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PAGES PAST GLOBAL CHANGES News

Isabelle Laroque
Christoph Kull and Keith Alverson, Editors

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Dendrochronology

Bristlecone pine trees in the area of Methuselah Grove, in the White Mountains, California (USA). These trees are growing near their lower elevational limit in the strong rain shadow of the Sierra Nevada. Together with the relict wood seen lying on the ground, they have yielded an 8000-year record of precipitation, as well as the original calibration of the radiocarbon time scale (see page 16, Photo: M. Hughes).

Contents

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Editorial:

PAGES does many things to try to knit the international, interdisciplinary paleoenvironmental community together. One of these activities is hosting visiting scientists in the International Project Office as a way to proactively enhance the interaction between the IPO and the many researchers involved in PAGES projects. Recent and planned visitors have included sabbatical visits from senior scientists, postdocs, and graduate students. They have come from home institutions in Canada, China, Ethiopia, Germany, India, Mexico, Morocco, Russia, South Africa, and the USA. PAGES has benefited enormously from these visitors' substantial efforts in hosting workshops, guest editing topical issues of this newsletter, editing books and special issues arising from PAGES' activities, developing new initiatives, and enhancing PAGES' visibility in their home countries. Senior visitors have benefited from an opportunity to get away from their home institution for a period to focus on a PAGES project or develop new interactions and lines of research. Younger scientists benefit from taking on interesting and challenging tasks that would not normally arise in their research and making many new contacts within the international PAGES network. We are now working hard in many different ways to improve our ability to host visiting scientists in the future. I strongly encourage any scientists interested in taking the opportunity to spend some time at the PAGES International Project Office in Bern, Switzerland to contact me.

Keith Alverson
PAGES executive director
alverson@pages.unibe.ch

YOUR OPINION COUNTS

The PAGES community includes YOU. The three thousand scientists receiving this newsletter all have an opinion about what PAGES is, what it should be, what it does and what it should do. Let us know these opinions!

A flexible, bottom up organization like PAGES can only succeed with the active participation of its members. PAGES promulgates an inclusive, international framework for global paleoenvironmental research. In this context, your feedback on both our existing activities, and what is needed in the future is vital. Comments on how to improve PAGES engagement in your country would be especially helpful.

Input is welcomed at any time, but would be greatly appreciated before July 1, 2002 by email (pages@pages.unibe.ch), fax (+41 31 312 31 68) or regular mail (Bärenplatz 2, CH-3011, Bern, Switzerland)

Open Call for Nominations

PAGES Scientific Steering Committee

SSC members from Australia, France and Canada are in their last year of service and many other nations are not represented at all. Furthermore, in order to better balance the scientific expertise on the committee, we are particularly interested in increasing the representation of modelers and scientists working with well dated, high resolution proxies of environmental change during the last millennium. With this open call we seek to obtain nominations of active scientists in any field, but especially those in the areas of research mentioned above. Nominations are welcome anytime, but those received before May 1, 2002 will be available for immediate consideration. Further information including past and present membership is available at http://www.pages-igbp.org/contact/ssc.html

Nominations consist of a name, c.v. and contact information. They should be sent to Keith Alverson, (email: alverson@pages.unibe.ch, fax: +41 31 312 3168) Bärenplatz 2, CH-3011 Bern, Switzerland.

New on the PAGES Bookshelf

Palaeoecology of Africa and the surrounding islands

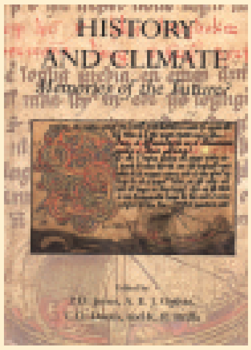
Proceedings of the XVth INQUA Conference Durban, South Africa, 3-11 August 1999, volume 27, 2001
guest editor: Jürgen Runge

orders can be directed to A.A. Balkema Publishers, P.O. Box 1675, 3000 BR Rotterdam, Netherlands (e-mail: orders@swets.nl).

History and climate: Memories of the future?

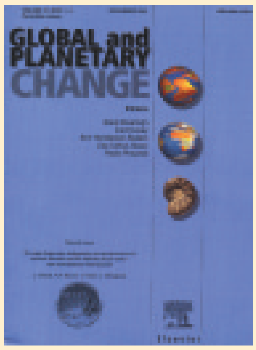
P.D. Jones, A.E.J. Ogilvie, T.D. Davies and K.R. Briffa (eds).
Kluwer Academic Publishers, 2001

If you would like an order form, please send an email, with 'History and Climate book' in the subject line to: j.burgess@uea.ac.uk



The late Quaternary stratigraphy and environments of northern Eurasia and the adjacent Arctic sea - new contributions

Global and Planetary Change, Special Issue, 31 (1-4)
edited by S. Cloetingh, C. Covey, A. Henderson-Sellers, L. Cirbus Sloan and P. Pirazzoli



Inside PAGES

Call for Contributions:

The next issue of PAGES News will highlight the use of stable Isotopes in continental paleoenvironmental investigations. Science highlights that fit within this theme, as well as the usual workshop reports and program news, are welcome. If you are interested in contributing a science highlight to this issue please contact Tom Edwards (twdedwar@sciborg.uwaterloo.ca).

Other types of contributions may be sent to Isabelle Larocque (larocque@pages.unibe.ch).

All submissions should follow the instructions for authors on our web-site and be submitted by May 15, 2002.

www.pages.unibe.ch/products/newsletters.html

START
IHDP • IGBP • WCRP

2002 START Young Scientist Award Program

The International START Secretariat is soliciting nominations for the START Award Program for young scientists from developing countries. Information is available under:

www.start.org

The deadline for submission of nominations/applications is June 30, 2002.

Analysis of Marine Sediments for Paleoenvironmental Studies

Frank Lamy & Gerold Wefer
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The Human Potential - Access to Research Infrastructures (ARI) Programme

Under the Human Potential-Access to Research Infrastructures (ARI) Programme of the European Community, access is provided for European visiting scientists to research facilities of the Faculty of Geosciences at the University of Bremen (GeoB), Germany.

The Faculty of Geosciences is a leading institution for paleoenvironmental analyses of marine sediments, a key research field for understanding past global changes and the prediction of future global environments. The infrastructure features a unique set of state-of-the-art, high capacity facilities for both initial handling and highly sophisticated analyses (e.g., stable isotope and elemental composition) of marine sediments (Fig. 1).

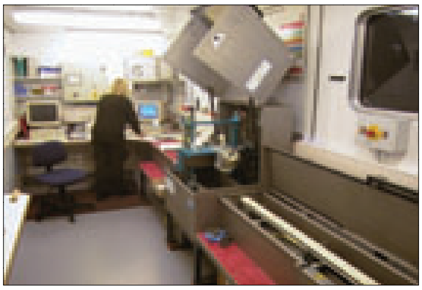

Fig. 1: Example of offered analytical facilities within paleostudies: X-ray fluorescence (XRF) core scanner for non-destructive, fast, and closely spaced (as small as 2mm) analyses of major and minor elements in split sediment cores.

Through financial support from the EC programme, visiting scientists are offered both extensive technical support, crucial for the successful application of the highly sophisticated analytical devices, and scientific consultation in the interpretation of the results, especially useful for young visiting scientists. Travel, accommodation, and living expenses for visiting scientists from EU Member and Associated States will be covered for visits of up to 2 months duration.

Research Fields

Interested European scientists are invited to conduct research projects within the general field of paleoenvironmental reconstruction primarily based on the analysis of marine sediments (though studies on continental archives, such as. lake sediments, are not strictly excluded). In order to guarantee optimum scientific support, potential research should fit within the range of activities at GeoB which focus on high resolution paleoenvironmental proxy analyses and modelling of:

- Climate and ocean variability on seasonal to 10^6-year time-scales
- Land-ocean interactions
- Marine productivity

Application and Contact

For more information see:
www.paleostudies.uni-bremen.de
or write to:
paleostudies@uni-bremen.de
The next application deadline is September 1, 2002.

PEP III News

Following the PEPIII open science conference in August last year, the transect leadership has been reorganized. After extensive consultation, a balanced steering group, both in terms of geographical coverage of the PEPIII transect and scientific expertise, has been formed. We are now happy to report that Thomas Litt has agreed to take overall responsibility, and that he will be advised by a steering group consisting of Nalan Koç, Pepe Carrion, Neil Roberts, Anne-Marie Lézine, Mohammed Umer and Tim Partridge. The group held a first scoping meeting in Bonn in March, 2002 and is now preparing an exciting future program. For more information about PEPIII, contact Thomas Litt (t.litt@uni-bonn.de) or any of the other steering group members or point your browser at http://www.geog.ucl.ac.uk/ecrc/pep3.

PAGES would like to take this opportunity to thank the new steering group for their willingness to serve, and we would also like to thank all of you who put forward nominations and especially those who volunteered their own services.

Finally, the outgoing leadership team, Françoise Gasse, Cathy Stickley and Rick Battarbee would like to thank the PEPIII community for their support and enthusiasm over the last few years culmunating in the enormously successful Aix conference and synthesis book.

Tree-Ring Variations over the Western Himalaya: Little Evidence of the Little Ice Age ?

HEMANT P. BORGAONKAR, RUPA K. KOLLI AND GOVIND B. PANT
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The Little Ice Age (LIA) is generally believed to have been a widespread phenomenon in the Northern Hemisphere around AD 1450-1850. While there is some consensus for a main phase of LIA from AD 1550-1800 over Europe, there is confusion associated with the use of this term and also considerable uncertainty as to the severity or synchroneity of the various cool events which have been ascribed to it (Briffa et al. 1990). Much of the evidence for LIA has come from documentary historical data and it is only recently that the potential of tree-rings as proxy climatic indicators has been exploited to address this issue. Briffa et al. (1990), using the analysis of a 1,400-year tree-ring record of summer temperatures in Fennoscandia, argue that the LIA is confined to a relatively short period between AD 1570 and 1650. These results have emphasized the probable spatial diversity of climate change, even across Europe through the last millennium (Briffa et al. 1992). With the availability of tree-ring chronologies over other regions across the world, it would be quite interesting to determine whether the spatial extent of LIA-associated climate changes has indeed been limited. The Himalayan region is a case in point.

Several leading tree-ring groups have been active in the Himalayan forest sites over the past two decades, more intensely over the western and central Himalayas. Using a large number of ringwidth and density chronologies of the Himalayan conifers, including *Pinus roxburghii*, *Picea smithiana*, *Cedrus deodara*, and *Abies pindrow*, covering the entire area of western Himalaya, we found that that the summer climate, particularly pre-monsoon (March-April-May) temperature and precipitation strongly influence tree-growth, a feature that cuts across species as well as sites.

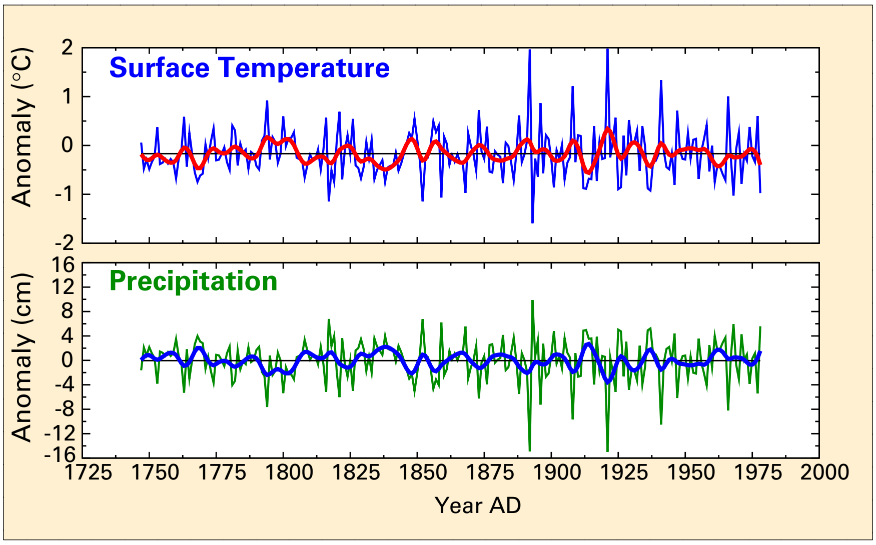

Fig. 1: Reconstructed pre-monsoon (March-April-May) temperature and precipitation anomalies since AD 1747 over the western Himalaya, India, using tree-ring chronology network. Smooth lines are based on cubic-spline-filtered values.

This response is possibly linked to moisture stress conditions during the early phase of the growing season causing growth anomalies in Himalayan conifers.

