Climate Change Impacts and Adaptation Strategies for Canada's Northern Territories: Final Workshop Report

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Explorer Hotel, Yellowknife, N.W.T.

Prepared for:
Natural Resources Canada
and Environment Canada

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Canada

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EXECUTIVE SUMMARY

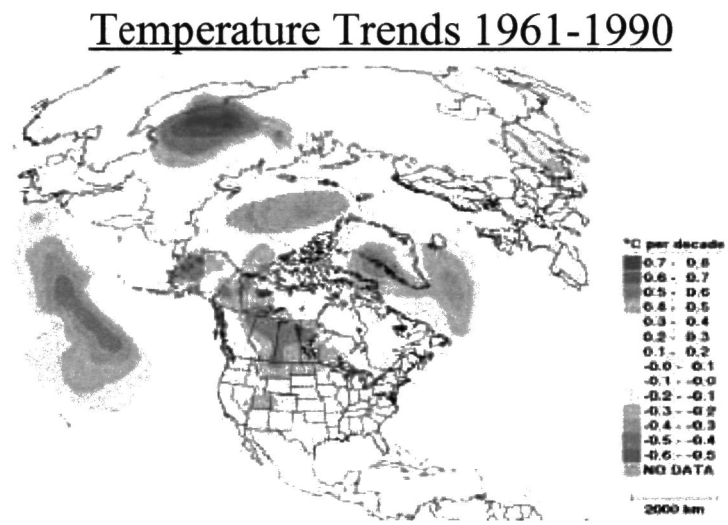
The Workshop on Climate Change Impacts and Adaptation Strategies in Canada's Northern Territories took place in Yellowknife in February 2000, after a proposal to the Government of Canada's Climate Change Action Fund (CCAF) was approved in August 1999. The overall goal of the workshop was to gain an understanding of the data and research required for developing appropriate adaptations to climate change, depending on the responsibilities of affected sectors and the quality of climate change forecasting available. Lead agencies, Natural Resources Canada and Environment Canada, were assisted by staff of Indian & Northern Affairs Canada, Fisheries & Oceans Canada, the Government of the NWT, and representatives from Yukon College and Nunavut Arctic College (on behalf of Yukon and Nunavut governments). Several agencies sponsored lunches or chaired parts of the workshop and the Prince of Wales Northern Heritage Centre donated use of their auditorium for an evening public session on climate change.

Origin of participants at Climate Change Workshop

Over 130 participants from federal and territorial governments, municipalities, land claim and hunter/trapper organizations, universities and northern colleges, private sector companies and consultants, and environmental groups came together in Yellowknife from across Canada for three days. They heard presentations on results of climate change science and impact studies, voiced their own observations on climate change and concerns about impacts, and discussed what can be done to prepare for and adapt to further change. Scientists described what is known and unknown about climate change, what monitoring programs and research are showing has already occurred, and what projections of further change are. Aboriginal participants described changes observed by elders about weather, the environment, and wildlife, particularly over the past 20-30 years. They indicated that these changes are cause for great concern for those still living a subsistence lifestyle, as well as by people who want to ensure that this lifestyle option is preserved for future generations. Representatives of environmental groups expressed their view that unrestrained development, overuse of renewable resources, and the extremes of a consumer-

based society are needlessly jeopardizing the environment. These participants also claimed that little commitment or concrete action has been taken by government to change this destructive lifestyle and path to an increasingly uncertain future.

Resource managers and private sector participants described how climate change is affecting current activities (management of wildlife populations and forest fires, transportation of construction materials and other supplies to remote communities and development sites, etc.). While impacts have not been dramatic to date, concern exists that further change in climate may produce significant environmental or economic impacts.



During break-out sessions, participants discussed impacts of climate change in various sectors (Communities and Infrastructure; Water Resources and Hydrology; Coasts, Marine Resources, & Traditional Use; and Forestry, Fisheries and Wildlife), and what further information is needed to adapt to climate change. They then provided their views on the desired nature and functions of a support system for climate change adaptation, and strategies for developing a northern impacts and adaptation research network.

At the conclusion of the 3 days, workshop facilitators presented a summary of their observations. These included: a sense of urgency (for action), significant variability and uncertainty (in climate, modelling, required action, etc.), strong linkages (between researchers and stakeholders), communications and marketing (to raise public awareness and mobilize action), bottom-up (experience, involvement, and application), continuity and commitment (required over the long term), pragmatism (funding constraints, application on front lines), accountability (high stakes, serious consequences), use of existing information and infrastructure (use what already exists and works), and momentum (build on workshop success).

Options for follow-up to the workshop were also discussed. Broad support was given to striking of a multi-stakeholder group, lead by the Natural Resources Canada and Environment Canada workshop convenors. As enthusiastic as workshop participation was, attendees recognized that they were still only a fraction of the stakeholders that are and will be affected by northern climate change. It was agreed that participation by all groups involved in the workshop, as well as others not present (health, socio-economic interests, etc.) was desirable. The working group would continue work on the climate change issue and prepare a proposal to CCAF for development of a northern network to identify priorities for and coordinate northern research on climate change impacts and adaptation. In addition to its northern role and activities, this network would also act as the northern contact point with networks being proposed for other regions and sectors of the economy.

SOMMAIRE

L'Atelier sur les impacts du changement climatique et les stratégies d'adaptation pour le Nord canadien s'est déroulé à Yellowknife en février 2000. Il avait été proposé au Fonds d'action pour le changement climatique (FACC) du gouvernement canadien et approuvé en août 1999. Il avait pour but général de comprendre les données et la recherche nécessaires à l'élaboration de mesures d'adaptation, en fonction des responsabilités des secteurs touchés et de la qualité des prévisions disponibles en matière de changement climatique. Les organismes responsables, Ressources naturelles Canada et Environnement Canada, ont reçu l'appui de représentants des Affaires indiennes et du Nord Canada, de Pêches et Océans Canada, du gouvernement des T.N.-O. ainsi que du Yukon College et du Nunavut Arctic College (au nom des gouvernements du Yukon et du Nunavut). Plusieurs organismes ont parrainé les repas ou ont présidé des parties de l'atelier. Le Prince of Wales Northern Heritage Centre a offert l'utilisation de son auditorium pour une séance publique sur les changements climatiques tenue en soirée.

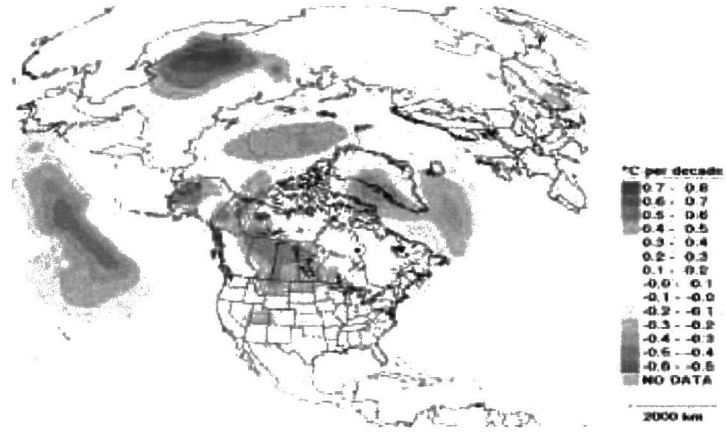
Origine des participants à l'atelier sur les changements climatiques

Plus de 130 participants des gouvernements fédéral et territoriaux, des municipalités, d'organisations de revendication des terres et de chasseurs/trappeurs, d'universités et de collèges du Nord, d'entreprises privées et d'experts-conseils, ainsi que de groupes environnementaux en provenance d'un peu partout au pays se sont réunis à Yellowknife pour trois jours. Ils ont entendu des exposés sur les résultats des études d'impact et des travaux scientifiques relatifs au changement climatique, exprimé leurs propres observations sur la question ainsi que leurs préoccupations à l'égard des impacts, et discuté des mesures de préparation et d'adaptation en vue d'autres changements. Les scientifiques ont décrit les aspects connus et inconnus du changement climatique, les changements ayant déjà pris place comme le démontrent les programmes de surveillance et la recherche, et les autres changements à prévoir. Les Autochtones ont parlé des changements touchant la température, l'environnement ainsi que la faune et la flore observés par les anciens, surtout au cours des 20 à 30 dernières années. Ils ont

affirmé que ces changements préoccupaient grandement ceux dont le style de vie en est encore un de subsistance, tout comme ceux qui souhaitent le préserver pour les générations à venir. Des représentants de groupes environnementaux se sont dit d'avis que le libre développement, la surutilisation des ressources renouvelables et les extrêmes d'une société axée sur le consommateur mettent l'environnement en péril inutilement. Ils ont aussi déclaré que le gouvernement avait pris peu d'engagements ou de mesures concrètes pour modifier ce style de vie destructif et rectifier cette voie orientée vers un avenir de plus en plus incertain.

Des gestionnaires de ressources et des participants du secteur privé ont décrit les impacts du changement climatique sur leurs activités actuelles (gestion des populations de la faune et des feux de forêts, transport des matériaux de construction et autres produits vers les collectivités éloignées et les lieux de travaux, etc.). Même si les impacts n'ont pas été dramatiques jusqu'à ce jour, d'autres changements climatiques pourraient avoir d'importantes répercussions environnementales ou économiques.

Tendances de la température 1961-1990



En petits groupes, les participants ont discuté des impacts du changement climatique sur divers secteurs (collectivités et infrastructure; ressources hydriques et hydrologie; littoral, ressources marines et utilisation conventionnelle; foresterie, pêches et faune) ainsi que des informations supplémentaires nécessaires pour s'adapter. Ils ont ensuite fait part de leurs vues sur la nature et les fonctions d'un mécanisme visant à soutenir l'adaptation au changement climatique, ainsi que sur les stratégies pour créer un réseau de recherche sur les impacts dans le Nord et l'adaptation.

À la fin des 3 jours, les animateurs ont résumé leurs observations : sentiment d'urgence (il faut passer à l'action), importantes variabilité et incertitude (climat, modélisation, mesures à prendre, etc.), relations solides (chercheurs-intervenants), communications et commercialisation (sensibilisation du public et mobilisation), démarche ascendante (expérience, participant et application), continuité et engagement (nécessaires à long terme), pragmatisme (financement restreint, application sur les lignes de front), responsabilisation (enjeux élevés, conséquences graves), utilisation d'information et d'infrastructure existantes (utilisation de ce qui existe déjà et fonctionne), et momentum (profiter du succès de l'atelier).

En outre, les participants ont discuté du suivi de l'atelier. Ils ont largement appuyé la formation d'un groupe multipartite, dirigé par les parrains de l'atelier de Ressources naturelles et d'Environnement Canada. Malgré l'enthousiasme suscité par l'atelier, les participants ont reconnu qu'ils ne constituaient qu'une fraction des intervenants qui sont et seront touchés par le changement climatique dans le Nord. Ils ont conclu que la participation de tous les groupes prenant part à l'atelier, ainsi que de ceux absents (santé, intérêts socio-économiques, etc.) était

souhaitable. Le groupe de travail continuera ses travaux sur le changement climatique et préparera une proposition qu'il soumettra au FACC. La proposition portera sur l'élaboration d'un réseau pour déterminer et coordonner les travaux de recherche prioritaires sur les impacts du changement climatique dans le Nord et l'adaptation. En plus de son rôle et de ses activités dans le Nord, ce réseau agira également comme point de contact régional auprès des réseaux proposés dans d'autres régions et secteurs de l'économie.

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ᑲᑎᒪᓂᐅᓚᐅᖅᑐᖅ ᓯᓚᐅᑉ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᐊᒻᒪ ᓱᖕᒋᐅᑎᕝᓪᓕᐊᔾᔪᓯᐅᔪᓂ ᑲᓇᑕᐅᑉ ᐅᑭᐅᖅᑕᖅᑐᖕᒐᓂ ᔭᓗᓇᐃᒦ [illegible]ᐊᓇ 2000_ᒥ ᑲᑎᒪᓂᐅᓚᐅᖅᐳᖅ, ᑐᒃᓯᕋᐅᑎᖃᓚᐅᖅᑎᓪᓗᒋᑦ ᑲᓇᑕᐅᑉ ᒐᕙᒪᒃᑯᖕᒋᓐᓄᑦ ᓯᓚᐅᑉ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᕿᓇᐅᔭᖅᑲᖅᑐᓄᑦ ᐊᖏᖅᑕᐅᓚᐅᖅᑎᓪᓗᒍ ...ᒡᒐᓯ 1999_ᒥ. ᑐᓛᕐᐅᔪᒪᓚᐅᖅᑐᖅ ᑲᑎᒪᓂᐅᔪᓂ ᑐᑭᓯᓂᖅ ᑐᓴᒐᒃᓴᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᔪᓂᒡᓗ ᐱᓕᕆᐊᖕᒍᕝᓪᓕᐊᓂᐊᖅᑐᓄᑦ ᓱᖕᒋᐅᑎᓴᓂᕐᒍᑦ ᓯᓚᐅᑉ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓂᒃ, ᒪᓕᒡᓗᒋᑦ ᑲᒪᒋᔭᐅᒥᐊᖅᑲᖅᑐᑦ ᐃᒃᐱᒋᔭᖅᑲᖅᑐᑦ ᐱᓕᕆᐊᖅᑲᕐᖓᓂ ᐊᒻᒪ ᓯᓚᐅᑉ ᐊᓯᐊᙳᕐᓂᖓᓂᒃ ᑐᓴᒐᒃᓴᑦ ᐊᑐᐃᓐᓇᐅᔪᑦ. ᓯᕗᓕᖅᑎᐅᔪᑦ ᑲᑐᔾᔨᖅᑎ□ᑦ, ᐱᕈᖅᑐᑐᖅᑲᓕᕆᔩᑦ ᑲᓇᑕᒥ ᐊᒻᒪᓗ ᐊᕙᓗᒥᐅᑕᓕᕆᔩᒃᑯᓪᓗ ᑲᓇᑕᒥ, ᐃᑲᔪᖅᑕᐅᓚᐅᖅᐳᑦ ᐃᖅᑲᓇᐃᔭᖅᑎᓂᑦ ᐃᓄᓕᕆᔩᑐᖅᑲᒃᑯᓐᓂᑦ, ᐃᒪᕐᒥᐅᑕᓕᕆᔩᒃᑯᓐᓂᑦ, ᓄᓇᑦᑎᐊᑉ ᒐᕙᒪᒃᑯᖕᒋᓐᓂᑦ, ᐊᒻᒪᓗ ᑭᓛᖅᑐᐃᔪᓂᑦ -™ᓂ ᐃᓕᓐᓂᐊᕐᕕᒡᔪᐊᖕᒐᓂᑦ ᓄᓇᕗᓪᓗ ᐃᓕᓐᓂᐊᕐᕕᒡᔪᐊᖕᒐᓂᑦ (ᑭᓛᖅᑐᐃᔪᑦ -™ᓐᒥᒃ ᓄᓇᕗᓪᓗ ᒐᕙᒪᖕᒋᓐᓂᒃ). ᑲᑐᔾᔨᖅᑎ□ᑦ ᐊᒥᓱᑦ ᐅᐸᓗᕈᒥᑕᒃᓴᓂᒃ ᓂᐅᕐᖃᑦᑕᓚᐅᖅᐳᑦ ᐃᒃᓯᕙᐅᑕᐅᐸᓗᑎᒡ[ᓐ#ᑦ ᑲᑎᒪᓂᐅᔪᓂ ᐊᒻᒪ ᔭᓗᓇᐃ ᐃᑦᑕᕐᓂᑕᐅᓯᕚᖕᒐ ᐸᓇᓐᔅ ᐊ ᕐᐅᔅ Hᐃᐅᓇᑎᔅ ᓯᐊᓐᑐ ᑲᑎᒪᕖᖕᒥᓐᓂᒃ ᐊᑐᖅᑎᑦᑎᓚᐅᖅᐳᑦ ᐅᓐᓄᐊᕐᒥ ᐊᑕᐅᓯᕐᒥ ᓯᓚᐅᑉ ᐊᓯᐊᙳᕐᓂᖓ ᐱᔾᔪᑎᒋᓪᓗᒍ.

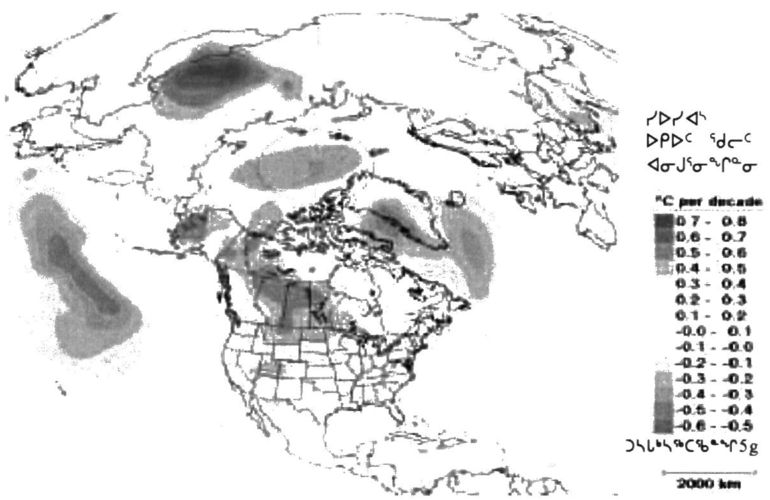
ᐃᓚᐅᔪᑦ ᑲᑎᒪᔪᓂ ᓯᓚᐅᑉ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓂ ᐱᓕᕆᐊᖅᑐᓂ

ᐅᖕᒐ¼ᓄᑦ 130 ᐃᓚᐅᓚᐅᖅᐳᑦ ᑲᓇᑕᐅᑉ ᒐᕙᒪᒃᑯᖕᒋᓐᓂᑦ ᓄᓇᑦᑎᐊᑉᓗ, ᓄᓇᕘᑉᓗ, ᓇᖕᒥᓂᖅ ᓄᓇ¼ᖅᓯᒪᔪᑦ ᐹᒪᔪᓕᕆᓂᕐᒧᑦᕝᐲᔭᖅᑦᑎᐊᖅᑎᓂ ᑲᑐᔾᔨᖅᑎ□ᓂ, ᓯᓚᑦᑐᖅᓴᕐᕕᖕᓂ ᐊᒻᒪ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐃᓕᓐᓂᐊᕐᕕᒡᔪᐊᓂ, ᐃᖕᒥᒃᓈᖅᑐᓂ ᑲᒻᐸᓂᓂ ᖃᐅᔨᓴᖅᑎᓪᓗ, ᐊᒻᒫ ᐊᕙᓗᒥᐅᑕᓕᕆᓂᕐᒧᑦ ᐱᓕᕆᔩᑦ ᔭᓗᓇᐃᒨᑦ ᑲᓇᑕᒥᑦ ᓇᑭᑐᐃᓐᓇᖅ ᐅᐸᓗᕐᓂᒃ ᐱᖕᒐᓱᓂᒃ ᑲᑎᒪᓚᐅᖅᐳᑦ. ᑐᓴᖅᑦᑕᓚᐅᖅᐳᑦ ᓯᓚᐅᑉ ᐊᓯᐊᙳᖅᐸᓪᓕᐊᓂᖓᓂᒃ ᖃᐅᔨᓴᖅᑕᐅᔪᓂᒡᓗ, ᐃᓱᒪᒋᔭᖕᒋᓐᓂᒃ ᐅᖃᐅᓯᖅᑲᖅᓗᑎᒃ ᓯᓚᐅᑉ

