Current Research

Our tree-ring studies in the Canadian Cordillera have covered a wide range of topics. Initially they were focused on the Canadian Rockies where dendrochronology was used to date glacier fluctuations and Little Ice Age moraine features. Subsequently we developed a number of longer chronologies that could be used to crossdate subfossil wood material that was found in glacier forefields. This enabled us to provide calendar dates for the first early Little Ice Age glacier advances in the Canadian Rockies, and we have now developed considerable expertise and experience in dendroglaciological work. Detailed studies have been carried out to develop chronologies for several glaciers in the Canadian Rockies involving novel applications and development of dendroglaciological techniques. Additional work has also involved the use of tree-rings to reconstruct past snow avalanche activity at several sites, to date significant debris flow events, and to examine the response of treeline populations to climate change.

Following initial experimental work to develop climate reconstructions using oxygen isotopes and densitometry we have concentrated on dendroclimate activities. We developed the first long temperature reconstruction from the Rockies based on ring-width and density chronologies from the Athabasca Glacier area. Comparison with the record of glacier fluctuations and other proxy data (including hemispheric data sets) suggest that this reconstruction is regionally representative. Notwithstanding this success, it is often difficult to disentangle purely local (site), regional or large-scale climate influences in reconstructions based on a single site. Therefore our more recent work has concentrated on developing single species chronology networks from which we can determine a representative regional climate signal for the proxy climate parameter of interest. We have continued however to develop long chronologies where suitable material is available.

Initially, we targeted upper treeline environments that yield temperature sensitive records from both ring-width and density chronologies. The densitometric work has been done in collaboration with other laboratories, namely Forintek Canada in Vancouver, WSL Birmensdorf, Switzerland and LDEO in Lamont. Several chronology networks have been established and may be briefly characterised as follows.

Tabel1: Summary Characteristics of standard tree-ring chronology networks from the Canadian Cordillera

			Chronology lengths[1]		**Chronology characteristics[2]: Mean Values**				
SPECIES	**REGION**	**N**	**1st Year**	**Absolute Range**	**Age**	**RW**	**MS**	**1AC**	**R_{bt}**
Larix lyallii	SBC/CR[3]	19	1216	799-1993	354	0.44	0.28	0.43	0.53
Picea engelmannii	SBC	21	1635	1447-1997	188	1.28	0.16	0.52	0.29
Picea engelmannii	CR[4]	21	1500	1346-1994	281	0.71	0.13	0.56	0.27

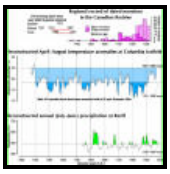
Picea glauca	SWY	9	1665	1470-1998	231	0.50	0.20	0.72	0.30
Abies lasiocarpa	SWY/NBC	5	1757	1645-1999	204	0.46	0.19	0.67	0.28
Pinus albicaulis	SBC/CR	13	1159	932-1999	311	0.55	0.15	0.71	0.28
Pinus ponderosa	SBC	13	1575	1450-1997	237	0.94	0.24	0.50	0.42
Psuedotsuga menz.	SBC/CR	40	1470	1306-1996	226	0.94	0.26	0.47	0.44

Upper treeline species Lower treeline species

1= The chronology lengths (and first year) are for the period when SSS>0.85 except for the absolute range which indicates the longest chronology in each network.
2= The mean values are for the final chronologies. Age is mean sample (segment) length; RW= Mean ringwidth; MS= Mean sensitivity; 1AC= First order autocorrelation; R_{bt}= Mean between tree correlation.
3= Regional abbreviations: SBC= South central British Columbia; CR= Canadian Rockies; SWY= Southwest Yukon.
4= Living tree chronologies. This does not include the snag chronology from Athabasca Glacier.

The distribution of *Larix lyalli* and *Pinus albicaulis* is restricted to the area south of about 51° and 55 °N (Northern Limit of *larix*), respectively. However these two species generally are longer lived and may contain more sensitive tree-ring series than other species. *Picea engelmannii* and *Picea glauca* are much more widely distributed throughout the Cordillera with *Picea glauca* having the more northerly distribution.

The spruce network covers the majority of Banff and Jasper National Parks and provides well-replicated chronologies for the last 300 years. The larch network utilises somewhat somewhat older trees and extends south from Banff and includes Waterton National Park and Kananaskis Country. Millennial length chronologies have been developed for all three major species and provide reference material to allow crossdating of undated dendrochronological series in this region.



