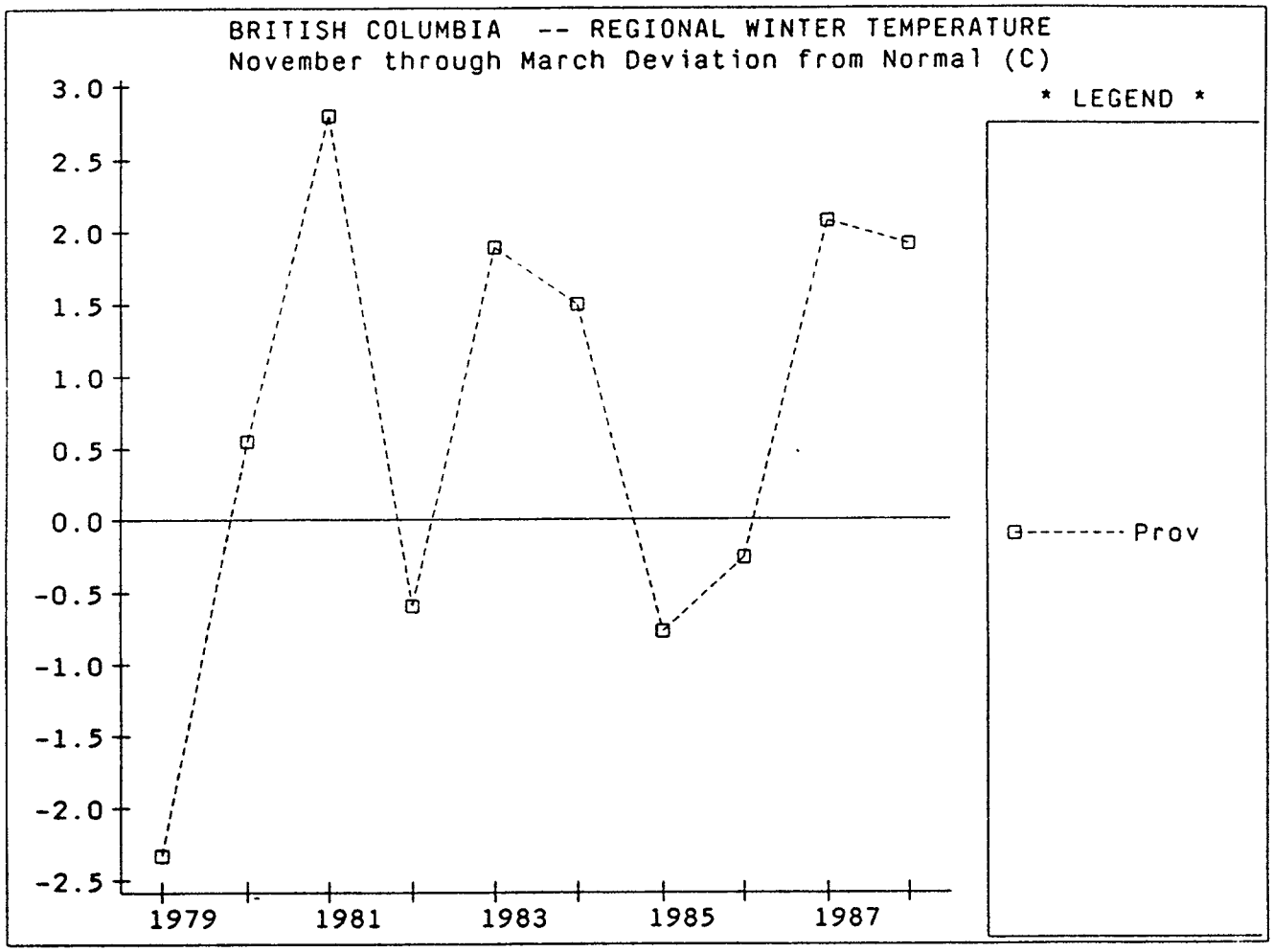

Figure 3. Regional winter temperature deviations from normal for British Columbia.

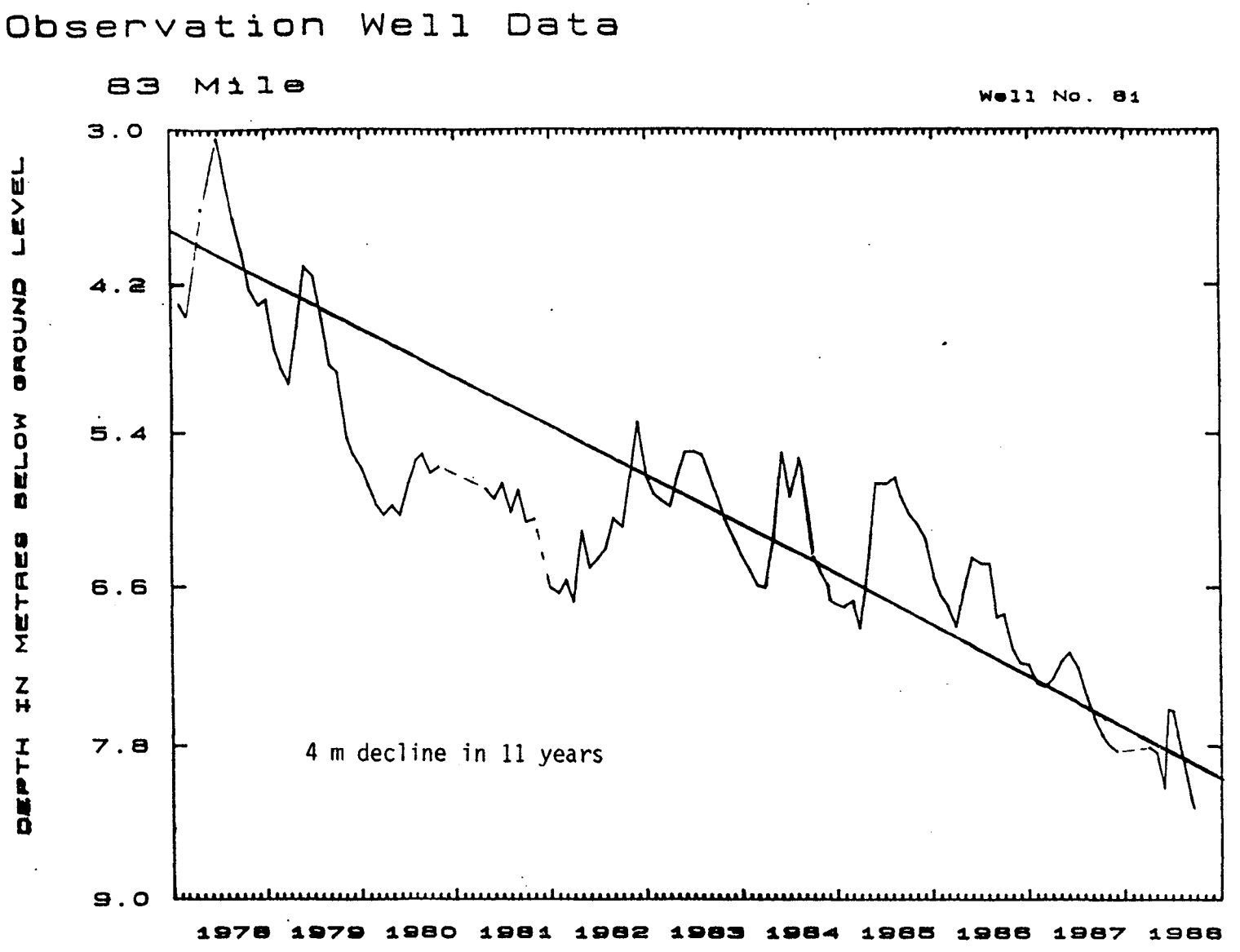

Figure 5. Well water depth at 83 Mile since 1977.