Reconstructed pre-monsoon (March-April-May) summer climate of western Himalaya since A.D. 1747 does not show any significant long-term trend over any part of the time series (Fig. 1). While these reconstructions are not long enough to comment with confidence on multi-centennial variability, they would have covered the later part of the LIA had it been of the time span 1450-1850. In such a case, it might be expected that the early part of the tree-ring based reconstructions contain at least the recovery phase from the peak of LIA. However, our studies to date do not indicate any unambiguous signal of the LIA phenomenon over this part of the globe. Other tree-ring based temperature reconstructions over the Himalaya (e.g. Hughes 1992, Yadav et al. 1999) also do not indicate evidence of long-term cooling associated with the LIA period. However, a recent analysis by Cook et al. (2002) based on Nepal tree-ring temperature reconstructions, in which they followed a novel approach to recover some low-frequency variance supposedly lost while detrending the tree-ring chronologies, provides some evidence of the LIA, probably for the first time over the Himalayas. However, they find that the cooling (possibly associated with the LIA) is prominent only in the winter (October-February) temperatures. Most analyses of tree-ring data from the western Himalayan region (of India) do not indicate significant response to winter climate (e.g. Borgaonkar et al. 1994, 1996, 1999, Hughes 1992), making it difficult to detect similar LIA signals. Even the raw tree-ring chronologies do not indicate any perceptible change in tree growth pattern that can be attributed to anomalous cooling conditions contemporaneous with the timing of LIA.

It is evident that the summer climate of the Himalayas as derived from tree-rings, particularly over the western parts during the past few centuries was not much different from the present climate and there is little evidence of cooling associated with the LIA. While this aspect needs further corroboration with more and longer chronologies and also support from other proxy sources, one can possibly surmise that the LIA might have had at best only a weak presence over the Himalayas.

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For full references please consult:
www.pages-igbp.org/products/newsletters/ref2002_1.html

Fire and Climate History in the Western Americas From Tree Rings

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The usefulness of tree rings in historical climatology derives from their high temporal resolution, exact dating, and sensitivity to precipitation and temperature variables. Another key strength of tree-ring climate proxies is that they can be massively replicated across broad-scale networks encompassing regions, continents, and hemispheres. In addition to influencing the growth of trees, climate variations affect ecological processes, and these processes are also recorded within tree rings. One of the most climatically responsive ecological processes is the occurrence and extent of wildfires. The record of past forest fires is often beautifully preserved within tree-ring sequences as "fire scars" on the lower boles of trees (Fig. 1). By extensively sampling fire-scarred trees in numerous locations, dendroecologists are now assembling broad-scale fire-scar chronology networks (Fig. 2) that are approaching the extent and replication of tree-ring width networks that dendroclimatologists have been assembling since the 1960s.

In combination with calibrated precipitation and temperature reconstructions from tree rings, fire-scar networks help improve our understanding of ecologically-effective climatic change. These records can assist in identifying important changes in regional to global climate patterns, and they can be useful in developing models for forecasting fire hazards in advance of fire seasons. In this brief note I review examples of findings from fire-scar networks in the western Americas. The fire history research community is just beginning to organize and coordinate at the global scale, and there are many new opportunities to collaborate, exchange data, and to analyze paleofire records from new regions.

Fig.1: Fire scars are created on the lower boles of trees by surface fires that injure the growing tissue beneath the bark (cambium), but do not kill the tree. Giant sequoias in the Sierra Nevada, California were repeatedly scarred by surface fires over the past three millennia (Swetnam 1993). By examining cross sections from dead trees, such as the one in the upper photo at Sequoia National Park, we can clearly identify fire scars within the ring sequences (lower photo), and date these fires to the year and season of occurrence. This particular tree had an innermost ring date of 256 BC, and contained more than 80 different fire-scar dates. Composites of fire-scar chronologies from individual trees, and from forest stands, provide time series reflecting fire occurrence and extent across a range of spatial scales.

Regionally Synchronized Fire Events

One of the strongest indications that fire-scar chronologies can reflect climatic variations is the occurrence of synchronized fire-scar events in widely scattered locations, from forest stands to regional scales (Fig. 3A). These regional fire events typically coincided with drought years (Fig. 3B). Similar patterns of fire event synchrony and drought are observed in the 20th century. For example, 1988 and 1989 were severe drought years in the western United States, and enormous areas burned during these years (e.g. the 1988 fires in Yellowstone National Park, and many large fires in the Great Basin and Southwest in 1989). Extensive fires occurred at the global-scale in the El Niño years of 1982-83 and 1997-98 in tropical forests of Indonesia, central Mexico, and the Amazon Basin.

A combination of modern and paleo time series of fire occurrence and weather indicates that high and low fire extent years were often associated with extreme phases of the ENSO (La Niña and El Niño). These patterns were not simply ENSO-related droughts causing high fire occurrence, or wet periods causing low fire occurrence, but also included inter-seasonal and inter-annual lagging patterns. For example, a common finding in the Rocky Mountains of Colorado, Arizona and New Mexico, in the Sierra Nevada of California, northern Mexico, and Patagonia and in Argentina was that the most extensive fire years tended to be dry years following 2 or 3 wet years (Fig. 3C). Moreover, the smallest fire years tended to be wet years that followed a dry year. These lagging relations occurred primarily in semi-arid woodlands and forests, and were most likely due to the importance of growth and accumulation of fine fuels (i.e. grasses and tree needles). Wet conditions in prior years were necessary for sufficient accumulation of fine fuels to carry surface fires in these open forests with widely spaced trees.

Combined with improved inter-seasonal climate forecasting based on ENSO conditions, these lagging patterns hold promise for developing useful fire hazard forecasting models. Fire managers could use these forecasts to position additional fire-fighting resources in advance of bad fire seasons, or to plan for conducting more "prescribed burns" during less hazardous seasons. These kinds of forecasting tools are currently in development and testing in the western and southern United States, where ENSO teleconnections are particularly important to seasonal precipitation amounts. Additional studies of paleofire records will be useful to identify the changing strength and consistency of ENSO-fire teleconnections, both spatially and temporally.

Inter-Regional Comparisons of Fire and Climate

An exciting research opportunity in paleofire climatology is the assembly and comparison of regional fire histories along the PEP-1 transect (Pole-to-Equator-to-Pole) in the western Americans (Fig. 2). We know that ENSO has important effects on seasonal precipitation and temperature along this transect, and these teleconnections are inverse between some regions. For example, rainfall amounts in the Pacific Northwest and northern Rocky Mountains of North America are usually opposite in response to El Niño and La Niña events relative to the southwestern and southeastern United States (e.g. El Niño events are dry in the NW and wet in the SW and SE). Recent studies have shown that paleofire records tend to follow these patterns: extensive fire events in Oregon tended to correspond with the El Niño phase of ENSO (Heyerdahl et al. in press), while extensive fire events in Arizona and New Mexico tended to correspond with La Niña events (Swetnam and Betancourt 1998). Because ENSO, the Pacific Decadal Oscillation (PDO) and other broad-scale ocean-atmosphere patterns modulate precipitation and temperature variations at regional to inter-hemispheric scales, we should expect that fire activity would be synchronized at similar scales. Indeed, in an inter-hemispheric comparison of fire-scar chronologies (Kitzberger et al. 2001), we found that fire activity in the southwestern United States was synchronous with fire activity in Patagonia Argentina from circa AD 1700 to 1900. Precipitation regimes in these two regions are affected in similar ways by ENSO. Not only were the two regional fire chronologies coherent within the ENSO frequency band (i.e. 2 to 7 years), we noted a similar decadal-scale secular change in the two fire-scar time series from circa 1780-1830. These are low fire frequency decades, and they coincided with an exceptionally cold period in both hemispheres (e.g. see the Mann et al. (1999) temperature reconstruction for the northern hemisphere). Moreover, this period had a markedly reduced frequency and amplitude of ENSO events, as indicated in tree-ring width, coral and ice core isotopic reconstructions (Kitzberger et al. 2001). In another study, using a fire-scar network from giant sequoia groves in the Sierra Nevada of California, we found that decadal fluctuations in temperatures were correlated with fire frequencies over the past 2,000 years (Swetnam 1993).

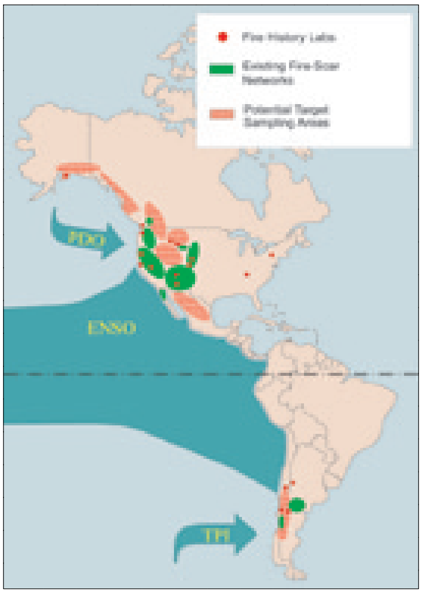

Fig. 2: Map of the Americas with current and potential sampling areas for fire-scar networks on the western side of the continents. Targeting locations with likely responses to ENSO (El Niño-Southern Oscillation), PDO (Pacific Decadal Oscillation), and TansPolar Index) variations will provide opportunities for inter-regional and inter-hemispheric comparisons. Locations of laboratories and individual scientists currently developing crossdated fire-scar chronologies in the western Americas are also shown.

New Fire-Scar Chronology Networks and Multi-Proxy Fire Histories

These encouraging results indicate that there is high potential to use fire-scar networks to evaluate interannual to decadal-scale climate variability. We are at an early stage in the development of regional paleofire networks, and there is a need for new collections in unsampled regions where interesting climatic teleconnections are expected. For example, networks of crossdated fire-scar chronologies are needed from British Columbia and southeastern Alaska, the Great Basin, and from additional regions in Chile and Argentina. Development of fire-scar chronology networks in the subtropics and tropics of Mexico, Brazil, Peru, and other countries will be challenging because annual tree rings are difficult to discern in many of the tree species in these regions. Nevertheless, an effective strategy might focus on sampling in high mountain areas, and regions with seasonal-

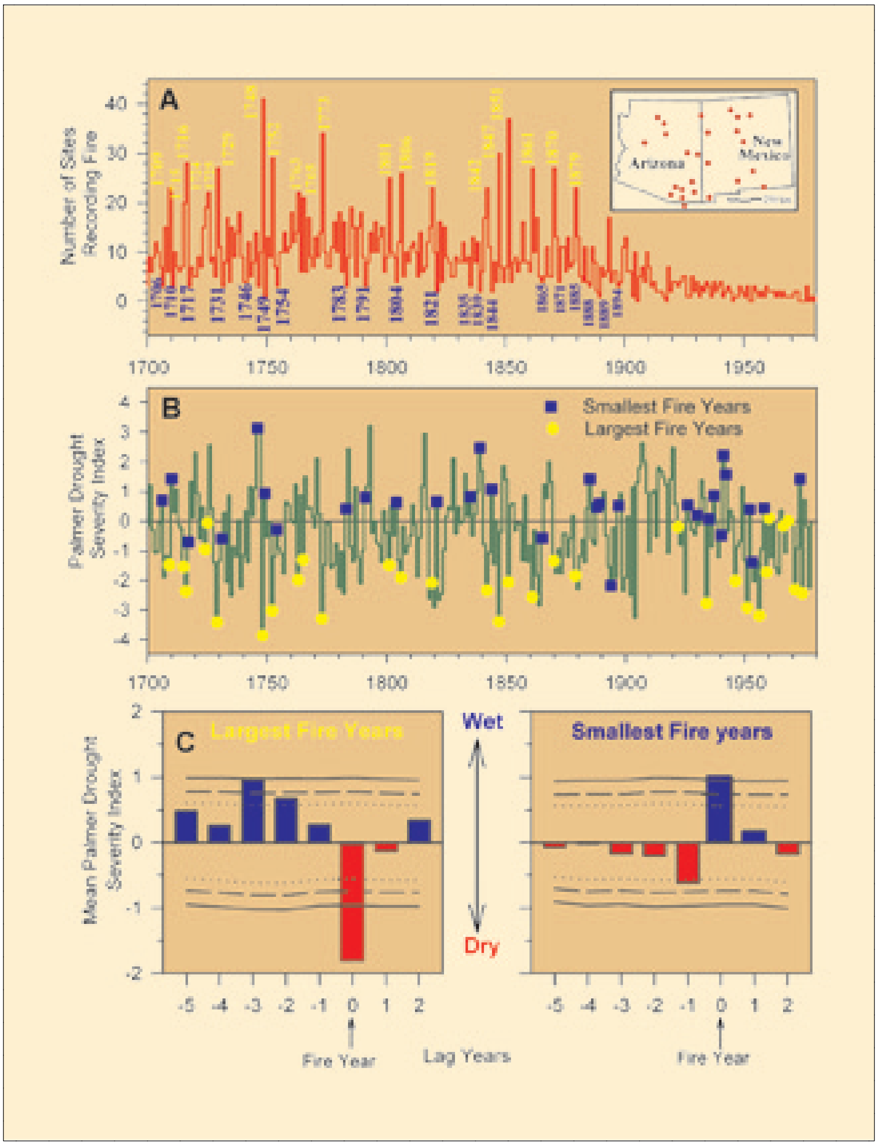

*Fig. 3: **A**: Fire-scar chronology from the Southwestern United States (Arizona and New Mexico, see inset map). This time series shows the number of sites recording fire-scar events each year from AD 1700 to 1980. A total of 63 fire-scar chronologies were composited from 25 mountain ranges (red dots on inset map) for this time series. The largest fire years are labeled in yellow, and the smallest fire years are labeled in blue. The lack of regional fire events after circa 1900 was due to the disruption of surface fire regimes by intensive livestock grazing, and organized fire suppression by government agencies. **B**: Time series of June-July-August Palmer Drought Severity Index (PDSI) from grid-point tree-ring reconstructions (Cook et al. 1999, locations of grid points are dots on inset map in A). The largest fire years (yellow dots) and smallest fire years (blue squares) are superimposed on the PDSI time series. The 1700 to 1900 largest and smallest fire years are from the regional fire-scar time series (in B), and the 1900 to 1980 largest and smallest years are from a time series of annual area burned from National Forests in Arizona and New Mexico. **C**: Results of superposed epoch analyses, where the mean PDSI values were computed for the twenty largest and twenty smallest fire years from 1700 to 1900, and previous 5 years and subsequent 2 years (lag years). The horizontal lines show the 90%, 95%, and 99% confidence intervals computed from a Monte Carlo re-sampling procedure. Note that largest fire years were very dry, with wet years preceding, and vice versa for smallest fire years (see Swetnam and Betancourt 1998).*

ly variable rainfall patterns and fire regimes.

