ACADEMIC PROGRAM REVIEW

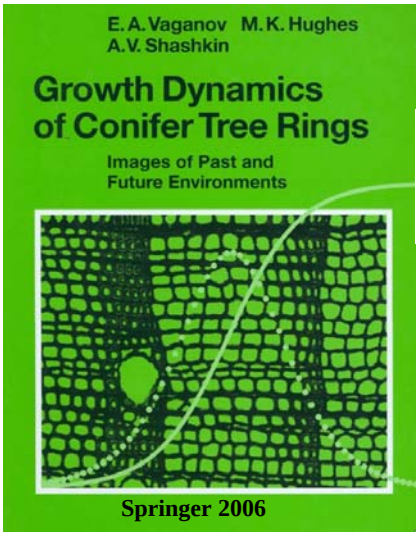
SELF-STUDY REPORT

2000-2006

LABORATORY OF TREE-RING RESEARCH

THE UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

January 2007



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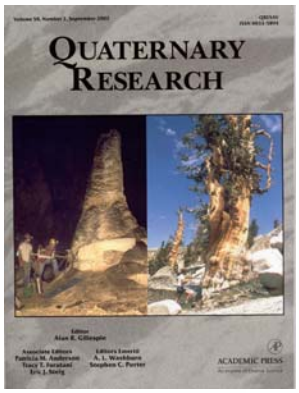
Journal of Hydrology 308 (2005) 196–213
Journal of Hydrology

Tree-ring footprint of joint hydrologic drought in Sacramento and Upper Colorado river basins, western USA

David M. Meko[a,*], Connie A. Woodhouse[b,1]



GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L04705, doi:10.1029/2005GL025050, 2006

Forward modeling of regional scale tree-ring patterns in the southeastern United States and the recent influence of summer drought

K. J. Anchukaitis,[1,2] M. N. Evans,[1,2,3] A. Kaplan,[4] E. A. Vaganov,[5] M. K. Hughes,[1] H. D. Grissino-Mayer,[6] and M. A. Cane[4]

RADIOCARBON, Vol 48, Nr 2, 2006, p 205–217

CLIMATE IN THE GREAT LAKES REGION BETWEEN 14,000 AND 4000 YEARS AGO FROM ISOTOPIC COMPOSITION OF CONIFER WOOD

Steven W Leavitt[1,2] • Irina P Panyushkina[1] • Todd Lange[3] • Alex Wiedenhoeft[4] • Li Cheng[1] • R Douglas Hunter[5] • John Hughes[6] • Frank Pranschke[7] • Allan F Schneider[8] • Joseph Moran[9] • Ron Stieglitz[9]

FREQUENCY-DEPENDENT CLIMATE SIGNAL IN UPPER AND LOWER FOREST BORDER TREE RINGS IN THE MOUNTAINS OF THE GREAT BASIN

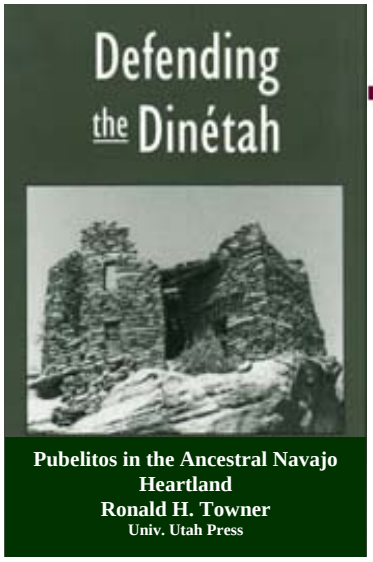
MALCOLM K. HUGHES and GARY FUNKHOUSER
Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ 85721, U.S.A.

Climatic Change **59:** 233–244, 2003.

Climate Dynamics (2004) 23: 869–881
DOI 10.1007/s00382-004-0473-2

P. R. Sheppard · P. E. Tarasov · L. J. Graumlich
K.-U. Heussner · M. Wagner · H. Österle
L. G. Thompson

Annual precipitation since 515 BC reconstructed from living and fossil juniper growth of northeastern Qinghai Province, China

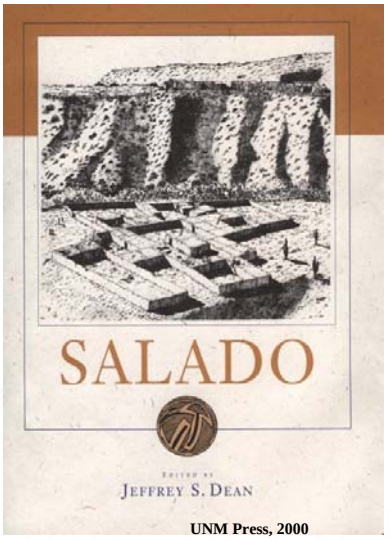


PNAS
Proceedings of the National Academy of Sciences of the United States of America www.pnas.org

Strontium isotopes reveal distant sources of architectural timber in Chaco Canyon, New Mexico

Nathan B. English*†, Julio L. Betancourt‡, Jeffrey S. Dean§, and Jay Quade¶

PNAS | October 9, 2001 | vol. 98 | no. 21 | 11891–11896



WATER RESOURCES RESEARCH, VOL. 37, NO. 5, PAGES 1405–1416, MAY 2001

Regional variations in small-basin floods in the United States

Jené D. Michaud
Department of Geology, University of Hawaii at Hilo

Katherine K. Hirschboeck
Laboratory of Tree-Ring Research, University of Arizona, Tucson

Michael Winchell
Northeast River Forecast Center, National Weather Service

Climate Dynamics (2005) 25: 75–98
DOI 10.1007/s00382-005-0016-5

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Reconstructions of spring/summer precipitation for the Eastern Mediterranean from tree-ring widths and its connection to large-scale atmospheric circulation

Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

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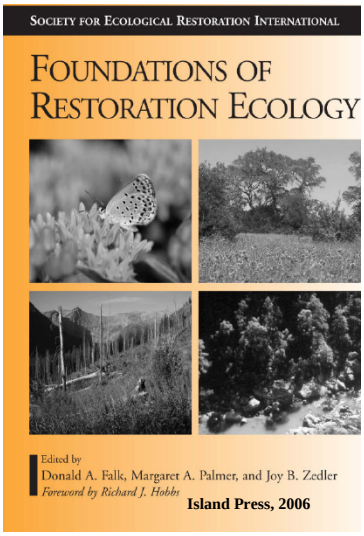
Journal for Nature Conservation
www.elsevier.de/jnc

Process-centred restoration in a fire-adapted ponderosa pine forest

Donald A. Falk*

Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ 85721, USA



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INTRODUCTION AND SUMMARY

This report is the product of a self-study carried out by the faculty and staff of the Laboratory of Tree-Ring Research (LTRR) at The University of Arizona (U of A) during the fall of 2006 and early January 2007. We summarize its main points here, with cross-reference to specific sections in the main report given in parentheses.

Achievements

- LTRR is a vibrant research entity, identifying new research questions, developing new techniques, and making significant contributions in diverse fields of science. Faculty, staff and student achievements have been particularly notable in recent studies of climate change, water resources, forest fire ecology, and human-environment interactions. We have also made advances in understanding the fundamental environmental controls of the formation, structure and composition of tree rings. In addition to increased topical breadth, we have recently pioneered tree-ring applications in new or little-worked regions (e.g., the Middle East, northern Africa, parts of Russia and the Far East, Central and South America, and elsewhere) and time periods (e.g. the early Holocene and late Pleistocene). Building on seven decades of achievement and international recognition, the LTRR's continuing high scientific productivity and impact demonstrates great potential for future innovation and growth. **(see sections A, B & F)**
- LTRR has expanded and diversified its teaching of undergraduate and graduate students since the late 1990s. Faculty members have participated in the Undergraduate General Education Program, developed new, multidisciplinary graduate courses, and served as leaders in Graduate Interdisciplinary Programs and the IGERT Program in Archaeological Sciences. Two faculty members have been recognized for excellence in teaching by College and University-level awards. Training programs for visiting scientists and students from other Universities have also strengthened LTRR's role as the foremost global center of basic and advanced education in dendrochronology and its applications. **(see section G)**
- LTRR sponsors extensive outreach programs to serve the growing public interest in tree rings, environment and human history. Locally, we host over 3,000 tour visitors and contacts with K-12 students annually, an endeavor constrained only by staff and faculty time. LTRR faculty members serve on many panels and advisory boards for professional societies and governmental organizations. LTRR is a highly visible unit of the U of A, frequently appearing in local, national and international print and television media in coverage of our research findings that are of broad public interest and societal relevance. (**see section H)**

Resources

- Expansion of our research and teaching programs has been achieved by recruiting two junior faculty members in 2001 and supporting their endeavors, by encouraging and supporting PhD staff members and post-docs, to develop grant-funded research programs as principal investigators, and by sustaining the creativity and productivity of senior faculty members. (**see section A.3.3)**
- Decreased staff support and declining operational resources as a consequence of University-wide budget cuts during 5 of the past 7 years (about 10% cumulative reduction of our state budget since 2002) have created strains and limitations on our research, teaching and outreach programs. The loss of staff lines because of budget cuts has decreased our capacity to maintain some central programs, particularly research involving basic tree-ring dating, advanced tree-ring measurements, and archival management. (**see section J.1**)
- Most of LTRR's offices, laboratories and wood archives are housed in dilapidated and crowded quarters (the West Stadium) that are substandard and inadequate in many ways. This is an impediment to growth and pursuit of research opportunities and threatens faculty retention and future recruitment of new faculty members or a new director. Incoming faculty and new federal collaborations (a recently arrived, joint-

appointed faculty member with Geography & Regional Development department, and a U.S. Forest Service scientist) increase the need for more and improved space accommodations in the very near future (i.e., in 2007 and 2008). (s**ee section J.2 & J.4**)

Plans and Strategies for Seizing Opportunities and Overcoming Weakness and Limitations

- Planned major research foci include: Long and ancient tree-ring chronology development (including wood from geological contexts); environmental sciences and human health; paleoclimatology and climate variability (including multi-proxy/multi-archive data and analyses); forest dynamics and fire ecology; water resources in semi-arid systems; and human-environment interactions. Two new generous endowments in Archaeological Dendrochronology will be employed to strengthen and increase the number of full-time faculty and graduate students in this topical area. **(see section D.5)**
- We will strive to attract and support beginning scientists as post-docs and graduate students via external grants, and with endowments (e.g., Archaeological Dendrochronology) and training programs. Promising post-docs who develop self-supporting, collaborative research programs may be encouraged to remain at LTRR to the degree that accommodations are available.
- LTRR will pursue the establishment of a graduate/professional Certificate in Dendrochronology which will allow us to offer degree-related certification in tree-ring coursework – an opportunity not available at any other institution. This formalization of our curriculum will enhance the recruitment of graduate students and provide a formal training mechanism for post-docs, professional scientists and other short-term visitors to the LTRR. **(see section G.7)**
- We will continue development of collaborations with federal scientists, including co-locating one federal scientist in LTRR space in 2007, and perhaps additional federal scientists in the future, so far as quality and quantity of space permits.
- If faculty lines become available through retirements or departures, we will seek to re-fill them immediately, and use these opportunities to expand in emerging areas of scientific importance. We identify several areas of expertise currently lacking or needing strengthening, including functional wood anatomy, archaeological dendrochronology, and spatial-analytical and modeling capabilities in climate and/or ecological dynamics. **(see sections D.2.3, D.2.4, & D.5)**
- We will urge the University to rapidly renovate the newly available space in the West Stadium in 2007. This new space (approximately 8,000 usable square feet) will be a significant improvement in our accommodations, but is not a long-term solution to our space needs. We need the University's support in securing new permanent accommodation for the whole laboratory, so long promised but still not delivered, and for our parallel efforts to identify new opportunities for constructing an archive building for LTRR. (s**ee sections J.2 & J.4**)

A. PROGRAM DESCRIPTION AND GOALS

A.1. Description of Unit

The Laboratory of Tree-Ring Research (LTRR) was established in 1937 and is an independent department within the College of Science. LTRR has long-standing preeminence in dendrochronology, a field founded by LTRR's first Director, Andrew Ellicott Douglass. LTRR is also unique as the oldest and largest tree-ring research laboratory in the world, a circumstance with which the University of Arizona has long been proud to be associated. The national and international renown of LTRR derives from its extensive academic contributions in research, teaching, and service. This status was achieved long before most of our present non-emeritus faculty arrived here, but accomplishments in recent years have strengthened and expanded the role of LTRR as a global leader and center of excellence in multiple applications of dendrochronology. Key areas of research and teaching emphases that have increased the fame of LTRR and its impact on science and society in recent years include studies of regional and global climate change, reconstructions of historic river flow levels, and the effects of climate and land-use history on forest fires. LTRR's reputation derives both from research excellence in these topics and from their increasing importance in an era of global change. LTRR faculty and staff have also continued a long tradition of leadership and excellence in archaeological applications of tree rings, and a new endowed chair and graduate fellowship program promises to further enhance this strength in the future.

The continuing and projected strength of LTRR is a product of the extensive interdisciplinary and multidisciplinary research in which we engage. LTRR faculty and staff come from a wide variety of backgrounds and bring a broad spectrum of expertise to bear upon research and teaching challenges. Our diversity of expertise and status as an independent department provide creative opportunities and freedoms for faculty to cross traditional disciplinary boundaries that often confine academic departments. The world's largest concentration of tree-ring scientists in one institution (currently numbering 62 people, including 18 full time faculty and staff) provides the critical mass necessary to engage and fully exploit the phenomenon of annual growth rings of trees.

The primary mission of the Laboratory of Tree-Ring Research is to remain in the forefront of world dendrochronology through the use of tree rings as natural chronometers and recorders of change in the environment with which human society is inescapably linked. The Laboratory makes significant contributions to understanding natural environmental variability in climatic, hydrologic, geomorphic, and ecological systems. A parallel and equally important focus of Laboratory activities is the interpretation of that variability in terms of the interactions of humans and their environments, both in the past in archeological contexts, and in modern landscapes.

The twelve core faculty members of LTRR are listed below along with their primary areas of research and dates of joining LTRR as a faculty member or principal investigator. More details on their backgrounds and interests are included in short curriculum vitae in **Appendix A**, brief statements of research interests are in section **F.2.**, and full curriculum vitae are in **Appendix B**:

Dr. Jeffrey S. Dean, Professor – archaeology; 1967
Dr. **Michael Evans, Assistant Professor** – paleoclimatology; 2001
Dr. **Donald A. Falk, Adjunct Associate Professor** – dendroecology, restoration and fire ecology; 2004
Dr. Katherine K. Hirschboeck, Associate Professor – hydroclimatology and synoptic climatology; 1991
Dr. Malcolm K. Hughes, Professor – paleoclimatology, tree-ring measurements and models; 1986
Dr. Steven W. Leavitt, Professor – stable-isotope geochemistry; 1990
Dr. **David M. Meko, Associate Research Professor** – paleohydrology; 1988

Dr. Irina Panyushkina, Adjunct Assistant Professor – paleoclimatology; archaeology; 2002
Dr. Paul R. Sheppard, Assistant Professor – geomorphology; 2001
Dr. Thomas W. Swetnam, Professor and Director – forest disturbance ecology; 1987
Dr. Ramzi Touchan, Associate Research Professor, paleoclimatology; 1997
Dr. Ronald Towner, Adjunct Assistant Professor – archaeology; 1998

State-funded scientific staff, their primary areas of responsibility and research emphases, and date of joining LTRR are listed below. Summary descriptions of their training and experience are included in section **E**.

Mr. Rex Adams, Research Specialist, Senior – outreach, laboratory teaching, collections management, archaeology; 1981
Mr. Christopher H. Baisan, Research Specialist, Senior – laboratory teaching, field collections, dendrochronological dating, fire history; 1986
Mr. James A. Fairchild-Parks, Research Specialist – archaeological dating; 1999
Dr. Martin A. R. Munro, Research Specialist, Senior – computer and network support, tree-ring measurement and image analysis; 1991
Mr. Richard L. Warren, Research Associate – archaeological dating, general dating quality control; 1964

A.2. Academic Program Being Reviewed

LTRR is somewhat unique in that it neither offers courses with LTRR as the home department nor has its own academic programs leading to specialized degrees. However, LTRR contributes significantly to teaching and academic programs in the University. LTRR faculty members teach tree-ring classes with home departments in Geosciences, School of Natural Resources, and Anthropology (and cross-listings soon to be added in Geography & Regional Development). The general education global change classes that we teach have a home in the University-wide Tier I, NATS-101 class grouping, and we also teach a popular Tier II 200-level course listed in Geosciences (GEOS 220). The graduate-level global change classes that we teach have their homes in Geosciences, Hydrology and Water Resources, Geography & Regional Development, and Global Change, an Interdisciplinary Program for a Ph.D. Minor.

Many LTRR faculty members have adjunct and joint-appointment affiliations with other departments. These appointments facilitate graduate student mentoring by LTRR faculty, and for some joint appointments they represent more extensive participation in activities of the other departments. Multidisciplinary and interdisciplinary research specialties have qualified LTRR faculty for extensive service on the graduate committees of students from many departments, including Geosciences, School of Natural Resources, Anthropology, Geography and Regional Development, Atmospheric Sciences, Ecology and Evolutionary Biology, Arid Lands Studies, Soil Water and Environmental Science, and Hydrology and Water Resources. In many cases this has been in the role as primary research advisor where LTRR has been the source of student monetary support, usually where tree-ring methods and applications are an essential part of the thesis research. LTRR faculty have served as chairpersons on 22 Ph.D. dissertation research committees and 9 M.S./M.A. thesis committees since 1999.

A.3. Major Goals and Changes in the Past 7 Years, and Future Changes

The Arizona Board of Regents established the Laboratory of Tree-Ring Research in 1937 "to promote teaching and research in dendrochronology". The Laboratory maintains and enhances its distinction by the pursuit of each of its main goals with creativity and vigor. These goals include:

- ***The development of new techniques for using tree rings based on improved mechanistic understanding of ring formation.***

- ***The application of these techniques to a wide range of scientific inquiry (e.g. global change, climatology, hydrology, anthropology, archaeology, forest ecology, tree physiology, Quaternary studies, geomorphology, geophysics, geochemistry, public health).***
- ***The provision of education and training through the world's most extensive curriculum in dendrochronology, including extensive training of scientific visitors from around the world.***
- ***The development and implementation of interdisciplinary undergraduate and graduate courses.***
- ***The curation and utilization of our large, internationally diverse and unique sample collection that is a world-heritage resource of great value for current and future research.***

In line with the above goals, LTRR plays an important role in (1) contributing to undergraduate, graduate and professional instruction, (2) engaging in basic and applied research of national and international importance, (3) creating, collecting, preserving and disseminating knowledge, and (4) seeking to bring advances in scholarship into everyday life, including that of our students.

In recent decades, LTRR success has changed the landscape in which the Laboratory operates. Other laboratories engaged in tree-ring studies are now established elsewhere in the U.S. and around the world. In many cases they are staffed by former students of LTRR or by scientists who have drawn much of their initial inspiration from LTRR. A worldwide network of tree-ring scientists and tree-ring laboratories has grown up and been intellectually nurtured by LTRR. This provides an increasingly challenging context for us with respect to maintaining leadership and in competing for funds, but it offers many more opportunities for worldwide collaborations. A continuing strength of LTRR in a global context is our unmatched breadth and depth of expertise in multiple fields of dendrochronological applications, ranging from climatology and geology to ecology and archaeology. Our diversity and high quality of disciplinary expertise fosters the evolving role of LTRR as both a center for training and education in dendrochronology as well as an incubator of research applications and innovations. **Additionally, synergistic University strengths in the broadly defined environmental sciences contribute to the status of LTRR as the best place in the world to study and apply dendrochronology.**

During the past decade, LTRR teaching and research goals have emphasized interdisciplinary applications of dendrochronology in a very broad range of sciences. Dendrochronological applications provide reference conditions and estimates of historical variability needed for assessing the impacts of past and future environmental fluctuations on ecosystems and humanity. More fundamentally, tree-ring research provides long-term data for evaluating and improving our understanding of climate, ecosystem, and human social dynamics. Among other uses, the insights provided are particularly useful for stimulating and informing the development and validation of models for predicting future changes. Several examples of recent LTRR involvement in major interdisciplinary applications of dendrochronology with important societal impacts are described below. Other new developments since the 1999 APR are also described, including new faculty members.

A.3.1. Global Change

Interdisciplinary applications of dendrochronology have met new challenges in archaeology, ecology, and environmental studies, particularly those of quantifying and understanding past global change. LTRR scientists have participated in numerous national global change research programs (e.g., NSF, NOAA, USDI, USDA, and NASA) and international programs (e.g., the International Geosphere-Biosphere program, its PAGES program and PEP project, and the Intergovernmental Panel on Climate Change [IPCC] assessment reports). In addition to conducting original research, LTRR scientists have led and organized some of these research programs. This involvement has had several direct benefits to teaching. For example, numerous graduate and undergraduate students have conducted global change-related and funded research. LTRR faculty have led in developing and teaching graduate and undergraduate global change courses and

establishing the Global Change interdisciplinary academic program at the University of Arizona. This educational involvement has grown directly from faculty engagement in the underlying research and in the national and international efforts to promote it and to evaluate and disseminate its results. This research involvement in questions of great public concern has also provided opportunities for outreach through the local, national and international news media, and in the recent highly successful College of Science public lecture series on Global Climate Change which attracted audiences of 800-1200 on seven successive Tuesday evenings. This lecture series will be repeated in the Phoenix area in 2007.
(Videos of the lectures are posted at: http://podcasting.arizona.edu/globalclimatechange.html).

A.3.2. Natural Resources and Water Resources

The importance and utility of information on the historical variability of past environments has also recently been emphasized by resource management agencies throughout the nation. For example, land managers have recognized, that both natural and cultural factors are involved in increasingly destructive wildfires and insect outbreaks in the mountain West, and that understanding the causes of these problems requires long-term, historical perspectives. In the context of recent extreme droughts and declining reservoir levels, water resource managers have also sought more information about long-term variability and trends in water supply. This information is needed for accurately modeling and anticipating future surpluses and deficits. In recent years, LTRR faculty, staff and students have expanded the contributions of dendrochronology in providing these historical perspectives of climatic, ecological, and cultural changes. A crosscutting theme of both global change research and these applications for resource management is the recognized importance of reconstructing and studying long-term variability and dynamics of complex systems.

A.3.3. New Faculty

A number of additions to the LTRR faculty have occurred in the past seven years (since our 1999 APR). These additions have contributed very substantially to new initiatives in research and teaching at LTRR. Outcomes of these faculty changes include expanded topics and geographic areas of research as well as new collaborations with federal and state entities. The new faculty and some of their recent contributions include:

Two new, tenure track faculty were recruited following national/international searches – Dr. Michael Evans and Dr. Paul Sheppard. Both are assistant professors who are now being considered for promotion to associate professor in 2007.

- Dr. Evans is a paleoclimatologist with expertise in quantitative spatial analytical techniques, modeling, and the use of state-of-the-art mass spectroscopy for isotopic studies in climate reconstruction. Among other projects, he is measuring and studying isotopic carbon and oxygen in tropical tree rings. This work has the exciting potential of making breakthroughs in tropical dendrochronology, where tree-ring research has been hampered in the past by the lack of clear annual ring structure in the wood of most tropical trees. His findings have important applications in the study of ocean-atmosphere patterns, such as the El Niño-Southern Oscillation.

- Dr. Sheppard has expanded tree-ring applications at LTRR in geology, soil science, and human health. His geological research includes studies of past volcanic eruptions and their signals in tree rings, with potential for providing new insights on the timing and effects of past volcanic eruptions on tree growth and ancient societies. His work on human health involves an innovative collaboration with medical scientists at the UA and elsewhere on the potential role of heavy metals contamination in childhood leukemia clusters that exist in several communities in the western US.

Two professional staff members were promoted to non-tenure track faculty status – Dr. David Meko and Dr. Ramzi Touchan, both of whom are now titled "Associate Research Professor".

- Dr. Meko has been a long-time principal investigator and professional staff member in LTRR. In recent years he has expanded his role as a course instructor and mentor of graduate students, and his re-titling as Associate Research Professor (formerly "Research Associate Principal") is an explicit acknowledgement of his full participation as a core faculty member. Dr. Meko has also expanded his research and collaborations (with Dr. Hirschboeck, among others) in research focused on improving understanding of long-term variations in the flows in major river drainages of the western U.S., including the Colorado River. This research has received considerable attention in the media and by policy makers because of important implications of the findings on our understanding of the limits and trends in water resources.

- Dr. Touchan was formerly a professional staff member ("Research Specialist, Senior"), and in recent years he has greatly increased his research leadership and teaching role, and his re-titling as Associate Research Professor reflects these increased contributions as a core faculty member. In recent years, with support from the National Science Foundation, Dr. Touchan has spearheaded a major dendrochronology program development in the Middle East and northern Africa. This work includes many new tree-ring width chronologies from ancient trees in this semi-arid region, and applications of dendrochronology to the study of climate variability, water supplies, and natural resource management. This work is providing new understanding of hydro-climatic variability in this critically important geo-political region, where water and natural resources are now, and will be in the future, key factors in issues of political stability and environmental sustainability.

Three adjunct professors were added who are grant supported, have offices and labs in LTRR, and participate as "core faculty" members engaged in research, teaching, and outreach. These new adjunct faculty are Dr. Ron Towner, Dr. Don Falk, Dr. Irina Panyushkina. In addition, Dr. Matthew Salzer also works as a grant-supported principal investigator in LTRR.

- In addition to research programs that fund most of their salaries, Drs. Towner and Falk regularly teach LTRR courses (specifically, two of our summer pre-session courses, paid for by course fees, temporary faculty funds, and other LTRR discretionary funds). They also engage in service programs. Recognizing this participation in our mission, we plan to re-title their positions to Research Professor (at ranks to be determined, non-tenure track, non-state funded). Dr. Towner is an archaeologist and dendrochronologist, and in recent years he has expanded his studies in the Southwestern US and northern Mexico (in collaboration with Dr. Jeff Dean). Dr. Falk has an extensive background in restoration ecology and is also a forest ecologist and dendrochronologist. He is developing an extensive program in fire sciences, forest ecology, and forest restoration in the Southwest and Mexico (in collaboration with Dr. Tom Swetnam). Dr. Panyushkina is trained as a dendrochronologist and she has research programs involving the study of Iron Age barrows in Central Asia (in collaboration with Dr. Jeff Dean), climate reconstructions in southern Siberia, and the study of Pleistocene and early Holocene deposits of buried and submerged wood in the Great Lakes States USA (in collaboration with Dr. Steve Leavitt). Dr. Salzer has a background in paleoclimate and archaeology, and is engaged in the extension, enhancement and exploitation of all aspects of work on bristlecone pine (in collaboration with Dr. Malcolm Hughes).

Four adjunct faculty were added who are employed by federal or state institutions. These new adjunct faculty are Dr. Julio Betancourt (with USGS), Dr. Henry Diaz (with NOAA), Dr. Ann Lynch (with USFS), and Dr. Steven Gray (with Wyoming State Climatology Office).

- We recently began making adjunct professorial appointments for close collaborators who are not employed by the UA. These non-core faculty contribute primarily to our research mission through collaborations, but are also involved in mentoring our graduate students (e.g., serving on committees) and in some cases co-teaching courses with core faculty. Adjunct faculty members bring a tremendous amount of expertise to LTRR. Detailed descriptions of their expertise and accomplishments are in sections **D.1.3**. and **Appendices A & B**. A particularly notable aspect of these new faculty relationships is the increased opportunity for collaboration with them and their research teams, support from federal funding of their programs, and in a couple of cases, co-location in LTRR. For example, Dr. Lynch has recently moved to Tucson, and arrangements are being made to locate her office and laboratory within a newly renovated part of the West Stadium that will house other LTRR personnel as well. Likewise, Dr. Diaz recently had a temporary office in LTRR during 2006, and plans are being formulated for a possible permanent location of his office in LTRR in 2007.

Three new joint faculty members were added who hold primary appointments in other UA departments. These include Dr. Peter Ffolliott (School of Natural Resources), Dr. Connie Woodhouse (Geography and Regional Development; she arrives January 2007), and Dr. Lisa Graumlich (School of Natural Resources; she arrives January 2007).

- Dr. Peter Ffolliott has been a long time mentor of LTRR graduate students and collaborator. He is exceptionally experienced in international forestry and watershed management, and is working closely with Dr. Touchan on his Middle Eastern tree-ring applications in resource management. Dr. Connie Woodhouse was recently hired as a tenure-track Associate Professor by the Geography and Regional Development department. LTRR will contribute a portion of her summer salary and also provide laboratory space for her in new space to be renovated in the West Stadium. She is a dendroclimatologist with a specialty in applying tree-ring information to water resource management. Dr. Woodhouse will co-teach courses with LTRR faculty and collaborate on research projects (30% of indirect cost returns from her future grants will accrue to LTRR). Dr. Lisa Graumlich is a dendroecologist and dendroclimatologist with long-time collaborations and interactions with LTRR personnel; she was formerly an LTRR faculty member before departing to Montana State University. She has recently been hired as the new Director of the School of Natural Resources. Her return to the UA and affiliation with LTRR offers excellent opportunities for building additional links between the School of Natural Resources, as well as mutual benefits to students and post-docs of Dr. Graumlich and LTRR.

At this time, none of the current faculty with state supported lines in LTRR has indicated an intention to retire within the next seven years, but there is a distinct possibility that at least one and possibly two or three faculty members may retire during this period. And of course, it is always possible that one or more of our faculty may leave to join another university or institution. Hence, it is prudent to consider now potential opportunities provided by vacated faculty positions (assuming the lines will be retained by LTRR, which we strongly advocate) for modifying our topical areas of expertise, or our anticipated needs to rebuild existing strengths that may be decreased with retirements or departures.

A.3.4. Anticipating and Planning for Future Changes

We envision continuing and expanding the development of our unique interdisciplinary unit. Future expansion of our programs is challenging for two reasons. First, we have sustained deep budget cuts (almost 10%) to our state funding over the past 4 years, and further cuts in the next 3 or more years are anticipated. Second, our current space accommodation in two on-campus buildings is approximately 10,000 square feet less than our current needs, as estimated by UA Facilities & Design planners (see section **J.2**). Nevertheless,

we have various new opportunities to build programs in specific areas with funds that will be internally available to us from endowments, from external funds via grants, and with newly acquired space (if renovation costs will be covered by the University). We briefly describe below several of these anticipated changes to our programs:

- Opportunities for strengthening and expanding our research and teaching programs in archaeological dendrochronology arise from two recent endowments. The Agnese & Emil W. Haury Endowed Chair in Archaeological Dendrochronology was established in July 2006 by a generous gift from Mrs. Agnese Haury. Dr. Jeff Dean was named the first Chair, and he will manage an Archaeological Dendrochronology development program funded from the endowment, in consultation with the LTRR Director (currently Dr. Tom Swetnam), and the Department Head of Anthropology (currently Dr. John Olsen). The Development Program may support post-doctoral associates, graduate students, or other personnel, and/or research and teaching initiatives. In July 2011, an entirely new faculty member at the assistant professor level will be recruited internationally to be appointed to the Chair. The second endowment, also a gift from Mrs. Haury in 2006, established a fellowship for support of a PhD graduate student pursuing studies related to archaeological dendrochronology. The endowment is sufficient to provide at least a half time stipend to a PhD student. This is a tremendous opportunity to strengthen and expand the archaeological dendrochronology research and teaching programs at LTRR into new emerging areas of emphases (Section **D.5.2** includes a brief description of potential areas of expansion).

- Ongoing, and likely accelerating climate change in the western U.S., other semi-arid regions, and globally will almost certainly increase the need for better understanding of historical and current climate variability, and its impacts on ecosystems, water resources, and people. Understanding and anticipating the coming changes to our world are among the most important scientific challenges of the 21st century. We anticipate that as major ecological and economic impacts mount regionally and worldwide, the federal, state and private funding sources for climate change research will surge. LTRR plans to strengthen its capacity to capitalize on an anticipated increased demand and external funding support for such research and teaching in the next decade. Strategies for achieving this will include focused and collaborative efforts by faculty on securing external grant funding in these areas and maintaining faculty strength in global change-related topics. Future LTRR faculty position openings through retirement or departure may provide good opportunities to focus on particular specialties that are of emerging importance in global change research but not well represented by the current faculty. Examples of such specialties and expertise we might consider include: climate and ecological modeling, biology and functional anatomy of trees with an emphasis on improved understanding of climate-tree growth relations, and integration of remote-sensing and geographic information technologies with tree-ring data for spatial analysis of climate, climate change impacts, and carbon dynamics. **A necessary basis for pursuing this strategy is that LTRR at least maintain its faculty numbers and strengths during the coming decade, and any retirements or departures of state-funded faculty should be followed promptly with searches and their replacement.**

- LTRR intends to pursue a range of strategies for fostering research innovation, and to apply renewed vigor in pursuing the major applications of dendrochronology. One approach will be to increase the presence of talented, beginning scientists working and studying here through expanded and new graduate student, post-doctoral, and visiting scientist fellowship programs. Some support that may be employed in this approach has just been acquired with the Haury Endowed Chair and Graduate Fellowship in Archaeological Dendrochronology. The existing Haury Fellowship program, which supports short-term visitors and/or graduate studies at LTRR, will also contribute here. Additional sources of support for graduate students and post-docs will be sought by faculty from various sources, including private donors, federal and state agencies, and other sources.

- LTRR plans to maintain, and where possible build, collaborations with federal scientists who have strong interests and experience in utilizing tree-ring data, or who bring important complementary skills for interdisciplinary collaborations with LTRR faculty and students. Collaborative opportunities with federal scientists have expanded in recent years (e.g., four new formally recognized, non-UA employed, Adjunct Professors). Space permitting, federal scientists and their teams who have strong overlapping and complementary interests and expertise might be co-located in LTRR quarters. As mentioned above, plans for such co-location for Dr. Lynch and possibly Dr. Diaz are underway. Advantages of this strategy include an increased diversity of research expertise and potential funding sources, opportunities for our students to be mentored by these scientists, teaching contributions by these scientists in our courses, and potential future employment of our students in the agencies. This strategy will also facilitate more direct input to federal agencies applying our research findings.

- LTRR plans to continue vigorous efforts to acquire appropriate space for our offices, labs and archives. Despite many previous requests over at least four decades for additional and better space, and our obvious needs, LTRR remains in sub-standard, dilapidated quarters in the West Stadium, where it has been located for 7 decades. The latest developments in this quest for appropriate space were (1) the collapse of the funding and planning process for the Environment & Natural Resources Building II, which would have met most of the space needs of LTRR, (2) a subsequent new planning effort to renovate newly acquired space in the West Stadium for LTRR, as well as some renovation of older spaces in the building, and (3) discussions about a new fund-raising effort to build either a stand-alone archive building for the valuable and extensive collections of LTRR, or funding for a large building that would house the entire LTRR. These efforts (2 and 3) will be actively pursued because the near and long-term ability of LTRR to sustain current activities, to grow, to retain faculty, and to recruit faculty replacements is critically dependent on finally acquiring appropriate space. Additional description of our space situation and related planning are included in section **J.2.**

- We have identified a set of particular, programmatic research topics and strategies. Section **D.5.** includes summary descriptions of these endeavors that we intend to initiate or strengthen in coming years as space, personnel, and funding allow.

A.4. Relationship of LTRR Goals to University Mission and Strategic Plan

The broad mission of the University of Arizona is "to discover, educate, serve, and inspire". The University's five strategic priorities (outlined in "Extending the Frontiers of Excellence: Five-Year Strategic Plan, FY 2006-2010") are the following:

1. Build a world-class and diverse academic community at the forefront of discovery.
2. Increase student engagement, achievement, retention, and graduation rate.
3. Extend the concept of a land-grant university to position the University of Arizona, across all colleges, as a model for linking scholarship and creativity to societal and community needs.
4. Achieve a strong financial foundation.
5. Increase recognition as a research university committed to an outstanding educational experience and connected to its community and the world.

Our goals to strengthen and maintain LTRR as the leading tree-ring research institution in the world is congruent with the University's broad strategic priority to "*Build a world-class and diverse academic community at the forefront of discovery.*" LTRR is a world leader in applications of dendrochronology on topics of very significant importance to the citizens of Arizona, the nation, and the world. For example, our

research emphases on historical climate, climate change impacts on ecosystems, and water resources have far reaching implications, and our discoveries and insights in these fields bring distinction to the University. The societal importance of our work, especially in the areas of climate change, water resources, and natural resources (e.g., forest fires, insect outbreaks, forest restoration, and ecology, etc.) contribute broadly to the University's strategic priority to "*Extend the concept of a land-grant university to position the University of Arizona, across all colleges, as a model for linking scholarship and creativity to societal and community needs."* In particular, the cross-disciplinary nature of our research and teaching and the multiple joint appointments in other departments that our faculty hold serve to build connections between faculty and students in different departments and colleges on campus.

Our reputation as the premier and largest institution dedicated to all aspects of tree-ring research attracts students, collaborators, and visitors from all over the world. Inclusion of expertise and leadership in archeological applications of dendrochronology, as well as earth and biological sciences, is one of our distinguishing features among all of the tree-ring laboratories of the world (which include about 40 laboratories with 2 or more researchers at academic institutions). These emphases, and our goals to strengthen and maintain them, also contribute to the University's strategic priority to "*Increase recognition as a research university committed to an outstanding educational experience and connected to its community and the world."*

Our goals to continue full participation in the teaching of undergraduate and graduate courses, involvement in graduate interdisciplinary programs, mentoring of graduate students, and undergraduate research is supportive of the University's priority to "*Increase student engagement, achievement, retention, and graduation rate.*" We find that undergraduate and graduate students are energized by their involvement in our research, and this fosters their creativity and achievements. Our fields of research offer an especially diverse set of attractions to undergraduates and graduates, including opportunities to carry out tree-ring research in outdoor field work in spectacular and exotic locations as well as in laboratory settings.

Our goals to build collaborations and to improve our space situation, and thereby grow our programs and capacity for external grant fund-raising, is a central strategy to improve our financial foundation for conducting research and teaching. This connects to the University's priority to "*Achieve a strong financial foundation*." Our strategy to increase fund-raising from private donors and other external sources also contributes to this goal of improving our financial situation.

B. PROGRAM HISTORY

B.1. The Last Seven Years

The Laboratory has enjoyed considerable success in the last seven years, both in research and teaching, as the sections below will attest.

B.1.1. Research

Major contributions have been made to the study of natural environmental variability and cultural ecology, both within the United States and globally. The following are examples of recent notable findings and breakthroughs by LTRR core faculty members:

- Dr. Dean's and colleagues' application of agent-based computer modeling to interactions between environmental variability and culture replicates salient aspects of Kayenta Anasazi subsistence and settlement behavior between A.D. 400 and 1350 in Long House Valley in northeastern Arizona. The success of these simulations confirms archaeological understanding of the local adaptive situation, illuminates aspects of past human behavior that cannot be observed archaeologically (including the locations of fields and relationships to past water resources), and reveals differences between simulated and actual behavior (such as the persistence of the artificial population after the actual abandonment of the Valley around A.D. 1300) that suggest new lines of investigation.
- Dr. Dean and collaborators used a novel application of strontium isotopic analysis of living trees, surface water, soil, and wood samples from archaeological sites to identify source areas for construction beams in specific mountain ranges surrounding Chaco Canyon in northwestern New Mexico. These results demonstrate the long-distance (up to 100 km) transport of large roof beams used in Chaco Canyon great houses in the 11^{th} and 12^{th} centuries A.D. and further document the social complexity of Chaco Anasazi society, its ability to mobilize numerous people for large-scale communal activities, and the broad spatial range of the Chacoan's exploitation of their environment.
- Dr. Dean and coworkers expanded the application of archaeological tree-ring dating in areas bordering the Southwest where dendrochronology has been underutilized. The analysis of archived and new samples illuminate the regional system centered on the immense site of Paquimé (Casa Grandes) in northern Mexico, clarify chronological relationships among Hohokam sites in the Sonoran Desert of southern Arizona, enhance understanding of Fremont sites in the Great Basin, and illuminate Spanish settlement of the western margins of the Great Plains.
- Dr. Evans has pioneered a method for oxygen isotopic analysis using induction heating and a new reactor design. The method will facilitate efforts to develop proxy rainfall estimates from intra-annual resolution tree samples collected from the global tropics.
- Dr. Evans, Dr. Hughes, students at LTRR and colleagues at Lamont-Doherty Earth Observatory demonstrated that variability in the ~190 US tree-ring chronology dataset used in the Mann et al. (1998) northern Hemisphere surface temperature reconstructions was consistent with first principles of the links between environmental forcing and conifer tree growth over the past century.
- Dr. Evans and colleagues adapted objective analysis techniques to produce global, temporally continuous estimates of the Pacific sea surface temperature (SST) field for up to the past four centuries from coral and tree-ring data. The results are archived at the WDC-A for Paleoclimatology. A further study illustrated coherency between independent northern and southern hemisphere-based reconstructions of Pacific decadal climate variability, and suggested a common tropical mechanism.
- Dr. Falk has developed theoretical models for spatial and temporal scaling of fire regimes. Scaling models for ecological disturbance processes are adapted from biogeographical theory and can predict fire regime parameters for a given area to facilitate meta-analysis. The slope and intercept of the scaling function provide important ecological information including mean fire size, spatial and temporal heterogeneity,

and rates of ecosystem production. Scaling parameters can also provide an index of climatic influence of the fire regime, and allow multi-century reconstruction of emergent properties at the landscape scale.

- Dr. Falk's group has completed a significant milestone in a restoration research program at Monument Canyon Research Natural Area, an old-growth ponderosa pine forest in the Jemez Mountains, Santa Fe National Forest, New Mexico. The site is one of the oldest Forest Service research areas in the United States, with tree-ring resources extending back into the early 1300s. Following a detailed fire history reconstruction, Dr. Falk's lab developed a restoration plan in collaboration with the SFNF using a novel process-centered restoration model. Ongoing research on the site includes tree physiological and understory responses to changes in stand density and restoration of the fire regime.
- Dr. Hirschboeck advanced her *synoptic dendroclimatology* research in western United States. Through the innovative use of atmospheric sounding data as a new way of linking weather, climate, atmospheric circulation, and tree rings from a process-based perspective.
- Dr. Hirschboeck's research group collaborated with Dr. Victor Baker in Hydrology and Water Resources and the U.S. Bureau of Reclamation to produce a dam-safety-related paleoflood data repository – one of the first instances of the systematic incorporation of paleodata into the *operational* mission of a U.S. government agency for regulatory and design practices.
- Dr. Hirschboeck's lab group continues to examine the relationship between synoptic circulation patterns and spatial patterns of frost-ring occurrence. Currently the susceptibility of high elevation bristlecone pines to unseasonable polar outbreaks is being analyzed via temperature sensors placed on trees in the field.
- Drs. Hirschbock and Meko's follow-up study funded by The Salt River Project involves a recollection effort in the Salt-Verde Basin, and an analysis of linkages between remote sensing, snow cover extent, snow water equivalent, and tree-ring variability (the dissertation work of Hirschboeck's Ph.D. student Ela Czyzowska). This latter work is also funded by NASA and is significant in that it holds the potential for linking remote sensing and dendrochronology, two of the most powerful analytical tools available for defining and interpreting changing environmental conditions in the past and present.
- Dr. Hughes, with Drs. Mann (Penn State) and Bradley (UMASS) and others, has continued to play an active role in the international effort to reconstruct the climate of the last millennium on a hemispheric scale and to place recent decades in this context, including joint authorship of a number of widely-cited papers. After much other work since the Mann, Bradley, Hughes (1998,1999) papers, our essential findings stand: the warmth of the late 20th century was unique in the context of the last several centuries, and the preponderance of relevant evidence supports the view that it was unique in the context of at least the last millennium. More and better evidence is needed. We have recently obtained very similar results using fundamentally different methods and a greatly expanded data base.
- Dr. Hughes has led a renewed effort to interpret the environmental information contained in the rings of the bristlecone and other 5-needle pine species in the interior West. This has included i) better understanding the environmental signal in these trees, ii) improving the network of multi-millennial chronologies, and iii) using them in climate reconstructions and inferences. Contrary to a widespread misconception, there is usable climate signal in these trees, as well as markers of other past events, notably volcanic eruptions over the last 5000 years. Dr. Matt Salzer, who has played a major role in this work.
- Dr. Hughes has addressed questions arising from the record of moisture availability in lower forest border bristlecone pine in and around the Great Basin, including the mega-droughts discussed by Hughes and Graumlich (1996). This work has led to a new synthesis of a wide ensemble of proxy climate records across the Pacific Basin, by Dr. Nick Graham (HRC, Del Mar, CA) and Dr. Hughes supporting links between a multi-century period of more frequent, persistent and intense drought in the interior West between ~AD 400 and ~1400 and La Niña-like features in the Pacific Ocean.

- Dr. Hughes has played a leading role in the application of a process-based model to problems of dendroclimatology. This has been based on a model developed by Vaganov and Shashkin in Russia, described in a recent English-language book (Vaganov, Hughes, and Shashkin, 2006) and collaboration with Dr. Evans, Kevin Anchukaitis and colleagues at Lamont-Doherty Earth Observatory. This approach is of great significance to the study of tree-ring responses to environment in a changing world, where the assumptions underlying empirical-statistical methods may reach their limits.
- Dr. Leavitt's group and colleagues have estimated sequestration of carbon in soils under high CO_2 and reconstructed past plant assemblages in the Great Plains using carbon isotopes. Isotope work with modern trees indicates valuable utility of C and O isotopes for reconstruction of drought and relative humidity, and work with Younger Dryas-age trees has revealed interannual environmental conditions during this period of abrupt climate change.
- Dr. Leavitt and Dr. Panyushkina have developed the first subfossil tree-ring network in the American Midwest centered on the Younger Dryas event. High-resolution chronologies from tree-ring width, stable isotopes and radiocarbon were used to identify climatic variability between 15,000 and 9,000 BP in the region of Lake Michigan.
- Dr Meko, in collaboration with Senior Research Specialist Chris Baisan, has developed a sampling strategy and analysis technique to extract a strong statistical signal for monsoon rainfall from semi-arid site conifers. The method is based strongly on false-ring interpretation and relies on strategic sampling of conifers from specific site-types – lower canyon reaches, young trees, and a bimodal monthly precipitation regime.
- Dr. Meko and Dr. Hirschboeck have used tree-ring data to address questions on reliability of water supply in Arizona. With funding from the Salt River Project, they demonstrated a strong coherence in occurrence of low-flow years in the Salt-Verde region and Upper Colorado River Basin. The results have implications for use of Colorado River imported water as a buffer against local hydrologic droughts.
- Dr. Panyushkina has contributed to understanding the Iron Age history of Eurasia by establishing calendar ages of two dozen Pazyryk culture kurgans in the Russian Altai Mountains and estimating impact of climate change on ancient nomadic societies in the first millennia BC in Central Asia.
- Through collaboration with Prof. M. Hughes and Academician E. Vaganov (Russian Academy of Sciences), Dr. Panyushkina has developed the first long-term chronology of cell dimensions from Siberia tree rings and built a model to reconstruct intra-seasonal variability of summer temperatures for the last 360 years. This reconstruction revealed different variations in decadal variability of early and late summer temperatures, which resulted in changes of growing season duration and initiation date of cambium growth.
- Dr. Sheppard has identified elevated airborne tungsten in Fallon, Nevada, which is experiencing a cluster of too much childhood leukemia. Biomedical research on the link between exposure to airborne tungsten and leukemia has been recommended.
- Dr. Sheppard has identified a dendrochemical signal of increased sulfur and phosphorus to the modern eruption of a cinder cone volcano. This signal is now being searched for in tree-ring samples dating to the prehistoric eruption of Sunset Crater.
- Dr. Sheppard has identified dendrochronological responses to a tornado, which is helpful in the research of Sunset Crater.
- Dr. Sheppard has solved the "magnification irony" and the heartwood-sapwood coloration problems of image-analysis of tree rings. This high-tech method is closer to being widely applicable in dendrochronology.
- Dr. Swetnam and his colleagues compiled and used broad-scale networks of tree-ring based fire history data sets from throughout the western U.S. and found that climatic variation and changes synchronized forest fire activity over the past 300 to 500 years. They showed that contingent states of large-scale ocean-atmosphere patterns, including the El Niño-Southern Oscillation, Pacific Decadal Oscillation, and the Atlantic

Multidecadal Oscillation have partly determined regional-to-continental temporal and spatial patterns of wildfire occurrence. These findings have important implications for basic understanding of fire climatology, and for the development of forecasting models.

- Dr. Swetnam and colleagues at Scripps Institute of Oceanography (Anthony Westerling, Dan Cayan, and Hugo Hidalgo) have collaborated on studies of modern fire and climate data sets to evaluate temporal trends and spatial patterns. Swetnam and Westerling have also collaborated on integrated studies of modern and tree-ring fire and climate data sets. They discovered that recent decadal trends in increased large fire occurrence in the western U.S. are associated with warming spring to fall temperatures, earlier arrival of spring, and consequent water deficits in mid-elevation forests across the west, especially in the Northern Rockies. These findings suggest that climate change is beginning to affect ecosystems in the western US via increased forest fire activity.
- Dr. Touchan and Dr. Hughes have conducted the first large-scale systematic dendroclimatic sampling for the eastern Mediterranean region and the Middle East (Turkey, Syria, Lebanon, Jordan, Cyprus, and Greece).
- Dr. Touchan and his colleagues have developed the first standardized precipitation index (drought index) reconstruction for the eastern Mediterranean region. This is the first known reconstruction of this climatic variable anywhere in the world.
- Dr. Touchan current research programs include establishing a network of multi-century climate records for the North Africa based on tree rings by extending and enhancing existing tree-ring datasets and by developing new tree-ring chronologies geographically and temporally. This network is being, and will continue to be, used to study inter-annual to century-scale climate fluctuations in the region and their links to large-scale patterns of climate variability.
- Dr. Touchan is also involved in the European Union project entitled "European Climate of the Last Millennium" to determine whether the magnitude and rate of 20th Century climate change exceeds the natural variability of European climate over the last millennium by using the best documentary, biological, and sedimentary archives available across Europe to extract palaeoclimate signals. Approximately thirty-eight European Institutes and only Dr. Touchan from the US are involved in this extensive project.
- Dr. Towner's research has significantly changed our understanding of early Navajo cultural development, migration, and adaptation to their social and physical environments in the northern Southwest. He has also spearheaded important new efforts for expanding dendroarchaeology into northern Sonora and Chihuahua, Mexico, coastal Peru, northeastern Utah, and south-central Texas.