ᐊᓯᐊᓐᖑᕐᓂᖓ ᐱᔾᔪᑎᒋᓗᒍ ᐊᒻᒪ ᐃᓱ$[ᑎᖏᓐᓂᒃ ᐃᑉᐱᒋᔭᐅᓂᐊᖅᑐᓂᒃ ᐅᖃᐅᓯᖃᖅᓱᑎᒃ, ᐊᒻᒪ ᐅᖃᐅᓯᖃᓚᐅᖅᐳᑦ ᖃᓄᐃᓕᐅᕈᓐᓇᓇᐊᒃᓴᖏᓐᓂᒃ ᐸᕐᓇᒍᑎᖃᕐᓱᑎᒃ ᓱᖏᐅᑎᔪᑎᖃᕐᓂᐊᕐᓱᑎᓪᓗ ᐊᓯᐊᓐᖑᒃᑲᓐᓂᖅᑐᓂᒃ. ᓱᓇᑐᐃᓐᓇᕐᓂᒃ ᖃᐅᔨᒪᔨᑦ ᐅᖃᐅᓯᖃᓚᐅᖅᐳᑦ ᖃᐅᔨᒪᔭᐅᔪᓂᒃ ᖃᐅᔨᒪᔭᐅᓐᖏᑦᑐᓂᓗ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᖅᑕᕐᓂᖓᓂᒃ, ᓱᓇᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ ᐱᓕᕆᐊᖑᔪᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᓪᓗ ᑕᒃᓴᐅᑎᑎᒋᐊᒃᓴᖏᓐᓂᒃ ᐱᓕᕆᐊᖑᓕᐊᓂᒃᑐᓂ, ᐊᒻᒪ ᓱᓇᓂᒃ ᐊᓯᐊᓐᖑᕐᓂᐊᖅᑐᓂᒃ ᓂᕈᐅᒋᔭᖃᕈᐊᒃᓴᖏᓐᓂᒃ. ᓄᓇᖅᑐᑐᖃᐃᑦ ᐃᓚᐅᔪᑦ ᐅᖃᐅᓯᖃᓚᐅᖅᐳᑦ ᐃᓐᓇᑐᖃᐃᑦ ᖃᐅᔨᒪᔭᖏᓐᓂᒃ ᓯᓚ, ᐊᕙᓗᒥᐅᑕᖅ, ᐊᒻᒪ ᓂᕐᔪᑎᑦ ᐱᔾᔪᑎᒋᓗᒋᑦ, ᐱᓗᐊᖅᑐᒥᒃ ᐅᑭᐅᓂ 20_30_ᓂ ᐊᓂᒎᖅᑐᓂ. ᐅᖃᓚᐅᖅᐳᑦ ¼ᒃᑯᐊ ᐊᓯᐊᓐᖑᖅᑐᑦ ᐃᓱ$[ᑕᐅᒥᐊᖅᒪᓇᖕᓂᖏᓐᓂᒃ ᐋᒪᔪᓂᒃ ᐃ®ᔾᔪᑎᖃᖃᑦᑕᖅᑐᓂᒃ, ᐊᒻᒪᓗ ᑭᒃᑯᑐᐃᓐᓇᕐᓄᑦ ᐃ®ᓯᕐᒥᒃ ᐃ®ᔾᔪᑎᖃᕐᑯᔨᔪᓄᑦ ᐅᑭᐅᓂ ᐊᑐᕐᓂᐊᖅᑐᓂ ᖃᐃᓕᒦᖅᑐᓂ. ᑭᓛᖅᑐᐃᔨᑦ ᐊᕙᓗᒥᐅᑕᓕᕆᓂᕐᒍᑦ ᐅᖃᓚᐅᖅᐳᑦ ᐃᓱᒪᒋᔭᖏᓐᓂᒃ ᐊᑐᖅᑕᐅᓗᐊᖅᓯᒪᓐᖏᑦᑐᖅ ᐱᕈᖅᐸᓪᓕᐊᑎᑕᐅᔪᑦ, ᐅᖓ¼ᓄᑦ ᓄᓇᒥᐅᑕᐃᑦ ᐊᑐᖅᑕᐅᔪᑦ, ᐊᒻᒪ ᓂᐅᕚᒃᓴᖃᖅᑐᑦ ᐅᖓ¼ᓄᑦ ᐊᑐᕐᓂᖏᑦ ᐊᕙᓗᒥᐅᑕᓄᑦ ᐊᑦᑕᓇᖅᑐᒥᒃ ᐊᑐᐃᓐᓇᐅᑎᑦᑎᒋᐊᖃᓐᖏᓪᓗᑎᒃ ᐊᑐᐃᓐᓇᐅᑎᑦᑎᒍᑦ. ¼ᒃᑯᐊ ᑲᑎᒪᔪᓂ ᐃᓚᐅᔪᑦ ᐅᖃᕆᒍᑦ ᐱᓕᕆᐊᖑᓗᐊᖅᓯᒪᓐᖏᓐᓂᖏᓐᓂᒃ ᐅᕚ[ᓐ#ᑦ ᓴᕿᑮᖅᑐᒃᑯᑦ ᑳᕙᒃᑯᑦ ᐊᓯᐊᓐᖑᐃᕙᓪᓕᐊᓐᖏᓐᓂᖏᓐᓂᒃ ᑕᒪᑐᒥᖓ ᓱᕈᖅᑎᑦᑎᕙᓪᓕᐊᔪᒥᒃ ᐃ®ᓯᕐᒥᒃ ᐊᒻᒪ ᓴᕿᑕᐅᕙᓪᓕᐊᖏᓐᓇᖅᑐᒍᑦ ᓇᓗᓇᖅᑐᒥᒃ ᓯᕗᓂᒃᓴᖃᕈᑕᐅᓂᐊᖅᑐᒥᒃ.

ᐱᓕᕆᐊᓄᑦ ᐊᖓᔪᖅ™ᑦ ᐃᖕᒥᒃᓈᖅ_ ᑐᓪᓗ ᐅᖃᐅᓯᖃᖅᐳᑦ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᕐᓂᖓ ᖃᓄᖅ ᐃᑉᐱᒋᔭ_ ᖃᖅᑎᑦᑎᒋᐊᒃᓴᖓᓂᒃ $ᓐᓇ ᐱᓕᕆᐊᖑᔪᓂᒃ (ᐊᐅᓚᑕᐅᓂᖏᑦ ᐋᒪᔪᐃᑦ ᐅᓄᕐᓂᖏᑦ ᐊᒻᒪ ᓇᑦᓯᖅᑐᐃᑦ ᐃᑯᐊᓚᑎᓪᓗᒋᑦ, ᐃᖏᕐ_ ᕿᔾᔪᑎᑦ ᓴᓇᔭᐅᔾᔪᓯᖏᑦ ᐊᓯ_ ᖏᓪᓗ ᓄᓇᓕᖕᓂ ᑎᑭᑕᐅᓴᕿᐃᓐ_ ᖏᑦᑐᓂ ᐱᕈᖅᐸᓪᓕᐊᑎᑦᑎᔾᔪᓯᐅᔪᑦ, ᐊᓯᖏᓪᓗ). ᐃᑉᐱᒋᔭᐅᔪᑦ ᐊᖏ-ᓗᐊᖅᓯᒪᓐᖏᑎᓪᓗᒋᑦ ᐅᐸᓗ_ ᒥᒎᑦ ᑎᑭᓪᓗᒍ, ᐃᓱ$[ᑕᐅᔪᑦ ᑕᐃᒪᐅᒐᑦ ᐊᓯᐊᓐᖑᒃᑲᓐᓂᕐᓂᖓ ᓯᓚᐅᑉ ᐊᕙᓗᒥᐅᑕᓄᑦ ᒦᓇᐅᔭ_ ᓕᐅᕈᑕᐅᔪᓄᓪᓗ ᐃᑉᐱᒋᔭᐅᒪ_ ᓇᑲᔭᕐᓂᖏᓐᓂᒃ.

ᐆᓇᕐᓂᑦ ᖃᓄᐃᓐᓂᕆᔭᖏᑦ ᓯᓚᒥ 1961 1990



ᐊᕝᑐᖅᐸᓪᓕᐊᑎᓪᓗᒋᑦ, ᐃᓚᐅᔪᑦ ᐅᖃᐅᓯᖃᖃᑦᑕᖅᐳᑦ ᐃᑉᐱᒋᔭᐅᔪᓂᒃ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᕐᓂᖓᓄᑦ ᐊᔾᔨ[]ᓐᖏᑦᑐᓂ ᐱᓕᕆᐊᖑᔪᓂ (ᓄᓇᑑᑦ ᐱᓕᕆᐊᖃᕝᐅᔪᓪᓗ; ᐃᒪᓕᕆᓂᕐᒧᑦ ᐊᒻᒪ ᐃᒪᕐᓂᒃ ᐊᑐᖅᓱᑎᒃ ᐱᓕᕆᐊᖑᔪᑦ; ᓯᓪᔭᐃᑦ, ᐃᒪᕐᒥᐅᑕᐃᑦ ᐊᒻᒪ ᐃᓕᕐᑯᓯᑐᖃᒃᑯᑦ ᐊᑐᖅᑕᐅᔪᑦ; ᐊᒻᒪ ᓇᑦᓯᖅᑐᓕᕆᓂᖅ, ᐃᖃᓗᓕᕆᓂᖅ ᐋᒪᔪᓕᕆᓂᖅ), ᐊᒻᒪ ᖃᓄᐃᑦᑐᑦ ᑐᓴᒐᒃᓴᑦ ᐊᑐᖅᑕᐅᒥᐊᖃᕆᐊᒃᓴᖏᓐᓂᒃ ᓱᖏᐅᑎᓂᐊᕐᓱᑎᒃ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᕐᓂᖓᓄᑦ. ᐊᑐᐃᓐᓇᐅᑎᑦᑎᓕᓚᐅᕆᒍᑦ ᐃᓱᒪᒋᔭᖏᓐᓂᒃ ᐃᓕᕐᑯᓯᐅᕐᑯᔭᖏᓐᓂᒃ ᐊᒻᒪ ᐊᐅᓚᑦᑎᔾᔪᓯᐅᔪᓂᒃ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᕐᓂᖓᓄᑦ ᓱᖏᐅᑎᔾᔪᓯᐅᔪᓂ, ᐱᓕᕆᔾᔪᓯᐅᔪᓂᓗ ᐱᓕᕆᐊᖑᕙᓪᓕᐊᓂᖓᓄᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᐃᑉᐱᒋᔭᐅᔪᑦ ᐊᒻᒪ ᓱᖏᐅᑎᕙᓪᓕᐊᓂᕐᒧᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᑦ.

ᐅᐸᓗᐃᑦ ᐱᖓᓱᑦ ᐊᓂᒎᖅᑎᓪᓗᒋᑦ, ᑲᑎᒪᔪᓂ ᐊᐅᓚᑦᑎᔨᑦ ᓇᐃᓪᓕᒋᐊᖅᓯᐸᓗᑎᒃ ᐅᖃᐅᓯᖃᖃᑦᑕᓚᐅᖅᐳᑦ ᑕᑯᔭᖏᓐᓂᒃ. ᐅᑯᐊ ᐃᓚᐅᑎᑕᐅᓚᐅᖅᐳᑦ: ᐃᓱᒪᒋᔭᐅᓂᖓ ᑐᐊᕝᐅᑕᐅᒋᐊᖃᕐᓂᖓ (ᐱᓕᕆᐊᖑᓗᓂ), ᐊᖏᓂᖓ ᐊᔾᔨ[]ᓐᖏᓐᓂᕆᔭᖓᑕ ᐊᒻᒪᓗ ᓇᓗᓇᕐᓂᖓ (ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᕐᓂᖓᓂᒃ, ᓴᕿᑕᐅᕙᓪᓕᐊᓂᖓᓂᒃ ᐱᓕᕆᔾᔪᓯᒃᓴᖅ, ᐱᓕᕆᐊᖑᒋᐊᖃᕐᒪᑕ, ᐊᓯᖏᓐᓂᓪᓗ ᐱᓕᕆᐊᖑᔾᔪᓯᖃᕐᓗᑎᒃ), ᓴᓐᖏᔪᑦ ᐊᑦᑕᑕᖅᓯᒪᔪᑦ (ᐊᑯᓐᓂᖏᓐᓂ ᖃᐅᔨᓴᖅᑎᑦ ᓇᖕᒥᓂᖃᖃᑕᐅᔪᓪᓗ), ᐅᖃᖃᑦᑕᐅᑎᓂᖅ ᓂᐅᕝᐊᒃᓴᖃᕐᓂᕐᓗ (ᑭᒃᑯᐃᓐᓇᐃᑦ ᑐᓴᐅᒪᑎᓐᓂᐊᕐᓗᒋᑦ ᐱᓕᕆᐊᖃᖅᑎᓐᓂᐊᕐᓗᒋᓪᓗ), ᖁᒻᒧᑦ_ᐃᖏᕐᕋᓗᓂ (ᑐᑭᓯᐅᒪᔪᑦ, ᐃᓚᐅᔪᑦ, ᐊᒻᒪ ᐱᓕᕆᐊᖅᑐᑦ), ᑲᔪᓯᐅᒪᐃᓐᓇᕐᓂᖏᑦ ᐊᒻᒪᓗ ᐱᓕᕆᐊᖃᕐᓂᖏᓪᓗ

(ᐱᓕᕆᐊᖑᔪᓂ ᐊᑯᓂ), ᐊᑐᕐᓗᑎᒃ ᖃᐅᔨᒪᔭᐅᔪᓂᒃ ᐃᖕᒋᕐᕋᓂᖃᕈᓐᓇᖅᑐᓂᒃ (ᕿᓇᐅᔭᑦ ᓄᖃᖕᒐᔾᔪᑕᐅᓂᖏᑦ, ᑐᒃᓯᕋᐅᑎᑦ ᑐᒃᓯᕋᕐᕕᐅᒋᐊᓕᖕᓄᑦ ᑐᒃᓯᕋᕐᕕᐅᓂᖏᑦ), ᑎᒃᑯᐊᖅᑐᖅᑕᐅᔪᓐᓇᕐᓗᑎᒃ (ᕐᑯᒡᕙᓯᒃᑐᒥᒃ ᐱᑕᖃᕐᓂᐊᕐᓗᑎᒃ, ᐱᒻᒪᕆᐅᔪᓂᒃ ᐱᕝᕙᒃᑐᓂᒃ ᓴᕿᑦᑎᓂᐊᕐᓗᑎᒃ), ᐊᑐᖅᑕᐅᓂᖏᑦ ᒫᓇ ᑐᓴᒃᓴᐃᑦ ᐊᑐᐃᓐᓇᐅᔪᑦ ᐊᒻᒪ ᐱᓕᕆᔾᔪᓯᐅᔪᑦ (ᐊᑐᕐᓗᒋᑦ ᐊᑐᐃᓐᓇᐅᓕᐊᓂᒃᑐᑦ ᐊᒻᒪ ᐃᖕᒋᕐᕋᓂᖃᕈᓐᓇᖅᑐᑦ), ᐊᒻᒪᓗ ᑕᒡᕙᑲᐅᑎᒋ ᐱᓕᕆᐊᖃᕐᓗᑎᒃ (ᑭᐅᓗᑎᒃ ᑲᑎᒪᓂᐅᔪᒥᑦ ᐃᖕᒋᕐᕋᓂᖃᑦᑎᐊᖅᑐᓂᒃ).

ᐱᓕᕆᔾᔪᓯᐅᓇᔭᖅᑐᑦ ᑲᑎᒪᓂᐅᔪᓂᑦ ᐅᖃᐅᓯᐅᖃᑕᐅᓚᐅᕆᕗᑦ. ᐃᑲᔪᖅᑐᐃᔾᔪᓯᐅᔪᑦ ᓴᕿᑕᐅᓚᐅᖅᐳᑦ ᐊᑕᐅᓯᐅᓐᖏᑦᑐᒥᒃ ᓇᖕᒥᓂᖃᖅᑐᑦ_ᑲᑎᒪᔩᑦ ᓴᕿᑕᐅᕐᑯᑉᓗᒋᑦ, ᓯᕗᓕᖅᑎᖃᕐᓗᑎᒃ ᔪᕐᑯᓯᐊᓐᖏᑦᑐᑦ ᐱᓕᕆᐊᖃᕐᖏᓐᓂᒃ ᑲᓇᑕᒥ ᓄᓇᒥᐅᑕᓂᒃ ᐊᒻᒪ ᐊᕚᓗᒥᐅᑕᓕᕆᔩᒃᑯᓐᓂᒃ ᑲᓇᑕᒥ ᐱᓕᕆᐊᖃᕐᖕᒥ ᐱᓕᕆᐊᓄᑦ ᐊᔪᐃᓐᓇᕈᑎᖃᖅᑐᑦ. ᑲᑎᒪᖃᑕᐅᔪᓂ ᐃᓚᐅᖃᑕᐅᔪᑦ ᐱᔪᒥᒍᓯᒃᑎᓪᓗᒋᑦ, ᐃᓚᐅᔪᑦ ᐃᓕᑦᑎᓯᓚᐅᖅᐳᑦ ᓇᖕᒥᓂᖃᖃᑕᐅᔪᑦ ᐃᓚᐃᓐᓇᖏᐅᓂᖏᓐᓂᒃ ᐊᒻᒪ ᐃᑉᐱᒋᔭᖃᖅᑎᑕᐅᓂᐊᖅᓗᑎᒃ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᕐᓂᖓᓄᑦ. ᐊᖏᖃᑎ□ᓚᐅᖅᐳᑦ ᐃᓚᐅᔪᑦ ᑕᒪᐃᓐᓂᒃ ᑲᑎᒪᔩᑦ, ᐊᓯᖏᑦᓗ ᐃᓚᐅᓐᖏᑦᑐᑦ (...ᓐᓂᐊᖅᑐᓕᕆᔩᑯᑦ, ᐃᓄᓕᕆᔩᑯᑦ_ᕿᓇᐅᔭᓕᕆᔩᑯᑦ, ᐊᓯᖏᑦᓗ) ᐃᓚᕐᑯᔭᐅᓚᐅᖅᐳᑦ. ᑲᑎᒪᔪᑦ ᑲᔪᓯᐅᒪᐃᓐᓇᕐᓗᑎᒃ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᖅᐸᓪᓕᐊᓂᖓᓂᒃ ᐱᓕᕆᐊᖃᕋᔭᖅᐳᑦ ᐊᒻᒪ ...ᖅᑭᒃᓯᐃᓗᑎᒃ ᑐᒃᓯᕋᐅᑎᒃᓴᒥᒃ ᑲᓇᑕᐅᑉ ᒐᕙᒪᒃᑯᖏᓐᓄᑦ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᕿᓇᐅᔭᖃᖅᑐᓄᑦ ᓴᕿᑦᑎᕐᑯᓗᒋᑦ ᐅᑭᐅᖅᑕᖅᑐᒥ ᑐᓴᒃᓴᓂᒃ ᓇᓗᓇᐃᖅᓯᔾᔪᑕᐅᓂᐊᖅᑐᓂᒃ ᓯᕗᓪᓕᐅᑎᑕᐅᕐᑯᔭᐅᔪᓂᒃ ᐅᑭᐅᖅᑕᖅᑐᒥ ᖃᐅᔨᓴᖅᑕᐅᔪᓄᑦ ᐱᕈᖅᐸᓪᓕᐊᑎᑕᐅᓂᖓᓄᑦ ᓯᓚᐅᑉ ᐊᓯᐊᓐᖑᕐᓂᖓᑕ ᐃᒃᐱᒋᔭᐅᓂᖓ ᔪᖏᐅᑎᔭᐅᓂᖓᓗ. ᐅᑭᐅᖅᑕᖅᑐᒥ ᐱᓕᕆᐊᖑᔪᓄᑦ ᐃᓚᐅᓗᑎᒃ, ¼ᓐᓇ ᑐᓴᐅᒪᔾᔪᓯᐅᔪᒃᓴᖅ ᐊᕕᒃᑐᖅᓯᒪᓂᐅᔪᒥ ᐱᓕᕆᐊᖅᕐᕕᐅᓇᔭᖅᐳᖅ ᑐᑦᑕᕐᕕᐅᓗᓂ ᑐᓴᒃᓴᐃᑦ ᑐᒃᓯᕋᐅᑕᐅᓗᑎᒃ ᐊᓯᖏᓐᓂ ᐊᕕᒃᑐᖅᓯᒪᓂᐅᔪᓂ ᐊᒻᒪ ᐱᓕᕆᐊᖅᕐᕕᖕᓂ ᕿᓇᐅᔭᓕᕆᔾᔪᓯᐅᔪᓂ.

INTRODUCTION

This workshop is one of a series held in 6 regions across Canada, all focused on the impacts of climate change with respect to the major sectors of the economy. It was funded by the Climate Change Action Fund (CCAF) as an opportunity for representatives from a broad range of interests to express their perceptions about climate change and opinions on coping with climate change in the North. Northerners are well aware that climate change and its' impacts are already occurring in the Arctic. The CCAF was established by the federal government to help Canada meets its commitments under the Kyoto Protocol to reduce greenhouse gas emissions and to raise awareness of the nature and consequences of climate by:

- public outreach activities to communicate information on climate change;
- determining the sensitivity of the natural environment to climate change; and
- promoting the development of existing or new means for anticipating climate change and adapting to it.

The federal government is encouraging all economic and social sectors of the country to become aware of and formulate plans for dealing with climate change. Canada's North is characterized by unique attributes of climate and terrain, with similarly unique vulnerabilities to climate change. Furthermore, the most pronounced warming of any region in Canada is expected in arctic regions if the climate responds, as predicted, to increasing carbon dioxide levels. Due to these factors, a special need exists to anticipate the effects of such a change in this region.

How various components of the natural environment react to climate change was described in a series of presentations to stimulate break-out group discussions. Break-out groups were divided by major sector (Communities and Infrastructure; Water Resources and Hydrology; Coasts, Marine Resources, & Traditional Use; Forestry, Fisheries and Wildlife) and asked to: 1) identify present impacts of climate change, 2) define the kinds of information needed to anticipate effects of climate change, and 3) specify the way that information should be communicated. Participants know that past climates have undergone significant change and that the natural environment adjusts. Although uncertainty remains over the accuracy of modeling results, by understanding the sensitivity of parts of the natural environment to climate change, we can nevertheless project what will happen if a certain change takes place in the future. Such projections of climate and the associated impacts provide a guide for deciding how thoroughly to adapt.

The reality of climate variability, sensitive environmental components, and probability of increased climate extremes point out the need to plan for continuing changes in future climates, despite the lack of confidence associated with climate change projections. Seeking opinions on how this is to be done and the kinds of information needed is the primary goal of this workshop.

Index of Acronyms

ACIA	**- Arctic Climate Impacts Assessment**	**GNWT**	**- Government of the NWT (similarly, YTG, NTG)**
AMAP	**- Arctic Marine Assessment Program**	**ITEX**	**- International Tundra EXperiment**
ARI	**- Aurora Research Institute**	**MBIS**	**- Mackenzie Basin Impact Study**
CAFF	**- Convention on Arctic Flora and Fauna**	**NEI**	**- Northern Ecosystem Initiative**
CCAF	**- Climate Change Action Fund**	**NCE**	**- Northern Climate Exchange (at Yukon College)**
C-CIARN	**- Climate Change Impacts & Adaptation Network**	**NAC**	**- Nunavut Arctic College**
CCS	**- Canada Country Study (on climate change)**	**RENEC**	**- Research Expertise in NorthEastern Canada**
CCIS	**- Canadian Climate Impact Scenarios project**	**RWED**	**- GNWT Resources Wildlife & Econ. Development**
GCM	**- Global Climate Model**	**YC**	**- Yukon College**
GEWEX	**- Global Energy & Water Cycle EXperiment**		

DAY ONE – SUNDAY, FEBRUARY 27, 2000

WORKSHOP OPENING

Facilitator Hal Mills opened the workshop at 1:30 p.m.