Assembly of many, well-dated fire-scar chronologies from multiple locations is a key to identifying fire-climate patterns. This will require sustained efforts and coordinated data sharing among investigators and laboratories. Educational exchange and financial support is needed to assist in developing new laboratories and trained paleofire dendrochronologists. There should be opportunities to do this by coordinating efforts with other tree-ring initiatives, such as the PEP-I, Inter-American-Institute tree-line dendrochronology project (see Luckman and Boninsegna, PAGES News 9(3) :17-19, Dec. 2001).

Another promising area of investigation is the linking of the tree-ring paleofire records with sedimentary charcoal records. When sampled from the same watersheds and drainage basins, or when the sedimentary records have high temporal resolution (e.g. varves, or fine interval sampling and ^{210}Pb dating), there may be opportunities to crossdate fire events between tree-ring and sediment-charcoal time series. This kind of multi-proxy approach could be very useful in distinguishing local versus regional fire events. Combined with pollen time series from the same areas, coordinated tree-ring/ sedimentary charcoal studies could provide new insights on the multiple scales of climatic change, fire regime and vegetative responses spanning years to millennia, and local areas to regions.

Paleofire climatology has great potential to improve our understanding of the effects of past climate variations – especially those variations relevant to ecosystem change. Other indirect climate proxies, such as lake levels and glacier fluctuations are commonly cited as corroborating evidence in support of climate reconstructions from tree rings, corals, and ice cores. It is now clear that paleofire time series are of similar and increasing utility as an independent measure of ecologically-effective climate change.

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For full references please consult:
www.pages-igbp.org/products/newsletters/ref2002_1.html

Treeline Dendroclimatology in the North American Tropics

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Tropical treelines typically occur at the highest elevations among all forest ecosystems. Paleoenvironmental and paleoclimate research in those mountains is particularly needed because of the tropics' importance for the global hydrological cycle, and the scarcity of multi-century, annually resolved climatic information from tropical land areas. Current studies on treeline dendroclimatology of the North American tropics are being conducted at the Department of Geography of the University of Nevada, Reno, in cooperation with the Centro Universitario de Investigaciones en Ciencias del Ambiente de la Universidad de Colima, and the Patronato del Nevado de Colima y Cuencas Adyacentes A.C. Funding has been provided from the Paleoclimatology Program of the U.S. National Science Foundation and of the U.S. National Oceanic and Atmospheric Administration. Research efforts to date have focused on *Pinus hartwegii*, which grows at elevations higher than 3000 m in Mexico and Central America (McVaugh 1992). Wood growth is characterized by very clear, distinct layers, whose variability resembles that of other treeline species, and is high enough for crossdating (Fig. 1). Initial results point to North American monsoon precipitation as the main climatic signal present in a 400-year tree-ring chronology from Nevado de Colima, Mexico (Fig. 2; Biondi 2001). This differs from the prevailing view that dendrochronological records from timberline environments are mostly indicators of temperature changes, but current paradigms on treeline processes have been developed from studies conducted mostly at high latitudes, or at high elevations in mid-latitudes, and may not be applicable to tropical treelines (Lauer 1978).

A suite of geoecological research activities is underway to clarify how environmental factors affect, and can then be reconstructed from,

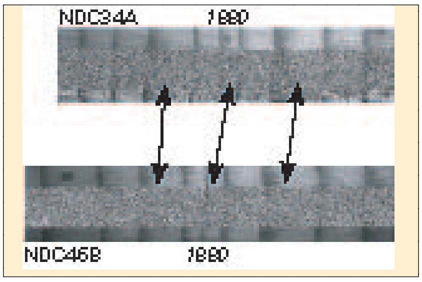

Fig. 1: Crossdating Pinus hartwegii core samples from Nevado de Colima, Mexico. Interannual variability is high enough to match ring patterns across samples, and this, in itself, is an indication that annual ring-width variability reflects climatic patterns.

Pinus hartwegii wood increment. First, a weather station was installed in May 2001 on Nevado de Colima to monitor treeline weather patterns at half-hour intervals (Fig. 3). Second, the length of the growing season, and the relationship between stem growth and climate at daily to weekly timescales, is being investigated at two sites using automated electronic sensors for recording wood increment and environmental parameters (Fig. 4). Sites are within a 1-km radius from the weather station, one at 3790 m elevation, on a 25% slope with west-northwest exposure, the other at 3780 m elevation, on a 58% slope with north-northeast exposure. Sensors at each site consist of 1 phytogram per tree (7 at site 1, 8 at site 2), 3 band dendrometers and 11 point dendrometers, 1 air temperature sensor, 1 PAR sensor, 4 soil temperature probes, and 7 soil moisture probes. One point dendrometer per tree was placed about 1.7-1.8 m above the ground on the south facing side of the stem after shaving most of the bark underneath the sensor. On a few trees, 1-2 more point dendrometers were installed on the north-facing side or without removing the bark or at higher levels to provide comparisons. Measurements began in May 2001, and it will take at least 2-3 years before reliable results will be available. Every effort has been made to involve local researchers, authorities, and forestry personnel to minimize the risk of vandalism on field equipment.

Additional studies being conducted on Nevado de Colima include testing for genetic differences between pine populations at different elevations, and examining

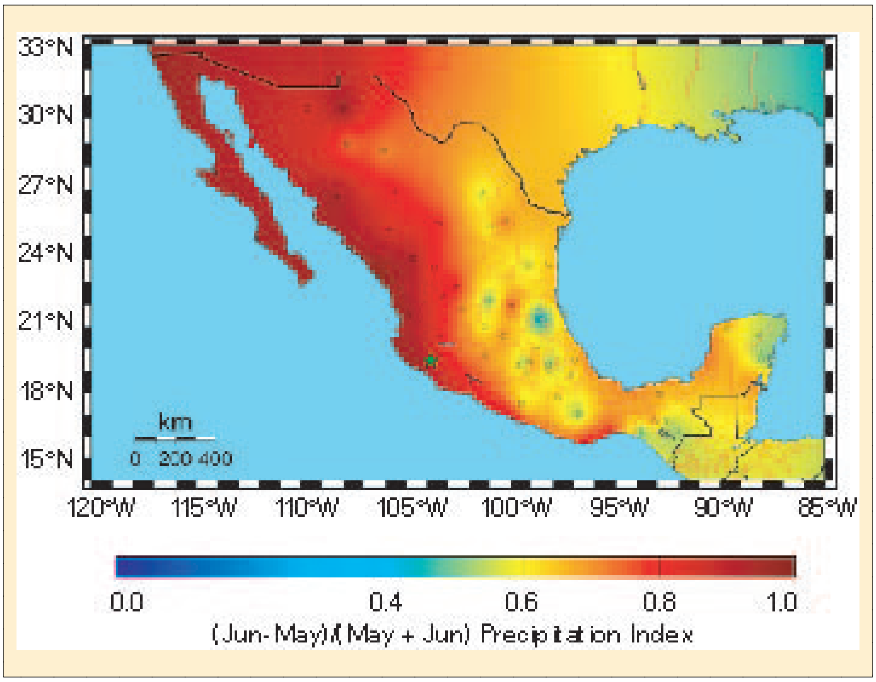

Fig. 2: Map of the precipitation index used to highlight areas in Mexico where monsoon rainfall begins in June, including Nevado de Colima (green star).

tree growth response to the 1913 eruption of the nearby Volcán de Colima (Martin del Pozzo and Sheridan 1993). Field observations have shown that trees at the edge of treeline (about 4000 m elevation) are 2-3 centuries younger than those 200-300 m below, and laboratory analysis has revealed peculiar features in the wood anatomy of upper treeline individuals. Therefore, two sites were sampled for isozyme analysis by clipping a branch terminal shoot from each of 50 trees per site. One site was at about 4000 m elevation, the other was within 1 km of the weather station, at about 3750 m elevation. Sampled trees were at least 25 m from each other, and in good health. Genetic analyses have not shown significant differences between the two pine populations (Constance I. Millar and Robert D. Westfall, Pacific Southwest Research Station, USDA Forest Service, Albany, California, pers. comm.). Spatial information on the impact of the 1913 Plinean eruption of Volcán de Colima on treeline forest growth is being generated by quantifying the 1913-14 wood growth reduction that is clearly evident in most *Pinus hartwegii* tree-ring records. Of 63 dated and measured wood increment cores that included those two years, 22 had no visible ring in 1913, and 8 were missing the 1914 ring as well.

Fig. 3: Automated weather station at 3760 m elevation on Nevado de Colima, Mexico (Photo F. Biondi).

Fig. 4: Phytogram (cable at lower right), band dendrometer (upper instrument), and point dendrometers (middle and lower left instruments) installed on a Pinus hartwegii stem. The point dendrometer in the middle measures radial changes outside bark, whereas the outer bark was shaved underneath the lower left point dendrometer (Photo: P.C. Hartsough).

Other activities are aimed at obtaining a clear representation of North American monsoon patterns in the region. Precipitation and temperature records provided by the University Corporation for Atmospheric Research include a total of about 200 stations throughout Mexico, and the data is being analyzed for spatial and temporal patterns, especially in relation to the onset of monsoon rainfall. Monthly precipitation indices and geostatistical techniques are being used to identify regions characterized by May, June, and July climatological onset of the summer rains (Fig. 2). Future research will concentrate on developing stable isotope and microdensitometry chronologies from *Pinus hartwegii* tree rings. Using Nevado de Colima samples, a preliminary $\delta^{18}O$ time series has been developed for the 1952-97 period, and microdensitometric records have been generated at the Laboratory of Tree-Ring Chronology, University of Arizona, Tucson, using a total of 18 segments from 9 trees. Additional tree-ring records from that site, and from other high peaks of Mexico and Central America, are slated for collection and analysis in the coming year.

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Progress in South American Dendrochronology

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Climate and Ecosystems

South America extends from 11°N to 62°S. Major boundaries such as the Andes on the western side of the continent and the land mass in the tropics create north-south and west-east variations in climate and ecosystems. Tropical forest covers 44% of the total land surface. Between 36 and 56°S, a temperate forest composed of high longevity trees dominates. The northern and central highlands are covered by small trees, shrubs and grasses. The central western part (Peru, Chile, the Andes, western Argentina and eastern Patagonia) is composed of deserts. These diverse climatic zones and ecosystems offer various potential sites for dendrochronological studies. The ideal conditions for paleoclimatic reconstructions using tree-rings are those that support the existence of long-living trees required to develop long chronologies, and/or the presence of subfossil woods. Over the last decade, the search for areas with some of these conditions has been one of the major goals of dendroclimatological studies in South America.

Dendrochronological studies in South America started in the temperate region, where conifer and broad-leaf species with well marked annual rings grow (Boninsegna and Villalba 1996). Following this initial period, interest in tree-ring studies spread throughout the region and several scientific centers in Argentina, Brazil, Bolivia, Chile and Peru are now using dendrochronological techniques to assess questions related to paleoclimate, forest ecology, biogeography, and forest production.

Long Chronologies

South American high longevity tress offer the possibility of reconstruction on long temporal scales. Long tree-ring chronologies have been developed in recent years using *Fitzroya cupressoides* (Alerce).