B.1.2. Teaching

Teaching of dendrochronology has seen a number of innovations since 1999 at the undergraduate and graduate levels, aided by the hiring of two new faculty (Sheppard and Evans) and the assumption of some teaching duties by Associate Research Professors (Meko and Touchan). Course content was revamped in our *Introduction to Dendrochronology* and *Dendrochronology Workshop* courses as new instructors (Hughes and Sheppard, respectively) took responsibility for these courses. Two analytical skill courses originally taught as modules in *Topics in Dendrochronology* expanded into separate courses: *Spatiotemporal Data Analysis Workshop* (Evans) and *Applied Time Series Analysis* (Meko). The latter course is also offered online as a correspondence course through the University of Arizona's Continuing Education and Academic Outreach program, one of only two graduate level courses offered through this program. Two new cross-disciplinary graduate courses in paleoclimatology and climate dynamics were built (Evans). One of these (Topics, Tools and Techniques in Paleoclimate Research) involved guest lectures from 12 faculty in 5 departments; the other (ENSO: Past, Present, Future) is cross-listed in ATMO and GEOS, and draws students from these departments, LTRR, GEOG, and SWES. In addition, an entirely new "Tree-Ring Summer School" course format was designed for expanding our advanced course offerings in dendrochronology to a broader audience of national

and international participants. The new format consists of a suite of 3 courses offered during the intensive three-week summer pre-session and was designed to increase enrollments in our specialist graduate classes, sustain the Laboratory's high profile in the field of dendrochronology both nationally and internationally, and provide a stimulating academic environment for our graduate students in which current issues in dendrochronology are explored along with participants from other universities, countries, and professions.

In addition to our expanded core curriculum of tree-ring courses, the Laboratory continues to have a significant impact on University-wide general education in the Natural Sciences. In 1999, the Tier I NATS 101 format of *Introduction to Global Change* (formerly GEOS 107a) had just been initiated and a new Tier II course, GEOS 220 *Environmental History of the Southwest*, was offered for the first time. Subsequent developments in these courses included: integration of undergraduate preceptors into the NATS 101 courses through involvement with the University Teaching Team Program, innovative use of collaborative learning groups, student-centered approach, and instructional technologies, and doubling of enrollments in both the NATS and GEOS 220 courses. Laboratory efforts in improving undergraduate education have been recognized by the Provost's General Education Teaching Award (Hirschboeck) and the College of Science's Distinguished Early-Career Teaching Award (Sheppard). Currently four Laboratory faculty are invested in teaching our general education courses on a regular basis: Evans, Hirschboeck, Leavitt, and Sheppard. During the 1999-2006 review period, 6 out of 7 tenure-track faculty participated in teaching General Education courses.

The Laboratory has continued to provide an excellent research and educational environment for graduate students, mostly supported by federal, state, and private grants to Laboratory principal investigators, or other sources such as NASA's Earth System Science Fellowship Program and the Integrative Graduate Education and Research Traineeship (IGERT) Program in Archaeological Sciences, of which Dr. Dean was a PI. Since 1999 LTRR faculty have served on graduate committees for 119 students from numerous programs in various colleges of the University, and been major advisors to 31. From 1999 to 2006, 9 students in this latter group have received Master's degrees, and 22 Ph.D.s. The graduates have found excellent posts, ranging from tenure-track faculty positions through prestigious postdoctoral fellowships to responsible positions in government agencies (see section **G.5.2**). The Laboratory continues to play a central role in the university-wide Global Change Ph.D. Minor Graduate Interdisciplinary Program, by offering global-change related courses and through faculty involvement on the GC-GIDP Executive Committee and Global Change Minor Ph.D. committees. LTRR graduate students are especially active in the Global Change program and have been recipients of its ISPE-sponsored Earth Fellowship, dissertation improvement grants, and travel awards.

B.1.3. Institutional

The faculty now includes four full Professors, tenured, on state-funded lines (Dean, Hughes, Leavitt, and Swetnam), one Associate Professor, tenured on a state-funded line (Hirschboeck), and two Assistant Professors, tenure-track on state-funded lines (Evans and Sheppard). Evans and Sheppard are currently undergoing tenure/promotion review (winter 2006-2007). Two other faculty are Associate Research Professors, non-tenure track, on combined state and non-state funded (i.e., grants) lines (Meko and Touchan). Three other faculty are currently titled Adjunct Assistant or Adjunct Associate Professor (Falk, Towner, and Panyushkina) and are supported on non-state funds (grants) and temporary teaching salary funds when available (e.g., when state-funded faculty take full year sabbatical leaves). These faculty members are considered "core" faculty by virtue of their contributions to all aspects of the mission of LTRR (i.e., research, teaching, service). We also recently added 3 joint faculty members who have primary appointments in other departments (see section **A.3.3.** for brief descriptions of new faculty).

Overall, changes in faculty over the past seven years reflect the retirement or departure to other institutions of three professors (Charles Stockton – retired, Robert Dickinson – departed, and Lisa Graumlich – departed, now returning to the School of Natural Resources as Director, and as a joint professor with LTRR). With hiring new faculty, re-titling of professional staff to faculty titles, and adding grant-funded, non-tenure track faculty, LTRR has had a net increase of about 2 faculty/principal investigators. This is substantial growth, especially with the additional students and grant funded temporary staff lines generated by these investigators.

While faculty and principal investigators have increased, staff lines have decreased due to budget-related layoffs and retirement. State budget cuts necessitated the elimination of an office staff line (Administrative Assistant) and a scientific staff line (Research Specialist). One Research Specialist Senior, who had worked with the archaeology group, retired after several decades at LTRR. The loss of research staff is of particular concern because these positions maintain an essential level of expertise and human knowledge-resource that is not quickly or easily replaced and is needed for the vital task of dating tree-ring samples. Tree-ring dating of archaeological tree-ring materials, in particular, requires a specialized skill set, aptitude, and some years of training. The training and time needed to master these positions makes it impractical to rely upon students to fill this need because their constant departure as they graduate and move on means that materials can not be efficiently or confidently processed in the time needed. The shortfall of experienced staff has become so serious that it threatens our ability to conduct research and acquire funding.

B.1.4. Resources

The recent history of the Laboratory's state-funded budget is illustrated in **Figures J.1** and **J.2**, in section **J**, and the recent record of grant funding from external sources is illustrated in **Figures F.1**, **F.2**, and **F.3** in section **F**. In summary, the state funding totals to the LTRR increased slightly in absolute terms over the past few years, but this small increase was due to cumulative salary increases to faculty and staff, although even they have not kept up with inflation. The salary increases (from general adjustments, equity, merit, and retention-related raises) have slightly offset a cumulative cut to the budget of more than $87,000 per year, and about 10% of the budget since 2002. These cuts came primarily from two staff lines that were eliminated and operations cost reductions. External funding has fluctuated, but has increased in recent years to over $1.1 million of new grant funding each year.

Two major gifts to LTRR were made by a private donor, Agnese N. Haury prior to the 1999 APR, and she recently gave two other gifts. In 1994 Mrs. Haury gave LTRR $0.5 million to endow a visiting fellows and training program in dendrochronology. In 1997 she committed $1 million as a challenge grant towards the cost of new accommodations for the LTRR. Unfortunately, the University did not raise the additional funding needed to cover the remainder of the costs needed for a new building for LTRR as promised in the original terms of the agreement with Mrs. Haury. In 2006, in consultation with the LTRR Director (Swetnam) and the Department Head of Anthropology (Olsen), Mrs. Haury approved the transfer of the $1 million in the original challenge grant fund to a new endowment, creating the Agnese and Emil W. Haury Endowed Chair in Archaeological Dendrochronology. In December 2006, Mrs. Haury committed an additional $750,000 toward a Graduate Student Fellowship endowment to support PhD graduate students pursuing archaeological dendrochronology in collaboration with the Endowed Chair.

In addition to Mrs. Haury's generous gifts of more than $1.75 million, including the Endowed Chair and the Graduate Fellowship in Archaeological Dendrochronology, the LTRR has been the recipient of more than $386,885 in other gifts since 1999. The largest donations included gifts from an anonymous donor in support of bristlecone pine research totaling $204,685, gifts from Mr. Ralph Smith for research and teaching equipment totaling $27,000, and several scholarship gifts ($3,000 to $5000 each) from donors to the College of Science's Galileo Circle. Other smaller gifts ($50 to $1,000 each) were received from individuals, including former LTRR students, associates, and current and emeritus faculty members.

B.2. Longer-Term History

A.E. Douglass joined the University of Arizona faculty in 1906, and the Laboratory of Tree-Ring Research was established by the Arizona Board of Regents on December 4, 1937. In regard to these dates, it is notable that 2006 marks the 100th anniversary of Douglass' joining the U of A, and 2007 will mark the 70th anniversary of LTRR.

LTRR is the oldest, largest, and most comprehensive dendrochronology program in the world. Originally, the Director of the Laboratory reported directly to the President of the University, and then successively to the Dean of the Graduate College (1958-9), the Provost (1966), the Director of the School of Earth Sciences (1967) the Dean of the College of Earth Sciences (1971-1982), and the Dean of first the Faculty of Science and second the College of Science (1982-present). This administrative history may be seen as a result of the interaction between the multidisciplinary nature of LTRR and a large modern university's need to impose administrative structures that may not reflect academic reality. LTRR directors have come from a variety of academic backgrounds. Andrew Ellicott Douglass (1937-1958) was an astronomer, Terah Smiley, Acting Director (1958-1960) a geoscientist, William McGinnies (1960-64) an authority on the world's deserts, Bryant Bannister (1964-1982) and William Robinson (1982-1986) archaeologists, Malcolm Hughes (1986-1999) an ecologist turned paleoclimatologist, and Thomas Swetnam, a forest and fire ecologist. The varied backgrounds of past and recent LTRR Directors demonstrate the disciplinary breadth of the Laboratory's work.

A. E. Douglass first established LTRR as a world-renowned institution during the 1920s and 1930s, particularly for his contributions to archaeology in developing tree-ring dating as a chronometric tool and in solving the mystery of the construction dates of the great ruins of Chaco Canyon and Mesa Verde. In the 1940s and 1950s, Douglass' first full-time colleague at LTRR, Edmund Schulman, advanced dendrochronology applications in climate history, and in the discovery of the oldest living trees (bristlecone pines in California exceeding 4,000 years). A period of great scientific success and growth of LTRR commenced in the 1960s under the directorship of Bryant Bannister, with recruitment of a number of highly productive and innovative scientists (particularly Harold Fritts, Valmore LaMarche, Jr., C. Wesley Ferguson, Charles Stockton, and Jeffrey Dean), culminating in the mid-1980s with retirement or death of most of this faculty cohort (Dr. Dean continues his work at LTRR, and in fact, has reached new heights of productivity and recognition in recent years). A renewed period of high productivity at LTRR in research, teaching, and especially global outreach as a center of training, began during the late 1980s and through the 1990s under Malcolm Hughes' tenure as Director. He led the recruitment of a new cohort of faculty (including Thomas Swetnam, Lisa Graumlich, Steven Leavitt and Katherine Hirschboeck). Additions since Dr. Swetnam's appointment as Director have been described above.

B.3. 1999 Academic Program Review and Recommendations

The previous APR was conducted in the fall of 1998 and spring of 1999. The external review panel consisted of the following members: Dr. Raymond Bradley (Univ. Massachucetts, Amherst, Chairman), Dr. Harold Mooney (Stanford University), Dr. Dan Cayan (Univ. California, San Diego, and Scripps Institution of Oceanography), Dr. George Gumerman (then of Arizona State Museum), Dr. Clem Chase (Geosciences department, U of A), Dr. William Doelle (President, Desert Archaeology, Inc., Tucson), and Mr. John Madden (Mountain View High School, Tucson, high school teacher). The 1998-1999 APR was conducted under the direction of Dr. Malcolm Hughes, who stepped down as Director of LTRR at the end of 1999. Dr. Thomas Swetnam was appointed Director in January 2000, and in consultation with the faculty, he prepared the original responses to the external APR panel's recommendations. The APR panel recommendations, original responses by LTRR faculty (*italic font*), and an update on those responses are provided below (***bold and italic font***).

B.3.1. LTRR Specimen Archives

The committee's foremost recommendation is that steps be taken as soon as possible to re-house the Laboratory's unique archive of wood in a custom-designed facility and to appropriately catalog and document the material. This will require that a dedicated Curator be appointed to oversee the reorganization of the collection, design a computerized database system to document and manage the archive, and provide on-going

oversight of the material.

We recommend that the Director of LTRR make efforts to obtain support to catalog and maintain such a facility a very high priority. At the same time, the university should be prepared to step in and take action should good faith efforts be unsuccessful.

Original Response:

We recognize that LTRR's specimen collection is a priceless resource for current and future research in environmental and archaeological sciences. Over the years, LTRR has spent considerable time and resources in maintaining and organizing this collection. Because of the over crowded nature of the current storage space, the collection might appear to be less well-organized than it is. We recognize, however, the need to improve its organization and accessibility via computerized databases and by obtaining better storage space and shelving. This would be most efficient to accomplish during a move to a new building within the next two years. We will attempt to obtain funding from the National Science Foundation to assist us in meeting this recommendation. Other agencies with an interest in our collections (e.g., National Park Service) might also assist us. Preliminary contacts with these agencies indicate there is a good possibility for funding to help reorganize our collections and to fully digitize the archive database. The Director (Swetnam) and a faculty member (Dean) will work together on developing these proposals this year.

Updated Response:

We made several efforts over the past seven years to obtain external support to improve the curation and public access to our collections. These proposals were primarily focused on digitizing records of our materials and making them available online. Proposals were not funded. The stated reasons were variable, but generally, there seems to be a lack of government-based funding support that is specifically appropriate for these purposes. Alternatively, we have not found the proper funding source or made a sufficient case for the support. In recent years there has been substantial progress in the re-organization and improved storage of large parts of the collections by other means. This derived from several developments: (1) A gift from an anonymous donor in support of bristlecone pine research has been used in part to support a very extensive re-organization and database development of the large and valuable bristlecone pine collections (effort led by Tom Harlan). This work is nearly completed. (2) LTRR acquired some new space in the basement of the old Purchasing & Stores Building (now Math East) in 2004. This new space was intended to replace lost space as a result of the condemnation and demolition of our previous quarters in the Berkowitz Apartments. Part of the new space in Math East basement was converted to archival storage, and the bulk of the giant sequoia and bristlecone pine specimens were moved into this space. This has resulted in much improved organization and storage conditions for these valuable collections. (3) Substantial efforts have been invested in reorganizing and consolidating collections in the West Stadium and the Sunnyside (off campus) storage rooms.

The much anticipated and promised new building for LTRR has not materialized in the past seven years. An entirely new building would have been, and perhaps one day in the future will be, a prime opportunity for a total reorganization of the archive. In the meantime, we are now pursuing opportunities to acquire gifts and grants to potentially construct a stand-alone archive building that may be built under the northeast corner of the West Stadium.

B.3.2. Research

We recommend that LTRR PIs amplify their research program by expanding collaborations with University of Arizona and outside researchers. Particular efforts should be made to establish strong links to the Institute for the Study of Planet Earth and the newly emerging Center for Surface Processes.

Original Response:

LTRR links with ISPE are well-established and have been strong since the formation of ISPE. Lab

faculty have been involved in both research and teaching grants obtained through ISPE and are currently involved in ISPE's NOAA-sponsored Climate Assessment Project for the Southwest (CLIMAS Project). We envision this collaboration to continue and expand – along with ISPE's future development under its new director, Jonathan Overpeck, who is currently serving on LTRR's faculty search committee. In particular, we see great opportunity for future collaboration on a variety of interdisciplinary research projects related to multi-proxy assessments of past climate variability, and climate impacts.

The newly emerging Center for Earth Surface Processes (see attached), is a collaboration between the University of Arizona and the U.S. Geological Survey. Two of its potential research themes are: "climate change and its impacts" and the "geological framework for (and history of) ecosystems." LTRR will seek official status as one of the collaborating units in the Center and envisions being involved in both climate change and ecosystem research with USGS personnel.

Updated Response:

LTRR is a highly collaborative institution, both internally at UA and externally, as attested by the long lists of local and distant collaborators in section I, and the many coauthored papers that faculty and staff have published in recent years. As stated in the original response, ISPE and CLIMAS were, and are, good opportunities for such collaborations. Dr. Hughes, Dr. Swetnam, and recently Dr. Hirschboeck have, in turn, all served as co-PIs on the CLIMAS project and have collaborated extensively with this program, and many other ISPE programs. Other examples of recent on-campus collaborations include LTRR involvement in planning and organization efforts for a UA response (proposal) to NSF's National Ecological Observatory Network initiative; the recent establishment of a National Phenology Center at UA; the organization of an "Arizona Geochronology Center" (a multi-department and multi-college effort to consolidate and strengthen geochronology expertise and capacity on campus); environmental research with a UA Pediatrics research on a public health issue; water resources research with faculty of the departments of Agricultural Economics, Hydrology & Water Resources, and the Arizona Water Institute; and direct involvement as co-PIs on both unsuccessful and successful IGERT proposals and projects on campus (e.g., the current Archaeological Sciences IGERT, with Jeff Dean as co-PI with Dr. John Olsen in Anthropology, and Dr. Joaquin Ruiz, Dean College of Science).

Our off-campus collaborations are myriad and worldwide. Long-standing and strong collaborations include Dr. Hughes and other faculty with Russian tree-ring scientists. Dr. Meko has collaborated since the mid-1990s with tree-ring scientists from Lamont-Dohertry Tree-Ring Lab, Columbia University, The University of Arkansas, and other institutions on analysis of long-term drought variability in North America. Among the newest and most promising of collaborations include Dr. Touchan's work in the Middle East, Dr. Falk's work with fire and forest scientists on restoration and disturbance ecology in the Southwest, Dr. Swetnam's interactions with climatologists at Scripps Institute and elsewhere on the climatology of forest fires, Dr. Meko and Dr. Hirschboeck's work with western water managers to provide useful long-term perspectives on hydro-climatic variability, Dr. Dean's collaboration on the development of "Artificial Anasazi" agent-based model with colleagues from the Brookings Institution, Santa Fe Institute, Arizona State Museum, and the University of Massachusetts, and Dr. Towner's relationships with archaeologists in the Great Basin, Great Plains, northern Mexico, Peru, and Japan.

The "Center for Earth Surface Processes" mentioned in the recommendation and original response is now defunct, as a consequence of the collapse of the Environment & Natural Resources Building II planning and collaborations with USGS.

B.3.3. Faculty and Staff Lines

We strongly recommend that an additional faculty line be approved next year (for a faculty appointment beginning in 2001) to bring the total faculty in LTRR to seven.

We recommend that the Laboratory staff positions be maintained at their current level due to the high demands for their technical (and not easily replaceable) skills in fulfilling the mission of LTRR.

Original Response:

We strongly concur with these recommendations. Note that the faculty line referred to in this recommendation would be the line recently vacated through retirement of Charles Stockton. We are currently conducting a search to fill one faculty line and we are very encouraged by the high quality of the applicants.

Updated Response:

This faculty line was approved, and it was filled following an international search with the hiring of Dr. Mike Evans. Subsequently, another line, vacated by the departure of Dr. Lisa Graumlich, was filled following a national search by the hiring of Dr. Paul Sheppard.

Unfortunately not all staff positions funded by state lines have been maintained because of temporary and permanent budget cuts.

B.3.4. Teaching

We recommend that the Laboratory continue its breadth of contributions to teaching at undergraduate and graduate levels. The expectations for level of undergraduate contributions should be specifically negotiated between the Laboratory and the Dean of the College of Science.

Original Response:

Over the last 5 years, and especially the past several semesters, LTRR has greatly expanded its undergraduate teaching role in addition to maintaining excellence in graduate student training. The Laboratory will continue its commitment to teaching on both these levels. The Laboratory will continue teaching "colloquium modules" to meet the instructional needs of our graduate students and regularly offer modules of campus-wide or interdisciplinary interest to build enrollments in graduate-level courses. It is expected that faculty now on leave and/or new faculty hired will contribute to our current Tier I and Tier II General Education teaching commitments.

Updated Response:

LTRR faculty members have continued to contribute to both undergraduate and graduate teaching. Two faculty members have been recognized for excellence in undergraduate teaching at the University level (Dr. Hirschboeck) and College level (Dr. Sheppard). New courses have also been initiated by several faculty, and these have been well-received. These include various colloquia courses directed at advanced studies for graduate students, as well as introductory pre-session summer courses, which have attracted graduate students and scientists from around the world. A new course on Time Series Analysis, offered online, has drawn students from both within and outside the United States. New efforts to recruit and support graduate students to work with the faculty have also been initiated, and the number and quality of graduate students carrying out tree-ring related theses and dissertations have grown.

B.3.5. Graduate Students

We recommend that the Laboratory review their policies and practices with a view to increasing the efficiency of graduate progress and decreasing the residence time of individual students in the program.

Original Response:

We do not have comparable statistics from other departments, so it is not clear that our graduate students take any longer to complete their degrees than is typical in other departments. We recognize, however, that it is wise to periodically review policies and procedures related to our graduate students and their degree progress. Although LTRR has no formal say in the policies of the degree-granting departments, we will evaluate the following possible actions related to our LTRR graduate students including:

- *negotiation of guidelines/policies specific to LTRR grad students with each of the relevant degree-granting departments – or at the very least, a clarification of current policies.*
- *establishment of an LTRR graduate coordinator role (rotated among the faculty) to streamline graduate student recruitment, orientation, communication, links to degree-granting departments, and oversee degree progress.*

Updated Response:

In general, LTRR graduate students have completed in a timely fashion in the past seven years. Moreover, there is a good track record of our former students entering professions and doing well, including in academia. We have instituted some changes that assist in helping monitor and facilitate graduate student progress, including a graduate student annual report that involves review and comment on student progress by all of the faculty, not just from the major advisor. Although an LTRR graduate coordinator position has not been formally established, Dr. Hirschboeck has carried out some of these duties. We are likely to soon formalize this as a rotating faculty job, particularly because the numbers of graduate students in LTRR are on the rise and the need for someone in this position has increased.

B.3.6. Communications

We recommend that better communication be fostered between the faculty, research staff and students, to make sure that they all benefit fully from the intellectual opportunities and interactions that are available.

Original Response:

LTRR will continue and expand its formal and informal vehicles of communication between the faculty, research staff and students. These are: weekly or biweekly Tree-Ring Talks; Annual Tree-Ring Day, during which all faculty, research staff, and graduate students report on their current research activities; and the Journal Club course with a broadened participation that includes more faculty and research staff. We expect that improved communication will be facilitated when LTRR moves out of the football stadium and into a facility that is better designed for interaction among its personnel.

Updated Response:

All of the mechanisms for better communication listed above have been maintained or increased in frequency. Additionally, several faculty retreats and faculty/staff retreats have been held to improve communications and collaborative planning. A departmental newsletter, called "Tree-Ring Times" was initiated and published approximately twice per year from 2001 to 2004. It has not been published in recent years because of lack of funding and staff time, but we hope to recommence publication soon if resources allow.

B.3.7. Dating Services

We recommend that the lab reassess its costs for providing dating services and ensure that its prices are set at levels that fully recover those costs. A two-tiered rate structure should be considered in which funded research users provide some subsidy for unfunded research users.

We recommend that the lab explore the potentials for expanding dating services within the United States and internationally in areas where long chronologies exist.

Original Response:

The various LTRR operations engaged in fee work continually assess the costs of their operations and attempt to recover the full cost of this work whenever possible. For many reasons, it commonly is impossible to recover the full cost of sample analysis; therefore, all dating operations have developed methods for subsidizing analysis for submitters who are unable to pay. These mechanisms include using funded work to

subsidize unfunded work, exchanging services with other institutions for things like chemical analysis and radiocarbon dating, and acquiring outside support (NSF) for the dating operations. Due to many variables, it is extraordinarily difficult to determine a fair per sample cost for analysis. For example, rapid processing of undatable samples that require only species identification decreases the per sample cost (to only $6.89 per archaeological sample in FY 94/95). Charging by date is impractical as well, because entire collections may produce no dates but take considerable time to process. Actual cost per archaeological date can range from $5.00 to more than $200.00. Finally, with regard to the APR Committee statement quoted above, all three LTRR operations that routinely process samples for outside parties already do everything the committee recommended. Therefore, we recommend continued monitoring of dating costs and necessary periodic adjustments in rates so that we can continue to subsidize unfunded submissions from fee income generated by funded work.

Updated Response:

We continue to monitor archaeological dating costs. Based on periodic assessments of the actual costs of sample analysis we adjusted rates in 2003 and 2004.

B.3.8. Outreach Programs

We recommended that LTRR outreach to local schools and teachers continue its important educational and public involvement efforts, and that the lab remain responsive to the public and press.

We recommend that the lab consider ways to formalize its outreach program for researcher training.

Original Response:

Our outreach efforts are divided into three different areas: public schools and other non-profit groups who tour the facilities for an hour or two, individual researchers who visit LTRR on short- and long-term bases in order to learn dendrochronological skills. Regarding the latter, in recent years we have instituted a fellowship program through the support of Agnese Haury, which supports 3 to 6 short-term training visits (one to several months) by scientists and students every year. One new outreach program that has been developed since the APR interviews is the new NSF-funded Chautauqua Series Short course for College teachers developed by Dr. Swetnam and Dr. Sheppard to be held May 18-20, 2000. The purpose of the course is to "provide college teachers with a basic understanding of dendrochronology principles and applications," and give teachers examples of how dendrochronology can be integrated into various college curricula. The addition of more grant-funded short courses like this one may be a viable strategy for increasing the impact of our outreach program with little additional effort.

We will explore other new ways to formalize outreach programs for researcher training. For example, we will consider organizing an intensive dendrochronology workshop of one to several weeks duration during the summer months. Potential visitors requesting training assistance may be directed to this course, rather than the less efficient and time consuming case-by-case arrangements and scheduling that we now accommodate for each individual.

Updated Response:

Our outreach program has expanded since 2000. Senior Research Specialist Rex Adams works as our outreach specialist, and he has contacts with thousands of K-12 students, visitors and others each year. The Haury Fellowship program has continued to support visiting scholars. We have followed through on plans to develop and teach summer workshop courses, and these courses have run very successfully for five consecutive years now.

B.3.9. Fund Raising

We recommend that the Laboratory Director develop a plan for fund raising activities and consider this as part of his portfolio of responsibilities, as time allows.

Original Response:

The past-Director (Hughes) was instrumental in facilitating very large gifts from Agnese Haury to the Tree-Ring Laboratory, as well as a couple of other recent, important gifts. The current Director (Swetnam) also sees fund-raising as a very important duty, and he has met with Charles Geoffrion (COS) to discuss several pending initiatives. These initiatives will include approaches by the Director to private foundations, and following up on opportunities to increase the visibility of the Tree-Ring lab with individuals who may be inclined to help LTRR.

Updated Response:

Swetnam has made substantial efforts to pursue multiple fund-raising strategies. These include: working with the current CoS development officer (Bob Logan) to identify potential donors and initiating the development and publication of a departmental newsletter (Tree-Ring Times), which served as an outreach mechanism to potential donors among alumni and interested people. Lack of available funds and personnel has resulted in a hiatus in the newsletter publication for 2 years, but we hope to re-start its publication soon. Swetnam has also participated in numerous fund raising-related efforts organized by the College of Science, such as a dinner and lecture (by Swetnam) to the Dean's "Galileo Circle", and participation (along with Paul Sheppard) on a "Sense of Place" tour and field trip for Galileo Circle members (donors). There has been some success in fund raising, but not necessarily due to Swetnam's efforts. Examples of gifts are mentioned in section B.1.4 above. Overall, it is recognized that continued efforts are needed, and more focused strategies must be pursued in coming years for particular needs, such as a new archive building or an entirely new LTRR building.

B.3.10. Advisory Council

We recommend that LTRR establish an Advisory Council, made up of prominent researchers and high profile business and/or community leaders to provide outside guidance and assistance in the Laboratory's research, education, and outreach missions.

Original Response:

We will consider establishing such a council.

Updated Response:

We concluded that, given the time required to organize and maintain such a Council, and uncertainty as to the ultimate payoffs of such an effort, we would wait until we learned more about the benefits accrued to other CoS departments that have established such Councils. We have heard mixed assessments as to the efficacy of such Councils. Also, other pressing needs and initiatives have taken priority. Nevertheless, we are open to a renewal of this recommendation, and reconsideration of establishing an Advisory Council.

C. OVERVIEW OF ACADEMIC QUALITY

The University of Arizona's Laboratory of Tree-Ring Research (LTRR) is recognized nationally and internationally as the only educational institution in the world that provides the full breadth of the basic skills necessary for the practice of dendrochronology and its application to archaeology, climatology, ecology, hydrology, and many other disciplines. LTRR is the birthplace of dendrochronology, and until approximately 25 years ago was the only educational facility with training in dendrochronology. As a result, most faculty and staff working at other tree-ring laboratories received their degrees or training at the University of Arizona. The faculty and specialized staff of LTRR come from a wide variety of academic and research backgrounds and have cumulative and collective experience in dendrochronology unmatched anywhere in the world.

C.1. Resource Criteria

C.1.1. Teaching and Training

LTRR offers uniquely broad educational and research opportunities in many aspects of dendrochronology. The breadth of the faculty and the research opportunities make LTRR a facility of choice for anyone interested in dendrochronological training and research.

Students and scholars trained at LTRR come from many other departments on campus, from each of the three State Universities in Arizona, from many other colleges and universities in the United States, and from numerous foreign countries (**Table C.1**). Students enrolled in the *Introduction to Dendrochronology* course (GEOS/ANTH/WSM 464/564), which is our primary course for new students in dendrochronology, hail from a wide variety of backgrounds and departments on campus. Many foreign visitors do not enroll in the introductory course, but receive specialized training in nontraditional settings, such as workshops or as part of research projects. Three summer pre-session courses (workshops) were recently created (beginning in 2002), and these serve to meet some of the training demand from students and scientists. Also, plans are underway to develop a "Dendrochronology Certificate" program, which would enable LTRR students, interns, and visitors to work toward this formal credential recognizing their training in multiple courses and workshops at LTRR. Complete details on the teaching activities of the LTRR are provided in section **G.**

Table C.1. Countries of origin and numbers of our visitors from 1999 to 2006. Visiting scholars travel to Tucson from many different countries, and return with in-depth knowledge of dendrochronology.

Algeria (2)	Italy (1)	Spain (3)
Argentina (1)	Japan (2)	Sweden (2)
Australia (1)	Jordan (8)	Switzerland (5)
Canada (11)	Korea (1)	Syria (2)
Chile (2)	Lebanon (1)	Taiwan (1)
China (3)	Mexico (2)	Tunisia (1)
Costa Rica (1)	Morocco (2)	Turkey (2)
Denmark (1)	Netherlands (1)	United Kingdom (5)
Finland (1)	Peru (1)	United States (224)
Germany (9)	Poland (1)	Venezuela (2)
India (2)	Russia (3)	(Israel (3)
South Africa (1)	Zimbabwe (1)	

Since 1999 LTRR has also provided specialized training in dendrochronology to Jordanian scientists and to students from Arizona State University, Northern Arizona University, Prescott College, the University of

Minnesota, Indiana University, the University of Utah, California State University at Long Beach, Cornell University, the University of Barcelona, The Norwegian Agricultural University, the University of San Diego, the University of Western Ontario, Nara National Cultural Properties Research Institute (Japan), and the Universities of Bradford, Bristol, and Sheffield (Great Britain) as part of their advanced degree programs.

C.1.2. Tree-Ring Collections, Data, and Application Examples

LTRR is the largest and most complete repository of tree-ring data and samples in the world. Many of our samples contain tree rings absolutely dated to the year, and all are available to students for research and independent study projects. We also retain undated specimens that might be useful for future research. Specialized collections include:

- More than 400,000 archaeological samples used to absolutely date archaeological sites and reconstruct climate in the U.S. Southwest and elsewhere and for specialized studies including additional dating of archaeological sites on Mesa Verde and the deserts of southern Arizona and northern Mexico, sourcing construction timbers in Chaco Canyon great houses, distinguishing cottonwood from aspen timbers in Chacoan sites, identifying patterns in wood-use behavior that characterize different ethnic groups (Puebloans, pithouse builders, Navajos, Spaniards, Anglos, etc.), and isolating frost damaged rings that identify cold intervals that may have adversely affected native crop production.
- Thousands of samples used to study the history of forest fires on U.S. public lands, and to study fire, climate, and land-use patterns in other parts of the world.
- More than 500 tree-ring width and wood density chronologies, each composed of dated samples from multiple trees, and which are used for detailed interpretation of past climatic patterns.
- Thousands of dated and undated samples of bristlecone pine, including the materials from Methuselah Grove that provided the basis for calibration of the radiocarbon time scale, and continue to be in demand by radiocarbon laboratories.
- Midwest sub-fossil timbers dated between Late-Pleistocene – Mid Holocene (15,000-6000 BP) includes more than 800 specimens from 24 locations through five states of the US (Wisconsin, Illinois, Indiana, Michigan and Nebraska). About 600 specimens are crossdated within the locations and calendar dates are established with numerous radiocarbon measurements.
- Siberian collections of larch include dozens of dendrolimatic sites across Northern and Southern Siberia that provide information on climate variability over the past 2,000 years. Another part of this collection consolidates unique archaeological timbers from Siberian-Scythian burials that have been scattered around Russian institutions for the last 70 years. This is the most representative and largest collection of timbers associated with nomadic cultures of Inner Asia, with significant implications for the Iron Age chronology in Eurasia.

LTRR was the original home of the International Tree-Ring Data Bank (ITRDB), an on-line repository of tree-ring data from around the world. LTRR now cooperates with the National Oceanic and Atmospheric Administration's Paleoclimatology Branch in Boulder, Colorado, which manages and maintains the database. The ITRDB offers unique opportunities for educational and training exercises in dendrochronological applications as well as in mathematics, statistics, and other sciences. LTRR faculty have also helped create a new database also maintained by NOAA, called the International Multiproxy Paleofire Database (IMPD), which contains fire history chronologies from fire scars in tree rings and charcoal in lake and bed sediments. This database is being used by researchers for fire climatology studies and by fire managers who need baseline information on fire history.

LTRR accomplishes its teaching and research mission with a variety of specialized approaches, most of which are relatively inexpensive to maintain. After proper surface preparation in our shop, tree-ring samples are used by many different researchers at LTRR in fields such as:

- Archaeology, relying on the skill of the analysts and previously collected reference materials to provide approximately 4000 archaeological dates per year to various state, federal, and private institutions.
- Fire History, using data bases to provide detailed information concerning past fire frequency, seasonality, and extent of fires on public lands throughout the western United States, and extending such research internationally.
- Isotopic Dendrochronology, in work largely dedicated to calibrations and reconstructions of climate and providing detailed information on the changing chemical nature of the atmosphere.
- Dendroecology, using tree-ring data to investigate environmental changes, including the effects of insect outbreaks and drought on tree growth and dynamics of forest and woodland ecosystems in the southwestern United States and northern Mexico.
- Synoptic Dendroclimatology, using absolutely dated tree rings to study and reconstruct past and present climate from the viewpoint of atmospheric circulation in order to understand the seasonal, annual, and decadal-scale variability of circulation patterns.
- Paleoclimatology, using tree-ring data to retrodict patterns of precipitation, temperature, cloud cover, stream flow, and other aspects of climate over long time periods in many areas of the world.
- Dendrohydrology, deriving information on long-term droughts, streamflow extremes, and water supplies from tree-ring measurements and modeling.

C.2. Reputation Criteria

The Laboratory of Tree-Ring Research is the oldest and most widely recognized dendrochronological facility in the world. Since its founding, LTRR has been the leading facility both nationally and internationally for the study of tree rings and the information they provide concerning past climate, past human behavior, and the interaction between the two.

The broadest and most complete dendrochronology curriculum in the country is offered at LTRR, and other institutions routinely send their students, undergraduate, graduate and postgraduate, to study and conduct research here. Although a few institutions may provide more detailed coverage of specific aspects of tree-ring analysis, none delivers the breadth available at the University of Arizona.

Tree-ring research is one of the University of Arizona's most nationally and internationally recognized scientific activities. The faculty, staff, and students of the Laboratory routinely publish results of their research in national, international, and regional journals, as books and monographs, and as articles directed toward the general public (**Table C.2**).

Table C.2. Scholarly publication venues (journals and book publishers) for LTRR faculty, staff, and students 1999-2006. (Additional venues not listed include institutional report series, and other miscellaneous publications.)

Academic Press
Agricultural and Forest Meteorology
Agriculture Ecosystems and Environment
Agronomy Journal
American Antiquity
American Geophysical Union
Applied Geochemistry
Archaeology in America
Arizona Archaeologist
Artificial Life
Astrobiology
Basic and Applied Ecology
Bioscience
Bulletin of the American Meteorological Society
Bulletin of the Ecological Society of America
Cambridge University Press
Canadian Journal of Forest Research
Carbon Cycle on the Territory of Russia
Chemical Geology
Chemosphere: Global Changes Science
Climate Change
Climate Dynamics
Climate Research

Climatic Change
Columbia University Press
Dendrochronologia
Discovering Archaeology
Doklady Earth Sciences
Earth and Planetary Science Letters
Earth Interactions
Ecological Applications
Ecological Studies (series), Springer, New York.
Ecology
Encyclopedia of Hydrological Sciences
Environmental Monitoring and Assessment
Environmental Science & Technology
Eos
Evolutionary Anthropology
Geochimica et Cosmochimica Acta
Geoderma
Geophysical Research Letters
Global and Planetary Change
Global Change Biology
Global Ecology and Biogeography
International Journal of Climatology
International Journal of Wildland Fire
Island Press
Journal for Nature Conservation
Journal of Experimental Botany
Journal of the American Water Resources Association
Journal of Archaeological Science
Journal of Arid Environments
Journal of Climate
Journal of Environmental Quality
Journal of Forestry
Journal of Geophysical Research
Journal of Hydrology
Journal of Imaging Science and Technology
Journal of Natural Resources and Life Sciences Education
Kiva
Landscape Ecology
Nature
Navajo Nation Papers in Anthropology
New Phytologist
Oecologia
Optical Engineering
Oxford University Press
Palaeobotanist
Paleoceanography
Paleoclimate, Global Change and the Future
Photosynthesis Research
Plant, Cell and Environment
Priroda
Problems of Ecological Monitoring
Ecosystem Modelling
Proceedings of the National Academy of Sciences of the USA
Quaternary Research
Quaternary Science
Quaternary Science Reviews
Radiocarbon
Remote Sensing of Environment
San Francisco Estuary and Watershed Science
Santa Fe Institute Studies in the Sciences of Complexity
School of American Research Press
Science
Science of the Total Environment
Smithsonian Books, Washington
Soil Science
Southwest Hydrology
Southwestern Lore
Springer Verlag, Berlin
The Holocene
The Palaeobotanist
The Strad
The University of Arizona Press
The University of Utah Press
Toxicology and Industrial Health
Tree-Ring Bulletin
Tree-Ring Research
Trees
University of New Mexico Press
University of Utah Press
Water Resources Research
Water Resources Update
Water, Air, and Soil pollution
Western North American Naturalist
Wood and Fiber Science

LTRR contributes substantially to efforts to promote and showcase the University of Arizona's research contributions, and we are often chosen as a representative example of the University's uniqueness and excellence. One example is a recent UA promotional set of materials created by the University in 2005, including a video, PowerPoint slide show, and a printed brochure that heralds the University's history and contributions to science and society. Dendrochronology, and "Using tree rings to learn about the Earth's past climate history", is prominently featured in these materials as a unique and notable "discovery" made at the UA. Another example is the recent production and airing of two 30-minute episodes of "The Desert Speaks" on tree rings, droughts, and forest fire research by LTRR scientists. "The Desert Speaks" is an Emmy Award winning

nature program, nationally syndicated (over 100 stations), and produced by KUAT, the PBS station located at the UA. Other examples include: a weekly "Tree-Ring Talk" brown-bag series at the LTRR, which draws audiences from on and off campus; participation of one of our faculty members (Hughes) in a recent public lecture series on Global Climate Change that drew crowds of hundreds; and graphical, photographic and text highlights on the use of tree-ring research in water management included in the annual report of Arizona's Salt River Project, and California Department of Water Resources.

C.3 Outcome Criteria

The faculty, staff, and students of LTRR have received numerous awards and sit on various national committees and advisory groups, which attest to their excellence and productivity. For example:

Jeff Dean:

- Appointed Curator of Archaeology, Arizona State Museum, The University of Arizona (2000).
- Appointed a Science Advisor, *Earth and Sky* public radio series. (2000)
- Lifetime Achievement Award, Society for American Archaeology (2001)
- Elected a Fellow of the Arizona-Nevada Academy of Science (2001)
- Byron S. Cummings Award, Arizona Archaeological and Historical Society (2005)
- Appointed Agnese and Emil W. Haury Professor of Archaeological Dendrochronology, Laboratory of Tree-Ring Research, The University of Arizona (2006)
- Alfred V. Kidder Award for Eminence in the Field of American Archaeology, American Anthropological Association (2006)

Mike Evans:

- NSF-CAREER award (2004-2008).

Don Falk:

- International Association of Landscape Ecology (US), Student Presentation Award, Honorable Mention. (2004)
- Ecological Society of America, Edward S. Deevey Award, for outstanding graduate presentation in paleoecology (2003)
- Member, Forest Health Advisory Council, appointed by Arizona Governor Janet Napolitano (2003-present)

Katie Hirschboeck

- American Meteorological Society, Editor's Award for the *Journal of Hydrometeorology*, "for exceptionally thorough reviews of papers submitted during the journal's inaugural year." (2001)
- National Research Council/National Academy of Sciences *Committee on Geography*, Board on Earth Sciences and Resources, Commission on Geosciences, Environment, and Resources (2000)

Malcolm Hughes:

- Bullard Fellowship, Harvard University (1999)
- Visiting Faculty Member, Earth Sciences Dept. University of Massachusetts, Amherst (2000)(year?)
- Visiting scientist, NOAA Paleoclimatology Program, Boulder, CO. (2000)
- UA College of Science Galileo Circle Fellow (2006)

Paul Sheppard

- Diploma Básico de Español Como Lengua Extranjera (Basic Diploma of Spanish as a Foreign Language) (1998)

- UA College of Science Staff Recognition Award of Excellence, Laboratory of Tree-Ring (2000)
- University of Arizona College of Science Staff Recognition Award of Excellence (2000)
- Associate Investigator of the Arizona Cancer Center (2005)
- University of Arizona College of Science Distinguished Early Career Teaching Award (2005)

Thomas Swetnam:
- Walter Orr Roberts Lecturer, Aspen Global Change Institute, Aspen Colorado (1999)
- Invited testimony to US House of Representatives, Committee on Natural Resources, on Forest ecosystem health and restoration, Washington, DC, June 7, 2000
- Invited testimony to US House of Representatives, Committee on Natural Resources, Subcommittee on Fire and Forest Health, field hearing Albuquerque, NM, August 14, 2000
- Weaver Lecturer, School of Forestry and Wildlife Science, Auburn University, January 20, 2000
- W. S. Cooper Award, Ecological Society of America, with J. L. Betancourt, for outstanding paper in geobotany and physiographic ecology (1998 J. Climate paper), (2001)
- Henry Cowles Award, The Association of American Geographers, Biogeography Specialty Group, for outstanding paper in biogeography, with J. Speer, Boyd Wickman and Andy Youngblood (2002)
- Member, Board of Trustees, Valles Caldera National Preserve, appointed by President William J. Clinton, (2000-2004)
- Member, Forest Health Advisory Council, appointed by Arizona Governor Janet Napolitano (2003-2006)
- Member, Climate Change Advisory Group, appointed by Arizona Governor Janet Napolitano (2005-2006)

Ron Towner:
- Arizona Archaeological and Historical Society, Appreciation Award, 2004

Our students routinely present papers at regional and national meetings, publish their results in scholarly journals, and receive merit-based awards for their research. Notably, undergraduate students in the Dendrochronology Workshop have also had their results published in the *Tree-Ring Bulletin* (now *Tree-Ring Research*). Student awards in the recent past include:

NASA Earth Science Graduate Fellowship
Alsie/Edmund Schulman Scholarship
American Meteorological Society Student Travel Grant
Andrew Ellicott Douglass Memorial Scholarship
Arizona Floodplain Managers Association Scholarship
Arizona Scholars Award
Association for Fire Ecology travel grant
Association of American Geographers Hazards Specialty Gp Kasperson Student stipend
Association of Pacific Coast Geographers, President's Award for Outstanding Paper by a PhD Student
Association of Pacific Coast Geographers Student Travel Award
Association of Pacific Coast Geographers Women's Network Margaret Trussell Memorial Fund Scholarship
Biogeography Specialty Group of the Association of American Geographers
Bristlecone Pine Award
Chevron Texaco Best Paper Award in Paleoclimatology/Paleoecology/Paleobiology
Collaborative Forest Restoration Program (US Forest Service)
College of Science Award: Outstanding Graduate Teaching Assistant (Spring 2005)
College of Social and Behavioral Sciences Pre-Doc Research Grant
Colorado Scientific Society Research Grant (Summer 2005)

Conoco-Phillips Prize for Best Quaternary Geology/Paleoclimate Talk, Geosciences Symposium, University of Arizona
Department of Arid Land Research Studies, Travel Award
Department of Geography and Regional Development, University of Arizona, Travel Grant
Exploration Fund Grant, The Explorers Club
Galileo Circle Scholar 2005, 2006
Geography and Regional Development, Professional Development Scholarship
GPSC Student Showcase, 2nd place in Physical Sciences, Mathematics, Computer Engineering, & Computer Science
Graduate and Professional Student Council Travel Grant, University of Arizona
Guest editor, Canadian Water Resources Journal, Special Issue on past drought in western Canada.
Hoshaw Scholar Award, Department of Ecology & Evolutionary Biology
Institute for the Study of Planet Earth Travel Grant, University of Arizona
ISPE Earth Fellowship
Lamont-Doherty Postdoctoral Fellowship at Columbia University
Lewis and Clark Field Scholar Award, American Philosophical Society
Marshall Foundation Fellowship
McGinnies Scholar Award, Department of Arid Land Research Studies
Mountain Studies Institute Mini-Grant: (Summer 2005)
NASA Earth Science Graduate Fellowship renewal
National Science Foundation Doctoral Dissertation Improvement Grant
NSF IGERT Fellowships
P.E.O. Scholar Award, P.E.O. International
Prairie Adaptation Research Collaborative Graduate Scholarship (renewal)
Professional Development Scholarship, Geography & Regional Development
Social and Behavioral Sciences Research Institute, UA Summer Research Grant Development Stipend
Sulzer Scholarship (Geoscience)
U.S. Environmental Protection Agency STAR Graduate Fellowship
UA Collaboration to Advance Teaching Technology and Science (CATTS) Fellowship
University of Saskatchewan award for best graduate student seminar for 2005/2006
USDA 3 Year Graduate Research Environmental Fellowship

The success of graduate students who have emphasized dendrochronology in their chosen field is another testament to the importance of the LTRR. Positions filled by former LTRR students include 53 academic positions, 17 government positions, and 26 private sector positions.

C.4. Program Improvements

Despite national and local academic retrenchment and budget cuts in the past decade, LTRR has continued to expand opportunities for students, faculty, and the general public to explore the natural world and humanity's place in it. Our expanded outreach program is described in section **H** of this document. In the early 1990s, we redesigned our course structure to provide more intensive seminar courses on specific applications of dendrochronology to aid those students whose career goals necessitated more in-depth knowledge of particular subfields of dendrochronology. New seminar courses developed in the past seven years include:

- applied time series analysis
- stable isotope dendroecology
- dendrochemistry
- dynamics of tree-ring formation
- the dendrochronology workshop

- X-ray densitometry and cell dimensions
- fire climatology
- dendroecology
- tree-ring dating in archaeological research
- spatiotemporal data analysis workshop
- paleoclimatology of El Nino/Southern Oscillation

In addition to graduate level seminars, LTRR has developed new undergraduate courses, such as Geos 478 (Global Change), Nats 101 (Introduction to Global Change), Geog 431 (Global and Regional Climatology) and Geos 220 (Environmental History of the Southwest), that provide undergraduate students with the opportunity to explore critical aspects of important contemporary topics. Global Change (Geos 478), cross listed in Geosciences, Hydrology, Atmospheric Sciences, and Renewable Natural Resources, has been well-received by undergraduate students. In the past, Nats 101 (Introduction to Global Change) has been limited to 60 students per semester, but the limit has doubled since the Fall 1999 semester. The Environmental History of the Southwest course commences in the Fall 1999 semester, and it has been essentially filled (maximum enrollment of 150) every semester. It is possible that these programs will develop into formal on-line courses available for "distance learning,"-- an approach that will significantly augment the number of students familiar with the theories and techniques of dendrochronology.