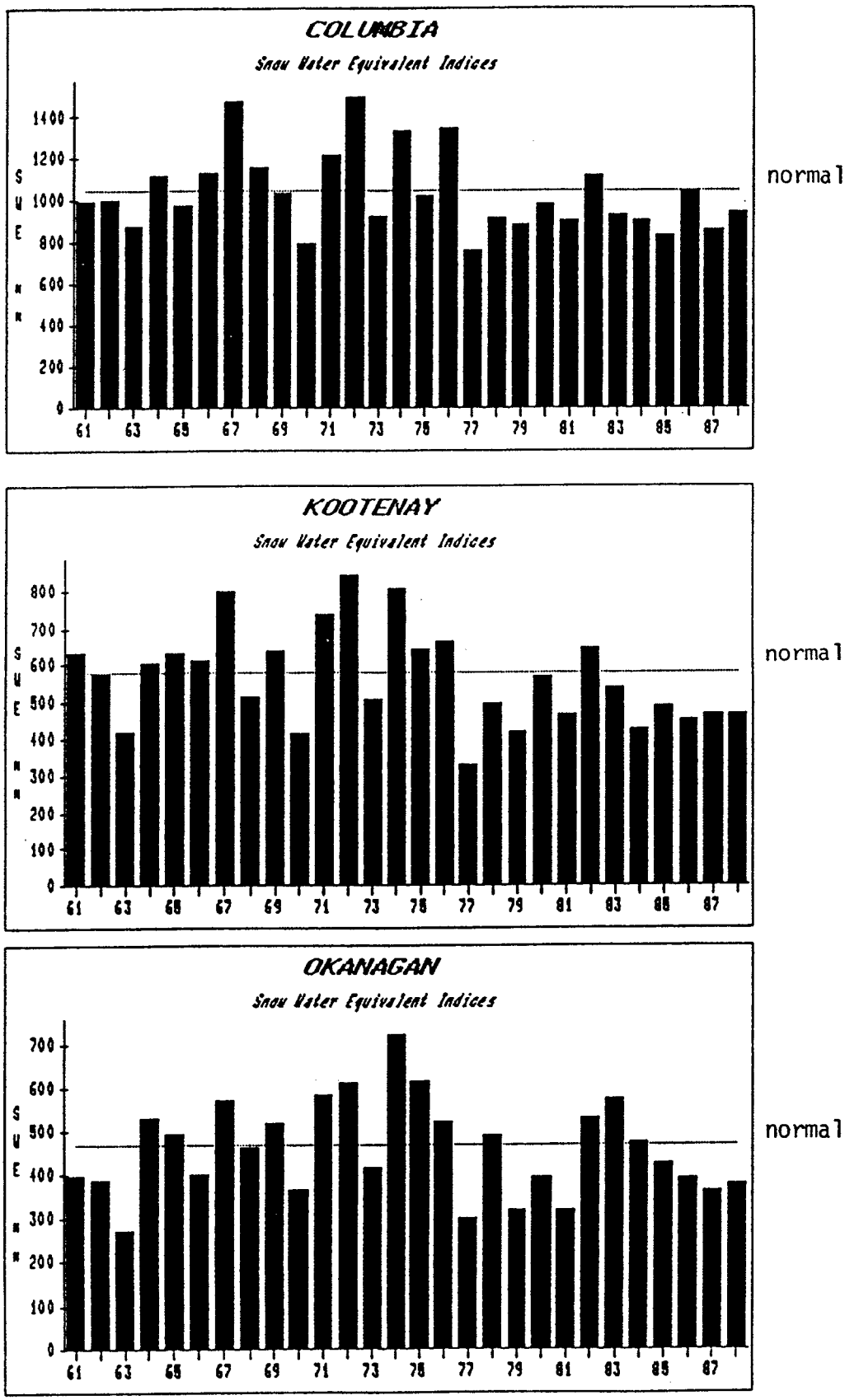

Figure 4. Basin snow water equivalent indices since 1961.

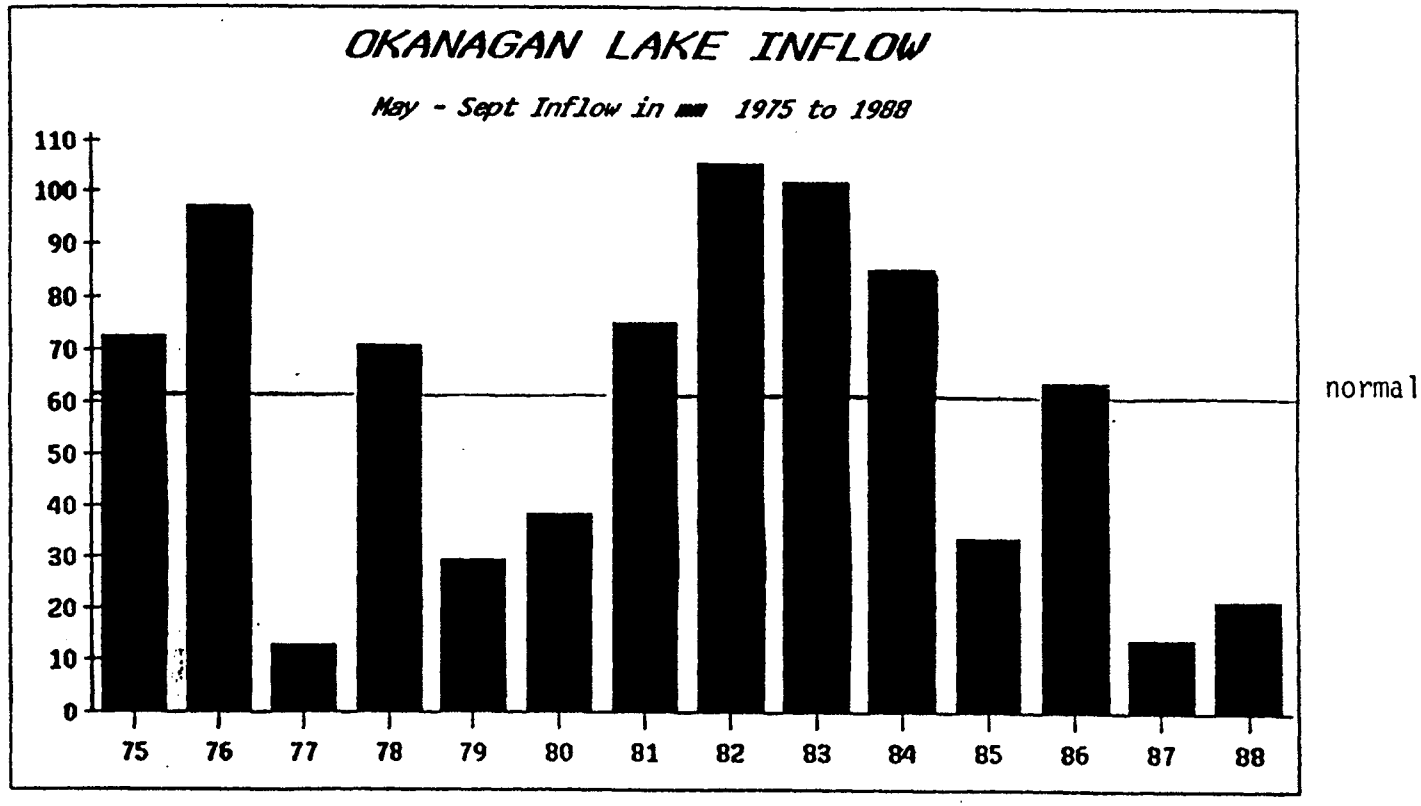

Figure 6. Okanagan Lake inflow (May to September) in millimetres.

IMPACTS OF CLIMATE CHANGE ON THE FOREST IN BRITISH COLUMBIA

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Climate change is asserting itself rapidly as a major issue in the public eye. It is characterized by great uncertainty, in its expected development, in its impacts, and in the response of humankind. The forest sector is thrust immediately into the issue because of the exceptionally long term planning implicit in modern forestry, and because of the obvious interrelationships of climate and forestry resources and practices. The possibility of moving carbon to or from the atmosphere through land use practices adds to the significance of this issue for the sector.

There is no doubt that the components of climate change - milder winters, longer seasons, more carbon dioxide - will favour productivity in forests as well as farms. However, increased productivity may not, initially, appear as merchantable timber. It may also express itself as increased diversity and increased turnover. It would seem prudent to expect opportunistic species - what we call weeds - to be favoured over our more conservative commercial species. Trees are not the only components of the forest. They are part of an ecosystem that is packed with climate-sensitive organisms, in the soil, in the ground and shrub layers, and in the trees themselves.

We should also remember that for many regions, including parts of B.C., climate change implies drought. Drought can be devastating to the security of timber resources. Northern California - which is not too far from here - contains a startling example of how climatic variation quickly impacts on timber. The mid-1970's saw two very dry summers which imposed considerable stress on extensive stands of ponderosa pine. The stressed stands became increasingly infected with bark beetles, dwarf mistletoes and root rots, some of which were favoured by the warm, dry conditions. In four years, the combined losses from drought, pests and diseases amounted to 45 million cubic meters of wood in 2.5 million hectares of national forests. This was more than the annual cut from the entire B.C. interior at that time.

In 1974, a group of scientists from the Pacific Forestry Centre determined the requirements of one of our most serious pests, the Mountain Pine Beetle. Using six climatic criteria, they worked out indices of outbreak hazard for the entire province of B.C. The criteria used for setting those indices included:

degree-day heat sums
winter temperature
maximum August temperature
precipitation from April until June
variation in precipitation during the growing season
annual water deficit.

These are precisely the kind of climate variables we can expect to see affected by climate change, and in this case, probably in favour of the mountain pine beetle. Recent observations by the Forest Insect and Disease Survey of Forestry Canada show new infestations in the Nass and Skeena Valleys of B.C., hitherto with only low indices of hazard.