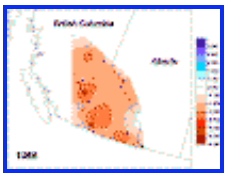
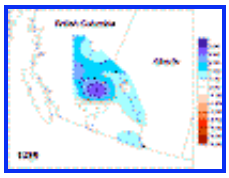
This diagram provides the first attempt to summarise climate variation during the last millennium in the Canadian Rockies. The upper section summarises the evidence of glacier fluctuations and moraine building periods over the last millennium. The April-August temperature reconstruction from 1073 to 1983 uses maximum density and ring-width data at the Columbia Icefield that shows general agreement with temperature histories deduced from glacier and treeline records. The lower graph shows the first long precipitation reconstruction from the Rockies. Although the reconstructions are both based on single records there is some evidence that they are regionally representative records. However, we are presently expanding our chronology holdings to verify this assumption. We also are developing sampling networks in the SW Yukon and Northern Canadian cordillera to develop a similar database for dendroclimatological studies. In this region *Picea glauca* and *Abies lasiocarpa* are the target species.

These regional networks also allow a more objective assessment of the regional signal in our long chronologies by comparison with the regional record over a common interval.

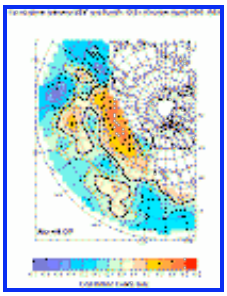
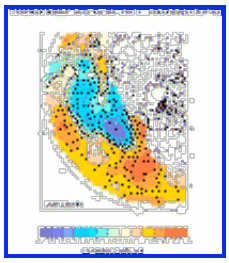
In a more recent development we have have collected chronology networks from moisture-sensitive, lower elevation (valley floor) sites across southern British Columbia and western Alberta in order to be able to reconstruct precipitation and other hydroclimate variables. The target species have been *Psuedotsuga menziessii* (Douglas fir) and *Pinus ponderosa* (ponderosa pine). This work, carried out mainly by Emma

Watson and funded by AES/MSC and Parks Canada, has enabled us to produce the first precipitation reconstructions from the Rockies (564 years at Banff, 284 years at Jasper). We plan to use this expanded network to reconstruct precipitation (and/or PDSI) patterns across the southern Cordillera. The availability of complementary reconstructions of both precipitation and temperature for the last 500 years in the southern Rockies is unique in Canada. As the network and reconstructions continue to develop they allow us to develop a comprehensive picture of climate variability through the so-called Little Ice Age.

When completed, these large multi-species networks offer exciting possibilities for the synoptic dendroclimatic studies to reconstruct possible changes in atmospheric circulation patterns across this region.

These two illustrations show preliminary results from this work. They show patterns of ring width variation over the entire 53 chronology sample network for selected years. Given that ring-width variability in these species strongly reflects annual precipitation, these patterns basically reflect precipitation patterns in the selected years. 1869 and 1829 are the most extreme patterns of the last 300 years

The potential to reconstruct sea surface conditions in the Northern Pacific is demonstrated by these figures on the right which show correlations between tree-ring width at individual sites and gridded sea surface temperatures. The Golf Course site is from Waterton, Alberta (113^{o} 50'W). The Merritt site (120^{o} 47'E) lies just east of the BC Coast Ranges. Both sets of diagrams courtesy of Emma Watson.

Oldest trees and long chronologies

Our work to date has yielded the oldest individual trees in the region for some species and the longest chronologies for many.

Our current maxima are as follows:

Table 2: Long tree-ring chronologies and oldest trees from the UWO network.

Common Name	Scientific Name	Oldest Living Specimen	Longest chronology record[1]
Whitebark Pine	*Pinus albicaulis*	>1060 Saskatchewan[2],	932-1999 Grassy Mt., B.C.[8]
Alpine larch	*Larix lyalli*	>838 Waterton, B.C.[3]	799-1993 Gray Creek Pass, BC[3]

Limber pine	*Pinus flexilis*	>826 Kootenay Plains	732-1996 Kootenay Plains[4]
Engelmann spruce	*Picea engelmannii*	>761 Peyto	760-1990 Peyto[5]
Douglas fir	*Psuedotsuga menziesii*	>691 Banff, Alberta	1306-1996 Banff[6]
White Spruce	*Picea glauca*	>600 Sandpit, Yukon	1105-1999 Landslide, Yukon[7]
Ponderosa pine	*Pinus ponderosa*	>548 Patriot, B.C.	1450-1998 Patriot[8]
Subalpine Fir	*Abies lasiocarpa*	>354 Snake Creek, Yukon	1645-1999 Snake Creek[7], Yukon

Notes: 1=longest absolute record; 2=Youngblut, 1999, with additions; 3= M. Colenutt, pers. comm.; 4= R. Case, pers. comm (Part of UCLA database), 1999; 5= Reynolds, 1992; 1999; 6 = Watson, 1998 1992; 7= Youngblut pers com; 8= E. Watson, pers. comm.

Several older floating chronologies of 200-400 years have been developed from buried forest sites overidden by glaciers between ca. 1000-3800 ^{14}C yr BP and recently exposed by glacier recession. We have developed floating chronologies from some of this subfossil material and hope, over the next few years, to crossdate the records between sites and possibly link them with living tree chronologies and develop a multi-millennial reference chronology for the southern Rockies.

