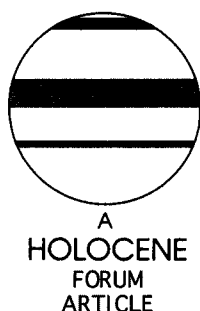


The International Tree-Ring Data Bank: an enhanced global database serving the global scientific community

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Manuscript accepted 1 September 1996



Abstract: The International Tree-Ring Data Bank (ITRDB) was established in 1974 to serve as a permanent repository for basic tree-ring data (measurements, chronologies, and derived reconstructions) developed and contributed by scientists from around the world. Housed at the World Data Center-A (WDC-A) for Paleoclimatology at the National Geophysical Data Center in Boulder, Colorado, USA, the ITRDB currently contains 3275 tree-ring chronologies and 2804 tree-ring measurement data sets from over 1500 sites, contributed by 139 researchers worldwide. These data sets represent information from over 100 tree and shrub species. As part of the WDC system, the ITRDB makes its holdings freely available to all scientists. The ITRDB is administered by an international Advisory Committee consisting of eight dendrochronologists representing different subdisciplines in the tree-ring sciences. The ITRDB also provides two additional important services: the creation and management of the ITRDB Dendrochronology Forum on the Internet, and development and distribution of a collection of computer programs for tree-ring analyses known as the ITRDB Program Library. Future efforts of the ITRDB will focus on increasing the worldwide coverage of its database holdings, and to make the ITRDB a more visible component in the scientific community.

Key words: International Tree-Ring Data Bank, ITRDB, tree-rings, dendrochronology, dendroclimatology, databases.

Introduction

Dendrochronology and its related subfields (e.g., dendroecology and dendroclimatology) have proven invaluable disciplines for investigating spatial and temporal aspects of processes in the earth sciences that operate at annual to centennial timescales. Dendrochronology is currently practised worldwide in laboratories at academic, government-funded and private institutions by nearly 1000 practitioners, which has resulted in the development of thousands of tree-ring chronologies from sites around the world. These data sets are increasingly being used to assess past changes in Holocene climate to place the global dynamics of present and future climate change in historical context. Recent, intensive efforts have focused on the development of millennium-length tree-ring chronologies to investigate not only short-term, intradecadal (<10 years) trends in past climate, but also longer-term, centennial scale (>100 years) secular trends (Brown *et al.*, 1992; Cook *et al.*, 1992; Lara and Villalba, 1993; Grissino-Mayer, 1995). Spatial networks or grids of tree-ring chronologies have been or are currently being developed to provide information about past climate on regional and global spatial scales (Fritts,

1991; Schweingruber *et al.*, 1991; Meko *et al.*, 1993). These efforts allow researchers to (1) develop and test new hypotheses that investigate the effects changes in regional and global-scale atmospheric circulation processes could have on human behaviour, pattern, adaptation and response, and (2) place current changes in global climate processes, often attributed to anthropogenic influences, in context with previous changes in past climate.

The rapid development of large numbers of tree-ring chronologies across the globe was addressed by dendrochronologists attending a workshop in 1974, who subsequently established the International Tree-Ring Data Bank (ITRDB), a professional organization that provides the only central repository for all types of dendrochronological data from around the world. For years, the ITRDB operated exclusively as a 'grass roots' organization, largely dependent on the time and efforts of volunteers. Modest funding was supplied by the United States National Science Foundation as a supplement to research support for Dr Harold C. Fritts, the founder of the ITRDB, at the Laboratory of Tree-Ring Research, The University of Arizona. In 1990, the Paleoclimatology Program of the National Oceanic and Atmospheric Administration (NOAA) took over the operation of the ITRDB with the

establishment of the World Data Center-A for Paleoclimatology at the National Geophysical Data Center (NGDC) in Boulder, Colorado, USA. This center houses many different types of palaeoclimatic data, such as ice core, sedimentary, tree-ring, palaeobiological, pollen and documentary data. With continued support from the Paleoclimatology Program, the ITRDB has established itself firmly in the scientific community as one of the premier palaeoclimatic databases.