I would not wish to suggest that bark beetles are already indicating that a change in climate is taking place. If our climatologists can't do this, I don't believe the beetles can. What I do wish to emphasize is that certain key elements of the forest ecosystem respond very quickly to shifts in climate, whether these are the year-to-year variability that we are accustomed to, or part of a long-term trend that characterizes climate change.

We are all familiar with the role weather plays in fire hazard. It would surprise no-one to find that climate change will impact on fire losses in this country. However, estimating fire losses from climate scenarios is not straightforward. But there is no doubt that drier than normal years lead to substantial increases in fire fighting costs, as illustrated by national data for the years 1970 to 1980. Costs in 1980 were roughly double those of any year in the previous decade.

The relationship between trees and their biological and physical environment is a dynamic relationship, and the adaptation equilibrium obtained is obviously quite sensitive to climate change. We can find examples of how human adaptations will be disrupted, by considering forestry operations. In some parts of Ontario, Quebec, and B.C., logging and hauling are essentially winter operations. Not only have fires and blackflies subsided by then, but also freeze-up makes otherwise intractable swamps passable.

Some companies, such as Spruce Falls Power and Paper Company in Kapuskasing, are highly dependent on frozen ground and ice bridges. The company has a narrow winter window through which it delivers its mill's wood requirements. Normally, roads and ice bridges are ready by January 5. In the winter of 1986-87, the formation of road bases and ice bridges were delayed by up to 3 weeks because of mild weather. In 1980-81, thaw and rain eliminated 13 days of hauling, and it required 24-hour days, 7-day weeks of working to get the wood out during the remainder of that winter.

In B.C., Northwood Pulp and Timber in Prince George have felt the absence of very cold weather in recent winters. They too suffered shut downs and production losses,

especially in the mild winter of 1980-81. Thus, even without climate change, we already have sufficient climate variation to give us problems.

One of the more certain features of climate change is that northern latitudes will experience greater changes than southern latitudes. This is partly because reduced snow cover in spring and fall will reduce the albedo of large areas of the Earth's northern surface. The resulting positive feedback is expected to amplify the global mean change by two, three or even four times as the North Pole is approached. The results will be far reaching.

On the one hand, we should be in a better position to regenerate forests on cold soils, where dense layers of moss and lichen currently insulate them from spring and summer warmth.

On the other, as ground layers are reduced we might expect impacts on other forest resources, such as woodland cariboo. In fact, the potential of climate change for impact on wildlife is another story in itself, not only in forests, but across all our ecosystems.

We can go on and on, of course, speculating on possible effects. But, initially it all boils down to the simple fact that, if our climatologists are correct, then our forests will not be adapted to the climatic regions they occupy. The potential for disruption has been illustrated graphically by Emanuel and co-workers, who took the Holdridge classification system to generate a digitized global map of vegetation. The system is based solely on the expression of temperature and precipitation in terms of associated life zones.

Their original map showed some inconsistencies with real-world vegetation, but it is an acceptable approximation for our purposes. They then generated a second map, using the temperature increment forecast for a doubled CO_2 scenario. Remarkable changes took place. Both the tundra and boreal forest disappear almost completely, to be replaced by a much extended cool temperate forest and steppe. In contrast, things change but slightly in the tropics to the south.

The same thing is now being done for the ecological land classification systems now in use in Canada. But, in order to realize the predictive utility of these systems, we shall have to modify them to be more dependent on climatic variables and less dependent on observed vegetation.

Seed zones for reforestation are essentially climatic zones, and can be modified easily to accommodate climate scenarios. The Swedes have defined seed zones that correlate spatially with climate patterns in Canada, to ensure appropriate use of imported lodgepole pine seed. In this context, we might ask ourselves where we shall get our genetic resources for stocking seed zones, especially in more southerly regions that are adjacent to extensive agricultural or urban regions, or the Great Lakes.

Canada is richly endowed with a diversity of natural forests. These forests comprise a multitude of locally-evolved, adapted populations that are still the mainstay of our industry. Current X2 CO_2 scenarios suggest that as a very rough approximation, there will be a northward displacement of climate regions of perhaps 200-300 km, possibly much more in the

north. This could take place in the next 80 years.

Does this mean that our forest ecosystems will be similarly displaced? In the long run, yes, provided that all the various components of the ecosystem can migrate. Of course, all species can migrate, but they do so at very different rates. Birds, for example, can cover great distances overnight; insects can cross a province in a few days, mammals in a matter of weeks. The migration of trees is measured in meters a year. Thus, in 50 years, firs may migrate perhaps 2-15 km, spruces, 2-25 km, pines, up to 75 km, and alder, 25-100 km. Even then, the slow evolution of soils in the new climatic regions may delay the establishment of suitable trees species.

In unmanaged forests trees may well become increasingly stressed by soil moisture deficits, increasingly ravaged by pests and diseases that are favoured by the changing conditions, and increasingly vulnerable to fire. The potential for ecological disturbance has implications for our current tree improvement programs.

At rather specific levels, we may be able to breed for traits such a drought resistance. Or we may consider moving provenances or species in anticipation of change. At a strategic level, we may need to rethink our philosophy of conservation, by which we preserve gene pools in situ and in isolation, not only as seed stands but as the comprehensive reserves we call ecological reserves and national parks. If these gene reservoirs are to have a chance to function, they must be part of an ecological continuum through which genes can migrate.

The situation may be alleviated in Alberta and B.C. by altitude. Mountains obviously form barriers to migration. But they also create ecological gradients on a local level, perhaps with sufficient variety that local gene pools can be contained intact within valleys and watersheds.

By definition, the managed forest is better protected from fire, pest and disease, and may well contain some cleverly proportioned seedlots that are ready for the new conditions. The intensively managed forest should have one singular advantage over the unmanaged forest - a shorter rotation. The shorter the rotation, the less we have to commit our investment to a changing environment. This may be the forester's cheapest and most effective strategy for addressing the climate change issue.

We tend to focus on the downside of climate change for forestry. The answer for any single factor is seldom cut and dried. This is because climate change of any kind will be a disturbance, and will affect all aspects of our ecosystems, including forestry operations. Nevertheless, there may be a brighter side to things. For a start, we can expect our trees to be fairly resilient to change, simply because of their long life cycles and the inherent genetic variation within populations. Possibly coming to the aid of foresters in this pursuit is the culprit gas itself, carbon dioxide.

The atmosphere has already been enriched in this most basic of fertilizers by 25 percent since the industrial revolution. To my knowledge, no one has yet shown conclusively that tree growth has responded. It is a very difficult job to unravel this particular thread from all the other changes that trees are now subject to. But consider the possibilities presented by CO_2

enrichment. Glasshouse crop growers have long known the benefits of CO_2. Controlled environment experiments have shown us that trees too will respond to CO_2 enrichment. But some species will be more responsive than others. In a word, hardwoods seem to be generally more opportunistic when it comes to just about any environmental improvement. Softwoods tend to be more conservative, because of the lock-step growth strategy they have evolved.

A response has been claimed for several species of pine. This response may be associated with the improved efficiency of water use that occurs with CO_2 enrichment. Simply put, stomates tend to close as CO_2 becomes more available, thereby reducing transpiration. The phenomenon has sparked considerable controversy over the effect of climate change on run-off. Some scientists believe that run-off will actually increase in forested arid regions as a result of reduced transpiration. Herbarium specimens of tree leaves collected 200 years ago actually show 60 percent more stomates than their modern counterparts. This may not necessarily reflect an evolutionary response, but there may well already be an adaptation to the higher concentrations of CO_2. It may be, therefore, that higher growth rates are not a foregone conclusion in long-lived species with wide adaptive capabilities.

We must also remember those bugbears of regeneration - weeds. Weeds are opportunists. They are rampant, short-lived, and highly productive. A comparative analysis of stocking species and their associated weed species under artificial enrichment of CO_2 would be useful at this point. We can also consider breeding for response to CO_2 enrichment, although the benefits may be limited to fast-growing poplar hybrids and the like.

There is another side to the CO_2 coin. Being a primary building block of biomass, carbon accumulates in trees in very substantial amounts. Half the dry weight of wood is carbon. A cubic meter of wood contains over a 1/4 ton of carbon. There is as much carbon in the living biomass - most of which is forest - as there is in the global atmosphere. Actually, we need a small correction here. Up until a century ago, there was 25 percent more carbon in the world's biomass than in the atmosphere today. Now there is 22 percent less than the atmosphere contains.

What this means is that there has been a net loss of 340 gigatons of carbon from the world's living biomass. Perhaps a larger quantity has been lost from the world's soils (a gigaton is a thousand million tons, or 10^{15} grams).