Opening Prayer
Led by Peter Esau.

Convenor's Welcome and Workshop Outline
Larry Dyke welcomed participants on behalf of Natural Resources Canada. Natural Resources Canada is leading climate change impacts and adaptation aspects of the Climate Change Action Fund (CCAF), including organization of this workshop.

Jesse Jasper described the origin of the workshop, including the roles of Environment Canada and Natural Resources Canada. Environment Canada has the CCAF lead for climate change science, as well as a special interest with the impacts of climate change on northern ecosystems. Funding from the new Northern Ecosystem Initiative (NEI) is also supporting the workshop. He noted that participants at the workshops were a cross-section of all stakeholders interested in contributing to the issue of climate change impacts and adaptation, but some areas (i.e. health) were not represented in the participants.

Welcome
Yellowknife Mayor Dave Lovell welcomed participants to Yellowknife and wished them well over the course of the workshop.

Bob McLeod, Deputy Minister, Department of Resources Wildlife and Economic Development, welcomed participants on behalf of the Government of the NWT (GNWT). He noted the NWT, and the North in general, is particularly vulnerable to climate change. GNWT is working on a greenhouse gas strategy to help control northern greenhouse gas emissions. The Deputy Minister was encouraged to see the wide range of representatives at the workshop and stressed the need for all of us to understand the impacts, identify knowledge gaps, set priorities for research and monitoring, and to determine how to anticipate and adapt to climate change impacts. The Deputy Minister wished participants good luck with the workshop and looked forward to the results.

Taking action on greenhouse gas emissions in the North
Lloyd Henderson

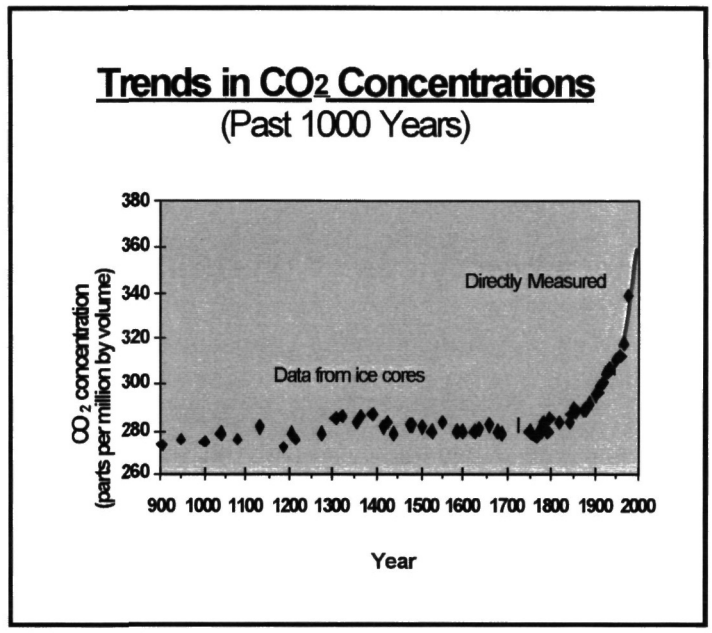
Lloyd Henderson provided a brief overview on the development of a *NWT Strategy to Control Greenhouse Gas Emissions*. The three objectives of the strategy are: 1) to increase awareness in the NWT of global climate change and the need to control greenhouse gas emissions; 2) to engage all northerners, including government, non-government, industry, and the general public, in taking action to control greenhouse gas emissions; and 3) to identify and implement achievable and practical actions immediately, as well as in the longer-term, to achieve sustained reductions in greenhouse gas emissions in the NWT, taking into consideration the economic, environmental and social costs and benefits.

Promoting a Northern capacity for adaptation to climate change
Paul Egginton

Paul Egginton's presentation stressed that adaptation and response measures are critical in the next 20 years. Continued changes in climate, including continued warming, are considered likely, based on

projections of the influence of increasing carbon dioxide and other greenhouse gases in the Earth's atmosphere. Even though Canada expressed the intention to reduce greenhouse gas emissions at the Kyoto meeting of the United Nations Framework Convention on Climate Change in 1997, global emissions have continued rising.

The Kyoto Protocol calls for Canada to reduce carbon dioxide emissions to 6% below the emission level of 1990 by the year 2012. Even if emissions could be immediately stabilized, the atmospheric carbon dioxide content would continue to rise until atmospheric levels equalized with current emission rates.



As a more practical example, to eventually stabilize the carbon dioxide concentration at, for instance, 450 parts per million (present concentration is 360 ppm) worldwide emissions would have to start decreasing by 2012, fall at the same rate they have been increasing, and eventually drop to less than 25% of the current level. Even with this optimistic course of events, climate change associated with the enhanced greenhouse effects of past and current emissions is inevitable.

As changes in climate, including continued warming, are likely to continue for some time, the federal government is encouraging a better understanding of the impacts of climate change and the development of ways to adapt to these changes. Past evaluations, such as the Canada Country Study, have focused on national concerns for the following sectors of our economy: municipalities and infrastructure, water resources, food supply, health, coasts and forestry. These sectors have been identified as priorities for research by the Canadian Climate Program Board, in a document that describes options for dealing with climate change. One recommendation is the establishment of a network of centres for co-ordinating climate change impacts and adaptation research and for disseminating information and research results (a Climate Change Impacts and Adaptation Research Network, or C-CIARN). All of the listed sectors are present in the North, an area expected to be heavily impacted by climate change. This workshop affords an opportunity for participants from these sectors to state their views on how a northern centre could function and what kinds of information will be required for devising adaptation measures

Operation of the Workshop

Facilitator Hal Mills gave an overview of the operation of the workshop and reviewed the agenda. Five break-out groups were established as follows:

1. **Communities and Infrastructure** - Facilitated by Janice Traynor
2. **Water Resources / Hydrology** - Facilitated by Matt Bender
3. **Coasts, Marine Resources, & Traditional Use** - Facilitated by Hal Mills

4 and 5. **Forestry Fisheries and Wildlife** - Facilitated by Jamie Bastedo (group 4) and Natasha Thorpe (group 5)

BACKGROUND ON CLIMATE AND IMPACTS

A series of presentations summarizing personal experience with climate change or studies of the impact of climate change on several time scales.

Session chaired by Larry Dyke

Effects of climate change on wildlife at Holman Island

Sadie Joss and Bessie Inuktalik

Information was gathered from elders in the community of Holman concerning changing sea ice and climate conditions and how these changes have affected travel, hunting and animal distribution. Specific observations noted during spring and summer trips include:

- ice in the bay in front of Holman used to last until late July/early August in the 1970's, but has gone by late May during the past 10-12 years, because it is thinner (less than 2 feet) and breaks up earlier, due to stronger winds
- complete freeze-up of the ocean has not taken place for the last 15 years
- for the past 5 to 7 years, there has not been much snow near Holman, and this has been blown away by winds, exposing gravel and making travel by snowmobile difficult
- settlement of the ground surface is taking place in summer, due to melting of permafrost
- permanent snow banks near Holman have disappeared in the past few years
- there are more bad storms and more wind in the past few years
- less wildlife is being seen near Holman, including small birds, lemmings, foxes, owls and caribou, but musk ox are more numerous
- earlier break-up means less time for seals to grow
- ocean levels have been higher recently

Discussion

Discussion included the influence of the increased storminess on the activities of the community. It was noted that in the community of Holman, more snow builds up, but there is less on the land as it is blown away. Sea ice doesn't form until the end of October now. Fewer polar bears were also noted. It is felt that this is related to the smaller numbers and lower body weight of seals.

Similarities were noted between the observations of the Holman elders concerning storminess and temperature, and by elders of Rankin Inlet, including the similar impacts this has for wildlife (changing migration routes of 3 major caribou herds in the area).

One participant asked how the people in Holman feel about what they have observed. Bessie Inuktalik indicated that elders are very worried, and frustrated, because they don't know who to report their observations to and they don't know how to solve the problem.

Sea ice extent during the past 10,000 years

Art Dyke

The distribution of sea ice in the channels of the Arctic Islands has been inferred from the distribution of radiocarbon-dated Bowhead whale bones. Bowhead whales feed at the edge of the sea ice pack, where they are harvested by hunters. The bones are found in archaeological sites on raised beaches in the High Arctic, and dated. The distribution and numbers of whale bones of various ages shows how much of the Arctic was covered by ice in the past (see paper in ***Arctic***, 1996, Vol. 49, No. 4, pp. 235-255).

For the last thousand years, stocks of whales and other sea mammals in the western (Bering Sea) and eastern Arctic (Davis Strait) have been separated by persistent summer sea ice blocking the channels of the central Arctic Islands. However, this ice-plug has not been present throughout all post-glacial time. An exclusion of whales from these channels started abruptly at 8,500 years ago and continued to about 5,000 years ago. This was probably due to a change in water ocean circulation patterns, which resulted in congestion of channels with sea ice, even in summer. This change in circulation was caused by a replacement of meltwater outflow (during continental deglaciation) by circulation induced by currents in the Arctic Ocean. After this, until about 3,000 years ago, warmer summers resulted in ice conditions favourable to movement of whales into channels. After 3,000 years ago, cooling probably once again produced ice conditions restricting the movement of whales. These later changes may be related to changes in the positions of regional high- and low-pressure areas over continental North America and the North Atlantic Ocean. Research indicates that sea ice conditions in the Arctic Islands reflect a dynamic system with large variability and extended periods of open or closed conditions lasting for millennia.

Arctic Ocean ice cover during the last 30 years

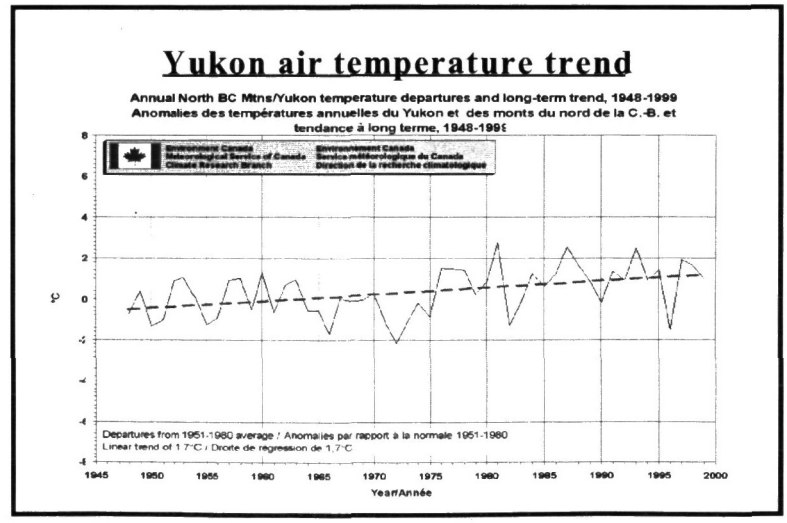
Sharon Jeffers

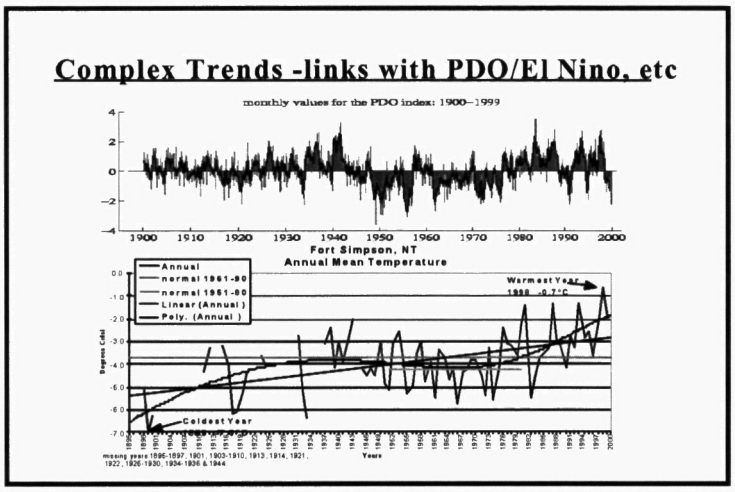
The Canadian Ice Service, which produces and distributes information on sea and river ice, has recently digitized 30 years (1968-1998) of weekly sea ice charts. Areas covered include Hudson Bay and the Arctic. The digitized data gives detailed information on sea ice extent, coverage, age and thickness. Sea ice distribution has a natural high variation from year to year. However, changes in ice patterns can be seen using the digitized data. The data show that 1) the amount of ice has increased in Baffin Bay in the 1990s, 2) Foxe Basin has had significantly less ice in the 1990s, 3) land fast ice is forming later in Penny Basin and Cumberland Sound, 4) the 1980s generally saw more ice than the average for the past 30 years, and the 1990s less ice (especially for NW Hudson Bay). Work is in progress to identify extreme years in the 30-year period and to identify the environmental causes of the extreme ice years. The website address for the Canadian Ice service is: http://www.cis.ec.gc.ca/. This site includes the Climatic Ice Atlas, showing weekly average ice conditions for the major regions of the Canadian Arctic.

Recent climate trends in Canada's North

John Bullas

This presentation summarized climate trends over the past 100 years or so of record available at weather stations in the North (see also Workshop Background document). There has been overall warming since 1945 in the Western portions of the Arctic, mainly in the winter and spring. This has led to decreased spring snowpack and longer ice-free seasons. Warming in the Tundra district is weaker and more evenly distributed seasonally. Eastern portions of the Arctic have been neutral or exhibit weak cooling. Precipitation has increased in the Tundra district but trends are neutral elsewhere. There is evidence in the west of a long-term (inter-decadal) cycle in the mean annual temperature field overlaid on the overall positive trend since the 19th century.





This cyclical nature seems to be related to a sea surface temperature phenomenon known as the Pacific Decadal Oscillation. Analyses of recent trends in temperature and precipitation on a regional and national basis can be seen at: http://ww.tor.ec.gc.ca/ccrm/bulletin/.

Sovereignty and science issues related to sea ice

Col. Pierre Leblanc

Evidence from the scientific community strongly suggests that warming is occurring in the Arctic, and that this is affecting the environment. But the impacts of climate change extend beyond weather, the environment, and wildlife. Decreasing ice conditions may result in the Northwest Passage becoming an international shipping route. Some studies conclude that the NW Passage may open completely in summers soon, and be accessible year-round to ice-reinforced vessels, as early as 10-15 years from now. Availability of a northern connection between Europe and the Far East would significantly decrease shipping distances from the current Europe-Panama Canal-Far East routes. This will raise issues of sovereignty because the passage is not currently recognized as internal waters. This is an important issue considering that Canada would bear the brunt of the costs of shipping disasters such as oil spills. Canada must be in a position to regulate any traffic in that fragile ecosystem. As the capital planning process to enact major infrastructure projects (i.e. large ice breakers, increased military presence, etc) takes 12-15 years, appropriate measures must be taken as soon as possible to improve our security posture and prevent spills in the first place. Predictability and forecasting of climate change is important information in the decision making process. Canada needs information of its own on changing climate and its' impacts, on which to base decision-making process. Canada must not depend on information provided by other countries, with national interests of their own at heart.

Discussion

Discussion focused on the Canadian interpretations of our international marine boundary limit (200 mile offshore of headlands) versus the American and European interpretation of 12 nautical miles. After the 1969 voyage of the oil tanker Manhattan (accompanied by a Canadian ice breaker), the United States agreed to advise Canada before any future transits, but refused to recognize any limitation to their access to what they claim is international waters. The concept of an ecological protection zone was discussed although no precedents were known.

Research Expertise in NorthEastern Canada (RENEC)

Yves Michaud

The objectives of the RENEC program, developed by a group of researchers in northern Quebec to address concerns about impacts of climate change, were reviewed. RENEC was formed to provide a forum for information exchange and to promote multidisciplinary research projects. The scope of the program includes assessments of: 1) past, current and future climates; 2) the impacts of climate on permafrost, vegetation, water, and soils; and 3) adaptation to future climatic variations, both of

infrastructures and traditional way of life. RENEC involves a wide range of expertise in natural sciences with a research program that concerns three tasks: 1) identification and assessment of climatic indicators in northern environments; 2) establishment of the dynamic links between climate, natural environment, vegetation and fauna; and 3) development of climate adaptation strategies.

PANEL ON CLIMATE AND IMPACTS

Chaired by Hal Mills

A panel of researchers and practitioners was asked to summarize individual experience with the impact of climate change. These presentations were followed by an open discussion and question period.

Stewart Cohen – Mackenzie Basin Impact Study (MBIS) Leader

This study took place from 1990-96, and was published in 1997. Results included some advantages to climate warming, as well as significant problems that may be encountered (i.e. less heating fuel will be required, but permafrost disturbance, forest fires, and other changes will occur). Layered on top of this are the changes to how the land is used and managed by humans. The final workshop for MBIS determined that proactive action is desired; there is a need to adapt and plan for adaptation. Everybody has a role in formulating a response and planning for climate change but the existing mechanisms for sharing and collaborating are not easy to work with, so there is a need to talk about the possibility for a national network with a northern node. If a northern research and consultation node had existed while MBIS was operating, it would have been much easier for MBIS to reach out and share information. Other arctic regions are thinking about this. International and national examples on responses to the climate change issue were provided, including Arctic Climate Impacts Assessment (ACIA) and the Bering Sea Impact Study (BESIS). For MBIS Internet information, see: http://www.tor.ec.gc.ca/airg/mbis.htm.

Norm Snow– Traditional Knowledge Study Coordinator

A project on Inuit observations of climate change, from the perspective of the Inuvialuit of Banks Island, is producing a 1-hour TV documentary video to demonstrate how climate change is having an impact on traditional lifestyle of Banks Island residents (see also the website at the following address: http://iisd.ca/casl/projects/inuitobs.htm). The study is working to integrate local and scientific knowledge. Several preliminary observations related to sea ice, marine and terrestrial wildlife, and effects on permafrost were presented, including:

- later freeze-up, earlier break-up, less multi-year ice
- netting of cohoe salmon, grizzly bear sighting on ice north of Banks Island, polar bear seen 250 km inland at Tsiigehtchic
- an increase in extreme weather after the 1950s, with more thunder and lightning, stronger wind storms and coastal erosion
- milder winters and more mosquitoes, blow flies, appearance of sand flies, plus reports of robins, warblers and other birds

Larry Fairbairn – Transportation specialist with RTL and Robinson's Enterprises

The all-weather and winter road system in the NWT was described, including the process of building and operating winter roads. RTL has been engaged in building winter roads for more than 30 years. While climate change has not, as yet, affected the duration of winter roads, warming could have large implications on maintenance of winter roads, the risk to freight, and the economic viability of ground

transportation, if the hauling season is shortened. Warmer winters of the past 10 years have not reduced the duration of winter roads, but additional efforts have been made to aid thickening of the ice, and late winter operations have been limited to cooler nights. Additional, new solutions may be needed to adapt and maintain the transportation system, should winters continue to be warmer.

Steve Solomon – **Coastal Researcher**

The magnitude of storm surges and coastal stability on the Beaufort Sea coast are directly related to the fetch (or distance) of late summer/fall ice-free water from the coast to the edge of the off-shore Arctic ice pack, as well as the severity and duration of major storms. Climate change models are not good at predicting impacts like changes to sea ice cover. Coastal changes are driven by changes in climate, like waves, tides, currents and water levels, interacting with geology of the coast, which is complicated by permafrost, massive ground ice, changes in sea level and the presence of sea ice, which has a protective role in terms of coastal erosion. The impacts of storm surges in the Tuktoyaktuk region (including the major recent 1993 storm surge) were reviewed. Increases to the open water season, along with more fall storms, may cause more erosion damage, particularly if sea ice freeze up occurs later in the year following the fall storms. Should storm surges become significantly worse or last much longer in the future, a few major events could destroy much of the peninsula on which the community sits, as well as exposing Tuktoyaktuk harbour facilities to direct attack from the sea.

Norman Snowshoe – **Gwitch'in Settlement Area Administrator**

From many interviews with elders, it has been noted that the Gwitch'in people are noticing warmer weather and more variable weather patterns. There are a number of impacts attributed to warming, including lower water levels, changes to fisheries and fish harvesting, more landslides contributing to increased sediment in the rivers, changes to wildlife distribution and movement with associated impacts to harvesting, changes to vegetation diversity and lower berry production, and more forest fires. New species have been observed (polar bear shot inland near Tsiigehtchic, moose falling through ice in the Mackenzie Delta, lower waterfowl populations, etc). Because river ice is thinner, it is more hazardous to travel to normal hunting areas, and the animals are not behaving as they did in the past. The elders want to know what is happening and if it can be fixed. Workshops like these provide answers to some of their questions. Due to the noticeable change in the last 20 years elders are worried about the speed of change that is occurring in the environment.

Bea Alt – **Climatologist**

Bea discussed how scientists could contribute to the explanation of climate change trends. Trends in climate data must be carefully assessed. Average trends from short station records may be misleading as a means for extrapolating to the future. Records for 100 years from the western arctic show cycles in mean annual temperatures lasting for decades whereas records for only the most recent 50 years tend to show only an increasing temperature trend. There has to be a better way to show time changes because data can be misleading depending on where the trend is started chronologically. To illustrate the scenario of climate change, the summer of 1998 was used as an example to find out what type of signal can be expected when the eastern arctic begins to warm. Information on the state of permafrost and ice conditions in the high arctic is being gathered from delegates who have witnessed climate changes. In addition, information was collected from the camps throughout the Arctic Islands that were occupied during this year. As well, additional information can be gathered from these camps on an ongoing basis.