C.5. Conclusions

LTRR has a long and distinguished history at the University of Arizona, and the faculty, staff, and students of LTRR are proud to contribute to the institution. Over the past seven years, we have maintained and strengthened our position as one of the leading institutions in the world for the study of past climate variability, human behavior, and the interaction between the two. The breadth of experience of our faculty remains unmatched anywhere in the world, our scientific staff continues to contribute to teaching and research in a significant manner, and our students, both graduate and undergraduate, win awards and grants and publish their results in important books and journals. Our outreach program continues to contact thousands of people every year, and our visibility both inside and outside the university continues to increase. We are continually revising our curriculum to meet the needs of students interested in various aspects of dendrochronology, and will continue to pursue our research, teaching, and service obligations with vigor.

D. CURRENT FACULTY AND OTHER PRINCIPAL INVESTIGATORS

D.1. Introduction

Currently, the Laboratory has 12 core faculty members. By "core faculty" we mean those individuals who contribute to all major aspects of the LTRR mission (research, teaching, and service), and their primary employment (state funded and non-state funded lines), as well as their offices and labs, are in LTRR. Of these 12 faculty members, 7 are tenured or tenure-track professors on state-funded lines, two are non-tenure track professors on combined state-funded and grant funded lines, and 3 are adjunct, non-tenure track professors in grant funded positions. All of the core faculty members are full time, except the adjunct professors, who occasionally are part time, depending on grant funding.

The core faculty consists of four tenured, full Professors (Dean, Hughes, Leavitt and Swetnam, who also serves as Director), one tenured Associate Professor (Hirschboeck), two non-tenure track Associate Research Professors (Meko and Touchan), two tenure-track Assistant Professors who are currently being considered for promotion (Evans and Sheppard), one Adjunct Associate Professor (Falk), and one Adjunct Assistant Professor (Towner). Two Emeritus Professors also maintain affiliation and activity in Laboratory affairs (Dr. Bryant Bannister and Dr. Harold Fritts). In addition to their primary academic appointments in LTRR, most of the core faculty members also have formal joint appointments in other departments, in particular: Anthropology, Arid Lands Studies, Arizona State Museum, Atmospheric Sciences, Ecology & Evolutionary Biology, Geography & Regional Development, Geosciences, Hydrology & Water Resources, and School of Natural Resources.

Abbreviated curriculum vitae for all faculty members are included in **Appendix A** and full length curriculum vitae are included in **Appendix B.** The CVs summarize the breadth and nature of the faculty's scholarly contributions.

D.2. Faculty Strengths and Weaknesses

D.2.1. Strengths

The primary strength of LTRR lies in its organic integration of many research specialties into a directed focus on all issues and applications to which dendrochronology is relevant. Lab personnel represent many of the fields touched by tree-ring analysis and engage in research that transcends the limits of a single specialty. With faculty from the natural and social sciences, the Lab is one of only a few truly interdisciplinary units at The University of Arizona. The composition, structure, and organization of LTRR result not only in cooperative research and teaching that involves different disciplines, they also create a particularly fruitful environment for interdisciplinary cross-fertilization in which ideas, procedures, and data developed by one program are adopted, adapted, and applied to the special requirements of other programs. For example, the theories and techniques of dendroclimatology are applied to long archaeological tree-ring chronologies to illuminate the role of environmental variability in human socio-cultural change, while climate-sensitive archaeological ring sequences help elucidate past climate change over periods longer than those generally available to living-tree-based dendroclimatology. Personal interactions among scholars representing different disciplines assure that each specialty benefits to the fullest from the input of others and that each does not inadvertently overstep the theoretical and procedural boundaries defined by the others. Face-to-face interaction within LTRR provides the conceptual and methodological impetus for advancing the field of dendrochronology and the cross-disciplinary rigor that ensures the quality and relevance of the work.

A second major source of faculty strength lies in the qualifications, talents, achievements, and potential of the individuals involved. As documented in the abbreviated curriculum vitae (**Appendix A**) and complete vitae (**Appendix B**), each core faculty member has made important contributions to dendrochronology, to the individual scientific fields with which he or she is allied, and to interdisciplinary considerations that bridge multiple fields. The joint faculty members and non-core adjunct faculty also bring substantial complementary expertise and resources to our research and teaching endeavors. Publication and

citation records, success in acquiring grants and contracts, student feedback, and peer evaluations testify to the impact of the faculty's research, teaching, and service. Their efforts have generated many expressions of recognition, ranging from achievement awards from scientific societies, to College and University awards for teaching, to appointments by state and national elected officials to advisory boards.

Many different academic specialties are represented by the current faculty and PIs of LTRR. In addition to the fields in which they hold degrees, most faculty members have developed recognized expertise in other disciplines that proved relevant to their dendrochronological work. Such specialties include anthropology, archaeology, atmospheric science, botany, climatology, ecology, forestry, geography, geosciences, global change, hydrology, soil science, and watershed management. The reach of the faculty's disciplinary proficiency is indicated by the wide range of courses taught in a large number of departments (see section **G**). This range of expertise and affiliation with different departments also makes the faculty available as advisors and committee members for students representing a broad spectrum of interests, majors, interdisciplinary applications, and academic programs at the University and other institutions of higher learning throughout the world (see sections **G** and **H**). Finally, the international reputation of the Lab and its faculty is a primary mechanism for establishing contacts with other scientists worldwide, bringing advanced scholars to the Lab, and attracting outstanding students to the various affiliated departments.

Another major strength of the faculty is its individual and collective ability to cooperate with one another and with scholars from other places. Joint research projects carried on by teams consisting of two or more faculty members have a long tradition in the Lab and have materially expanded the scope of dendrochronology and enhanced scientific knowledge of numerous of topics. Similarly, LTRR faculty have evinced a strong propensity for working with colleagues from other institutions in other parts of the country and around the world. These activities are thoroughly documented in sections **C**, **I**, and **J** and **Appendices A and B**, and only a few examples are mentioned here.

Intra-laboratory collaboration is exemplified by collaborative research by Hirschboeck and Meko on hydro-climatic patterns in major river basins of the western U.S., Hughes and Evans on modeling of responses of trees to climate, Swetnam and Falk on forest fire research and restoration ecology in Southwestern forests, Touchan and Hughes in the extension of dendrochronology in the Near East, and Dean and Towner with joint work on Navajo dendroarchaeology and archaeological chronologies in western North America. Intra-laboratory and intra-departmental educational cooperation involves the team teaching of undergraduate and graduate courses in Anthropology, Geosciences, the Global Change Interdisciplinary Program, the undergraduate general education program, and supervision of students involved in the University of Arizona's NSF IGERT program in archaeological sciences.

Collaboration with scholars from other institutions is exemplified by Touchan, Hughes, and Meko's involvement with Jordanian, Turkish, Syrian, Lebanese, Tunisian, and other colleagues in chronology building and dendroclimatic research in the Middle East and northern Africa; Hughes and Swetnam's work with Russian dendrochronologists in dendroclimatology and dendroecology; Hughes' collaborations with colleagues at University of Massachusetts, Pennsylvania State University and elsewhere on hemispheric-scale climate reconstructions; Sheppard, Falk, Swetnam and Towner's work with different colleagues and institutions in Mexico on volcanology, fire ecology, and archaeology investigations; and Dean's cultural modeling research with scholars from the Arizona State Museum, the Santa Fe Institute, the Brookings Institution, and the University of Massachusetts.

Collectively, faculty members have contributed significantly to the advancement of knowledge along a broad front. All members have actively furthered the development of dendrochronological theory and methods in ways ranging from expanding archaeological dating theory to modeling environmental effects on ring growth to refining techniques for capturing and analyzing tree-ring width, density, and cell data. Basic tree-ring chronology building activities have produced proxy records of past climatic variability for many regions and standards for the absolute dating of past geologic and human events. Dendroclimatic, dendrohydrologic, dendroecological, and dendroisotopic work around the world has materially advanced knowledge of climatic, hydrologic, and ecological conditions in many areas as well as increased

understanding of large scale (hemispherical and global) events and processes such as the Medieval Warm Period, the Little Ice Age, global change, El Niño-Southern Oscillation, the North Atlantic Oscillation, atmospheric circulation, and others. Archaeological and geological tree-ring dating coupled with local and regional dendroclimatic reconstructions have illuminated the prehistory of western North America, elucidated the processes of human sociocultural stability, variation, and change, and advanced general understanding of the evolution of culture.

D.2.2. Weaknesses and Needs

The faculty and staff of the Laboratory have been creative, productive and industrious over the past seven years, but are frustrated by some limitations on their capacity to respond to a number of exciting research opportunities. One prime source of limitation is the small size of the tenured and tenure-track faculty and the absence of some key areas of expertise within that faculty. This weakness was identified in the 1999 APR, where we noted that state-funded faculty FTEs had decreased since the mid 1980s from nine to seven lines as a consequence of budget cuts. No new state-funded faculty or staff lines have been added since that time. On the contrary, the LTRR and the University as whole, have been burdened with numerous additional state budget cuts in the past seven years, which have been met in LTRR by cutting operational costs to the bone (and beyond), and by eliminating two state funded staff lines (an office staff member and a science staff member). Reduced faculty and staff numbers have increased the burden of maintaining some programs. These reductions have also decreased the faculty's capacity to maintain the greater breadth and depth of dendrochronological coverage that the Laboratory achieved over many years of development.

We were glad to be able to replace two faculty members in 2000 (one retirement and one departure) with two new faculty members (Evans and Sheppard). The renowned climatologist, Robert E. Dickinson, a joint faculty member during the previous APR (with 0.25 each of his FTE in the LTRR and the department of Hydrology and Water Resources, and 0.50 in Atmospheric Sciences), departed to another University. Since then, our total state-funded faculty lines have remained constant at seven FTEs.

In this context the LTRR has pursued several strategies to build research strength and breadth in its faculty. One strategy has been to encourage two PhD scientific staff members (Meko and Touchan) to expand their research programs as principal investigators, and to fully engage as core faculty. The expansion of these scientist's roles in the Lab, and conversion of their titles to "Research Associate Professor", have been successful in terms of increasing the breadth and depth of our research and teaching programs. Increasing their salaries, however, has been difficult, and has been achieved to some degree by supplementing their state lines (originally at staff salary levels) from their grant funding to amounts more commensurate with faculty levels. This is not a satisfactory arrangement because the financial accounting is cumbersome, dependent on grant funding success, and supplementary funding of this sort is limited by some agencies (such as NSF, which will pay only for summer months of salary for faculty on academic year appointments). Additionally, the conversion of these staff lines has necessarily decreased the support staff available to assist other faculty and carry out basic functions of our operations. Dr. Meko had previously operated for a number of years primarily as an independent principal investigator, and so his conversion to a professor title and primarily a faculty role only slightly decreased the staff support. Dr. Touchan, however, was primarily a support staff member prior to the expansion of his scientific leadership and teaching role and change of his title. Hence, these changes have been beneficial overall in generating more research dollars, publications, etc., but have placed strains on various Lab operations, such as basic tree-ring dating and measuring services, archival management, field work assistance, etc.

A second strategy to build research and teaching capacity has been to encourage highly productive postdocs and associates to remain at the Laboratory in a core faculty role and to further develop their research and teaching programs (i.e., Falk, Panyushkina, and Towner). These scientists bring valued breadth of expertise and resources to our research, teaching and outreach missions, and they have demonstrated abilities to generate all or some of their salaries from grant funding. This encouragement has taken the form of providing office and laboratory space (limited and substandard as it is), some partial and temporary salary

support for teaching or research, and inclusion of these individuals as "core adjunct faculty" in Lab decision making and goal setting. This approach is working fairly well, in the sense that greater breadth of expertise is achieved, more valuable research is underway, etc. Again, however, the weakness of this approach is that the lack of reliable funding support for these individuals is stressful on them, and ultimately they may decide to seek more stable employment elsewhere, and we would then lose their direct contributions and collaborations. Also, their participation as full faculty members is proscribed by their need to work exclusively on funded projects during most of their time, with limited time for teaching or service functions, except where we find temporary dollars to support these endeavors.

The weakness in our faculty discussed in the 1999 APR – i.e., a reduction of state-supported faculty lines, which reduced our "critical mass" of expertise and research breadth and depth – has only partly been corrected by pursuing the strategies described above. Moreover, these strategies and additional budget cuts imposed upon LTRR have contributed to other problems (e.g., staff shortages and operational constraints). Two areas of deficiency in faculty numbers and area of expertise are most notable: archaeological dendrochronology, and wood biology and functional anatomy. These needs and plans to overcome them are described below.

D.2.3. Archaeological Dendrochronology: Needs and Plans to Meet Them

As late as the mid 1980s, the LTRR faculty included three archaeologists (Bryant Bannister, Jeff Dean, and William Robinson). Retirements, and their replacements in other topical areas, have reduced the state-funded faculty lines in archaeological dendrochronology to one – Jeff Dean. This reduction has two consequences: (1) an inability to fully manage the archaeological dating program, and (2) a decrease in the breadth of research and teaching coverage in archaeological dendrochronology, and therefore an inability to expand the programs into new topical and geographical areas.

The LTRR archaeological program differs from other Lab programs in that it exists independently of the faculty member(s) that run it. While other research efforts are bound to the faculty members who operate them, the archaeological program has an important component that transcends the participation of any single individual. By custom and formal agreements between the University and other institutions, the program routinely accepts and analyzes tree-ring samples submitted by archaeologists working in western North America. This procedure involves processing and analyzing an average of 4,000 samples per year, adding suitable samples to our permanent collection, and reporting the results to the submitters. This program is the sole source of archaeological tree-ring dates for western North America. The nature of this program and its obligations impose certain inescapable and irreducible tasks on its administrators: tracking accessions, supervising sample analysis, reporting results, managing finances, curating the collections, and responding to innumerable requests for information or assistance from scientists, administrators, students, and journalists. All these activities are in addition to the usual faculty obligations of performing original research, teaching and service.

A related problem is the loss, through retirement, of one of the three skilled dating technicians that analyzed the samples. Our inability to replace this individual, due to the lack of qualified replacements, has substantially reduced production. The situation has reached the point where we can no longer submit research grant proposals because there are no qualified staff people to analyze the samples that would be collected by the project. The only recourse is for the PIs to do the dating themselves, which of course hugely reduces the time available for other duties.

The recent creation, through the generosity of multiple donors, of the Agnese and Emil W. Haury Chair in Archaeological Dendrochronology and the Agnese Nelms Haury Graduate Fellowship in Archaeological Dendrochronology will go a long way toward stabilizing the LTRR archaeological research program. Providing that one state-supported faculty position remains devoted to archaeology, the Chair will restore the two-person faculty commitment necessary to maintain and expand the archaeological program. Two people sharing administration of the dating program will be free both to devote significant amounts of time to pursuing current research, responding to research opportunities as they arise, and developing new

research initiatives to expand the topical scope and geographical range of archaeological dendrochronology.

Two especially promising topics that need further development are chronometric theory and dendroarchaeology. First, with its unequalled accuracy, precision, and resolution, dendrochronology is ideally suited to exploring the nature of dates produced by different dating techniques and the unique contributions each of these makes to dating past archaeological, historical, and geological contexts. Refining chronometric theory will materially enhance the evaluation and comparison of all kinds of dates and thereby improve understanding of past human and natural events. Second, the more rigorous integration of tree-ring dates into archaeological contexts will illuminate many aspects of past human behavior including settlement, subsistence, social organization, demography, interaction within and among groups, and adaptation to environmental stability, variation, and change. The American Southwest – with its unequalled archaeological, anthropological, dendrochronological, and paleoenvironmental records – is an ideal place to pursue these issues. Although archaeological tree-ring dating is routinely applied in many regions of the world, many others are ripe for dendroarchaeological expansion. While eastern Asia is a hotbed of dendroclimatic applications, much remains to be done with the rich, well preserved troves of archaeological tree-ring samples available in this region. Current contacts with archaeologists establish the potential for investigating dendroarchaeological applications in northern Mexico, Mesoamerica, and South America. Dendrochronological work by Touchan and other LTRR investigators indicates a huge potential for archaeological tree-ring dating in northern Africa. The presence of two archaeologists at LTRR would allow the aggressive pursuit of these and many other, as yet unanticipated, opportunities.

Finally, considerable effort needs to be devoted to resolving the serious problems created by the diminishing number of qualified tree-ring daters that could impede the day-to-day operations and progress of LTRR. It is becoming clear that academia is not a prime source of people who possess the uncommon combination of aptitude, talent, experience, and patience to become effective tree-ring dating technicians. Therefore, we intend to pursue nontraditional ways of identifying, training, and hiring dating technicians to sustain the staff infrastructure of the archaeological program. Conceptually, this could involve contacts with high schools, community colleges, field schools, and avocational programs as well as targeted advertising campaigns and other approaches to the problem.

The new Graduate Fellowship will be a major benefit to developing archaeological dendrochronology at LTRR. The ability to recruit and support graduate students will be an integral part of our pursuit of new research opportunities whether they be chronometric, dendroarchaeological, or focused on traditional academic disciplines such as anthropology, archaeology, and geosciences. Thus, the graduate fellowship will be an important component of the topical and geographic expansion of archaeological dendrochronology.

D.2.4. Wood Biology and Functional Anatomy: Needs and Plans to Meet Them

The past decade has seen great progress in systematizing understanding of the biological basis of tree-ring variation, primarily through the efforts of Russian colleagues, originally working in collaboration with an emeritus faculty member here (Dr. Fritts), and in recent years with Dr. Hughes. The stronger our understanding of the mechanisms creating the natural archive becomes, the better the information available from them. This work is now beginning to yield important insights on the role of forests in biospheric change, particularly as it affects the carbon cycle. There has also been a considerable expansion of the kinds of record extracted from tree-rings, not only using stable isotopes and wood density, but also anatomical and microanatomical features. Opportunities exist for exploration and quantification of CO_2 fertilization effects on forests by means of tree-ring analysis in natural ecosystems around the world, and careful tree-ring analysis in association with future replicated CO_2 fertilization field experiments. Exciting possibilities also exist using chemical and other sophisticated analyses to extract new kinds of information from tree rings, for example, the rate of soil acidification in polluted areas, and the influence of nitrogen availability on growth on large spatial scales. The application of dendrochronology to tropical trees also requires strength in tree biology and wood science. More than half the Earth's land mass is found between the Tropics, but relatively little dendrochronology has yet been done there. All this work needs a strong background in tree biology and wood

science, areas in which we are currently weak.

Currently the only means we have to meet this need for expertise in wood biology/functional anatomy are external collaboration, to seek external grant funding opportunities which could attract post-doctoral associates, or to consider replacing filling a future faculty opening with a person having these strengths.

D.3. Participation, Leadership, and Influence on Academic Profession

Active participation by the faculty in their professions is demonstrated by their membership and involvement in many different professional societies. They are (or have been) elected officers, honored members (fellows), or both, in about half of those societies. The faculty provides extensive service as reviewers and unpaid consultants to dozens of regional, national, and international research organizations. These organizations include regional and national archaeological research institutions, land management agencies, the National Science Foundation, National Academy of Sciences, the International-Geosphere Biosphere Program and the World Climate Research Program. Faculty service to their professions and disciplinary interests are also reflected in their participation as editors and associate editors for eleven different professional journals. The faculty also serves on numerous departmental, college, and university committees. Professional contributions and involvement by each tenure track faculty member with primary appointments in LTRR are listed in more detail on their individual curricula vitae.

D.4. Potential for Response to Change

The Lab faculty has manifested in the past and maintains in the present a generally high aptitude for responding to important discoveries, changing directions in the field, and new external demands. This facility is demonstrated by LTRRs ability to remain in the forefront of most aspects of dendrochronology and to contribute meaningfully to the development of new applications, approaches, and methods. For example, the discovery that tree-ring attributes other than width contain useful crossdating and environmental information led LTRR to develop programs in ring density and isotopic content analysis that have advanced the reconstruction of several aspects of past environmental variability. Similarly, LTRR rapidly responded to recent changes in the direction of paleoclimatic research toward an emphasis on hemispherical and global scale environmental patterns and processes, and its faculty members have been leaders in the University's global change research and teaching programs.

Not content merely to respond to changing circumstances, the faculty adopts a proactive rather than reactive stance within dendrochronology and allied sciences. As outlined above, the faculty works hard to maintain a position of leadership in world dendrochronology, to anticipate impending developments, and to initiate ground-breaking, potentially productive research projects. While the last activity often is fraught with risk, such ventures commonly engender major progress. Even rare instances of failure are productive in that they help establish the limits of dendrochronology, improve methods, or indicate new, potentially fruitful lines of research. Risky or innovative ventures that have paid off in these ways include the stable isotope initiatives, applications of hydroclimatology in water management, fire history studies, the development of continental and larger arrays of tree-ring chronologies, and agent-based modeling of cultural systems.

Although burdened by the increasing constraints and obligations outlined in section **D.2**, the faculty maintains high levels of morale, commitment to the profession, and sense of self improvement. High morale is indicated by the collegiality of the faculty (whose members evince a willingness to cooperate with one another in research, teaching, and activities that benefit the Lab as an institution), by a readiness to share responsibilities and duties, and by the efficiency and general good will with which it responds to demands on its collective time, and resources. Commitment to the profession is demonstrated by service on national and international committees and panels and by participation in the academic life of the University, particularly in cross-cutting initiatives in the environmental sciences. Finally, a collective sense of self improvement is evident in the faculty's continuing efforts to improve teaching, expand research, solicit feedback on performance, and respond to changing academic conditions.

Individual faculty members have managed to strike a productive balance between traditional

dendrochronological pursuits and work on the frontiers of the science as is shown by the depth and breadth of scholarship outlined in previous sections and in abbreviated curriculum vitae in **Appendix A**. In terms of traditional research, nearly every faculty member engages in fundamental enterprises such as building composite tree-ring chronologies as standards for dating natural and human events and for reconstructing aspects of past environmental variability. As chronology is the essence of dendrochronology, every individual is deeply involved in applying absolute dates to past events including the growth of individual rings, forest fires, insect infestations, changes in plant community composition and distributions, changes in the chemical composition of the atmosphere and the surface environment, droughts, cold outbreaks, floods, the construction and modification of archaeological structures and sites, and many others. All are also engaged in using tree-ring records to reconstruct aspects of past environmental variability ranging from streamflow to atmospheric circulation patterns.

Every faculty member employs the traditional tree-ring pursuits as a foundation for pushing the frontiers of the discipline into uncharted topical, geographic, and temporal territory. Recent examples of expanding the compass of dendrochronology include Hughes', Evans', and Meko's cooperative efforts with other scientists to construct large (continental to hemispherical) networks of tree-ring chronologies and develop their paleoclimatic potential, Hirschboeck's linkage of tree-ring variability to synoptic atmospheric circulation patterns, Evans' work to expand the reach of dendroclimatology into the tropics using innovative stable isotopic techniques, Falk's and Swetnam's expansion of fire climatology investigations into the Great Basin and northern Mexico, Sheppard's collaborations with medical researchers in studying environmental contaminants and human health, Leavitt's investigations of the environmental implications of isotopic variations in tree rings, and Touchan's expansion of dendroclimatology and natural resource applications in the Middle East and northern Africa, Towner's revolutionary revisions of Navajo chronology, and Dean's agent-based modeling of cultural systems.

D.5. Collective View of Program's Future

During the past decade the LTRR's strategies in faculty recruitment, research, and teaching have emphasized new and important roles for dendrochronology in regional, national, and international scientific programs. These include a prominent role of dendrochronology in global change studies (especially past climatic changes) and expanding applications of tree-ring research in the ecological sciences. The importance of dendrochronology in these scientific programs arises from a central need to understand the historical range, variability, and trends in climate, ecosystems, and cultural processes. An informed assessment of modern conditions depends upon accurate, long-term, historical reconstructions for comparative perspectives. A particular strength of dendrochronology, and the LTRR, is interdisciplinary research that brings together historical perspectives of climate, ecosystems, and cultures. Continued human population growth, rising production of greenhouse gases, and increased pressures on natural ecosystems assure that there will be an expanding demand in the 21st century for basic knowledge and understanding of complex earth systems. This knowledge and understanding will be provided, in part, by tree-ring research. More generally, LTRR research, education and service activities support development of techniques and skills in multivariate geospatial data analysis and interpretation.

In order for LTRR to sustain its leadership role in research and teaching in tree-ring applications, it must capitalize on its existing strengths, engage in new interdisciplinary opportunities, and expand into areas of emerging scientific importance. We outline some strategies for achieving this (***D.5.1.***), and describe some of the new areas of research strengths that we have and/or which we plan to build (***D.5.2.***).

D.5.1. Strategies for the Future

Our strategy for facilitating the expansion of LTRR's research capabilities and activities rests on building depth and support of research foci represented by current researchers and expanding into new and promising areas by creating a greater through-flow of bright, young, motivated scientists, developing unit-wide and campus-wide initiatives in climate change, ecosystems, and society in collaboration with federal

scientists, and pursuing additional and more appropriate building space. We will pursue these strategies in the following ways:

- LTRR intends to increase the presence of talented, beginning scientists working and studying here through expanded and new graduate student, post-doctoral, and visiting scientist fellowship programs. Some support that may be employed in this approach has just been acquired with the Haury Endowed Chair in Archaeological Dendrochronology. The existing Haury Fellowship program, which supports short-term visitors and some graduate studies at LTRR, will also contribute here. Additional sources of support for graduate students and post-docs should be sought from various sources, including private donors, federal and state agencies, and other sources.

- LTRR will pursue the establishment of a graduate/professional Certificate in Dendrochronology will allow us to offer degree-related certification in tree-ring coursework—an opportunity not available at any other institution. This formalization of our curriculum should further enhance the recruitment of graduate students into our program in addition to attracting post-docs and professional scientists to spend periods of time at the LTRR. We will also continue our involvement in other teaching and training programs on campus, including Graduate Interdisciplinary Programs (e.g., Global Change and Arid Lands Studies), and a renewal of the Archaeological Sciences IGERT program (see below).

- LTRR will seek to continue and enhance inter-departmental and campus-wide collaborations. The Laboratory played a leading role in the establishment of the Institute for the Study of Planet Earth, the Global Change minor Interdisciplinary Program (IDP), the CLIMAS project (Climate Assessment for the Southwest), and the NSF IGERT (Integrative Graduate Education and Research Traineeship program) in Archaeological Sciences, a venture involving three colleges of the University. LTRR will continue to seek new opportunities for such teaching and research collaborations with colleagues elsewhere at the University of Arizona.

- LTRR plans to maintain, and where possible build, collaborations with federal scientists who have strong interests and experience in utilizing tree-ring data, or who bring important complementary skills for interdisciplinary collaborations with LTRR faculty and students. Collaborative opportunities with federal scientists have expanded in recent years (e.g., four new formally recognized, non-UA employed, Adjunct Professors) , and there is great potential for department-wide collaboration on societally-relevant climate change issues. Space permitting, federal scientists and their teams who have strong overlapping and complementary interests and expertise might be co-located in LTRR quarters. Advantages of this strategy may include an increased research diversity and pool of complementary expertise and funding sources, opportunities for our students to be mentored by these scientists, and potential future employment of our students in these agencies. This strategy will also facilitate more direct input to federal agencies applying our research findings.

- LTRR plans to continue vigorous efforts to acquire appropriate space for our offices, labs and archives. Despite many previous requests for additional and better space, and our obvious need, LTRR remains in sub-standard, dilapidated quarters in the West Stadium, where it has been located for 7 decades. We hope that current efforts to renovate existing spaces in the West Stadium will be pursued in the near term (i.e., 2007-2008), and efforts to acquire gifts and University support for a new building will be pursued over the long term (i.e., the next 7 years). Additional description of our space situation and planning are included in section **J.2.**

- LTRR will continue efforts to divert indirect cost returns from applications toward staff salaries so as to be more readily available for discretionary scientific needs and urgent opportunities. This will be

accomplished by continuing our efforts to increase the proportion of non-state staff salaries that derive from direct costs charged to grants.

D.5.2. Research Opportunities

There are number of broad topical areas in which we see major research and teaching opportunities. LTRR already has significant strengths and ongoing programs in some of these areas, but expansion in these areas is possible. Through joint faculty appointments the LTRR is at the heart of the multidisciplinary UA global change research environment, which spans over 20 departments, six colleges, the cross-cutting Institute for the Study of Planet Earth, and the planned Arizona Geochronology Center. In addition, LTRR personnel are engaged in local, national and international collaborations with geochemists, ecologists, archaeologists, toxicologists, and hydrologists. Hence the LTRR is well-positioned to pursue new opportunities in environmental quality and human health, paleoclimatology, geochronology, forest ecology, archaeology, and water resources.

Paleoclimatology and Climatic Variability: How and why has climate varied on interannual to multicentury time scales? The present paradigm for using tree rings to address these questions was pioneered here. It was based on building continental-scale networks of hundreds of well-replicated tree-ring chronologies, and using an empirical-statistical approach to identify and extract the climate signal. Further progress will depend on improved data and methods. For data, we need to: (1) extend the global network of high-quality dendroclimatological records to cover sparsely covered regions, most notably the tropical regions, along with large parts of the mid-latitude semi-arid regions in both Old and New Worlds; (2) update chronologies sampled in the mid-20th century to place them in the context of recent climatic variability and atmospheric-ocean circulation drivers; (3) exploit opportunities for extending and enhancing existing tree-ring networks; and (4) use modern analytical techniques to broaden the range of measurements made on existing tree-ring material, e.g. cell dimensions, density, isotopic ratios, trace elements, and trace organics, so as to better constrain estimates of the environmental conditions under which the wood was formed. Additionally, improved methods and insights are needed to solve problems that have emerged or whose significance has been recognized during the application of the "traditional" approaches. These include: (1) a better, mechanistic, basis for (a) removing the effects of tree size and age from series of tree-ring measurements; (b) understanding persistence in tree-ring variables; (2) identifying and characterizing non-linear responses of tree-ring variables to meteorological variables; (3) understanding errors and biases in tree-ring reconstructions of climate; (4) finding new ways to use tree-ring records to improve knowledge of past climate; and (5) integrating tree-ring paleodata with other proxy climate data sources, such as corals, cave deposits, lake and marine sediment records, ice cores and documentary records. To meet these challenges, LTRR will need strength in tree biology, functional wood anatomy, structural, chemical and isotopic analyses of wood, tree-growth and ecosystem modeling, an array of skills in multivariate statistics and related fields, and the capacity to link to work using forced climate models of recent centuries and millennia.

Long Chronologies: How may we make best use of the treasure trove of information on past environments contained in very long tree-ring records (1000-9000m years)? The last decade has seen a resurgence of work on multimillennial tree-ring chronologies at the LTRR, mainly, but not exclusively, in western North America. Existing networks have been expanded geographically, extended and enhanced in sample depth back in time, and, in many cases, updated close to present. An intensive effort has greatly improved and consolidated documentation of the longest tree-ring chronology, at Methuselah Walk in California as well as other extensive collections of long chronology materials and data at LTRR. Major opportunities exist to extend, enhance, and better exploit this extraordinary resource. For example, dated tree-ring material covering at least 1000 years exists from more than 80 locations in western North America, and at six of those sites they extend back 5000 or more years. In many of these cases, good provenience information exists for each of the many hundreds of trees contributing to these records. Modern geospatial techniques make

possible better understanding of the distribution of these materials on the landscape, for example, through the changing limits of tree growth over the Holocene or the identification of unexplored sites where additional samples might be found. There is also great scope for the regional integration of these chronologies with other evidence on past environmental variability and change, and of human responses to such change. We intend to coordinate studies of these archives with the planned Arizona Geochronology Center to estimate for establishing dates and rates of changes for landscape-scale environmental processes. Apart from a few isotopic studies little analysis has been done of tree-ring variables other than ring width and the occurrence of frost rings in these materials, and development of mechanistic understanding of the formation of even these two variables is at an early stage. This world-class scientific resource is unique, but it is currently dramatically underutilized and LTRR is developing strategies for making much better use of it.

Ancient Chronologies: Can our suite of tree-ring methods be applied to extract important information about interannual, and even seasonal, environment and environmental variability from sub-fossil wood? New collections of truly ancient wood dating to the Pleistocene or even earlier are being unearthed in various places of the world, providing new opportunities to learn about past environments in deep time. For example, an LTRR graduate student has been studying in Arctic regions subfossil and fossil tree-ring collections dating to the Pliocene as well as samples as old as the Cretaceous. These wood samples obviously do not extend to the present to connect with modern chronologies. Their principal novelty is their relatively great geological age and, therefore, their representation of environmental conditions substantially different from now. An exceptional opportunity exists for LTRR to contribute to current international efforts to extend the radiocarbon calibration curve into the Pleistocene by means of our own recent bristlecone pine chronology-building endeavor and Great Lakes wood project, both of which are focused on chronologies from wood greater than 10,000 years old. The strong radiocarbon dating presence on our campus should help facilitate this objective.

Stable Isotope Analysis: The 7th International Conference on Dendrochronology at Beijing in June 2006 had over two dozen talks and posters on tree rings and isotopes, the largest number of papers devoted to this topic of any scientific meeting heretofore. This illustrates the degree to which isotope methodologies have rapidly matured and proliferated across geographical regions, fields (e.g., "dendro-" ecology, physiology, climatology, hydrology, etc.), and species. LTRR now has three faculty members who have prominently incorporated stable isotopes into their research programs, Leavitt (mainly carbon), Evans (mainly oxygen) and Sheppard (mainly nitrogen), and others who have used some isotopic results in specific projects (e.g., Meko and Panyushkina). In fact, one Faculty member (Touchan) has become an active participant in the tree-ring isotope component of the European Millennium Project to characterize the environment of the last 1000 years across Europe. Furthermore, Prof. Evans has obtained a mass-spectrometer to pursue high-resolution research with tropical trees, with the intent of dating trees that may not be datable by the more traditional dendrochronological methods. Expansion of tree-ring isotope applications into "new" geographical areas and "new" species can be expected (at least pilot testing, if not actual reconstructions) where there is the possibility for isotopes to provide environmental information on a particular variable or season that standard tree-ring methods do not capture. There may be opportunities associated with continued technological improvements, such as rapid analysis using new laser technologies and computer-automated milling devices, the former of which is largely being developed in Europe. Likewise, we can anticipate in the near future more contributions to improve the mechanistic understanding of processes affecting isotopic composition in tree rings, new methods of data analysis of isotope series, more multi-isotope studies, compound-specific analysis, and analysis of isotopomers. The directions LTRR takes will be dictated by interests and research questions developed by faculty and future students and post-docs, and will be limited by availability of equipment and facilities. LTRR has modest laboratory facilities now, but a major improvement is expected with the hoped-for West Stadium remodeling in the near future. Cooperation with the Dept. of Geosciences has been extremely helpful in advancing current LTRR isotope activities despite the lack of appropriate laboratory

facilities at LTRR.

Environmental Sciences and Human Health: An emerging application of dendrochronology and other techniques of environmental science is to measure and characterize local environments for plausible contaminants that might be related to some existing public human health concern. For example, multiple spatial and temporal techniques have recently been used around various towns experiencing higher than average rates of childhood leukemia. In the prominent case of Fallon, Nevada, definitive environmental contaminants have been found, and now new lines of biomedical research are starting up as a response to this environmental work. To broaden this environmental science-public connection, dendrochronological and other environmental assessment techniques can be applied around communities experiencing too much breast and/or brain cancers, which are even more prevalent than childhood leukemia. Our studies are a total assessment of the environment of case towns. Dubbed the "ecologic" research strategy, this idea looks promising, but more testing is needed to determine its true usefulness. LTRR plans to be a leader in this line of research, with funding sources including NIH, EPA, and various private foundations.

Interdisciplinary Research in Human-Environment Interactions: Interdisciplinary research and teaching are long standing strengths of LTRR. LTRR faculty research and teaching, for example, commonly integrate the topics of change and variability in human cultures, ecosystems, and climate. Meanwhile, there has been an increasing recognition of the importance of the "human dimension" in national and international global change research programs and funding agencies. For example, dendrochronology could make additional significant contributions by linking dendrochronologically informed archaeological, anthropological, and historical reconstructions of human population movements and cultural developments with tree-ring and other measures of environmental variability. Outside the environmental change arena, dendrochronological dating in the service of archaeology and anthropology is well developed in western North America and Europe, but has yet to be systematically applied in other regions, for example, Mesoamerica, South America, and much of eastern Asia. Even within North America there are many opportunities, including involving Native Americans in the application of dendrochronology to the better understanding and management of their own natural and cultural resources. Tree-ring research is particularly well suited to the integrated study of cultural, ecological, and climatic change because it is possible to simultaneously reconstruct and compare independent histories of all three of these elements using different types of tree-ring data and quantitative methods and other paleoenvironmental reconstruction techniques. A particularly fruitful approach to the systematic study of human interaction with their physical and social environments is agent-based computer modeling, which integrates tree-ring and other paleoenvironmental reconstructions with archaeological, anthropological, and human demographic data into dynamic simulations that illuminate both human adaptive behavior and the modeling process. To capitalize on this interdisciplinary strength, to seize new research opportunities, and to maintain viable archaeological research and teaching programs in human-environment interaction, the LTRR will need to recruit at least one additional faculty member supported by the state and post-docs and graduate students with interest and expertise in the interactions between human cultures and environmental stability, variation, and change,. Finally, important research issues that require additional study and refinement are the theory and method of archaeological chronometry. Because of its unequaled accuracy, precision, and temporal resolution, dendrochronology is uniquely positioned to contribute to this subject, which is vital to understanding past human behavior.

Forest Ecology: The relationship of ecological disturbance to climatic and topographic variability is emerging as a central question in ecosystem studies. LTRR has long been recognized as a leader in several key areas of dendroecological research, including fire history and fire-climate relationships, insect outbreaks, and forest dynamics. LTRR has led development of the field of fire history reconstruction, including field exploration and the development of sampling methods, analytical procedures and software. Fire history has long been coupled with fire-climate analysis at LTRR, including analysis of the influence of interannual to

multi-decadal climate variation on fire regimes. Recent work is expanding the spatial domain of fire-climate analysis to sub-continental and inter-hemispheric scales in North, Central, and South America, including development of distributed multi-scale fire history networks. The detailed reconstruction of insect outbreaks using the tree-ring record has been pursued and developed at LTRR since the 1980s, with major advances in data processing and analysis to detect the dendroecological signal of outbreaks of multiple insect species on host and non-host species. Recent work has tied the timing and spatial distribution of insect outbreaks to climate variability and disturbance interactions between fire, climate, and insect population dynamics. In forest dynamics, LTRR investigates factors that influence tree distributions, including studies of the dynamics and mechanisms regulating upper and lower treeline. Recent and emerging work includes tree growth and ecophysiological responses to competition and disturbance as well as forest community dynamics on forest-grassland ecotones.

Water in Arid and Semi-arid Systems: Given that about a third of the Earth's land surface and a quarter of the world's expanding population are in arid/semi-arid lands where water availability is highly vulnerable to climatic variation and climate change, the collective expertise at LTRR together with the University's strength in this area can greatly contribute to improved assessment and understanding of this precious resource. Research questions particularly well suited to LTRR research efforts include: (1) How can tree-ring information be transferred into river management and decision-making practices in water-stressed regions throughout the world? (2) What new laboratory and statistical techniques will enable seasonal resolution of precipitation and runoff from partial-ring (earlywood-width, latewood-width) measurement? (3) How can traditional ring-width variables be integrated with stable isotope data to reconstruct long-term probabilities of droughts and other hydrologic events? (4) How can tree-ring information of riparian trees be exploited to better understand the susceptibility of riparian systems to stresses associated with climate variation and anthropogenic influences? Key geographical regions for expansion of LTRR's water-resources related tree-ring studies are the Middle East and North Africa, where water resources are intricately tied to economic and political stability. A focus of future research must also be improved discrimination of the hydrologic signal in tree-ring data from growth variations induced by temperature trends and changing snowmelt regimes, under the backdrop of likely changes in frequency and quantity of precipitation.

D.6. Annual Performance and Post-Tenure Review Results – Overview by Director

LTRR carries out an annual performance review of all faculty member's accomplishments each year. An annual report is prepared in a prescribed format that includes all research, teaching, and outreach activities for a period of three calendar years, including the just completed year, and the previous two years. The reports are generally prepared and submitted to the Director in late January. A faculty committee, composed of at least three tenured faculty members is appointed (on a rotating basis) by the Director, and they read the reports and prepare a summary evaluation and recommended rating. Each of the three primary mission areas are rated separately and commented on: teaching, research, and service/outreach, and an overall rating is recommended. The overall rating is based on the three ratings (research, teaching service) and the percentage weighting (time devoted to) of each of these endeavors. The percentage weights for the upcoming year for the three areas of endeavor are set each year at the time of the annual performance evaluation with the Director.

Committee members who are being reviewed recuse themselves (and leave the room) when their own annual report is being discussed and evaluated by the other committee members. The committee's evaluations and recommendations are then delivered to the Director. The Directory evaluates the annual reports and the comments and recommendations of the faculty committee and then assigns ratings for each faculty member, and adds his comments. The final step involves a meeting with the Director and the faculty member being evaluated, during which the review comments and recommended ratings by the committee, and comments and final ratings assigned by the Director, are discussed, any performance issues are addressed, and the faculty member has an opportunity to write comments and responses on the review form.

This process is fully in accord with University and College of Science guidelines and procedures (see http://uhap.web.arizona.edu/chap3.html#3.10). The potential performance ratings are as follows:

Unsatisfactory, Meets Expectations, Exceeds Expectations, Truly Exceptional

Table D.1. illustrates the record of ratings received by faculty since 1999. As is evident, the faculty has generally performed above expectations, and individuals have occasionally performed in a truly exceptional manner in some areas and overall. No unsatisfactory ratings have been assigned during this period. In the view of the Director (Swetnam) the goals of the post-tenure/annual performance review have been well met over the past seven years. In particular, this process has served to focus the tenured (and tenured-track) faculty's and the Director's attention on an introspective, and peer evaluation of performance, accomplishments, and goals. Faculty who have performed particularly well have received some positive feedback from this process, and needs for change direction or proportion of effort in different areas were identified. The process also served to provide a basis and justifications for the limited merit and equity salary increases that have been allocated.

Table D.1. Annual performance review ratings for all tenured faculty at LTRR, 1999-2005. The ratings for the two tenure-track Assistant Professors (Sheppard and Evans) are not included here, and sabbatical leaves in some years also reduce the numbers.

		Teaching	Scholarship	Service	Overall Performance
1999	Truly Exceptional	1	2		
	Exceeds Expectations	3	2	4	5
	Meets Expectations	1	1	1	
2000	Truly Exceptional	1	1	1	
	Exceeds Expectations	2	3	4	5
	Meets Expectations	2	1		
2001	Truly Exceptional	1	2	1	
	Exceeds Expectations	1	1	3	4
	Meets Expectations	2	1		
2002	Truly Exceptional	1	2	1	1
	Exceeds Expectations	2	1	3	3
	Meets Expectations	1	1		
2003	Truly Exceptional	1		1	
	Exceeds Expectations	3	4	3	5
	Meets Expectations	1	1	1	
2004	Truly Exceptional	1			
	Exceeds Expectations	2	2	4	3
	Meets Expectations	1	2		1
2005	Truly Exceptional				
	Exceeds Expectations	3	4	4	5
	Meets Expectations	2	1	1	

E. SCIENTIFIC AND PROFESSIONAL STAFF

E.1. Introduction

A varied and proficient scientific and professional staff is vital to the successful operation of a unit whose central missions are research and education. The Laboratory of Tree-Ring Research is fortunate to have a staff of talented and dedicated individuals who, individually and collectively, contribute significantly to the operation and success of the program. These people are accomplished dendrochronologists with many years of accumulated experience who cannot be readily replaced and without whom LTRR could not perform its teaching, research, and service functions. The staff members possess a variety of skills that are absolutely essential to the routine functioning of LTRR and to maintaining high levels of production. As indicated in section **E.2**, staff members are responsible for vital support functions, monitoring and maintaining computers and other equipment, assisting with teaching (especially the laboratory sections of the Introduction to Dendrochronology course and the summer pre-session courses), coordinating and aiding short and long-term visitors, training visiting scholars in tree-ring techniques, organizing and conducting orientation sessions and tours, processing (preparing, studying, and measuring) thousands of tree-ring samples per year, assuring analytical quality control, inaugurating and conducting research projects, supervising student and other workers, assisting with research projects, and many other important activities. LTRR would be severely disadvantaged without the crucial contributions of these individuals.

It is an unfortunate consequence of the fiscal constraints experienced by the University that one research staff FTE has been lost since the 1999 APR. While the scientific staff of LTRR has, over the years, consistently been funded by a mix of soft and hard money FTEs, the continuity in research skills and student educational opportunities provided by State funded FTEs are vital to LTRR as an institution. Insecure and transient funding from research grants is an important, but insufficient platform from which to maintain the highest quality research and educational programs.

E.2. Biographical Sketches

Alphabetically arranged biographical sketches and brief descriptions of achievements establish the staff members' qualifications and their varied and important contributions to the Laboratory, dendrochronology, and the University. The diversity of applications and scale of effort embodied in these short entries convey the importance of these individuals in the overall performance of the LTRR.

E.2.1. REX ADAMS

Rex Adams, Research Specialist, Sr., has a 1967 double major B.A. in Chemistry and Sociology/Anthropology from Adams State College, Alamosa, Colorado. In 1980 he received a M.A. degree in Anthropology from Eastern New Mexico University, Portales, New Mexico. He joined The University of Arizona staff in August 1980 at the Arizona State Museum. In July of 1981, he became a research technician employee of the Laboratory of Tree-Ring Research. From July 1981 to October 1986, he worked with other LTRR staff members on collecting, preparing, crossdating and measuring increment cores from California, Oregon, Idaho and Nevada. This was a National Science Foundation supported project which resulted in the publication of Tree-Ring Chronologies of Western North America: California, Eastern Oregon and Northern Great Basin with Procedures Used in the Chronology Development Work including Users Manuals for computer Programs COFECHA and ARSTAN, Chronology Series VI, 1986. This basic research has provided the data for many additional research projects, students' (both undergraduate and graduate) papers and degrees and fostered cooperation in planning efforts between various governmental agencies.

From October 1986 to January 1990, he was involved in field collections, sample preparation, crossdating and measuring of bristlecone pine and foxtail pine samples from across the Great Basin to the Front Range of the Colorado Rockies and the crest area of the Sierra Nevada Mountains in California. During this same time period, he was involved in the field collection, preparation, crossdating and measuring of nine

different conifer species from Arizona, New Mexico and Colorado as part of a multidisciplinary baseline study of the health of western conifer forests by the Environmental Protection Agency.

In January of 1990, he became a full-time state supported staff member of the LTRR. His duties and responsibilities in this position include teaching the laboratory portion of the 464/564 course Introduction to Dendrochronology and the 497/597 course Workshop in Dendrochronology. He has also been the laboratory instructor for the BIOC 597 course for secondary school teachers. He is responsible for teaching and training visiting scholars (both national and international) who then return to their home locations to set up programs in dendrochronology research. He is responsible for organizing the Laboratory of Tree-Ring Research Outreach Program, which involves visiting K-12 schools in the Tucson area and other locations in southern Arizona to provide students with face to face and hands-on experience with tree-ring information and samples. Schools are also invited to visit the Laboratory of Tree-Ring Research, and each year many teachers make arrangements for such visits. Local civic groups such as Kiwanis and Optimists Club are also visited and/or come to the LTRR. University of Arizona classes are also given tours of the Laboratory facilities each semester. Samples are also provided to museum and school facilities for permanent display. He has also been responsible, in part, for building shelf sets and organizing the very large permanent archive collection of dendrochronological wood samples from around the world.

Over the past six years he has participated in an ongoing project to update and extend the bristlecone pine chronology from the White Mountains of California. This important and unique research has remained a fruitful avenue for exploring the history of global climate change and providing the underpinning of geochronology for the radiocarbon community over the past 50 years and promises to continue to provide insight in the future.

E.2.2. CHRISTOPHER H. BAISAN

Christopher Baisan, Senior Research Specialist, has worked at the LTRR since 1986, first as a Student Assistant and Research Technician, and subsequently as a Research Specialist. He received a Bachelors of Science degree in Renewable Natural Resources from the University of Arizona in 1991, with honors (Summa Cum Laude). He also has received other academic honors, including Phi Kappa Phi Outstanding Graduating Senior, 1991; Outstanding Senior in Watershed Sciences 1991 (Presented 1992); A.E. Douglass Scholarship 1988; E.S. Schulman Scholarship 1989; and the Dougherty Scholarship 1988-1991. Following completion of a dendrochronological fire history study for the National Park Service in Saguaro National Park which resulted in several published papers, he has participated in numerous funded projects at the LTRR. These projects have included a ten-year effort to reconstruct fire in the Sierra Nevada forests funded by the U.S. Department of Interior's Global Change Program and numerous contracts with the U.S. Forest Service and National Park Service to develop dendrochronology-based fire histories. Recent field efforts have included expansion of fire history reconstructions into new geographic areas and the utilization of new, multi-proxy reconstruction techniques. His field collection efforts have resulted in the development, over the past seventeen years, of a new network of millennial-length tree-ring chronologies that are being used in climate reconstructions and as archaeological dating controls. Most recently this has resulted in the development of a new 2,300 year long tree-ring chronology in central Utah. He has developed, in collaboration with other Laboratory scientists, techniques to extract more refined seasonal reconstructions of environmental variables and co-authored a proposal to reconstruct multi-proxy estimates of past climate in central Utah. Additional duties and accomplishments include designing projects and developing work plans, running field operations, supervising students and staff, teaching the basic and advanced skills of dendrochronology to numerous visiting scholars and students, teaching the laboratory portion of the Introduction to Dendrochronology course and developing a new course program and teaching protocol for the laboratory section.