We are currently releasing close to 6 gigatons a year from the combustion of fossil fuels. Is it possible to compensate for the injection of fossil carbon with appropriate management of the terrestrial biomass i.e. the forests? The short answer is yes, in theory. There is sufficient potential for enhanced growth in the world's forests to boost carbon assimilation for a few decades to balance combustion of fossil fuels. Before we consider whether this is achievable, we must first remember that CO_2 is only half the problem. Other greenhouse gases such as methane, ozone, CFC's and nitrogen oxides, collectively affect climate as much as CO_2, and their effect is increasing. Furthermore, no matter how much extra growth we generate, sooner or later the trees will be cut, burned, or otherwise killed. The release of their accumulated carbon starts immediately.

In North America, the area of forest land has probably stabilized, and we can expect both volume and growth rates to increase modestly over the coming decades. In fact, North American forests will probably form a net sink for carbon. The actual amount of increased growth needed to fully compensate for fossil fuel emissions is enormous. One way to achieve full compensation would be to establish 500 million hectares of new, highly productive plantations in the tropics. That will be difficult: we are currently losing 18 million hectares in the tropics every year. Another approach would be to increase growth over the entire 3000 million hectares of closed forests around the world. The required increase of 1.7 ton carbon per hectare per year translates into 6 cubic meters per hectare per year, a daunting prospect for any forester.

Nevertheless, public opinion may force foresters to look at the opportunities they have to help resolve the climate change issue. We should therefore consider some of the more obvious options, such as protection of our large carbon reservoirs, including forest soils; we must brace ourselves for energy restrictions and new demands for renewable energy. And there is a desperate need to help developing countries to improve their fuelwood resource. Really, there is nothing new here. It is just sound forestry in an era that calls for sustainable development.

Our efforts in forestry are fragmentary at present. Nevertheless, concern over climate change has been expressed in the new National Forest Sector Strategy. The Strategy recommends enhanced monitoring of pollutants, reduction in emissions, and continued research into the mechanisms and impacts of pollutants. Forestry Canada itself has drafted a strategy to address the climate change issue specifically. The Northern Forestry Centre has contributed significantly to the Saskatchewan Research Council's analysis of climate change and its implications for the Boreal Forest, funded by the Atmospheric Environment Service of Environment Canada. The Pacific Forestry Centre has just committed its program to a new project on climate change.

Whatever we do, we must ensure that our priorities are aligned with what is practicable, what is most urgent, and what is most vulnerable to climate change. We can adapt some of our operational activities very rapidly, and keep ahead of the change. We can change our product range surprisingly quickly to suit sources and markets. But we cannot readily change our basic resource. And it is the resource that is vulnerable. It is being placed in the ground right now, for a generation that will indeed experience climate change.

SEA LEVEL RISE AND IMPLICATIONS TO COASTAL BRITISH COLUMBIA: AN OVERVIEW

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INTRODUCTION

In any discussion of sea level rise, at this point in time, there will likely be more questions than answers. Regardless, if there is to be a serious and concerted effort to anticipate and plan for this possibility then there can be no bias; all possibilities should be considered and hypotheses tested. The purpose of this symposium was to prepare the groundwork for this type of planning.

The paper is presented in four parts:

1. A brief introduction to the nature of the B.C. coast.
2. The key processes which presently shape the coast.
3. The implications of sea level rise, in light of the above two parts and potential effects on susceptible areas.
4. Concluding questions for future considerations and action.

COASTAL BRITISH COLUMBIA

The Pacific Coast of Canada is 25,717 km long or 10.5% of the total Canadian marine shoreline. It has a complex history which is reflected in its mountains, narrow coastal lowlands and fjords. Figure One illustrates the coastal physiographic regions of British Columbia.

Coastal Character

Table One provides a summary of coastal character distribution. Clearly, the coast of British Columbia is bedrock dominated. This general character can be further subdivided into what researchers have defined as replicate shoreforms. That is, simple shoreforms which can re-occur throughout a coastal area (Owens 1980, Howes 1980, Harper 1981, 1983, Bastaja 1983, Levis 1984, Dunn 1984). There are perhaps nine such units which represent most of the shoreforms likely to be found on the British Columbia coast (Table 2).

TABLE 1: COASTAL CHARACTER DISTRIBUTION

- BRITISH COLUMBIA

COASTAL TYPE	PERCENT OCCURRENCE
Bedrock	83
Mixed (Bedrock and Sediment)	8
Beach	6.5
Fjord Delta	1
Open Coast Delta	1
Mud Flat	0.5

TABLE 2: REPLICATE SHOREFORMS

Bedrock
Cliff/ramp
Platform
- with sediment veneer (<1 m)
- without veneer

Unconsolidated
Cliff
Beach (spits, tombolos, and dunes are included here)
- fine textured
- coarse textured

Man-modified

Bedrock Coasts

McLaren et al, (1983) note that cliff and ramp coasts are most commonly associated with igneous, metamorphic, and volcanic rocks. They state that these rock types are highly resistant to marine erosion. Cliffs associated with sedimentary rocks are also present, but not as extensively.

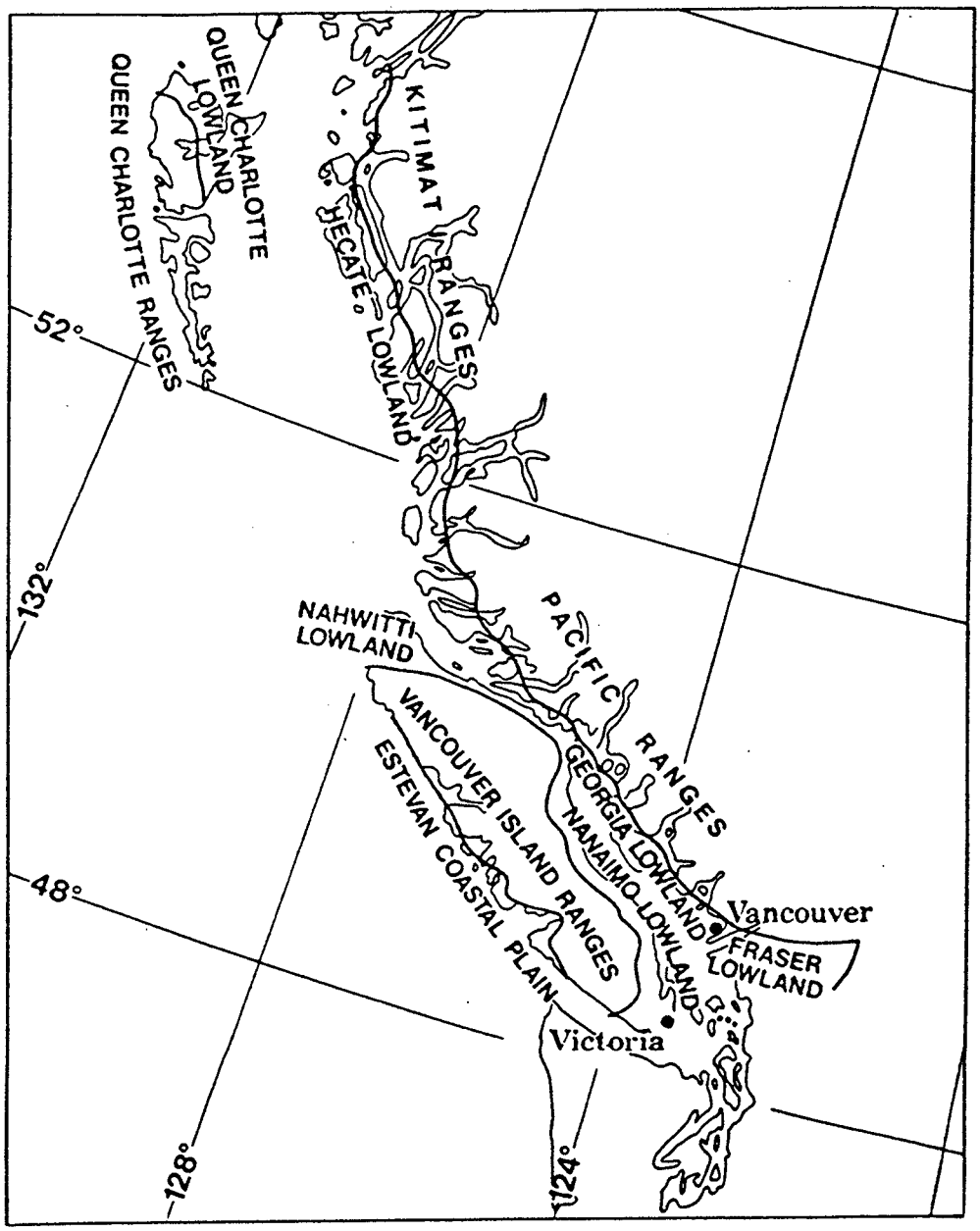

Figure 1. Physiographic divisions of coastal British Columbia (after Bostock 1970 and Holland 1974).

Platforms, on the other hand, are found predominately along the sedimentary rock shorelines. These are wave cut features, some with steep cliffs at, or above the high water mark. These types of rocks are much less resistant to marine erosion processes.