Discussion

One participant asked if there is a potential for an exponential (rapidly increasing) rate of climate change, as opposed to a linear change. Discussion included the points that there could presumably be

a non-linear build-up of temperature if greenhouse gas emissions rose at higher rates than current models predict, but the full extent of that possibility is unknown. There could also be drastic changes occurring rapidly if certain thresholds were crossed that caused, for instance, a sudden change in ocean currents.

Evidence for sudden shifts was discussed. There is evidence that rapid deglaciation was linked to rapid changes in climate. Reversals from glacial to interglacial phases have occurred in just a few years, leading to, for instance, the sudden melting of the Laurentide ice sheet. The influence of this melting was to put a freshwater cover over the North Atlantic and shut off the warming influence of currents to the south. Processes such as these that are going on in the world's oceans are critical in determining the scale and pace of global change in climate.

Further evidence was presented that small changes of climate, such as a warming of one or two degrees, may cause significant changes. Past evidence suggests a large advance in the tree line of the Yellowknife region under similar increases in temperature. Smaller scale changes in climate can cause significant environmental changes through various feedbacks. There will be many surprises when it comes to the impacts of climate change.

One participant raised the concern of positive feedback that results when there is more sea ice melting, thereby increasing the amount of darker ice, resulting in even more rapid melting. Although much of the discussion around climate change focuses on temperature, in terms of sea ice one of the most important things is the amount of snow cover and when it falls. There are obvious feedbacks from one season to the next when it comes to sea ice formation and melting. Many of these have been observed by local community members who watch sea ice, and cannot be predicted by western science.

Another participant wondered if predictions for environmental change were too dramatic, given that it often takes the ecosystem a long time to respond to climate change. It was agreed that caution was required when making correlations, but there are clear direct links such as the number of landslides in the Yukon that have been directly linked to the fire index.

Another participant noted that predictions regarding changes that are expected to occur are contradicted by observations and other studies. For instance, recent studies for the Global Water & Energy Cycle EXperiment (GEWEX) suggest that Mackenzie River water levels could rise, but the opposite has been occurring in recent years (earlier MBIS studies suggested that summer water levels could decrease). It was agreed by the panel that there is dispute about the possible scenarios for the future and there has been much controversy, in particular, about water levels on the Mackenzie River. Better communication is needed to help refine predictions, but predictions can be useful; those making predictions, however, need to be very clear when there are discrepancies and major uncertainties.

One participant shared observations about changes around Rankin Inlet that included a decrease in the amount of snow that lasts through the year and changes in the conditions of caribou fat deposits.

The question was raised on the types of impacts to marine mammals that can be expected from climate related features, like sea ice plugs. Are populations that are separated by these features diverging genetically? Although the answer was not known, there is some evidence from the whaling period that whales were able to get through the sea ice plugs, allowing some genetic mixing of eastern and western Bowhead populations.

One of the issues raised in discussion was with regard to the possible evidence of changes in winter road performance. One panel member indicated that the winter road system has been relatively stable in its duration for the past 20 years, however it is getting more difficult to maintain the winter road system for the entire season. One question raised was what is the minimum number of days after which it would not be profitable to have a winter ice road. If the season decreased enough, an economic study would have to be done to determine when it would not make sense to operate the ice roads.

One of the participants noted that there was a lack of discussion on solar radiation and its impact on climate change. There has been a slight increase in solar radiation, although this cannot explain the increase warming of the 20th century. The impact of greenhouse gasses cannot be ignored. There is a need to design improved models and to implicate them to monitor trends in global climate changes. It was pointed out though, that emphasis should not be placed on certainty with models but with dealing with the impacts that are being faced presently.

DAY TWO – MONDAY, FEBRUARY 28, 2000

IMPACTS AND ADAPTATIONS

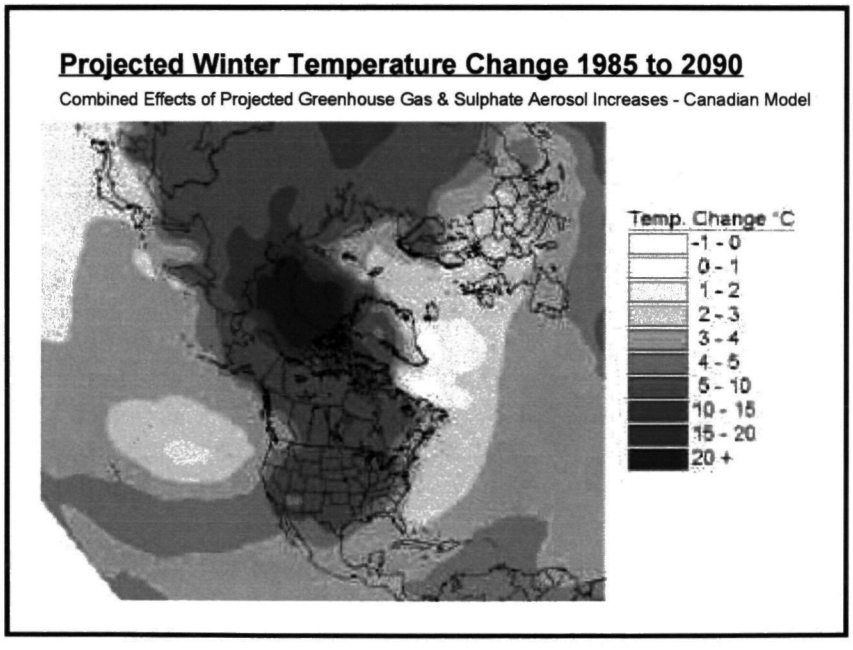
Session I Chaired by: Jesse Jasper

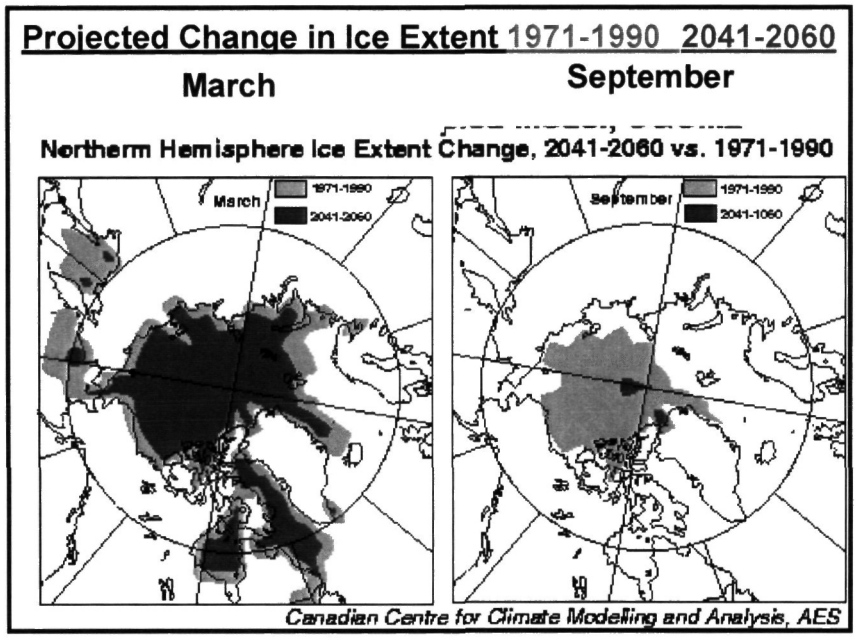
A summary of the latest advances in climate modelling followed by reports on how different parts of the environment may be affected by climate change.

Results and implications of climate change models

Francis Zwiers

The focus of this presentation was on results from climate change modeling of the Northern hemisphere. Projections of climate change in the Arctic for air temperature, ice content and snow are drastically different from present conditions. Results from Canada's global climate model (GCM) indicate that average annual global temperatures may increase by 3-5°C, much of this in the winter.





Temperatures in northern Canada may increase by 5-8°C, including winters 8-10°C warmer in the Mackenzie Valley and 10-20°C in the Arctic Ocean/Arctic Islands. (Note potential impacts on sea ice left from Canadian GCM's). While much smaller changes are expected during the summer, the stability of weather patterns could still change significantly.

Discussion

One participant suggested using a more complex model, such as linking climate and hydrological models. There is a simplified streamflow built into the climate model, however, it is a very simple representation of river basin flow. Another participant raised the question of how these climate models incorporate the occurrence of extreme events. Winds are simulated in the climate models, however only large-scale structures are looked at (e.g. tornadoes, cyclones). At the scale of current models, large changes in winds or frequency of major storm events are not detected. Thus, there is a problem with scale, since the intensity and frequency of storms are experienced at a much smaller scale than the models can deal with.

A suggestion put forth for the climate models was to incorporate plans for enhanced inclusion of ocean factors. In current models there is a good 29-layer model for deep ocean currents but atmospheric models will be enhanced in the next generation computers to better incorporate oceanographic factors such as mixing, as well as increasing the number of layers in the atmosphere and significantly decreasing the size of grids in the models. These changes should dramatically improve the ability of models to handle local to regional weather conditions.

Recent climate–related shifts in hydrology of northern Canada

Paul Whitfield

This presentation dealt only with shifts in hydrology north of 60°. A pattern of increasing streamflow is seen right across the North. For example, data from the Lockhart River have shown a significant increase in streamflow over every month of the year. Climatic and hydrologic variations between the decades 1976-1985 and 1986-95 were examined. Temperatures were generally warmer in the more recent decade, particularly during spring and summer time periods. The hydrologic responses to these variations in climate typically result in increases in stream discharge throughout the entire year. These results suggest that water stored on the landscape is lost during warmer periods from storage in permafrost, stored snow and glaciers. However, in mountainous areas, an earlier onset of snowmelt was followed by decreased summer and fall flows. These recent variations illustrate the leverage effect of small variations in climate, particularly temperature, on hydrologic systems. Climate change impacts on northern hydrology are described in *Canadian Water Resources Journal*, 1998, Vol. 23, pp. 219-229.

A survey of climate change impacts on northern ecosystems: Gaps in our understanding and suggestions for improving knowledge

Tom Clair

The presentation summarized results of a report to the Northern Ecosystem Initiative (NEI) management group of Environment Canada on scientific literature available on climate change and ecosystems in the North. The objective of the work was to identify what has been done on the subject until now, and what main research needs exist. With this information in hand, the report makes recommendations on useful contributions to improving knowledge on the topic.

This task was done in several steps. The report summarized information on recent changes in the climate of the North, as well as what current General Circulation Models predict for the region. Canada Country Summary reports were scanned to provide a summary of recent climate-related research in the North, and regional research recommendations summarized to identify local knowledge shortcomings.

A further step was survey to government and academic scientists on what they were doing in terms of ecosystems and climate change in the North, as well as what they felt were data and information shortcomings. Seventy-one replies were received and summarized. An extensive literature survey was conducted to see what researchers have been doing relating climate change in the North in the past (more than one thousand reports and papers were identified and divided into groups).

The report makes a number of recommendations, based on these results. The recommendations were broad-based and were not aimed at local or specific issues, as these were already done in the regional CCS Volumes. These recommendations were designed to encourage linkages between various knowledge specialties and interests which otherwise would not occur.

The first recommendation to NEI is to make available to ecologists, environmental and social scientists, and aboriginal people, a summary of climatological conditions in the North, along with a discussion of what climate models predict. This will sensitize interest groups to the problem, and allow them to design studies and data interpretation relating climate, climate change and ecosystems, more intelligently. A second thrust is to encourage ecosystem research that incorporates climate, climate elements or climate scientists in the design or in the study teams. The third suggestion is to encourage the incorporation of traditional knowledge, or aboriginal concerns in the selection of projects. The website site for NEI Climate Change report is http://www.atl.ec.gc.ca/nei/.

Adapting to changes in river flow and water levels in the Arctic

Hans Martin

The main objective of the presentation (a comparison of the current climate change concerns to the story of the Biblical Flood and Noah's Ark) was to encourage planning, mitigation and adaptation strategies for the impacts of climate change and variability. Suggestions resulting from the report were for contingency plans to be reconsidered and strengthened, and for the compilation and analysis of past adaptation practises. Major environmental disasters may begin to drive the push for GHG emission reductions soon, but adaptation will be a key strategy for the foreseeable future. A report on ***Water Sector: Vulnerability and Adaptation to Climate Change*** has been produced by the International Institute of Sustainable Development (IISD) in Winnipeg (see IISD Website: http://iisd/ca/).

Discussion

One participant suggested that mitigation was a key aspect missing from climate change efforts. A response to this is that there are alternative methods for future development that are related to CO_2 emissions. An important consideration is whether a sustainability lifestyle or developmental lifestyle should be pursued.

Session II Chaired by: Stewart Cohen

Tundra plants and ecosystems as indicators of climate change

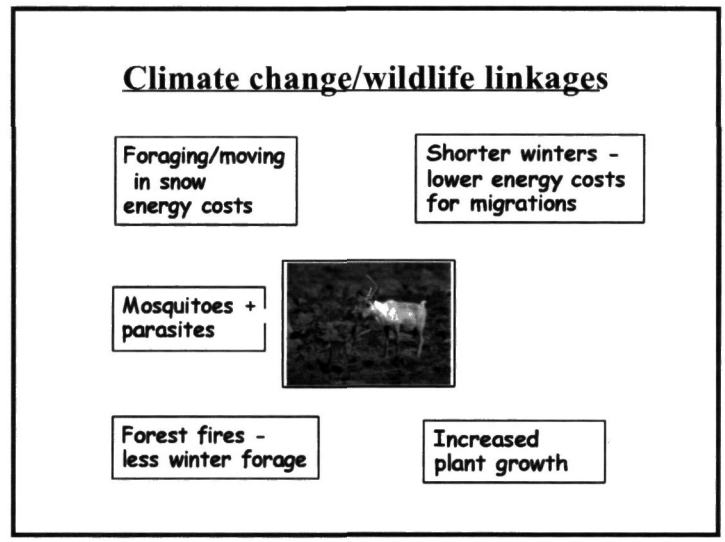
Greg Henry

An international network for monitoring plant growth and changes in the number of plant species on the northern hemisphere tundra has been organized over the last few years – the International Tundra Experiment (ITEX). Predictions for longer, warmer seasons will lead to increased rates of phenology, growth and reproductive success. Results from warming experiments in tundra ecosystems (construction of simple enclosures of plastic to act as miniature greenhouses around arctic tundra plants to warm their macro-environment as predicted for future climates) have shown that significant increases in these rates can occur with relatively small increases in temperature. There will be a greater net primary production as a result of early snowmelt and an extended growth period. Ecosystem structure will change with shifts in the dominance of plant species and species composition. These changes will affect processes such as nutrient cycling through litter quality and quantity. One of the positive aspects of these changes may be increased availability of forage plants for important herbivores such as caribou, muskox and migratory birds. Feedbacks between tundra ecosystems and the atmosphere will also change, and it is unclear whether tundra systems will act as a sink or a source of greenhouse gases such as carbon dioxide and methane. Information about ITEX is available at the following website: http://www.dpc.dk/about_us/NSN/ITEX.html.

Impacts of climate change on caribou

Anne Gunn

The diversity of caribou habitat and regional variations in climate limit generalizations about possible effects of climate change on caribou. Changes in the weather will result in both gains and losses for caribou but it is uncertain how these gains and losses will balance and change the sustainability of caribou herds. Gains for caribou will include more plentiful summer food if warmer summers increase plant growth through increased thaw of the soil and enhanced cycling of nutrients.



Other gains are shorter winters that could save caribou the energy costs of walking through and searching for food in under deep snow. However, losses may include warmer summers that increase the severity of mosquito and warble fly harassment for caribou unless the weather is also windier. More lightening strikes and drier forests will reduce caribou winter forage as the number and intensity of forest fires increase. Other losses include the energetic costs of winter foraging if warmer winters mean more freezing rain and deeper snow. Some impacts on caribou may be critical (i.e. if spring arrives two weeks earlier, energy modelling indicates that caribou may lose weight over the summer, rather than gaining weight for the next winter).

For caribou populations already under stress (i.e. Peary caribou in the High Arctic), increased occurrence of mild winter temperatures and rain (producing ice covering their food supply) may cause further declines.

Sustainability of arctic communities under climate change

Gary Kofinas

Research scientists and four partner communities (Aklavik and Fort McPherson, NWT, Old Crow, Yukon, and Arctic Village, Alaska) within the international range of the Porcupine Caribou Herd have cooperatively developed a simulation model for predicting caribou populations. The project is part of an integrated assessment of climate change on Arctic Communities. The project evaluated the possible effects of climate change, oil and gas development, tourism, and government spending on communities, on Porcupine Caribou hunting communities, and demonstrates how a new approach to integrated assessment that is includes local knowledge can improve communication among groups and lead to better common understanding. The model attempts to help the communities assess sustainability of activities can be viewed and operated from the following website: http://www.taiga.net/sustain/.

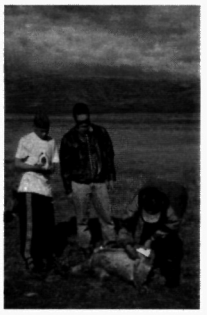
Inuit ecological knowledge of climatic influence on caribou and calving areas

Natasha Thorpe and Sandra Eyegetok

The project originated as an attempt to demonstrate how traditional knowledge and Inuit can contribute to knowledge and understanding of climate change. Inuit in the Kitikmeot region have observed a general warming trend since the 1950's. Within this trend, there have been short-term fluctuations both within and between decades. This has led to seasonal effects including earlier spring snowmelt, increased snowfall, warmer temperatures and sporadic freeze-thaw cycles.

Inuit ecological knowledge contributes

- because "Inuit are first to notice" and adapt to climate change
- focused local and regional insights and historical observations
- survival based knowledge of environmental relationships and components (e.g. relationship between climate change and vegetation and caribou)
- research priorities, directions and scientific hypotheses



" Weather is always changing. It has a caretaker of it's own... it's never the same."
- George Kuptana 1996

A key primary effect of a changing climate has been an increase in abundance and diversity of vegetation. This has impacted the movements, migrations and calving ground selection for the Bathurst caribou herd. For example, warmer temperatures have caused small shrubs to flourish and provide key habitat for caribou, particularly along water bodies. More abundant vegetation has provided shade and allowed caribou to remain cooler during hot days.

Discussion

One of the issues raised was if traditional knowledge had been given a real opportunity to ask new questions regarding climate change. A response by one of the participants was that elders and hunters have provided valuable information to scientists, which have been different from what the models have suggested. One scientist noted that traditional knowledge has been a contributing information source in research for decades, with it becoming increasingly recognized in present scientific research. For more information, please see http://www.polarnet.ca/tuktu.

MONDAY LUNCH PRESENTATIONS - Northern Colleges

Yukon College/Northern Climate Exchange - *Aynslie Ogden*

The Northern Climate Exchange (NCE) is a centre for climate change research and education in the circumpolar North. It was established in February 2000 at the Northern Research Institute at Yukon College. Major funding for the Centre has been provided from the Climate Change Action Fund, Government of Yukon, Environment Canada and Yukon College. The centre is intended to advance knowledge of the effects of climate change on the North and of adaptation to potential changes. It is also interested in increasing science and research capacity among northerners and promoting local economic opportunities for developing technologies and practices that can mitigate climate change impacts. The NCE is working towards engaging northern stakeholders in climate change discussions and strengthening circumpolar links through the exchange of knowledge and expertise. See Northern Climate Exchange website: http://www.taiga.net/nce.

Aurora Research Institute - *Valoree Walker*

The old NWT Science Institute split into Aurora Research Institute (ARI) of Aurora College, and the Nunavut Research Institute of Nunavut Arctic College. Aurora Research Institute provides research support from Inuvik and Fort Smith centres, and operates an office at the Aurora College office in Yellowknife. Its' primary activities include licensing research activities in the NWT (GNWT Dept. of Resources, Wildlife and Economic Development (RWED) covers wildlife research and the Prince of Wales Northern Heritage Centre archaeological research). ARI coordinates research under the NWT Science Act, conducts community reviews of research proposals, promotes public awareness of science, technology, and traditional knowledge, and exchanges between practitioners, provides logistics support to researchers, and distributes information on annual research activities. See Aurora College Website: http://www.auroranet.nt.ca/aurora/.

Nunavut Research Institute - *Jamal Shirley*

Formerly the Science Institute of the NWT/East, Nunavut Research Institute (NRI) amalgamated with Nunavut Arctic College (NAC) in 1995 to serve as the College's research arm. NRI acts as research broker on behalf of Nunavut community groups and individuals, provides information on research projects and funding programs, and can assist with the development of project proposals. NRI also issues research licenses under the Nunavut Scientists Act, and coordinates a variety of research, monitoring, and Inuit Qaujimantuqangit (IQ) documentation initiatives through Research Centres in Iqaluit and Igloolik. Current projects include recording Iglulingmiut, mapping place names of the Iqaluit area, facilitating renewable energy technology demonstrations (i.e. wind generators in several communities), plant phenology monitoring for Environmental Monitoring and Assessment Network (EMAN-North), etc. For further information, see the Nunavut Arctic College Website: http://pooka.nunanet.com/~nachq/.

ATTITUDES AND EXPERIENCE OF PRACTITIONERS

Breakout group discussion to assess practitioner experience with climate change and requirements for increasing the ability to cope with climate change.