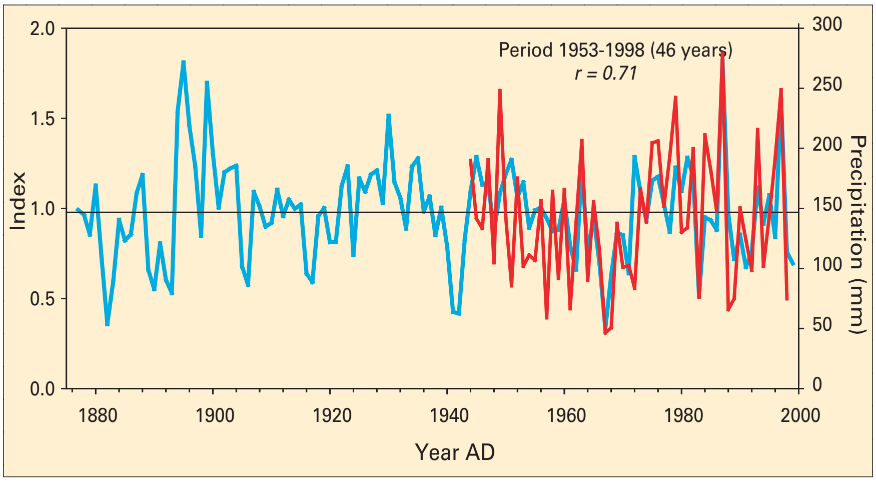

Fig. 1: Polylepis tarapacana chronology developed by Argollo and Villalba in 2001 (personal communication) at Volcan Tunupa (19°S, 4600m. a.s.l.). The chronology is drawn in blue, while the dark red line correspond to precipitation data from Oruro (Bolivia).

Fitzroya is a conifer growing between 40° and 43°S and reaching ages of about 3,000 years. A network of 20 chronologies over 1,000 years long is already available in Argentina and Chile and a 5,100-year chronology is being developed in Chile (Wolodarsky, personal communication).

Austrocedrus chilensis is another long-lived conifer growing in north-western Patagonia (32 to 39 °S). It is possible to find living trees 900 – 1,000 years old. A network of 27 chronologies from *Austrocedrus chilensis* has been used to reconstruct past precipitation variations in northern Patagonia since A.D. 1600. Recently, a new set of millennial scale chronologies (using living trees and sub-fossils) have been produced. A combination of ring width, $\delta^{18}O$ and density chronologies is being used to study El Niño Southern Oscillation (ENSO) variability in this sensitive region.

Sub-fossil Wood

Often, the acidity in peat bogs provides conditions that permit the preservation of stumps. On Tierra del Fuego Island (51°-56°S), peat bogs are rather common. Samples extracted from different places yield radiocarbon dates ranging between 3,000 to 4,000 years. A floating chronology is now available and extensive sampling is being carried out in order to fill the gap between the floating and the "living trees" chronologies (Roig 2002 personal communication).

Tree rings are routinely used to reconstruct Holocene climate variations at high temporal resolution, but only rarely have they offered insight into climate variability during earlier periods. Roig et al. (2001) reported a floating 1,229-year chronology developed from sub-fossil stumps of *Fitzroya cupressoides* in southern Chile (41.4°S) dating to ca. 50,000 ^{14}C years B.P. They used this chronology to calculate the spectral characteristics of climate variability at that time, which was probably an interstadial (relatively warm) period. A comparison with the power spectra of chronologies derived from living *F. cupressoides* trees shows strong similarities with the 50,000-year-old chronology, indicating that similar growth forcing factors operated in this glacial interstadial phase, as during the current interglacial conditions.

Chronology Network

The existing chronology coverage of South America is patchy and largely concentrated in the temperate region of Argentina and Chile. In the last three years, an important number of new chronologies (ca. 85) using the southern beech *Nothofagus pumilio* have been produced in the southern part of Argentina and Chile (Lara et al. 2001). An important product based on this network is a 400 years reconstruction of meridional and zonal atmospheric circulation index over the Southern Ocean (50-60°S). The zonal index shows dominant modes of variation at 4.4 – 5 year period, which may be associated with the Antarctic Circumpolar Wave. The meridional index shows that the 19th century was dominated by southerly flow; while during the 20th century northerly flow prevailed over the region. These results are consistent with the warming observed in the Southern Ocean in recent decades (Villalba et al. 2002 in prep.).

An interesting number of chronologies developed from *Cedrela lilloi* and *Juglans australis* from the cloudy montane forest known as the "Yungas" (22-25°S) in the subtropical region of Argentina were successfully used in estimating past changes in precipitation (Villalba et al 1998). Additional chronologies in the same area are under development in an effort to extend the temporal scale.

Tropical Chronologies

Reconstruction of low latitude climate variability has been hampered by the lack of suitable annually resolved proxy climate records. Several factors can be invoked to explain the unbalanced distribution of tree-ring records between tropical and temperate regions in the Americas. Most tropical species do not form distinct rings and when rings are present, they are not annual. Some species show clearly visible rings but the circular uniformity is uncertain. Absence of seasonality appears to be the main reason for the lack of well-defined boundary rings in the tropics. Nevertheless, there are tropical and subtropical regions that experience seasonal changes in precipitation or temperature that can induce the formation of defined growth rings. In order to fill the "tropical gap" between the presently available tree-ring chronology networks, scientist from Argentina and Bolivia are working together in the search of woody species suitable for dendrochronological research.

Fig. 2: Cedrela odorata tree growing at Pando, Bolivia (11°S 200m a.s.l.) in the southwestern part of the Amazon basin. The climate presents a mean annual temperature of 27°C and 1800 mm of precipitation with a marked dry period during the months of May to September. The diameters of the dominant trees reach 1.0 – 1.5 meters (Photo: F. Roig).

High Altitude Chronologies

Highlands are climate-sensitive sites of particular interest to tree-ring research in tropical and subtropical regions. In the South American subtropics (15°-25°S), the moderate seasonality of temperature may induce the formation of well-defined rings more effectively at colder treeline environments. At lower elevations in the Bolivian subtropics, the presence of annual growth bands may be related to the occurrence of dry-wet cycles and/or flood conditions. Because it is adapted to dry and cold conditions, *Polylepis tarapacana* reaches the highest elevation (between 4100 and 5200m) of tree growth in the world. Some living *P. tarapacana* trees are known to reach ca. 600 years of age indicating the potential for long chronologies. One of these chronologies, at Tunupa (19°45'S), shows a remarkable correlation with precipitation as illustrated in Fig. 1. Presently, four chronologies are available at Volcan Sajama, Volcan Tunupa, Soniquera and Volcan Granadas. The Soniquera chronology covers the interval AD 1411-2000. Bolivian chronologies are the highest elevation tree-ring chronologies in the world.

In Piura (Peru) Rodríguez and Córdova (2001, pers. comm.) successfully developed a tree-ring chronology using *Bursera graveolens* at Vicus Hill (5°9'S). The 38-year old series recorded the last two mega ENSO events (1982-83 and 1997-98). This important result suggests that dendroclimatological reconstruction of El Niño-Southern Oscillation (ENSO) in Peruvian north coast is possible.

Amazonian Chronologies

The complex Amazonian forest is a true challenge for dendrochronology. Several attempts to explore the potential for new species to yield annual ring series have been carried out in different regions. Most of these studies were conducted in species of the *Meliaceae* family, in particular *Sweitenia mycrophilla* and *Cedrela odorata*. In a recent work, *C. odorata* sampled at Pando, in Bolivia (11°S) showed visible and circularly uniform rings, and reached ages of ca. 250 years (Roig pers. comm., Fig. 2). Strong variations in the width of the rings suggest high sensitivity to the variations of a common factor in the stand, probably climate or a climate-related phenomenon. *C. odorata* has a wide latitudinal range, from the northern part of Mexico through the Amazonia basin as far as approximately 24°S, making the species a good candidate to develop a chronology network.

Thanks partly to the efforts of the PAGES Focus I Pole-Equator-Pole Transect (PEP-I), and with the support of the Interamerican Institute for Global Change Research (IAI), a collaborative project involving 15 investigators from 15 institutions in Argentina, Bolivia, Canada, Chile, Mexico, Peru and the USA aims to develop a comprehensive geographical coverage of tree-ring treeline chronologies. It is expected that they will allow the reconstruction of global-scale spatial and temporal patterns of temperature and precipitation along this transect over the last several hundred years and to encourage the training of scientist and the application of dendrochronology and paleoenvironmental science within Latin America (Luckman and Boninsegna, 2002).

Acknowledgments

I thank J. Argollo and R. Villaba for providing the data used in figure 1.

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Post-fire Vegetation Dynamics in Southern Switzerland

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Introduction

Because forest fires in central Europe are rare compared to North America, knowledge about the post-fire behavior of native European species is scanty. The expected climate change for the next century could influence fire regimes in central Europe thereby leading to more frequent forest fires. Thus, knowledge about post-fire behaviour and fire-sensitivities of central-European plant species may become more important for understanding and managing forest ecosystems.

In Switzerland most fires occur in the region south of the Alps during the early spring season (March to April). During this period the deciduous forest belt is threatened by fast spreading surface fires that, in certain cases, represent a very important disturbance factor (Conedera et al. 1996). It is well known that the vegetation shows different reaction patterns to fire depending on the life strategy of the species and the fire regime (Bond and van Wilgen 1996, Hofmann et al. 1998), but because fire affects species composition at timescales of years to centuries, direct observation of the full range of post-fire vegetational change is not possible. To overcome this difficulty, we combine paleoecological, dendroecological and phytosociological methods in order to (1) determine vegetation response patterns during different historical periods and fire regimes and (2) provide information on related long-term ecosystem dynamics.

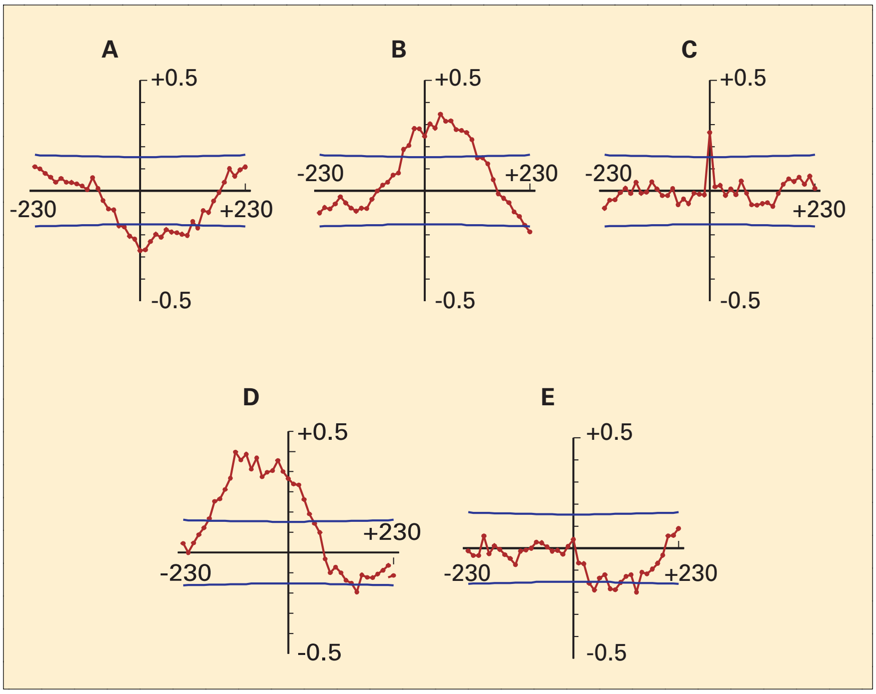

Fig. 1: Correlograms of charcoal influx, pollen percentages and diversity from Lago di Origlio (5,100-3,100 BC cal.). Horizontal axis shows lag in years (one lag = 11.6 years). Vertical axis shows correlation coefficient – those outside the lines are significant at p = 0.05. ***A****: decreasing taxa (charcoal vs. Ulmus spp.);* ***B****: increasing taxa (charcoal vs. Alnus glutinosa t.);* ***C****: opportunists (charcoal vs. Cichorioideae);* ***D****: fire precursors (charcoal vs. Pteridium aquilinum);* ***E****: plant diversity (charcoal vs. pollen diversity).*

Paleoecology

Sediment analyses of two small lakes (Lago di Origlio and Lago di Muzzano) were used to reconstruct vegetation history and fire ecology of the last 15,000 years (Tinner et al. 1999). A comparison of the recent sedimentary record with the wildfire database of southern Switzerland indicates that charcoal concentration and influx estimated from pollen slides correlate well with the number of forest fires occurring within a distance of 20 to 50 km from the coring site (Tinner et al. 1998). In order to determine post-fire vegetation responses, we computed cross-correlations for pairs of pollen types and charcoal concen-

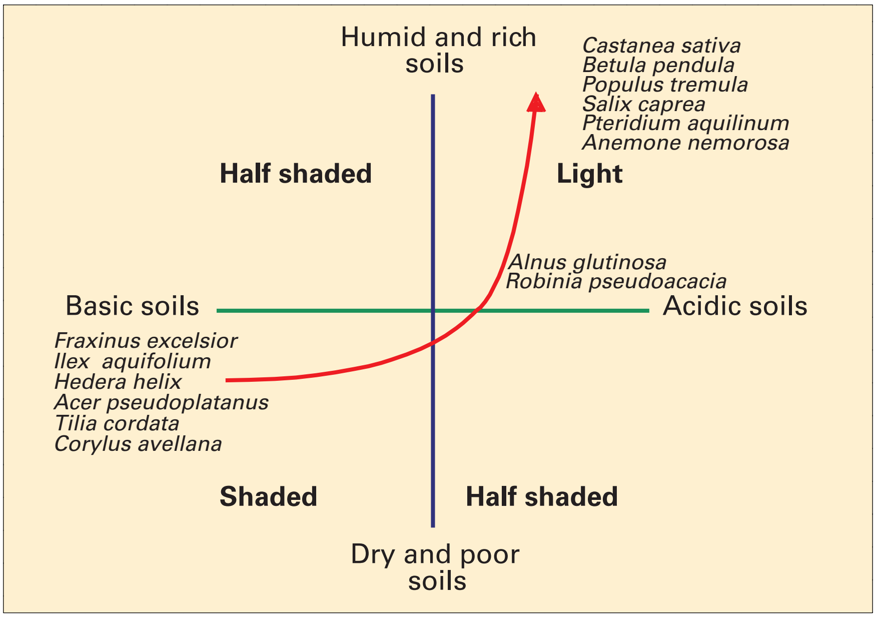

Fig. 2: Effect of fire on vegetation and soil types. The arrow indicates the directional change following fire. Communities change from shade-tolerant species on basic soils to shade-intolerant species on acidific soils.

trations during the period 5100-3100 BC, using a sample interval of approximately 10 years.