E.2.3. JAMES M. BURNS

James Burns, Research Specialist in Dendrochronology, received a B.A. degree in Anthropology from the University of Arizona in 1976 and an Associate Degree in Applied Science - Digital Electronics from Pima

Community College in 1982. He started work at the LTRR as a UA student in 1972 and joined the lab's classified staff in 1976. He worked one year, 1982-1983, at Hughes Aircraft Company as an Electronic Technician. He returned to the LTRR in 1983.

In the 1970s, he did the tree-ring dating of bristlecone pine for Drs. Ferguson and Graybill. Jim dated the unknown remnants and cores collected in the field and in the lab's archives. This work resulted in the Ferguson-Graybill 8000+ year BCP Chronology. Jim also helped Dr. Ferguson in "forensic" dendrochronology. For example, the ends from stolen saguaro plants were matched with the roots from the plants that were still in the ground. Enough matches were found to convict the saguaro thieves.

From 1983 to the present, Jim has been in charge of the X-ray densitometry facility at the laboratory. He has done extensive revision and development of the densitometry software and hardware and is presently upgrading the software for use on DOS computers. He has taught the lab's densitometry procedures to scholars and students from around the world.

Jim also works in Dr. Leavitt's isotope laboratory where he helps with chemical preparation and isotope analysis. He has also helped train students and visitors in these techniques.

Jim also does general electrical and mechanical repairs of the lab's equipment in the measuring, densitometric, and isotopic areas of the LTRR.

E.2.4. MARTIN A. R. MUNRO

Dr. Munro, Research Specialist, Sr. originally trained as an archaeologist, receiving an M.A. from the University of Edinburgh in 1978. His studies included a one-year course in computer science, and he wrote software to display and manipulate large sets of magnetometer and conductivity readings, since his early research interests included applying geophysical techniques to archeological site surveys.

Munro's Ph.D. studies were based in the Palaeoecology Centre at the Queen's University of Belfast, but involved collaborations and fieldwork with archaeologists in Denmark, using pollen analysis to learn more of the farming practices during the Scandinavian Pre-Roman and Roman Iron Age. His laboratory work included extensive experience with optical microscopy, and before he graduated in 1983 he had already become involved in the other research work at the Palaeoecology Center, notably dendrochronology and ^{14}C dating. As a postdoctoral research assistant he wrote Cross84 (a program to crossdate tree-ring series that is still used in some institutions), and helped archive a large collection of tree-ring data. He was employed to administer PDP-11 minicomputers in a laboratory setting, provided advice on statistical and database problems, and taught undergraduate courses on European prehistory and on basic computer skills. His first visit to the Laboratory of Tree-Ring Research at The University of Arizona was in 1987, when he spent two months helping with data analysis for a project on the effects of increasing atmospheric CO_2 concentrations on tree-ring chronologies. Between 1988 and 1991 he worked in the Department of Geography at University College London, helping produce a large palaeolimnological database.

He has worked at the Laboratory of Tree-Ring Research since 1991, where he is responsible for computer system and network administration, and provides support to several projects applying image analysis techniques to dendrochronology. Munro has helped produce a system for measuring cell dimensions within conifer tree rings, by adding custom-written code to the NIH Image software, and participated in a joint project with the department of Electrical and Computer Engineering to develop a semi-automated system for tree-ring crossdating and measurement (TREES). He revised the LTRR's database of site collection information, and has experience of programming in C, C++, Ruby, Pascal, Scheme, Fortran, assembler, Java, and Perl, including CGI programming for Web servers. He administers the LTRR's ten Linux-based servers, including the email system (first established in 1992) and the departmental web site (established in 1974), although he is now delegating some of the network administration to the central University computing services (CCIT NTS).

E.2.5. JAMES A. PARKS

James Parks, Research Specialist, earned a B.A. degree in History from The University of Arizona in

1990. In 1987, he began his career in dendrochronology as a student assistant to D. A. Graybill working on bristlecone pine dating, verification, and chronology building. As an undergraduate, Parks was awarded both the Alsie French Schulman and Edmund Schulman Memorial Scholarship and the Andrew Ellicott Douglass Memorial Scholarship by the Laboratory. In 1991, he transferred to the archaeological research program where he has worked on a variety of projects under J. S. Dean, as well as assisting in other Laboratory programs from time to time.

Since 1999, Parks has derived 434 dates from 795 archaeological tree-ring samples in the archaeological research program. From 2000-2002, he was the primary technician for the Navaho Land Claim reanalysis project under R. L. Towner, analyzing 1925 samples from 334 sites and deriving 1053 dates. Since 2004, Parks has been the primary NSF-funded technician working on the Southwestern Archaeometry grant. In addition, he has assisted M. W. Salzer on several field trips to the Great Basin collecting ancient bristlecone pine samples, as well as preparing and dating many of these samples. Parks has assisted P. R. Sheppard on field trips to Southern California, collecting tree-ring, soil and air samples, and he spent one summer analyzing fire-scarred Sequoia samples for the fire history program. Parks regularly participates in outreach, giving tours of the Laboratory and outdoor presentations to schoolchildren and adult groups. Parks recently wrapped up a study of environmental change and human adaptation in South-Central New Mexico in the late seventeenth century, resulting in the publication listed below.

E.2.6. RICHARD L. WARREN

Richard Warren, Research Associate in Dendrochronology, received a B.A. degree in Anthropology from The University of Arizona in 1962 and has been at the Laboratory since 1964. Warren is the most experienced and accomplished dendrochronological technician in the world, maintaining unmatched high rates of analytical speed, accuracy, and reliability. He developed and honed his tree-ring skills as a principal analytical contributor to the Dendrochronology of Southwestern United States Project, an NSF-sponsored reanalysis of the LTRR's archaeological tree-ring sample holdings that extended from 1963 through 1975. Since that time, he has been responsible for numerous archaeological assignments and has participated in many field collection operations including archaeological sampling with the Three-Mile Draw, Tsegi, Chetro Ketl, Walpi, and Acoma projects and living-tree coring for several phases of the Southwest Paleoclimate project. Through the years, he has served as a general dating "troubleshooter" for the LTRR, providing chronological quality control for a wide range of research projects involving several principal investigators. In addition to archaeological dating, his experience includes analyzing bristlecone pine samples, dating and measuring living-tree samples for dendroclimatic analysis, constructing long tree-ring chronologies for Alaska and the Southwest, geological tree-ring dating, preparing samples for non-dendrochronological analysis, and checking other technicians' crossdating and chronology construction. He also assisted in teaching laboratory sections of the Introduction to Dendrochronology course, delivering lectures to visiting groups, and guiding tours of the Laboratory. Finally, he supervised the LTRR's shop, maintaining and repairing equipment, requisitioning supplies, training individuals in the use of shop machines, and ensuring a safe working environment for the users of this facility. Warren officially retired from the University in 2004 but continues to work half-time in the archaeological dating program.

During the last seven years, Warren analyzed 8,833 archaeological and living-tree tree-ring samples and derived 3,067 dates. During this period, he reanalyzed the Harvard Peabody Museum’s tree-ring sample collection from Awatovi, a large prehistoric-historic period Hopi site in northern Arizona. Major accomplishments include: analyzing archaeological tree-ring samples from sites in northern Sonora; the production of dates that illuminate the prehistory and history of the Four Corners area, the Navajo homeland in Dinétah, the Upper Pecos River Valley, northern Colorado, and central New Mexico; preparing dated wood samples for exhibits at several museums and Park Service facilities; analysis of wood samples designed to characterize the environmental history of the Mesa Verde National Park pinyon-juniper woodland over the last 500 years; and checking the dating of samples for research projects directed by J. S. Dean, R. H. Towner, I. Panyushkina, and L. N. Ababneh.

E.3. Significant Publications

The following list of a few important publications produced singly or with others by staff members includes only one entry per person and is designed merely to give a flavor of the breadth and variety of staff contributions to the scholarly literature. The variety of significant publications illustrates the degree to which staff members are integrated into the general program of LTRR and the degree to which they contribute to fulfilling the LTRR's academic responsibilities.

Adams, R. K. 2006. "Depositional Processes and Sequences at Salmon Ruins" p 71-81. In "Thirty-Five Years of Archaeological Research at Salmon Ruins, New Mexico Volume One: Introduction, Architecture, Chronology, and Conclusions" Ed: Paul Reed. 393pp. Center for Desert Archaeology and Salmon Ruins Museum.

Leavitt, S.W., Idso, S.B., Kimball, B.A., **Burns, J.M.**, Sinha, A. and Stott, L. 2003. The effect of long-term atmospheric CO2 enrichment on the intrinsic water-use efficiency of sour orange trees. *Chemosphere* **50**: 217-222.

Meko D. M. and **Baisan C. H**. (2001) Pilot study of latewood-width of confers as an indicator of variability of summer rainfall in the north American Monsoon region. *International J. of Climatology* **21**, 697-708.

Panyushkina, I.P., Hughes, M.K., Vaganov, E.A. and **Munro, M.A.R**. Summer temperature in northern Yakutia since AD 1642 reconstructed from radial dimensions of larch tracheids. *Canadian Journal of Forest Research* 33: 1-10 (2003)

Parks, J. A., Dean, J. S., and Betancourt J. L. 2006 Tree Rings, Drought, and the Pueblo Abandonment of South-Central New Mexico in the 1670s. In *Environmental Change and Human Adaptation in the Ancient American Southwest*, edited by David E. Doyel and Jeffrey S. Dean, pp. 214-227. University of Utah Press, Salt Lake City.

F. RESEARCH

F.1. Introduction

Since its inception, the Laboratory has engaged in a broad range of research in fields as diverse as hydrology, climatology, forest science, ecology, geomorphology, stable isotope geochemistry, global change, geophysics, solar-terrestrial science and archaeology. In most cases the research is based on the use of the techniques of dendrochronology, and their power to provide accurate, precise and high resolution chronological and environmental information. Not all the Laboratory's research is based on dendrochronology, however, because the investigators' curiosity may, legitimately, lead in directions where these methods are not suitable. There is no general Laboratory of Tree-Ring Research view on any scientific matter. As in any university department, the principal investigators act as independent academic entrepreneurs, developing their own research agendas, and finding funding for them. The Laboratory provides a hospitable environment for this, not least by providing opportunities for interaction with colleagues from very different backgrounds, and a core of common principles, methods, equipment, and facilities for dendrochronology.

F.2. Research Summaries

This section provides brief summaries of each of the 12 core faculty member's research activities and accomplishments since submission of the previous APR document in 1999. These entries highlight activities that are covered in greater detail in the curriculum vitae in **Appendices A & B**. and identify trends that point the way to future dendrochronological applications at the Lab. Additional information on research programs of new joint and adjunct faculty are also contained in the Appendices. In this category are joint appointees Peter Ffolliott, Lisa Graumlich, and Connie Woodhouse and adjunct appointees Julio Betancourt, Henry Diaz, Steven Gray, and Ann Lynch.

F.2.1. JEFFREY S. DEAN

Historically, Dr. Dean's research has featured an integrated and evolving emphasis on human ecology in the broadest sense and on human behavioral adaptation to environmental stability, variability, and change in the American Southwest in a more specific sense. The fine focus on the Southwest - which is blessed with unusually high quality paleoenvironmental, archaeological, and anthropological data - provides refined local and regional studies that illuminate the universal principles and processes involved in the general case. This research has progressed from particular to more general issues and from simple to increasingly complex considerations. Given this trajectory, the research has employed data from a broad range of disciplines and benefited from collaboration with scholars representing several dendrochronological sub-disciplines, anthropology, archaeology, geology, alluvial geomorphology, hydrology, palynology, archaeobotany, physics, chemistry, political science, artificial life, complexity, and computer modeling. This eclectic approach dictates emphasis on all three aspects of archaeological dendrochronology: chronology, behavioral analysis, and environmental reconstruction. Since 1999, several investigations have been directed at these research themes.

The crucial importance to human paleoecology of establishing exact time relationships between past human and natural events drives the chronological research. A major component of this effort is the analysis of all archaeological tree-ring samples from the Southwest, an endeavor that has enjoyed 23 consecutive years of NSF support (1985-2007). In the last seven years, this project derived 6,563 dates from 40,946 samples; expanded archaeological tree-ring dating in the Great Basin, the Great Plains, the Sonoran and Chihuahuan Deserts, and Alaska; and produced numerous local tree-ring chronologies. More localized research has involved intensive dating programs to illuminate social organization, intergroup relationships, and environmental adaptation among the Anasazi of Mesa Verde, Chaco Canyon, and Tsegi Canyon and among the Navajos of northwestern New Mexico. Chronological work also involves an empirical characterization of the magnitude of the "old wood problem" (the degree to which the use of dead wood for fuel and construction

can skew archaeological radiocarbon and tree-ring dates) in northwestern Colorado and in general.

Behavioral research has been focused on the wood use and adaptive patterns of Anasazi and Navajo populations in the Four Corners region. These studies elucidate the evaluation of archaeological tree-ring dates and illuminate the ways in which different societies respond to environmental variation and change. Considerable attention has been given to how wood use behavior affects the distribution of tree-ring dates and to archaeological dating theory. Two studies using strontium isotope ratios in forest surrounding the San Juan Basin and in construction timbers from archaeological sites in Chaco Canyon document the extraction of spruce and fir constructions beams from mountain ranges up to 70 km from the Canyon and of ponderosa pine beams from a wide are to the north and west of the Canyon. In addition to illuminating the environmental impact of prehistoric logging, these results testify to the Chacoan social system's ability to mobilize large groups of people for communal projects.

Dean's environmental research has emphasized reconstructing past climatic variability across the Southwest, combining dendroclimatic reconstructions with other paleoenvironmental indicators, and assessing the potential effects of environmental change on the human populations of the region. This effort produced a geographical network of 30+ dendroclimatic reconstructions that illuminate local and regional variability in climate during the last two millennia. Current research is focused on characterizing the effects of precipitation and temperature variability on the agricultural populations of the Zuni, Tsegi Canyon, Mesa Verde, and Flagstaff areas over the last 2,000 years. A cooperative study is attempting to refine the dating of the eruption of Sunset Crater to better understand the impact of this major natural event on the prehistoric human inhabitants of the San Francisco Peaks area of northern Arizona.

All these concerns are integrated in an effort - in cooperation with scientists from the Arizona State Museum, Santa Fe Institute, Brookings Institution, the University of Massachusetts, and the School of American Research - to model environmental impacts on socio-cultural systems. The agent-based modeling of human subsistence and settlement behavior uses paleoenvironmental data to recreate annual potential crop-yield variability in Long House Valley in northeastern Arizona and simulates the behavior of households (agents) on this changing production landscape. Comparing the results of the simulation to archaeological data on the Anasazi occupation of the area allows objective assessment of all aspects of the model including the paleoenvironmental input and the demographic properties of and behavioral rules for the agents. This process isolates problems with the model and indicates ways in which it can be improved to more accurately replicate real human behavior and enhance understanding of universal aspects of sociocultural adaptation, change and evolution.

F.2.2. MICHAEL N. EVANS

Dr. Evans is interested in the mechanisms by which tropical processes both influence and respond to global change on seasonal to centennial timescales. The role of the hydrological cycle is especially important to uncover, because of the multiple, intricate, and linked roles of all three phases of water in the climate system, and the importance of water resources for society. Are new mechanisms required, or are the observations consistent with the activity of known patterns of climate variability? Validation of mechanistic studies using paleoproxy data are limited, because proxy paleoclimate data tend to be sparsely and unevenly distributed, multivariate in nature, and contain systematic errors. Dr. Evans addresses these questions and problems using a combination of proxy data development, analysis, and modeling.

1. Development and calibration of chronology and rainfall estimates from trees from the terrestrial tropics, using intraseasonal oxygen isotope measurements. A continuous flow stable isotope ratio mass spectrometry facility has been established, and a new, economical, rapid and precise method for making the necessary oxygen isotopic measurements has been developed. Pilot studies in Costa Rica, Peru, Indonesia and Brazil established the viability of the approach. Projects are underway to develop long paleo-raingauge records and error estimates from sparsely-observed ENSO and monsoon influenced regions worldwide.

2. Forward modeling of proxy observations to better understand underlying nonlinear, multivariate and frequency dependencies. The Vaganov-Shashkin (VS) forward model of the environmental and biological controls on conifer tree growth was validated for almost 200 sites in North America and Russia. An observed and modeled mid-1970s shift in southeastern US tree growth dependencies was associated with the regional dynamical effects of anthropogenic climate change. Future projects include identification of data biases, study of forest growth under future and past climate change scenarios, and model development.
3. Inverse modeling of paleoclimates based on sparse observational networks and modified objective analyses. The Pacific sea surface temperature (SST) field was reconstructed for up to the past four centuries from coral and tree-ring data. Results are available from the World Data Center-A for Paleoclimatology. Future projects include development of more robust calibration and reconstruction methodologies, joint precipitation-temperature-drought field reconstructions, and improved reconstructions of the Hadley Circulation and of Pacific decadal variability.

Use of physical climate models and data analyses to investigate mechanisms of tropically mediated climate change on time scales relevant to the greenhouse warming debate. Based on 2-4 centuries of reconstructed Pacific Basin sea surface temperature fields, it was suggested that Pacific decadal SST variability may result from decade-to-decade changes in the strength and frequency of ENSO, an idea consistent with recent modeling and observational studies. Future research will continue to explore the viability of this hypothesis.

F.2.3. DONALD A. FALK

Dr. Falk's work focuses on three general areas: fire regimes, disturbance interactions and fire-climate relationships, and restoration ecology. Most fieldwork is conducted in western North America, including ongoing programs in New Mexico and Arizona. New initiatives include fire history and fire-climate analysis in the North American Great Basin and the Sierra Madre of Mexico.

One set of questions addressed in Falk's lab revolves around the mathematical foundations of fire regime reconstruction and the development of analytical tools for fire history. A central case concerns the existence of scaling relationships in fire regimes, a problem not previously studied systematically. We also work on probability models for surface fire regimes and mathematical theory for sample size analysis in fire history.

A second emerging area of interest is fire-climate relationships. Collaborating with Dr. Swetnam, we use multivariate methods to understand persistent cross-scale patterns of synchrony in fire regimes of the western US. Collaborators include Rocky Mountain Tree-Ring Research, the US Forest Service Fire Sciences Laboratory, and Northern Arizona University. A new project funded by the Joint Fire Science Program links fire history, fire behavior, and land management practices in forest-grassland ecotones of the Valles Caldera National Preserve (VCNP), New Mexico. This project will attempt to reconstruct the ecotonal fire regime using remnant tree-ring evidence, and to infer spatial patterns of fire spread and climate regulation. The USGS Jemez Mountains Field Station is a central collaborator. In 2006 we initiated a program of fire history and climate work in the North American Great Basin, the largest area of the western United States lacking a basic network of fire history sites; the region is also located pivotally with respect to the "dipole" of the El Niño Southern Oscillation (ENSO) teleconnection in North America. We are beginning fieldwork in 2007, with collaborators in the Bureau of Land Management and US Forest Service.

The Falk lab collaborates with Dr. Ann Lynch, US Forest Service, Rocky Mountain Research Station (RMRS), to study disturbance interactions in the Pinaleño Mountains, Arizona, one of the highest "sky island" ranges, supporting high-elevation spruce-fir forests as well as extensive areas of mixed-conifer and other forest types. Our work combines reconstruction of historical fires, insect outbreaks, tree demography, and the role of climate variability in regulating short- and long-term forest dynamics.

In restoration ecology, a key project was a book addressing the theoretical basis for the science of restoration ecology. Falk collaborated with Joy Zedler (University of Wisconsin), Margaret Palmer (University of Maryland), and more than 20 colleagues to assemble the first book on this subject. Foundations

of Restoration Ecology was published by Island Press in 2006.

In the field, the Falk group has been working on forest and fire regime restoration at Monument Canyon, New Mexico since 2003. We have established a plot-based program of annual monitoring of tree condition, understory diversity, and other variables. 230 ha were thinned in 2005-6 following a "process-centered restoration" model designed collaboratively with the Santa Fe National Forest (SFNF). We are also continuing a longitudinal study of old-tree responses to drought and competition in collaboration with the USGS Jemez Mountains Field Station, and a study of ecophysiological response of old trees to competition and release in collaboration with Los Alamos National Laboratory. A new restoration project linking forest thinning, fire behavior models, ecophysiology, and restoration of the fire regime is beginning in the Sangre de Cristo Mountains, New Mexico. This project, also with the SFNF, will use strategically-placed thinning treatments ("SPLATS") followed by reintroduction of fire. Our lab's role includes monitoring of treatment effects on old trees, as well as expanded fire history and post-treatment responses.

F.2.4. KATHERINE K. HIRSCHBOECK

A unifying theme in Dr. Hirschboeck's research is the linkage between atmospheric circulation, along with its associated weather and climate mechanisms, and variability in extreme events. Her investigations have progressed from the theoretical examination of the patterns that produce extreme flood events in statistical time series, to analyses of the synoptic circulation patterns that produce frost rings and drought signals in tree-ring records, to new stakeholder-driven research on synchronous high and low extreme streamflow episodes detected from tree-ring reconstructions (in collaboration with Dave Meko) Hirschboeck's tree-ring related research is based on *synoptic dendroclimatology*, an approach that links tree ring variations to weather events and atmospheric circulation patterns. Research questions that she has been addressing over the past decade include: (i) What role does large-scale atmospheric circulation and its attendant weather events play in local and regional tree-growth responses as revealed in tree-ring records? and (ii) How can a mechanistic link between circulation and tree rings be used to improve the understanding of past climatic variability from a process-based perspective? She uses a variety of techniques, such as manual and automated synoptic circulation typing, the integration of atmospheric sounding data into traditional dendroclimatic analyses, and various statistical approaches, to advance a more process-based understanding and interpretation of tree-ring reconstructions of both climatic and hydrologic variables.

Hirschboeck's flood-climate research centers on *flood hydroclimatology,* the analysis of observed floods and paleofloods in the context of their history of variation over time and the meteorological processes that produce them. Research questions being addressed include: (iii) How can an understanding of the atmospheric and hydrologic mechanisms that produce floods and droughts in the observed and paleo- records be used to assess the nonstationarity of hydrologic time series and the reliability of flood estimates and drought probabilities? (iv) How are anomalous atmospheric circulation patterns and persistence linked to clustering of major flood or low flow events in time and space? and (v) Can knowledge of circulation patterns and hydrologic processes examined over long *climatological* time scales improve meteorological flood forecasting?

F.2.5. MALCOLM K. HUGHES

The prime research question Dr. Hughes seeks to address is: "*How and why does climate vary on interannual to century time scales?.*" He views this as the central question of what he calls "*meso-climatology*". This approach overlaps with but differs from "*neo-climatology*" in which models arise from consideration of first principles and large masses of directly observed instrumental data on the atmosphere, land surface, oceans and cryosphere. The difference arises primarily by virtue of decreasing data density with antiquity and an interannual to millennial perspective. It is less often recognized that meso-climatology also differs in important respects from "*paleo-climatology*", where changes in the boundary conditions of the climate system impose very large scale changes that that can be well captured at a small number of locations, such as the onset and retreat of the Pleistocene glaciations. As a result of the relatively small changes in

climate that occurred over the Holocene, it is much less likely that uniform, global responses will be observed, and so it is necessary to build relatively dense networks of proxy climate records of annual or close to annual resolution.

Hughes focuses on building large scale (continental to global) networks of instrumental and 'proxy' climate records with defined chronology, temporal resolution and climate signal. To do this he works to:

i) establish new kinds of tree ring record (new species, new regions, new variables) that may be used, in combination with other records, to 'thencast' the behavior of the climate system. He has cooperated with Dr. Touchan in the establishment of a major new dendroclimatic network in the Near East, explored the use of cell dimensions as climate proxies with Dr. Panyushkina, and of the separate signals of ring width and density with Fulbright Fellow Kirdyanov. He has continued to work on hemispheric and global reconstructions.

ii) use these 'thencasts' to raise questions about the behavior of the climate system. These questions not only apply to the nature of the 20th century in comparison to earlier periods, but also to the potential existence of multimillennial “regimes” at the scale of the Pacific Basin and perhaps on even larger scales.

iii) base this on improved understanding of the mechanisms controlling tree-ring variability. To this end he has energetically promoted the use of process-based models to test ideas about these mechanisms.

F.2.6. STEVEN W. LEAVITT

Dr. Leavitt’s research centers on past, present and future global change, variously using light stable-isotope analysis of tree rings, native plant leaves, crop plants, soils and geological materials. Leavitt’s involvement with the FACE (Free-Air CO_2 Enrichment) experiments conducted at the Maricopa Agricultural Center has phased out. However, continued analysis of specific sorghum plant and soil compounds by PhD student Li Cheng (now Dr. Cheng), continued to assess the impact of CO_2 fertilization on crop production and soil organic carbon pools. Furthermore, analysis of sour orange trees from Dr. Sherwood Idso’s long-lived sour orange tree CO_2 experiment in Phoenix provided the opportunity to assess water-use efficiency using stable-carbon isotopes.

The investigation of water-use efficiency of trees has been further pursued by Leavitt through completion of an unsupported project by re-sampling a 14-site Southwestern pinyon between 1999 and 2003. This network had been developed in the mid-1980s with analysis of pentads, and stable-carbon isotope analysis has been completed to bring the chronologies up to 1999 with single-year analysis from 1985-99. These data are additionally being used to explore relationships with environmental moisture. Water-use efficiency is also being probed through a collaborative study of Aleppo pine tree rings in Israel with Dr. Daniel Yakir.

Much of Leavitt's efforts over the past 6 years have involved ongoing investigation of wood from ancient buried forests from around the Great Lakes area. The focus of the study is the Younger Dryas period, and Leavitt and Dr. Irina Panyushkina have collaborated to assemble a massive collection of ancient wood from the area spanning the period from about 4,000 to 15,000 years ago, representing ca. 15 different sites. Some of the wood had been previously collected by other researchers, but a large number of new pieces were collected in this effort. Standard ring-width techniques have been applied to develop floating chronologies, and stable isotopes have been used to further infer past environmental conditions. This study has involved collaborations with more than a dozen researchers, most of whom are located in the Midwest. The centerpiece of the project has been full tree-ring characterization of a Younger Dryas-age black spruce site from Indiana.

By long-standing collaboration with Dr. Ron Follett of USDA, radiocarbon dating and stable-carbon analysis has been applied to depth profiles of Great Plains soils sampled in undisturbed remnants of the original grasslands. The results have been used to make maps inferring distribution of C_3-C_4 grasses over the past 10,000+ years.

Collaboration with Dr. Iain Robertson (University of Wales-Swansea) has helped Dr. Zewdu Eshetu to establish a dendrochronology lab in Addis Ababa and to initiate projects on junipers from the Ethiopian Highlands. The hope is that tree-ring work in Ethiopia will better inform understanding and decisions about water resources. Collaboration with Dr. Chris Still (UC-Santa Barbara) has resulted in tree-ring chronologies and isotopic analysis of Bishop pine from Santa Cruz Island and Torrey pine from Santa Rosa Island off the coast of Southern California. Here the question of contribution of fog during the normally arid summers to tree growth is being examined.

F.2.7. DAVID M. MEKO

Dr. Meko applies tree-ring data to identify features of the natural variability of streamflow, precipitation, and other hydroclimatic variables that might not be evident from relatively short gaged instrumental records. His work geographically focuses on the semi-arid western United States, but has included studies in Canada, Mexico, and the Meditteranean region. Meko's early work had a strong methodological emphasis, which has continued to the present and resulted in several advances in streamflow reconstruction modeling: the incorporation of time-varying subsets of tree-ring sites into reconstruction models; the probabilistic interpretation of reconstructions; interpretation of earlywood-latewood width parameters to refine the seasonal resolution of reconstruction of moisture variations; and exploitation of remnant-wood collections for improved robustness of streamflow reconstructions in early centuries of the tree-ring record.

Water resources reliability is an overriding theme in much of Meko's more recent work in western North America. Meko's streamflow reconstruction studies have generally been directly funded by water agencies. Research for the California Department of Water Resources found strong evidence that extreme past droughts in the Sierra Nevada have been associated with a sustained northward shift of the storm track and decreased moisture delivery to the Sierra Nevada. Work for the Salt River Project (SRP) quantified the likelood of simultaneous drought hitting the local and remote runoff-producing areas for SRP water supply. An ongoing project for the U.S. Bureau of Reclamation is aimed at incorporating climate-variability and climate-change information into management of the Colorado River. The questions addressed by Meko's research sometimes extend beyond water supply. For example, a project for the National Park Service addressed effects of climatic variation on the ecosystem health of a riparian stand of cottonwood trees in Great Sand Dunes National Park; and a project for B.C. Hydro was aimed at determining whether construction of a dam on the Peace River has led to unprecedented alterations in the hydrologic regime of the Peace-Athabasca Delta, a climatically sensitive wetland of major international importance for its stature as a wildlife habitat and staging ground for migrating bird species.

F.2.8. IRINA PANYUSHKINA

Dr. Panyushkina has been devoting her tree-ring efforts over the last five years to two NSF-supported projects: Pleistocene/Holocene mid-North America climate and Iron Age archaeology of Central Asia.

These efforts resulted in development of a network of subfossil tree rings in the Midwest for the late Pleistocene – Early Holocene transition (from 15,000 to 10,000 years ago) that retains high-resolution chronologies of tree-ring widths, stable isotopes and radiocarbon. This network provides climate proxy and high-resolution radiocarbon data that assesses regional environment response to global climate change. An identified ENSO-like signal in tree-ring variance of developed chronologies provides valuable insights to long-term changes in decadal variability of climate associated with ENSO. In a broader sense, the project results and tree-ring collection contributes to earth science, geology, paleoclimatology, paleoecology, paleobotany and paleolimnology. New dates for geological deposits and high-resolution radiocarbon data place the changes in lake levels of Lake Michigan and Lake Huron within the context of global changes during the Pleistocene deglaciation. The long-term goal of the project is to improve our understanding in atmosphere-ocean-land interaction under changes in climate forcings. Overall, the U.S. Midwest collection has over 600 subfossil tree samples from 24 sites ranging in age from about 4000 years ago to 15,000 years

ago, centered at the abrupt climate change associated with the Younger Dryas (YD) Event 10,000 years ago. Almost two dozen collaborators from 16 institutions have been associated with this project, and newly collected wood samples provide a basis for continued work. The prize site is the only know *in situ* Younger Dryas age forest in N. America, which Dr. Panyushkina intensively analyzed to produce the first annually resolved record of YD environment.

The project on the Iron Age in Central Asia acquired hundreds of tree-ring samples from 1) several dozen archaeological sites associated with Siberian Scythians, Hun-Sarmatians and Turks, and 2) eight upper tree-line sites in the Altai Mountains, South Siberia. This collection provided tree rings for a 2,700-year composite record of larch from ca. 710 BC to AD 2006. The record combines i) two floating tree-ring chronologies from wooden constructions of Pazyryk culture barrows (a 482-year record between 710 and 240 BC) and Hun-Sarmatian kurgans (from AD70 to AD 240) and ii) overlapped chronology from wooden Türk posts and Huns coffins (AD 200-650), and upper tree-line remnant logs and living trees (AD 343-2006). The 2,700-year record has a ca. 300-year gap in the period 240 BC and AD 70 that needs more field collections to be filled. This record suggests absolute dates for the highly debated and controversial chronology of the Pazyryk culture (Siberian Scythians). A 486-year master tree-ring chronology of Pazyryk culture overlaps tree rings of the tribal chief large frozen barrows at elevations of 1600 m and 2400 m asl by establishing a highly replicated chronology of small barrows of ordinary Pazyryks at 1900-2100 m asl elevation. The Pazyryk master chronology synchronizes the 85-year history of thirty two barrows built from BC 320 to BC 240. The crossdated tree rings have provided a new perspective with which to interpret the history of Siberian Scythians evident from the Pazyryk archaeological culture. The developed accurate and precise dates reinforce our understanding of steppe nomadic societies and their interactions with other groups in Eurasia. Climatic extrapolations from the Altai's tree ring address our understanding of adaptation of ancient nomads to seasonal temperature fluctuations and climate change overall.

The project activities established strong ties with leading archaeologists at the Siberian Branch of Russian Academy of Sciences and State Hermitage Museum (St. Petersburg). Important collaborative contacts were developed with archaeology specialists from Kazakhstan and National Research Institute for Cultural Properties, Nara, Japan. The relationships may form the basis of further work in the area, including workshops and educational opportunities for the local scientists and land administrators in light of the evidence of past climate variability and recent regional climate changes.

F.2.9. PAUL R. SHEPPARD

Dr. Sheppard uses tree rings to reconstruct environmental conditions of the past and/or to monitor modern-day environmental change:

Volcanic Effects: The dating of Sunset Crater of northern Arizona, long thought to have erupted in A.D. 1064, is being re-examined. This research began by focusing on a more recent cinder cone, Parícutin of central Mexico, where results suggest dendrochemical increases in sulfur and phosphorus during the eruption. With modern calibration now established, dendrochronological attention is turning to Sunset Crater itself. A substantially different date of eruption of Sunset Crater would be a truly important contribution to Southwest archaeology. Initial results are promising, and we are hopeful that additional funding will be generated through archaeology, volcanology, and geosciences granting programs.

Childhood Leukemia: The existence of multiple, concurrent clusters of childhood leukemia (e.g., Fallon, Nevada; Sierra Vista, Arizona; and Calvine-Florin, California) is a unique research opportunity: Is there any environmental issue held in common by these places that might be linkable to leukemia? Trees associated with the clusters have been sampled and measured in order to monitor temporal changes in urban settings. Dendrochemistry of trees in Fallon indicates that tungsten increased there in the mid 1990s, about the time of onset of the cluster of childhood leukemia in Fallon. This research has included other data types, including soil, inhalable dust, and even lichens. Results from all data types confirm that airborne tungsten is high in Fallon relative to that of other Nevada towns or the outlying desert in general.

General Pollution Studies: Understanding the ramifications of the anthropogenic doubling of fixed

nitrogen in the atmosphere is considered one of the great research challenges of ecology. Fieldwork has been initiated in the mountains of southern California to investigate the effects of changing nitrogen availability on tree growth. These mountains are in the air pollution plume of greater Los Angeles, and as such they receive enhanced quantities of fixed nitrogen. Long-term ring-width patterns might demonstrate tree responses to this extra nitrogen. Soil nitrogen should also be a key variable in this research. Tree and soil samples have been collected across microsites in an effort to associate tree vigor with soil nutrient availability. This sampling scheme is relatively unusual for dendrochronology, but it incorporates basic fundamentals of tree and site selection as well as of soil formation factors.

Image Analysis Innovations: The practical and expedient use of image analysis in dendroclimatology of conifer species has been a long-standing goal. Recent efforts have been made to solve sample preparation issues of heartwood discoloration. Once quantitative image analysis of conifers is fully operational, it will be applied to strategic sites in the American Southwest, where summer rainfall is important for many stakeholders.

F.2.10. THOMAS W. SWETNAM

Dr. Swetnam's research focuses on understanding forest disturbances and dynamics, and how they are influenced by climate and humans. He uses tree-rings and documentary sources to reconstruct disturbance histories of forest fires, insect outbreaks and tree demographics (i.e., natality and mortality) at local scales of forest stands and watersheds, to broad scales at regional to global scales. In addition to his interest in basic ecological questions about forests, disturbances, and climate, the practical applications of this work for resource management have been a key interest and emphasis. His recent projects have involved compilation and analyses of extensive fire-scar chronology networks that enable synthetic fire climatology investigations at multiple scales. The parallel of this work in tree-ring studies is the compilation of vast networks of tree-ring width and density chronologies by dendroclimatologists, and the resulting reconstructions of climatic indices spanning centuries to millennia, and continents to hemispheres. Swetnam, his students and colleagues have been capitalizing in recent years on the availability of these long climate reconstructions in comparative analyses with the tree-ring based disturbance history networks. Their results have important implications for the understanding of past and present climate changes in driving disturbance and ecosystem changes at regional to global scales.

A continuing goal of Swetnam's research and teaching is to foster and contribute to the development of the fields of dendrochronology and fire climatology, and their applications in global change studies and resource management. To this end, he has taken a leadership role in a number of efforts, including helping to create an international data bank for archiving and making accessible fire history data sets, organizing multiple national and international workshops on fire climatology, editing books and special issues of scientific journals on these topics, and mentoring graduate students, post docs and young faculty with these specialties at U of A and at other institutions. At the same time, he has also been working with graduate students and colleagues on clarifying the basic understanding of how disturbance processes and events are manifested in tree rings, particularly using modern (i.e., 20^{th}-21^{st} century) disturbance, climate, and tree-ring records. Ultimately, Swetnam envisions a continued expansion of the geographic coverage and temporal depth of the tree-ring based disturbance history networks that are developing worldwide in temperate and boreal ecosystems. These data networks, combined with improved and expanded climate reconstructions, improved analytical techniques, and modeling approaches are likely to provide new and useful insights about the responses of past and current ecosystem to climate change.

F.2.11. RAMZI TOUCHAN

Water is a limiting factor for agricultural, industrial, and urban development in arid and semi-arid regions, such as the Middle East and North Africa. The quantity and quality of water will constrain development plans for future expansion in many countries. Water management in arid and semi-arid regions is challenged by the rapid increase in the population that competes for shrinking water resources for

agricultural development. Skilled management of water resources in arid and semi-arid environments, such as the Middle East and North Africa require detailed information on the expectation of extreme events, such as prolonged drought. One needs to know the variability of local climate on time-scales of, not just of decades, but for centuries to better understand and prepare for drought conditions in the Middle East.

During the last seven years, Dr. Touchan in collaboration with Dr. Hughes conducted the first large-scale systematic dendroclimatic sampling for the eastern Mediterranean region and the Middle East (Turkey, Syria, Lebanon, Jordan, Cyprus, and Greece). They were able to build an extensive network of well-replicated, climatically-sensitive tree-ring chronologies in the Middle East, based on a variety of tree species. Several well-calibrated and verified climate reconstructions reaching back as far as AD 1097 have been produced and are either already published, have been submitted for publication, or are at a late stage of preparation for publication. Their precipitation patterns, and the patterns of tree-ring variation they produce, have been found to be related to large-scale atmospheric circulation features during the instrumental period (1948-2000). . Drs Touchan and Hughes in collaboration with colleagues from the University of Bern, Institute of Geography and NCCR Climate, Switzerland did a pioneering comparison between the derived tree-ring data and an independent reconstruction (based primarily on documentary and early instrumental evidence) of large-scale SLP and surface air temperature estimates. It showed that the large-scale climatic patterns associated with precipitation and tree-ring growth in this region have been substantially stable since AD 1764. Their research in the region depended on the collaboration of scientists from different institutes in the region.

In support of an ESH Holocene Project (2001) objective to reconstruct global climate, Dr. Touchan conducted the first region-wide systematic tree-ring sampling for climatological study in North Africa. His objectives were to establish a multi-century network of climate records for the North Africa based on tree rings by extending and enhancing existing tree-ring datasets, and by developing new tree-ring chronologies geographically and temporally. This network is being, and will continue to be, used to study interannual to century scale climate fluctuations in the region and their links to large-scale patterns of climate variability. Dr. Touchan's research will improve and update climate history of the Mediterranean and Near East, and provide a baseline for assessing present and future change. Data generated by his work will continue to fill critical gaps in multiple regional and global climate databases valued by modeling programs such as PAGES, CLIVAR, NOAA-OGP, and NASA-EOS and can be used and applied independently to active investigations in regional paleoecology and archaeology. His findings from his research will contribute essential information about climatic variability and its role in global change to the research-policy community. It also should have considerable impact on international water resource policy, management and political agreements between countries in the Middle East and Mediterranean region.

F.2.12. RONALD H. TOWNER

Dr. Towner's research over the past decade has revolved around three major issues: human/environment interactions, dendroarchaeological method and theory, and expansion of archaeological dendrochronology nationally and internationally. These areas have been addressed using grant-funded projects, collaborative efforts with federal, state, tribal, and private entities, and by involving students directly in the research.

Dendroarchaeology is uniquely situated to examine human/environment interaction at fine temporal and spatial scales. By precisely dating archaeological sites and retrodicting climate parameters, Towner has examined cultural responses to both low- and high-frequency climatic variation and avoided the typical environmental determinist explanations that have been discredited in the past. One of his specific research areas has been on the Early Navajo and their adaptation to the fluctuating climate and very unstable social environment of the protohistoric period on the Colorado Plateau.

Dendroarchaeological method and theory is critical to understanding past human/environment interaction. An important aspect of Towner's research has been to examine and promote understanding of the arboreal archaeological record across cultures using a landscape-scale approach. Although necessarily

temporally limited by tree age, such an approach provides abundant data relevant to the illumination of cross-cultural technological, social, and ecological transformations. Another role of dendroarchaeological method and theory is the calibration of other chronometric techniques. Towner is currently involved in research that will have significant impacts on radiocarbon dating in the Intermountain West and elsewhere.

Finally, one of Dr. Towner's major goals has been to expand dendroarchaeology beyond the U.S. Southwest. Preliminary efforts, some successful and some that require additional effort, have been made in northern Sonora and Chihuahua, Mexico, coastal Peru, the Texas Hill country, the central Rockies, and northeastern Utah. Although some of these efforts have not yet yielded chronometric data, all have significantly contributed toward a fuller understanding of past wood use practices and cultural adaptations to different environments.

F.3. Research Funding

External research funding to LTRR faculty and principal investigators varied year-to-year from the late 1990s through 2002, with a rise since that time (**Figure F.1**). Part of the variation in the year-to-year funding was due to the relatively small number of full time, permanent faculty in the LTRR. As a consequence of our relatively small size, the grant-funding success of one or two faculty in any given year can have a proportionally large effect on the Lab's overall funding levels. The departure of two full time faculty members (Graumlich and Stockton), and one 0.25 faculty FTE (Dickinson) in 1999, may partly explain the decline in funding two years later (2002).

The numbers shown in **Figure F.1** reflect grant funding expended from LTRR accounts each year. The total grant funding to the LTRR core faculty from 1999 to 2006 was over $8.4 million (**Table F.1**). Other grants where faculty were (and are) co-PIs are managed in accounts held in other departments, and in other institutions in a few cases, were much higher over the period (**Table F.1,** although there is some duplication in this figure for collaborative grants among LTRR PIs). Most of theadditional funding in the PI and Co-PI funding column in **Table F.1** was from large on-campus collaborative projects, including the NOAA funded Climate Assessment for the Southwest (CLIMAS) project (Hughes and Swetnam were both PIs at different times), the NSF funded Archaeology IGERT project (Dean), and the EPA-funded Wildfire Alternatives (WALTER) project (Swetnam), and others.

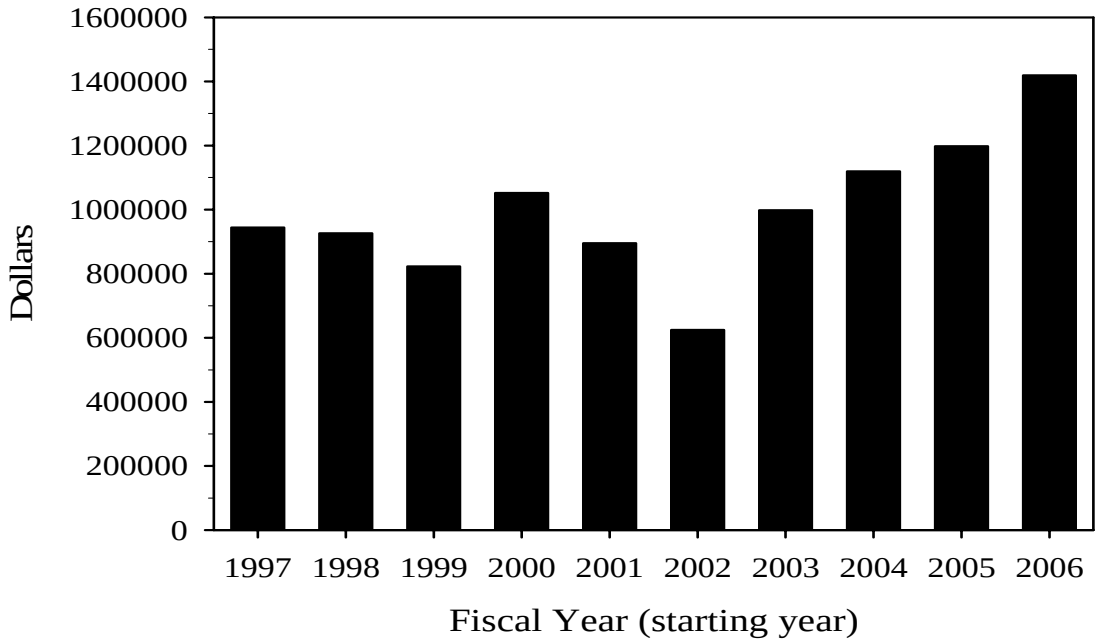

Figure F.1. Annual grant funding credited to the LTRR, 1997-2006. These data include only grant funding expended from LTRR accounts each year, except the 2006 value which includes additional recent

grants received since August 2006 (about $350K), of which only a portion has been expended to date (January 2007).

Table F.1. Research funding by core faculty members (1999-2006). The amounts listed under "Awarded as PI" include only funds received as lead Principal Investigator, and on accounts located in the LTRR. The amounts listed under "Awarded as PI or Co-PI" are funds awarded on all collaborative projects on which faculty are formally listed as PIs or Co-PIs, including accounts in the LTRR, other UA departments, and in some cases, other institutions.

Faculty Member	Awarded as PI	Awarded as PI or Co-PI
Jeff Dean	$444,069	$4,563,011
Mike Evans	$747,109	$1,559,360
Don Falk	$894,229	$1,785,958
Katie Hirschboeck	$475,226	$542,671
Malcolm Hughes	$1,730,876	$6,084,340
Steve Leavitt	$310,000	$985,000
Dave Meko	$394,444	$1,269,102
Irina Panyushkina	$479,888	$479,888
Paul Sheppard	$353,757	$605,688
Tom Swetnam	$1,049,758	$7,565,522
Ramzi Touchan	$674,850	$674,850
Ron Towner	$897,000	$1,352,500
Totals*:	$8,451,206	

* A total is provided only for the first column because the second column includes some grants on which multiple LTRR faculty members are co-PIs, so there is duplication.

Within the College of Science, the LTRR ranks approximately in the middle of the 11 most comparable departments, in terms of grant funding obtained per state-funded faculty line (**Figure F.2**). The early high point in funds per faculty FTE in 2000 was due to the dip in state-funded faculty FTEs in this year from 7 to 5 because of departures of two faculty members.

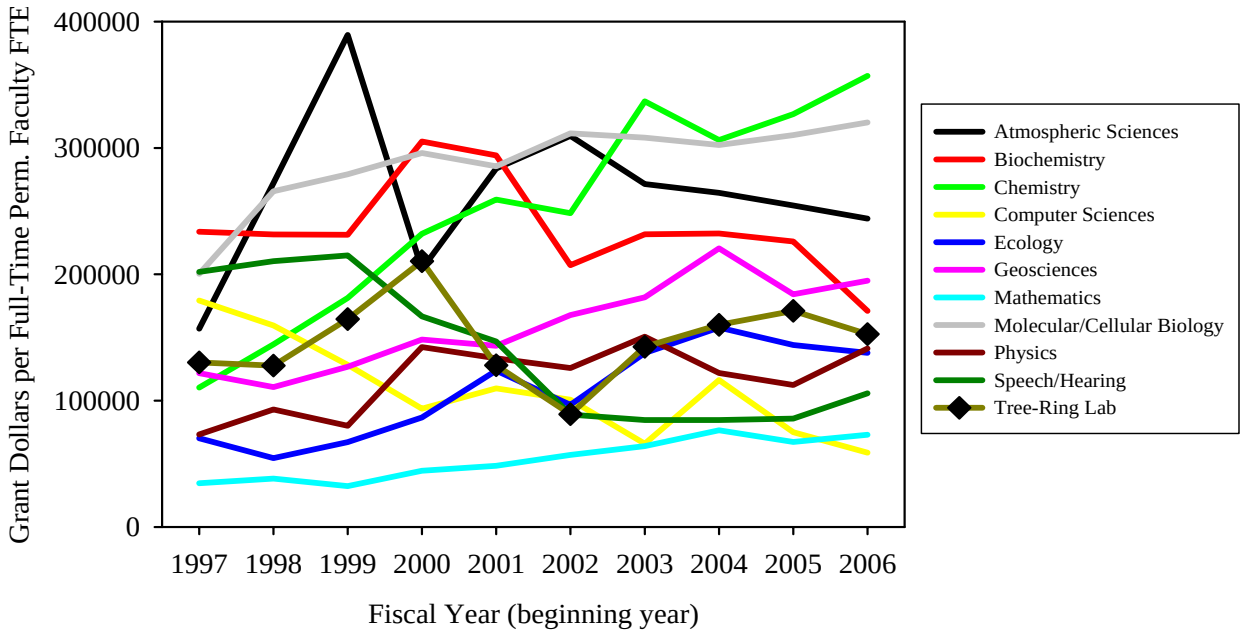

Figure F.2. Grant funding per full-time permanent, state-funded faculty FTE (LTRR has 7 FTEs currently). Astronomy and Planetary Sciences are not included here because their grant funding per faculty FTE is an order of magnitude larger than other College Science Departments, largely because of the enormous grants they process for building and maintaining telescopes, and vehicles and instruments for space probes.