Report of Breakout Groups to Plenary

Group 1: Communities and Infrastructure

Opening remarks by break-out session resource people:

Scott Williams, Environmental Manager for BHP at Ekati Diamond Mine

- Some positive benefits in terms of:
  - safety to personnel who work outside,
  - lower costs in terms of heating and electricity, and
  - more reliability and lower costs for operating equipment.
- Much larger list of negative impacts:
  - construction activities and infrastructure rely on frozen ground (e.g. frozen core dams, building and road foundations),
  - storms and events such as ground fog result in cancelled flights,
  - windstorms can create risks for those working in the pits,
  - permafrost hinders groundwater movement into the pits – this may change with warming, and
  - water discharge issues related to higher levels of solids from thawing permafrost.
- Monitoring for indications of change in dams and pits via ground temperatures.
- Warming will change the way the mine operates.

Réjean Couture, Visiting Scientist, Terrain Sciences Division, GSC, NRCan, Ottawa

- Examining the reaction of building foundations to climate change in Norman Wells, N.W.T.
- Reviewed impact of climate change on performance of engineering designs in permafrost and the types of structures that may be affected.
- Impacts generally related to soils, e.g. landslides, slope and riverbank erosion, leaving facilities vulnerable.
- Consideration of climate change in design may lead to more conservative and costly designs.
- Need to update engineering references to include climate change.
- What else do we need to do to adapt in the next 2 to 5 and 10 years?

Group 1 Rapporteur - *Ed Hoeve*

1. ***What positive or negative impacts, is current climate variability having on your sector?***

- Transportation (particularly winter roads and ice crossings) is one of the most challenged elements of this sector. The impacts for transportation are all negative.
- Ice spray technologies has allowed the ice crossing at Fort Providence to be built faster so although climate warming has meant that crews can't get on the ice to work until later in the season, the crossing is ready about the same time.
- On the Rae Lakes winter road, there has been increased maintenance costs and an impact on safety with melting permafrost and slumping. Slower freeze up takes longer to get the road up to full capacity, if it gets there at all. Lots more use of salt and gravel (3 times the amount of salt, 8-9 times the amount of gravel).
- Having an economic impact on transport of goods and for industry, because at the same time there are bigger demands on the road with faster and bigger trucks.
- More freezing rain in the winter is having an impact on caribou. Hunters have noticed that the animals are thinner. Moose are falling through the ice and there are now muskox in the mountains in the Sahtu.

- In Whitehorse, the hydro-power system has seen impacts due to more evaporation from reservoir. Yukon Power has to use more diesel due to less dependable water supply, with negative effects on people, such as noise, particulates (particularly during frequent thermal inversions that trap air near ground level in the city).
- Land use regulators need to factor in climate change in things like abandonment and restoration plans, so that projects that revert back to the Crown have limited liability. To date, this hasn't been done. May have to change security bonds to account for this.
- Trying to plan for climate change is a large cost to the proponent. During the environmental assessment process, it is a challenge for proponents to account for climate change. In terms of gravel resources, melting ground ice is a problem, although a deeper active layer makes extraction easier.
- Government does some active layer and ground temperature monitoring, although there are large blank areas where there is not monitoring (e.g. some parts of Nunavut and the Slave Geological Province). Climate change is taken into account for some engineering (e.g. at BHP diamond mine) but is the amount of warming accounted for enough? Engineering does not take into account variability or extremes in climate.
- Municipal infrastructure in continuous permafrost zones sees some benefits to climate warming. Later freeze up means the construction season now extends into October to get sewer pipes in the ground. Shipping season is longer.
- Reduction of heating costs (both cheaper and reduced contributions to greenhouse effect). In the longer term, more negative effects as permafrost melts. Snow fences are anchored in permafrost; these are stressed by major storm and wind events. Permeable embankments surrounding sewage ponds may mean that spring seepage through embankment may occur as active layer deepens.
- Buildings don't seem to showing effects of climate change, probably due to the factor of safety built into designs, but problems will come first in the discontinuous permafrost zone. Extreme events, like high winds, contribute to building damage.

2. ***Will your Sector be challenged by climate change?*** Yes!

3. ***What further information do you need to adapt to climate change?***

- Need early warning! Need more ground temperature monitoring and active layer monitoring. How are water temperatures of small lakes changing? What are the impacts of these on winter road?
- Designs that account for variability, instead of mean temperatures.
- More heat transfer and mass balance modeling needed to better understand heat and moisture exchanges.
- Funding for research and development projects needed.
- Need to know what are the impacts and what are the engineering solutions. Science and industry have to get together – communicate what impacts are affecting industry so the scientists can work on solutions!

Group 2: Water Resources/Hydrology – Rapporteur *Bill Quinton*

1. ***What impacts, positive or negative, is current climate variability having on your sector?***

- There was consensus that anticipating change with any degree of confidence is extremely difficult; as a result, so too is planning for adaptation. The bottom line: it is hard to adapt to climate change if you don't know what the outcome will be.

- Participants agreed on the major difficulty of distinguishing between positive and negative impacts.
- Impacts specific to the group included municipal water management in the Kitikmeot, hydroelectric planning on the Snare River, and transportation problems related to lower water on the Mackenzie. The hamlet of Kugluktuk, for example, recently experienced problems with sedimentation entering water intake lines. Slumping from melting permafrost along the Coppermine River has been noted as a key cause. The freezing of water pipes and unstable soils are also recurring problems in the region.
- In the North Slave, fluxes to the hydrology of Snare River have made it difficult to determine how much water should be stored in reservoirs for hydroelectric power generation. The reservoirs are designed to accommodate average water levels. Hydrological changes can skew predictions for energy production.
- Finally, it was noted that lower water levels on the Mackenzie River have led to difficulties in transportation and barging. This was not discussed in much detail.

2. Will your sector be challenged by climate change?
- All participants were unanimous on this question: Yes! It was decided that elaboration would require too much time and that the accuracy of these predictions could not be guaranteed.

3. What further information do you need to adapt to climate change?
- Due to prevalent information gaps, more data is needed in the North.
- Levels of environmental monitoring should be expanded.
- Avenues for information sharing should be improved.

Group 3: Coasts, Marine Resources, & Traditional Use – Rapporteur *Sharon Jeffers*

1. ***What impacts, positive or negative, is current climate variability having on your sector?***
Mostly negative effects have been witnessed, such as sudden severe storms (sometimes causing loss of life, coastal erosion, low water levels on the Mackenzie River, changes to species distribution and reproduction and the introduction of new predator species such as killer whales, etc).

2. ***Will your sector be challenged by climate change?***
A major concern stressed was that there is an enormous amount of uncertainty in this sector with regards to climate variability. There is a drastic need for an improved forecasting model, which will benefit all. Elders especially have found it challenging to deal with the sudden climate changes that are occurring in the environment. Science is also challenged, and better severe weather and land fast ice break-up forecasts are required. Too much heat in the summer will be hard on people not used to such temperatures.

3. ***What further information do you need to adapt to climate change?***
The group expressed that an improved communication network involving various sectors and organizations is essential for information flow. The knowledge and information passed on by the elders of communities must also be a vital component of this network. Additional information on physical processes such as polynyas, ice formation and break-up, plus study areas that are cooling, is needed.

Group 4: Forestry, Wildlife and Fisheries – Rapporteur *Jamie Bastedo*

Opening remarks by break-out session resource people:

Doug Stewart, Director, Wildlife and Fisheries, RWED, Yellowknife

- We are in a time of pronounced uncertainty when it comes to the impacts of climate change on northern wildlife. Most wildlife studies are not long enough (2 to 3 years) to accurately monitor possible impacts. However there are long-term studies for polar bears. These show that reproductive rates are going down.
- We need better systems for monitoring exactly what is happening "on the ground". This kind of information can influence political priorities and funding decisions. There is a need for "marketing" the importance of climate change both within government and by government.
- The results of climate change monitoring may not be popular. More intensive management may be needed. For example, in cases where climate change may be linked to declining wildlife, hunting quotas may have to be more conservative.
- A more coordinated approach to prioritize research and monitoring programs is needed across the North. One way to do this is to establish a community-based environmental monitoring system. People in communities are "the eyes and ears of the land" and are therefore well placed to contribute reliable information.

Ian Stirling, Environmental Scientist, Environment Canada, Edmonton.

- Unlike most northern wildlife species, there are several decades worth of excellent scientific data collected for the polar bear. Even with such comprehensive information it is still very difficult to determine what impacts climate change is having on this species or to predict what may happen in future.
- Generally, the polar bears of western Hudson Bay seem to be declining in their physical condition and reproductive success. These trends raise many questions about their movement patterns and relationships with their various prey species.
- Hunters are finding it more and more difficult to hunt this species. Quotas may have to be reduced in future to compensate for climate-induced stresses on this species.

Group 4 Rapporteur - *Lorne Napier*

1. ***Discussion of positive and negative impacts of climate variability in your sector.***

- Declines in both the quantity and quality of caribou may be linked to climate change. On the quality side, northerners may for example have to learn to adapt to more parasites in caribou meat as temperatures rise.
- Hunters may have to travel farther to access caribou because of changed migration patterns. Changing ice conditions on lakes, rivers and the sea as well as unusual terrain conditions due to melting permafrost may make it more difficult to access caribou and other wildlife.
- One positive effect of climate change is that concerns over this issue have generated a lot of excellent research and better sharing of information between communities and scientists.
- Concerns were raised about diseases and parasites moving between animal hosts as wildlife species shift their ranges in response to climate change (e.g. white-tailed deer parasites infecting moose, Dall sheep parasites infecting muskoxen).
- The drying and decomposition of wetlands could have serious impacts on ducks and geese with a consequent loss or change of species (e.g. local declines of Lesser Scaup may already be linked to climate change).
- The forest composition may change dramatically if subjected to more intense and more frequent forest fires. For example, over time the dominant tree species could shift from spruce to pine that in turn could shift to aspen. Such changes could have major impacts on the species composition of forest dwelling wildlife. There is much uncertainty on this matter.

2. ***Will your sector be challenged by climate change?***
All participants were unanimous on this question: Yes!

3. ***What is needed to adapt to climate change?***

- Unanimous support for D. Stewart's proposal for community-based environmental monitoring.
- Northern schools and colleges should be linked into this system. The "Globe" environmental monitoring program was presented as a good example of involving students in such studies (contact: *<Peter_Hardy@ycs.learnnet.nt.ca>).*
- Raising public awareness of northern climate change issues should be a top priority. An important part of this should be the repackaging of technical information into more user-friendly formats accessible to the public and the media. We must also "market" the idea that early planning for possible impacts is absolutely essential.
- There is a lot of misinformation about climate change out there. For instance, a recent Reader's Digest article dismisses the whole concept. Any public education campaign should help correct such problems and explain the issue clearly in terms that are directly relevant to northerners.
- We need to take a very practical and applied approach to research and monitoring programs. More coordination and consistency is needed in these programs across the North.
- Long-term environmental data sets are vitally important.
- We need to prepare people for making changes they may not want to make, for instance, changes in hunting practices or energy use. In order to help implement such changes, it is important to "sell" their benefits up front.
- Monitoring programs must be adapted to meet different needs and priorities from community to community and region to region.
- Community elders should be recognized as valuable "data storage and retrieval systems" for long-term environmental observations.

Group 5: Forestry, Wildlife and Fisheries – Rapporteur *Aynslie Ogden*

1. ***Discussion of positive and negative impacts of climate variability in your sector.***
Introductions and round table discussion occurred on the positive and negative impacts associated with climate change. Some specific impacts were discussed with respect to weather, forestry, fisheries and wildlife. In many cases, people had difficulty attaching a value statement such as positive or negative to an impact. They felt it was impossible to develop a comprehensive list of information gaps in this forum. Instead, they simply outlined various impacts.

Weather

- Community members and researchers alike agree that there has been a general warming trend from 1960s to 1990s. It has been windier and stormier during all seasons.
- Community members commented that the weather is more unpredictable these days. This has affected travelling conditions of ice (not thick enough, too much overflow) as well as igloo building conditions. Lightening is more frequent and glacial ice is disappearing.
- We are focused on global warming, but if the North Atlantic conveyor belt is stopped, it might lead to global cooling.
- Warmer temperatures are not positive: winter should be winter. People enjoy winter activities.

Forestry

- There was a general discussion about what an increase in fire frequency means. People agreed that both the number of fires and extent across the landscape has increased.

- People talked about fire as a natural process. Very large fires are common to boreal forests. Older forests burn better because there is more fuel. Younger forests have a natural buffer network. For fire dependent ecosystems, increased fire frequency has a neutral impact.
- We need to know if more frequent wind events coincide with drier weather and increased fires. Any rise in storm frequency causes an increase in the size and area burned.

Wildlife

- There was discussion regarding the fact that wildlife populations normally fluctuate. Some animals are more sensitive to climate change, particularly in the North. Some animals will be more impacted than others (able to adapt). Already there have been observed negative effects to polar bears, seals, birds, and fish. To what extent do we help species adapt to climate change?
- A positive impact is that biodiversity issues can be tabled with new interest because they relate to climate change. Biodiversity will be altered with climate change and we must be careful not to attach values to this. Caribou populations may decrease while bird populations may increase. Climate change causes fragmented habitats and changes species composition. Extinctions will occur, as they have for millennia. Is this "bad"?
- One negative impact is the presence of new types of insects in the North. At the same time, the arrival of new bird species is viewed as a positive impact.

Fisheries

- Fish have changed their habitat. Salmon sightings in Western Arctic have occurred over the past 50-60 years. We need to have better understand whether or not this is related to climate change.
- A negative impact of ice dynamics has been that people must fish for turbot in sub-optimal areas.
- There is concern about extinction, for example, of bowhead whales and walrus.
- Hatcheries will need a period of adjustment to climate change. Presently they favour one genotype over another.

2. ***Will your sector be challenged by climate change?***
   All participants were unanimous on this question: Yes!

3. ***What is needed to adapt to climate change?***

- More anecdotal research (on the ground, bottom-up, and based on both traditional and scientific knowledge) is critical. Researchers need detailed observations at a local scale. These are still useful even if climate change doesn't happen. This data helps model problems dealing with grid sizes that are too large to be incorporated into regional management plans. Most money goes into modelling whereas very little goes towards on-the-ground research. This needs to change.
- Significant information gaps need ameliorating. To do this, we need more ecological monitoring; transect/comparative studies; and local-level ecosystem studies to understand natural processes and climate change impacts and adaptations.
- There should be closer links between community members, regulators and researchers. Multi- and inter-disciplinary approaches are needed. We need to reallocate budgets to facilitate this.
- It is difficult to ascertain how climate change affects natural variability. Variability is a normal process, but we need to understand variability on long time spans. Basic biological (local and scientific knowledge) data will help us understand this better. There is too much money spent on models and not enough on basic biology.
- Monitoring programs are important in bringing forward our knowledge.
- We need to know the data needs from climate community (weather observations; cut- backs mean less data available). There has been a drastic loss of climate records because of cutbacks (e.g. snow survey). We cannot afford this if we are to think about climate change in the long-term.

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- This discussion of impacts calls for a fundamental shift in how we think about climate change. There is a need to change the way our economy works (e.g. heavily depends on fossil fuels). The best adaptation is to reduce impacts. More money is needed to explore this. Should we presume that we can adapt?
- One negative impact of climate change is the increase in workload for researchers. A positive impact is that it has brought researchers together. Global warming research receives more attention and funds than global cooling research. This could hinder important research in cooling areas such as the Baffin.
- Concerns were raised about the fact that climate change is only one of many ecosystem stressors occurring in Canada. For large agencies and bureaucracies, it is difficult to prioritize climate change issues.
- Whether an impact is positive or negative can depend on where people are in relation to the event. In most cases, it is the rate of change for all impacts that is of greatest concern. There is a threshold to positive and negative effects of climate change.
- Significant negative impacts are cumulative impacts. For example, many northern organisms are at the northern extent of their range. How will they be impacted?
- Government organizational structures and bureaucracies are significant challenges to implementing adaptation measures quickly and efficiently.

Summary

- Need more baseline "on the ground", anecdotal, biological, traditional science. Local level versus regional or northern data important. From here we can see how regional data apply to other areas. Shift funding away from modelling and towards baseline, comparative, local level study of ecosystem processes. Issues identified include:
- cutbacks mean fewer weather stations, less important data.
- the rate of change is significant concern.
- there is a need for ecological monitoring.
- an important adaptation is to focus on prevention.
- multi- and interdisciplinary research is critical.
- biodiversity change is both positive and negative.
- What is positive for one sector or one species not necessarily be true for another.
- In some cases, we need more information before determining nature of impact.

BECOMING AWARE OF CLIMATE CHANGE
An Evening of Public Information on Climate Change
7:00 - 9:30 PM, February 27, 2000 - Prince of Wales Northern Heritage Centre

Chaired by: Larry Dyke and Kevin McCormick

The session, hosted by the Northern Heritage Centre, was attended by 102 people, including about 60 workshop participants (the largest turnout to a Heritage Centre public session thus far).

Canada's Climate Change Initiatives

Paul Egginton

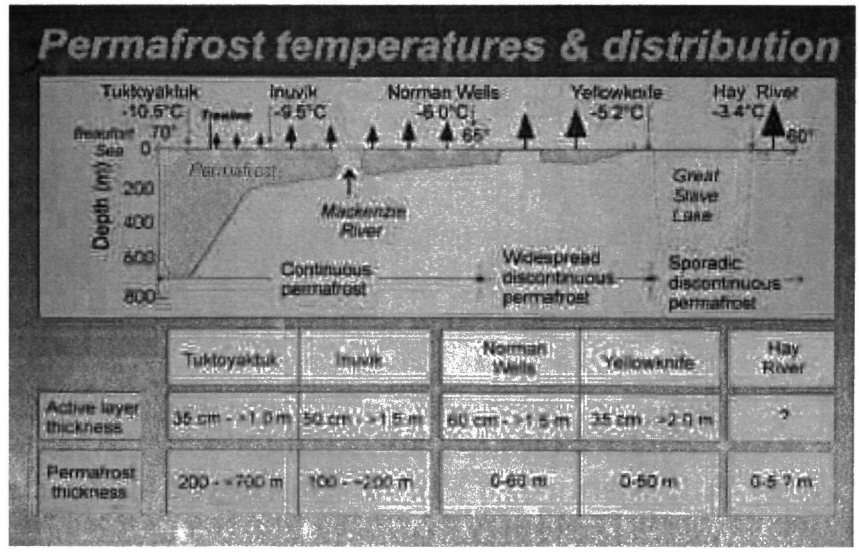
There are indications that the globe's climate is changing in response to industrial developments of the last 200 years. Carbon dioxide, a gas effective at trapping incoming solar heat, has increased throughout this period. Production of this and other gases contributing to the greenhouse effect continue. By 2050, the atmospheric concentration will be about double the concentration at the beginning of the industrial era. The effect of doubling on climate is being studied with computer simulations that attempt to duplicate all the processes controlling the distribution of heat in the earth's atmosphere and oceans. All the models indicate that mean annual temperatures will continue to rise over most of the earth. Work is continuing to increase the accuracy of models and the detail with which they represent future climates. More than just average temperature will change. There will be more frequent occurrences of warm temperatures we now consider to be extreme. Warming is expected to be more pronounced in the arctic because of decreased refection of heat back out to space resulting from less ice and snow cover.

Because climate change due to increasing greenhouse gas concentrations is inevitable, even if we meet the reduction agreed to in the Kyoto Protocol, the federal government is promoting the need to understand impacts accompanying warming and more frequent occurrence of severe weather. Research on the climate sensitivity of various geographic environments and the sensitivity of economic sectors operating in these environments is being encouraged. These efforts are intended for developing ways of adapting to climate change and minimizing the impact of climate change, not as a replacement for reducing greenhouse gas emissions. Reduction of greenhouse gas emissions will improve air quality and result in economic benefits from improved health. Initiatives being undertaken by the federal government and information on the greenhouse effect are available on the following Website: http://www.climatechange.gc.ca/.

Permafrost and climate change in the Northwest Territories

Stephen Wolfe

Permafrost exists when the climate can maintain a temperature within the ground which does not rise above 0°C. This condition exists beneath about half of Canada, including most of the NWT. Some ice is present in most permafrost soils and can locally occur as massive ice bodies metres thick and 100's of metres long. Problems arise when disturbances caused by construction result in thawing of ice in permafrost.



Continued growth of ice can also result in heaving of the soil and structures. Yellowknife is the most northerly city in Canada and is located in the discontinuous permafrost zone. The climate is not cold enough to maintain permafrost everywhere but it does occur beneath areas with a surface-insulating layer of organic-rich soil and vegetation. Construction has had to adapt to ice-rich silts and clays that are subject to differential subsidence when southern style construction techniques, with foundations resting on grade, were used. Now, careful preliminary investigation of soil conditions along with appropriate foundations, such as piles to bedrock, are used.