Dendroecology and Vegetation-Ecology

To study the effects of modern forest fires on the vegetation physiognomy we used a methodology consisting of community sampling in quadrats of 100 m^2, in order to analyse post-fire reactions of the vegetation as a function of forest type, fire frequency over the last 30 years and time elapsed since the last fire (Delarze et al. 1992, Hofmann et al. 1998). Dendroecological data were recorded for each plot to verify the reliability of the wildfire database of southern Switzerland and to reconstruct the fire history on the basis of fire scars where fire history was lacking (Hofmann et al. 1998). Ecological indices according to Landolt (1977) were used to evaluate the site conditions.

Results

Cross-correlations prove to be a very useful technique for detecting post-fire behavior of various taxa (Fig. 1). During the first part of the Neolithic (5,100-3,100 BC) four different reaction patterns could be distinguished (see also Tinner et al. 1999):

- decreasing type (i.e. *Abies*, *Fraxinus excelsior*, *Tilia*, *Hedera*, *Vitis*, *Ulmus* – see Fig. 1A): a significant negative correlation between fire occurrence and taxa abundances, marked at lag 0, reflecta a supposed fire sensitivity of the concerned taxa;
- increasing type (i.e. *Corylus*, *Salix*, *Sambucus nigra*, *Humulus t.*, *Alnus* – see Fig. 1B): the fact that the highest significant positive correlation between fire occurrence and taxa abundances occurs 10-30 years after the charcoal peak, reflects the recovering capacity of the concerned taxa;
- short term opportunist type (i.e. *Anemone*, *Trifolium repens*, *Mentha*, *Rosaceae*, *Cichorioideae* – see Fig. 1C): positive correlation between fire occurrence and species abundance

Table 1: Life strategies of selected fire favoured and unfavoured species in chestnut forests on siliceous soils on north facing slopes (source: Hofmann et al. 1998).
P = summer-green phanerophytes, E = evergreen phanerophytes, N = summer-green nanophanerophytes, J = evergreen nanophanerophytes, C = herbaceous chamaephytes, G = hemicryptophytes, G = geophytes; M = dissemination by mammals, U = dissemination by man, V = dissemination by wind, I = dissemination by insects (ants), O = dissemination by birds.

Chestnut forests < 1000m, north facing		**Biological form** (Landolt, 1977)	**Resprouting capacitiy** (very good: 5, very bad: 1)	**Colonisation capacity** (pioneers: 5, climax sp.: 1)	**Dissemination vector** (according to Oberdorfer, 1983)
Favoured	*Pteridium aquilinum*	G	5	4	V
	Betula pendula	P	3	5	V
	Robinia pseudoaccacia	P	5	4	U/V
	Populus tremula	P	5	5	V
	Salix caprea	P	5	5	V
Relative frequency of discriminating factors		H: 59%	E: 0%	V: 62%	O: 6%
Disfavoured Species	*Corylus avellana*	N	5	4	M/O
	Fraxinus excelsior	P	2-3	4	V
	Acer pseudoplatanus	P	4	4	V
	Tilia cordata	P	2-3	2	V
	Hedera helix	E	1	2	O
	Ilex aquifolium	E	2-3	2	O
Relative frequency of discriminating factors		H: 14%	E: 29%	V: 50%	O: 36%

is restricted to a very short time period (< 10 years). These taxa seem to take advantage of open-land conditions in the first years after fire;

- fire precursor type (i.e. *Plantago lanceolata*, *Quercus* (deciduous), *Pteridium*, *Caryophyllaceae*, *Poaceae*, *Pteridium aquilinum* – see Fig. 1D): A positive correlation exists but precedes charcoal peaks. Thus, these taxa seem to be responding to anthropogenic activities.

These findings are congruent with results of dendroecological and plant-community studies (Hofmann et al. 1998). Vegetational development after repeated forest fires is characterized by a decrease of the tree cover and by an increase of light-demanding shrub and herb species. Characteristics such as resprouting capacity, dissemination capacity and dissemination vectors are thought to play the basic role in the fire survival of species (Table 1). Favoured or disfavoured tree and shrub taxa under the present fire regime conditions widely correspond to those indicated by paleoecological studies. The ecological and dendroecological studies show that fire changes the composition of forest communities from a high abundance of shade tolerant species on basic soils to a high abundance of shade intolerant species on acidic soils (Fig. 2). This directional change can also be affected by various types of fire frequencies (Fig. 3). Increases in fire frequency lead to the dominance of fire-enhanced and fire adapted species (e.g. *Castanea sativa*). In some cases, fire can lead to local extinction of fire-intolerant and fire-damaged species (E.g. *Abies alba*). The resulting decrease in plant diversity is documented both for paleovegetation (Fig. 1D, for details see Tinner et al. 1999) and modern plant communities (Delarze et al 1992).

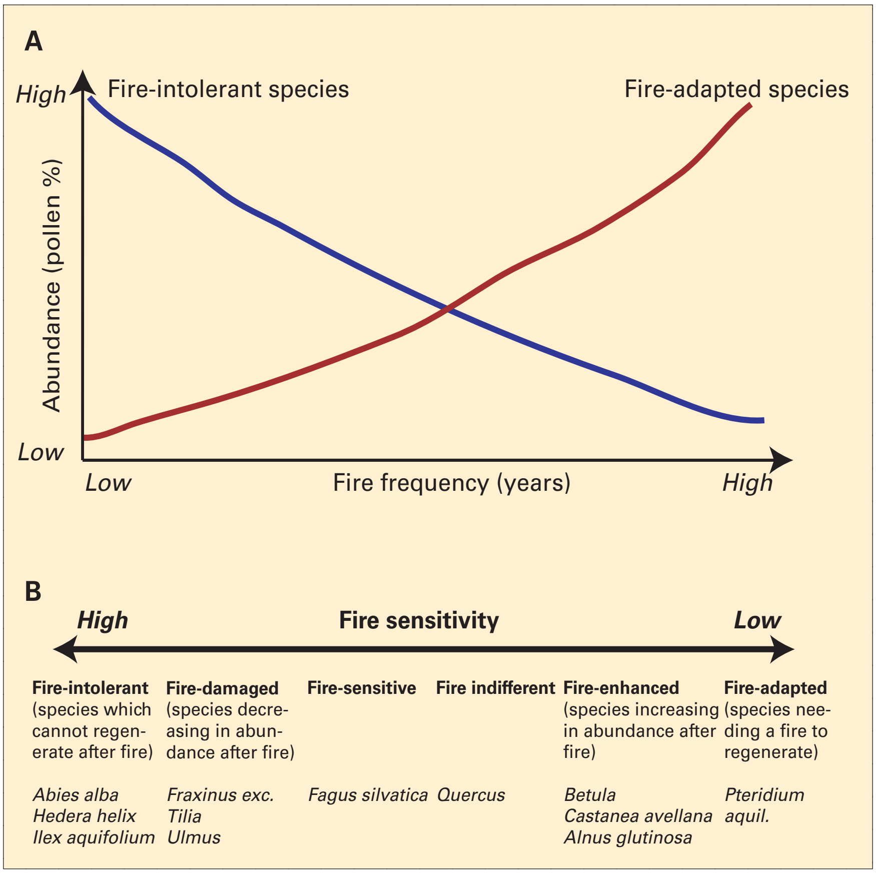

*Fig. 3: **A**: Effect of increased fire frequency on the abundance of fire-intolerant and fire-adapted species. With increased fire frequency, fire adapted species increase while fire-intolerant species decrease. **B**: Fire sensitivity classification for selected European plant taxa.*

Conclusions

A combined approach using both dendroecology and paleoecology provides important information about the sensitivity and the annual to century scale reaction patterns of woodland ecosystems after fires. This integrated approach has lead to initial classification of fire sensitivity of European tree species. Fire sensitivity of European species is similar that of related North-American species (e.g. very fire sensitive: *Abies amabilis*, *A. lasiocarpa*, *Ilex opaca*; fire-sensitive: *Fraxinus grandifolia*, *F. americana*, *Ulmus americana*, *Tilia americana*, fire adapted: *Quercus rubra*, *Betula papyrifera*; see Fire Effect Information System, http://www.fs.fed.us/database/feis/) confirming our hypothesis that genetically fixed characteristics are decisive for post-fire responses of plant species. Understanding fire-sensitivity may help to develop fire-disturbance parameterisations for existing forest-succession models. From a more practical point of view, a fire-sensitivity ranking may also be helpful for forest management and restoration after fires. Furthermore, until now little or no attention has been paid to fire-driven changes in Central and Western European vegetation history. As shown for the southern Alps (Tinner et al. 1999), failing to account for past fire disturbances may lead to spurious conclusions about ecosystem responses to past environmental change.

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The Ancient Bristlecone Pines of Methuselah Walk, California, as a Natural Archive of Past Environment.

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Longest Tree-Ring Chronology

Almost fifty years ago, Edmund Schulman (1956) recognized the unique longevity of the bristlecone pines (*Pinus longaeva*) of the White Mountains on the border between California and Nevada. Alerce (*Fitzroya cupressoides*) in south-central Chile is the only other tree species to even approach the 5,000-year lifespan of the bristlecone pine. Even after death, the pines may remain standing for millennia, and their tight-ringed, resinous wood may survive several thousand years after falling to the ground. The persistence of this wood results from the combination of its properties with the cool, dry conditions that exist for much of the year at elevations of 2,800 – 3,400 meters in the severe rain shadow of the Sierra Nevada. In Methuselah Walk (Fig. 1 and cover photograph), many hundreds of ancient living trees, dead snags and logs have been sampled over the decades. The oldest pieces of wood were alive 11,000 years ago, and Ferguson (1969) used the relict wood to extend Schulman's tree-ring chronology to the beginning of the seventh millennium BC. Dendrochronologically dated material from this site provided the basis of the calibration of the radiocarbon timescale in the 1960s, and so played an important role in the chronological revolution that swept the study of Holocene environments and human prehistory. The Menthuselah Walk provides the longest single-site tree-ring chronology in the world.

Fig. 1: Location map showing the position of Methuselah Grove (red circle), the other five lower forest border, moisture sensitive long chronologies (red plus signs), and the boundary of Nevada Division 3 (heavyline).