Purpose of the ITRDB

The primary purpose for the ITRDB is to provide a permanent location for the storage of well-dated, high-quality dendrochronological data from around the world. This central repository protects data from loss due to: (1) mishandling of tree-ring data; (2) the relocation or termination of laboratories; (3) scientists who move to other projects or retire; or (4) the death of scientists. Besides providing secure storage of the original basic tree-ring information (the actual dated measurements and derived chronologies), the ITRDB is also an increasingly valuable archive of well-dated baseline information on the world's oldest trees, thus providing environmental information before anthropogenic changes became pervasive. As more forests are harvested or restructured due to human intervention, the information in such a database could provide the only surviving long-term record from some of the world's more threatened regions. Such information may be critical for evaluating anthropogenically induced climatic change, its magnitude and extent, as well as for reconstructing past climates. Thus, expansion and maintenance of the basic tree-ring data housed in the ITRDB could well assume a greater importance in the coming years.

Requirements of tree-ring data submitted to the ITRDB

Tree-ring data submitted to the ITRDB must meet certain requirements before assimilation into the holdings. First, each tree-ring chronology must have been developed from at least ten trees. Second, the minimum length of the final chronology should be at least 100 years. Third, the ITRDB requests contributions of the original tree-ring measurements used to develop the final master chronologies. We make this request to ensure that original measurements are available in the future should new methods and techniques be developed. Fourth, it is expected that the series have undergone intense scrutiny by the principal investigator to ensure all individual series are correctly cross-dated, and that errors during measurement have been minimized. Finally, all necessary documentation must be delivered to the ITRDB (for example, all site data or information on publications that used the data) to ensure that as much information is archived as possible. Under special circumstances, these requirements can be waived when samples are too few and scarce (as, for example, with archaeological tree-ring material), or when the data were developed for extremely detailed analyses (as, for example, in stem-growth analyses).

Recently, the ITRDB completed a massive, two-year quality-control assessment of its holdings of raw measurement data sets for nearly 1400 sites. This assessment was necessary to ensure that (1) all data files were completely and accurately documented, (2) all data files were in standard Decadal (measurement) and Index (chronology) formats, and (3) all individual series were accurately cross-dated. Using a modified version of the computer program COFECHA (Holmes, 1983), results of the cross-dating accuracy tests were output to separate text files that will provide

nondendrochronologists with an impartial assessment of the quality of the data sets. These text files are now included in the holdings of the ITRDB. The ITRDB is currently developing guidelines for cross-dating accuracy to be used by NOAA personnel, and will soon be confirming the accuracy of cross-dating for all new contributions.

Holdings of the ITRDB

Currently, the ITRDB contains over 6000 data sets, including 2804 raw measurement files, 3275 tree-ring chronologies and numerous climate reconstructions derived from these tree-ring data. These data were collected from over 1500 sites around the world representing over 100 tree and shrub species. All final chronology files contain necessary site information and documentation, such as location (site name, state/province, country, latitude and longitude), elevation, species analysed, specific site characteristics, source of materials (living trees, historical sites), number of trees sampled, type of samples (cores, cross-sections), type and unit of measurement, general chronology statistics (if submitted) and names of the principal investigators. The contribution of separate text files containing even more detailed information is especially encouraged. The tree-ring measurements represent mostly total ring widths, but numerous data sets consist of earlywood and latewood widths, as well as minimum earlywood and maximum latewood densities, and new ring characteristics have been contributed derived from digital image analyses.

As part of the World Data Center system, the ITRDB makes its holdings freely available to any and all researchers. It is more important to stress that the collective data are shared around the world when they are submitted to the ITRDB. All newly contributed tree-ring data are archived by personnel at the National Geophysical Data Center in Boulder, Colorado. Membership in the ITRDB is automatic for those individuals and institutions that contribute dendrochronological data. Currently, the ITRDB has 139 members from 21 countries: Argentina, Australia, Belgium, Canada, the Czech Republic, Finland, France, Germany, Italy, Japan, Lithuania, Mexico, the Netherlands, New Zealand, Poland, Russia, Slovenia, Sweden, Switzerland, the United Kingdom, and the United States.

Obtaining the ITRDB holdings

To encourage contributions, contributors will receive free the entire holdings of over 3300 standardized tree-ring chronologies in the ITRDB, and a user-friendly program for display and retrieval of the tree-ring information. These can be obtained on diskette by contacting the Data Manager of the ITRDB: Bruce Bauer, Paleoclimate Program, NOAA/NGDC, 325 Broadway E/GC, Boulder, CO 80303 USA (303-497-6280), e-mail: bab@mail.ngdc.noaa.gov.