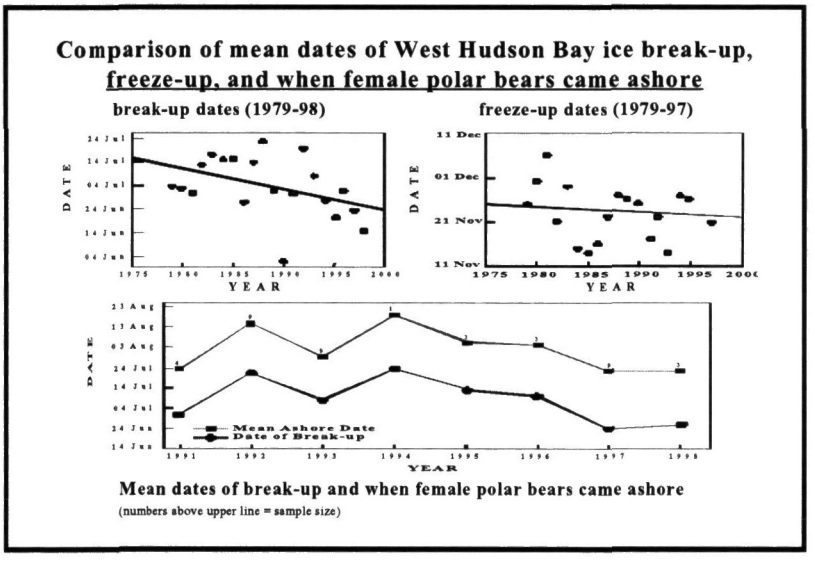
Present average annual ground temperatures in the Yellowknife area range from -2 to 2°C. If mean annual air temperature increases 4 to 5°C by the mid 21st century, as projected by Canadian versions of computer climate models, all permafrost in the Yellowknife area will eventually thaw. While complete disappearance will likely take centuries, especially warm years can have noticeable impacts. Mean annual air temperatures in the Mackenzie district in 1998 were the warmest (3.9°C above the 1948-1999 average) since the beginning of records in 1948. Along the Beaufort Sea coast, comparison of ice wedge tops between 1975 and 1999 indicate about 30 cm of permafrost thaw over that time period. Companion measurements of summer thaw depth generally show a progressive increase since records began in 1991 with the greatest depth occurring in 1998. The common occurrence of thaw slides along the Beaufort coast in seen in 1999 may also be a product of excessive thaw.

Impacts of Climate Change on Polar Bears in Hudson Bay

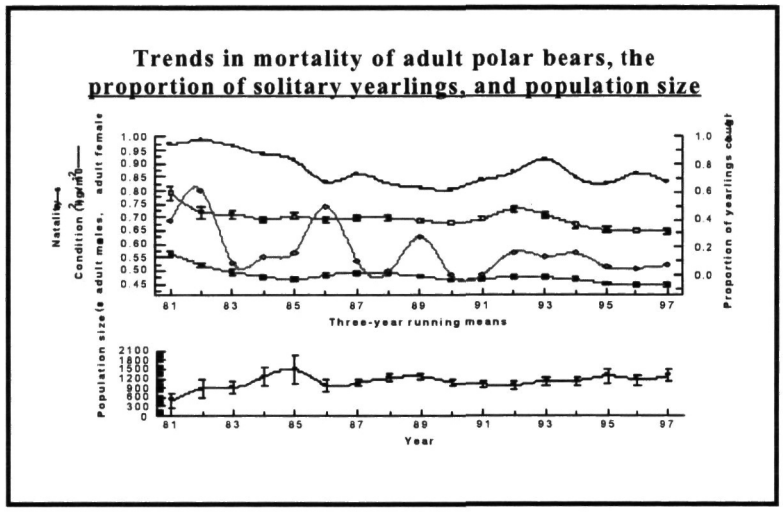
Ian Stirling

Results were presented on nearly 30 years of polar bear studies at Churchill and western Hudson Bay (see paper in ***Arctic***, 1998, Vol. 52, No. 3, pp. 294-306). Ringed and bearded seals are the principal prey of polar bears, who spend 7-8 months of the year on the sea ice in Hudson Bay.

Polar bears are after the fat on the seals, which they are very efficient (95%) in turning into fat on their own bodies. When the sea ice melts in the summer (July), polar bears come ashore all around Hudson Bay and survive on accumulated fat reserves until ice reforms in the fall (October/November). Female bears expecting cubs must survive even longer periods (nearly 8 months) ashore, in order to bear cubs.



Area climate has been warming by 0.4 - 0.6°C/decade, the duration of sea ice has decreased by several weeks (longer open water), area polar bears have been losing weight for 15 years, and the number of cubs borne to each



female has dropped from 2 - 3 (the highest fertility rate in all the Arctic) to 1 or 2. The overall west Hudson Bay population has not yet begun to decrease however, as one of the cubs usually survives (as before warming was observed).

Sensitivity of the areas' ecosystem is illustrated by global cooling for 18-24 months after Mount Pinotubo exploded in the Philippines in 1991, which resulted in a delay of Hudson Bay sea ice break-up in 1992 by 2-3 weeks, summer polar bear weights significantly higher than pervious years, and higher survival rates for cubs. This year of high survival and better nutrition is still evident in the polar bear population. The outcome of continued warming in the Hudson Bay area is not completely clear, but polar bears are apparently under stress, and will have to change habits (i.e. more active hunting versus fasting through summers) or be reduced in number and range during our lifetime.

Discussion

Questions from the audience included whether sightings of grizzly bears in the Beaufort Sea and polar bears far inland were signs of climate change (not likely), can polar bears relocate if warming/shorter ice seasons continue (no, other areas occupied), has development affected survival of bears along the Yukon/Alaska North Slope (no, except perhaps for a few bears).

Impacts of Climate Change on Sea Ice and Sea Ducks

Grant Gilchrist

Studies began on thick-billed murres (marine offshore) and common eider (inshore) ducks of Hudson Bay and the High Arctic, as indicators of the health of marine ecosystems before climate change was viewed as a major issue. While studies are of shorter duration than polar bear studies, they have also pointed out sensitivities of these species to climate change (see paper in **Arctic**, 2000, Vol. 53, No. 1, pp. 61-68).

Murre colonies at Coates Island forage on shrimp by diving 100 - 200 m under the waters of the bay. Statistics on percentage body fat indicate how hard they have to work in feeding their young, and contaminant loadings (i.e. doubling of Hg levels since 1970's) indicate how affected they are by pollution along their migration routes and globally. Earlier break-up of sea ice might be viewed as beneficial to murres, but turns out to be detrimental because shrimp congregate below open water, and when this increases relative to the extent of ice cover, the shrimp disperse and are harder to find by the birds. Just 13 years of studies has shown decreased murre populations are related to climate change and earlier break-up.

Studies of common eiders in the Belcher Islands of Hudson Bay/James Bay were initiated after 1997 reports of significant population declines (80% less than 1987). Mass winter kills have been observed in 1996, due to extreme cold and freezing of normally open water areas or polynyas.

DAY THREE – TUESDAY, FEBRUARY 29, 2000

RESPONDING TO CLIMATE CHANGE

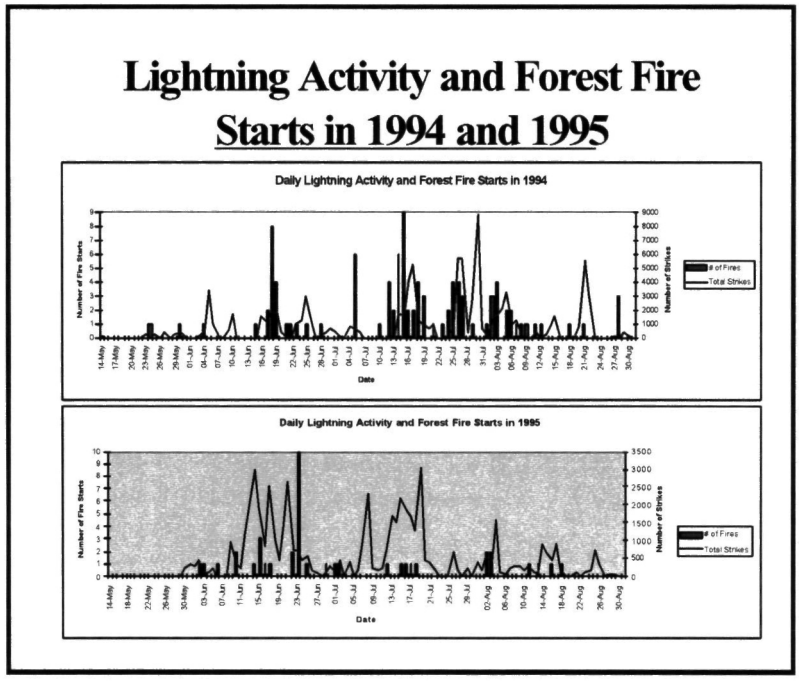
Presentations highlighting research initiatives addressing climate change

Chaired by: Steven Matthews

Extreme weather and lightning

Bob Kochtubajda

Climate model studies suggest that regional changes in thunderstorm activity are a possible outcome of global warming. One possible impact of this warming could be an increased frequency and severity of lightning-initiated forest fires over the boreal regions of the Northwest Territories. This presentation examined lightning activity during the summers of 1994 and 1995 and their impacts on forest fire ignitions over the Mackenzie Basin.



The lightning was mainly linked with daytime-heating initiated thunderstorms. The nature of these thunderstorms combined with very dry surface weather conditions and near-record light surface winds produced record areas of burned forests. Due to the light winds, smoke did not disperse and showed up as a major distinct area of smoke haze over the mid-Mackenzie Valley. The cloud bank may also have had different electrical properties that surrounding air, increasing the propensity for lightning strikes (a recent scientific article identified smoke from NWT forest fires as a major factor in high air pollution indexes in the eastern United States during summer 1995 - see ***Science***, 14 April 2000, Vol. 288, pp. 324-328).

Awareness, attitudes & concerns for climate change in northern Manitoba/ southern Nunavut

Peter Scott

The presentation focused on activities and services of the Churchill Northern Studies Centre (CNSC), a detailed summary of the centre's objectives for northern science, its research support system and climate changes surrounding the region (CNSC Website at http://www.cancom.net/~csnc/.) CNSC recently held a Circumpolar 2000 conference (Feb 16-23, 2000), during which climate change, impacts and adaptation was discussed.

Recent studies on polar bears indicate that climate warming has changed the ice regime of Hudson Bay, to the extent that polar bears in western Hudson Bay in particular are under stress, have been

getting thinner and having fewer cubs in recent years. Their ability to survive in the long term is starting to be questioned by biologists and local residents. Hudson Bay is also being considered as a new major shipping corridor to the centre of North America (2,200 km from Europe to Chicago versus 4,200 km via the St. Lawrence), and the port and rail facilities have recently been upgraded. Manitoba is also looking north for development, with proposals to connect the Kivalliq Region to southern hydropower and highways.

Overview on the Circumpolar Arctic Climate Impact Assessment (ACIA)

Kevin McCormick

Formation of the Arctic Council in 1996 was described as a high level council of ministers from 8 circumpolar countries. Five Working Groups have been established to support the Arctic Council (Conservation of Arctic Flora & Fauna (CAFF), Arctic Marine Assessment Program (AMAP), Emergencies Preparedness Prevention & Response, Protection of Arctic Marine Environment, and Sustainable Development). CAFF and AMAP were asked to do an arctic climate impacts assessment for the Arctic Council over the next three years, with assistance from the International Arctic Science Committee and the World University Research Program. The assessment will consist of reports on science of climate change, a synthesis for the public, and policy document for Arctic Council Ministers. Organizational meetings for the reports on science issues are occurring in Washington at the same time as the Yellowknife CCAF Workshop, with scientists from all 8 circumpolar countries. Academics interested in contributing to the assessment reports were invited to offer their services. A conference call is scheduled between CCAF Workshop Steering Committee and ACIA leaders in Washington, and a verbal report on this call is planned.

Discussion

One participant expressed a concern that vital information contained within the climate impact assessment, which was presented to various ministers in the circumpolar countries has the potential of being lost in government and the scientific community. Pertinent information on climate change needs to be made accessible to all people, not just political and scientific channels. It is disappointing, despite convincing evidence of climate change and its' impacts, the priority is still 'preparing briefing material for senior government officials' rather than concrete action involving citizens to reduce CO_2 emissions and the impacts of climate warming.

TUESDAY LUNCH PRESENTATIONS - Fisheries & Oceans Canada

Doug Chiperzak described DFO's Oceans group, formed to deliver on the Oceans Act through integrated management, marine environmental quality programs, and marine protected areas.

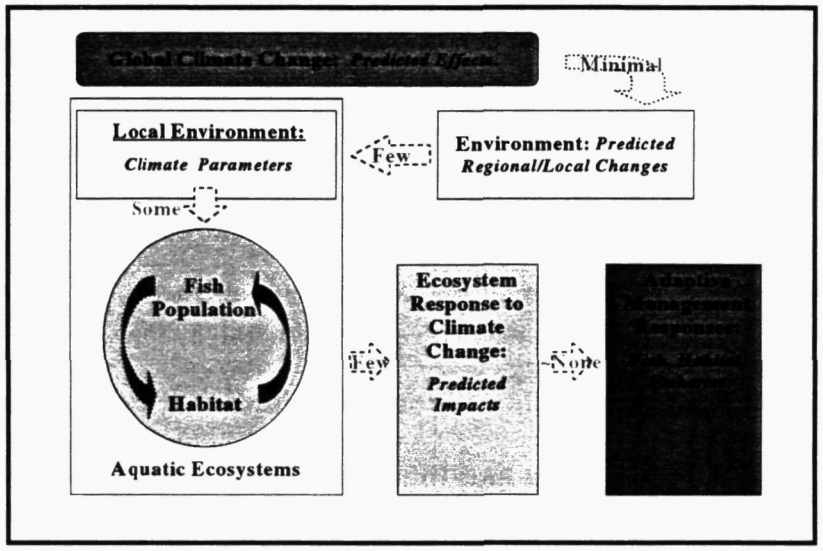
Reproduction & condition variations in ringed seals of western Prince Albert Sound, from hunter-based sampling - *Doug Chiperzak (for Lois Harwood, Tom Smith & Humfrey Melling)*

Ringed seals are the smallest, most numerous seal species in the Arctic, and prefer stable land-fast ice. Seals haul out on the ice to have their young, nurse, and sun themselves. Young are born in April, and are nursed for 6 weeks. About one week after being born, they begin entering the water for short periods and learn to feed themselves. By the end of the six-week lactation period, they are feeding on their own entirely. While the Inuvialuit harvest of seals has dropped significantly (currently only about 1000 seals, or 15 - 20% of the 1960's harvest) since the 1960's and 1970's, they are still important to residents of the coastal communities of Holman, Paulatuk, Sachs Harbour, and Tuktoyaktuk.

The timing of clearing of land-fast ice varies among years, and along with date of freeze-up in fall, determines the length of the open water season. The shortest open water season on recent record occurred in 1974, when there was no clearing of land-fast ice and no open water period. In contrast, the year with the longest open water season (168 days) and earliest break-up was 1998. Corresponding ice-free periods for Amundsen Gulf were 28 days in 1974 and 185 days in 1998. Severe ice conditions in 1974 were correlated with reduced body condition and ovulation rates of adult female ringed seals. Environmental conditions in 1998 had an opposite trend. For 1998, marine resources seemed more favourable for seal feeding and the condition of seals was significantly better. At the same time, however, about 20% of young-of-the-year seals harvested were "starving in the midst of plenty". This was the first time that local hunters had seen seal pups in this condition, which is thought to be the result of an interrupted lactation period due to earlier break-up. The seal pups were still too young to fend for themselves. Study results will be published in the journal ***Arctic*** in December 2000.

Understanding responses of fish to climate change - *Jim Reist*

While there is substantial literature on climate change effects on fish, very little of it covers arctic fish and most is related to the effects of power plants on water temperatures and fish. Studies are rare because fish move about underwater and are difficult to track. Impacts of climate change include physical and chemical aspects, as well as the effects of changes in habitat.



Topics requiring study include adaptive response strategies of fish, more information on impacts of climate change, and better linkages between fish populations and climate change (via temperature, precipitation, UVB, etc). Studies of Arctic char in Labrador point out the crucial importance of the survival of fish through the first summer of life (only 10% survive through the first migration to the marine environment), in overall populations. Some excellent relationships have been documented between fish survival and winter precipitation/fish productivity, summer precipitation/temperature and survival. Communities require better regional and local models of climate change impacts, to relate biology to entire watersheds. Better adaptive management strategies are required (see paper in ***Journal of Fish Biology***, 2000, vol. 57, pp. 82-98). Study results will also be published in the journal ***Arctic*** in late 2000.

CONFERENCE CALL between CCAF and ACIA WORKSHOPS

The CCAF Northern Workshop Steering Committee and participants in the Washington Arctic Climate Impacts Assessment Workshop discussed workshop progress on Tuesday, February 29.

ACIA: Tom Calder, of NOAA indicated that some 40 scientists from the eight circumpolar countries (including a number of Canadians) had organized specialty groups and were developing an

outline and implementation plan for the arctic climate assessment. Subgroups are looking at modelling & paleoclimates, as well as native, coastal, terrestrial, and infrastructure issues. The initial focus will be on science and impacts, with adaptation aspects to be covered later in policy documents. ACIA plans open discussions, via many workshops over the long term for this persistent issue, with indigenous people, industry, and others across the Arctic. Completion of ACIA reports will occur by 2002, with the first step (authorized by Arctic Council Ministers) to be documentation of climate change impacts.

CCAF: Paul Egginton described Canada's plans for regional and sectoral workshops, and indicated that ongoing connections with ACIA could occur through the proposed Northern Research Node, native people from Canada and Alaska on the Arctic Council, involvement of northern communities, etc. CCAF Workshop activities to date were described, and the keen interest and enthusiasm of participants in participating in further climate change activities was noted.

Follow-up: Conference call participants agreed that a few participants (Stewart Cohen, Paul Egginton, Tom Calder, Bob Corell) would maintain contact between the two groups to exchange information on each groups' activities. One ACIA participant observed that we have entered a new geological era for Earth, which he suggested calling the 'Anthropocene', or era affected by man's activities.

ESTABLISHING A CAPACITY FOR ADAPTING TO CLIMATE CHANGE

Breakout group discussion to gather opinions about how a facility for providing climate change information to researchers and practitioners should operate.

Report of Breakout Groups to Plenary

Group 1: Communities and Infrastructure – Rapporteur *Bea Alt*

Function of a northern adaptation system

- Communication
  - Sharing of impacts experienced between researchers and those affected
  - Existing research
  - Co-operation in setting research direction between practitioners and researchers
  - Public/political outreach
  - Forum for discussion of problems, adaptations, solutions
- Make information accessible
  - Links between practitioners and researchers needed
  - Information sharing on databases, libraries, websites
  - Make information available/useful - repackage for more use & share with others
  - Consider standardizing data
  - Access expertise to solve problems
- Research Issues
  - Encourage practical R&D, based on data gathered. Practical projects and solutions.
  - Address the gap between data collection and application
  - Encourage on-the-ground testing of adaptation (get it out of computers)
  - Reassess standards of risk to apply to engineering on permafrost, e.g. safety factors. This should include accounting for recent climate variability, as well as a more realistic assessment of climatic means, given warming trend.

- Encourage research to address vulnerability and thresholds of the system
- Consider cumulative impacts (holistic approach); effects of climate change coupled with other impacts/activities, e.g. the way humans use the environment is changing
- Proponent of solutions; support the innovations/solutions

Form of a northern adaptation system

- Physical and a "virtual" home
- Principle residence of the support system should be in the North.
- Look at existing organizations as a "home" for the support system, with changes for what functions the support system needs (this needs an examination of mandates of existing organizations in the North). Don't create another new acronym.
- Linkages to various other groups, as needed, depending on focus of the support system at the time. May include international and national forums, e.g. Arctic Council and Canadian Polar Commission, other monitoring networks, professional organizations, governments (national, territorial, provincial), private sector, NGOs, universities and colleges.

Group 2: Water Resources/Hydrology - Rapporteur *Bill Quinton*

Function of a northern adaptation system

It was determined that the main function of the support system would be to initiate and coordinate a northern approach to climate change research and information dissemination. The system would build networks between communities, researchers, practitioners and the general public to further our combined understanding of climate variability and adaptation.

Form of a northern adaptation system

The form of the adaptation system would take on the following characteristics:

- a need for a group support system rather than an individual effort,
- a group system would be well connected, have political influence, consist dominantly of northern individuals with a strong representation from scientists and researchers,
- community involvement was noted as a key objective to the support system. Ideally, the program would be 'northern driven', and
- the support system would work to coordinate information gaps while taking a practical approach to its initiatives.

Group 3: Coasts, Marine Resources, and Traditional Use - Rapporteur *Steve Solomon*

Function of a northern adaptation system

- Need a system for reporting and exchanging information on coastal occurrences. This information network should be designed to provide community and public access.
- Information exchange can occur in a manner that encourages two-way flow – an interactive system.
- This system should include more "hands-on" climate monitoring, however not just through research but include operational data and information as well.

Form of a northern adaptation system

- A facility located right in the North that is designed to include a partnership with national, regional and local sectors.
- To function as an improved coordination system, not just for northerners, but among scientists or anyone who has an interest in northern climate variability.

- Rather than one central northern node, implement a system consisting of a hierarchical set of nodes meeting regional needs within the North.
- Identify and utilize existing and developing networks. Example discussed of a well-communicated system is the Northern Contaminants Program

Group 4: Forestry, Wildlife and Fisheries - Rapporteur *Lorne Napier*

Function of a northern adaptation system

This system should:

- Monitor the rate of environmental change, for instance how quickly plant, animal and insect ranges are expanding northward.
- Link existing research and monitoring facilities.
- Be tied into communities - they are "on the front lines" of climate change. Communities should be involved in the collection, exchange, compilation and interpretation of environmental data relevant to climate change. Part of their unique contribution should be to report on "strange events" that would likely be missed through conventional scientific monitoring programs (e.g. unusual wildlife sightings or weather patterns).
- Have a well funded "science marketing" role to link to and learn from communities.
- Include an inventory of key resource people and community contacts, ongoing research and monitoring programs, and funding sources.
- Avoid costly duplications of effort.
- Identify important information gaps.
- Promote consistent protocols for research, monitoring and communication appropriate to the North. As one participant put it, "We need a shared map".
- Conduct periodic wide-scale consultation in communities in addition to regular communication and information exchange links.
- Establish clear channels of communication and response.
- Establish strong and reliable links with the media. This promotes both public and political awareness of the issue. It can also help raise money for on-the-ground work.
- Design a media communications strategy that regularly identifies, features and markets "newsworthy" research and monitoring results with high potential to "grab" public attention.
- Promote regular workshops and other "face-to-face" events like the Yellowknife workshop that bring a wide range of stakeholders together for a lively exchange of ideas and information.