The National Science Foundation (NSF) is the largest source of funding, followed by the U.S. Department of Agriculture (primarily the U.S. Forest Service), and various other agencies such as U.S. Department of Interior (mainly U.S.) Geological Survey, and the National Oceanic and Atmospheric Administration (**Figure F.3**).

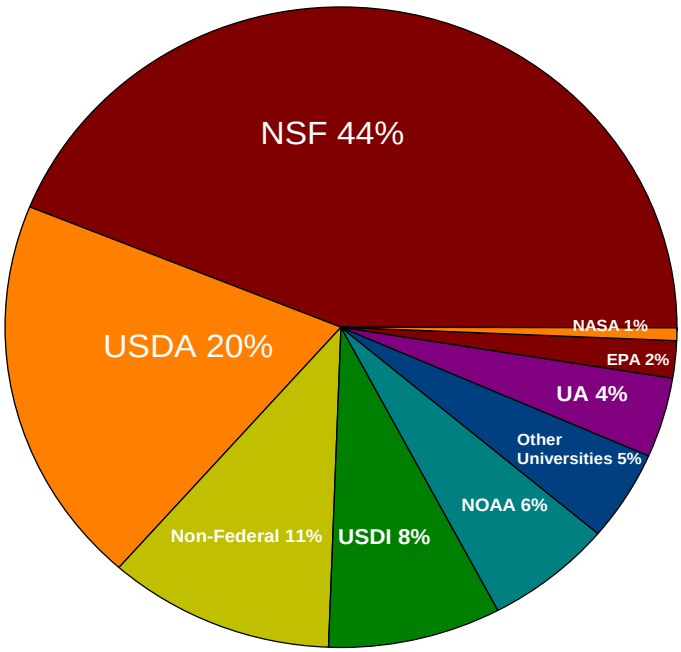

Figure F.3. Sponsors of grant funding received by the LTRR core faculty.

G. TEACHING [1]

LTRR does extensive teaching and advising at both the undergraduate and graduate levels even though it does not offer its own undergraduate or a graduate degree program in dendrochronology. One of the major goals of the Laboratory of Tree-Ring Research is: *"the provision of education and training through a comprehensive curriculum in dendrochronology, including extensive training of scientific visitors from around the world."* Accordingly, LTRR has been involved in the teaching of dendrochronology since its inception and currently offers the most diverse curriculum in tree-ring related courses available anywhere in the world. Two basic courses in dendrochronology, open to both graduate students and upper division undergraduates, serve as the foundation for the Laboratory's core curriculum of tree-ring related courses. Building on these, graduate students may take a broad range of general and specialized topical classes in dendrochronology to enhance or focus their M.S., M.A. and Ph.D. research activities. Because of the high number of LTRR visitors staying for a week or more, we have traditionally had many people "sitting in" on our classes, for whom we do not get teaching credit with the University. To partially address this, our most recent curriculum innovation has been a new suite of dendrochronology courses taught as part of a "Tree-Ring Summer School" during the intensive three-week summer pre-session. These newest additions to our core curriculum accommodate students and visitors from outside the University in addition to students in residence.

Along with these core dendrochronology course offerings which fulfill the Laboratory's mission, LTRR has had a lengthy tradition of diverse contributions to the instructional mission of the College of Science and broader University. LTRR faculty teach a full spectrum of courses from freshman colloquia, to lower division general education courses, to upper division and graduate-level courses that address an array of topics indicative of the interdisciplinary character of the Laboratory. As a non-degree granting unit, LTRR does not "own" its curriculum, hence our classes are listed and offered through other home departments such as Geosciences, Anthropology, Geography and Regional Development, and Hydrology and Water Resources, and School of Natural Resources/Watershed Management. Due to their crosscutting nature, several of our courses are listed in two or more of these departments. Prior to the 1990s, most courses taught by LTRR faculty were upper-division and graduate level only, but a shift in emphasis toward more undergraduate teaching took place in the 1990s. During the 1999-2006 review period all seven tenure-track faculty, as well as one research professor, taught both lower division and upper division/graduate courses. Student credit hours taught by LTRR faculty more than doubled between calendar years 1999 and 2000 (see **Figure G.1**) as a result of a strategic plan for increasing enrollments outlined as part of our 1998 Academic Program Review. Along with this expanded emphasis, LTRR faculty have become key contributors to teaching global change-related courses for undergraduate general education classes and for the Global Change Ph.D. Minor Graduate Interdisciplinary Program (GC-GIDP) (see section **G.1.2** below).

[1] *All tables for Section G are at the end of the section*

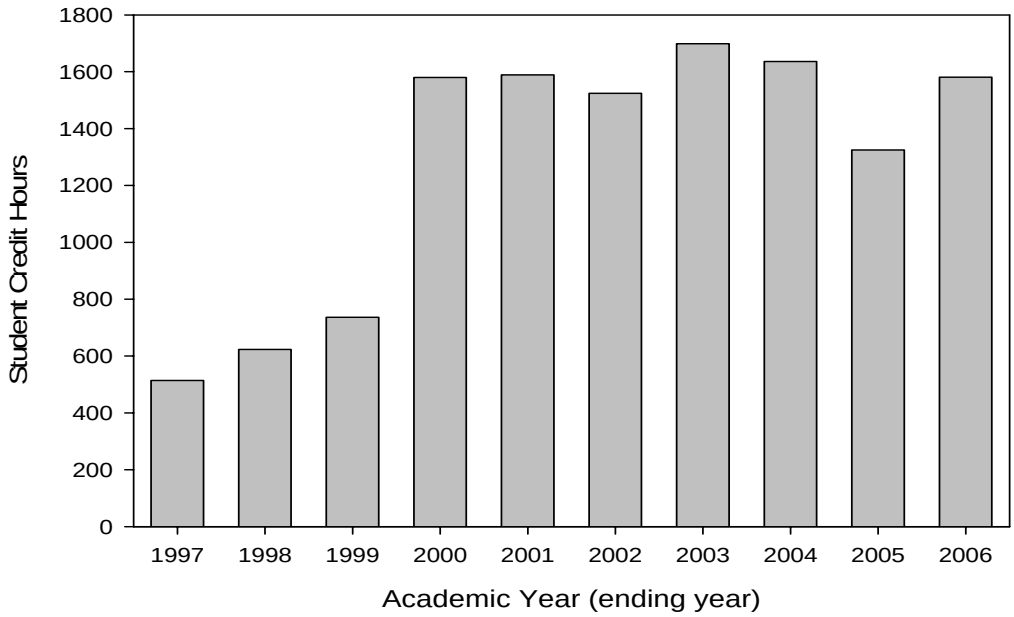

Figure G.1. Total Student Contact Hours from LTRR course teaching, 1999-2006.

We engage in other teaching through graduate and undergraduate independent study classes, and through our participation in programs that bring us students for periods of varying length, such as the Undergraduate Biology Program (UBRP), the NASA Space Grant Internships, NSF's Research Experiences for Undergraduates (REU) Program, the UA Undergraduate Research Program, the UA Graduate College Summer Research Institute, the University of Bradford (England) Department of Archaeological Sciences Undergraduate Student Placement Program, and the Integrative Graduate Education and Research Traineeship (IGERT) Program in Archaeological Sciences. LTRR faculty have been involved in University-wide General Education curriculum enhancement activities–including the development of a science course for Tohono O'odham Community College. Three of the faculty have developed and taught separate courses designed for current and future high school or college teachers. Several have participated in faculty development workshops on instructional innovations and technology-aided learning in the classroom, and have given presentations on science teaching activities and learner-centered pedagogy to campus, community and national groups.

Assignment of classroom teaching responsibilities has generally been done on a collegial basis with mutual agreement between the faculty and Director. The teaching load per faculty member is comparable to that in other College of Science units, especially when the amount of informal instruction and training provided to scientific visitors on extended stays in the Laboratory is taken into account. In addition to classroom teaching, LTRR faculty are engaged in substantial mentoring, research advising, and supervision of theses and dissertations for our affiliated graduate students (section **G.2**) as well as specialized instruction in dendrochronology and in the areas of our individual expertise to visiting students and scholars.

G.1. Classroom Teaching (see Course Descriptions in **Table G.1**)

G.1.1. Core Dendrochronology Course Offerings

G.1.1.1. Core Dendrochronology Course Offerings at Beginning of Review Period

LTRR has historically offered classes in dendrochronology through other cooperating departments, e.g.,

Geosciences, Watershed Management, and Anthropology. Technically, the students taking our "core curriculum" of tree-ring courses are earning degrees in other units, but most tend to have LTRR faculty as primary advisors and receive funding through grants of LTRR Faculty. At the beginning of this review period, two core dendrochronology courses and a varying set of module offerings under Topics in Dendrochronology" comprised our core dendrochronological curriculum:

- GEOS/ANTH/WSM 464/564 *Introduction to Dendrochronology* (4 cr) (soon to be crosslisted with Geography)
- GEOS/ANTH/WSM 497c/597c *Dendrochronology Workshop* (2 cr)
- GEOS/WSM 595e *Topics in Dendrochronology Colloquium*
  *(*wherein a set of 1-3 unit "modules" are offered each semester; may be repeated for up to 9 units)

The *Introduction to Dendrochronology* and *Dendrochronology Workshop* courses provide a basic foundation in tree-ring analysis ranging from the principles of dendrochronology, to field and laboratory techniques, to the basic analytical steps of measurement and data checking as well as chronology building and interpretation using a real collection of tree-ring samples. The *Topics in Dendrochronology* course was introduced in the late 1990s as a course module system that would allow more flexibility in: (1) offering modules in which the current crop of students is especially interested, (2) offering a wide diversity of specialty topics depending on faculty interests and availability each semester, and (3) enabling us to meet or exceed the graduate course enrollment limit every semester. Under the 595e course name, a unique section number is assigned to each faculty member so that multiple modules can be offered and taken by students in the same semester. Past module topics in the 595e *Topics in Dendrochronology* have included:

- Journal Club (recurrent offering)
- Dynamics of Tree-Ring Formation
- Cell-Size and Microdensitometric Analyses
- Topics in Dendroclimatology **
- Presentation & Display of Analytical Results
- Dendroenvironmental Analysis of Inorganic Elements
- Isotope Dendroecology
- Tree-Ring Dating in Archaeological Analysis **
- Dendrochronology in Forest Ecology **
- Dendroentomology
- Fire and Climate
- Synoptic Dendroclimatology
- Synoptic Sense: Wise Use of NCEP Reanalysis
- Topics, Tools & Techniques in Paleoclimate Research
- ENSO: Past, Present and Future **
- Applied Time Series Analysis for Dendrochronology **

** *course module topic is now taught formally as a separate course*

One advantage of the system is that it allows new classes to be offered experimentally to stay current with topical scientific issues and student interests. A graduate student representative attends our faculty meetings and provides an excellent interface between faculty and students to aid in selecting the modules that will likely be the most successful in a given semester. One drawback of the system is that these specialist courses do not generate the large numbers student credit hours becoming increasingly important to the College of Science. Another drawback is that the number of credit hours that students may receive from GEOS 595e as applicable toward their academic curriculum cannot exceed 9 units, which imposes a limitation on those students who wish to take the Journal Club (a discussion of the scientific literature, moderated by a faculty member) every semester in addition to most, if not all, of the module offerings. (To date, the latter concern has not emerged as a major problem.) There has been yearly sustained interest and enrollment in the 595e module classes, in addition to the foundational Introduction and Workshop courses. Thus far, five 595e classes that were offered originally as modules have evolved into their own courses with separate course numbers. This has somewhat reduced the number and variety of 595e modules offered in recent semesters. We have also noticed that the request for

module offerings waxes and wanes depending on the academic needs of each cohort of LTRR graduate students.

G.1.1.2. Recently-Implemented "Tree-Ring Summer School" Pre-Session Course Format

A significant expansion of our dendrochronology core curriculum began in 2002 with the establishment of the "Tree-Ring Summer School": short summer courses in dendrochronology addressing the subfields of dendroclimatology, dendroarchaeology, and – beginning in 2005 – dendroecology. These three-week intensive courses introduce students to theory, laboratory methods, field techniques, and current research in each subfield. We chose to move in this direction for several reasons: (1) the need to be able to fill 3-unit specialized graduate classes on dendrochronological topics with more predictability than could be attained by relying exclusively on UA grad students, (2) the desire to sustain the Laboratory's high profile in the field of dendrochronology both nationally and internationally, and (3) to provide a really stimulating academic milieu and foster network-building for all the participants, most especially our own graduate students.

The current suite of 3 summer pre-session courses is:

- GEOS/ANTH/WSM 497I/597I *Practical Dendroclimatology* (3 units)
- GEOS/ANTH/WSM 497J/597J *Dendroarchaeology* (3 units)
- GEOS/ANTH/WSM 497K/597K *Dendroecology* (3 units)

They can be taken for university credit by both UA and non-UA students through University of Arizona Summer School registration, with special arrangements possible for international students. Participants in all three courses share a common set of lectures and some laboratory activities the first few days before splitting into separate courses. The courses typically reconvene for a class finale wherein students share the results of their respective class projects. Participants in the Summer School have come from many countries: Canada, Austria, Switzerland, Poland, Portugal, Brazil, Peru, Chile, Mexico, Nepal, Sri Lanka, Japan, China — and from other walks of life: the National Park Service, U.S. Forest Service, the program manager of a major federal climate change program, a distinguished senior scientist from NASA who is currently at the U.S. Global Change Research Program office, and other professionals. Graduate students, postdoctoral researchers— and even some professors— from universities across the United States regularly attend. Some drawbacks of the new format have included the time limitations of a three-week intensive class, the lack of a prerequisite background in statistics (for some students in the *Dendroclimatology* course), and the lack of involvement of our own graduate students during the first few years due to substantial summer session fees that are not covered by graduate assistantship tuition benefits. The Laboratory is developing strategies to address these issues. Course evaluations and a sampling of anonymous student comments have deemed the Summer School courses to be well received and highly effective learning experiences: *"An enormously valuable experience." "The course has been the highlight of my university career. It was amazing to be around so many people interested in the same subject." "Among the most concentrated learning and fun of any course I've taken. Excellent job by the whole lab!"*

In addition to the extensive hands-on laboratory instruction that takes place in our core courses, field trips to tree-ring sites in the Santa Catalina Mts., the Pinaleño Mts., the Huachuca Mts., the Zuni Mts., and El Malpais and to archaeological sites of Anasazi, Navajo, Hispanic, Anglo, and Zuni origin have been an integral part of both the *Introduction to Dendrochronology* class and the *Summer School* courses. With particularly strong class projects, we have encouraged our undergraduate and graduate students in the *Introduction, Workshop,* and *Summer School* classes to develop their research into published papers. Recent student papers have appeared in *Kiva* and *Tree-Ring Research.*

G.1.2. Other Courses Taught by LTRR Faculty

G1.2.1. Upper Division and Graduate Courses

Table G.1 includes descriptions of all courses taught by LTRR faculty during the review period and **Table G.2** summarizes courses offered (and enrollments) from Spring 1999 through Fall 2006. The interdisciplinary nature of our courses draws students from across the University, especially in the areas of global change. Another draw has been the expertise of LTRR faculty in the teaching of analytical methods that can be applied to research in several biogeophysical disciplines. In 2004 and 2006, a new data analysis course: *GEOS 597e Spatiotemporal Data Analysis Workshop* (Evans) was offered. In addition, an analytical skill course that had originally been taught as a module in *Topics in Dendrochronology* was expanded into a separate course: GEOS 585a *Applied Time Series Analysis* (Meko). This course is also now offered online as a correspondence course through the University of Arizona's Continuing Education and Academic Outreach program, one of only two graduate level courses offered through this program. Instructor Evans also developed an interdisciplinary course on methods in paleoclimatology offered as a module in *Topics in Dendrochronology, featuring contributions from 12 faculty representing 5 College of Science departments, and* developed another module into a separate course crosslisted with the Atmospheric Sciences Department: GEOS/ATMO 513: *ENSO: Past, Present, Future.* This course adds to the growing list of LTRR courses addressing global change (discussed below).

G.1.2.2. Upper Level Classes in Support of Archaeology

Building on the Laboratory's longstanding collaboration with the Archaeology Program, several courses in the Anthropology/Archaeology curriculum involve Laboratory faculty, e.g., ANTH 447/547 *Anasazi Archaeology* (Dean), the summer pre-session *Dendroarchaeology* course (Towner), and several other archaeological interpretation, method, and dating courses in which Dr. Dean teaches. In addition, laboratory faculty and graduate students have participated in the IGERT Program in Archaeological Sciences Seminar Series (2004-2006)

G.1.2.3. Graduate Classes in Global Change – Contributions to the Global Change GIDP

LTRR has been central to the development and teaching of science-related global change curricula, and our faculty have played a major role in the development and expansion of the Global Change Graduate Interdisciplinary Program (GC-GIDP), which offers a PhD. Minor. Although the departure of two faculty (Graumlich and Dickinson) in the late 1990s reduced the teaching involvement of LTRR in the GC-GIDP courses, one core course and several elective GC-GIDP courses are currently taught by our faculty:

- GC/GEOS/HWR 572 – *Global Biogeochemical Cycles* (3 units) (Leavitt)
- GEOG 531 – *Global and Regional Climatology* (3 units) (Hirschboeck)
- GEOS 595e – *Topics in Dendrochronology Colloquium* (1-4 units) (LTRR faculty)
- GEOS/ATMO 513 – *ENSO: Past, Present, Future* (2-3 units) (Evans)

LTRR faculty Leavitt, Hirschboeck, and Hughes have been active members of the GC-GIDP Executive Committee at different times over the past decade. Currently Hirschboeck is Chair of the program (Leavitt served as Chair in the late1990s). The program is undergoing a curriculum revision, which is likely to add one ore two additional LTRR courses as electives and a new GC core course, GC695G *Global Change Toolkit*, to be taught by Hirschboeck. LTRR involvement in these classes is a natural outgrowth of the extensive global change-related research conducted in our Laboratory. Accordingly, LTRR graduate students represent a large proportion of the students in the GC-GIDP Ph.D. minor program. The GC-GIDP also officially "owns" the NATS 101 *Introduction to Global Change* undergraduate general education course (see below), which has prompted the GIDP Office to support the course with one or two 0.25-FTE Graduate Teaching Assistantships (GTAs) per semester, subject to the availability of funds. Several eligible LTRR graduate students have received one of these GTAs.

G.1.2.4. General Education Undergraduate Courses in Global Change

The Laboratory continues to have a significant impact on University-wide general education in the Natural Sciences for non-science majors. In 1999, the *Introduction to Global Change* course (formerly GEOS/HWR 107a) was revised and offered as a NATS 101 (The Earth and Its Environments) Tier I course. Also in 1999, a new Tier II course, GEOS 220 *Environmental History of the Southwest*, was offered for the first time. As in the case of the graduate-level Global Change classes, LTRR faculty with its interdisciplinary proclivity and active research in the areas of global climate and environmental changes has been particularly well-positioned to take a leading role in these classes. During the 1999-2006 review period, 6 out of 7 of our tenure-track faculty participated in teaching General Education courses. Currently, four Laboratory faculty are invested in teaching our general education courses on a regular basis: Evans, Hirschboeck, and Leavitt (NATS 101) and Sheppard (GEOS 220). Enrollments in these courses doubled in 2000, and they have been taught at maximum capacity since then.

G.1.2.5. Other Undergraduate Courses

In addition to general education courses, Dr. Sheppard has been involved in teaching a successful First-year Colloquium course – GEOS 195d *A Sense of Place* – which introduces students to the geology, ecology, and cultural history of Tucson and surrounding mountain ranges, including interactions between past and present societies and our desert environment. In another innovative contribution, Dr. Evans has worked closed with the Tohono O'odham Community to design a special weather and climate course that addresses fundamentals of the science of meteorology in addition to discussing related aspects of Tohono O'odham culture: GEO 101 *Introduction to Weather and Climate* (designed for Tohono O'odham Community College).

G.1.2.6. Courses Taught in Support of Teaching

One final area in which several LTRR faculty have made a unique contribution over the past 7 years is in courses dedicated to teaching and preparing teachers themselves. These courses include: GEOG 695E *Preparing Future Faculty: College Teaching Practicum* (Hirschboeck), BIOC 595F/597C *The Biology of Tree Rings for High School Science Teachers* (Hughes and Adams) , an NSF Chautauqua Short Course on *Teaching Dendrochronology at the College Level*. (Sheppard and Swetnam), and training workshops associated with the University of Arizona Teaching Teams Program (Hirschboeck).

G.1.3. Individual Course Planning and Upgrading

As noted above, several new courses were developed by Laboratory faculty during 1999-2006, all of which required significant energy and effort to organize and implement. Course content was revamped in our *Introduction to Dendrochronology* and *Dendrochronology Workshop* courses as new instructors (Hughes and Sheppard, respectively) took responsibility for these courses. Two new analytical skill courses were developed, along with a new course on ENSO, and the new "Tree-Ring Summer School" course format was designed and taught for the first time during the review period. In addition, the 595e module courses were often newly designed and offered for the first time (e.g., *Synoptic Dendroclimatology* and several others). Likewise, our established courses undergo continuous revision when a faculty member repeatedly teaches them in order to upgrade the content in light of new theories and developments in the field. Those courses also experience shifts in emphasis and focus when taught by different faculty members. In our general education courses, several pedagogical innovations have taken place including: involvement of honors students and undergraduate preceptors in the NATS 101 courses through participation in the University Teaching Team Program, the use of collaborative learning groups, the integration of hands-on learning activities in the classroom, and implementation of instructional technologies to support student-centered learning. Students in Hirschboeck's and Sheppard's courses learn the basics of tree-ring skeleton plotting and crossdating via the Laboratory's online crossdating applet: http://www.ltrr.arizona.edu/skeletonplot/introcrossdate.htm and in the NATS 101 course, students complete an in-class activity involving hand plotting, crossdating and interpretation of actual bristlecone

pine core data. At least two preceptors trained to facilitate this activity have later been hired as undergraduate research assistants in the Laboratory.

G.1.4. Evidence of Instructional Quality

Student Course evaluations are completed for all classes and compiled for all faculty members. Generally, student responses are in the top 3 (of 5) categories, and averages are similar to those seen around the University. The evaluations and student comments for the Tree-Ring Summer School courses have been extremely positive. This is only one way to assess instruction, however. In the late 1990s a faculty subcommittee studied other ways to assess teaching quality, including course content, course-related materials, course presentation, and classroom visitation. Based on the subcommittee's recommendation, the Laboratory adopted a new policy of using Teaching Portfolios and peer review to augment our evaluation of instructional quality. This practice has had a positive impact by providing an annual exchange of information and ideas about teaching among our colleagues and has helped guide our faculty in accumulating the necessary teaching documentation needed for Promotion and Tenure and Post-Tenure Review. Our faculty have also participated in focus groups and instructional research surveys which have helped to improve classroom instruction and – in the case of a recent survey-based Ph.D. study – revealed that the quality of instruction in one of our Tier I NATS 101 classes helped students reach a level of understanding of the greenhouse effect comparable to that of an end-of-semester Tier II science class.2 One final piece of evidence that attests to the quality of instruction by Laboratory faculty is that of teaching awards. Dr. Hirschboeck received the prestigious Provost's General Education Teaching Award in 2003 and Dr. Sheppard received the College of Science's Distinguished Early-Career Teaching Award in 2005.

Just one of many examples, the following is a recent message from a former undergraduate student in the Introduction to Dendrochronology course (GEOS/WSM.ANTH 464/564) course:

Sent: Saturday, January 27, 2007 7:33 PM
Subject: Hello from DC

Dear Rex and Dr. Hughes,

I have been meaning to email you both, as I wanted to thank you for a wonderful semester. Between the two of you, you made Intro Dendro the best (really!) class I took at the UofA. After 4 years of ok and good classes, I'm glad I stayed the extra half year to finally take a really excellent class. I thoroughly enjoyed your teaching methods, your humor and the course content. I also appreciate the your help in finding a good grad school program.

At the moment, I am settling into an internship in geoscience public policy with the American Geological Institute in DC, which is absolutely fascinating. It's very, very neat to be in the midst of the climate change and alternative fuels debates (I spend about 3 days a week attending hearings, briefings, conferences, and every other permutation of the word "meetings"...all dealing with some political aspect of geoscience). Politics aside (yep, Iraq included), the city itself is a blast!

I have been accepted at the University of Bern in Switzerland, but am still waiting to know if they want me enough to fund me. If they do, I'll probably be doing a lot of dendro-type work (that's how much I enjoyed the class!). So with any luck, by the time things start to heat up in DC, I'll be headed toSwitzerland!

I hope you're both enjoying a wonderful new year!

---

2 Keller, John, 2006. (personal communication) Survey results for NATS 101 Sec 34 Fall 2004 completed as part of Ph.D. Dissertation on "Eliciting and Addressing Misconceptions about the Greenhouse Effect".

Best, [name omitted to preserve privacy]

G.2. Thesis/Dissertation Teaching: Supervising and Mentoring of Graduate Students

A major component of our Laboratory teaching takes place outside of the classroom. Although we do not offer a formal curriculum and graduate degree in dendrochronology, faculty in the Laboratory are fully active in serving as major advisors and committee members for graduate students working on theses and dissertations in the disciplinary areas of our respective expertise. A longstanding special arrangement with the Geosciences Department has designated our faculty as official major advisors for Geosciences students who are primarily affiliated with LTRR. Faculty hold joint appointments in one or more other departments or programs (e.g., Anthropology, Arid Lands Resource Sciences, Atmospheric Sciences, Ecology & Evolutionary Biology, Geography & Regional Development, Global Change, Hydrology & Water Resources, School of Natural Resources, Soil, Water & Environmental Science, Watershed Management) to facilitate the recruitment, advising, and supervision of graduate students enrolled in these degree-granting units.

Faculty members sat on the committees of more than 100 graduate students, 31 of these as chairpersons, between 1999 and 2006 (**Table G.3**). Degrees were awarded to a total of 45 graduate students affiliated with the Laboratory by association with LTRR faculty as either committee members or advisors: 27 Ph.D. and 18 M.S. degrees. Of these, 27 were *primary-affiliated graduate students* [3] *, i.e.* graduate students for whom LTRR faculty serve as major professors and thesis/dissertation supervisors: 19 Ph.D. and 8 M.S. degrees. The number of both masters and doctoral program primary-affiliated graduate students supervised by Laboratory faculty in each calendar year has increased since 1999 (**Figure G.2**). Only 1of the graduate students for whom we have been major advisors since 1999 withdrew from the program before achieving a degree. Although statistics on faculty involvement in minor degree programs have not been compiled systematically, our records show that LTRR faculty serve increasingly as Global Change Minor representatives on Ph.D. committees of students electing the Global Change Ph.D. Minor.

[3] All anthropology/archaeology students who have LTRR faculty on their graduate committees are also considered "primary-affiliated graduate students."

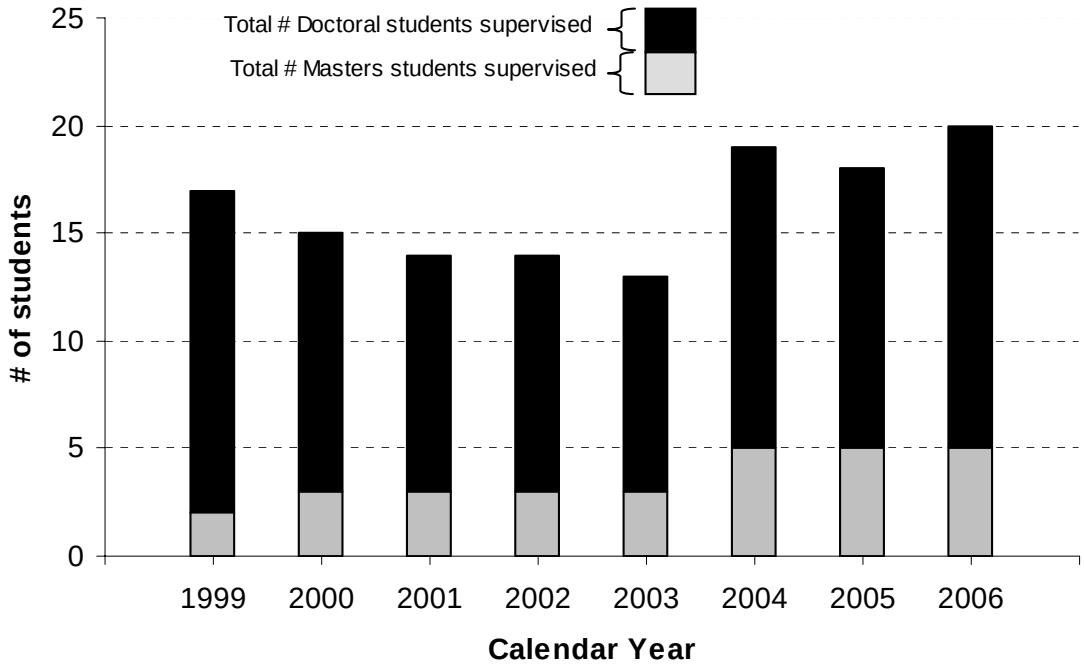

Figure G.2. Annual numbers of primary-affiliated graduate students supervised by LTRR faculty, 1999-2006.

G.3. Teaching through Undergraduate Research Opportunities

Funded positions were made available for 129 undergraduate students who received Laboratory research experience in the last seven years by working on faculty grants. Other programs in which LTRR faculty were involved in providing research experience mentoring for undergraduates include: the Undergraduate Biology Program (1 student), the NASA Space Grant Internships (2 students), NSF's Research Experiences for Undergraduates (REU) Program (3 students), the UA Undergraduate Research Program (2 students), the UA Graduate College Summer Research Institute (1 minority student), the University of Bradford (England) Department of Archaeological Sciences Undergraduate Student Placement Program . Laboratory faculty also routinely provide independent study classes for undergraduates and have served as undergraduate research and/or thesis advisors for 3 students, including one Honors College thesis: Diana Higdon Chandler (Plant Sciences), Laura Marshall (Ecology & Evolutionary Biology) and Vanessa Bechtol (Latin American Studies), Christopher McPhee (Yale University Environmental Studies).

G.4. Other

LTRR contributes to instruction of a wide variety of students and professionals whose academic "home" is not at The University of Arizona but who come here to visit for time periods ranging from short field trips to extended periods of study in residence. Additionally, LTRR Faculty and Staff travel to various institutions for short-term and extended instruction. Details of these outreach activities are described in section **H**. Laboratory faculty are also involved in several University committees and advisory boards in support of teaching and mentoring on campus.

G.4.1. Postdoctoral Fellows

LTRR has sought to increase the number of post-doctoral fellows trained and supported in the Laboratory. Since 1999, 5 post-docs have been in residence in the Laboratory for one or more years funded entirely on LTRR faculty grants or grants obtained by the post-doc as a principal or co-investigator.

G.4.2. Visiting Scholars

One of the distinctive aspects of teaching by the Laboratory is with respect to visiting scholars, both from other U.S. institutions (largely academic and governmental) and from other countries. The prestige of the affiliations of many of these visitors is testimony to the high regard with which the Laboratory of Tree-Ring Research is held by researchers all over the world. More than 309 visiting scientists stayed for periods of one week to a year for extensive instruction during the past six years (see section **C**). Additionally, four Fulbright Scholars visited the Laboratory during 1999-2006 from Mexico, Russia (2), and Syria.

G.4.3. Educational Outreach

The Laboratory is a widely known, frequently used educational attraction for many types of groups including University of Arizona classes and labs, class groups from other universities, class groups from primary and secondary schools, and various non-academic organizations such as groups of retired persons (see section **H** for complete details). Additionally, staff, students and faculty spend many hours each year visiting schools and community organizations. Faculty/staff have helped prepare museum displays, and appeared in PBS, BBC, CNN, Japanese, Korean, Canadian, Chinese and German Public TV productions.

G.4.4. Teaching Grants, Committees, and Advisory Boards

Faculty members have been involved in several externally-supported instructional grants and programs, in particular the multi-year University Teaching Teams Program and Dr. Evans's funding to develop a weather and climate course for Tohono O'odham Community College. Faculty have also served on committees and advisory boards whose purpose is to improve teaching at the University of Arizona, such as the General Education Assessment Committee, the Learning Technologies Center Faculty Advisory Board, and the Graduate College's TA Training Task Force.

G.5. LTRR Students

G.5.1. Graduate Students

Graduate students for whom LTRR faculty serve as major professor and thesis/dissertation supervisor are typically housed and funded in the Laboratory and considered primarily affiliated with LTRR. They function as our core group of graduate students, but because their degree is being offered by another unit they – in a sense – hold "dual citizenship" and are often called to participate actively in both units. Our graduate students frequently work intently on tree-ring and/or global-change-related projects on which LTRR faculty members are PIs. Therefore, a significant amount of space is provided throughout the Laboratory for housing students. Most of these students have graduate research assistantships/associateships, although some graduate teaching assistantships/associateships are also available and often used to fund first-year graduate students (see section **G.6.2**).

Students are primarily recruited by: (1) personal contacts of faculty members at conferences, agencies and universities, (2) referrals by former students now in academic positions, (3) outreach, (4) advertising at conferences, on the web, and at The University of Arizona, (5) direct contacts with students in our *Introduction to Dendrochronology* and other classes, and (6) close communication with relevant degree-granting units on campus. Students must meet all admission requirements of the academic program in which they enroll. Some of our graduate students involved in research projects that do not employ tree-ring tools may not take any dendrochronology classes but are still considered primarily affiliated with LTRR and housed in the Laboratory to work closely with their faculty research supervisors. In recent years, we have made efforts to build up our recruitment efforts via our webpage, a new graduate student flyer, advertisements on listservs and publications such as EOS, individual email exchanges with prospective students, and hosting visits to the Laboratory by prospective students. Grant-funded research assistantships/associateships and College of Science GTA funds are used to fund our incoming graduate students. Also, a new ISPE Earth Fellowship program provides a recruitment incentive for incoming Ph.D. students who agree to elect the Global Change minor program.

Resources for graduate student research projects normally come from the monetary support of research

projects of the faculty PIs, although several graduate students have been successful in obtaining their own research funding with the assistance of their advisors. LTRR provides support through a common computer area stocked with paper and printer ink cartridges, a local computer network and systems technical assistance, limited access to photocopy machines, and some routine office supplies.

G.5.2 Undergraduate Students

Numerous undergraduate students are affiliated with LTRR in a variety of functions. A few students are employed by the department for assistance in office and computer operations. Many students typically assist with dendrochronology and global-change supported-research projects. During the 1999-2006 review period, others have obtained outside support through programs such as the Undergraduate Biology Program, NASA Space Grant Internships, NSF's Research Experiences for Undergraduates (REU) Program, the UA Undergraduate Research Program and the UA Graduate College Summer Research Institute. For these programs, the student projects are frequently tied into supported research projects of Faculty members, although not necessarily so. Undergrad employees are commonly recruited from our classes, from advertisements placed around the University, by word of mouth, and from applications that any students interested in working at the LTRR fill out and are on file in our office. Undergraduates also become associated with the Laboratory as preceptors in the NATS 101 *Introduction to Global Change* course. A preceptorship combines elements of an internship, an assistantship, honors work, and peer tutoring. The program allows a lower division undergraduate to receive academic credit for working on a teaching team with the instructor and GTAs to help fellow students with the course. At least 2 former preceptors have been recruited to work in the Laboratory based in part on experience gained facilitating tree-ring learning activities in the class. Rarely are undergraduate students recruited from outside the University, except for University of Bradford undergraduate interns.

G.5.3. Gender/Race/Ethnicity of Students

The demographic make-up of our primarily affiliated and associated graduate students is similar to that seen in other comparable University departments such as Geosciences. Female:Male ratios of LTRR primarily affiliated graduate students completing Masters and Doctoral degrees were 3:5 and 5:14 respectively during the 1999-2006 review period. Because of the international reputation of the Laboratory, we have graduated and/or hosted student visitors from Mexico, Latin America, Europe, Africa, the Middle East, and Asia. Our faculty have also mentored Native American undergraduate students and been involved in the *Students Across Borders* program, which welcomes Hispanic and other minority high school students to the University of Arizona campus for Earth science studies of their natural environment.

G.5.4. Student Outcomes Assessment and Improvement of the Graduate Program

As a non-degree granting unit, LTRR is not included in The University of Arizona Student Outcomes Assessment Plan wherein desired student outcomes are determined and assessed within their home departments. We can, however, provide an informal assessment of the success of our graduate student program based on the degree to which the Laboratory fulfills its stated teaching goals and assists our graduate students in obtaining jobs and thriving in their post-graduate careers. Our Mission Statement calls for *"education and training through a comprehensive curriculum in dendrochronology, including extensive training of scientific visitors from around the world."* With our newly expanded Tree-Ring Summer School format now augmenting our foundation of basic dendrochronology courses we have made major advancements since 1999 in fulfilling the Laboratory's teaching mission. Furthermore, our primary-affiliated LTRR graduates have continued to be very successful in their career work. Among those who graduated with a Ph.D., many have held academic professorships, and a few of those have served as department directors and/or college deans (**Table G.4**). Among those who graduated with M.S. or M.A. degrees, many have held government and/or private land management or technical scientist positions, and many others are continuing on with Ph.D. studies (**Table G.5**). We have even had some notable graduates involved in LTRR research at the bachelor's level who have continued

on as either technical scientists in dendrochronology or as future teachers (**Table G.6**). In total, of 110 LTRR graduates at all levels since tabulation began, 38 (34%) have held academic positions as professors, 15 (13%) have held academic positions at other technical specialist levels, 26 (24%) have worked in private industry or foundations, and 17 (15%) have served in various levels of government. Our current and former graduate students author scientific publications and participate actively in a broad and multidisciplinary array of professional/scientific organizations and societies (**Table G.7**).

During the 1999-2006 review period, in any given year we have had an average of ~16 primary-affiliated graduate students in our LTRR student body, with a slight increase in recent years (see **Figure G.2**) One concern of our last Academic Program Review was the length of time to degree of our graduate students and the need to better track student progress. Despite the frequent need for most of our graduate students to take additional tree-ring coursework that is over and above the requirements of their respective degree programs, the graduation rate for our students appears to be comparable with that of other units, with the exception of a few students who either switched research topics and/or advisors, or took full-time jobs prior to completion. Among our primary-affiliated LTRR graduate students during the 1999-2006 Self-Study period, the Laboratory has averaged about 3.4 graduate-level graduations per year for a total of 27 graduates supervised by LTRR faculty, ~70% at the Ph.D. level and ~30% at the Masters levels (**Figure G.3**). When *all* graduate students for whom LTRR faculty served as either an advisor *or* committee member are tabulated, an average of 5.6 graduate-level graduations have occurred per year for a total of 45 graduates associated with LTRR faculty, 60% at the Ph.D. level and 40% at the Masters levels (**Figure G.4**). Among primary-affiliated graduate students, as many as 5 have completed their degrees in a single year (2004 and 2006) and among all graduate students, the peak year was 2004, when 10 graduate students associated with Laboratory faculty completed their degrees.

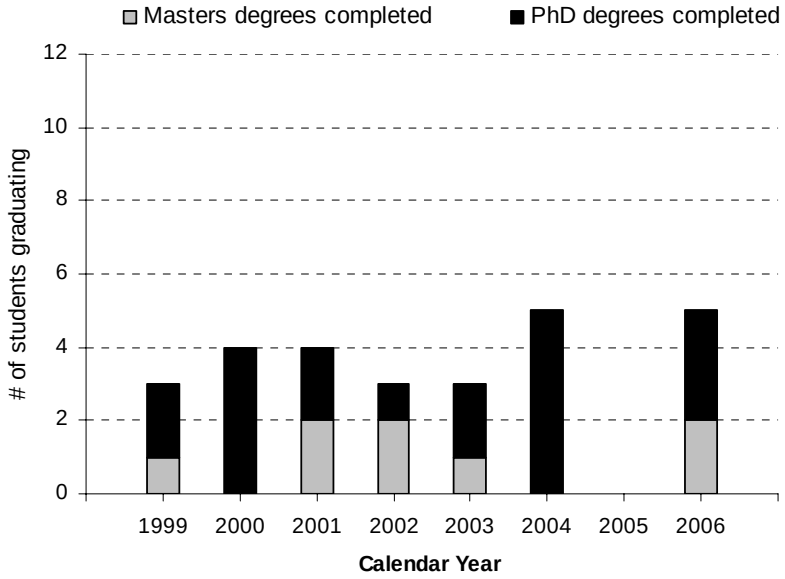

Figure G.3. Annual number of LTRR primary-affiliated graduate students completing their degrees, 1999-2006.

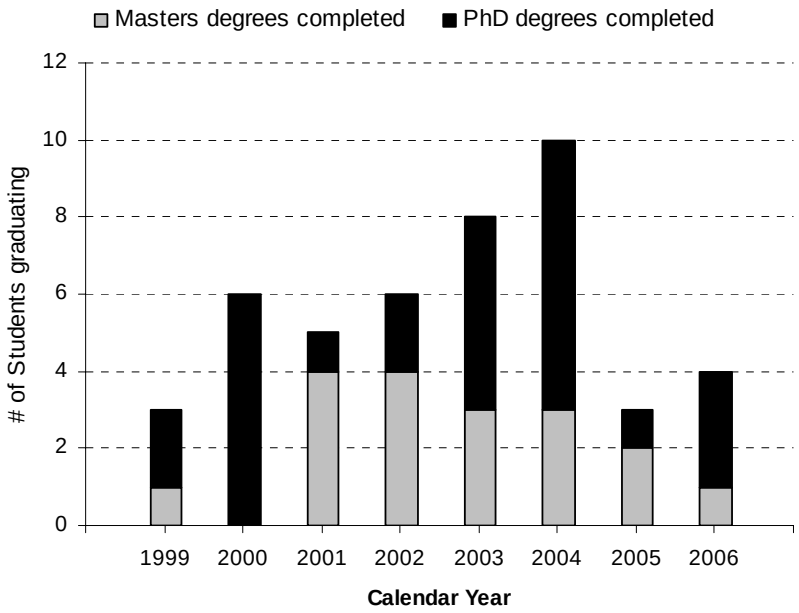

Figure G.4. Annual number of all graduate students associated with LTRR faculty completing their degrees, 1999-2006.

We have heeded the recommendation to better track the progress of our students and in 2003 established a graduate student annual report procedure to follow LTRR graduate student progression through their respective degree programs and render feedback and encouragement.

Other graduate program issues were raised during the 1998 Self Study and Academic Program Review and were echoed in the recent 5-Year Review of the LTRR Director. Overall LTRR and its Director were praised by graduate students for the quality of the curriculum in its breadth and depth, the reputation and stature of the Laboratory and its faculty, the existence of an environment that promotes trust and collaboration, the approachability and accessibility of the Director, and a general attitude of openness and responsiveness to new ideas. Suggestions by students for improving the graduate program included: a more structured, collaborative approach to recruiting future students, and for planning visits by prospective students, the negotiation or clarification of guidelines and policies specific to LTRR grad students with each degree-granting department, and the establishment of an LTRR-based graduate student coordinator position. These same issues reappeared as recommendations in the Director's 5-Year Review: "develop a more formal program for recruitment, orientation, mentoring, tracking, and training of graduate students." Also recommended was "the appointment of a graduate student coordinator – either staff or faculty – and assurance that the coordinator gets the necessary training for this position." The Laboratory is in the process of following up on these recommendations.

G.6. LTRR Teaching Resources

G.6.1. Classroom Space and Teaching Facilities

To accommodate our dendrochronology courses, three spaces have been used for on-site teaching between 1999-2006. LTRR has one multi-purpose room that is used, *inter alia*, as a classroom. Prior to 2004 this space was located in 104 West Stadium, but currently we use Room 20 in the Tree-Ring Lab Annex (basement of Math East), a 5-10 minute walk from our main West Stadium location. Room 104 and its successor—Room 20 in the Annex—have been equipped with the latest presentation technology, including a camera-microscope unit that allows classroom projection of cores and cross sections for teaching demonstrations. Our multi-purpose room can accommodate about 30 people for seminars and lectures, and about

15 comfortably for laboratory exercises. It is used for our weekly "Tree-Ring Talks" seminar series, for the *Introduction to Dendrochronology* and *Workshop* classes and occasionally for other classes. Our LTRR conference room (formerly 105-A West Stadium, currently located in 104-C West Stadium) is used for smaller classes, graduate examinations, and faculty meetings. Expanded enrollments of the summer school courses and the need to co-convene the separate course sections at certain times resulted in an exceedance of the room capacity of our LTRR facilities, and hence arrangements for nearby classroom and lab space were necessary. Our other classes are taught with classroom space allotted from throughout the University's pool of classrooms. Although this often lacks convenience for us with respect to distance, in many cases we have obtained some very good classroom space in some of the state-of-the-art lecture halls around campus, in particular, the Integrated Learning Center (ILC), which has been a model facility for the integration of teaching technologies into the classroom.

G.6.2. Graduate Teaching Assistantships/Associateships (GTA's)

LTRR has received GTA funds from the College of Science for our General Education courses, in the amount of 1.0- 1.5 FTE GTA for the academic year. This basic allotment has increased only slightly from the 0.75 FTE received in 1998 when LTRR taught half the student credit hours we now teach. GTA funds have normally been divided between a small number of individuals in stipends of 0.25, 0.33, or 0.50 FTE with the bulk of the academic year's allotment being distributed in the Fall semester when two large-enrollment sections of general education courses are taught (NATS 101 and GEOS 220). (Our GTA stipends are at the same monetary level as those in the Department of Geosciences.) Given the hands-on and lab-like nature of the collaborative learning activities that take place in the large NATS courses and the writing-intensive assignments central to the large GEOS 220 course, the amount of GTA support that is actually needed for these courses is at least 1.00 FTE – and ideally, 1.50 FTE – per year, rather than the 0.75 FTE the Laboratory currently receives from the College of Science. Fortuitously, in recent years the Graduate Interdisciplinary Program Office has from time to time supplied our courses with an additional GTA for a student in one of the GIDP major programs at either 0.25 or 0.50 FTE. Since the GIDP assistantships must be awarded to a student enrolled in a GIDP major, this allotment does not generally support our own LTRR-affiliated students directly. The exception is the 0.25-FTE GTA-ship sometimes offered by the GIDP Office on a semester-by-semester basis to Global Change GIDP Minor Program students, some of whom are also LTRR-affiliated. When available after our lower division courses have been covered, some GTA funding has been used in the Spring semester to support preparation of the upcoming Tree-Ring Summer School courses. Each year there is always some concern that we may not receive the necessary GTA funds to support our courses and recruit incoming graduate students. In addition, our limited GTA funds have hindered the Laboratory's ability to offer more high-enrollment general education courses and increase our overall student credit hours.

Teaching Assistantships have not been used for the *Introduction to Dendrochronology* course, which has an important laboratory component requiring much one-on-one instruction. We have continued to address this need in the most appropriate manner possible by having extremely experienced staff dendrochronologists teach the laboratory. Given the size of the class, with lab sections two days per week, this typically amounts to 15-20 hours of work.

G.6.3. LTRR Fellowships/Scholarships/Awards

For about three decades, LTRR has been able to offer two small scholarship awards to outstanding undergraduate and graduate students affiliated with our classes and Lab. The *Alsie French Schulman and Edmund Schulman Memorial Scholarship* has primarily gone to distinguished undergraduate students in dendrochronology. It is offered approximately every other year, with the awards in intervening years going to the Department of English. The *Andrew Ellicott Douglass Memorial Scholarship* is likewise awarded approximately every other year, but it has primarily gone to worthy and deserving graduate students in dendrochronology. The amount of these awards varies from year to year, particularly dependent on whether satisfactory candidates were found and awards given at every opportunity, but they each typically fall into the

$500-1000 range. In the 1990s, an endowment from Agnese Haury has been used to provide fellowships/scholarships for foreign graduate students studying at LTRR pursuing degrees, and for visiting scholars staying for much shorter time periods. In 2002, a new award was established through a gift from an anonymous donor. *The Bristlecone Award* recognizes outstanding contributions by a graduate or undergraduate student working in LTRR on research related to bristlecone pine.

G.7. LTRR Adaptation to University and College Needs

LTRR has been responsive and flexible with respect to teaching priorities set forth by the University and the College of Science. Beginning in the 1990s, we placed a high priority on increasing enrollments in courses taught by LTRR faculty and in getting more of the faculty members teaching each semester. Our faculty began contributing to instruction in more classes than had been done historically by LTRR over the past 25 years. The University emphasis then shifted to getting more faculty members into teaching lower-division classes, and we were particularly responsive to this need with the development and teaching of our *Introduction to Global Change* General Education classes. By the academic year ending in 2000, we had more than doubled our average student credit hours of the previous decade and we have maintained our enrollments at this level. Nevertheless, the student credit hours generated per faculty member in LTRR are lower than most units of the College of Science. We have balanced this by continuing to develop and offer courses (e.g. dendrochronology workshop, global change, data analysis courses, physical climatology seminars, topics in paleoclimatology) that provide analytical skills and global change content for students across a number departments. We have been exploring actions to further increase our enrollments, including inauguration of a new Tier II class as a large enrollment offering, developing a NATS 104 course that emphasizes ecology and global change, and offering more or larger sections of our successful NATS 101 *Introduction to Global Change* course.