Many of the platform systems of the coast have beach veneers in the upper tidal zone. These sediments are generally associated with local river discharges, glacial deposits, or in situ weathering of the sedimentary parent rock.

Unconsolidated Coasts

Cliffs: Spectacular eroding coastal bluff systems are the sediment sources for many of the more extensive beaches along the coast. Much of the material is of glacial origin and of variable texture. Notable examples of these bluffs are found within the Strait of Georgia, west coast Vancouver Island, and northern Graham Island (Queen Charlottes).

Beaches: Beaches along the coast are more often coarse textured, narrow, and discontinuous. Extensive beach systems, however, are found where sediment supplies are large; examples are eastern and western Vancouver Island, the southeast shores of the Georgia Lowland, and the northeast Queen Charlotte Islands. The pocket beach-rock headland systems are more common, in that they occupy a greater percentage of total shoreline (8%). They tend to be small features commonly under one km in length, but repeating along the shore.

Deltas: Claque and Bornhold (1980) identify 2 types of deltas which occur along the British Columbia coast; fjord deltas and open coast deltas. They estimate 182 major fjord delta systems which occupy only one percent of the total shoreline length. Many of these deltas are prograding at rapid rates due to their large sediment load from alpine glaciers. Of the 42 open coast deltas those of the Skeena and Fraser rivers are the largest. The major concentration of smaller open coast deltas (over 50%) are located on eastern Vancouver Island (McLaren et al. 1983).

Tidal Flats: These features are a minor component of the coast, occurring virtually anywhere that offers shelter from wind and waves and has a source of fine sediments.

Man-Modified: About 80% of the population of British Columbia lives on or near the coast. Fully 70% are located around the Strait of Georgia. Table Three provides a summary of the most common types of shoreline modifications.

PRESENT COASTAL PROCESSES

These are the modern processes which act continuously on the coast, which either alone or in concert, help to shape the shoreline. As trends in sea- level change, these processes will be major factors in the effects on the coast and how we respond.

Tectonics

Coastal British Columbia is situated near the junction of major crustal plates, the tectonics of the region thus are very complex. Figure Two provides a graphic illustration of the movement of the coast relative to the present sea level. The trends indicate general uplift on the outside islands' coasts with subsidence on the inner coast. Given the rate of subsidence for the Fraser Lowland (-1 mm/year) one could anticipate a relative rise of sea level in the order of 10 cm over 100 years. This would occur regardless of the extent of the greenhouse induced water level.

TABLE 3: COMMON MAN-MODIFIED SHORE TYPES

STRUCTURE	EXTENT
Shore Armour (riprap, sheet piling, rubble)	Coastwide in association with marinas, small craft harbours, private property and shore protection.
Breakwaters	Coastwide in association with marinas, small craft harbours and some ports.
Seadykes	Most in association with coastal deltas used for farming. Presently the Fraser and Squamish Deltas have upgraded seadykes.
Seawalls	Associated with protection of railways or roads on the shorezone or to provide recreational access to the shorezone, e.g., Stanley Park seawall in Vancouver.
Jetties	The largest of these structures are associated with the Fraser River Training works, and Roberts Bank coal terminal.
Groynes	Very localized to prime recreational beaches near Vancouver and some private residential areas on eastern Vancouver Island.

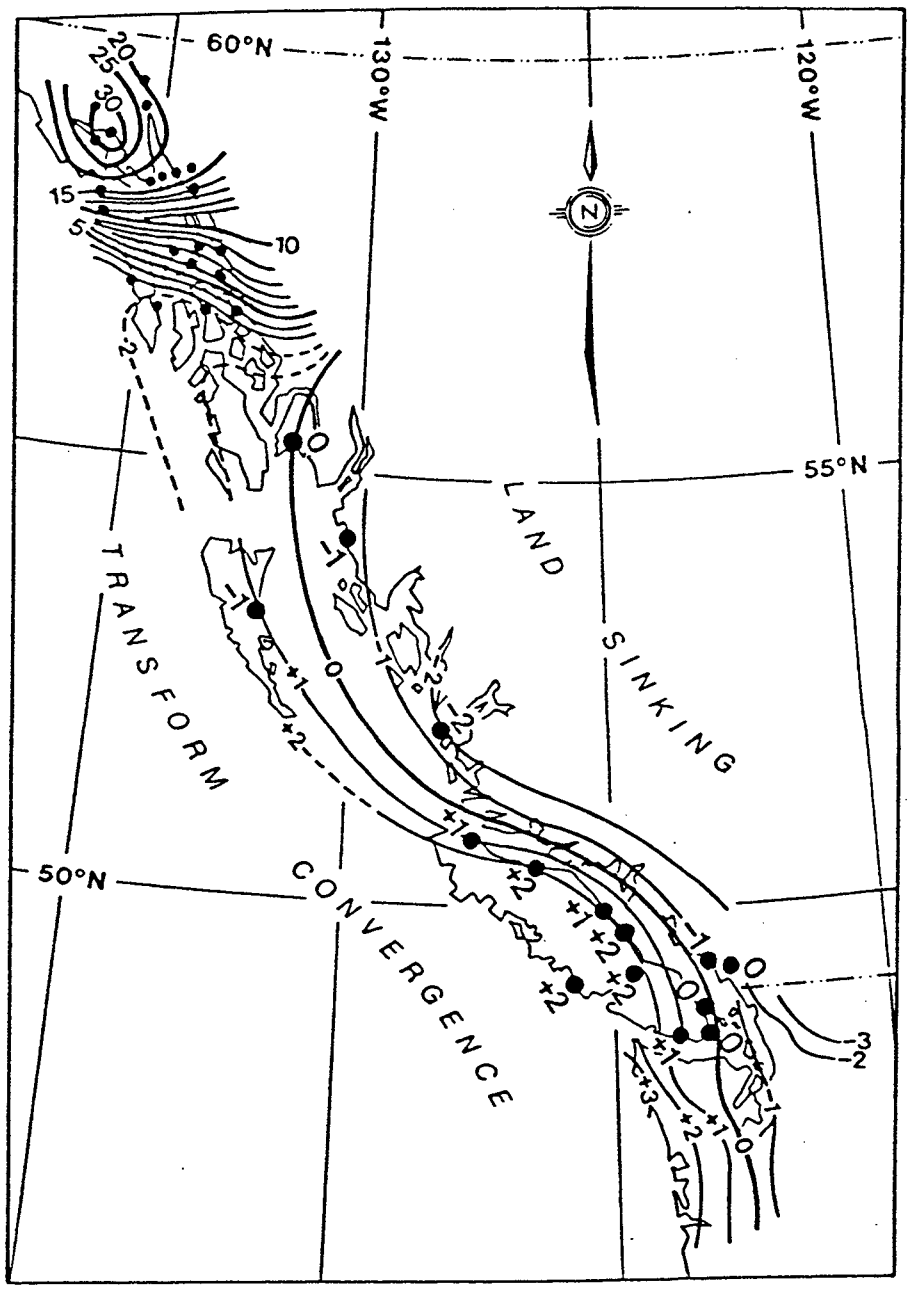

Figure 2. Vertical movements of land relative to sea-level in mm/yr based on tidal records (after Riddihough 1982, in McLaren et al. 1983).

Waves and Littoral Currents

In terms of worldwide geographical variations in wave height, the Pacific Coast of Canada ranks among those with the highest wave energy levels. Waves upon the shoreline act continuously to breakdown the coast and distribute sediments along and offshore. Additionally, waves and related littoral currents are a constant hazard to coastal structures and property.

Tides

Tidal processes are significant in that they not only influence the movement of sediments but, more importantly they help to distribute wave energy over the intertidal area. Tidal ranges for coastal British Columbia are from 4 m in the south to 8 m along the north coast.

Storm Surge

Storm surges result from intense low pressure weather systems which push up the level of water as they approach the coast. They are considered a hazard and compound the effects of tides and waves on the shorezone. In British Columbia surges typically range between 1 m and 1.5 m with a 1 in 12 and 1 in 20 return probability respectively. These are not infrequent phenomena. Figure Three represents a typical storm surge profile measured on this coast.

Riverine Processes

Many of the rivers which enter coastal British Columbia are unregulated. These systems serve to move sediment from the upland to the coast, where they are sorted and distributed by marine dominated processes. These rivers fed by glacier melt-waters tend to be heavily sediment laden at certain times of the year (Bella Coola River). Others, however, contribute very small amounts of sediment (Nanaimo River). For example, the Fraser River discharges over 15 million metric tons per year of sediment to the Strait of Georgia. At Sandheads, this represents a sedimentation rate calculated to be 8.6 meters per year. A typical fjord-head delta, during peak freshet, can have a sedimentation rate in the order of 9 meters annually. Compare this rate to the Nanaimo River delta which has reached an equilibrium and in fact, is a relatively stable shoreform.