Form of a northern adaptation system

- As far as possible, use existing information, institutions and community-based organizations. Participants felt strongly that we don't need a new agency or "another layer of bureaucracy".
- A virtual on-line network (e.g. a web page with multiple links to various climate change programs) was seen as a potential new tool but many agreed that this would not be of much use for communities with limited or no access to computers or the Internet. The wide variety of educational, cultural and linguistic backgrounds in the North points to the need for other communication and networking tools.
- Several community-based environmental programs were identified that could serve as a model for, or be expanded to include, climate change priorities. The most frequent suggestion was the Northern Contaminants Program. Other examples included the Mackenzie Valley Cumulative Effects Monitoring Program and the NWT's Community Eco Co-op Program.
- Several scientific programs and facilities must link their northern climate studies. Notable examples include the northern Ecological Monitoring and Assessment Network (EMAN), the

Churchill Northern Studies Centre, the Daring Lake Tundra Ecological Research Station, and the Arctic Institute's Kluane Lake Research Station.

- Northern colleges should have a key role in coordinating research, monitoring and the flow of information to and from communities. The training and empowerment of northern students to tackle this problem was identified as one of the many benefits of taking his route.

Group 5: Forestry, Wildlife and Fisheries – Rapporteur *Jim Bahr*

The group spent much time discussing existing research institutes and systems and how they might be improved. Next they discussed "wants" and "operating principles" with respect to how northern support system might operate. Lastly, they discussed the form a northern support system should take.

Function of a northern adaptation system

There is existing research structure, although it is not working as well as it could. We should not throw out what we already have, but should build upon it, particularly by learning from the Yukon Arctic Borderlands example. Improvements to existing system could be:

- increasing information flow,
- agencies working closer together,
- improving upon the fact that lots of research does not go through the existing process;
- streamlining existing processes, and
- increasing communication between government agencies would decrease duplication.

A northern support system should understand that:

- the most effective way to communicate is to sit face-to-face and talk,
- horizontal information exchange is critical,
- capacity building must occur at the community level,
- ownership of the support system must be shared,
- there may be problems with translation - best communication is in several northern languages,
- adapting to climate change means using existing knowledge,
- top-down approach must be avoided as it is best to have bottom-up/community-dictated research,
- local knowledge should be integral at a community level,
- long-term planning is important,
- there will be problems with support resources ($), and
    - there is a need for Internet access in some communities.
    -

Form of a northern adaptation system

Several options were discussed for a northern support system. These included:

1. one individual in one office,
2. offices in each region (with staff),
3. individuals housed/seconded in existing institutions,
4. 3 regional nodes (one per territory), and
5. unlimited number of nodes

After a lengthy discussion, the group voted for the last option: to have an unlimited number of nodes overseen by a central secretariat. An interim committee would be established to form the operating principles of the secretariat. People did not want another new organization to add complications to the existing process. There are already several northern nodes operating. A good example is the Yukon Community-Based Monitoring Program.

REQUIREMENTS FOR PROMOTING ADAPTATION

Breakout group discussion of the stages necessary for developing a northern impacts and adaptation research and information network

Report of Breakout Groups to Plenary

Group 1: Communities and Infrastructure – Rapporteur *Dan Forsyth*

1. ***How should it start?***

- Need a core: champion and secretariat – who?
  - Colleges, Government, solicit partners – those who are interested
  - Champion: possibly the three territorial governments, the federal government; these would act as a driving force to get things started – probably initiated by a government department because it needs political and funding support (also need public to put pressure on government to do this)
  - Recommend to the "champion" to establish a steering committee – who?
    - Same groups as on linkages diagram – regional reps
    - Develop terms of reference
- Where?
  - Define spatial boundaries of the region (need criteria, based on components of the ecosystem, e.g. permafrost distribution or caribou distribution)
  - Northern region (node) needs not to overlap with other regions, but no national gaps r
  - There may be difficulties in overcoming political boundaries
  -

2. ***How should it function?***

- Champion and secretariat (not a bureaucracy – keep it practical/applied)
- Balance political accountability and the need for practical solutions applicable to the North.
- Work with those committed to the purpose
- Include aboriginal governments and land claim groups and regulators
- Include a consultative process
- Need to define clients/purpose
- Overlap with existing organizations
- Matching users and researchers – system could act as a broker to match needs to those doing the research
- Funding? Debate over whether the system would identify priorities for applied research or financially support these research priorities

3. ***How should it evolve?***

- Short-term focus – looking at impacts, education, political pressure; except for dealing with those immediate problems that need adaptation now.
- Long-term focus – adaptation in all fields.

Group 2: Water Resources/Hydrology – Rapporteur *Bill Quinton*

Strategies for the development of a successful Northern Impacts and Adaptation Network:

- Funding was deemed to be *the* fundamental requirement. Without firm understanding of funding possibilities, program design was seen as impossible. This group took up a 'bottom-up' approach to building the support system, with money clearly being at the foundation.

- The importance of having a 'champion' – someone to take time and effort and commit to taking the lead for such an operation was discussed. The champion would initiate and co-ordinate operations, would be experienced and well connected, and would represent the ultimate authority for the support system.
- It was agreed that a secretariat should be formed to coordinate efforts of contributors. A team could be seconded from communities, government, industry, academia, and researchers. Staff would also be a key aspect of a functioning support system, taking care of information acquisition and dissemination, linking community people to academics, and vice-versa.
- The importance of linking existing research (consisting of TK and Western Science), databases, research institutes and practitioners was seen to be paramount.
- An educational component to the system was also recognized to be a priority. Opportunities were noted for public education on issues related to climate variability and adaptation.
- The concept of 'continuity' was raised as a key goal. Leaders must ensure the system is fully operational and integrated. Training of staff and the secretariat were seen as key objectives.

Group 3: Coasts, Marine Resources, and Traditional Use - Rapporteur *Doug Chiperzak*

Strategies required for a Northern Impacts and Adaptation Network: this group focused on the gradual development of a network, building on existing linkages rather than starting from scratch:

- some money is needed, but not a lot of money, to get started,
- utilize already existing networks, such as in science institutes and colleges,
- use a 'bottom-up' model with partnerships at the local/regional level,
- learn from programs like the Northern Contaminants Program, which represents a partnership organization, and consider that structural approach, and
- don't worry about how it should evolve/adapt, just let that happen as and when required.

Group 4: Forestry, Wildlife and Fisheries – Rapporteur *Lorne Napier*

This group interpreted the questions with respect to short and long term requirements for a northern impacts and adaptation network.

What is needed in the short-term?

- All participants agreed that no one location should or could serve northerners' diverse needs.
- Regional "nodes" may be needed in order to adequately account for ecological and community differences across the North.
- Some kind of inter-regional steering committee may be required for coordination and support.
- There is a need to identify and cultivate common ground related to northern climate change (e.g. research and monitoring protocols, communication principles and standards, etc.).
- Programs must be relevant to local priorities and activities "on the land".
- Monitoring studies should specifically address local or regional needs while capturing a wide variety of key environmental indicators. In the words of one participant: "We must accept that we can't measure everything everywhere. Monitoring focus will vary region to region."
- To get things started, begin with a small interim group with community-based representatives from each major region.
- Keep up the momentum generated in this workshop, or this initiative will quickly lose steam and political attention.
- In summary, "keep it simple. Start small. Go slow. Keep it relevant."

What is needed in the long-term?

- There must be a stable, long-term commitment to the program while remaining flexible and adaptable to changing community needs and concerns.
- We must "remain true" to the underlying reason for the initiative: helping northerners adapt to climate change.
- Both research and support functions should be established solidly enough to withstand the comings and goings of different people over time.
- Establish strong feedback linkages between information gatherers and users to ensure accountability and relevance.
- Demonstrate clearly and widely how information is used and applied.
- Communicate powerful incentives for participating to maintain public and political interest in climate change. Everyone needs to be convinced that "there's something in it for them."
- Needs to be supported by "real money" (e.g. not just by volunteers in communities) and possible infrastructure as needed (e.g. websites etc.)
- Any kind of steering committee will need to have a well established "voice of authority" to help bridge the gap between communities and decision-makers.

Group 5: Forestry, Wildlife and Fisheries – Rapporteur *Jim Bahr*

What linkages should the northern support system have?

- Aboriginal organizations
- Arctic Council
- Association of Canadian Universities for Northern Studies
- Canadian Circumpolar Institute
- Canadian Polar Commission
- Canadian Tundra Experiment
- Ecological Monitoring and Assessment Network
- Governments (Federal, Territorial and Local)
- Inuit Circumpolar Conference
- Inuit Tapirisat of Canada
- International Tundra Experiment
- Land claims institutions
- Non-Government Organizations (e.g. Ecology North)
- Research institutes
- Schools (school boards)
- Scott Polar Institute
- University of the Arctic
- others

The northern support system must be a real entity, with people associated with it. People from the Northern Climate Exchange, Aurora Research Institute and Nunavut Research Institute (NCE, ARI, NRI) could act in both capacities (research institute and northern support system). The institutes should take the lead on establishing an interim steering committee to form a northern support system.

There was a strong common voice for the need for a regional approach versus having one northern centre. The North is too big and diverse for this. Since climate change is different across the North, people have different concerns depending on their region. Across all regions, the impacts and

adaptations associated with climate change are said to be greatest in the North. This points to the importance of having several regional "nodes".

An independent node may be housed within an institution (e.g. ARI), but it would be a skeleton secretariat to oversee a series of regional nodes. Whoever takes initiative on implementing the northern support system will have a say in how it will operate. For now, a steering committee could be established, with at least one member from each institute, to set up the operating principles of the northern support system.

One proposed name for the northern support system is the "Northern Climate Research Alliance". This would have multi-stakeholder/sectoral and research institute partners. In the interim, a steering committee would:

- Write a MOU/IV with stakeholders,
- Prepare operating guidelines for regional nodes so that they can submit proposals to operate nodes that meet regional, territorial and national needs,
- Operate a website,
- Raise funds to secure a "pot" of money to fund regional nodes,
- Ensure horizontal communication (international and national),
- Work closely with communities (face-to-face), and
- Learn from the Yukon experience.

People are concerned about ensuring strong communication with community members in order for a meaningful information exchange. Having several regional nodes would help to achieve this goal. Regional nodes would be self-managing. Functions of the node would include:

- community outreach to present findings and collect information/direction, and
- serve as an information conduit between all linked agencies.

Other important issues:

- must include the entire North despite jurisdictional problems (e.g. Churchill),
- need to move quickly so that Yukon funds can be used to help establish the node,
- there is a strong need for an Arctic University to house climate change research,
- the support system should have heavy industry funding,
- the system must be accessible to industry, community, government, and everybody else, and
- not all communities have computers and Internet.

SUMMARY OF WORKSHOP RESULTS

One way of reflecting on this workshop is that we were tasked to help design the shape and size of the band-aid needed to deal with the "wound" we call climate change. That's adaptation. But we should always remember that this work must go on hand in hand with efforts to deal with the healing of that wound and prevention of further injury - that's what mitigation is all about.

Jamie Bastedo provided the following summary on facilitators' observations of the workshop.

1. URGENCY

Northerners are already beginning to experience some of the world's most rapid and pronounced impacts of climate change. Abundant evidence was presented pointing to the need to increase efforts to prepare for these impacts now.

2. VARIABILITY

We can no longer think just in terms of a simple warming trend. Though this is certainly true on a planetary scale, the effects of climate change in the North vary widely from year to year, season to season, and region to region.

3. UNCERTAINTY

No amount of tinkering or refining of climate change models will ever give us an exact prediction about the kinds of impacts northerners may face. Nor can we accurately predict potential losses or gains from these changes. We must expect the unexpected and plan for a wide range of possible impacts.

4. LINKAGES

It is very important to establish good links between the people involved in collecting information on northern climate change. But this is not enough. These people must in turn have strong, meaningful links with northerners who can use this information to help adapt to possible impacts.

5. COMMUNICATIONS & MARKETING

We need to raise public awareness of northern climate change issues. In this regard, the repackaging of technical information into more user-friendly formats accessible to the public and the media is a high priority. We must also "market" the idea that early planning for possible impacts is absolutely essential.

6. BOTTOM-UP

This was perhaps the strongest theme of the workshop. It is the people living in northern communities that are the ones to first experience the effects of climate change, the ones with the longest record (generations) of personal experience with northern climate and environmental change, and the ones who stand to lose most if nothing is done to prepare for impacts. Local, "on-the ground" information and insights are essential to sound adaptation plans.

7. CONTINUITY

Climate change is a long-term problem that will require consistent research and monitoring over many years in order to accurately document its effects and understand just what is going on. A secure support system will also be needed to help northerners adapt to climate change impacts over the long term. This system should share common operating principles and protocols appropriate to the North while being flexible enough to respond to different regional needs and priorities. Both the research and support functions should be established solidly enough to withstand the comings and goings of different people over time.

8. COMMITMENT

Preparing for climate change cannot be perceived as a bandwagon idea that is supported one year and abandoned the next. Funding agencies and those directly involved in the design and delivery of adaptation plans must keep climate change as a top priority on their typically crowded northern environmental agenda.

9. PRACTICAL

The urgency of this problem and ever-tighter constraints on funding sources demand that the collection and exchange of information on climate change impacts and adaptation strategies be as practical as possible. The ultimate test is: Will this information be useful to those on the "front lines" of northern climate change - the people that live here.

10. ACCOUNTABILITY

Because of the urgency and potential seriousness of this problem, it is important that high standards and clear lines of accountability be brought to bear on all aspects of this initiative.

11. EXISTING

As far as possible, existing information, institutions and community-based organizations should be used to get a climate change adaptation system "up and running" in the North.

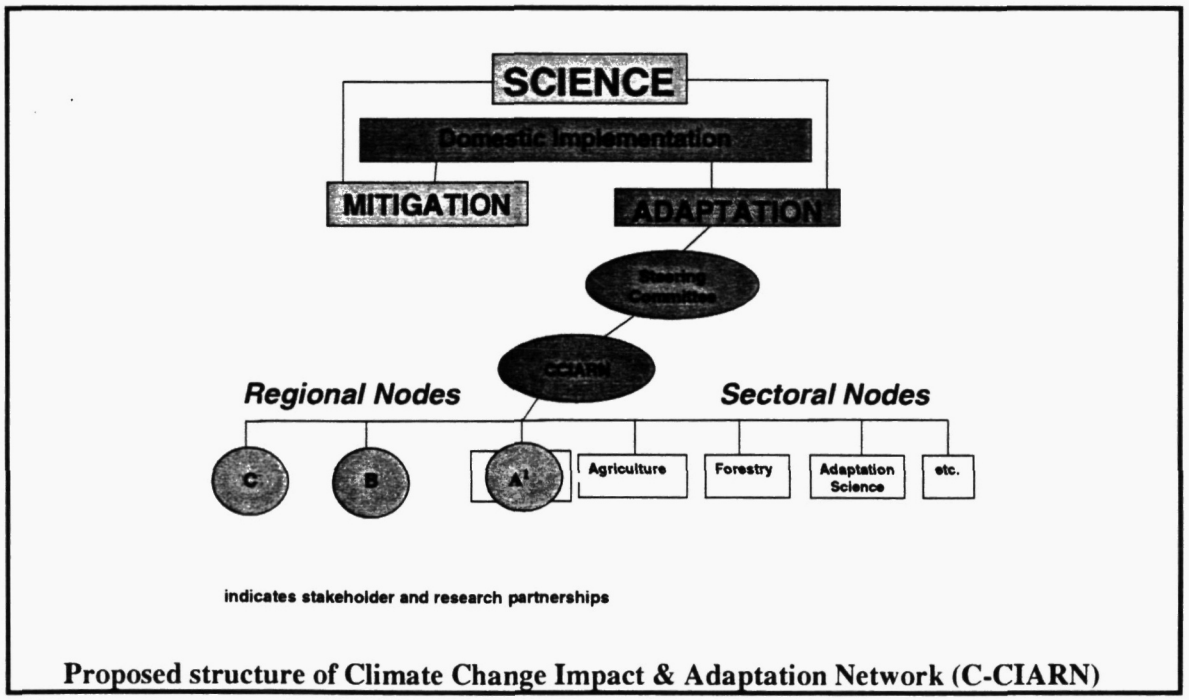
12. MOMENTUM

The Yellowknife workshop generated a huge amount of momentum among participants. Prompt, concrete action is needed in order to take full advantage of our collective interest and energy. **"Let's keep it moving!"**

FOLLOW-UP PLANS

Paul Egginton, NRCan, addressed the follow up to the workshop. He was part of a national working group addressing the issues of impacts and adaptation related to climate change. He stressed that there is a need to keep the momentum going once the workshop is over; this seemed to be clearly the message of participants. Paul recommended that a steering committee be implemented immediately. He named a number of individuals whom he had asked to work on the committee, from the federal government, territorial government, and the research institutes and colleges from the Yukon, NWT and Nunavut.

Paul also discussed recommendations previously made by the impacts and adaptation working group to the federal Ministers concerning a series of national nodes (see diagram below, and discussion paper at http://www.nccp.ca). These recommendations included a single point of reference (a node) for the North. He recognized that there was growing interest in establishing a node, however federal funding needs to be reallocated to support its implementation.



Proposed structure of Climate Change Impact & Adaptation Network (C-CIARN)

Discussion
Participants raised concern that there was no Aboriginal representation on this steering committee. In addition, it was suggested that the committee have representation from the sectors corresponding to the workshop working groups. Although it was recognized that regional representation was important, federal government representatives felt there was a need to keep the group small.

It was clarified that the mandate of the committee would be to look at the output from the workshop and see how it should be implemented. The committee will be a short-term group that works to help establish the northern node.

It was pointed out that communications cannot take place only through the Internet. Not all communities have access, and those that do may lack the experience necessary to navigate the web and find the information they need. Paul noted that some communications would flow through the colleges and research institutes, but newsletters were also a possibility. Efforts will be made to keep up the communication.

FACILITATORS' RECOMMENDATIONS

Many of workshop presentations reflect impacts of climate change and variability already occurring, as precursors of greater impacts in the future. These brought a sense of urgency to the workshop over a need for immediate action. The following were identified for action:

1. Adaptation, and the research required to address adaptation, needs to happen now to address the impacts that are being experienced. This urgency had the effect of creating a great deal of momentum among participants to work on these issues. This momentum should be tapped into as soon as possible, to move forward with establishing the northern node.

2. A working group, with representation reflecting the participation at the workshop, should be established quickly, with the mandate to work with the participants' suggestions and come up with a proposal for how the northern node should function, what form it should take and how it should evolve.

This working group need not be a costly exercise, with the use of conference calls and electronic communications, but in order for the design of a northern node to reflect the needs of northerners, it should include fairly wide representation. Many participants at the workshop advocated this "bottom-up" approach. Representatives from Natural Resources Canada and Environment Canada, who organized the workshop, should do the work of soliciting participants to become members of the working group.

WORKSHOP CONVENOR'S SUMMARY

In the break-out discussions, all sectors expressed the need to know more about how various parts of the environment react to climate change. Although there is frustration at not confidently knowing exactly how our climate will change in the near future, our understanding of environmental sensitivity to climate change is improving. The understanding of how particular game species fit into ecosystems and the sensitivity of these ecosystems to climate change is benefiting increasingly from the combination of aboriginal knowledge and scientific studies. Agencies responsible for providing services, facilities or operations which are vulnerable to climate change are also interested in a better understanding of how terrain and water will react to climate variability.

Connecting sources of data, analyses, and interpretations with those needing information or advice is fundamental to promoting climate change adaptation. Local experience, practice and knowledge were also identified as crucial to thorough research on climate change and climate change impacts on the environment. Organizations already exist (colleges, research and monitoring initiatives) that are addressing these objectives locally or regionally. The Northern Climate Exchange (NEC) program at Yukon College is currently the most directed activity promoting climate change awareness and communication with a mandate to cover the entire North. The NEC has conducted an evaluation of the state of climate change awareness and knowledge of climate change effects for all three territories. Of necessity, it has limited other efforts, such as community consultation, to Yukon. However, it serves as a model for a facility to coordinate communication and research on climate impacts and adaptation for the entire North.

Interest in the impacts of climate change falls into two broad categories, based on how easy it is to understand the scope and magnitude of those impacts:

1. **Ecosystem response and the effects of climate change on game species, forage, and fisheries**. Interest in this sector is based primarily with aboriginal organizations, communities, academia and government research branches. It is the category where aboriginal knowledge is most able to contribute to the formulation of research questions and observations on the behaviour, distribution or condition of components of the environment. Interest in ecosystems is easily generated because ecosystem dependency on climate is obvious, government research mandates include the understanding of ecosystems and there is a subsistence economy based on ecosystem well-being. However, determining the sensitivities of plant or animal species to climate is difficult because of the dependence of individual plant, animal or fish species on other climate-sensitive environmental factors such as soil development, moisture, species competition and fire. Where aboriginal interests are engaged, it is essential to interpret research objectives and results in non-technical terms.

2. **Infrastructure performance and impacts on industry.** Interest in this category is varied, largely due to the difficulty of determining how thoroughly to adapt in the face of the uncertainty associated with climate projections. Public and private agencies responsible for providing transportation services are most aware of climate change impacts. The response of transportation infrastructure to climate change is usually direct because of the role that ice, either as lake and river ice or ground ice, plays in providing a stable foundation. Projected climate warming has been taken into account in foundation design but only as a projection of trends to date, not in anticipation of greenhouse gas effects. A pro-active approach may be especially necessary with industry, partly because of a lack of familiarity with current climate change research and partly due to a reluctance to incur the cost of adaptation without a clear understanding of the likelihood of a benefit.