Other strategic planning underway in support of the teaching missions of both the Laboratory and the University will benefit our graduate student program directly and potentially raise the profile of LTRR to a new level as a national and international instructional center for dendrochronology. We are in the process of developing a *Graduate Certificate in Dendrochronology* as one of several new certificate programs currently being established by the Graduate College. A graduate certificate comprises a linked series of credit-bearing graduate courses that constitute a coherent body of study. They may either enhance the education of currently enrolled graduate students or serve professionals in the workforce through continuing graduate education. In effect — through our existing core curriculum, our various outreach and visiting scholar programs and the Tree-Ring Summer School — the Laboratory already has in place the courses and infrastructure to offer a certificate. Once the program gets established, it should aid us in increasing enrollments and enhancing the education of our graduate students who will then be able to graduate with both a degree in their home department and a Certificate in Dendrochronology.

Lastly, the success of Dr. Meko's online *Applied Time Series Analysis* distance learning course has prompted us to begin to explore the possibility of developing one or more online/distance learning modules or courses to support learning in specific areas of either tree-ring science (e.g., statistical background in principal components needed to understand dendroclimatology) or climate science (e.g., how to use gridded climate data and reanalysis datasets wisely). These modules or courses could eventually become part of the planned LTRR *Graduate Certificate in Dendrochronology* or be offered in the semester preceding the LTRR summer pre-session courses so that students would have the necessary prerequisite knowledge for the summer courses before the students arrive on campus.

Table G1. Course Descriptions for LTRR Courses Taught 1999-2006

CORE COURSES (courses central to the LTRR's mission of education and training through a comprehensive curriculum in dendrochronology)

GEOS/ANTH/WSM 464/564: Introduction to Dendrochronology (4 units) Fall / Instructors: Hughes / Towner
webpage: http://www.ltrr.arizona.edu/introdendro/
Survey of dendrochronological theory and methods. Applications to archaeological, geological, and biological dating problems and paleoenvironmental reconstruction. Emphasis on dating methods, developing tree-ring chronologies, and evaluating tree-ring dates from various contexts. (Lecture and lab. Field trips.) Graduate-level requirements include a research paper reviewing critically some aspect of dendrochronology.

GEOS/ANTH/WSM 497c/597c: Dendrochronology Workshop (2 units) Spring / Instructor: Sheppard
webpage: http://www.ltrr.arizona.edu/~sheppard/workshop/
The practical application of theoretical learning within a group setting and involving an exchange of ideas and practical methods, skills, and principles. This course is taught in a workshop environment to give students experience in the use of the computer and the basic software necessary to convert tree-ring samples into usable chronologies. The class will be assigned samples from a tree-ring site that has been crossdated. The class will measure and then process the ring-width series into a stationary, mean value function, usable to interpret past environmental variation. The final chronology will be submitted to the ITRDB in the names of the students in the class.

GEOS/WSM 595E Topics in Dendrochronology / Dendrochronology Colloquium (1+ units, may be repeated for up to 9) Fall/Spring / LTRR faculty
webpage: http://fp.arizona.edu/kkh/geos_595e.htm
Multiple course modules offered, topics vary by semester according to student interest.
Past modules have included:

Journal Club (rotated among all LTRR faculty)
Topics in Dendroclimatology (Hughes)
Presentation & Display of Analytical Results (Hirschboeck) http://fp.arizona.edu/kkh/dendro/tufte.htm
Dynamics of Tree-Ring Formation (Hughes)
Dendrochronology in Forest Ecology (Hughes)
Synoptic Sense: Wise Use of the NCEP/NCAR Reanalysis (Hirschboeck) http://fp.arizona.edu/kkh/dendro/synoptic_sense.htm
Synoptic Dendroclimatology (Hirschboeck) http://fp.arizona.edu/kkh/dendro/synoptic_dendroclimatology.htm
Topics, Tools & Techniques in Paleoclimate Research (Evans) http://ic.ltrr.arizona.edu/ic/ttt/

Table G1. Course Descriptions for LTRR Courses Taught 1999-2006 (cont.)

Dendroentomology (Swetnam)
ENSO: Past, Present and Future (Evans) http://ic.ltrr.arizona.edu/ic/enso/
Fire and Climate (Swetnam)
Archaeological Dendrochronology (Towner / Dean)
Cell-Size and Microdensitometric Analyses (Hughes)
Dendroenvironmental Analysis of Inorganic Elements (Sheppard)
Isotope Dendroecology (Leavitt) http://www.ltrr.arizona.edu/~sleavitt/G595E.htm

CORE COURSES: TREE-RING SUMMER SCHOOL

GEOS/ANTH/WS 497I/597I Practical Dendroclimatology (3 units) 3 week summer pre-session / Instructors: Hughes and Touchan
webpage: http://www.ltrr.arizona.edu/summerschool/
An intensive introduction to the practical application of dendrochronology to paleoclimatology. Synthesis and presentation of analytical results by Graduate students. Intensive lab course. Learn fundamentals of dendrochronology, sample preparation, crossdating and chronology construction. Develop and test climatic reconstructions from tree ring data through practical exercises. Understand tree rings as natural archives within the context of interannual to millennial fluctuations in climate.

GEOS/ANTH/WS 497J/597J Dendroarchaeology (3 units) 3 week summer pre-session / Instructors: Towner and Dean
webpage: http://www.ltrr.arizona.edu/summerschool/dendroarch2006.html
An intensive introduction to the practical application of dendrochronology to a selected topic drawn from archaeology, ecology, forest science, geoscience. Synthesis and presentation of analytical results by graduate students. Intensive lab course. Learn fundamentals of dendrochronology, sample preparation, crossdating and chronology construction. Learn the chronological, behavioral and environmental interpretation of archaeological tree-ring samples. Participate in a field trip to famous southwestern archaeological areas (e.g., Chaco Canyon and the Navajo Pueblitos)

GEOS/ANTH/WS 497K/597K Dendroecology (3 units) 3 week summer pre-session / Instructors: Falk and Swetnam
webpage: http://www.ltrr.arizona.edu/summerschool/
An intensive introduction to the practical application of dendrochronology to dendroecology, the study of ecology through the use of the tree-ring record. Ecological variables in the tree-ring record, theory and techniques of dendrochronology, applications to forest ecology. Intensive lab course. Learn fundamentals of dendrochronology, sample preparation, crossdating and chronology construction. Lectures, laboratory training, and a multi-

Table G1. Course Descriptions for LTRR Courses Taught 1999-2006 (cont.) —

day field trip including data collection. Graduate-level requirements include a brief paper on an applied problem in dendroecology and make a presentation to the class.

OTHER COURSES TAUGHT BY LTRR FACULTY — UPPER DIVISION & GRADUATE COURSES

GEOS 597e: Spatiotemporal Data Analysis Workshop (3 units) alternate Falls / Instructor: Evans
webpage: http://ic.ltrr.arizona.edu/ic/stda/
Students will learn to analyze and interpret principal features resolvable in historical climate data sets using two commonly-applied empirical techniques. In parallel we will critically assess similar analyses published in the climate dynamics literature.

GEOS 585A: Applied Time Series Analysis (3 units) alternate Springs; also offered as a correspondence course / Instructor: Meko
webpage: http://www.ltrr.arizona.edu/~dmeko/geos585a.html
Analysis tools in the time and frequency domains are introduced in the context of sample data sets drawn from hydrology, climatology, and paleoclimatology. Students optionally use their own data sets in series of assignments. This is an introductory course, with emphasis on practical rather than theoretical aspects of time series analysis. Methods are hierarchically introduced -- starting with terminology and exploratory graphics, progressing to descriptive statistics, and ending with basic modeling procedures. Topics include detrending, filtering, autoregressive modeling, spectral analysis and regression.

GEOS/ATMO 513: ENSO: Past, Present, Future (2-3 units) Spring / Instructor: Evans
webpage: http://ic.ltrr.arizona.edu/ic/enso/
ENSO stands for: El Nino/Southern Oscillation. Overview of the tropical ocean-atmosphere system, ENSO theory, observations, predictive modeling and impacts; paleoclimatology; and evolution of ENSO in a greenhouse world.

UPPER DIVISION & GRADUATE COURSES

GC/GEOS/HWR 572 Global Biogeochemical Cycles (3 units) Fall / Instructors: Leavitt and Brooks (HWR)
Study of processes affecting global chemical fluxes. Particular attention to current global concerns, i.e., ozone hole, carbon cycle, climate warming, atmospheric oxidation, hydrologic cycle.

Table G1. Course Descriptions for LTRR Courses Taught 1999-2006 (cont.) --

GEOG 431/531 Global and Regional Climatology (3 units) Spring / Instructor: Hirschboeck
webpage: http://fp.arizona.edu/kkh/climate/
Description and analysis of the atmospheric circulation process that produces differences in climates throughout the world. Emphasis on the earth's problem climates and climatically sensitive zones most susceptible to floods, droughts, and other environmental stresses due to global change.

RAM/GEOS 696B Use of Stable Isotopes in Ecological Research (1 unit) Fall / Instructor: Leavitt
A growing number of ecologists are relying on the use of stable isotopes to investigate complex processes that transcend spatial and temporal scales. Graduate students enrolling in this course will hear first-hand from a number of U of A and visiting researchers how this technology is being applied to questions in paleo, terrestrial, marine, and global change ecology. Foster interdisciplinary collaborations among researchers and students confronted with similar technological and conceptual problems.

ANTH 447/547 Anasazi Archaeology (3 units) Spring / Instructors: Dean and E. Charles Adams (Arizona State Museum)
Detailed review of the archaeology of the Colorado Plateau emphasizing its agriculturally based occupants, the Anasazi, and their descendants, the Pueblo Indians. Graduate-level requirements include a longer term paper.

ANTH 636 Foundations of Archaeological Interpretation (3 units) Fall / Instructors: Dean and other ANTH faculty
Survey of the history of archaeological interpretation. Central concepts in archaeological method and theory are presented.

ANTH 637 Archaeological Methodology (3 units) Spring / Instructor: Instructors: Dean and other ANTH faculty
Survey of the fundamental principles, methods, and techniques of archaeological analysis and inference from a multidisciplinary perspective.

ANTH 696A Dating in Archaeology (1-3 units) Fall/Spring / Instructor: Instructor: Dean and other ANTH faculty
Presents the problems and procedures in the archaeological application of techniques for dating prehistoric events. Independent and intrinsic techniques are defined. Independent techniques include dendrochronology, radiocarbon, archaeomagnetism, hydration, and stratification. Intrinsic techniques include ceramic crossdating, architectural stratification, abandonment measures, and seriation methods. The analytical implications of varying degrees of temporal resolution are discussed using actual cases.

Table G1. Course Descriptions for LTRR Courses Taught 1999-2006 (cont.) —

ARL 595a Current Research Arid Lands Resource Sciences Colloquium (1 unit) Spring / Instructor: Hirschboeck
The exchange of scholarly information and/or secondary research, usually in a small group setting.

WS M 531 -- Dryland Forest Management (3 units) alternate Falls / Instructors : Touchan and Ffolliott (WSM)
Utilization and management of forest resources in dry environments; biophysical and socio-economic issues related to the development of forest commodities and amenities.

WS M 532 -- Agroforestry (3 units) alternate Springs / Instructors: Touchan and Ffolliott (WSM)
Ecological and socioeconomic factors related to the planning and implementation of agroforestry systems.

GENERAL EDUCATION COURSES:

NATS 101 The Earth and Its Environments -- Introduction to Global Change (3 units) Fall/Spring / Instructors: Hirschboeck / Leavitt / Evans
Hirschboeck's webpage: http://fp.arizona.edu/kkh/nats101gc/
Leavitt's webpage: http://www.ltrr.arizona.edu/nats101/
Evans' webpage (Honors section): http://ic.ltrr.arizona.edu/ic/nats101c/
A Tier I General Education Course. The basics of physical science are presented within the context of global environmental change processes (climatic change, global warming, deforestation, etc.) that impact Earth and its inhabitants. Includes hands-on activities, discussions, computer exercises, and a personal interest project.

GEOS 220 Environmental History of the Southwest (3+ units) Fall / Instructor: Sheppard (in previous years: Towner, Dean, Swetnam, Betancourt)
webpage: http://www.ltrr.arizona.edu/geos220/
A Tier II General Education Course. Environmental and cultural history of the Southwest emphasizing discovery of the past using historical science techniques of tree-ring and packrat midden analyses and repeat photography.

FIRST-YEAR COLLOQUIUM COURSES
(First-year colloquia introduce students to the methods and standards of the discipline for discovering new knowledge, the values which characterize the field of study, advances in the field, impact on society, and career opportunities.)

Table G1. Course Descriptions for LTRR Courses Taught 1999-2006 (cont.) —

GEOS 195D First-Year Colloquium: A Sense of Place (1 unit) Spring / Instructors: Sheppard (with Huckleberry, and previously, Butler GEOS)
webpage: http://www.ltrr.arizona.edu/~sheppard/sop/
Students are introduced to the geology and ecology of Tucson and surrounding mountain ranges, including interactions between past and present societies and our desert environment. Four Saturday field trips (one per month) are scheduled during the semester, each emphasizing a particular region with its unique geological and biological aspects. A Tuesday evening class meeting will take place prior to each Saturday field trip. This is a First-Year Colloquium Course.

SPECIAL OUTREACH GENERAL EDUCATION COURSE :

GEO 101 Introduction to Weather and Climate (designed for Tohono O'odham Community College) / Instructor: Evans
webpage: http://ic.ltrr.arizona.edu/ic/tocc/
We will learn practical fundamentals of the science of meteorology, and discuss related aspects of Tohono O'odham culture. Class sessions will include hands-on activities, guest lectures by members of the O'odham community and their friends, and field trips. This brand-new course meets University of Arizona Tier I Natural Science requirements, and will be submitted for AGEC approval.

COURSES TAUGHT IN SUPPORT OF TEACHING
GEOG 695E Preparing Future Faculty: College Teaching Practicum (1 unit) Spring / Instructor: Hirschboeck
webpage: http://fp.arizona.edu/geog695c/
Introduces graduate students to pedagogical theory, skills, practice and technological tools for college classrooms. Covers learning philosophies, cognitive skills, assessment, classroom dynamics and ethics. Provides practice in developing and presenting course materials.

BIOC 595F/597C The Biology of Tree Rings for High School Science Teachers Spring / Instructors: Hughes and Adams
Distinct annual growth layers (tree rings) are formed in the wood of many tree species in the temperate and cooler parts of the world. The scientific use of these layers (dendrochronology) was pioneered at The University of Arizona in the early 1900s and has now extended into many scientific fields, including ecology and tree physiology as well as climatology, hydrology, archeology and geophysics. Explore the biological bases of tree-ring formation, and discuss applications of dendrochronology to such topical issues as disturbance ecology (e.g. the role of fire and insect outbreaks in forests), landscape ecology (if the climate changes, how do forests respond?) and global ecology (exploring imbalances in the global carbon cycle using carbon isotopes in tree rings). Informal lectures and discussions combined with laboratory sessions introduce the basic concepts of dendrochronology.

Table G1. Course Descriptions for LTRR Courses Taught 1999-2006 (cont.) —

The use of a small kit of class materials will also be discussed during the laboratory sessions.

NSF Chautauqua Short Course on Teaching Dendrochronology at the College Level. / Instructors: Sheppard and Swetnam
Webpage : http://www.ltrr.arizona.edu/~sheppard/chautauqua/
The purpose of this course is to provide college teachers with a basic understanding of dendrochronology principles and applications. The course will provide various tools and ideas for teaching dendrochronology as part of an existing course in environmental sciences or archaeology. The course will include overviews of applications of dendrochronology plus benchmark examples, hands-on experiences of lab and computer activities, and a trip to the nearby Santa Catalina Mountains to experience fieldwork techniques and to see examples of environmental issues to which tree rings apply. Participants will carry home hand outs that will be helpful in the classroom for teaching dendrochronology.

UNVR 197a General Education Preceptor Training Workshop (2units) Fall/Spring / Instructor: Co-Hirschboeck
Workshop for undergraduate preceptors currently enrolled in a general education class. Course teaches teamwork, communication, and collaborative learning skills. P, currently enrolled in a general education class. (Course managed by the University Teaching Team Program.)

UNVR 397a General Education Teaching Teams Training Workshop (2 units) Fall/Spring / Co- Instructor: Hirschboeck
Workshop for undergraduate preceptors working with a general education teaching team. Course covers elements of learning environments, communication skills, giving feedback, performance evaluation, and cooperative learning strategies. Must have completed a general education course in same. (Course managed by the University Teaching Team Program.)

UNVR 597a Teaching Team Graduate Assistant Training Workshop (1-2 units) Fall/Spring / Co- Instructor: Hirschboeck
Workshop for graduate teaching assistants working with a general education team. Course covers teaching skills, assessment and feedback strategies, team building, communication, and course development skills. graduate status. (Course managed by the University Teaching Team Program.).

TABLE G2 Chronology of Courses Taught by LTRR Faculty 1999 -2006

** = co-taught with non-LTRR faculty*

Semester	Course	# of units	Instructor	# of students
Spring 1999	ANTH 637 – Archaeological Methodology	3	Dean *	14
	AAHS [1] - Archaeological Tree-Ring Dating	-	Dean *	30
	NATS 101 Intro to Global Change	3	Leavitt	57
	GEOS 596e – Tree-Ring Dating in Archaeol Analysis	1	Towner +Dean	7
Fall 1999	ANTH 636 – Foundations Archaeol. Interpretation	3	Dean *	20
	AAHS [1] – Case Studies in Dendroarchaeology	-	Dean *	15
	GEOS 220 – Environmental History of the SW	3	Swetnam + Dean*	49
	GEOS 595e – Journal Club	1	Hirschboeck	5
	GEOS/ANTH 464/564 – Intro to Dendrochronology	4	Towner	19
	NATS 101 Intro to Global Change	3	Hirschboeck	122
	UNVR 197a +197h / 597a – Teaching Team Training	1-2	Hirschboeck *	7 / 2
Spring 2000	ANTH 637 – Archaeological Methodology	3	Dean *	15
	GEOS 220 – Environmental History of the SW	3	Dean + Towner	117
	GEOS 497c/597c – Dendrochronology Workshop	2	Sheppard	7
	GEOS 596e – Tree-Ring Dating in Archaeol Analysis	3	Towner	7
	GEOS 595e – Journal Club	1	Dean	1
	GEOS 595e – Synoptic Dendroclimatology	2	Hirschboeck	5
	GEOS 597e – Dendroecology	2	Swetnam + Baisan	6
	GEOS 599 – Independent Study	1	Leavitt	1
	GEOS 195d – A Sense of Place	1	Sheppard	20
	NATS 101 / 101 honors – Intro to Global Change	3	Hirschboeck	123 / 26
	UNVR 197a / 397a / 597a – Teaching Team Training	1-2	Hirschboeck*	11 / 2 / 2
Summer 2000	GEOG 498 – Senior Capstone	3	Hirschboeck	1
Fall 2000	GEOS 220 – Environmental History of the SW	3	Sheppard +Swetnam	85
	GEOS/ANTH 464/564 – Intro to Dendrochronology	4	Towner	18
	GEOS 572 – Global Biogeochemical Cycles	3	Leavitt	3
	GEOS 595e – Isotope Dendrochronology	1	Leavitt	4
	NATS 101 / 101 honors – Intro to Global Change	3	Hirschboeck	137 / 19
	UNVR 197a / 397a / 597a – Teaching Team Training	1-2	Hirschboeck*	6 / 1 / 2
Spring 2001	ANTH 637 – Archaeological Methodology	3	Dean*	15
	GEOG 431 / 531 – Global & Regional Climatology	3	Hirschboeck	16 / 8
	GEOS 497c/597c – Dendrochronology Workshop	2	Sheppard	2
	GEOS 595e – Dendrochemistry	2	Sheppard	2
	GEOS 596e – Tree-Ring Dating in Archaeol Analysis	3	Towner	7
	NATS 101 / 101 honors – Intro to Global Change	3	Leavitt + Salzer	115 / 10
	NATS 101 – Intro to Global Change (addl section)	3	Leavitt + Salzer	59
Fall 2001	GEOS 220 – Environmental History of the SW	3	Sheppard + Dean	145
	GEOS 572 – Global Biogeochemical Cycles	3	Leavitt *	8
	GEOS 595e – Journal Club	1	Leavitt	5
	NATS 101 – Intro to Global Change	3	Hirschboeck	155
	UNVR 197a/197h – Teaching Team Training	1-2	Hirschboeck*	9
	NATS 101 – Intro to Global Change (honors)	3	Evans	14

TABLE G2 Chronology of Courses Taught by LTRR Faculty 1999 -2006 – cont.

** = co-taught with non-LTRR faculty*

Semester	Course	# of units	Instructor	# of students
Spring 2002	GEOS 497c/597c – Dendrochronology Workshop	2	Sheppard	5
	GEOS 597e – Fire Climatology	2	Swetnam*	5
	NATS 101 / 101 honors – Intro to Global Change	3	Leavitt	130 / 15
	GEOS 595e – ENSO: Past, Present, Future	2,3	Evans	7
Summer 2002	GEOS 497i/597i – Practical Dendroclimatology	3	Hughes + Touchan	14
	GEOS 497j/597j – Dendroarchaeology	3	Towner	8
Fall 2002	ANTH 447/547 – Anasazi Archaeology	3	Dean *	19
	ANTH 636 – Foundations Archaeol. Interpretation	3	Dean *	10
	GEOS 220 – Environmental History of the SW	3	Sheppard	145
	GEOS 572 – Global Biogeochemical Cycles	3	Leavitt *	11
	GEOS 595e – Isotope Dendrochronology	1	Leavitt	5
	NATS 101 / 101 honors – Intro to Global Change	3	Hirschboeck	133 / 14
	UNVR 197a – Teaching Team Training	2	Hirschboeck*	7
	NATS 101 – Intro to Global Change	3	Evans	55
Spring 2003	GEOG 431 / 531 – Global & Regional Climatology	3	Hirschboeck	11 / 5
	GEOS 497c/597c – Dendrochronology Workshop	2	Sheppard	5
	GEOS 595e – Dendroentomology	1	Swetnam	4
	GEOS 595e – ENSO: Past, Present, Future	2-3	Evans	4
	GEOS 595e – Applied Time Series Analysis	3	Meko	7
	GEOS 595e (online) – Applied Time Series Analysis	3	Meko	3
	NATS 101 / 101 honors – Intro to Global Change	3	Leavitt	123 / 14
	WSM 531 – Dryland Forest Management	3	Touchan*	6
Summer 2003	GEOS 497i/597i – Practical Dendroclimatology	3	Hughes + Touchan	17
	GEOS 497j/597j – Dendroarchaeology	3	Towner	14
Fall 2003	GEOS/ANTH 464/564 – Intro to Dendrochronology	4	Hughes	10
	ANTH 636 – Foundations Archaeol. Interpretation	3	Dean *	20
	GEOS 220 – Environmental History of the SW	3	Dean + Sheppard	150
	GEOS 572 – Global Biogeochemical Cycles	3	Leavitt *	10
	NATS 101 – Intro to Global Change	3	Hirschboeck	150
	NATS 101 honors – Intro to Global Change	3	Evans	21
Spring 2004	BIOC 595f/597c Biology of Tree-Rings / H.S. Science	-	Hughes	8
	GEOS 195d – A Sense of Place	1	Sheppard *	25
	GEOS 497c/597c – Dendrochronology Workshop	2	Sheppard	7
	GEOS 595e 3a. Synoptic sense 3b. Synoptic Dendro	1 / 1	Hirschboeck	7 / 4
	GEOS 595e 2. Dynamics of Tree Ring Formation	1	Hughes	4
	GEOS 595e 4. Topics, Tools ,Techniques Paleo Res	2	Evans	6
	GEOS 595e (online) – Applied Time Series Analysis	3	Meko	3
	GEOS 597e 1. Fire Climatology/Dendroecology	1	Swetnam	6
	NATS 101 / 101 honors – Intro to Global Change	3	Leavitt	115 / 10
Summer 2004	GEOS 597i – Practical Dendroclimatology	3	Hughes + Touchan	13
	GEOS 497j/597j – Dendroarchaeology	3	Towner	14

TABLE G2 Chronology of Courses Taught by LTRR Faculty 1999 -2006 – cont.

** = co-taught with non-LTRR faculty*

Semester	Course	# of units	Instructor	# of students
Fall 2004	GEOS/ANTH 464/564 – Intro to Dendrochronology	4	Hughes	8
	ANTH 636 – Foundations Archaeol. Interpretation	3	Dean *	20
	GEOG 595c College Teaching Practicum	1	Hirschboeck	10
	GEOS 220 – Environmental History of the SW	3	Towner	158
	GEOS 572 – Global Biogeochemical Cycles	3	Leavitt *	8
	GEOS 595e – 4. Isotope Dendrochronology	1	Leavitt	4
	GEOS 597e – Spatiotemporal Data Workshop	3	Evans	10
	NATS 101 – Intro to Global Change	3	Hirschboeck	146
Spring 2005	ANTH 447/547 – Anasazi Archaeology	3	Dean *	19
	ARL 595a – Current Research Arid Lands Colloq	1	Hirschboeck	11
	GEOG 531 – Global & Regional Climatology	3	Hirschboeck	4
	GEO 101 – Weather & Climate (TOCC)	4	Evans	5
	GEOS 195d – A Sense of Place	1	Sheppard*	12
	GEOS 497c/597c – Dendrochronology Workshop	2	Sheppard	7
	GEOS 585a – Applied Time Series Analysis	3	Meko	12
	GEOS 585a (online) – Applied Time Series Analysis	3	Meko	5
	GEOS 595e 2. Dendrochronology in Forest Ecology	1	Hughes	3
	NATS 101 / 101 honors – Intro to Global Change	3	Leavitt	123 / 8
Summer 2005	GEOS 497j/597j – Dendroarchaeology	3	Towner	4
	GEOS 497/597k – Dendroecology	3	Falk + Swetnam	20
Fall 2005	ANTH 636 – Foundations Archaeol. Interpretation	3	Dean*	10
	GC 572 – Global Biogeochemical Cycles	3	Leavitt*	11
	GEOS 220 – Environmental History of the SW	3	Sheppard	130
	GEOS 464/564 – Intro to Dendrochronology	4	Hughes	9
	GEOS 595e 1. Journal Club	1	Swetnam	8
	NATS 101 honors – Intro to Global Change	3	Evans	25
	NATS 101 – Intro to Global Change	3	Hirschboeck	144
	WSM 532 – Agroforestry	3	Touchan*	6
Spring 2006	GEOS 595e 1. Journal Club	1	Swetnam	3
	GEOS 595e 2 Topics in Dendroclimatology	1	Hughes	4
	GEOS 595e 3. Present/Display of Analytical Results	1	Hirschboeck	7
	GEOG 595c – College Teaching Practicum	1	Hirschboeck	12
	GEOS 497c/597c – Dendrochronology Workshop	2	Sheppard	4
	GEOS 195d – A Sense of Place	1	Sheppard*	13
	GEOS 513 – ENSO: Past, Present, Future	2-3	Evans	9
	NATS 101 / 101 honors	3	Leavitt	121 / 10
Summer 2006	GEOS 597i – Practical Dendroclimatology	3	Hughes + Touchan	10
	GEOS 497j/597j – Dendroarchaeology	3	Towner	8
	GEOS 497/597k – Dendroecology	3	Falk + Swetnam	18

TABLE G2 Chronology of Courses Taught by LTRR Faculty 1999 -2006 – cont.

** = co-taught with non-LTRR faculty*

Semester	Course	# of units	Instructor	# of students
Fall 2006	ANTH 636 – Foundations Archaeol. Interpretation	3	Dean*	15
	GEOS 464/564 – Intro to Dendrochronology	4	Hughes	10
	GEOS 220 – Environmental History of the SW	3	Sheppard	142
	GEOS 595e 1. Journal Club	1	Swetnam	4+
	GEOS 597e – Spatiotemporal Data Anal. Workshop	3	Evans	8
	NATS 101 – Intro to Global Change	3	Hirschboeck	145

NOTE: Faculty also offered numerous Independent Study courses with individual undergraduate and graduate students that are not recorded above.

TABLE G.3. LTRR Faculty Participation on Graduate Degree Committees* During 1999-2006

		Masters Committees			Doctoral Committees		
	Total # of Committees	**Committee Member**	**Committee Chair**	**# Degrees Completed**	**Committee Member**	**Committee Chair**	**# Degrees Completed**
FACULTY *(fully state-funded)*							
Jeffrey S. Dean	20	4	-	2	16	2	13
Michael N.Evans	7	4	-	1	2	1	-
Katherine K. Hirschboeck	29	7	3	5	16 [a]	3 [b]	9
Malcolm K. Hughes	7	-	1	1	4	2	4
Steven W. Leavitt	12	2	-	1	7	3	3
Paul Sheppard	4	-	1	-	2	1	-
Thomas W. Swetnam	28	8	4	12	6	10	9
FACULTY *(partly state-funded or grant funded)*							
David Meko	9	-	-	-	9	-	3
Ramzi Touchan	1	-	-	-	1	-	-
Ron Towner	2	2	-	1	-	-	-
Don Falk	-	-	-	-	-	-	-
		Total committees chaired = 9			Total committees chaired = 22		

* Committee counts include M.S./M.A. degree and thesis committees, Ph.D. examination and dissertation committees, and outside examiner for students from other Universities. Note that some students have more than one LTRR faculty member on their committees.

[a] one student did not pass comprehensive exams [b] one advisee left the program for personal / family reasons

Table G.4. Primary-affiliated LTRR students graduated with a Ph.D.

Name	Year	Dept.*	Positions held since graduation or 1999
Dr. Linah Ababneh	2006	GEOS	White Mt Research Station, Bishop CA
Dr. Jose Pepe Iniquez	2006	WSM	Landscape Fire Ecologist, Rocky Mountain Research Station, Flagstaff Lab, USDA Forest Service
Dr. Bruce Bachand	2006	ANTH	New World Archaeological Foundation, Brigham Young University, Provo UT
Dr. Don Falk	2004	EEB	Adjunct Associate Professor LTRR, University of Arizona
Dr. Dale Brenneman	2004	ANTH	Research Associate, Arizona State Museum, University of Arizona, Tucson AZ
Dr. Douglas Craig	2004	ANTH	Principal Investigator, Northland Research Inc., Flagstaff AZ
Dr. Stacey Lengyel	2004	ANTH	Project Director, Archaeomagnetic Research Program, Statistical Research Inc., Tucson AZ
Dr. Susan Stinson	2004	ANTH	current position unknown
Dr. Kurt Kipfmueller	2003	GRD	Assistant Professor, Dept of Geography Univ of Minnesota
Dr. Li Cheng	2003	SWES	Research Scientist, NSF Accelerator Facility, Dept. of Physics, U of AZ
Dr. Melanie Lenart	2003	RNR	Research Associate, Institute for the Study of Planet Earth, Univ of Arizona
Dr. David Grow	2002	GEOS	current position unknown
Dr. David Street	2001	ARCH and PREH Univ of Sheffield (UK)	Consulting Dendroarchaeologist, Bristol UK
Dr. William E. Wright	2001	GEOS	Research Scientist, Lamont-Doherty Earth Observatory
Dr. Fenbiao Ni	2000	ATMO	Research Associate, LTRR, University of Arizona
Dr Amy Hessl	2000	GRD	Assistant Professor, Department of Geology and Geography, West Virginia University
Dr. Matthew Salzer	2000	GEOS	Research Associate, LTRR, University of Arizona
Dr. Matthew Rollins	2000	WSM	Landscape Fire Ecologist, Rocky Mountain Research Station, Missoula Fire Sciences Laboratory, USDA Forest Service
Dr. Sarah Herr	2000	ANTH	Project Director, Desert Archaeology Inc., Tucson AZ

Table G.4. (Cont.) Primary-affiliated LTRR students graduated with a Ph.D.- cont.

Name	Year	Dept.*	Positions held since graduation or 1999
Dr. Patrick Lyons	2000	ANTH	Research Associate, Center for Desert Archaeology, Tucson AZ Curator of Collections, Arizona State Museum, University of Arizona
Dr. Peter van der Water	1999	GEOS	Post-doctoral Fellow, EPA, Corvallis, OR
Dr. Charles Riggs	1999	ANTH	Assistant Professor of Anthropology, Fort Lewis College, Durango CO
Dr. Eric Kaldahl	1999	ANTH	Curator of Education & Research, Tohono O'odham Nation Cultural Center & Museum, Sells, AZ Educational Project Director, Old Pueblo Archaeology, Tucson, AZ
Dr. Gregg Garfin	1998	GEOS	Program Manager &Investigator, Institute for the Study of Planet Earth Adjunct Assistant Professor, Geography and Regional Development, Univ of Arizona Research Associate, LTRR, Univ. Arizona
Dr. Elizabeth Miksa	1998	GEOS	Consulting Petrologist, Tucson AZ
Dr. Diane Douglas	1998	GEOG Arizona State Univ	current position unknown
Dr. Stephen Nash	1997	ANTH	Chair, Department of Anthropology and Curator of Archaeology, Denver Museum of Nature and Science Head of Collections, Department of Anthropology, Field Museum of Natural History Postdoctoral Fellow & Director of Paul S. Martin Project, Field Museum of Natural History
Dr. Elise Pendall	1997	GEOS	Assistant Professor, Dept. of Botany, University of Wyoming Postdoctoral Fellow, NOAA Climate and Global Change, Univ. Colorado
Dr. Ronald Towner	1997	ANTH	Adjunct Assistant Professor, Dendrochronology, LTRR, Univ. Arizona Assistant Visiting Professor, Dendrochronology, LTRR, Univ. Arizona Book Reviews Editor, *Kiva* Consulting Project Analyst in Archeology
Dr. Mark Varien	1997	ANTH Arizona State Univ	Research Director, Crow Canyon Archeaological Center, Cortez, Colorado

Table G.4. (Cont.) Primary-affiliated LTRR students graduated with a Ph.D.- cont.

Name	Year	Dept.*	Positions held since graduation or 1999
Dr. Connie Woodhouse	1996	GEOS	Associate Professor, Geography and Regional Development Univ of Arizona Physical Scientist, NOAA Paleoclimatology Program, National Climatic Data Center Research Scientist, Institute of Arctic and Alpine Research, University of Colorado Research Associate, Institute of Arctic and Alpine Research; Research Associate, National Research Council, National Geophysical Data Center, NOAA
Dr. Andrea Lloyd	1996	EEB	Associate Professor of Biology, Middlebury Coll. Assistant Professor, Ecology, Middlebury Coll.
Dr. Wallace Woolfenden	1996	GEOS	Archeologist-Paleoecologist, USDA Forest Service Bishop CA
Dr. Mark Elson	1996	ANTH	Research Archaeologist, Desert Archaeology, Inc., Tucson AZ
Dr. John Welch	1996	ANTH	Canada Research Chair in First Nations Cultural and Environmental Resource Management, Simon Fraser University, Burnaby, British Columbia, Canada Archeologist, USDI Bureau of Indian Affairs, Fort Apache Agency, Whiteriver AZ Historic Preservation Officer, White Mountain Apache Tribe, Whiteriver AZ
Dr. Paul Sheppard	1995	GEOS	Assistant Professor, Dendro., LTRR, Univ. Arizona NSF-NATO Postdoc. Fellow, Barcelona, Spain Research Specialist Senior, LTRR, Univ. Arizona
Dr. Henri Grissino-Mayer	1995	GEOS	Associate Professor, Department of Geography, University of Tennessee Postdoctoral Research Assoc., LTRR, Univ. Arizona Assistant Professor, Physics, Astronomy, & Geosciences, Valdosta State Univ., GA
Dr. Therese Muranaka	1993	ANTH	Associate State Archaeologist, San Diego Coast District CA

Table G.4. (Cont.) Primary-affiliated LTRR students graduated with a Ph.D. (cont.)

Name	Year	Dept.*	Positions held since graduation or 1999
Dr. Dana Oswald	1993	ANTH Univ of New Mexico	Professor, Environmental Studies, Prescott College, Prescott AZ Curator of Archaeology, Natal Museum, Pietermaritzburg, Natal, Union of South Africa
Dr. Nabil Chbouki	1992	GEOS	Corning Glass, New York
Dr. Shao Xumei	1992	GEOS	Postdoctoral Scientist, Institute of Geography, Chinese Academy of Sciences Research Professor, Institute of Geography, Chinese Academy of Sciences
Dr. Franco Biondi	1991	RNR	Associate Professor, University of Nevada-Reno Postdoctoral Researcher & Assistant Project Scientist, Geosciences Research Division, Scripps Institution of Oceanography, UC San Diego
Dr. Ramzi Touchan	1991	WSM	Associate Research Professor, LTRR, Univ. Arizona Initiated dendrochronology collaborations in the Near East and North Africa
Dr. Yasushi Kojo	1991	ANTH	Archeologist, Tokyo, Japan, Deceased
Dr. Won-Kyu Park	1990	WSM	Associate Professor, Forest Products, Chungbuk National Univ., Korea
Dr. Alex McCord	1990	GEOS	State of Arizona Division of Emergency Management
Dr. Carla Van West	1990	ANTH Washington State University	Director, Preservation Research, Statistical Research Inc. Rio Rancho NM Project Director, Statistical Research, Inc., Tucson
Dr. David Stahle	1990	GEOG Arizona State Univ	Professor, Department of Geosciences, University of Arkansas, Fayetteville
Dr. Elaine K. Sutherland	1988	WSM	Research Ecologist, USDA Forest Service Adjunct Professor, Plant Biology, The Ohio State Univ.
Dr. Christian Downum	1988	ANTH	Associate Professor, Anthropology, Northern Arizona Univ. Assistant Professor, Anthropology, Northern Arizona Univ.

Table G.4. (Cont.) Primary-affiliated LTRR students graduated with a Ph.D.- cont.

Name	Year	Dept.*	Positions held since graduation or 1999
Dr. Tom Swetnam	1987	WSM	Director, LTRR Professor, Dendrochronology, LTRR, Watershed Management, Ecology & Evolutionary Biology, and Geography & Regional Development, Univ. Arizona
Dr. Julie Lowell	1986	ANTH	Professor, Sociology, Anthropology, Criminology, University of Northern Iowa, Cedar Falls IA
Dr. Malcolm Cleaveland	1983	GEOS	Associate Professor, Geography, Univ. Arkansas Associate Editor, Tree-Ring Bulletin
Dr. Katie Hirschboeck	1985	GEOS	Associate Professor, Climatology, LTRR, Hydrology and Water Resources, Atmospheric Sciences, and Geography and Regional Development, Univ of Arizona
Dr. Ed Cook	1985	WSM	Senior Research Scientist, Lamont-Doherty Earth Observatory, Columbia Univ. Vice President, Holocene Commission, International Union for Quaternary Research
Dr. Richard Ahlstrom	1985	ANTH	Archaeologist, HRA, Inc., Tucson, AZ
Dr. Chester Shaw	1985	ANTH	Private Consulting Archeologist
Dr. Tracy Andrews	1985	ANTH	Professor of Anthropology, Central Washington Univ, Ellensburg WA Adjunct Assistant Professor, Anthropology, Central Washington Univ
Dr. Miranda Warburton	1985	ANTH	Martial Arts Trainer
		Washington State Univ	Director, Navajo Nation Archaeology Department, Flagstaff AZ Office
Dr. Barney Burns	1983	ANTH	Native Seed Search, Tucson
Dr. Eugene Rogge	1983	ANTH	Archaeologist, Dames and Moore, Phoenix AZ Regional Archeologist, USDI Bureau of Reclamation, Phoenix AZ
Dr. Steve Leavitt	1982	GEOS	Professor , Dendrochronology, LTRR, Univ. Arizona
Dr. Bruce Harrill	1982	ANTH	Regional Archeologist, USDI Bureau of Indian Affairs, New Mexico
Dr. Dave Meko	1981	HWR	Associate Research Professor, LTRR, Univ. Arizona Research Specialist Principal, LTRR, Univ. Arizona
Dr. John Cropper	1981	GEOS	Systems Programmer, Computer Science, Univ. Arizona

Table G.4. (Cont.) Primary-affiliated LTRR students graduated with a Ph.D.- cont.

Name	Year	Dept.*	Positions held since graduation or 1999
Dr. Alan Sullivan	1980	ANTH	Professor and former Head, Department of Anthropology, University of Cincinnati, Cincinnati OH
Dr. Laura Conkey	1979	GEOS	Associate Professor, Geography, Dartmouth Coll. Chair, Geography, Dartmouth Coll.
Dr. Richard Effland	1979	ANTH Arizona State Univ	Professor, Cultural Sciences – Anthropology, Mesa Community College, Mesa AZ
Dr. Richard Ciolek-Torrello	1978	ANTH	Project Director, Statistical Research, Inc. Redlands CA
Dr. Gordon Bronitsky	1977	ANTH	President, Bronitsky and Associates, Denver CO
Dr. Arthur Douglas	1976	GEOS	Chair and Professor, Atmospheric Sciences, and Director, Environmental Sciences, Creighton Univ.
Dr. Izumi Shimada	1976	ANTH	Associate Professor of Anthropology, Southern Illinois University, Carbondale
Dr. Meade Kemrer	1974	ANTH	Archeological Consultant, Las Cruces NM
Dr. J. Jefferson Reid, Jr.	1973	ANTH	Professor of Anthropology, University of Arizona, Tucson
Dr. Chuck Stockton	1971	HWR	Professor, Dendrochronology, LTRR, Univ. Arizona, Special Water-Climate Consultant to His Majesty King Hassan II of Morocco
Dr. Ben Brown	1968	ANTH	Chihuahua State Archeologist, Chihuahua, Mexico
Dr. Ward Weakly	1968	ANTH	Bureau Senior Archaeologist, USDI Bureau of Reclamation, Denver CO, Deceased
Dr. Jeffrey Dean	1967	ANTH	Professor, Dendrochronology and Anthropology, Curator of Archaeology , Arizona State Museum, Univ. Arizona
Dr. Scott Beasley	1966	WSM	Professor, Forestry Stephen F. Austin SU Dean, College of Forestry, SFASU

* ANTH = Anthropology, ARCH = Archaeology, ATMO = Atmospheric Sciences, EEB = Ecology & Evolutionary Biology, GRD= Geography & Regional Development, GEOG = Geography, GEOS = Geosciences, HIST = History, PREH = Prehistory, HWR = Hydrology & Water Resources, PLS = Plant Sciences, SNR = School of Natural Resources (formerly RNR = Renewable Natural Resources), SWES = Soil, Water and Environmental Science, WSM = Watershed Management

Table G.5. Primary-affiliated LTRR students graduated with M.S. or M.A. degree

Name	Year	Dept.*	Positions held since graduation or 1999
Erica Bigio	2006	GEOS	Fulbright Scholar, Swiss Federal Forest Institute, Birmensdrorf.
Chris McPhee	2006	GEOS	Professional Master of Forestry student, Master of Environmental Management Program, Duke University
Jeff Balmat	2004	GRD	Sonoran Institute, Tucson, AZ
Ellis Margolis	2003	WSM	Ph.D. student, WSM, Univ. Arizona
Nicole Arendt	2002	ANTH	Ph.D. student, Anthro, Univ of Arizona
David Mehalic	2002	ANTH	Archeologist, Apache-Sitgreaves National Forest AZ Ph.D. student, Anthro, Univ of Arizona
June Psaltis	2001	WSM	J.D. Student, Pace Law School, Pace University, White Plains, NY
Christine Hallman	2001	GEOS	Ph.D. student, Geography & Regional Dev, Univ Arizona Instructor, Pima Community College
Daniel Ryerson	1999	WSM	Forest Health Specialist, New Mexico Zone, Southwestern Region, USDA Forest Service
Mark Kaib	1998	WSM	Regional Ecologist, U.S. Fish & Wildlife Service, Albuquerque, NM Research Associate, LTRR and Arizona State Museum, Univ. Arizona
Shelley Danzer	1998	WSM	Research Specialist, The Nature Conservancy Research Specialist Sr., Geography, Univ. Arizona
Matthew Littler	1998	ANTH	Applications Systems Analyst, Office of Continuing Education and Outreach, University of Arizona, Tucson
Lisa Pedicino	1997	RNR	Instructor, College of the Redwoods, Eureka, CA Analyst, Cascade Analytical Lab. Instructor, Wenatchee Valley Coll., WA
James Speer	1997	GEOS	Assistant Professor of Geography and Geology Department of Geography, Geology, and Anthropology, Indiana State University Ph.D. student, Geography, Univ. Tennessee Starting a tree-ring laboratory at Univ. Tennessee Instructed graduate-level Dendrochronology USDA Forest Service Technician
Rena Ann Abolt	1997	RNR	Stewardship Ecologist and Fire Manager, The Nature Conservancy, Louisiana
William E. Wright	1997	ANTH	Research Scientist, Lamont-Doherty Earth Observatory Ph.D. student, Geosciences / LTRR Univ. Arizona Graduate Teaching Assistant, LTRR

Table G.5. (Cont.) Primary-affiliated LTRR students graduated with M.S. or M.A. degree – cont.

Name	Year	Dept.*	Positions held since graduation or 1999
Margot Kaye	1997	WSM	Assistant Professor of Forest Ecology, Penn. State Univ. Associate Dendrochronologist, Rocky Mountain Tree-Ring Research, Colorado Ph.D. student, Ecology, Colorado State Univ.
Kiyomi Morino	1996	WSM	Ph.D. student, Geography & Regional Dev, UA Research Specialist, Laboratory of Tree-Ring Research
Michelle Wood	1996	GEOS	Environmental Scientist, California Environmental Protection Agency Central Valley Regional Water Quality Control Board Project Geologist, Arizona Geological Survey Project Hydrologist, Pima Association of Governments Associate Geoscientist, Environmental Consulting
Dana Perkins	1995	RNR	Ecologist, U.S. Bureau of Land Management, Challis, ID. Ph.D. student, Utah State Univ.
Anthony Caprio	1995	WSM	Ecologist, Biological Resources Division, USGS, Sequoia and Kings Canyon Field Sta.
Rebecca McKim	1994	ANTH	current position unknown
Sarah Herr	1994	ANTH	Project Director, Desert Archaeology Inc., Tucson AZ
Linda Mutch	1994	WSM	Ecologist, Biological Resources Division, USGS, Sequoia and Kings Canyon Field Sta.
Wanmei Ni	1993	RNR	Research Specialist, USDA Agricultural Research Station, Southwest Watershed Research Center, Tucson
Peter van der Water	1993	GEOS	Post-doctoral Fellow, EPA, Corvallis, OR Ph.D. student, Geosciences, Univ. Arizona Postdoctoral Fellow, Univ. Oklahoma
Kedra Segler	1993	HWR	Captain, US Army Garrison, Vicenza Italy
MaryBeth Keifer	1991	EEB	Ecologist, USDI, National Park Service, Sequoia and Kings Canyon National Park
Peter Brown	1991	WSM	Director & President, Rocky Mt. Tree-Ring Research Co-Director, North American Dendroecological Fieldweek Ph.D. (awarded 2003) Natural Resources, Colorado State Research Assistant, Institute of Arctic and Alpine Research
Jean McCollom	1990	WSM	Ecologist, National Audubon Society

Table G.5. (Cont.) Primary-affiliated LTRR students graduated with M.S. or M.A. degree – cont.

Name	Year	Dept.*	Positions held since graduation or 1999
Dr. Christopher Earle	1986	GEOS	Ph.D. 1993, Univ. Washington Research Watershed Hydrology Specialist, Beak Consultants, Inc.
Dr. Patricia Fall	1981	GEOS	Associate Professor, Geography, Arizona State University, Tempe
Martin Rose	1981	GEOS	Private Consulting Dendrochronologist Desert Research Institute, Reno, Nevada
Dr. Allan Drew	1967	WSM	Professor, Forest Ecology and Tree Physiology, SUNY Syracuse

* ANTH = Anthropology, EEB = Ecology & Evolutionary Biology, GRD= Geography & Regional Development, GEOS = Geosciences, HIST = History, HWR = Hydrology & Water Resources, PLS = Plant Sciences, RNR = Renewable Natural Resources (currently SNR = School of Natural Resources), WSM = Watershed Management

Table G.6. Undergraduate students closely affiliated with LTRR -- graduated with B.S. or B.A. degree.

Name	Year	Dept.*	Positions held since graduation or 1999
Laura Marshall	2006	EEB	PhD program at UC Irvine Earth System Science Program.
Diana Higdon Chandler	2004	PLS	High School Science Teacher, Alta Vista High School, Tucson , M Ed Univ Arizona.
John King	1994	RNR	Research Specialist Senior, LTRR, Univ. Arizona
Chris Baisan	1991	RNR	Research Specialist Senior, LTRR, Univ. Arizona
Jim Fairchild-Parks	1990	HIST	Research Technician, LTRR, Univ. Arizona

* EEB = Ecology & Evolutionary Biology, HIST = History, PLS = Plant Sciences, RNR = Renewable Natural Resources (currently SNR = School of Natural Resources)

Table G.7 . Professional Memberships by Previous and Current LTRR Graduates

American Geophysical Union (AGU)	Geological Society of America (GSA)
Ecological Society of America (ESA)	Tree-Ring Society (TRS)
American. Assoc. for the Advancement of Science	International Assoc. of Landscape Ecologists
International Association of Wildland Fire	Association for Fire Ecology (AFE)
Student Association for Fire Ecology (SAFE) (national co-chair, UA chapter president)	GLOCOPH – INQUA Commission on Global Continental Palaeohydrology
International Association of Wood Anatomists (IAWA)	American Quaternary Association (AMQUA)
American Meteorological Society (AMS)	SE Arizona Chapter – American Meteorological Society
Association of American Geographers (AAG)	AAG Specialty Groups: Biogeography, Climate, Hazards
Society of Woman Geographers	Association of Pacific Coast Geographers
Arizona Floodplain Managers Association (AFMA)	Weather and Society – Integrated Studies
Society of Wetland Scientists	Soil Science Society of America (SSSA)
Society for American Archaeology (SAA)	Arizona Archaeological and Historical Society
American Institute of Hydrology	Xi Sigma Pi Honor Society for Students in Natural Resources

H. ACADEMIC OUTREACH

H.1. The Nature of LTRR outreach

H.1.1. Introduction

As a primary source of information on dendrochronological theory, method, and practice, the Laboratory of Tree-Ring Research engages in a broad spectrum of off-campus outreach activities. A substantial proportion of this outreach is initiated by off-campus individuals and organizations seeking the best possible instruction in all aspects of tree-ring analysis. People and institutions involved come from all areas of the state, nation, and world, span a broad spectrum of scholarly disciplines, and represent a wide range of private, academic, and governmental affiliations. The scope of these activities is a result of and testament to the international reputation of LTRR in the field of dendrochronology.