In addition to the dendroclimate work we continue investigations of the fluctuations of glaciers at individual sites and the dating of various geomorphic events. New material is always appearing in glacier forefields and offers the promise to crossdate and link various long chronologies and sites.

Ongoing Projects

Reconstructing climate variability from treeline sites in the southern Canadian cordillera (National Science and Engineering Research Council Grant 1998-2002).

Research associated with this project over the last four years has extended our *Picea* and *Pinus* chronology networks westwards from the Rockies across the southern interior of British Columbia. It is planned to continue this work within the submission to NSERC for the funding through the next round of awards (see below)

The Assessment of Past Present and Future Climate Variability in the Americas from Studies at Treeline Environments. (Inter American Institute for Global Change: Collaborative Research Network (CRN03) B.H.Luckman and J.A. Boninsegna (Mendoza, Argentina) PIs (1999-2004)

IAI CRN03 was established in 1999 following a major international competition for proposals. It was developed and is coordinated by Luckman, involves 15 primary researchers from 13 institutions in seven countries throughout the Americas. The primary scientific goals of the project are (i)

to develop a network of tree-ring chronologies from climatically-sensitive treeline sites in the Cordillera of the Americas that can be used to reconstruct and compare regional climate variability along the transect from Alaska to Tierra del Fuego (PEP-1) and , (ii) to define interannual-decadal scale modes of natural climate variability along this transect. Our work in the Canadian Cordillera clearly contributes to the extensive, growing database for this project and to answering the large scale questions it addresses. The project also focuses on enhancing the development and utilization of dendrochronology for tropical mountain tree species. In addition it will expand training in and application of dendrochronology and paleoenvironmental science within Latin Americaand has established new tree-ring laboratories in Mexico (summer, 2000), Bolivia (October 2000) and Peru (April, 2001) to address the issues of climate variability and change. This project allows significant interaction with scientists from the major dendroclimate laboratories of the Americas (Tucson, Lamont, Arkansas, Mendoza) and also provides opportunities and funds allow training and student exchange between participating laboratories and research projects. Annual reports and other information are available on the project's web site.
http://www.cricyt.edu.ar/IAI/

More information:
PAGES Newsletter Spring 2002 (In press): The Assessment of Present, Past and Future Climate Variability in the Americas from Treeline Environments

IAI Annual Report 2000

IAI Annual Report 2001

Dendroclimatic reconstruction of climate patterns in the Canadian Cordillera
Meteorological Service of Canada: Collaborative Research Agreement (2001-2002).

This project funds ongoing work on the reconstruction of precipitation from moisture sensitive sites in the Southern Cordillera and also exploratory work in chronology development in the SW Yukon Territory and NW BC

Developing a proxy climate database for the last 300 years in the Canadian Cordillera (Canadian Foundation for Climate and Atmospheric Research B. H. Luckman and D. J. Smith PIs, 2001-2004

This joint project with the tree-ring Lab of the University of Victoria will significantly enhance the Canadian component of the IAI project. It will merge the extensive data holdings from the UWO and UVIC laboratories (BC Coast Ranges and Vancouver Island) with other published material into an integrated database of almost 300 chronologies for the Canadian Cordillera that will be housed and managed at UWO. This will facilitate the development of reconstructions of precipitation, temperature, SST and other indices (e.g. PDO) for all or part of this region. The proposal will also support for the development of new chronology networks in British Columbia that will be complemented by proposed NSERC-funded research (see below). These two projects will fill the major gap in Canadian Chronology network between Alaska and the southern Cordillera and the United States.

Reconstructing climate variability from treeline sites in the northern Canadian

cordillera (National Science and Engineering Research Council Grant, pending, 2002-2006).

This project will target the reconstruction of spatial and temporal patterns of climate variability over the northern Canadian Cordillera in the Yukon and adjacent NWT during the last millennium using a network of tree-ring width and density chronologies from spruce and fir treeline sites. The relatively short (and sparse) instrumental climate records from this area indicate it was one of the most responsive regions to 20^{th} century warming. There is also evidence of a "see-saw" relationship with climates in the SW BC/ US Pacific NW regions. Documenting and identifying such large scale patterns of climate variation and their stability over time provides information about the nature, magnitude and frequency of changes in the dominant atmospheric circulation patterns that drive these changes (e.g.ENSO, PDO, PNA, etc). These new chronology networks from the Northern cordillera will improve our coverage from the Canadian Cordillera, fill a major gap in our knowledge of regional climate variation in Canada and complement our work in the southern Cordillera. In addition to developing new sample networks of 2-300 year long chronologies we plan to continue developing a small number of representative long chronologies (>800-1000 years) across the entire cordillera to benchmark climate variability during the last millennium. This research is integrated with the IAI and CFCAS projects outlined above. The results will provide a major contribution to the IGBP-PAGES PEP-1 transect and also contribute to the UN "Year of the Mountains" in 2002.