Promoting impacts and adaptation research in the North

Most population centres in the North are small communities having a considerable dependence on a subsistence economy. Thus communities are likely to be interested in contributing to decisions on how to conduct ecosystem research and apply results. Public works operations and infrastructure maintenance also serves a small population and tends to be occupied primarily with daily and annual responsibilities. Industry and public works are aware of climate change as a disruptive factor and have experienced recent impacts of warmer than normal seasons. Although projections of climate are too uncertain to be fully factored in to future operations, these sectors are receptive to research,

provided that economically beneficial results can be anticipated. Thus, with climate change impacts and adaptation research, a proactive approach is necessary to engage the involvement of communities and service providers alike.

No officially sponsored entity fulfilling the intentions of the Options Paper published by the Science, Impacts and Adaptation Group under the National Climate Change Secretariat (i.e. a CCIARN northern node) presently exists. The Northern Climate Exchange at Yukon College in Whitehorse is the only initiative in the North to date that exists to promote climate change awareness and adaptation across the entire Canadian arctic (although to maintain realistic goals given the small staffing, it is confining its outreach efforts to Yukon). At present it is assessing the state of knowledge about the sensitivity of sectors to climate change and is also seeking direction from selected Yukon communities as to requirements for information on climate change. The NCE would like to act as a repository and access point for observations, data and research results on climate and climate change. It has also identified an advisory role whereby inquiries would be received and answered by staff or referral to other information sources.

Given the present likelihood of only modest funding for a centre or node with a budget for research, promoting interest in climate change will require strategies for increasing the effectiveness of a climate change information centre. More than anything else, a proactive approach, as has been taken by the NCE, will be required. Engaging the cooperation of interested individuals (i.e. contacts from all sectors likely to be affected by climate change) as information sources or users may be fundamental to the successful operation of such a centre.

Strategies will probably be different for promoting the understanding of ecosystem vs. infrastructure adaptability. Research for understanding the way individual wildlife and plant species or ecosystems respond to climate variability is ongoing and extensive. Programs such as Northern Ecosystem Initiative, Ecological Monitoring and Assessment Network, Mackenzie Valley Cumulative Impacts and Monitoring Program, the Arctic Borderlands Ecological Knowledge Society and northern college programs with climate change components all conduct or promote research and make available results. Interpretation and distribution of these results could be a major function of the information centre. Infrastructure construction and maintenance is the concern of public and private agencies. Both sectors deal with climate variability as required and are well aware of the impacts of climate variability. However, both industry and government will require a clear indication of the benefits before incorporating policies which may risk expenditures for uncertain outcomes. In the infrastructure case, adaptation to climate change may mean developing and encouraging practices which reduce rather than eliminate climate change impacts. An information centre could play an important role communicating the results of research and establishing links between university or government research groups and public or private agencies responsible for the provision of services.

CONCLUSION

It was agreed that interest would be solicited by Natural Resources Canada and Environment Canada leads, for broad participation in a Working Group to develop a proposal for a northern climate change impacts and adaptation network. This could occur when the workshop report is distributed. Discussions by the working group should begin this summer, as a tentative target date of December 2000 for completion of this task is required to meet anticipated deadlines for submission of proposals for CCAF funding in 2001/02 and beyond, as well as consideration of partnerships with other programs (i.e. Northern Ecosystem Initiative) related to climate change.

APPENDICES

APPENDIX A

FINAL AGENDA

Workshop on Climate Change Impacts and Adaptation Strategies for Canada's Northern Territories

February 27 - 29, 2000 - Explorer Hotel, Yellowknife, NWT

SUNDAY, February 27

11:00 **Workshop Registration** Marlene Levesque, Environment Canada and GeoNorth staff

WORKSHOP OPENING

1:30 **Convenor's Welcome and Workshop Outline** - Jesse Jasper, Larry Dyke
Welcome: David Lovell, Mayor of Yellowknife
Robert McLeod, Deputy Minister, Department of Resources, Wildlife, and Economic Development, Government of the Northwest Territories
Promoting a Northern Capacity for Adaptation to Climate Change - Paul Egginton
Operation of the Workshop - Hal Mills

BACKGROUND ON CLIMATE AND IMPACTS

Chaired by: Larry Dyke

2:30 **Effects of climate change on wildlife at Holman Island** - Sadie Joss with Bessie Inuktalik
Sea ice extent during the last 10,000 years - Art Dyke
Arctic Ocean ice cover during the last 30 years - Sharon Jeffers

Refreshment Break

Recent climate trends in Canada's North - John Bullas
Sovereignty and science issues related to sea ice - Col. Pierre Leblanc
Research Expertise in NorthEastern Canada (RENEC) - Yves Michaud (for Gérald Vigeant)

PANEL ON CLIMATE AND IMPACTS

Chaired by: Hal Mills

7:30 **Features of climate, the environment, subsistence, land use, and economy that are variable or changing, i.e. What is the climate capable of doing? What is our experience?**
Stewart Cohen - Mackenzie Basin Impact Study leader
Norm Snow - Traditional Knowledge Study Coordinator
Larry Fairburn - Transportation Specialist
Robert Hanna - Community Affairs
Norm Snowshoe - Settlement Area Land Use Impacts
Bea Alt - Climatologist

Open discussion and question period with panel to express opinions on importance of climate and find out more about impacts on particular parts of the environment.

MONDAY, February 28

8:00 **Late Registration**
8:15 **Observations from Sunday night** - Paul Egginton and Stewart Cohen

IMPACTS AND ADAPTATIONS

Session I - Chaired by: Jesse Jasper

8:30 **Climate change impact, sensitivity to climate change and adaptive strategy presentations**
Results and Implications of climate change models - Francis Zwiers
Recent climate-related shifts in the hydrology of northern Canada - Paul Whitfield
A survey of climate change impacts on northern ecosystems: Gaps in our understanding and suggestions for improving our knowledge - Tom Clair
Adapting to changes in river flow and water levels in the arctic - Hans Martin

Refreshment Break and Discussions Around Posters (Kat C room)

Session II - Chaired by: Stewart Cohen
Tundra plants and ecosystems as indicators of climate change - Greg Henry
Impacts of climate change on caribou - Anne Gunn
Sustainability of arctic communities under climate change - Gary Kofinas
Inuit Ecological Knowledge of Climatic Influence on Caribou and Calving Areas - Natasha Thorpe and Sandra Eyegetok

12:00 **Buffet Lunch, sponsored by Northern Climate Exchange, Yukon College**
Chaired by: Paul Egginton
Presentations: Established research and education facilities in the North - Aynslie Ogden/Yukon College, Valoree Walker/Aurora College, Jamal Shirley/Nunavut Arctic College

ATTITUDES AND EXPERIENCE OF PRACTITIONERS

1:30 **Round Table Discussions in Break-Out Groups** Facilitators + Technical Resource Assistants

Grp #1 - Communities & Infrastructure - Traynor + Burgess & Williams
Grp #2 - Water Resources/Hydrology - Bender + Mortsch & DiPizzio
Grp #3 - Coasts/Marine - Mills + Solomon & Reiss
Grp #4 - Forestry/Fisheries/Ecosystems - Bastedo + Stirling & Stewart
Grp #5 - Forestry/Fisheries/Ecosystems - Thorpe + Bloomstrand & Forsyth

Short presentations by sector representatives on studies or perceptions of climate change, impacts and how climate variability is accommodated.

Open discussion within group on the role of climate in operations or the impact of climate on a particular phenomenon of importance to an operation. What are existing adaptation measures and what is the attitude towards adaptation? What components of the environment would sectors like more information about?

3:00 Refreshment Break and Discussions Around Posters (Kat C room)
3:30 **Round Table Discussions in Break Out Groups**

4:30 **Summaries of Discussions to Entire Group**

Remainder of Evening Program
Participants encouraged to re-arrange themselves for group discussions next day

BECOMING AWARE OF CLIMATE CHANGE

An Evening of Information on Climate Change - Prince of Wales Northern Heritage Centre
Chaired by: Kevin McCormick

7:00 - 9:30
Canada's Climate Change Initiatives - Paul Egginton
Permafrost and climate change in the Northwest Territories - Stephen Wolfe
Climate change impacts on polar bears in Hudson Bay - Ian Stirling
Climate change impacts on Sea Ice and Sea ducks in the Arctic - Grant Gilchrist

TUESDAY, February 29

RESPONDING TO CLIMATE CHANGE

Plenary Discussion on Implications of Climate Change/Experience with Climate Change Issues
Chaired by: Steven Matthews

8:30
Extreme Weather and Lightning - Bob Kochtubajda
Awareness, attitudes and concerns for climate change in northern Manitoba and southern Nunavut - Peter Scott
Overview on the Circumpolar Arctic Climate Impact Assessment - Kevin McCormick

Opportunity for entire group to hear the impressions of individuals who have had a chance to survey interest in climate impacts and adaptation from a variety of viewpoints. Followed by discussion on what to do to react to climate change.

10:00 Refreshment Break and Discussions Around Posters (Kat C room)

ESTABLISHING A CAPACITY FOR ADAPTING TO CLIMATE CHANGE

10:30 **Round Table Discussions in Break Out Groups**
Topic: The nature and function of a northern support system for climate change adaptation
- round table on personal observations on climate change and reactions to it
- what role should a facility or network to aid and promote adaptation to climate change have?
- what will be the relationship of the facility to existing sources of information or research?
- what physical form should the facility take?
- through what means would northern practitioners like to express their concerns?
- information requirements regarding climate change?
- in what form would northern practitioners like to receive information about climate change?
- what are the shortcomings of presently existing information systems or networks?

12:00 Buffet Lunch, sponsored by Department of Fisheries and Oceans
Presentation by Doug Chiperzak, DFO on Oceans Act, Marine Environmental Quality Program.
Assessment of reproduction and body condition of ringed seal in Prince Albert Sound, NWT by harvest-based sampling. - Doug Chiperzak (authored by Harwoord et al)
Response of fish to climate change - Jim Reist, Freshwater Institute, Winnipeg

12:45 Conference call between Yellowknife Workshop Breakout Group chairs/rapporteurs and key participants at the Arctic Climate Impact Assessment meeting in Washington, D.C.

1:30 Summary of conference call to Plenary or Break-out groups

REQUIREMENTS FOR PROMOTING ADAPTATION

2:00 Round Table Discussions in Break Out Groups
Topic: A strategy for developing a northern impacts and adaptation research facility or network.
- How should the facility be administered?
- How should it evolve?
- Who must be convinced that expanding adaptive capacity is necessary?
- How will the objectives and function of a facility be promoted?

3:00 Refreshment Break

3:30 Plenary Session to Summarize Results of Break Out Sessions
Chaired by: Paul Egginton and Hal Mills
Breakout Group Summaries
Workshop Facilitators Summary - Jamie Bastedo

4:00 Follow-Up Plans and Closing of Workshop - Chair: Hal Mills
CCAIRN + Interim Northern Working Group - Paul Egginton
Closing Comments - Larry Dyke & Jesse Jasper

Participants' List – CCAF Northern Workshop, Yellowknife

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APPENDIX C

Climate change and regional hydrology of Northern Québec: Some ideas about research priorities/evaluation of data collection systems

Following our telephone conversation (with Jesse Jasper, CCAF Workshop Convenor) earlier this week, I have drawn up a short list of topics which, I believe, are relevant to Northwestern Québec and the aboriginal communities in this region in the context of the CCAF. You will find that these notes summarise a number of issues which we touched upon in our telephone conversation. Although I am writing about NW Québec, I think that the observations are probably relevant to a broad portion of the boreal forest region within the Canadian Shield.

1. Adequacy of hydro-meteorological data collection systems

I would like to make the case for a critical assessment of the basic hydrometeorological data collection network for northern Québec, and – by extension – the Canadian sub-arctic region generally. The number of active stations providing meteorological data has been significantly reduced in recent years, and there are very few alternative or additional sources of climate data. This seems to me to impose major constraints on the analysis of regional trends in thermal regimes, precipitation and evaporation (as well as the ability to assess duration/intensity relations for extreme events). Hydro-electric development, forestry and mining all require such reference data – what are the constraints imposed by the nature of the network itself?

2. Adequacy of river gauging systems

In several areas of public environmental policy, it is desirable to be able to reconstruct flow-duration relationships for rivers of varying catchment size and different physiographic regions. Ecological effects monitoring for mining is a case in point. Existing stream gauging systems also pose significant constraints, and they need to be understood more completely. In areas affected by major hydro-electric systems, it is common to find that gauging was done in order to supply reference data (presumed long term averages; flow duration relationships for control structures) prior to development and using short run-off series. After construction, there is often no longer any public record of run-off which can be used to evaluate specific yield in relation both to the hydro-electric systems themselves and other forms of land use change (including forestry). We seem to be severely limited in our capacity to identify and assess changes in specific yields, and even more so in interpreting changing yields in relation to climatic determinants.

3. Adequacy of the original gauging stations?

A related problem is that of the original acquisition of data for rating curves. It is very difficult in arctic or sub-arctic regions to represent adequately discharge during critical periods of the overall hydrological year (notably spring run-off and mid-winter), and I suspect that there is in any case a need to inspect the existing rating curves before judging the extent to which they can be relied upon for studies of the run-off component of regional hydrological change.

4. Hydrological implications of hydro-electric development

Hydro-electric systems in sub-arctic regions can substantially increase the overall percentage of the area of open water in major watersheds (the La Grande Complex is one example, but one could also use the Churchill complex in Labrador). Increases in net water vapour flux to the atmosphere are no doubt system-specific, but appear rarely to have been evaluated. In the La Grande case, there is some evidence (albeit indirect) to suggest that this is a significant factor in long term estimates of energy production from hydro-electric systems, and that consistent shortfalls are becoming a non-negligible factor in the assessment of overall system reliability. This is a climate change – related topic with significant implications for energy policy and a worthwhile area for future research.

5. Regional climate change and hydro-electric energy production

The reliability of energy production from hydro-electric systems is also influenced both by regional trends in precipitation/run-off relationships and by the stochastic properties of inter- and intra-annual run-off time series. This has been a significance source, apparently, of concern to hydro-electric utilities, but has yet to be addressed in the area of public policy (energy; environment). We would also argue here that there are here significant implications for reservoir hydrology and ecology, and that aboriginal communities affected by the operation of large hydro-electric systems have a direct interest in the matter.

6. The importance of long-term time series in limnological studies

Although there are important issues of scaling that need to be addressed, the existing data series for present and past research on physical limnology (Experimental Lakes Area; Turkey Lakes; Killarney Lakes etc.) are important in this context. Many of these programmes have a very uncertain future, and they require sustained public support. In a number of cases, these studies are also invaluable sources of information on the hydrological response of small catchments for which there is also a strong meteorological record. This is an area of public policy which requires closer examination, and is consistent with what I know about the objectives of the CCAF.

7. Regional impacts of forestry in boreal ecosystems

It has been our experience in Québec that neither established gauging systems nor networks for water quality appraisal make it possible, in sub-arctic regions, to trace the implications of significant change in land use. We have in NW Québec the case of some 15,000 sq. km. of clear cutting in fairly dense black spruce in the last thirty years. There is widespread interest (and concern) in local aboriginal communities about the implications of rapid change in land use of this type on drainage basin response and on water quality (including the mobilization of trace metals, including mercury). We are beginning to see the first manifestations of research interest in this area (S. of the Gouin reservoir), but this is, in our view, a significant regional policy issue with broader implications for Canadian Shield ecosystems.

8. Security of access in hunting economies

Somewhat distinct from the other topics listed above is the issue of climate change in relation to ice conditions. During our conversation, I mentioned that along the coast of James Bay and Hudson Bay there is a considerable amount of accumulated knowledge on probable sea ice conditions at different times of the year. This information is critical to travellers along the coastal shelf ice, and to hunters dependent on the distribution of open water in winter (I mentioned the case of eiders and seals, and the detailed studies on this topic at Sanikidluaq (Belcher Islands). This is an important security issue for senior Cree hunters who have some responsibility locally for determining when it is safe (or not safe) to travel. The combination of climate change on a time scale of a few decades, and of isostatic rebound, also on a scale of a few decades, make this a significant regional environmental issue for coastal hunters.

I hope that you will find these themes of some interest and relevance to the CCAF. Please let me know if you would like to have more detail.

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The Canadian Climate Impacts Scenarios (CCIS) Project

Introduction

The Canadian Climate Impacts Scenarios (CCIS) Project, funded by the Climate Change Action Fund until March 2001, started in October 1999. The three principal investigators responsible for the CCIS project are Elaine Barrow (Science), Fred Herfst (Project Management) and Roger Street (Project Director). The project is housed at CICS, University of Victoria, with additional assistance being supplied by Trevor Murdock, Rick Lee, Badal Pal, Mary Kenderdine and Lana Kenderdine.

The main role of the project is to provide climate scenario information and scenario construction advice to impacts researchers in Canada, in order to ensure that the resulting impacts studies can be used to provide Canadians with a meaningful national assessment of the impacts of climate change. Conforming with the Intergovernmental Panel on Climate Change (IPCC) *Guidelines on the Use of Scenario Data for Climate Impact and Adaptation Assessment* will also facilitate the use of Canadian research results in future international assessments such as those undertaken by the IPCC.

The aims of the project can be summarised as:

- the provision of basic national climate change scenarios, advice and related information to the Canadian impacts and adaptation communities;
- the development of a nationally consistent framework within which sector- and region-specific climate change scenarios can be developed;
- the development and maintenance of a capacity within the Canadian impacts and adaptation research communities to develop nationally-consistent climate change scenarios to support climate impacts and adaptation research and assessments, and
- the engagement of the university research community and scenario users in the further development of the young and growing science of climate change scenarios.

This pilot project is supervised by an advisory committee consisting of representatives from the federal government and from the university and impacts communities, in order to ensure that the project is meeting the needs of impacts researchers in Canada.

Scenarios

The climate change scenarios being constructed as part of this project will be available from the CCIS Project web site (http://www.cics.uvic.ca/scenarios). In the first instance, these scenarios will be based on warm-start global climate model (GCM) experiments undertaken with IS92a-type forcing and will consist of monthly, seasonal and annual change fields for the 2020s, 2050s and 2080s, calculated with respect to 1961-1990. For each experiment, scenarios will be calculated for a set of core variables (minimum, mean and maximum temperature, precipitation, a radiation variable, a humidity variable and wind speed), with additional variables where available. Scenarios will be at the original spatial resolution of each GCM, as well as interpolated to 0.5° latitude × 0.5° longitude. The interpolation routine simply smoothes the discontinuities between adjacent grid boxes, thus ensuring that two neighbouring sites with similar climates which are located in different grid boxes do not end up with widely-differing climates in the future.

The **core scenarios** are based on the CGCM1 model of the Canadian Centre for Climate Modelling and Analysis (CCCMA). Four climate change experiments have been undertaken with this model, namely three greenhouse gas + sulphate aerosol experiments and a single greenhouse gas only experiment. Averaging the three greenhouse gas + sulphate aerosol experiments results in an ensemble mean, which can be considered to be an approximation to the climate change signal. Climate variables which will be available for each of these experiments are: minimum, mean and

maximum temperature, precipitation, cloud cover, total incident solar radiation, specific humidity, wind speed, sea level, surface temperature, snow water content, sea level pressure, sea ice, evaporation and soil moisture. Vapour pressure, relative humidity, potential evapotranspiration and diurnal temperature range will be derived since these variables are not directly available.

Additional scenarios will be calculated from the GCM experiments currently available on the IPCC Data Distribution Centre (DDC) web pages (http://ipcc-ddc.cru.uea.ac.uk/), i.e., from the Hadley Centre for Climate Prediction and Research, the Australian Commonwealth Scientific and Industrial Research Organisation, the German Climate Research Centre, the Geophysical Fluid Dynamics Laboratory, the Japanese Centre for Climate Research Studies and the National Centre for Atmospheric Research. These scenarios will be made available on the CCIS Project web site. In the longer term, the CCIS Project will provide scenarios of climate change based on the four scenario 'families' identified in the Special Report on Emissions Scenarios (SRES) commissioned by the IPCC for the Third Assessment Report.

Another major component of the CCIS Project will be the interpretation of the climate change scenarios for Canada. Although the climate change scenarios can be visualised on the project web site, a number of indices will be calculated which should aid the understanding of the scenario changes. These indices will include degree days (using threshold temperatures relevant to plant growth and space heating/cooling requirements), length of the frost free season, wind chill, frequency and intensity of hot and cold periods, maximum rainfall events and a drought severity index, where possible. The significance of the scenario changes will also be examined by comparing the projections of future climate with model-simulated natural climate variability.

In addition to providing scenarios of climate change, the CCIS Project will also facilitate the use of historical climate and palaeoclimate data in climate impacts studies. These data are important for describing average conditions, spatial and temporal variability and anomalous events, for identifying ongoing trends and cycles and for specifying the reference situation with which to compare future projections of climate change. The project web site will provide access to historical climate data, or, at least, links through to sites where historical climate data are available, and the process of collecting, formatting and supplying palaeoclimate data will be initiated. Workshops discussing the use of palaeoclimate and historical climate data in climate impacts studies will also be facilitated by the CCIS Project.

The CCIS Project also plans to host a number of workshops examining the construction and use of climate scenarios for different impacts sector studies, e.g., natural resources, water resources and marine and coastal zone applications. The first workshop, planned for late June 2000, will discuss the methods and techniques available for constructing regional climate change scenarios.

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