H.1.2. Educational Outreach

LTRR emphasizes educational contact with primary and secondary schools of Tucson and Arizona. This activity routinely involves sending speakers to elementary, middle, and high schools and providing lectures, demonstrations, and tours at LTRR for school groups. LTRR personnel regularly devote considerable time to assisting pupils from throughout the country with class and science fair projects involving tree-ring analysis. In addition, LTRR has developed tree-ring teaching kits consisting of samples, examples, and instructional materials for distribution to elemtary and secondary school teachers for class use. LTRR personnel also teach special courses to help Arizona school teachers broaden their command of science.

Since 1999, the number of individual tour visitors to LTRR or in-class students who saw an LTRR demonstration or presentation has increased every year, with a maximum number of almost 3500 people in 2005 (**Figure H.1**). Most of these visits have been students of local school districts and/or of the University of Arizona itself, while other visitors have been from various non-academic civic groups.

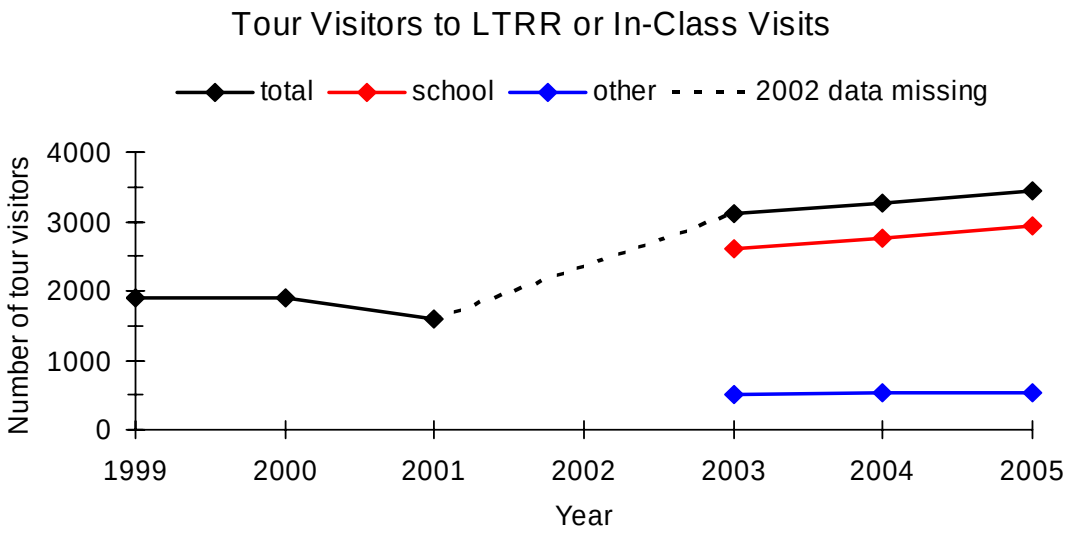

Figure H.1. Tour visitors to LTRR or in-class visits, 1999-2006.

LTRR also pursues educational contacts with other institutions of higher learning throughout the world. Faculty and staff members present numerous lectures, demonstrations, training sessions, and short courses at other colleges and universities; provide LTRR talks and tours to visiting classes; and assist undergraduate and graduate students with research projects involving tree-ring data. Included among these efforts are presentations and short courses at Arizona State University, Southern Methodist University's Taos NM campus, New Mexico, Rice University, Lakehead University in Thunderbay, Canada, Yale Forestry, the Santa Fe Institute, and the School of American Research. LTRR also supplies study sets of tree-ring samples and instructional exercises for classes at other institutions, including the University of Illinois and the Queen's University in Belfast, Northern Ireland. LTRR personnel routinely present talks and demonstrations at numerous field schools and are frequent contributors to the international Dendroecological Field Weeks held at irregular intervals in various parts of the world. Visits have been made to the archaeological field schools of the University of Arizona, Arizona State University, Northern Arizona University, the Museum of Northern Arizona, Oberlin College, the Crow Canyon Archaeological Center, and the Afognak Native (Aleut) Corporation in Alaska.

Another important educational program provides exhibit and study materials to educational and scientific institutions. LTRR routinely supplies tree-ring display samples and information to museums and frequently assists in the design and development of exhibits on various aspects of tree-ring work. More than 25 museums from Arizona to New Zealand have benefited from this endeavor and have helped spread the tree-ring message to millions of people around the world. A few of the institutions that have availed themselves of this service are the Arizona State Museum, Arizona-Sonora Desert Museum, Museum of Northern Arizona, Sunset Crater National Monument, Anasazi Heritage Center, Maxwell Museum of Anthropology, Florence Hawley Ellis Museum, New Mexico Museum of Natural History, Inyo National Forest Ancient Bristlecone Pine Forest Museum, Tucson Children's Museum, Corps of Engineers/Bureau of Reclamation Museum in Riverdale, North Dakota, and Botanic Gardens Museum in Timaru, New Zealand.

H.1.3. Research Outreach

LTRR actively assists other scholars and institutions with tree-ring related research, undertakes cooperative research projects with other individuals and organizations, and promotes the dissemination of dendrochronological knowledge through scholarly interchange among scientists. LTRR personnel allocate substantial time and effort to counseling other scientists on the relevance of tree-ring analysis to their research and to providing technical assistance with the work. Examples of this endeavor include advising numerous individuals and institutions on the techniques and tools of sample collection and analysis; assisting the Universidad Autónoma de Zacatecas, Mexico, to establish a tree-ring program; conducting on-site training courses for Jordanian, Israeli, and Palestinian scientists, Appalachian State College, Oregon State University, Georgia State University, the Universities of California at Berkeley and Davis, the Los Alamos National Laboratories, and many others; and analyzing several thousand archaeological and geological tree-ring samples per year from the Southwest, Texas, California, Nevada, Oregon, Wyoming, Montana, Alaska, Chihuahua, Sonora, Durango, Zacatecas, and Peru. LTRR also provides dated wood samples to other institutions as raw material for a variety of research projects. Among these are efforts by the University of Arizona and other radiocarbon laboratories to calibrate the radiocarbon time scale against absolutely dated tree-ring samples; attempts at Northern Arizona, Eastern New Mexico, and Rutgers Universities to use trace element analysis to identify the sources of architectural beams in prehistoric archaeological sites; and a study of the decay rates of different types of wood by the Smithsonian Institution Center for Materials Research and Education.

LTRR personnel devote considerable time to developing cooperative research ventures with individuals and institutions around the world. Prominent among these are developmental projects with government ministries of Israel and Jordan; dendroclimatic and fire history research in cooperation with the Russian Academy of Science in Siberia, the Urals, and Kirghizia; basic dendrochronology for forestry managers in Central America; dendroclimatic research in cooperation with government science agencies in Morocco, India, and Nepal; dendroarchaeological studies with private cultural resource management companies such as Desert Archaeology and Western Cultural Resources Management; Mesa Verde National Park; Bureau of Land

Management; Taos Valley Water Users Association; Center for Beethoven Studies at San Jose State University; flautist R. Carlos Nakai; chronology building and dendroclimatic or dendrohydrologic work with Great Sand Dunes National Monument in Colorado; NSF Sevilleta Long-Term Ecological Research, New Mexico; GeoTrans Inc.; Instituto Argentino de Nivología y Glaciología; University of Valdivia, Chile; and computer modeling of human adaptation to environmental variability in cooperation with the Santa Fe Institute and the Brookings Institution.

Since its inception in 1937, LTRR has committed substantial effort to developing and facilitating communication among dendrochronologists and other scientists interested in issues to which tree-ring analysis can make a contribution. In 1935, A. E. Douglass founded the Tree-Ring Society, still a prominent international professional organization devoted to all aspects of dendrochronology. Traditionally, LTRR has been the institutional home of the Tree-Ring Society and its publication, the *Tree-Ring Bulletin*, now *Tree-Ring Research* (T-RR). The Society and T-RR are important mechanisms for linking the world dendrochronological community. Similarly, LTRR personnel were instrumental in developing and maintaining the International Tree-Ring Data Bank (ITRDB) and the electronic ITRDB Tree-Ring Forum. The ITRDB, now managed by The World Data Center-A for Paleoclimatology of the National Oceanic and Atmospheric Administration's National Climate Data Center, is a central repository for tree-ring data, including ring-width and density measurements, standardized ring-width index series, and dendroclimatic reconstructions, all submitted by scholars from around the world and made available to other researchers for their own projects. The LTRR network Home Page and its links to related sites on the web provide electronic communication with the dendrochronological community and other interested parties. Finally, as part of this effort, LTRR sponsored *Tree Rings and Climate" Sharpening the Focus,* an international dendrochronological conference that attracted ~80 contributors from several countries to Tucson in April, 2004.

H.1.4. Public Outreach

LTRR faculty and staff make conscientious efforts to communicate with the nonacademic world through the delivery of lectures, demonstrations, and training sessions to groups ranging from businesses to government agencies. Through the auspices of the UA Speakers' Bureau, LTRR personnel have delivered many tens of public talks to civic and interest organizations throughout the state ranging from alumni associations to the Secular Humanist Study Group at the Wilmot Federal Prison and from the Arizona Archeological Society to the Pima County Environmental Quality Committee. This outreach also involves participating in scientific, policy, and management meetings throughout the world. Recent examples of such efforts include participation in and organization of government agency workshops on fire and ecosystem management; field training for the National Park Service, U.S. Forest Service, and state forestry agencies; and dendroarchaeological field training for the Bureau of Land Management, private cultural resource firms, and representatives of various Indian Tribes. Fieldwork around the world provides innumerable opportunities for informal talks to ad hoc gatherings at parks, field stations, and campgrounds from California to Siberia. LTRR maintains an active program of instruction in dendrochronological methods for government departments including state and federal land management agencies, Indian Tribes, and a host of foreign units.

Consulting by faculty members extends widely throughout the business and government communities. Although many requests for consultation are turned down due to inappropriateness or lack of time, those opportunities that are accepted disseminate dendrochronological practice into a wide variety of contexts ranging from agribusiness to archaeology. Examples have included work on a land damage claim for the Zuni Indian Tribe, advising the USDI Bureau of Reclamation on cultural resource management issues in connection with the Central Arizona Project, advising Archaeological Consulting Services, Ltd., on archaeology connected with the rerouting of Arizona Highway 88, age-dating trees in various cases of land boundary disputes, and pursuing groundwater studies for the Water Resources Department of the Tohono O'odham Nation.

Interaction with the media is an important aspect of LTRR efforts to disseminate information to the public. This endeavor involves countless interviews with the print and broadcast media and assistance with the production of special radio and television programs. Over the last several years, hundreds of contacts have been

made with various media outlets. These contacts range from brief phone interviews about currently hot topics to several days spent filming or video taping in LTRR and in the field for television documentaries or instructional videos. Some of the media and programs involved have included Southwest Parks and Monuments Association, KUAT and other local television stations, National Public Television, the major radio and television broadcast networks, German Public Radio, the BBC, Terra-X (a cooperative venture of German Public Television and the BBC), Principal Film Company, Cambridge Studios, Maslowski Nature Films, Italian Television, Japanese National Television, Guatemalan Television, Kurtis Productions (*The New Explorers*), and *Newton's Apple*. Of special note is KUAT Television's use of footage from the LTRR collection of A. E. Douglass films in two special productions, one on Emil W. Haury and one on the history of Tucson. LTRR supplies, on request, an average of more than 50 photographs per year for use in popular and professional articles, instructional pamphlets, and news releases. Media outreach encompasses countless newspapers and magazines including the *Arizona Daily Star, Tucson Citizen, Arizona Republic, Albuquerque Journal, Gallup Independent, San Jose Mercury, San Diego Tribune, Reno Gazette-Journal, Lahontan Valley News, Sierra Vista Herald, Los Angeles Times, San Francisco Chronicle, New York Times, London Times, Helsingfors Sanomat, Popular Mechanics,* and *National Geographic Magazine* among many others.

An activity that takes immense amounts of time and effort that cannot be documented is responding to requests for information, assistance, or materials that arrive daily by post, phone, or e-mail. These communications include questions from school children working on class projects, requests for guidance from graduate students or university faculty, questions from individuals wanting to know something about dendrochronology or wanting help with problems that tree-ring analysis might be able to solve, and requests for assistance with law suits of various kinds.

H.1.5. Results of Outreach

The outreach activities enumerated above have had numerous favorable ramifications for LTRR, the University, and the state. Contacts like these are a primary mechanism for recruiting students into LTRR educational programs and into associated degree-granting programs, either precollege students inspired by presentations at their schools or university students from the UA or other institutions stimulated to apply dendrochronology to their own research. As is demonstrated elsewhere in this document, many of these students have gone on to make major scientific contributions and expand the scope of tree-ring analysis. Outreach has stimulated monetary donations to both LTRR and the University. Although such funding is not large, it illustrates the appeal of the discipline to a wide audience. Outreach has spurred numerous fruitful contacts and cooperative activities with other academic and governmental institutions ranging from joint archaeological projects to global-scale dendroclimatic research. Interaction with the media has spread knowledge of the discipline, LTRR, the University, and the state of Arizona to millions of people around the world.

H.2. Relevance to Program Goals

H.2.1. Goals of LTRR

The outreach activities described above are an integral part of LTRR efforts to accomplish its teaching and research goals. Outreach is an important means of disseminating dendrochronological knowledge beyond academia and for generating new research and teaching opportunities. The wide scope of our outreach reflects the interdisciplinary nature and global impact of LTRR. Outreach has involved all facets of dendrochronological practice including archaeology, climatology, ecology, paleoenvironment, and global change. This broad-front effort has touched audiences that include elementary and secondary school children, university students and faculty, government scientists and administrators, businesses, print, broadcast, and electronic media, and interested individuals from most parts of the world. To the extent that outreach contributes to LTRR goals, it also contributes to the University's Mission and Strategic Plan and its outreach obligations as a Land Grant Institution.

Additionally, feedback resulting from contacts with a broad spectrum of scientists and laypersons helps maintain and expand the interdisciplinary applications of dendrochronology and the interdisciplinary capabilities

of LTRR in both teaching and research. Outreach alerts students and scientists to the training and research opportunities of LTRR and contributes directly to our efforts to improve the quality and scope of our educational program for undergraduate, graduate, and postgraduate students. Interaction with many different media outlets helps educate the general public about potential contributions of dendrochronology to resolving environmental and social problems that affect today's world and supports our intent to expand the discipline's relevance to understanding the past and determining the future of our planet.

H.2.2. Needs of Arizona

LTRR outreach contributes to particular needs of the state of Arizona in many ways. Educational outreach contributes significantly to the education of Arizona's primary and secondary school students across a broad spectrum of important issues ranging from the human past of the Southwest to future global environmental change. In addition, LTRR outreach provides both instruction and research opportunities for community college and university students throughout the state. LTRR also serves as a resource of knowledge and information for Arizona businesses wanting to improve their standing and competitive position in the environmental and cultural resources fields. Dissemination of dendrochronological research results helps elected officials and administrators plan Arizona's future with regard to a host of vital issues including deployment of human resources, population growth, water acquisition and allocation, natural and cultural resource management, and response to episodic environmental events (for example droughts) and long-term environmental trends (such as global change). Finally, LTRR outreach has directly helped various Arizona Indian communities illuminate their own histories, pursue land claims, and evaluate and manage their land, water, and cultural resources.

H.3. Quality and Effects of Outreach

Although LTRR records specific contacts, without formal mechanisms to elicit feedback from the individuals and institutions affected, it is difficult to quantitatively document the quality or impact of LTRR outreach. However, taking uniformly enthusiastic unsolicited responses from school children and continuing and repeated demand as accurate gauges of success, the LTRR program must be judged to be both outstanding and effective. Schools, colleges, universities, museums, and other educational institutions have repeatedly availed themselves of LTRR for opportunities for information and instructional materials. In addition, the list of new participants in the educational outreach program continues to grow. Outside scholars who have studied at LTRR or have been helped by LTRR personnel not only commonly return for additional training or guidance but also recommend LTRR to colleagues, a factor that accounts in part for the steadily growing number of contacts U.S. and foreign students and scholars.

Local, state, tribal, and federal agencies that have received assistance from LTRR repeatedly request additional training and materials. The integration of dendrochronological principles and methods into the management and research programs of these agencies testifies to the effectiveness of LTRR outreach. Examples of this response include the incorporation of dendrochronological sampling and analysis into the cultural resource management policies of government agencies ranging from the Bureau of Land Management to the Corps of Engineers; the use of dendrochronological fire history and insect damage studies to structure U.S. Forest Service and National Park Service forest fire management and insect control policies and programs; the development of intensive archaeological tree-ring sampling programs by the National Park Service; efforts to identify and protect culturally modified trees by various land management agencies; the use of tree-ring dating to document settlement histories by Indian groups including the Acoma, Hopi, Navajo, and Zuni tribes; and the utilization of tree-ring data in various types of litigation ranging from land boundary disputes to water rights cases. Frequent requests for consultation with LTRR faculty by private sector businesses, government agencies, and Indian tribes also attest to the quality and impact of LTRR outreach program.

Finally, the innumerable requests for comments, information, photos and illustrations, interviews, and appearances by the print and broadcast media affirm the effectiveness of LTRR outreach. The increasing media awareness of dendrochronology and its applications to a variety of topics important to the modern world – global warming, the effects of El Niño, anthropogenic climate change, cultural resource management, groundwater

depletion, and many others – is a major example of the effectiveness of LTRR efforts to reach out to the community at large.

I. COLLABORATION WITH OTHER UNITS

One of the major strength of the Laboratory of Tree-Ring Research (LTRR) is its local, national and international collaborations. Given the diverse backgrounds of its faculty, the interdisciplinary nature of many of the research problems they address, and the necessarily multidisciplinary character of successful approaches to these problems, every aspect of LTRR is marked by collaboration with other units. This applies to teaching, research, and service at every level from inter-departmental to inter-collegiate to international. Collaborative research projects carried on by teams consisting of two or more faculty members have a long tradition in LTRR and have materially expanded the scope of dendrochronology and enhanced scientific knowledge of numerous topics. Similarly, LTRR faculty have evinced a propensity for working with colleagues from other institutions in other parts of the country and around the world, as documented in **Table I.4**. The following paragraphs describe the different kinds of collaborations in which LTRR faculty are involved.

I.1. Faculty Appointments in Other UA Departments and Programs

- Jeffrey Dean – joint appointment in Anthropology, Arizona State Museum
- Michael Evans – joint appointments in Geosciences and Atmospheric Sciences
- Katherine Hirschboeck – joint appointments in Hydrology and Water Resources, Atmospheric Sciences, and Geography & Regional Development
- Malcolm Hughes – joint appointment in Watershed Management
- David Meko – joint appointment in School of Natural Resources
- Thomas Swetnam – joint appointment in Ecology & Evolutionary Biology, Geography & Regional Development, and School of Natural Resources
- Ramzi Touchan – joint appointment in School of Natural Resources

Laboratory faculty serve from time to time as *de facto* members of the Geosciences faculty in chairing and membership of graduate committees.

Note that these joint and adjunct appointments span four colleges of the university - Agriculture, Engineering, Science, and Social and Behavioral Sciences, reflecting the wide range of our activities.

Drs. Evans, Hirschboeck, Hughes, Leavitt, Meko, and Swetnam are on the faculty of the Global Change Ph.D. minor Graduate Interdisciplinary Program (GIDP). Dr. Hirschboeck currently chairs the Executive Committee of that GIDP. Drs. Evans and Meko are on the faculty of the Statistics GIDP. Drs. Hirschboeck and Swetnam serve on the faculty of the Ph.D. program in Arid Lands Resource Sciences.

I.2. Local Collaboration in Teaching

Intra-laboratory and intra-departmental collaboration is exemplified by cooperative teaching and research (See **Table I.1 and I.2**). As LTRR does not directly award degrees, all of its teaching is done in collaboration with other units of the University. General education courses for undergraduate non-science majors are offered through the general education program. Dendrochronology courses have Geosciences as their home department and are cross-listed in the School of Natural Resources (SNR) and Anthropology. Upper division and graduate Global Change classes are offered either through the Interdisciplinary Committee on Global Change, which oversees the Global Change Ph.D. minor, or through cross-listing in Geosciences, Atmospheric Sciences, Hydrology and Water Resources, Natural Resources, Geography and Regional Development, and Ecology and Evolutionary Biology. Several of these courses are taught either jointly, or in parallel sections with colleagues in the Departments of Hydrology and Water Resources, and Atmospheric

Sciences. LTRR has taken a leading role in the development of Global Change curriculum at the University.

Table I.1. Collaborative courses taught within the University of Arizona with LTRR participation.

Course Title and Number	Unit & Level	Instructors
ANTH 447/547: Anasazi Archaeology	3, under-graduate/graduate	Dean (LTRR), Adams (Anth)
GEOG 696C: Surface Moisture in Arid Lands: Mechanisms, Models, Mediations	3, graduate	Yool (Geogr), Meko, Hirschboeck (LTRR) guest lecturers
GEOS. 195D: Sense of Place	1, first-year colloquium	Sheppard (LTRR), Butler, Huckleberry (Geos)
GEOS 220: Environmental History of the Southwest	3, Under-graduate	Dean, Swetnam, Towner, Sheppard (LTRR), Betancourt (USGS)
GEOS 464/564: Intro. Dendrochronology	3, upper division/graduate	Hughes & guest lecturers (LTRR)
GEOS 513: ENSO Past, Present, Future	2-3, graduate	Evans (LTRR), anyone else?
GEOS 595E Topics, Tools, Techniques in Paleoclimatic Research	2, graduate	Dean, Leavitt , Hughes (LTRR), Betancourt (USGS), Cohen, Cole, Jull, Quade (Geos), Overpeck (ISPE), Ekwurzel, Hahmann
GEOS/WSM 595E: Isotope Dendro.	1-2, Graduate	Leavitt, Hemming (LTRR)
GEOS/WSM 595E: Journal Club	1, Graduate	Swetnam, Falk, Evans, Dean, Sheppard, Hirschboeck (LTRR)
GEOS 597E: Spatiotemporal Data Anal. Workshop	3, graduate	Evans (LTRR), anyone else?
GEOS 597I: Practical Dendroclimatology	1, Graduate	Hughes, Touchan (LTRR)
GEOS 597I: Practical Dendroclimatology	3, Graduate	Hughes & guest lecturers (LTRR)
GEOS/HWR/GC 572: Global Biogeochem. Cycles	3, Graduate	Leavitt (LTRR), Brooks, Bales (Hydrol)
NATS 101: Intro. Global Change	3, Undergraduate	Leavitt, Salzar (LTRR)
NATS 101: Intro. Global Change, Honors	3, undergraduate	Evans (LTRR), anyone else?
WS M 531: Dryland For. Manag.	3, Graduate	Ffolliett (SNR), Touchan (LTRR) guest lecturer
WS M 532: Agroforestry	3, Graduate	Ffolliett (SNR), Touchan (LTRR) guest lecturer

I.3. Local Collaboration in Research

LTRR has established strong joint research with departments of the University of Arizona as well as local and state entities (**Table I.2.**).

Table I.2. Collaborative research between faculty of LTRR, other University of Arizona departments, and institutions in Tucson and Arizona.

Project Name	Funding Agency	Outcome	Investigators
Southwestern Archaeological Tree-Ring Dating	NSF Archaeometry ($473k)	7200+ dates, numerous publications	Dean, Towner (LTRR)
US 89 Wupatki-Fernwood Archaeological Project	ADOT, ($66.2k)	S.F. Peaks BCP chronology, climate reconstructions, Salzer diss.	Dean, Salzer (LTRR), Elson (Desert Archaeology, Inc.)
Strontium Isotope Sourcing of Chaco Canyon Spruce & Fir Beams	USGS	PNAS publication	Dean (LTRR), Quade, English (Geos), Betancourt (USGS)
Dendroarchaeology of the Navajo Occupation of the Southwest	NSF Archaeology, ($267k)	Navajo sites database, new dates, publications	Dean, Towner (LTRR)
Absolute Chronology of Pazyryk Culture and Climate Variability in Altai Mountains from Tree Rings	NSF Archaeology, ($259.7k)	Larch tree-ring chronology, temperature reconstruction, relative archaeological dates	Dean, Panyushkina (LTRR)
Strontium Isotope Sourcing of Chaco Canyon Ponderosa Pine Beams	USGS, NSF IGERT (UA Archaeological Sciences	Journal of Archaeological Sciences Publication	Dean (LTRR), Quade, Reynolds (Geos), Betancourt (USGS)
Archaeological Sciences: An Integrated Approach to Human Use of Ancient Landscapes Through Chrono-metry, Paleoecology, and Technology	NSF IGERT, (3.0m)	Support for 50+ graduate students in several departments, many dissertations, extensive research	Dean (LTRR), Olsen (Anth), Ruiz (Geos)
The Evaluation of Paleo Data to Determine Past, Present, and Future Hydrologic Variability in Arizona	UA Technology Research Initiative Fund, Water Sustainability ($132k)	Tree-ring chronologies, streamflow reconstructions, hydrologic characterizations	Dean, Towner, Meko (LTRR), Baker (HWR), Valdes (CE/EM)
Keet Seel Architectural Documentation Project	US NPS ($200+k)	LIDAR map and elevations and detailed documentation of Kiet Siel Ruin, Navajo National Monument	Dean (LTRR), Culpepper (US NPS)
A.D. 1064: Pilot Study of Archaeological Tree-Ring Samples to Re-examine Eruption of Sunset Crater	Western National Parks Association ($7.5k)	Morphological & dendrochemical evidence for possible eruptions of Sunset Crater	Dean, Sheppard (LTRR), Elson (Desert Research), Street (consultant)

Project Name	Funding Agency	Outcome	Investigators
Hohokam Irrigation Modeling Project	NSF, Resilience Alliance	Agent-based model of Hohokam irrigation using dendrochronology	Dean (LTRR), Redman, Kinzig (ASU)
Alliance and Landscape: Perry Mesa, Arizona, in the Fourteenth Century	NSF Archaeology ($210+k)	Just getting underway	Dean (LTRR), Abbott, Spielmann, Ingram (ASU)
Acquisition of an analytical facility for high resolution paleoclimatology	NSF/Major Research Instrumentation	5 instruments for interdisciplinary research; graduate courses	Evans, Hughes (LTRR), Cole, Overpeck (Geos), Beck (Physics)
Realistic synthetic tree-ring data to constrain climate models.	NOAA	In progress	Evans, Hughes (LTRR)
Culturally infused introductory course in weather and climate	NSF/ATM	Course developed; teachers trained to offer it	Evans (LTRR), Buseck, Marlow (Tohono O'odham CC, Sells, AZ)
Near East Climate Variability from Tree-Rings	NSF-ESH	Manuscripts	Hughes, Touchan (LTRR)
Development of an enhanced computer-assisted analysis system for earth science investigation of laminated sediments and tree rings	NSF	Manuscripts	Hughes (LTRR), Schowengerdt (ECE), Overpeck (ISPE)
Time-dependent bias in tree-ring based reconstruction	NOAA	Computer model still under development	Hughes, Meko, Kipfmueller, Ni (LTRR)
Meeting on tree-ring and climate: sharpening the focus	NSF and NOAA	Workshop in April 2004, book at late stage of development Fall 2006	Hughes, Swetnam (LTRR), Diaz (NOAA)
Volcanic eruptions 3400-3700 years ago recorded in *Pinus longaeva* rings	Institute for Aegean Prehistory	Paper in Quaternary Research	Hughes, Salzar (LTRR)
Geospatial approach to dendro-climatology of bristlecone pine	NSF	In progress	Hughes, Salzar (LTRR)
Global multidecadal to century-scale climate oscillations of last 1000 years	NOAA	manuscripts	Hughes, Ni (LTRR)
Variability, social vulnerability, and public policy in the Southwestern, US	NOAA	Manuscripts, web sites, many other outreach materials	Hughes (LTRR), Morehouse (HWR), Comrie (Geogr), Liverman (Latin Am), Finan, Lemos (BARA)

Project Name	Funding Agency	Outcome	Investigators
Climate of the Southwest	CLIMAS	Several conference pubs & peer reviewed manuscript	Hughes (LTRR), Swetnam (LTRR), Hirschboeck (LTRR), Geography, ISPE, and others
Paleovolcanology of Sunset Crater	NSF Petrology and Geochemistry	Several conference pubs, peer reviewed manuscript	Sheppard (LTRR), Desert Research, Inc., NAU
Wood color research	AZ 301 funds for Image Science	Conference pub, peer reviewed manuscript	Sheppard (LTRR), Wiedenhoeft (USFS FPL)
Near East Climate Variability from Tree Rings	NSF-ESH	Manuscripts	Touchan, Hughes (LTRR)
Wildfire Alternatives	EPA	Conference papers, peer-reviewed book chapter, manuscripts, web site: http://walter.arizona.edu/	Swetnam (LTRR), Morehouse (ISPE), Yool (Geography), Orr (Arid Lands), others
PaleoWater in Arizona Database	U of A TRIF		Meko, Hirschboeck (LTRR), Baker (HWR), Valdez (CE/EM)
Hydroclimatology of floods	U of A	Book chapter	Hirschboeck (LTRR) Maddox (ATMO), Ely (Univ W. Wash.)
Tree-Ring Hydroclimatic Assessment of Synchronous Extreme Streamflow of Upper Colorado, Salt-Verde Rivers	The Salt River Project	Reports, workshops, AP Press report, conference presentations	Hirschboeck, Meko (LTRR) Jon Skindlov (The Salt River Project)
Current Drought In Context: Tree-Ring Evaluation of Water Supply Variability for the Salt-Verde River Basin	The Salt River Project	In progress	Hirschboeck, Meko (LTRR) Jon Skindlov (The Salt River Project)
Hydrology of the San Pedro River	U of A	Book chapter in press	Hirschboeck (LTRR), MacNish, Baird, Maddock III (HWR)
Fire history and climate relationships in the North American Great Basin	ISPE	New fire histories, multi-range climate analysis	Falk (LTRR), ISPE, CLIMAS
Restoring fire in Sangre de Cristo Mtns	CFRP, NSF	Watershed restoration, new fire-climate histories; published papers	Falk (LTRR), NAU Ecological Restoration Institute

I.4. National Collaborations

LTRR has established strong joint research with other universities, state and federal agencies, and private foundations (**Table I.3**).

Table I.3. Research between faculty members at LTRR and scientists from national institutes

Project Name	Funding Agency	Outcome	Collaborators
Climate and Society on the Colorado Plateau, A.D. 600-160	SFI ($20k), NSF Archaeo. ($33.3k)	Interaction with scientists representing many disciplines	Dean (LTRR), Santa Fe Inst.
Artificial Anasazi		Agent-based model of Long House Valley Anasazi behavior, A.D. 800-1350, MA thesis, many publications	Dean (LTRR), Santa Fe Inst., Brook. Inst., UMass
Wetherill Mesa Tree-Ring Redating Project	Colorado Historical Society	1,121 new tree-ring dates from 40 archaeological sites	Dean (LTRR), Fiero (Mesa Verde NP Assoc.
Coupled Human/Ecosystems Over Long Periods: Mesa Verde Prehispanic Ecodynamics	NSF Archaeology & Biocomplexity Programs	Site database, agent-based models using dendroclimatic input	Dean (LTRR), WSU Anthro., Crow Canyon Arch. Ctr.
Old Wood Calibration Project	Colorado Historical Society/State Hist. Fund ($24.7k)	200+ samples analyzed, characterization of time gap between wood and time of procurement (present)	Dean, Towner, (LTRR), Baker (Centuries Research, Inc.)
Pilot project in tropical isotope dendroclimatology	NSF	3 papers (1 student-led)	Evans (LTRR), Harvard Earth Planetary Sci.
Objective interpretation of paleoproxy data for improved paleoclimatic reconstructions	NOAA	Partial support of 15 papers (7 student-led)	Evans (LTRR), Columbia Univ.
Global multidecadal to century-scale climate of last 1000 years	NOAA	Manuscripts	Hughes (LTRR), UVA, UMass
Natural variability of climate of Western US in the late Holocene	NSF	Manuscripts	Hughes (LTRR), Hydrologic Res. Center
Reconstruction and analysis of patterns of climate variability over one to two millennia	NOAA	Manuscripts	Hughes (LTRR), Penn State, UMass, Univ. Rutherford
Geospatial approach to dendroclimatology of multi-millennial bristlecone pine	NSF	In progress	Hughes (LTRR), Woods Hole RC, West. WA Univ.

Project Name	Funding Agency	Outcome	Collaborators
Dendrohydrology of Blue Oak of Central Valley of California	CALFED	Conference pubs; ms in preparation	Meko (LTRR), U. AR, Scripps, Desert Res. Inst.
Drought on Colorado River from tree-rings, since 1200s	Calif. Dept of Water Resources	Conference presentations; Manuscript in preparation	Meko (LTRR), NOAA Paleoclimatology
Childhood leukemia environmental science	Gerber Foundation, Cancer Res. & Prev.	Conference pubs & peer reviewed manuscripts	Sheppard (LTRR), McCrone Group
Childhood leukemia environmental science	Gerber Foundation, Cancer Res. & Prev.	Conference pubs & peer reviewed manuscripts	Sheppard (LTRR), Missouri Res. Reactor
Review of SW Prehistory	None	one book chapter	Sheppard (LTRR), Chicago Field Museum
Dendrochronology of Stringed Instruments	Violin Society of America	one conference pub and one peer reviewed manuscript	Sheppard (LTRR), Univ. TN Geogr.
Western Mountain Initiative	USGS	Fire Climatology Workshop Intern. J.Wildland Fire, in prep. (http://www4.nau.edu/firehistory/index.htm)	Swetnam (LTRR), Falk (LTRR), NAU, USGS
Colorado Old Wood Project	CSHPO/LTRR	Archaeological dates	Towner (LTRR), others
Dendroarchaeology of Range Creek Fremont	NSF	Archaeological dates	Towner, Salzar (LTRR), Univ. Utah
Dendroarchaeology and Paleoclimate of Pajarito Plateau	(Los Alamos National Laboratory)	Archaeological dates	Towner, Salzar (LTRR), Los Alamos Natl. Lab.
Dinetah Paleoclimate Reconstruction	WCRM	Archaeological dates	Towner, Salzar (LTRR), WCRM
Dendroarchaeology of the SEJ Farmstead, LBJ National Park	WNPA	Archaeological dates	Towner (LTRR), NPS
Pueblito Dating Project	BLM/LTRR	Archaeological dates	Towner (LTRR), BLM Farmington
La Ventana Mesa Navajo Dendroarchaeology		Archaeological dates	Towner (LTRR), BLM Rio Puerco
Blanco Mesa Survey	BLM/SRI	Archaeological dates	Towner (LTRR), Statistical Res., Inc.
Morris 1 Project Dendroarchaeology	NNAD	Archaeological dates	Towner (LTRR), Navajo Nation
Ft. Wingate Dendroarchaeology	NNAD	Archaeological dates	Towner (LTRR), Navajo Nation

Project Name	Funding Agency	Outcome	Collaborators
Zuni Peeled Trees	CNF/NMAC	Archaeological dates	Towner (LTRR), Cibola NF
Cebolla Cabins Dating Project	BLM/LTRR	Archaeological dates	Towner (LTRR), BLM Rio Puerco
A Global Paleoflood Databank	U.S. Bureau of Reclamation, NOAA	Paleoflood database product submitted to agency, several conference presentations	Hirschboeck (LTRR) and Baker (HWR), USBR
River Flooding, Global Climatic Change: Multi-Sensor Approach	NASA	Manuscripts and reports, data provided for the Dartmouth Flood Observatory	Hirschboeck (LTRR), Baker (HWR) Brakenridge (Dartmouth)
Regional variations in small-basin floods in the United States	NSF	Journal article	Hirschboeck (LTRR), Sorrooshian (HWR), Michaud (U. Hawaii)
Younger Dryas Climate Environment of US Midwest	NSF-ATM	Sample exchange with many scientists, papers and numerous conference presentations	Leavitt, Panyushkina (LTRR), 15 other instit.
Fire in the forest-grassland of the Valles Caldera National Preserve	JFSP	New research project	Falk (LTRR), Valles Caldera National Preserve
Fire history in the Sierra Madre, Mexico	NSF	New research project	Falk (LTRR), Rocky Mountain Tree-Ring Res.

I.5. International Collaborations

LTRR faculty have built strong collaborative relations with other institutes around the world. This includes collaborations in regions where dendrochronology was initially poorly understood or at their developing stages (See **Table I.4**). For example, Ramzi Touchan (LTRR) and Peter Ffolliott (SNR) developed seven International Memoranda of Understanding with the Universities (IMOU) of Aleppo and Damascus, Syria; National School of Forest Engineering, Sale, Morocco; the Institute of Research and High Agricultural Education; the Institute of Sylvo-pastoral of Tabarak, Tabarka, Tunisia; University of Ouargla, Faculty of Science and Engineering Sciences, Algeria (this IMOU includes LTRR, SNR, Department of Agricultural and Biosystems Engineering, and Office of Arid Land Studies); and Aristotle University of Thessaloniki, Thessaloniki, Greece. The purpose of these IMOUs is to facilitate and enhance academic cooperation between parties of the agreement.

Several hundred scientists around the world apply dendrochronological techniques in many fields of science. LTRR is a central place where they most commonly turn for advice and training. LTRR offers uniquely broad educational and research opportunities in all aspects of dendrochronology. The breadth of the faculty and its research opportunities make LTRR a facility of choice for anyone interested in dendrochronological research. More than 20 foreign visitors have spent one week or more in LTRR in recent years. Recent students and visitors have come from countries as diverse as Russia, Lithuania, Finland, Italy, Austria, Spain, Morocco, Algeria, Tunisia, Turkey, Cyprus, Greece, Syria, Lebanon, Jordan, Canada, Mexico, Chile, Peru, Argentina, South Africa, China, Japan and India (See **Figure I.1,** and **Table I.4**).

Figure I.1. Home locations of individuals who have visited and studied at LTRR in recent years.

Table I.4. Collaborative research among faculty members at LTRR and scientists from international institutes.

Country	Project Name	Funding Agency	Outcome	LTRR Collaborators
Germany	Paleoclimate in China Qinghai Plateau	NSF Paleoclimatology	One peer reviewed pub	Sheppard
Gulf States	Tree Ring Reconstruction of Past Climate Variability in United Arab Emirates Oman: Pilot Study	USGS	Just starting	Touchan
Mexico	Expanding Dendroarchaelogy into Northern Mexico	NSF Archaeology ($108k)	100+ archaeological Tree-ring samples	Dean, Towner
Mexico	Paleovolcanology of Sunset Crater	NSF Petrology and Geochemistry	Conference pubs, peer reviewed pub	Sheppard
Mexico	Fire History and Forests	NSF	In progress	Falk, Swetnam
Morocco, Algeria, & Tunisia	Climate Variability from North African Tree Rings	NSF-ESH	Manuscript in preparation	Touchan
Peru/Ecuador	Isotope dendroclimatology: NW coastal Peru and SW Ecuador	NSF/ATM	>120 samples and 12 species	Evans
Russia	Objective interpretation of paleoproxy data for improved paleoclimatic reconstructions	NOAA	3 papers published or in review (1 student-led); two new proposals	Evans, Hughes
Russia	Growth Dynamics of Conifer Tree Rings: Past, Future Environments	Not funded	Book published by Springer, 2006	Hughes
Russia	Tree-rings, NDVI for forest growth in Siberia as influenced by climate	Civilian Research and Development Fund	Manuscripts	Hughes
Russia	New and improved tree-ring records of climate from Siberia	NSF	Manuscripts	Hughes
Russia	Dendroclimatology	Fulbright	Manuscripts	Meko
Russia	Iron Age chronology of Eurasia	NSF Archaeology	Archaeol. samples, pub-lications, conferences	Panyushkina
Turkey	European Climate of the Last Millennium	EU Sub-Priority 6-Global Change & Ecosystems	Ms in preparation	Touchan
Turkey, Syria, Lebanon, Jordan, Greece, Cyprus	Near East Climate Variability from Tree-Rings	NSF-ESH	Several manuscripts	Touchan

Country	Project Name	Funding Agency	Outcome	LTRR Collaborators
Israel, Near East	Structure, Dynamics of Rainstorms Inducing Floods in the Negev	ILAC	Manuscripts by Hebrew University collaborators	Hirschboeck
Argentina	Inter-hemispheric and Western US Fire Climatology	USGS Western Mountain Initiative	Two manuscripts and two workshops	Swetnam
Israel	Water Use Efficiency of Aleppo Pine	ILAC	Manuscript in preparation	Leavitt

LTRR has also provided specialized training in dendrochronology to Jordanian, Syrian, Lebanese, Turkish, Tunisian, Moroccan, and Algerian scientists. Ramzi Touchan and other LTRR faculty and collaborators (e.g. M.K. Hughes, P.F. Ffolliott, C. Stockton, D. Meko) also offered three workshops in the Middle East on the role of dendrochronology in natural resources management.

I.6. Appraisal

Collaboration is so essential to our activities that it is not possible to appraise it separately. It is a sign of excellence and relevance of the work of LTRR that collaboration with it is so frequently sought at all levels from interdepartmental to international. Within the University, an increasing portion of our collaborative activities is arranged through the Institute for the Study of Planet Earth, an entity that LTRR played a major part in establishing. This has led, and should lead in the future, to stronger and broader collaboration. It is essential that collaboration described here be nurtured in order to maintain and increase our effectiveness in research, teaching, and outreach.

J. RESOURCES

J.1. Budget

The State budget covers salary and employee-related expenses for 6.0 academic year faculty, including the Director, 1 fiscal year faculty, 3 administrative staff, 4 scientific staff, student hourly wages and, in recent years, about 1.5 FTE Graduate Teaching Assistants. Temporary teaching funds have also been allocated year-by-year, and are dependent on sabbatical leaves of full-time faculty, or allocation of temporary funds for teaching from the College of Science (and these funds have been nil in recent years). The state budget also contains about $40,500 for operations. The largest items under this last heading are telecommunication equipment and charges and rental of off-campus storage facilities. There is no State capital budget.

The annual state funding to the LTRR was relatively stable from the late 1990s to 2003, and has slightly increased in recent years (**Figure J.1**). These temporal patterns in funding, however, are misleading because during this period salary raises generally off-set budget cuts, which were largely taken from staff lines and operations. Cumulative, permanent budget cuts since 1999 have totaled 9.66%, and now (December 2006) amount to an annual reduction in our budget of about $87,000 since 2003 (**Figure J.2**). The 3% cut in 2002 was to temporary funds, and the anticipated 1.03% cut to the 2007 fiscal year budget, are not included in these figures.

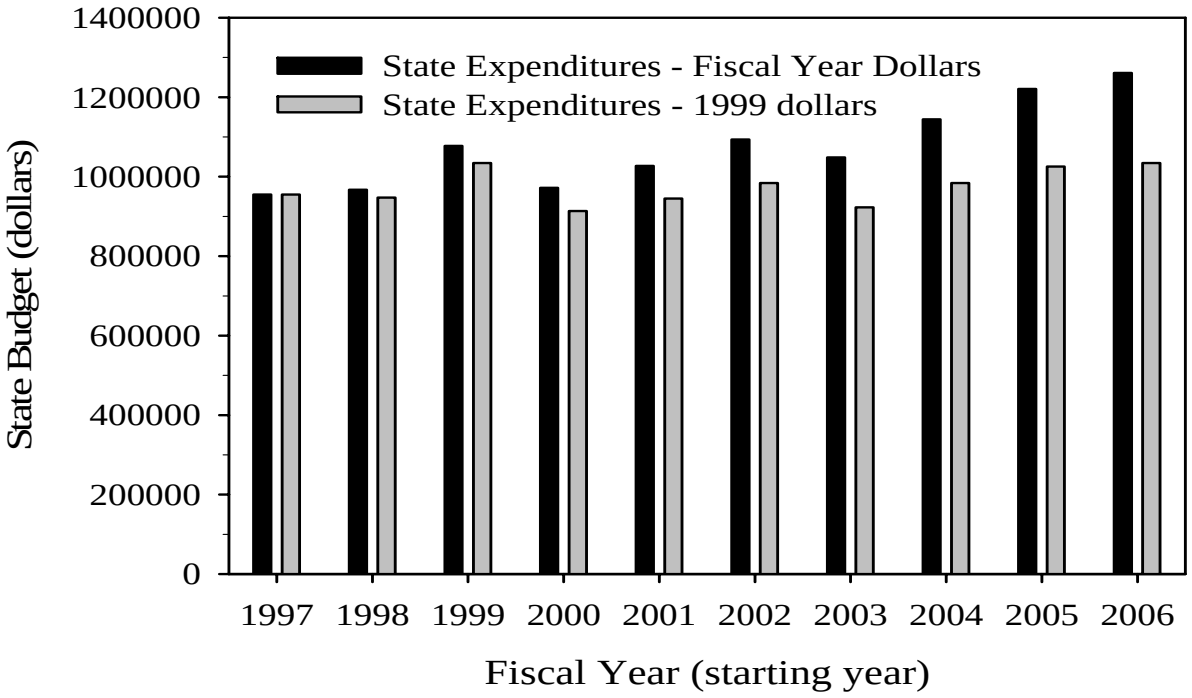

Figure J.1. State allocations to the LTRR in fiscal year dollars, and adjusted for inflation since 1997.

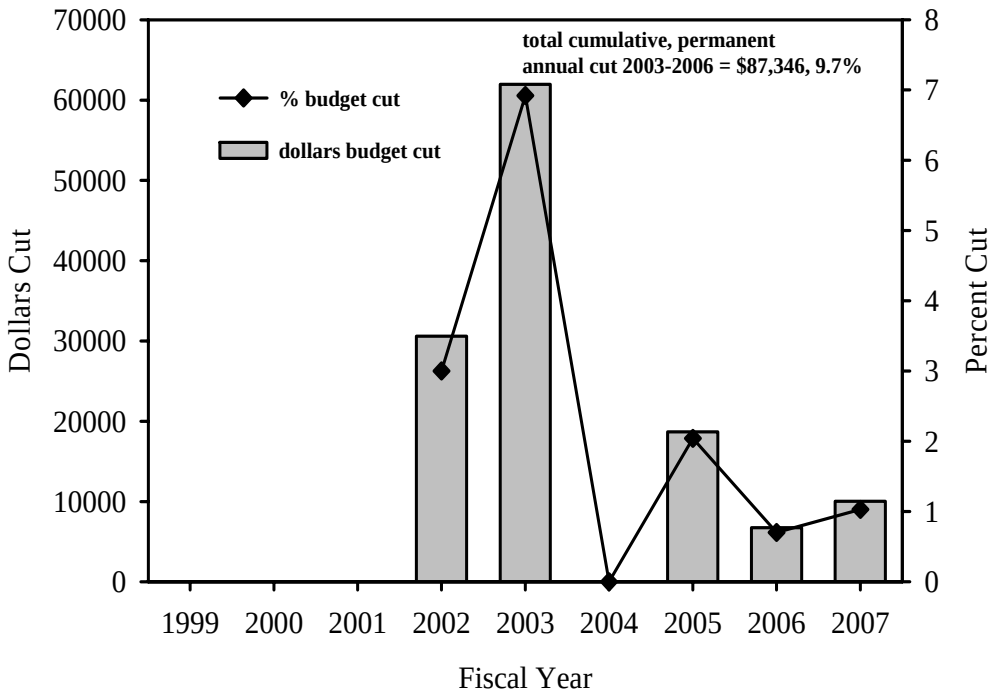

Figure J.2. Annual cuts to the LTRR state budget.

Salaries have been raised several times, including for retention of one faculty member, equity/merit for all faculty and staff, and cost of living raises. Although the salary raises are of course welcome, in general they have not kept pace with the rates of inflation (**Figure J.1**), or other increases to the cost of living. Moreover, faculty salaries generally remain below those of peer Universities in the U.S. (see section **J.5.**), especially full professor salaries. In any case, the budget cuts, as described elsewhere in this report, combined with inflation have had major impacts in reducing our staff support, operations, and our difficulties in continuing to function at the same levels of productivity.

J. 2. Space

J.2.1. Quantity

The University provides a total of 15,009 usable square feet (NASF) of building space on campus in two buildings; 3,574 NASF in the Mathematics East basement area and 11,425 NASF in the West Stadium. The Laboratory also rents about 2,000 NASF of storage space at the University's Sunnyside facility at an annual cost of about $5,000.

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Of the space in the West Stadium and Mathematics East basement (15,009 NASF), the distribution of space is approximately as follows:

- 1,300 NASF is used for administration, including the Director's office, the main office, and storage,
- 1,500 NASF. for central, common scientific facilities such as shop, dark room, computer services, and tree-ring measuring room;
- 450 NASF for a multipurpose room which is used for laboratory classes, lectures, seminars, training on specialized equipment, and laboratory space for visitors;
- 3,500 NASF for modern collection storage and approximately 400 NASF for archeological collection storage;
- The remaining 7,800 NASF is used primarily for faculty, staff and student offices and laboratories. Only one small room (252 NASF) has wet lab facilities.