Biological Processes

These are the processes which serve to stabilize and colonize accreting shorelines. Examples include dune stabilization, coastal wetland development, and tidal flat colonization. The latter two processes are important in that the areas created are among the most productive systems and are critical to the survival of many fish and wildlife populations.

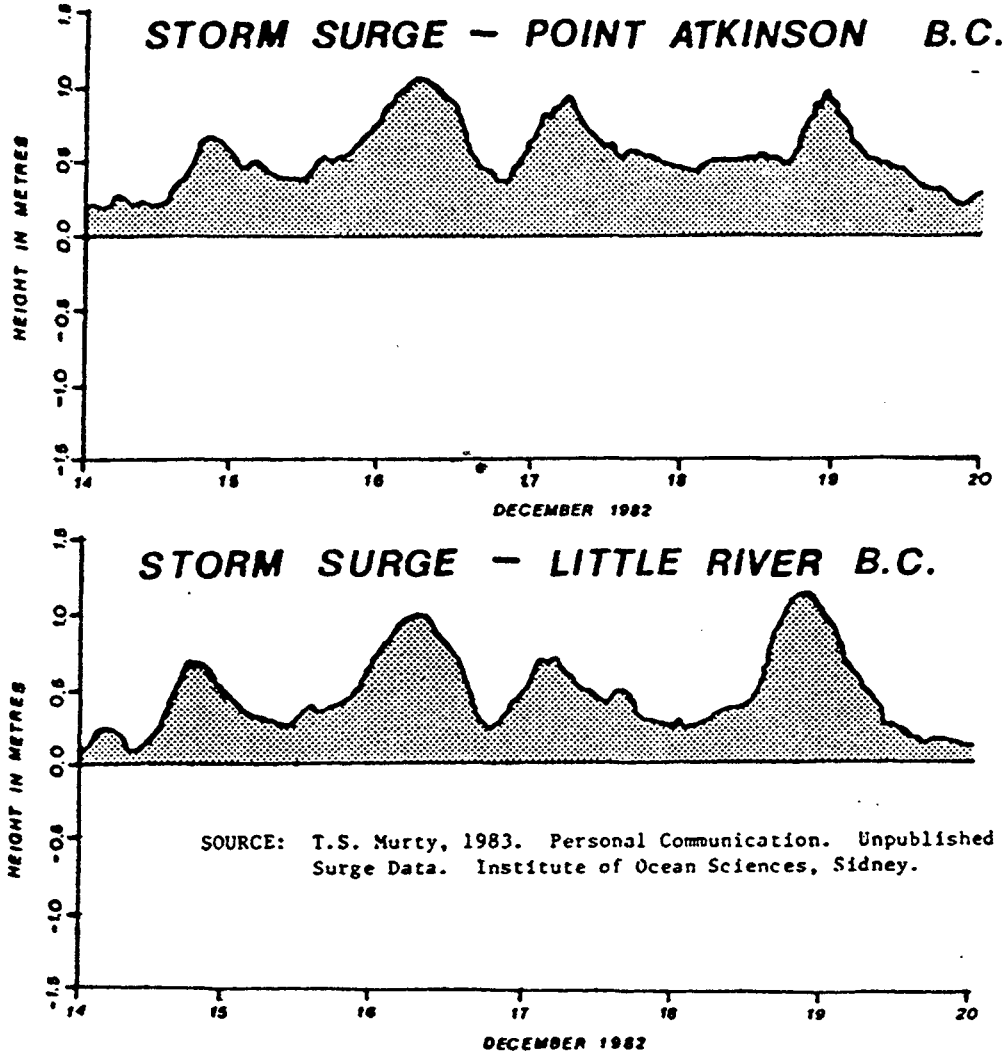

Figure 3. Storm surge profile for December 14-20, 1982.

IMPLICATIONS OF SEA-LEVEL RISE

In the following discussion the assumed scenario is a one meter rise in relative sea-level over the next 100 years. Two general mechanisms are expected to be the main contributors to a rise in sea level in response to the greenhouse effect. They are:

Thermal expansion: As the greenhouse effect increases and global temperatures trend upward, it is expected that the oceans will absorb much of the initial temperature increases causing an increase in sea surface temperatures. This increase will expand the water and raise relative sea levels around the margins of the ocean basins. Measurements and predictions of this effect are expected to be fairly accurate as the principles involved are well known.

Glacial/Ice Cap Melting: As the global trends in atmospheric temperatures increase it is expected that there will be less extremes of cold temperatures such that alpine glaciers and polar ice caps will begin to melt. The amount of freshwater bound by these ice masses is considerable and their effect on sea level would be very significant. Presently, there are ranges of predictions as to the actual contributions to sea level rise. These predictions are still largely based on scenarios, actual measurements are sparse to non-existent. Table Four provides a summary of estimates by various authors; thermal expansion is included for comparison.

TABLE 4: ESTIMATES OF FUTURE SEA LEVEL RISE (CENTIMETRES)

Year 2100 by Cause (2085 in the case of Revelle 1983):

	Thermal Expansion	Glaciers	Alpine Greenland	Antarctica	Total
Revelle (1983)	30	12	12	a	70
Hoffman et al. (1983)	28-115	b	b	b	56-345
Meier et al. (1985)	-	10-30	10-30	-10 - +100	50-200[c]
Hoffman et al. (1986)	28-83	12-37	6-27	12-220	57-368
Thomas (1986)	28-70	14-35	9-45	13-80	64-230

a - Revelle attributes 16 cm to other factors.
b - Hoffman et al. (1983) assumed that the glacial construction would be one to two times the contribution of thermal expansion.
c - This estimate includes extrapolation of thermal expansion from Revelle (1983).

From: J.S. Titus, et. 1987. Greenhouse Effect, Sea Level Rise and Coastal Wetlands. Office of Policy Analysis, U.S. Environmental Protection Agency, Washington, D.C. 20460. p.8.

Effects on Coastal British Columbia

There would be three major effects of a rise in sea level on the B.C. Coast. They are:

1. Coastal erosion/sedimentation
2. Coastal flooding
3. Permanent inundation of low gradient, intertidal areas.

Given these effects, what are the most susceptible shorelines? A brief overview of these features and the likely effects is provided below.

Low Gradient Bedrock Shorelines

Low gradient rock shorelines with unconsolidated backshores are very common in the Gulf Islands and they represent the prime waterfront property of this area. Higher water levels would allow wave and log debris attack at the backshore area and result in the inland movement of the shoreline. This would be at the expense of some very valuable real estate.

Coastal Bluffs

These features are common around the Strait of Georgia but exist elsewhere along the coast. Many are presently problematic including Cowichan Head (Saanich Peninsula), Point Grey (Vancouver) and Cape Lazo (Comox). Additionally, these bluff features are a source of sediments for some of our most spectacular beaches and accretional shoreforms. These include Sidney Spit Marine Park, Long Beach and Goose Spit.

High water levels will increase the wave effects on the bluffs, thus increasing erosion rates. Cliff top retreat would accelerate.

For eroded sediments, littoral processes would move it offshore and alongshore. However, it is unknown as to whether or not this increased sediment supply would maintain the present valuable beach and shoreform systems above the rising sea. The human response to this increased erosion will be largely predicated on the perceived value of the upland area. Should it be defended or left to reach a new equilibrium?

Beach Barriers - Wetland Systems

These are not common features along B.C.'s coast, nonetheless they do represent a significant and productive wetland system. The effect of rising sea levels would be more frequent breaching, and perhaps even permanent inundation of the barrier allowing intrusions of saltwater and sediments into a generally brackish to freshwater system.

The ability of the established wetland vegetation to adapt to this new regime is unknown. It is likely that there will be a short term, net loss of some plant and animal species with a gradual replacement by more salt-tolerant ones. The effect on overall productivity is unknown at this time.

Delta Estuarine Wetland Systems

For coastal B.C., sea level rise would have the single most crucial environmental impact on these low-gradient features. Where undyked, many will be permanently inundated by salt water. Several factors influence the effect of this inundation.

1. If there is a gradual water level rise then the wetland community may adapt by moving inland. This would only be possible if there is adequate and suitable upland area to do so. That is, no topographic restrictions or man-made hindrances.

2. For the glacier-fed coastal rivers the climate change will increase wash load sediments from glacial melting. Whether this increased sediment supply is enough to continue to build the delta as sea level rises is unknown. As well, the changes in precipitation are also not well understood on the local level. However, given some of the present rates it is likely that delta building processes will keep pace in some instances. The wetland units, therefore, may be able to continually colonize the new level.

Should the natural processes not be able to keep up to sea level increases then the significant effects expected would include:

- The loss or reduction of brackish and freshwater wetland plant and animal species and their replacement over time by more salt tolerant species representing a potential loss of natural diversity.