In addition, all data in the holdings of the ITRDB can be assessed by using anonymous ftp ('file transfer protocol'), connecting to this address: ftp.ngdc.noaa.gov, and changing to the /paleo/treering subdirectory on the NGDC server. Detailed information for retrieving data from the ITRDB is also available on the World Wide Web at <http://www.ltr.arizona.edu/people/henri/resource.htm> or through the NOAA Paleoclimatology Program Tree-Ring Page at <http://www.ngdc.noaa.gov/paleo/treering.html>. The holdings of the ITRDB can be searched by connecting to <http://www.ngdc.noaa.gov/paleo/ftp-treering.html>. Once the search is completed, one or all of the chronology files can be downloaded automatically to your own computer.

Administration of the ITRDB

An Advisory Committee of dendrochronologists administers the ITRDB and consists of a chairperson and individuals selected from its members. In 1994, committee membership was expanded to provide a wider geographic coverage among dendrochronologists, and to also provide representation for the numerous subdisciplines within the science. This Advisory Committee assures that the ITRDB keeps pace with new developments in dendrochronology, and has the special function of reporting annually to NOAA on the functioning of the organization. Current committee members are as follows.

Sylvain Archambault, Centre d'études nordiques, Université Laval, Québec, Canada (*climate, ecology*)

Edward R. Cook, Tree-Ring Research Laboratory, Lamont-Doherty Earth Observatory, Columbia University, Palisades, New York, USA (*climate, ecology, methods*)

Henri D. Grissino-Mayer, Laboratory of Tree-Ring Research, The University of Arizona, Tucson, Arizona, USA (*climate, ecology*)

Esther Jansma, Dutch Centre of Archaeological Dendrochronology, State Department of Archaeology, Amersfoort, The Netherlands (*archaeology, methods*)

Jonathan G. Palmer, Lincoln University, Plant Science Department, Canterbury, New Zealand (*climate, ecology*)

Fritz H. Schweingruber, Swiss Federal Institute of Forestry Research, Birmensdorf ZH, Switzerland (*climate, ecology, methods*)

Stepan G. Shiyatov, Institute of Plant and Animal Ecology, Ural Division of Russian Academy of Sciences, Ekaterinburg, Russia [through 1997] (*climate, ecology, methods*)

David W. Stahle, Tree-Ring Laboratory, Department of Geography, The University of Arkansas, Fayetteville, Arkansas, USA (*climate, ecology*)

Ricardo Villalba, Laboratorio de Dendrocronologia, CRICYT-Mendoza, Mendoza, Argentina (*climate, ecology*)

The ITRDB dendrochronology forum on the Internet

An Internet forum for dendrochronology (ITRDBFOR) has been sponsored by the ITRDB since 1988 as part of the ITRDB mission to foster communication among dendrochronologists worldwide, and to help and advise those collecting and developing tree-ring data. Currently, over 500 scientists from over 50 countries subscribe to the forum. Anyone interested in dendrochronology can join and participate in the forum, and benefit from discussions concerning important issues confronting dendrochronologists. For example, the forum is used to:

- discuss current issues relevant to tree-ring research, such as cross-dating procedures and available tree-ring software
- announce upcoming meetings dendrochronologists may wish to attend
- announce the publication of articles and books relevant to dendrochronology
- announce and acknowledge recent contributors of tree-ring data to the holdings of the ITRDB
- foster communication with other members of the forum to help establish new research initiatives
- announce news items that other scientists may find useful.

To join the ITRDBFOR, send the command 'subscribe itrdbfor <your first name> <your last name>' as one line of text in the mail message (please omit the brackets) to the following address: LISTSERV@LISTSERV.ARIZONA.EDU. New participants are

encouraged to submit a short, one-paragraph outline of interests and current research to inform members who may have similar interests. Messages sent to the forum are automatically routed to the entire membership. The address for the forum is: ITRDBFOR@LISTSERV.ARIZONA.EDU. Be forewarned that *any* message sent to this address is automatically sent to over 500 scientists worldwide, so personal messages should never be sent via this address. Participation on the forum is optional, but is more useful if a large number of researchers actively contribute. The ITRDB forum is managed by Henri D. Grissino-Mayer and Martin A.R. Munro of the Laboratory of Tree-Ring Research at The University of Arizona in Tucson, Arizona. More information on the ITRDB forum can be found on the World Wide Web at <http://www.ltrr.arizona.edu/people/henri/forum.htm>.