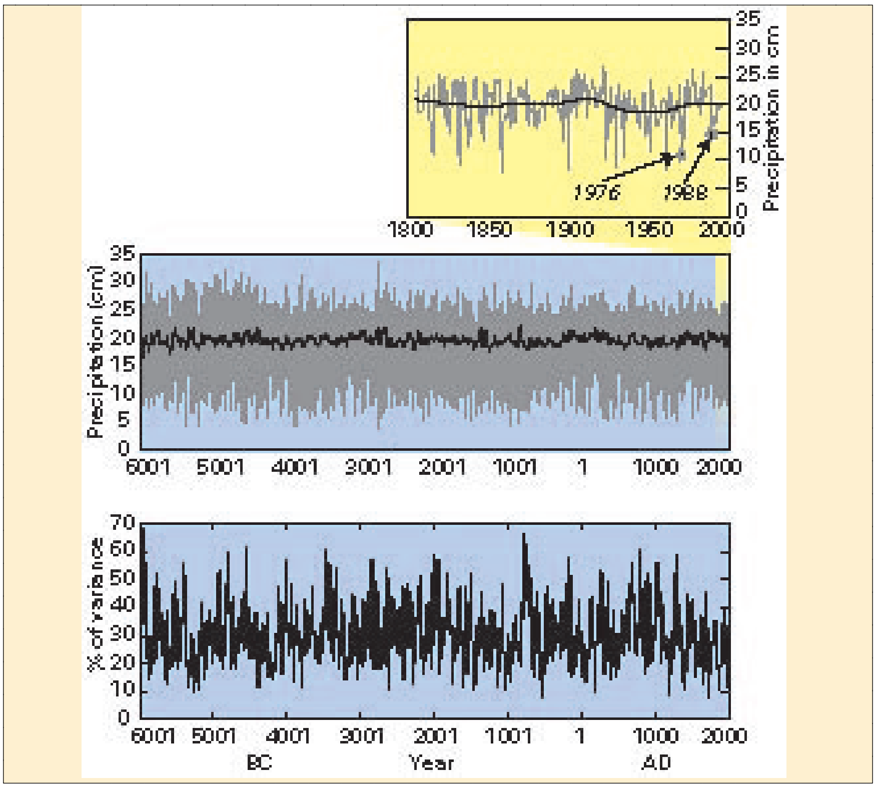

Fig. 2: Upper and middle panel: the reconstruction of Nevada Division 3 July through June precipitation based on the Methuselah Walk bristlecone pine chronology. The year-by-year reconstruction is shown in gray. The thicker, black line shows the reconstruction smoothed by a 50-year low-pass Gaussian filter. Lower panel: the percentage of total chronology variance accounted for by the 3-7 year waveband over a moving 30-year window in the Methuselah Walk chronology.

Variability in Precipitation

The new version of the chronology reported by Hughes and Funkhouser (1998) is strongly replicated, with at least 10 or more samples for every year since 6,000 BC up to AD 1995. Due to the strongly moisture-stressed and variable nature of the site, the cross-dating between the trees at Methuselah Walk is extremely clear, and so it can be inferred that there is a climate signal in the variability of the rings. Intensive investigations of the autecology and dendrochronology of bristlecone pine by Fritts, LaMarche and Graybill and others provided the basis for an almost 7,996-year long reconstruction of precipitation in the southern portion of the Great Basin (Fig. 1, Hughes and Graumlich 1996; Hughes and Funkhouser 1998). The tree rings account for 40% of the interannual variability of precipitation, and clearly capture decadal and multidecadal variability, as exemplified by the regional switch to wetter conditions after 1976 (Fig. 2, upper panel). They also show the multiyear drought of the late 1980s, which caused serious problems in water-hungry California. In fact, the reconstruction shows that this drought was far from exceptional, hundreds more severe droughts were recorded in the last eight thousand years. The reconstruction captures the character of precipitation variation in this very dry region, with striking interannual variability (Figure 2, middle panel), and a small proportion of decadal and longer-scale fluctuation.

Hughes and Graumlich (1996) pointed out that the precipitation reconstruction based on the Methuselah Walk chronology contains two multidecadal droughts in the period from the tenth to fourteenth centuries AD. These droughts correspond-ed to low stands of nearby Mono Lake as reported from geomorphological evidence by Scot Stine (1994). These same droughts were seen in independent reconstructions based on tree-ring width chronologies by Graumlich and by Graybill and Funkhouser based on other tree species in the neighboring Sierra Nevada, and in stable isotope ratios in the Methuselah Walk wood reported by Leavitt. The Methuselah Walk ring-width data, and the isotope data also correspond to Stine's geomorphic data in another, revealing, respect. All three records show the two major, sustained droughts ending in a decade or two of very unusual moisture excess.

Further support is given to the veracity of these century-scale and longer fluctuations in a reconstruction based on the Methuselah Walk chronology by comparison with another, more than 1,700-year long, reconstruction of precipitation in the same portion of the southern Great Basin, for the same July-June period (Hughes and Funkhouser 1998). It is based on six chronologies, including Methuselah Walk, all well replicated for at least 1,700 years. The reconstruction accounts for 48% of precipitation variance and has century-scale fluctuations very similar to the Methuselah Walk-based reconstruction (Fig. 3). This pattern is almost unchanged even if the Methuselah Walk-based series is excluded from the multi-chronology-based reconstruction. There was clearly a greater incidence of intense, persistent, moisture deficits after AD 400 and before approximately AD 1500 than in the periods immediately before and after. Hughes and Funkhouser (op.cit.) point out that "*there is a broad similarity between the multicentury pattern over the last 1600 years reconstructed here for the Great Basin, and the broad patterns of accumulation measured on the high-elevation ice-caps at Quelccaya in Peru, and Dunde in Tibet (Thompson, 1996). This could be mere coincidence, or it may represent a feature of variability in the hydrological cycle on a global scale.*"

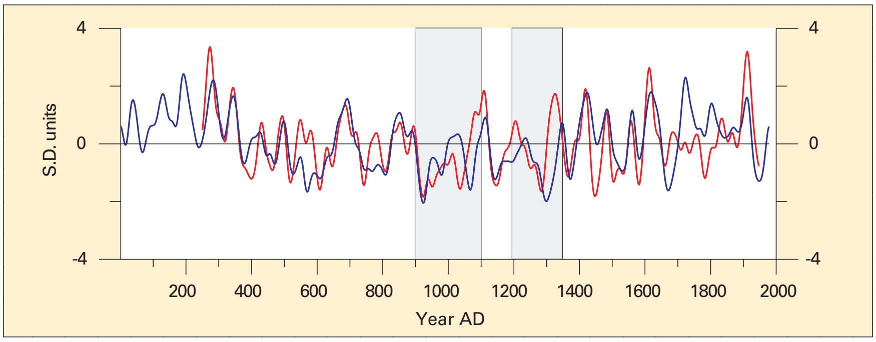

Fig. 3: The 50-year smoothed Nevada Divisions 3 precipitation reconstructions based on only the Methuselah Walk chronology (blue line) and on all six lower forest border chronologies (red line). The reconstructions have been converted to z-scores. The gray areas indicate the times of low stands of Mono Lake identified by Stine (1994).

ENSO-related Fluctuations

In recent years, PAGES scientists have reported convincing evidence of regime-like behavior in the last two centuries in the El Niño-Southern Oscillation phenomenon (ENSO), using coral bands and tree rings. Although the regional expression of ENSO effects in eastern California and the Great Basin are complex, the region is part of a large, southwestern quarter of the United States where winter half-year precipitation is strongly correlated with the Southern Oscillation Index (SOI) during the instrumental period. In order to identify potentially ENSO-related fluctuations in the Methuselah Walk chronology, we used a band-pass filter designed to conserve variability on 3 to 7 year timescales, which are empirically associated with ENSO. This filtered version of the reconstruction has a correlation pattern with global surface November through April temperatures for the period 1959-1994 that is strongly reminiscent of the pattern associated with ENSO. The proportion of the total variance of the reconstruction that is accounted for by this 3-7 year waveband in a 30-year moving window fluctuates in a distinctly regime-like manner over the past 8,000 years (Fig. 2, lower panel). ENSO-timescale variance has been as much as 60% and as little as 10% of total variance on occasion. There is no indication of an absence of ENSO-timescale variability in the early part of the reconstruction. The periods since AD 1500 and before AD 400 are marked by relatively limited ENSO-timescale variability. These periods correspond to times of enhanced occurrence of severe, sustained droughts.

Human Impact

Understanding the causes and predictability of the variability of precipitation is of great importance to the burgeoning human population of California, and its neighboring states. The questions that arise from the dendroclimatology of the trees of Methuselah Walk are only likely to be resolved by using the characteristic PAGES approach of large geographic scale comparison and integration of multiple proxy records, and exploration of their climatic signals using coupled ocean-atmosphere models.

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For full references please consult: www.pages-igbp.org/products/newsletters/ref2002_1.html

Change in Fire Frequency During the Last 300 Years in the Eastern Canadian Boreal Forests.

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There is little doubt that climate changes cause changes in forest disturbances, including natural fire regimes. Several local records from both the western and eastern parts of Canada suggest that a major decrease in fire frequency (i.e. area burnt per year) occurred alongside climatic warming at the end of the Little Ice Age around 1850. To assess the degree to which this was a general phenomenon in the boreal forest of eastern Canada, we have reconstructed fire frequency for the last 300 hundred years over an area covering more than 30 000 km^2 along a 1000-km long transect from eastern Ontario (80° 30` W) to central Québec (73° 30` W) between 48 and 50° north (Fig. 1, Table 1). With the exception of the southern part of the Abitibi-West region, which was colonized for agriculture in the beginning of the twentieth century, the area is essentially unpopulated and is typical of the eastern boreal forest. The area is currently under extensive forest management.

Fire history reconstruction

Three lines of evidence were used to map the distribution of forest stands as a function of time since the last fire:

- Historical maps and documents (from forest companies, protection agencies)
- Old aerial photographs (1920s and 1930s)
- Standard dendrochronological techniques

The length of the reconstruction was therefore limited by tree longevity.

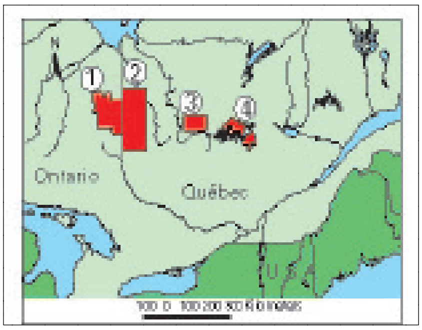

Fig. 1: Location of the four study areas. 1) Lake Abitibi Model Forest; 2) Abitibi-West; 3) Abitibi-East; and 4) central Québec

Forest Age Distribution and Fire Cycles

The mean age of stands and the high percentages of forest older than 100 years (Table 1) indicate a low proportion of current stands which grew up following fires more recent than 1920. The average stand age decreases from the western-most study area (172 years) to the eastern region (111 years). There is a slight increase in central Québec (127 years) (Table 1).

Fire cycles were computed for three predefined time periods (before 1850, 1850-1920 and after 1920; Fig. 2). The 1850 limit was selected because it corresponds to the end of the Little Ice Age in the area (Archambault and Bergeron 1992), while 1920 corresponds to the beginning of the intensive colonization. Throughout the transect, a substantial decrease in fire cycle is observed over time with shorter fire cycles (69–132 years) before 1850 increasing to more than 190 years after 1920 (Fig. 2).

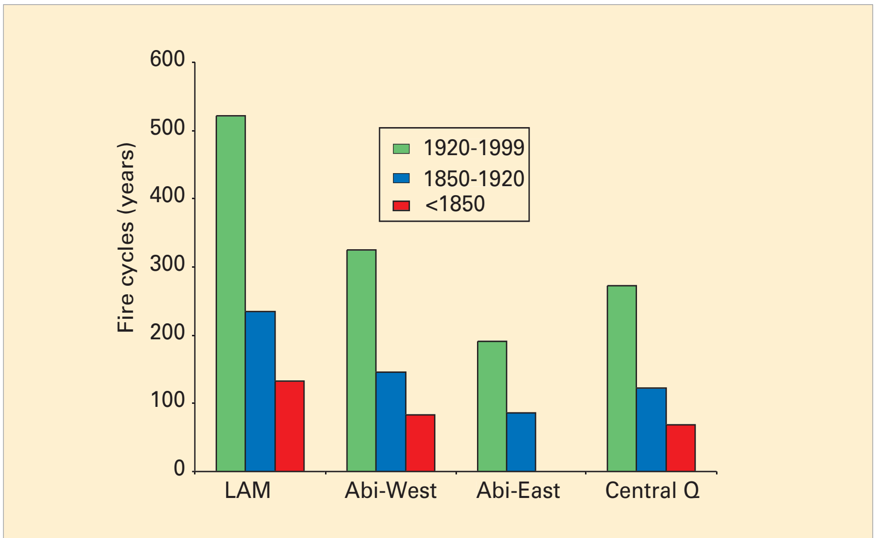

Fig. 2: Fire cycles for each region: 1) Lake Abitibi Model Forest (LAM); 2) Abitibi-West (Abi-West); 3) Abitibi-East (Abi-East); and 4) Central Québec (Central Q).

Change in Fire Frequency Triggered by Climate Change

Fig. 3 indicates the global cumulative time since the last fire disturbance. Since none of the relationships are straight lines, they suggest that fire frequency has changed over time. Each relationship indicates a change in the slope in the early 20th century and around the mid 19th century (vertical lines in Fig. 3). The western part (LAM) is characterized by a fire frequency that is significantly longer than in the other regions, whereas the shortest fire frequency length is observed in the eastern part (Abitibi-East).

Since the areas examined were still untouched in 1850, the decreasing fire frequency observed probably was not caused by direct human activity. Although the influence of native people on fire frequency can not be totally ruled out, we believe that the low population density in this part of the boreal forest rules out human ac-

Table 1. Characteristics and estimated fire cycles for each region.