- As the shoreline moves inland in response to sea level rise, the effects of waves and tides move inland as well. Present marsh areas would be subjected to wave action on a frequent to continuous basis thereby increasing erosion and redistributing the fine sediments.

As these wetland areas represent critical waterfowl wintering and fish rearing habitats, the effects of a reduction in their already limited area or productive capacity must be a crucial consideration for future studies.

Cultural Features

Coastal B.C. has a rich cultural heritage and many remnants of our early pre-settlement history are found along the coast. Higher sea levels will seriously erode or inundate many known and perhaps unknown sites of importance. An example is the Nistints site on Anthony Island, a world heritage site. Many of the standing mortuary poles are just above present higher-high water. What action, if any, would be taken to preserve this site as sea level begins to rise?

Recreational Features

Low gradient recreational beach areas will have their intertidal area reduced or shifted inland while the backshore will also move inland. The erosion of the intertidal and backshore areas and redistribution of sediments would be expected to continue until a new equilibrium

is established. The continued viability of the beach system and its desirable sediments cannot be predicted at the present time. The above assessment, of course, assumes that there will be no intervention to protect backshore areas or sediment losses to the offshore. On the eastern U.S. seaboard, where present sea level rise is a problem, areas with high recreational/ tourist values already are experimenting with remedies such as beach nourishment to maintain an artificial equilibrium. Figure 4 illustrates the response of the beach profile to successively higher sea levels known as the Bruun Rule. This knowledge has been used to calibrate the beach nourishment requirements. Could this approach be an option for coastal B.C.?

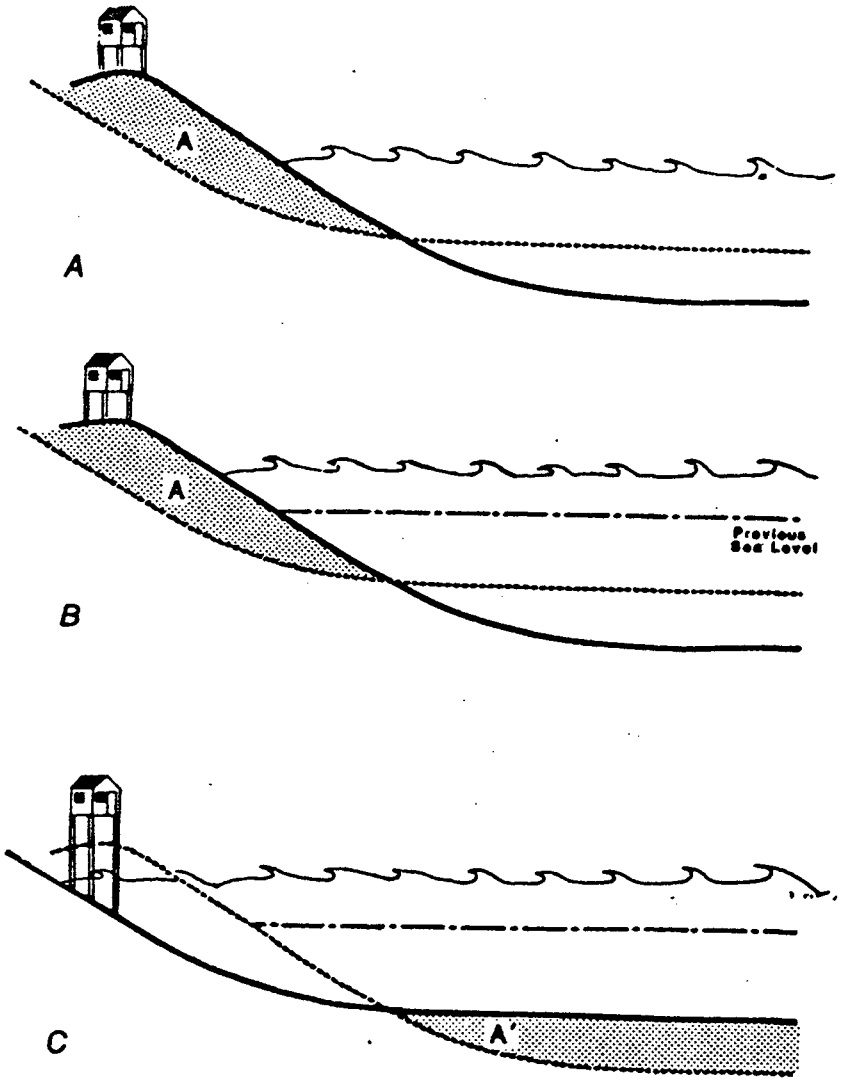

Figure 4. The Brunn Rule. *A*, initial conditions; *B*, immediate inundation when sea level rises; *C*, subsequent erosion due to sea level rise. A rise in sea level immediately results in shoreline retreat due to inundation, shown in the first two examples. However, a 1 metre rise in sea level implies that the offshore bottom must also rise 1 metre. The sand required to raise the bottom (A') can be supplied by beach nourishment. Otherwise, waves will erode the necessary sand (A) from the upper part of the beach as shown in *C*.

Man-modified Shorelines

When dealing with the potential for impacts of sea level rise on man-modified or valued shorelines it should be noted that engineering solutions are perhaps the most costly, especially if done as remedial efforts rather than preventative. A rise in sea level would increase incidences of flooding and storm related damage to coastal structures and properties. As well, in low lying coastal areas, natural drainage and municipal sewage and drainage works utilizing gravity or natural patterns are at risk to increased flooding during high rainfall. Related coastal structures are vulnerable to storm wave and storm surge damage. Coastal communities susceptible to these processes must decide, at an early stage, whether or not it is desirable to design modifications that consider future sea level rise. This would have to be done in spite of the uncertainties about what the future levels might be.

Specific areas which would be affected include:

Fraser Delta

The Lower Fraser Delta will, perhaps, require the most innovative policy, planning and engineering considerations. Many of the structures and works in place along the river, including the dykes, have built-in design features such as a 1 in 200 flood level or a 1 in 200 storm surge level. These safety factors ensure the viability of the structure over a predicted period of time. A rapid rise in sea level over a short time has not been included in these calculations. The simple response would be to increase the height or capacity of the protection, yet at what cost? For example, the Fraser Dyking Program sea dykes, which have been constructed along part of Boundary Bay, represent the upper limit of a well established salt marsh community. Given a gradual rise in sea level, the marsh community response would be to move inland. In this case, however, it would not be possible, thereby putting it at risk to increased wave effects. The erosion of the marsh and even its total loss is a probable scenario.

In terms of the sea dykes themselves, higher base sea level in concert with a storm surge, waves and log debris could have serious affects on the integrity of the structures. The response to this scenario would be to widen the base and raise the crest of the dykes to withstand the new extremes. Again, the marsh community would be significantly affected by this activity alone.

Within the Lower Fraser River system other effects could include:

- The effect of increased salinity on the extensive estuarine marshes. Will there be a loss of diversity and productivity? Impacts on these marshes would be further compounded due to wave activity moving into the present high tide line.

- Increased sea level will push ground water levels up behind dykes, thereby requiring increases in pumping capacity.

- With climatic warming, the alpine glaciers will contribute larger volumes of wash load (suspended) to the Fraser. This sediment presently is directly discharged into the Strait

of Georgia. It would be expected that the delta area at Sandheads would increase more rapidly in response to increased suspended load.

- As the volume discharge for the Fraser increased there would be a tendency for the river to increase the scouring of its shorelines. The implications of this effect could be substantial.

- Effects of salt water intrusion and the upstream migration of the salt wedge on flood tides are not known. The related effect on tidal levels on the lower river also are not known.

Englishman River Delta

This river delta system was chosen as an example of the dilemma faced by government with respect to existing property owners (some of which already have an erosion problem) and their susceptibility to sea level rise. These properties are located on a relict gravel barrier on the delta. Present littoral processes are actively redistributing sediments alongshore. Behind this barrier is a coastal wetland system which is also susceptible. In fact, this area has a water fowl reserve dedicated and recently has undergone some enhancement of the wetland. In terms of response to sea level rise what would be the priority in this instance? Wetland or real estate?

CONCLUSION

A brief overview of the key implications of sea level rise to coastal B.C. has been presented, there have been numerous questions and impact possibilities identified. One must bear in mind that any effort to reduce the impacts of sea level rise through advanced planning must recognize the uncertainties and long-term nature of the issue. Given the sparseness of many of the susceptible features and their significance to coastal productivity, efforts to identify and develop appropriate responses must begin now. For the relatively dense population around the Strait of Georgia the process to define the hard decisions on what should or should not be done to the susceptible shorelines must begin immediately.

QUESTIONS TO PONDER

1. At what time should the planning of future coastal projects take into account the risk of sea level rise:

   - should it wait until there is more compelling evidence, or
   - should there be a basic assumption now that a rise will occur and do anticipatory planning based on this?