The ITRDB program library

The ITRDB also provides at no charge a library of computer programs specifically designed to develop standardized tree-ring index chronologies from raw tree-ring measurement data. The ITRDB Program Library Version 2.1 is for use on IBM-compatible personal computers, and includes the following programs:

- DPL, the Dendrochronology Program Library developed by Richard L. Holmes, which contains the highly acclaimed quality-control program, COFECHA
- MEDIR, a measurement program originally created by Paul J. Krusic and later revised by Richard L. Holmes, designed for use with Velmex[®] measuring systems
- ARSTAN, the widely used standardization program developed by Edward R. Cook that creates standard, residual and Arstan chronologies
- ITRVIEW, a program created by Thierry Varem-Sanders for graphically displaying tree-ring measurement and chronology data
- CONVERT5 (Henri D. Grissino-Mayer) and CORING (Oriol Bosch), programs capable of converting files to and from Trims, Catras and Decadal formats
- VERIFY5 (Henri D. Grissino-Mayer), a program that performs independent quality-control checks on raw measurement data.

Full documentation is provided for all programs on the diskette, and online help is available from within all individual programs. In addition, the Program Library comes with two databases: an address database of over 900 researchers and laboratories around the world practising dendrochronology, and a species database that contains information on over 500 dendrochronologically studied or useful tree and shrub species, including their scientific names, common names, and standard four character ITRDB species codes. Detailed information about the Library can be found at <http://www.ltrr.arizona.edu/people/henri/software.htm>.

By providing the ITRDB data, retrieval and display software, and the Program Library in return for contributions to the ITRDB, we and the WDC-A hope that response will be an increase in submissions of chronologies and measurements to the ITRDB. Indirectly, we hope this encourages more cooperation not only between dendrochronologists and the WDC-A but also among dendrochronologists around the world.

The future of the ITRDB

The primary purpose of the ITRDB is to assimilate tree-ring measurement and chronology data into a central location for permanent archiving. In the past, solicitation efforts concentrated on tree-ring data useful for climate reconstruction purposes. As scientists applied tree-ring data to more and more different types of

studies, however, the ITRDB realized this view was too narrow – tree-ring data developed for nonclimatic purposes were being overlooked. The ITRDB has since relaxed this requirement to allow contributions of all types of tree-ring data. New data types that have been or will be assimilated include: (1) isotopic measurements of hydrogen, carbon and oxygen; (2) information on cellular structure (e.g., cell-wall thickness and cell-wall area measurements); (3) data from stem analyses; (4) data gathered from image analyses; and (5) data from event chronologies (e.g., frost-ring chronologies). Tree-ring chronologies developed for reconstructions of disturbance regimes (for example, spruce budworm outbreaks) will also be included in the holdings of the ITRDB. These data files should have special text files included that discuss the unique nature of the study for which these data were developed. The ITRDB will also increase its solicitation for actual climate reconstruction developed from tree-ring data.

Another major goal of the ITRDB is to increase awareness among dendrochronologists concerning the role of the ITRDB in its relationship with the World Data Center system and the International Council of Scientific Unions (ICSU). We would like to clarify to the worldwide dendrochronological community the guidelines established for the WDCs, and how these guidelines apply to the ITRDB and to the availability of tree-ring data. In the coming years, the Advisory Committee of the ITRDB will begin developing preliminary guidelines for the ITRDB that clearly state its mission and purpose, responsibilities, requirements, and policies regarding data submission and distribution. Hopefully, these guidelines will be published in a future edition of the *Guide to the World Data Center System* by the ICSU. We feel this is a critically important step to facilitating the steady flow of tree-ring data to the ITRDB and the WDC-A for Paleoclimatology. The proposed improvements to the ITRDB will initiate and facilitate processes that will lead to mutually agreeable guidelines representing the consensus of dendrochronologists worldwide.

Acknowledgements

The ITRDB graciously thanks those who, over the years, provided continuous support for our efforts by contributing their valuable tree-ring data, which will serve generations of future researchers

in years to come. We especially thank Richard Holmes for his continuous involvement with development of the ITRDB Program Library, often on his own time, and for his steadfast support for the ITRDB mission. Special thanks to Mariette Seklecki who laboriously executed nearly 2000 runs of COFECHA, and prepared all documentation and computer files during the quality-control assessment. Generous support for the ITRDB database efforts was supplied for many years by the Paleoclimatology Program of the National Oceanic and Atmospheric Administration, and to them we are very grateful. Finally, we would be remiss if we did not acknowledge the longstanding and continued support of the Laboratory of Tree-Ring Research, The University of Arizona, since the inception of the ITRDB. The ITRDB would not have survived these many years without this backing, and the Laboratory has played and continues to play a significant part through supporting facilities, faculty salaries and other personnel time for many different aspects of this undertaking.

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