Region[3]	Area (km²)	Mean age (yr)	over 100 yr (%)[1]	Fire cycles (yr)[2] 1920-1999	1850-1920	<1850
Lake Abitibi Model Forest[a]	8 245	172	78	521 (370–733)	234 (171–321)	132(98–178)
Abitibi-West[b]	15 793	139	57	325 (248–424)	146 (114–187)	83 (65–105)
Abitibi-East[c]	3 294	111	54	191 (124–294)	86 (56–131)	------ [4]
Central Québec[b,c]	3 844	127	56	273 (183–408)	123 (83–181)	69 (47–102)

[1] Percentage of the stands that are older than 100.
[2] The three periods are significantly different at p< 0.001, in all regions.
[3] Regions marked with different letters are significantly different at p< 0.05 for the fire cycles of the three periods.
[4] There was not enough data to allow for fire cycle computation for this period.

tivities as an explanation of the observed decrease. The subsequent decrease in fire frequency around 1920 corresponds to a period of important human settlement, especially in the southern section of the study area and may therefore have resulted from human activities such as passive and active fire suppression. However, it is difficult to explain the observed decrease as solely due to anthropogenic effects. Active suppression using water bomb tankers began only around 1970. Fire danger reconstitution studies suggest that there was a decrease in the duration and/or magnitude of the fire season in the study area during the 20th century. Furthermore, the pattern during the 300-year period is also similar to that reported for the islands of Lake Duparquet (Bergeron 1991), where fires have never been suppressed. Taken together, these factors suggest that the decrease in fire frequency is at least partly driven by a change in climate. The decrease in fire cycle at Lake Duparquet has been shown to be related to a reduction in the frequency of drought events since the end of the Little Ice Age (Bergeron and Archambault 1993). The present results suggest that this phenomenon can be extended to a larger area of the eastern boreal forest. It is hypothesized that the warming that started at the end of the Little Ice Age was accompanied by a change in the circulation of air masses and consequently the drought regime. This is supported by simulations using the Canadian General Atmospheric Circulation Model, which predicted a decrease in forest fire activity for most of the eastern boreal forest, in the event of future warming (Flannigan et al. 1998).

On the other hand, the increase in fire frequency from west to east does not seem to be related to a similar trend in the severity of climatic conditions. In fact, precipitation and computed fire weather indices suggest a decrease in the severity of the fire season from west to east (Kafka et al. unpublished results). This suggests that non-climatic factors such as lightning occurrences could influence the fire regimes in these areas. The longer fire cycles observed in eastern Ontario and western Québec might be explained in part by the abundance of wetlands that characterized the region as compared to the eastern portion of the study area, located on the Canadian Shield. Currently it is not possible to discriminate between the relative importance of climatic versus geological characteristics as controls on fire frequency.

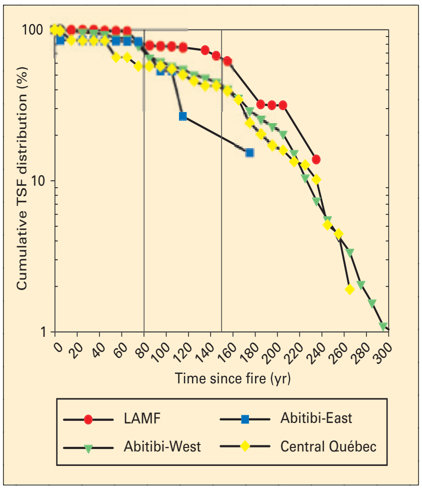

Fig. 3: Semilog cumulative time since fire (TSF) distribution for each of the sectors. Since distributions did not show a constant hazard of burning, fire cycles were computed for periods of relatively constant fire frequency (see Table 1 for the results).

Conclusion

Our results show that there is considerable spatial and temporal variation in fire cycles along a east-west transect in the boreal forest of northeastern Canada. In all of the four studied regions, there has been an increase in the fire cycle period since the end of the Little Ice Age around 1850. Climate change, though not the only factor involved, seems to have played a role in the spatial and temporal variability of fire frequency (see Bergeron et al. 2001). The fire cycles reported here are longer than those generally reported for the boreal forest. Our results indicate that fire frequency is highly variable in time and space, results that are consistent with other studies. These temporal and spatial variations suggest that fire in the boreal forest is a complex process.

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Recent Fennoscandian Pine Records of Temperature, Precipitation and the North Atlantic Oscillation

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Various climatic phenomena have recently been extracted from ring widths of Scots pine (*Pinus sylvestris L.*) in Fennoscandia. Individual chronologies have provided millennial temperature proxies in the northern forest-limit region and records of relative drought in the south. Furthermore, networks of pine chronologies have provided reconstructions of the North Atlantic Oscillation.

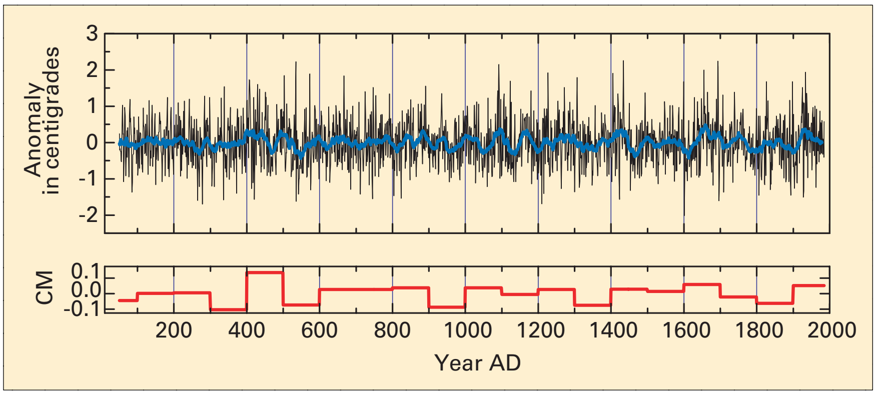

Fig. 1: Reconstructed northern Fennoscandian summer temperature anomalies (July mean). 20-year centred moving averages superimposed on interannual variability (upper plot). Non-overlapping 100-year means (CM) showing centennial variability (lower plot).

Reconstruction of Summer Temperature

Mid-summer (July) temperatures since 50 years AD have been reconstructed in Lapland, (68-70° N, 20-30° E) (Fig. 1) (Lindholm and Eronen 2000). Seasonal anomalies indicate that the warmest summer was experienced in 535 AD (2°C above the mean), although warm summers of similar amplitude occurred at least once every 200 years between 1,000 and 1,800 AD. The coldest summer (2°C below the mean) was recorded in 1601. The most dramatic interannual shift (greatest difference between any consecutive pair of years) took place between the summers of 535 and 536 AD.

The non-overlapping 100-year means of summer temperatures show little evidence of a Medieval Warm Epoch or the Little Ice Age in Fennoscandia. This only applies to summer climate and not to other seasons.

During the whole reconstruction period, the 4th century was the coolest with anomalies 0.104 below the mean. The warmest century was the 5th with anomalies 0.136 above the mean. Somewhat unexpectedly, the 20th century is only the third warmest (0.0514 above the mean) for the last two thousand years. This reconstruction work is presently being extended using a 7500-year chronology (Eronen et al. 1999).

Seasonal North Atlantic Oscillation

A network of 30 pine chronologies from various parts of the boreal forest belt in Fennoscandia were calibrated against seasonal indices of the North Atlantic Oscillation (NAO) by Lindholm et al. (2001). The northernmost pines, from the forest-limit region, proved to be sensitive to summertime variations of the NAO, while most southern pines respond to winter variations in the NAO index. Our north to south transect of growth response data shows a drastic shift directly south of the northern boreal belt. The southern part of the pine network was used for building a transfer model of wintertime NAO between 1893-1981 (Fig. 2). This network is being actively expanded spatially and temporally to complement the increasing experimental activities in reconstructions of various aspects of the NAO.

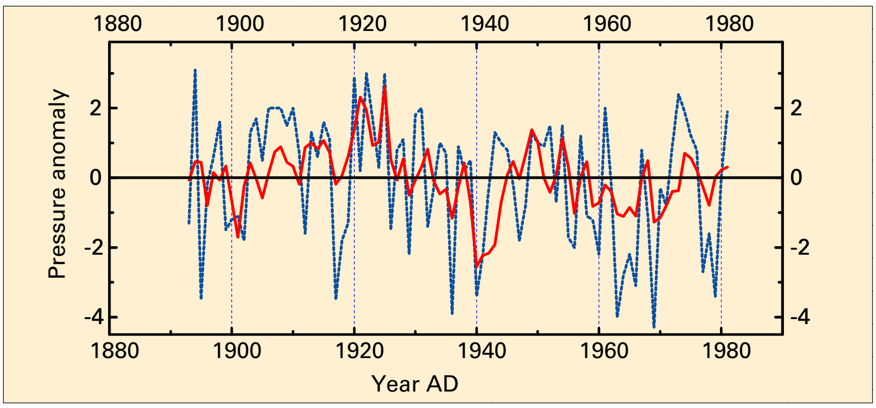

Fig. 2: The actual winter NAO index (blue, dash) plotted together with the modelled values (red, solid). The experimental model was built using 17 Fennoscandian pine chronologies south from the northern forest-limit region. Although the model explains only one quarter of the dependent winter NAO variance, the verification statistics show reasonable skill in reconstruction.

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Extreme Climatic Events in South America: Tropical-Extratropical Links

CACHOEIRA PAULISTA, SAO PAULO, BRAZIL, 3-4 DECEMBER 2001

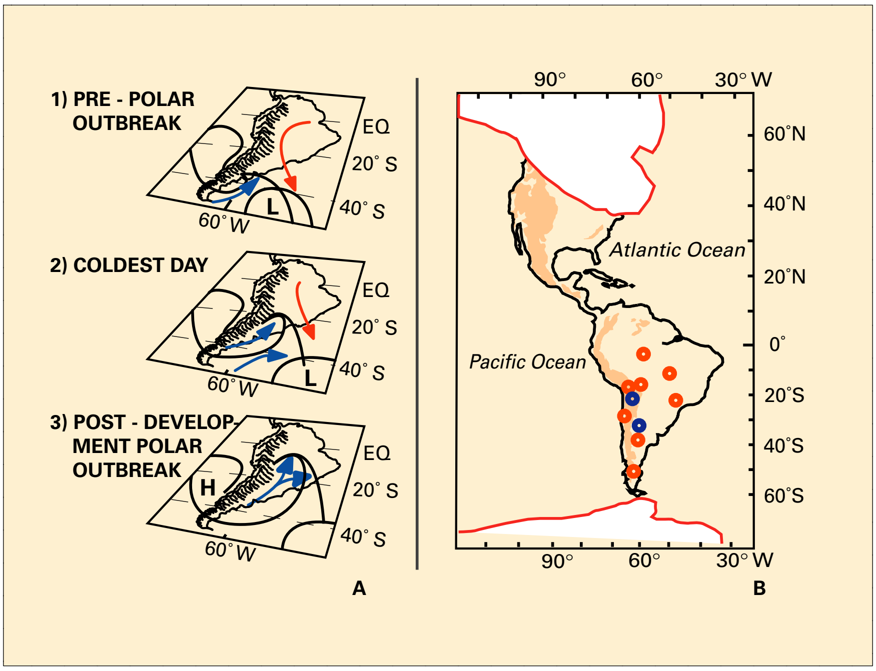

*Fig. **A**: Schematic trajectories of cold and dry air masses over South America (blue arrows) and warm and moist tropical air masses (red arrows). **B**: Full glacial conditions in South America interpreted from pollen and lake level records. Red circles are conditions drier than today, blue circles are wetter than today.*

Meridional air mass exchanges have a strong impact on climate variability in tropical and temperate regions of South America. Polar air advection is of special interest since it is related today to freezing events in southern and southeastern Brazil with serious economic consequences. Polar advection also influenced past climates, with Antarctic air reaching as far as central Amazonia circa 13,000 years ago. To further our understanding of the present-day characteristics of polar outbreaks in South America and their effects on present and past climates, a meeting was convened at the Instituto Nacional de Pesquisas Espaciais (INPE) near São Paulo to bring together climatologists, climate modelers and paleoclimatologists. The questions adressed were: What are the primary circulation features that produce cold air outbreaks in the Americas? How do Antarctic cold air masses interact with seasonal climates of South America? What are the specific climate signals related to polar outbreaks in low and high latitudes? What are the paleoclimatic responses to polar outbreaks in paleoenvironmental records?

The opening presentation by José Marengo (CPTEC-INPE, Brazil) presented a record of extreme climatic events that occurred at tropical latitudes during recent decades and their relation to Antarctic cold air outbreaks.

Climatological analysis of the Antarctic cold air masses reported by Pedro Silva Dias (IAG-USP, Brazil) showed different frequencies and intensities according to the season, which implies a complete reorganization of the atmospheric circulation.