2. What will be the basic strategy with respect to erosion of shorelines.

   - will the first response be defence, or
   - in terms of wetland habitats that will be inundated, will the strategy be to allow them to migrate inland to reach a new equilibrium wherever possible, even at the expense of valuable real estate?

3. With the potential loss of present aquatic habitat how will the no net loss principle be applied in response to rising sea levels?

4. In terms of anticipatory planning what tools are available now to reduce the impacts of sea level rise on coastal areas? Some include:

   - the identification of classes of susceptible areas and strategies developed for each class; (Such strategies could include dedicated buffer areas in subdivision planning, covenants on private lands that stipulate that certain properties revert to Crown lands after a defined period (100 years), expropriation of lands which have become hazardous, all vacant Crown foreshores especially delta/estuarine areas be allowed to naturally adapt to changing sea levels, i.e. no flood protection or protection of areas through engineering works.)

   - if sea level rise is accepted, what new areas of research would be needed in order to benefit the planning process, eg. applied research, modelling, habitat redevelopment, organism response and survival in increased salinity in estuarine areas?

5. What options are available to maintain recreational beach areas?

6. How and when should the message of the implications of sea level rise be presented to the public and local planning authorities?

7. What is government's responsibility in helping coastal communities cope with sea level rise and who should show leadership?

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WATER RESOURCES WORKSHOP REPORT

by

P. Duffy
Symposium Rapporteur
West Vancouver, B.C.

There is a need to develop and maintain a public information program. Keeping in mind the level of uncertainty on climatic change trends, it will be important to convey an accurate picture to the public-at-large while maintaining scientific credibility. The challenge is to convey an unambiguous message and reflect the uncertainties, in order to avoid contradictions. It is time to begin informing the public about adaptive and preventive measures, i.e. the need to adapt to the inevitable change which is predicted and the need to "restrict the build-up of greenhouse gases." In all of this it will be necessary to target the public and carefully construct the message. This information program should also seek to inform other professional groups (e.g. economists, planners) and should involve communications specialists in its planning and execution.

Research Needs

In terms of research needs, it was held that general circulation models are not designed for regional impact studies but rather for global sensitivity studies. Therefore it will be necessary to develop methodologies for regional impact studies, while continuing to bring improvement to the general circulation models in the long run.

Research needs to be concentrated on the physical processes and links between meteorological variables and hydrological response. Evapotranspiration is a very important factor here, because there is a critical inability to measure or estimate evapotranspiration at a level of accuracy for use in models of climatic change. There is also a need to develop physical models of responses to climate extremes. As well, it will be necessary to extend the system of benchmark stations at which climatic change data is gathered, over and above the British Columbia stations presently being used.

Next steps

It was recommended that a broadly based representative forum should be held in B.C. to identify and discuss the issues associated with climatic change. Public sectoral workshops should be held with the intention that they report back to a regional climate change coordinating committee.

In terms of communications, there is a need to distribute information to target groups in a timely way. Existing newsletters and the CO_2 Digest are not filling the need. Computer based bulletin boards are being used by some agencies and could be applied to the distribution of climate change information.

Other action items called for included support for the 1990 Congress of the Canadian Meteorological and Oceanography Society which will deal with climatic change, identification of informed speakers on climatic change, and a workshop on data gathering, collation, and analysis relevant to the subject of climate change.

FOREST RESOURCES WORKSHOP REPORT

by

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There was general consensus that climatic change is a major issue for the forestry sector in B.C. and that early action is required on a number of fronts. As with other sectors it was emphasized that the scientific data base is not precise enough for predictions of impacts. However a number of actions can be taken now, at the same time that the data base is being improved. These include energy conservation, conservation of gene pools of living material, enhanced technology transfer using existing knowledge, public information programs on climatic change, and making current information from the federal Atmospheric Environment Service (Climatic Change Program) more available to users interested in climatic change.

The public-at-large needs to be informed on the climate change phenomenon, in order that politicians and other decision-makers can give priority to related programs. Recently national magazines (Macleans, Time) have underscored the importance of the subject and government publications have done likewise. Such efforts need to be continued and stepped up.

Current Activities

It was found that climate change does not figure prominently in current activities and planning of the agencies represented at the workshop. In fact there was a wide diversity ranging from consideration of climatic change in strategic planning (Forestry Canada, B.C. Ministry of Forests), to increased recognition in research and teaching at the University of B.C. and the University of Victoria, to inclusion in water management planning (B.C. Ministry of Environment), becoming more active in co-operative research (Canadian Wildlife Service), to simply seeking more information (MacMillan Bloedel Ltd.).

Follow-up action was recommended along seven lines:

1. Information on climatic change needs to be dispersed widely through symposia, conferences, meetings, and workshops as a responsibility of all of the end users, both in government and in non-government agencies.

2. The forest industry would probably be very receptive to an information session at the operational level, in the near future.

3. The best available information should be accessible to the public-at-large.

4. Commence dialogue between Environment Canada/AES and other partners on such matters as joint research, student internships with industry and governments, preparation of illustrative and interpretive materials, and a focus on the regional perspective.

5. The development of more comprehensive analysis of terrestrial resources and of the impacts of various climatic change scenarios on them.

6. Where it is necessary to do so, influence the agenda of key regional and national forestry meetings to include climatic change items. Examples include the Association of B.C. Professional Foresters and the Canadian Institute of Forestry.

7. Exert pressure to obtain political leadership, new resources, and the will to make the changes to reduce the generation of greenhouse gases. Climatic change needs to be seen as a non-partisan issue, and a subject to which Canada can make a major contribution through a coordinated response by specialists, decision-makers and publics.

SEA LEVEL AND THE COASTAL ZONE WORKSHOP REPORT

by

P. Duffy
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Issues

Data credibility is important because there is a range of projections for sea-level change in the future. The public, the planners. and the decision-makers need to be informed on the range of impacts and the probabilities. A defensible 10-year projection is vital to a credible information program and to political decision-makers.

In a broader context, a policy contradiction has arisen in man's use of hydrocarbons and industrial developments of a kind that contribute to the Greenhouse Effect.

To successfully address changes, it will be necessary to co-ordinate government policy-making and activities at the three levels, together with those of other agencies in the industrial and public interest sectors. This co-ordination needs to be in place at the regional level and to be tied into the global picture, in order to be mutually supportive and not contradictory.

What do we know now?

Projections of sea level rise range from a probable rise of 30 cm. up to a possible rise of as much as 1.5 meters by the middle of the next century. The U.S. Environmental Protection Agency prefers a value of slightly over 1 meter. The challenge is to work with the uncertainty and to seek low cost adaptive solutions such as amending by-laws to prohibit development in coastal flood plains.

What must we find out?

In order to develop a reliable information base we require a baseline measurement technique to monitor changes over time. This should be compatible with international monitoring techniques. With such information, confidence will grow in the projections and it will then be possible to carry out an inventory of coastal areas at risk by land use or habitat categories.

There is a need to understand the amount of error or uncertainty in temperature rise predictions and the statistical validity (confidence levels) of the predictions. As well, there is a need to know if we can be sure that present trends will continue. Policy and decision-makers will be further assisted if the impacts can be quantified and even costed in dollar terms. The subject is a vague one for decision-makers when compared to present-day environmental problems which sometimes require a strong lobby to generate political action.

Adaptive approaches in policy and program planning will be required to minimize costs and preserve future options. Flexibility is required to permit planning and engineering know-how to have full play in dealing with the predicted impacts of sea level rise.

How do we get the message across?

"It may require a few disasters to get the message across."

The severe prairie drought helped to raise the level of awareness of the public and at the 1988 Toronto Conference.

Sea level rise is a creeping problem and needs to be described in a meaningful way for public information programs.

It was agreed that current information should be furnished to agencies and the public now, and that fresh information should be distributed as it becomes available. In the U.S.A. the Environmental Protection Agency is distributing sea level rise data to public agencies. In Canada such information should be in the context of the overall subject of climatic change.

Precautionary design criteria could be prepared now. They would incorporate probable sea level rise estimates into design criteria for coastal developments. They would give recognition to coastal hazards and the attendant risks in development.

How to keep the momentum going.

Moving ahead from this first regional symposium on climatic change, momentum should be maintained by:

- widely circulating the symposium proceedings;
- developing a climatic change newsletter which covers the subject of sea level rise;
- encouraging the sharing of leadership between the key provincial and federal agencies. Within Environment Canada, the Committee of Regional Executives (CORE) would arrange for co-ordination;
- initiating local studies of impacts from sea level change;

- translation of the scientific information for use by the policy makers and decision makers;

- creating an inter-agency group for the delivery of global/international aspects to the regional setting. Such a group would have representation from the three levels of government, industry, academic and other agencies and should seek to build up a network of interested parties, and review and recommend priorities for action on climatic change, including sea level rise;

- arranging workshops and seminars in the near future. It may be feasible for an institution to handle this on a contract basis (e.g. the Westwater Institute).

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