Bruno Turcq (IRD, France) presented lake-lavel records from Brazil and compared his results with Pedro Silva Dias' model reconstructions for the mid Holocene, when the change in insolation resulted in warmer winters and colder summers, weakened the Inter Tropical Convergence Zone and shifted the South Atlantic Convergence Zone northwards. This might have resulted in stronger cold air outbreaks at ca 6,000 yr BP.

A climate reconstruction for the last 2,000 years was presented by Ricardo Villalba (CRICYT, Mendoza, Argentina). Southern hemisphere tree ring records allowed reconstruction of pressure gradients between New Zealand and Chile and/or Australia and Chile, related to the Transpolar Index. Vera Markgraf (INSTAAR, Boulder, USA) presented records of lake-level and vegetation changes in Patagonia for the last 18,000 years. Finally Marie-Pierre Ledru (IRD-USP, Brazil) presented vegetation and lake-level records for three extreme paleoclimatic events, at 18,000, 13-12,000, and 11-10,000 ^{14}C yr BP. These events were interpreted as documenting a reorganization of air masses due to changes in the pole equator temperature gradient.

The primary outcomes of this workshop are: 1) the need to improve our understanding of the synoptic conditions that produce polar outbreaks at present; 2) the need to improve our understanding of how polar outbreaks affect seasonal climate patterns in South America; 3) the importance of comparing modern and paleoclimate data in order to better understand past climates and their hemispheric and interhemispheric climatic teleconnections; and 4) the relevance of teleconnections with the pacific warm pool area as a possible trigger for major readjustments in Southern Hemisphere atmospheric circulation. To continue the discussion, a second meeting will be held in São Paulo, Brazil, in 2003.

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Achieving Climate Predictability using Paleoclimate Data: Euroconference on Abrupt Climate Change Dynamics

CASTELVECCHIO PASCOLI, ITALY, 10-15 NOVEMBER 2001

What have we learned about abrupt climate change in the past decade and is this knowledge applicable to the future? What drives abrupt change, and how do other parts of the earth system respond to it? These, and other important questions were the focus of a Euresco Conference on Abrupt Climate Change Dynamics held at Castelvecchio Pascoli, Italy. The goals of the workshop were to summarize our current understanding of abrupt climate change dynamics in both glacial and interglacial intervals and to help guide future research efforts in the area.

A variety of presentations showed that local to regional ecosystem response to abrupt climate change is immediate and substantial. Of particular note were the presentations by Brigitta Ammann (Switzerland) and Brian Huntley (U.K.) showing rapid and large amplitude vegetation changes in central and southern Europe during the late Glacial in response to the large climatic changes of that period. These and other presentations clearly showed that vegetation is a dynamic component of the climate system in that it can respond on the same timescale as abrupt change and can also influence abrupt change.

Another important theme arising from the meeting was the nature of a muted Holocene millennial-scale climate oscillation. It is best developed in the North Atlantic as a record of enhanced southerly sea-ice drift as described by Bond et al. (1997). It appears that many records miss some or all of these oscillations due to their muted nature. Peter Fawcett (United States) presented a study detailing Holocene climatic oscillations from several different paleorecords from western North America that correlate strongly with each other, and with the North Atlantic record (Fig. 1). Mikhail Levitan (Russia) also presented a compelling record from the Laptev Sea for similar timing of Holocene cold events.

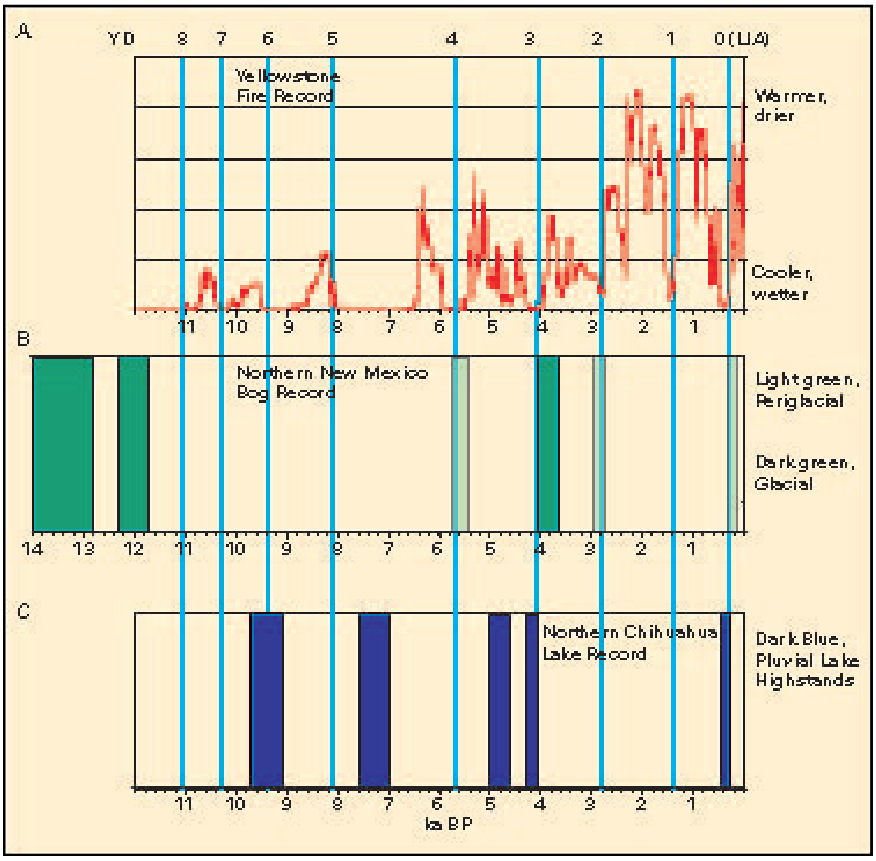

*Fig. 1: Three Holocene paleoclimate records from western North America displaying colder and wetter events that are synchronous with cooler climate episodes in the North Atlantic (Bond et al. 1997). **A**: Fire and alluvial record from Yellowstone National Park, Wyoming, adapted from Meyer et al. (1995). **B**: Glacial and periglacial record from a high-elevation bog core in northern New Mexico, adapted from Armour et al. (2002). **C**: Pluvial lake highstand record from northern Chihuahua, Mexico, adapted from Castiglia and Fawcett (2001). Blue lines and numbering represent ice-rafting episodes in the North Atlantic, adapted from Bond et al. (1997).*

Presentations by Jean-Claude Duplessy (France), Claude Hillaire-Marcel (Canada) and Jürgen Willebrand (Germany) highlighted the critical role of the oceans in abrupt climate change, especially in sensitive regions like the Labrador Sea and the North Atlantic. The ocean-climate link was also explored in detail through a variety of climate system model presentations (e.g. Thomas Stocker, Switzerland). Other presentations addressed issues of climate model variability and its relationship to natural variability (e.g. Andrey Ganopolski, Germany). All of these talks addressed in different ways the critical role of models in understanding the dynamics of abrupt climate change and the issue of future predictability. Sigfus Johnson (Denmark) discussed results from the new Greenland ice core, NGRIP, a highlight was the recognition of a large cooling event at 9.2 ka (calendar). Dominique Raynaud (France) discussed phasing of abrupt change at both poles during the late glacial and the Holocene and the role of methane and carbon dioxide in the system.

After discussion of the abrupt climate change events of the late Glacial and the Holocene, the focus switched to the last millennium. Heinz Wanner (Switzerland) discussed two changes: one that occurred during the middle part of the 19th century, and a significant change in variability in ENSO and the NAO that occurred during the mid 1970s.

The meeting was co-chaired by Jean-Claude Duplessy (France), Thomas Stocker (Switzerland) and Keith Alverson (Switzerland). The conference was held under the auspices of the CLIVAR and PAGES programs with funding provided by EURESCO and PAGES, which is gratefully acknowledged.

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Tree-rings and People - A "Pointer Year" for the Tree-ring Community?

Davos, Switzerland, 22-26 September 2001

"Pointer year" means a very unusual year when most trees within a large area form a particular ring, creating a distinct mark for crossdating and reconstructions. The year 2002 probably represents a "pointer year" for the international dendrochronological community. Indeed, in September 22-26, 2001, the members of this community met in Davos, Switzerland.

The general discussion was focused on the past achievements and future challenges for tree-ring research.

The main take-home messages from the talks given during the different sessions are the following: a) We need to better understand the physiology of wood formation, and to communicate these research results to forestry planners to increase the quality of forest products b)The enormous climatological potential contained in tree rings in archaeological remains is still underestimated, and c) better cooperation between archaeologists and climatologists is highly desirable.

More than twenty new reconstructions based on ring width, wood density and isotopic ratios were presented during this session. Other posters displayed studies of solar variability and of the influence of environmental factors such as elevation and continentality on tree growth.

New approaches revealed the potential of parts of trees usually neglected in climate reconstruction, such as roots and needles. Shrubs and even mosses were found to be potentially useful to dendrochronology.

A flowering application of dendrochronology is the use of tree-ring studies in forest ecology. Here, tree rings are used to detect the effect on the tree growth of aging, genetics, gender, as well as external non-climatic disturbances. Natural and anthropogenic disturbances like fire or hurricane frequency can also be studied.

Tree-ring studies may be used to reconstruct the past severity of pollution events in heavily-polluted areas. For example, heavy-metal air pollution in the Urals has an influence on rates of trunk decay. Proton Induced X-ray Emission was used in the Mexican basin to trace element content in tree-rings and soil samples. The historical trend in metal and monomeric lignin constituents from 1940s was studied in Aosta Valley, Italy. In contrast to the acidification processes ongoing in Central Europe, alcalisation is the most important problem in the industrial areas of Estonia, where reduced radial increment and high concentration of lignin is found in conifers growing in polluted areas.

37 violins made by Antonio Stradivari were dated using an Alpine spruce chronology. He discovered that on many occasions Stradivari used wood 4-5 years after felling. Martinelli reported an early medieval chronology from Venice, which reveals a maximum building activity in Venice during the second half of the 7 century AD. According to tree-ring data the Ljubljana Moor in Slovenia was inhabited in the 4th and the 3rd millennium BC.

Tree rings enable the past history of debris flows, landslides, thermokarst, ground instability, glaciers, rock glaciers, floods, river flows, coastal erosion, lake level, and even extra-terrestrial disturbance to be reconstructed. The availability of supra-long multi-millennia chronologies will hopefully enable soon a considerable extension of time frames covered by dendrogeomorphological records in many regions.

At the same time that traditional branches of tree-ring analysis are developing and numerous "side" branches are expanding, the use of tree-ring techniques, namely crossdating to develop charcoal or mollusk chronologies shows that the use of multiple proxies is both possible and fruitful. When will the link within different disciplines using different proxies and methods to study the Holocene become a reality? If it happens, the resolution of these new multi-proxy reconstructions based on carefully crossdated time series, and thereby our knowledge about past climatic conditions will be increased dramatically.

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CALENDAR 2002

May, 13 - June 1, 2002, Tucson, Arizona, USA:
Tucson Tree-Ring Summer School

Further information:
GEOS/ANTH/WS 497I/597I "Practical Dendroclimatology"
http://www.arizona.edu/newschedule/parse-schedule-new.cgi?GEOSz497Iz022
GEOS/ANTH/WS 497J/597J "Dendroarcheology"
http://www.arizona.edu/newschedule/parse-schedule-new.cgi?GEOSz497Jz022

May, 16 - 17, 2002, Moscow, Russia:
PAGES SSC meeting and Workshop on High Latitude Paleoenvironments

Further information:
Isabelle Larocque: larocque@pages.unibe.ch
http://www.pages-igbp.org/new_website/calendar/2002/moscow.html

May, 22 - 25, 2002, Rimouski, Quebec, Canada:
The Northern Environment, 36th Congress Canadian Meteorological and Oceanographic Society

Further information:
Special PAGES session on paleoclimate and paleoenvironments (contact: larocque@pages.unibe.ch)
http://scmo-cmos-2002.osl.gc.ca
François Roy: royf@dfo-mpo.gc.ca

June, 22 - 28, 2002,Tromso, Norway:
5th International INTIMATE (Integration of Ice-core, Marine and Terrestrial Records of the Last Termination) workshop

Further information:
Wim Hoek: w.hoek@geog.uu.nl
http://www,geog.uu.nl/fg/INTIMATE

June, 24 - 27, 2002, Stara Zagora, Bulgaria:
Cave Climate and Paleoclimate - Best Record of the Global Change

Further information:
Contact e-mail: YYShopov@Phys.Uni-Sofia.bg
http://www.seedot.com/uisws

July, 15 - 18, 2002, Madrid, Spain:
Quaternary Climatic Changes and Environmental Crises in the Mediterranean region

Further information:
Ana Vadeolmillos Rodriguez: climatic.changes@uah.es
http://www2.uah.es/qchange2002

http://www.pages-igbp.org/calendar/calendar.html