The Laboratory of Tree-Ring Research has been located in the West Stadium since 1937. There have been a number of aborted attempts to secure a new building for LTRR in the past 7 decades. Plans have proceeded as far as architectural designs for stand-alone buildings, and most recently (in 2004-2005) to selecting an architect and builder for a multi-department building called the Environment and Natural Resources Building II (ENRBII). All plans and funding have repeatedly collapsed, including this latest effort. There were many reasons for these failures, but in general the University has ultimately decided that there were other, greater priorities for on-campus buildings.

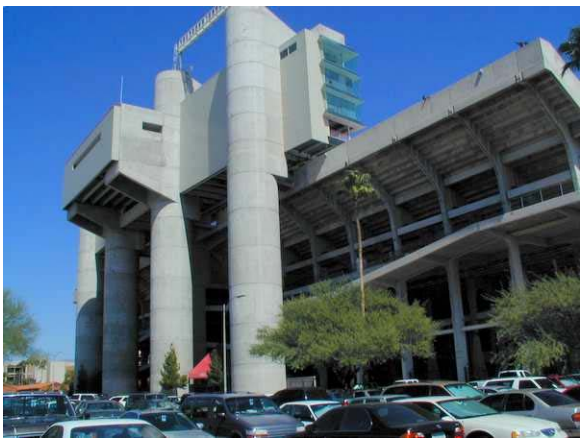
At the time of the 1999 APR, we were relatively optimistic that we would finally see a new building within a few years, largely because in 1997 a major benefactor to UA and LTRR, Agnese Nelms Haury, pledged $1 million towards a new LTRR building, with an agreement from the U of A that it would assist in raising the additional funding needed, either from donors or state funds. As noted above, this did not happen (including the collapse of the ENRB II planning), and so, by agreement with Mrs. Haury, we recently converted her building gift to an endowed chair in 2006 (the Agnese and Emil W. Haury Endowed Chair in Archaeological Dendrochronology). It was our judgment and Mrs. Haury's, that the funds should be put to use now, rather than to continue to wait for the University to fulfill past promises.

One of the findings of the ENRBII planning effort was that, given the number of the LTRR faculty, staff, and students, and the laboratory and storage space needs, at the time of the planning (2004) the LTRR's total space need was 25,863 of usable square feet (NASF). Based upon reasonable expectations and opportunities for future growth (if space permitted), the five-year projected space need for LTRR was 30,146 NASF. **The current total of on-campus space held by LTRR (not including the newly acquired Printing & Graphics space described below) is 15,009, making a current space deficit of 10,754 NASF.**

J.2.2. Quality

The West Stadium is a 77 year old building, and it shows. In addition to overcrowding, the roof leaks, rainwater repeatedly floods into our offices and labs from the football field, sewage has backed up into our spaces requiring total wall replacements, the building is noisy, and dusty, and the electricity is unsteady. Lavatories have neither heating not air-conditioning. The general appearance of the building, inside and out, is shabby (see photos in **Figure J.3.**). In their written report, the 1999 external APR panel stated: "The physical facilities pf the LTRR are simply awful."

Figure J.3. Photographs showing the West Stadium and LTRR quarters.



West Stadium. The “sky boxes” were added in the in the 1980s.

The tree-ring archive is contained in multiple odd-shaped rooms in back corners of the old stadium. These areas are now mostly filled in inadequate and inappropriate space for these world-class collections.

The Tree-Ring Lab occupies most of the 1st and 2nd floor of the old building, which was built in 1929.

Chronic leaking through the concrete bleachers overhead repeatedly ruins ceiling tiles and damages research and teaching materials in our offices and labs.

Our labs are over crowded, and in the case of this wet lab, with only one exit.

Entrances to steps and the 2nd floor have rickety, old metal gateways that are closed and locked between 5PM and 8AM, making entry/exit difficult for staff and faculty after hours, and a hazard in case of emergencies.

The entrance to the Tree-Ring Lab's main office is somewhat hidden and indistinctive -- an odd "public-face" for an institution that the University is proud of, and which receives hundreds of visitors from throughout the world each year.

Space recently vacated by Printing & Graphics in the West Stadium is an opportunity for expansion of the Tree-Ring Lab's quarters, but a significant investment will be needed.

The irregularly shaped space used for storing the world's largest collection of dated wood (obviously flammable) shares an internal wall with a dormitory. This area (the store) is, however, served by fire alarms and a dry-riser sprinkler system. Another area, containing many thousands of wood and charcoal samples from archeological sites throughout the southwest, has neither fire alarms nor any kind of sprinkler system. The building is difficult to modify, given both its primary function as a sports stadium, and its age and construction.

We have recently been allocated about 8,000 square feet (NASF) of additional space in the West Stadium, following the departure of the Printing & Graphics department. We are now engaged with the University Facilities & Design department in planning potential renovations in that space. It will be a costly endeavor if the University does indeed carry through on this, but certainly less expensive than the construction of entirely new space for us.

In sum, LTRR has waited seven decades for a new building. Our current space conditions are very sub-standard and have often been an embarrassment to us and the University, especially when we host national leaders, international scholars, and the media. We have been heralded for decades as one of the most unique units on campus, and the University has highlighted our accomplishments in numerous promotions of the University (including the recent "Arizona's First University" advertisements), but we have yet to receive top prioritization for our building needs. Our world-class scientific accomplishments and fame are a testament to the creative talents and energies of our faculty, staff, and students *in spite of a grossly inadequate building.*

It is essential that this latest effort to improve our space situation receive the necessary support from the University. Hanging in the balance is our ability to accommodate our current research programs and to grow our research and teaching programs with opportunities that now exist. Even more important than the potential growth, is our need to have at least adequate facilities to meet our current needs, to retain our faculty, and to recruit new faculty in the future.

J.3. Support Services

J.3.1. Scientific Support for Research and Teaching: Equipment, Staff and Collections

LTRR has equipment for a very wide range of tree-ring analyses. Although largely provided from research grants, this equipment is used extensively by undergraduate and graduate students, both in formal classes and in research projects. They include collecting equipment (corers, chain saws, plot and tree measurement tools, etc.), machines for the measurement of ring widths, intra-annual density variation (X-ray, microwave, and reflected light-based densitometers), cell dimensions (dedicated image analysis system). Additionally the LTRR has a shop and shop equipment for sample preparation, and facilities for the preparation of wood for the measurement of the stable isotopes of carbon, hydrogen and oxygen. A sample preparation lab, wet lab and facilities for stable isotope analysis (CNOS) on solid organic, carbonate and water samples cannot be housed in the LTRR's facilities for safety and space reasons, and is currently located in borrowed space in the Geosciences Department. A wide range of computing equipment (Unix, Apple Macintosh, PC and various peripherals) is linked by a local network, which is also connected through campus Ethernet to the University's servers. In addition to the computers maintained by the faculty's research groups, and the servers which support the Laboratory's network, several machines are available in a common area for use by students and visitors, along with a large capacity laser printer, a laser color printer, and two network-enabled high-capacity photocopiers. Other peripherals, such as slide and flat-bed scanners, are available through individual research groups. In addition to access through the Internet, we have considerable holdings of quality controlled climate data.

The Laboratory's network and other common computer facilities are supported by a staff member (Martin Munro) at the Senior Research Specialist level, with some backup from other staff members in his

absence. A wide range of custom and proprietary software is available. There is an experienced staff skilled in many phases of tree-ring analysis. This is particularly relevant to the basic processes of chronology building and quality control of chronologies, which is extremely labor-intensive.

State budget cuts since 2002 necessitated the elimination of an office staff line (Administrative Assistant) and a scientific staff line (Research Specialist). The impacts of these loses are briefly discussed in section **B.1.3.** In essence, these losses seriously reduce our capacity to carry out a number of functions which have been important to our role as a world center of dendrochronology excellence. In particular, the loss of experienced dendrochronologists on our staff who carry out archaeological tree-ring dating work, and other demanding, specialized duties, limits our ability to continue the level of past productivity, or to respond to future research opportunities.

The Laboratory's collections constitute a scientific and educational resource of global significance. They are the largest and broadest accumulation of dendrochronologically dated wood in the world, having been accumulated over 100 years of activity in Tucson and elsewhere. In addition to being used daily by Laboratory personnel, the collections are from time to time visited by scholars, for example those planning to commence a tree-ring project in some region or country for which we have holdings. The collections also permit the application of newly developed analyses, for example for cell dimensions, to materials collected long ago, with potentially great scientific benefits.

This amounts to a high level of support, but one which could be usefully enhanced by more technical help for computer-based activities, in-house mass spectrometer facilities for existing equipment, and better and larger wet laboratory facilities for isotopic and other chemical analyses.

J.3.2. Support of Teaching

In addition to the facilities and equipment mentioned in the previous paragraphs, extensive support is provided for teaching and training. Our multi-use room in the Math East basement is made available for lectures, laboratories and seminars, and is the primary laboratory facility for students pursuing individual projects, and for scientific visitors to the Laboratory. It is equipped with 14 binocular microscopes, and projection facilities, including a computer-linked projector for direct projection of presentations, software use, or live microscope images of wood and techniques.

A central component of the most popular dendrochronology class, GEOS/WSM/ANTH 464/564 is a laboratory in which students are taught the rudiments of cross-dating and chronology building. Classified staff with many years experience in these activities plays a major part in the teaching of this laboratory, which requires intensive individual tuition. Most years, two staff are involved in this activity in the Fall Semester. The Laboratory makes other resources available for this and other classes, including equipment and financial support for field classes, an essential part of learning dendrochronology. Faculty members have been encouraged to adjust their annual workload so as to be able to develop innovative courses and teaching materials. The 1.5 FTE Teaching Assistants made available in recent years have largely been assigned to support faculty teaching the lower division classes.

The present level of support for teaching is good, but, as faculty seek to increase significantly the number of student credit hours they generate, more TA and other resources will be needed.

J.3.3. Support of Training

Being a uniquely broad and large facility in a rather specialized field of wide application, the Laboratory is the primary global source of training in dendrochronology for scientists from many fields and countries wishing to use tree rings in their work. Requests for various levels of training arrive at a rate that cannot be absorbed by the faculty and their research groups, and so a staff member is assigned the task of coordinating such training. This activity has received a significant boost during in 1994 by a $500,000

gift/endowment by Agnese N. Haury to support such training in the Laboratory. This program has supported one to two-month training visits by dozens of trainees from around the world, as well a graduate PHD program for a student from Jordan, who recently completed her dissertation. This continues a long tradition which has enhanced the reputation and influence of the Laboratory in the U.S. and around the World.

Almost all the major investigators in the burgeoning field of dendrochronology have either been students at the Laboratory, been trainees here, or made extended scientific visits. Many Federal scientists and officials with the major land management agencies which make use of dendrochronology in their daily work have received training at the Laboratory. The provision of this training requires faculty and staff time, space and access to facilities. These resources are made available for training as an important contribution to the University's Land Grant role. Thanks to the Haury Endowment, and the staff time committed by the Laboratory, current activities are adequately supported. The availability of microscopes, computers and staff time are likely to present increasing problems as demand for dendrochronological training increases above the present level.

J.3.4. Support of Outreach

Faculty members are encouraged to play an active role as professionals, and in outreach to the community at local, national and international levels. The Laboratory currently provides an administrative home for the Tree-Ring Society and the editorial home for its publication, the Tree-Ring Bulletin. In addition, a large fraction of staff members time is devoted exclusively to outreach in Tucson and the rest of Arizona (see section **H**) and to guided tours of the Laboratory for large numbers visitors, including many elementary and high school groups.

A large amount of valuable outreach work is achieved with the current level of support.

J.3.5. Support of Administration

The Director and faculty receive administrative support from three staff members, an Business Manager (Ana Martinez), and Administrative Assistant (Susan Hautala), and a Accounting Specialist (LeAudrey Giordano). They handle all administrative, personnel and business matters, including those related to the Laboratory's research grants. Faculty and other principal investigators are expected to develop their own proposal budgets, with advice from the administrative staff, and to maintain surveillance on their project budgets.

With this proviso, the amount of administrative support is adequate, and the quality is excellent.

J.4. Resource Needs

The Laboratory has two major needs for new or additional resources – accommodation and a continuing flow of new talent.

J.4.1. Accommodation

The Laboratory currently needs approximately 25,800 usable square feet (NASF) of good quality accommodation, which is about 10,000 NASF less than it currently has allocated on campus. As noted above in section **J.2.1**., this space need was recently estimated following analysis by planners in the Facilities & Design department in 2004, based on our personnel numbers, office, lab, and storage requirements. By "good quality accommodation" we mean space that is suitable for use in scientific research, with a good power supply, wired for ethernet, adequate life safety and materials security, and in some of the space, special provision such as fume hoods and shielding for X-ray use. The need is urgent because the Laboratory's present work and development is hampered by the inadequacies of the present accommodations.

Moreover, it is unreasonable to expect the faculty to work with such poor accommodation, when they

would get better accommodation for their work almost anywhere else they might go in the U.S., even in institutions with much less of a basis for a claim to distinction than the LTRR. A current solution to these problems, at least in the near-term, would be a relatively small investment in renovation of the new space to the LTRR in the old Printing & Graphics space in the West Stadium. This is far from an ideal solution, but at this point – 70 years after our move into the Stadium "as temporary quarters" – *it is the least* the University should do to properly house the LTRR.

For some perspective on this matter, the costs being discussed for the renovations (in two phases) of spaces in the West Stadium are at minimum about $2.3 million and up to $3.4 million. The costs originally planned for the LTRR portion in the defunct ENRBII building that would have housed most of the LTRR, would have been about $15 million.

J.4.2. New Talent

Scientific and educational enterprises suffocate without a flow of new talent. This is an issue of particular concern as many of the LTRR faculty have outstanding national and international reputations, and would probably have opportunities to take positions elsewhere if they were so inclined. Furthermore, one or more faculty members may retire within the next seven years. A chief concern about replacement of faculty members is low quality of most our available laboratory and office space, and the inadequate amount of space (see sections **J.2.1.** and **J.2.2**.). It may be difficult to retain some faculty members, or to entice the best and brightest to join our faculty if improvements are not made to our quarters in the near future

J.4.3. Changes in Program Quality if New Resources Become Available

One of the major benefits of accommodation in a suitable building would be the removal of a limitation on the number of soft money researchers in the Laboratory. An increase in the numbers of such researchers would broaden the range of educational and research experience we could offer our students, enhance our research standing in the international scientific community, and serve to keep the core faculty at peak effectiveness, by continually exposing them to new ideas and challenges.

J.5. Faculty Compensation Comparisons

Current permanent, state-funded tenure-track faculty includes 4 Full Professors, 1 Associate Professor, and 2 Assistant Professors. In comparison with Earth Sciences departments in peer institutions identified by the Arizona Board of Regents, the average salaries of the LTRR Associate and Assistant Professors are slightly higher, whereas the full professor salaries, on average, are significantly lower (see **Table J.2.** below). In comparison with a set of selected UA College of Science with similar areas of academic interests and pursuits (i.e., Geosciences, Atmospheric Sciences, and Ecology & Evolutionary Ecology) LTRR state-funded faculty salaries are lower in all categories. This may be due in part to "salary compression", where in these other CoS departments with larger faculty sizes (except ATMO) there is more faculty turnover, and hence more recent recruitment of both junior and senior faculty (as well more retention cases), resulting in some higher salaried individuals raising their department averages. However, even in the case of ATMO, with a similar faculty size to LTRR, the salaries are generally higher than LTRR's faculty salaries.

Table J.1. Comparison of the LTTR faculty with other faculty in Geosciences and Earth Sciences departments at U of A and other Universities.

Average Academic and Fiscal Year Salaries (FTEs)	Full	Associate	Assistant
LTRR	$90,015 (4)	$71,649 (1)	$61,992 (2)
[1]AAUDE Public – Geological and Earth Sciences/Geosciences departments in peer institutions.	$104,000	$70,000	$60,000
Difference from AAUDE	-$13,985	+$1,649	+$1,992
UA CoS Earth Science Departments	$94,082 (26)	$74,693 (5)	$68,856 (9)
Difference from Selected UA Depts	-$4,067	-$3,044	-$6,864

[1]AAUDE Public Institutions

1. University of California – Berkeley
2. University of California – Davis
3. University of Minnesota – Twin Cities
4. University of California – Irvine
5. University of California – Los Angeles
6. University of California – San Diego
7. University of California – Santa Barbara
8. University of Colorado – Boulder
9. University of Florida
10. *Georgia Institute of Technology
11. University of Illinois – Urbana
12. Indiana University
13. Purdue University (Indiana)
14. University of Iowa
15. Iowa State University
16. University of Kansas
17. University of Maryland – College Park
18. *McGill University – Montreal, Canada
19. University of Michigan – Ann Arbor
20. Michigan State University
21. University of Minnesota – Twin Cities
22. University of Missouri – Columbia
23. University of Nebraska – Lincoln
24. State University of New Jersey – Rutgers
25. State University of New York – Buffalo
26. State University of New York – Stony Brook
27. University of North Carolina – Chapel Hill
28. Ohio State University
29. University of Oregon
30. Pennsylvania State University
31. University of Pittsburgh
32. University of Texas – Austin
33. Texas A & M
34. *University of Toronto – Canada
35. University of Virginia
36. University of Washington
37. University of Wisconsin - Madison

[+] Georgia Institute of Technology is not a member of AAU but has an agreement to participate in the faculty salary data exchange.

[*] Institutions not included in the benchmarks because Canadian wage markets are substantially different from those of the U.S.

K. ADMINISTRATION

K.1. Organization

The Laboratory is administered by the Director, who is a tenured faculty member. The Director acts as department head in all personnel matters, operations, and annual reviews of faculty and staff. The Director is advised by a regular (approximately monthly) meeting of all faculty, and elected staff and graduate student representatives. In most instances where a departmental or faculty committee might exist, this function is performed by these regular faculty meetings. Promotion and tenure reviews, and annual faculty evaluations, are processed through specific committees of three tenured or tenure-track faculty elected by the whole faculty and constituted in accordance with University and College of Science policies. Principal investigators (whether appointed personnel or classified staff) are responsible for the development and execution of their own funded projects as governed by University and other regulations, in collaboration with the Administrative Associate and under the general supervision of the Director. Faculty teaching assignments are discussed at the regular faculty meeting, and agreed between the faculty member and the Director in the light of the Laboratory's needs and all aspects of the faculty members' workloads. The Director is responsible for the supervision of State-funded classified staff engaged in scientific work and of the Business Manager who in turn supervises classified staff working in the main office.

K.2. Unit Head Review

A review of the Director (Thomas Swetnam) was conducted in 2006. A committee appointed the College of Science Dean included Dr. Katie Hirschboeck (Associate Professor, LTRR, who served as chair of the Committee), Dr. Steve Leavitt (Professor, LTRR), Dr. Paul Sheppard (Assistant Professor, LTRR), Mr. Rex Adams (Research Specialist, Senior, LTRR), Mr. Scott St. George (LTRR graduate student in the Geosciences Ph.D. program), Dr. David D. Breshears (Professor, School of Natural Resources) and Dr. Kate Dixon (Professor & Department Head, Molecular & Cellular Biology).

The following major conclusions and recommendations are taken from the final report of the review committee (in italics):

1. Dr. Swetnam's overall performance is viewed extremely positively by his faculty colleagues, as well as the staff and students of the Laboratory of Tree-Ring Research. Questionnaire results showed that 97.2% of the survey respondents rated his performance as "Good " or higher and 83.3% rated his performance as either Very Good (44.4%) or Outstanding (38.9%).

2. Dr. Swetnam has been especially effective in the areas of accessibility, responsiveness, maintaining an active research program in addition to his administrative duties, mentoring a large group of graduate students, engaging in new teaching efforts, enhancing the visibility of the LTRR and promoting it externally in academic, governmental, and policy arenas.

3. External comments, along with the Committee's own review, indicate that the local, national, and international reputation of the LTRR is stellar. This has been enhanced in part by the high profile and prestige that Dr. Swetnam's many activities have garnered during his 5 years as Director.

4. Even with these accolades, improvement is possible – and necessary – to move the LTRR forward over the next 5 years. The Committee therefore identifies five important initiatives for improving the Director's performance and advancing the LTRR and its mission:

(a) Develop a clear and compelling lab-wide strategic vision for the next 5 years that is linked to strategic

planning `and is based on scenarios both with, and without, a new building. New visions and innovations are necessary to move the LTRR ahead in the here-and-now, even if a new building does not happen. At the same time, the vision for the Lab and all it could evolve into by being housed in a new building should not be abandoned.

(b) Move ahead immediately and explicitly to address the APR's foremost recommendation to re-house and archive the Laboratory's priceless wood collection – independent of efforts to move into a new building.

(c) Identify and act upon ways to improve communication throughout the Laboratory between the Director and graduate students especially, but also with the LTRR faculty and staff. These might include periodic Director-graduate student meetings, dissemination of the LTRR's Annual Report, more frequent laboratory-wide retreats, or an annual "State of the LTRR" address.

(d) Develop a more formal program for recruitment, orientation, mentoring, tracking, and training graduate students. This should include the appointment of a graduate student coordinator – either staff or faculty – and assurance that the coordinator gets the necessary training for this position. In addition, take a direct leadership role in developing the Graduate Certificate in Dendrochronology and moving it forward through the University system.

(e) Continue exploring innovative ways to expand and enhance the research and teaching capabilities of the Laboratory, such as the potential for shared-appointments with other units.

In summary, Dr. Swetnam's leadership efforts have served to maintain good intra-departmental collegiality, help advance some of the goals of the unit, sustain the department's visibility and endeavors in the University community, and uphold the Laboratory's influential standing around the world. Nevertheless, we have identified several important areas that we believe can significantly improve Dr. Swetnam's performance over the next five years, and respectfully offer them for the Dean and Dr. Swetnam to consider.

K.3. Classified and Professional Staff

There are at present three classified staff assigned to administrative tasks and 5 to scientific and educational tasks. All of these are supported by the State budget. There are in addition 4 staff funded by grant and gift funds assigned to work on the funded projects, who are supervised by the principal investigators of the projects on which they are employed, or the Director. The Administrative staff consists of Business Manager, an Administrative Assistant and a Accounting Specialist. They deal with all personnel and financial paperwork, as well as providing administrative support for the Director. The core scientific staff consists of a three Senior Research Specialists and a Research Specialist. The three Senior Research Specialists and the Research Specialist are each responsible for specific areas: maintenance of software, computer and network support; maintenance of microscopes and workshop equipment; organization of public outreach and training of scientific visitors; operation of specialist equipment of image processing and X-ray densitometry; support for isotopic analyses; support for dendroecological work; support of the Director's research program. All but one share a responsibility for checking the quality of tree-ring dating done by others (e.g. graduate students), and for helping with training and dendrochronological laboratories. Turnover in all these positions is low. Three State funded staff left since 1999, 2 positions were eliminated because of budget cuts, and a third was terminated for negligence and dereliction in the performance of duties (as Administrative Associate).

L. AFFIRMATIVE ACTION

The University of Arizona is committed both to Equal Employment Opportunity and Affirmative Action. Equal Employment Opportunity (EEO) refers to the right of individuals to be judged on the basis of relevant training, skills, experience, and performance, and not on criteria irrelevant to the performance of their jobs. Affirmative Action (AA) involves necessary special efforts to search for qualified women and minority candidates, as well as candidates from other groups, all previously excluded from equal access to opportunities, to ensure that they are considered for available positions along with other qualified applicants. University policy prohibits hiring unqualified individuals. When a woman or minority candidate is substantially equally qualified as other candidates and when there is under-utilization of persons in that category in the employment unit, then University policy favors selecting the member of the under-represented group.

The Laboratory of Tree-Ring Research, like all University units, is dedicated to planning, implementing, and adhering to EEO and AA measures for current and future recruitments. It is essential to maintain a welcoming environment if women and minorities are to be retained. **Figure L.1** illustrates the numbers of personnel employed at LTRR by gender and minority status since 1999.

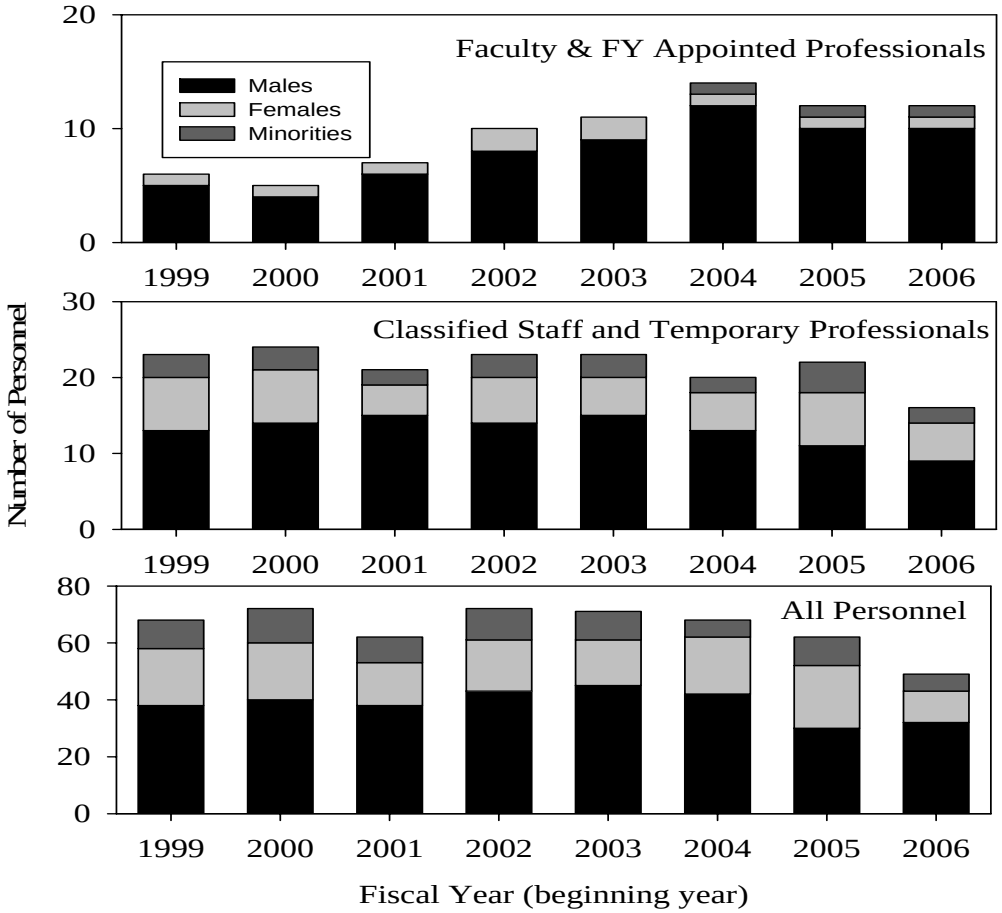


Figure L.1. Number of personnel in LTRR by gender and minority status (1999-2006). The "All personnel" graph (bottom) includes graduate and undergraduate students in addition to faculty and staff.

M. DEPARTMENTAL DATA PROFILE

Tree-Ring Laboratory	FY01-02	FY02-03	FY03-04	FY04-05	FY05-06	FY06-07
Student Credit Hours (Fall Census)						
..Lower-division Courses	960.1	1,054.23	1,046.82	641.15	888	861
..Upper-division Courses	32	51	46		16	21.34
..Graduate Courses	57	70	37.5	134.5	104.5	102.18
..Total Student Credit Hours	1,049.10	1,175.23	1,130.32	775.65	1,008.50	984.52
Student Credit Hours (Spring Census)						
..Lower-division Courses	429	411	441	399	434.5	
..Upper-division Courses	3	50	6	26	3	
..Graduate Courses	43	63	58	125	136	
..Total Student Credit Hours	475	524	505	550	573.5	
Student Credit Hours (Fall + Spring Census)						
..Undergraduate Student Credit Hours	1,424.10	1,566.23	1,539.82	1,066.15	1,341.50	882.34
..Graduate Student Credit Hours	100	133	95.5	259.5	240.5	102.18
..Total Student Credit Hours	1,524.10	1,699.23	1,635.32	1,325.65	1,582.00	984.52
Student Full Time Equivalents (Fall Census)						
..Lower-division Courses	64.01	70.28	69.79	42.74	59.2	57.4
..Upper-division Courses	2.67	4.25	3.83		1.33	1.78
..Graduate Courses	5.7	7	3.75	13.45	10.45	10.22
..Total Student FTE	72.37	81.53	77.37	56.19	70.98	69.4
Student Full Time Equivalents (Spring Census)						
..Lower-division Courses	28.6	27.4	29.4	26.6	28.97	
..Upper-division Courses	0.25	4.17	0.5	2.17	0.25	
..Graduate Courses	4.3	6.3	5.8	12.5	13.6	
..Total Student FTE	33.15	37.87	35.7	41.27	42.82	
Student Full Time Equivalents (Fall + Spring Census)						
..Undergraduate Student FTE	95.52	106.1	103.52	71.51	89.75	59.18
..Graduate Student FTE	10	13.3	9.55	25.95	24.05	10.22
..Total Student FTE	105.52	119.4	113.07	97.46	113.8	69.4
Expense by Fund Group						
..01-State	1,093,208.01	1,048,338.98	1,144,092.42	1,220,492.13	1,261,017.65	488,933.15
..01-StateAgExtsn						
..01-StateFedAgExtsn						
..01-StateFedAgRsrch						
..01-StateMedCol						
..02-AdmServiceChg						
..02-ExtendedUniv						
..02-IndirectCostRecov	121,866.50	83,380.56	284,279.52	179,158.85	48,615.75	34,383.52
..02-InvestmentIncome						

..02-StudentFee						
..02-SummerSession		4,583.36	6,880.63	9,597.72	3,614.26	232.47
..03-OtherDesignated	64,585.68	93,058.14	40,273.14	23,364.54	32,580.82	8,952.18
..04-Auxiliary						
..05-Grant&Contract	483,064.70	726,659.97	859,319.19	940,985.72	784,853.81	287,843.63
..06-OtherRestricted	87,484.71	48,329.68	29,808.32	20,666.50	72,695.24	44,084.89
..07-Loan						
..09-Plant	621.11					
..10-Agency						
..Fund-ASCsource	2,767.90	3,433.12	2,146.67	1,980.94	2,727.92	63.91
..Fund-IDCsource	141,605.56	271,101.12	260,014.22	256,530.90	283,395.21	98,299.13
..Total Expenditures	1,995,204.17	2,278,884.93	2,626,814.11	2,652,777.30	2,489,500.66	962,792.88
Personnel FTE by FactBook Grps (State Funds - Fall)						
..Executive Administrators						
..Other Administrators						
..Dept Heads and Directors (acad)	1	1	1	0.6	1	1
..Instructional Faculty	6	6	6	6	6	5.6
..Other Faculty	0.23	0.25	0.25	2.47	2	2.5
..Grad Asst (teaching)	0.91	1.5	2	1.5	1.5	1.75
..Grad Asst (research)	0.25	0.25				
..Grad Asst (other)	0.5	0.25	0.25			
..Professional				0.49	0.46	0.45
..Staff	8.93	7.81	7.34	4.9	4.75	5
..Subtotal (total excluding Other)	17.82	17.06	16.84	15.96	15.71	16.3
..Other (LWOP, NoSal, Student, Temp, ...)	1.24	2.16	1.49	0.25		0.75
..Total FTE	19.06	19.22	18.33	16.21	15.71	17.05
Personnel FTE by FactBook Grps (Other Funds - Fall)						
..Executive Administrators						
..Other Administrators						
..Dept Heads and Directors (acad)						
..Instructional Faculty						
..Other Faculty	0.77	0.75			1.59	1
..Grad Asst (teaching)	0.5			0.25		
..Grad Asst (research)	1.75	3	2.75	2.08	1.5	0.75
..Grad Asst (other)						
..Professional		2.75	4.09	2.5	2.86	1.54
..Staff	3.57	3.19	4.6	2.51	2.41	1.9
..Subtotal (total excluding Other)	6.59	9.69	11.44	7.34	8.36	5.19
..Other (LWOP, NoSal, Student, Temp, ...)	2.41	4.94	3.76	3.9	2.49	4.52
..Total FTE	9	14.63	15.2	11.24	10.85	9.71
Personnel FTE by FactBook Grps (All Funds - Fall)						

..Executive Administrators						
..Other Administrators						
..Dept Heads and Directors (acad)	1	1	1	0.6	1	1
..Instructional Faculty	6	6	6	6	6	5.6
..Other Faculty	1	1	0.25	2.47	3.59	3.5
..Grad Asst (teaching)	1.41	1.5	2	1.75	1.5	1.75
..Grad Asst (research)	2	3.25	2.75	2.08	1.5	0.75
..Grad Asst (other)	0.5	0.25	0.25			
..Professional		2.75	4.09	2.99	3.32	1.99
..Staff	12.5	11	11.94	7.41	7.16	6.9
..Subtotal (total excluding Other)	24.41	26.75	28.28	23.3	24.07	21.49
..Other (LWOP, NoSal, Student, Temp, ...)	3.65	7.09	5.25	4.15	2.49	5.27
..Total FTE	28.06	33.84	33.53	27.45	26.56	26.76
Space by Program_Code in square feet						
..Instruction	1,340.00	1,318.00	729	1,294.00	1,294.00	1,294.00
..Research	10,713.00	14,085.00	13,205.00	12,365.00	12,365.00	12,365.00
..Public Service	275	275	11	322	322	322
..Academic Support	3,585.00	3,423.00	2,947.00	3,112.00	3,112.00	3,112.00
..Student Services						
..Institutional Support						
..Independent Operations						
..Unassigned						
..Building Service		386	128			
..Total Space	15,913.00	19,487.00	17,020.00	17,093.00	17,093.00	17,093.00

APPENDIX A. ABBREVIATED CURRICULUM VITAE FOR ALL FACULTY

Core Faculty

JEFFREY S. DEAN

EDUCATION

- University of Idaho, 1957-1958, Mechanical Engineering
- University of Arizona, B.A., 1961, Anthropology, Geology
- University of Arizona, Ph.D., 1967, Anthropology

EMPLOYMENT (since 1977)

- 2006-present Agnese and Emil W. Haury Professor of Archaeological Dendrochronology, Laboratory of Tree-Ring Research
- 2000-present Professor of Dendrochronology (Laboratory of Tree-Ring Research), Professor of Anthropology (Department of Anthropology), Curator of Archaeology (Arizona State Museum)
- 1985-1986 Senior Scientist, Center for Archaeological Investigations, and Adjunct Professor of Anthropology, Southern Illinois University, Carbondale, Illinois
- 1977- Professor of Dendrochronology, Laboratory of Tree-Ring Research

PROFESSIONAL ACTIVITY AND RECOGNITION

- Member Phi Beta Kappa, Phi Kappa Phi, American Anthropological Association, Arizona-Nevada Academy of Science, Arizona Archaeological and Historical Society, Museum of Northern Arizona, School of American Research, Sigma Xi, Society for American Archaeology, Society for Archaeological Sciences, Tree-Ring Society.
- Fellow, American Association for the Advancement of Science
- Editorial Boards: Arizona State Museum Archaeological Series (1991-present), Tree-Ring Research (Associate Editor)
- Member Advisory Panel, Archaeometry Program, National Science Foundation (1994-1996)
- Awards: Certificate of Appreciation, Zuni Indian Tribe, New Mexico (1990); Emil W. Haury Award, Southwestern Parks and Monuments Association (1995), Lifetime Achievement Award, Society for American Archaeology (2001), Byron S. Cummings Award, Arizona Archaeological and Historical Society (2004), Alfred V. Kidder Award for Eminence in the Field of American Archaeology, American Anthropological Association (2006), appointed Agnese and Emil W. Haury Professor of Archaeological Dendrochronology, Laboratory of Tree-Ring Research
- Consultant for Archaeological Consulting Services Ltd., Navajo Nation Archaeology Department, and USDI Bureau of Reclamation

RESEARCH SUMMARY

Dean's research integrates dendrochronology into the anthropological and archaeological study of sociocultural stability, variability, change, and evolution. The long term goal of this research is to enhance understanding of how human groups interact with their physical and social environments and the function of these complex interactions in sociocultural evolution. This research has followed a progression from specific to more general concerns and from simple to increasingly complex applications. In order to encompass the

range of huan-environment relationships, the research has been focused on theoretical, methodological, and practical aspects of archaeological chronology and tree-ring dating, patterned human behavior, and paleoenvironmental reconstruction. Given the topical breadth of these concerns, the research emphasizes cooperation with scholars from other sciences. Dean, his students, and collaborators currently are studying the eruption of Sunset Crater in northern Arizona, the nature and magnitude of the “old wood” problem in archaeological chronology, Navajo and Anasazi sociocultural development, paleoenvironmental reconstruction to illuminate human adaptive behavior in the Southwest, and the agent-based computer modeling of human subsistence-settlement systems.

Publications (Since 1999):

- 1 coauthored book
- 1 edited book
- 1 coedited book
- 7 nonreviewed technical reports
- 17 peer reviewed book chapters
- 1 nonreviewed book chapter
- 5 papers in refereed journals
- 2 popular articles
- 1 obituary

Research Grants and Contracts (since 1999):

- PI on 3 funded research projects
- Co-PI on 11 funded research projects
- Total funding as Co-PI & PI: $4,563,011
- Total funding as PI: $444,069
- Funding from NSF, ADOT, the Santa Fe Institute, Western National Parks Association, Colorado Historical Society, UA Water Resources Research Center Technology and Research Initiative Fund, and scores of archaeological and geological projects

TEACHING SUMMARY (since 1999)

Dean teaches undergraduate and, primarily, graduate students in a variety of contexts. Much of this effort involves delivering topical lectures in several "core" courses, mentoring, serving on graduate student examination and dissertation committees, and directing dissertations at The University of Arizona and other institutions. Specific educational objectives include (1) conveying the place of dendrochronology in the study of human behavior, (2) teaching students how to apply advanced tree-ring methods to social science questions, and (3) imparting knowledge of the complex interrelationships among environmental, cultural, and demographic variables, especially in the American Southwest.

Courses co-taught:

- ANTH 447/547, Anasazi Archaeology, Fall 2002, Spring 2005, approximately 20 undergraduate and graduate students per semester
- GEOS/WSM/ANTH 596V Dendrochronology Colloquium (Journal Club)
- GEOS 220, General Education Tier II, Natural Sciences Course, Environmental History of the Southwest, Fall 1999, 2001, 2003, Spring 2000, approximately 100-150 students per semester

Graduate students:

- Dissertation committee chair for 2 Ph.D. students (2 completed)
- Service on 4 M.A. and M.S. students' exam and/or thesis committees (4 completed)
- Service on 18 Ph.D. students' exam and/or dissertation committees (13 completed)

SERVICE SUMMARY (SINCE 1993)

Dean serves on several departmental and University committees, most notably the Laboratory's Promotion and Tenure Committee. He is on the editorial board of one publication series, is Associate Editor of *Tree-Ring Research*, and referees manuscripts for several journals and publishers. Other professional service includes reviewing promotion and tenure applications for other universities, grant proposals, program proposals, and publication series proposals. Outreach includes advising government agencies, Indian tribes, businesses, museums, and academic institutions; delivering lectures to lay and professional groups; presenting short courses and demonstrations to university and avocational groups; and providing interviews and assistance to local, national, and foreign print and broadcast media.

MICHAEL EVANS

EDUCATION

- Harvard College, A.B, 1992, Special Concentration in Environmental Science and Policy
- Columbia University, Ph.D, 1999, Earth and Environmental Sciences

EMPLOYMENT (since 1999)

- 1999-2000: Postdoctoral Research Scientist, Lamont-Doherty Earth Observatory, Columbia University
- 2000-2001: Postdoctoral Research Fellow, Dept. of Earth and Planetary Sci., Harvard University
- 2001-present: Assistant Professor, Laboratory of Tree-Ring Research, University of Arizona
- 2001-present: Adjunct Associate Research Scientist, Lamont-Doherty Earth Observatory, Columbia Univ.
- 2003-present: Joint Asst. Prof., Geosciences Dept., University of Arizona
- 2004-present: Joint Asst. Prof, Atmos. Sci. Dept., University of Arizona

PROFESSIONAL ACTIVITY AND RECOGNITION

- 1993—1996: NASA Global Change Research Fellowship
- 2000—2001: NOAA/UCAR Climate and Global Change Postdoctoral Fellowship
- 2004—2008: NSF CAREER Grant

RESEARCH SUMMARY

Dr. Evans studies mechanisms by which tropical processes both influence and respond to global change on seasonal to centennial timescales, including (1) Development and calibration of intra-seasonal oxygen isotope measurements on tropical woods for derivation of chronology and rainfall estimates from trees from the terrestrial tropics; (2) Forward modeling of proxy observations to better understand underlying nonlinear, multivariate and frequency dependencies; (3) Paleoclimate reconstructions based on sparse observational networks and modified objective analyses; (4) Use of physical climate models and data analyses to investigate mechanisms of tropically mediated climate change on time scales relevant to the greenhouse warming debate.

Publications (since 1999):

- 3 peer-reviewed book chapters
- 11 papers in refereed journals
- 4 non-reviewed technical reports
- 1 book review

Research Grants and Contracts (since 1999)

- PI on 5 funded projects
- Co-PI on 2 funded projects
- Total funding: $936,251.
- Funding from NSF, NOAA.

TEACHING SUMMARY (since 2001)

Dr. Evans teaches course in the General Education curriculum, paleoclimatology, and statistics.

Courses taught:

- NATS 101, Introduction to Global Change, a Tier I General Education physical sciences course for non-science major Honors College undergraduates (2001, 2002, 2003, 2005), 25 students/semester.
- GEOS 513, ENSO: Past, Present, Future, a graduate interdisciplinary seminar in paleoclimatology (2002, 2003, 2006), 5 students/semester.
- GEOS 597e, Spatiotemporal Data Analysis Workshop, a graduate workshop course in statistical analysis (2004, 2006), 10 students/semester.
- GEOS595e, Topics, Tools and Techniques in Paleoclimatology, a graduate interdisciplinary seminar in paleoclimatology (2004), 5-10 students/semester.
- GEO101IN, Introduction to Weather and Climate, a lower division introductory course merging meteorology, climatology and related aspects of Tohono O'odham culture, taught at Tohono O'odham Community College, Sells, AZ, 5-10 students/semester.

Graduate students:

- Dissertation chair for 1 PhD student (0 completed)
- Service on 2 PhD committees (0 completed)
- Service on 4 masters committees in Geosciences and Atmos. Sci. (12 completed)

SERVICE SUMMARY (since 2001)

Reviewer of journal manuscripts for Paleoceanography, Geophysical Research Letters, J. Climate, Climatic Change, Palaeo3, Science, Geology, Ecology, Nature, Geochemistry-Geophysics-Geosystems, J. Ocean Technology, Geochimica et Cosmochimica Acta; reviewer for NSF, NOAA, NERC; Member, Graduate Interdisciplinary Degree Programs in Global Change and Statistics;Member, University Committee on Elections, Institute for the Study of Planet Earth; Member, working groups, USGS/UA biogeochronology program; Biosphere 2, “version 3”.

DONALD A. FALK

EDUCATION

- University of Arizona, Ph.D., 2004, Ecology & Evolutionary Biology

- Tufts University, M.A., 1980, Environmental Policy
- Oberlin College, B.A., 1972, Interdisciplinary Studies

EMPLOYMENT (1999-2006)

- 2004 – Adjunct Associate Professor, Laboratory of Tree-Ring Research, University of Arizona

- 1998 – 2004: Graduate Associate in Research, Laboratory of Tree-Ring Research, University of Arizona
- 1993 – 2002: Executive Director, Society for Ecological Restoration, Madison, WI/Tucson, AZ

PROFESSIONAL ACTIVITY AND RECOGNITION

- Awards and honors: Center for Plant Conservation, STAR Award (2004); International Association of Landscape Ecology (US), Student Presentation Award, Honorable Mention (2004); Edward S. Deevey Award, Ecological Society of America (2003); Marshall Foundation Graduate Fellowship (2001 – 02); National Science Foundation, Doctoral Dissertation Improvement Grant (2001 – 03); Robert W. Hoshaw Scholar, Ecology & Evolutionary Biology, University of Arizona (2001 – 02); William McGinnies Scholar, Arid Lands Studies, University of Arizona (1999 – 2000); Achievement Rewards for College Scientists (ARCS) Scholar (1998 – 2001); Fellow, American Association for the Advancement of Science (AAAS) (1991 – current).
- Editorial activities: Co-founder and Associate Series Editor, Science & Practice of Ecological Restoration, Island Press and Society for Ecological Restoration (9 titles to date, 1998 – current).
- Professional memberships: American Association for the Advancement of Science (Fellow), Ecological Society of America, International Association for Landscape Ecology, Society for Conservation Biology, Society for Ecological Restoration.
- Conference and technical workshop presentations (selected): American Association for the Advancement of Science (AAAS); Association for Fire Ecology; Center for Plant Conservation; Chicago Botanic Garden; Collaborative Forest Restoration Program, US Forest Service; Colorado State University; Columbia University, Lamont-Doherty Earth Observatory; Ecological Landscape Association; Ecological Restoration Institute, Northern Arizona University; Ecological Society of America; Fire Learning Network, The Nature Conservancy; Forest Guild; International Association for Landscape Ecology; International Institute for Tropical Forestry, Puerto Rico; Joint Fire Science Program; National Center for Ecological Analysis & Synthesis; National Fire Sciences Laboratory; New England Wildflower Society; Oklahoma State University; Pacific Southwest Research Station, US Forest Service; Society for Ecological Restoration; St. Albert Forum on Theology and Science, Newman Center, University of Arizona; University of Gröningen, Netherlands; University of North Carolina; USGS Wildland Fire Conference; USGS Western Mountain Initiative.

RESEARCH SUMMARY

- Don Falk's research focuses on fire history, fire-climate relationships, fire ecology, dendroecology, and restoration ecology. A broad area of interest is the study of fire as a multi-scale ecological and physical phenomenon. Field-based research is conducted currently in New Mexico (Jemez and Sangre de Cristo Mountains), Arizona (Pinaleño Mountains), with emerging areas of interest in the North American Great Basin and Sierra Madre, Mexico. In addition to reconstructing and analyzing historical patterns of fire and fire-climate relationships, current work includes modeling fire behavior and application to restoration of forest structure and dynamics in old-growth ponderosa pine forests.

A recent book (*Foundations of Restoration Ecology*, co-edited with M. Palmer (University of Maryland) and J. Zedler (University of Wisconsin) reflects an ongoing interest in fundamental ecological theory in relation to the emerging science of ecological restoration.

- Publications (1999-2006):
    - Books (1)
    - Journal articles (5)
    - Other technical publications (2)
    - Peer reviewed book chapters (3)
    - Dissertation (1)

- Research Grants and Contracts (1999-2006):
    - PI on funded research projects (5)
    - Co-PI on funded research projects (5)
    - Total funding for period $1,082,958
    - Primary funding sources: Institute for the Study of Planet Earth, Joint Fire Science Program, National Science Foundation, US Forest Service (Collaborative Forest Restoration Program and Rocky Mountain Research Station).

TEACHING SUMMARY

- Courses taught: GEOS 497k/597k (Dendroecology) Summer Pre-Session, 2005-6.
- Lectures: Conservation Biology ECOL/GEOS 406R/506R, Conservation Biology (2005-6); Advanced Fire Effects, National Advanced Fire & Resources Institute (2005); ECOL 206, Environmental Biology (2005); WFSC 696C, Restoration Ecology (2005); GEOS/ANTH/WSM 464/564, Introduction to Dendrochronology; Rx-510 (2003-4); GEOS 220, Environments of the Southwest (2002)

SERVICE SUMMARY (1999-2006)

- Professional service: Office of the Governor, Arizona Forest Health Council (2003 – current); US Forest Service, Collaborative Forest Restoration Program, Technical Advisory Panel (2001 – 2003); Indigenous Peoples Restoration Network (1994 – current); Native Seeds/SEARCH, Board of Directors (1993 – 2003)
- Peer review: *Artic & Alpine Research*, Blackwell Science, Cambridge University Press, *Canadian Journal of Forest Research*, *Canadian Journal of Water Resources*, *Conservation Biology*, *Ecological Applications*, Foundation for Science (New Zealand), *Forest Ecology & Management*, Island Press, *Journal of Arid Environments*, *Journal of Vegetation Science*, *Landscape Ecology*, MacArthur Fellows Program, National Science Foundation (US), *Oecologia*, Oxford University Press, *Restoration Ecology*.

KATHERINE K. HIRSCHBOECK

EDUCATION

- University of Wisconsin - Madison, B.S.1973 (Geography)
- University of Wisconsin - Madison, M.S, 1975 (Geography)
- University of Arizona, Ph.D., 1985 (Geosciences)

EMPLOYMENT (since 1984)

- 1991– present: Associate Professor of Climatology, Laboratory of Tree-Ring Research
- 2004 – present: Chair, Global Change Graduate Interdisciplinary Program

University of Arizona Joint Appointments as Associate Professor

- 2004 – present: Atmospheric Sciences
- 1991 – present: Hydrology and Water Resources
- 1992 – present: Geography and Regional Development

University of Arizona Graduate Interdisciplinary Program (GIDP) Appointment :

- 1992 – present: Arid Lands Resource Sciences GIDP
- 1992 – present: Committee on Global Change for the Global Change GIDP

Appointments at other Universities:

- 1990 – 1991: Assoc Prof, Dept of Geography and Anthropology, Louisiana State Univ
- 1985 – 1990: Asst Prof, Dept of Geography and Anthropology, Louisiana State Univ.
- 1984 – 1985: Instructor, Dept of Geography and Anthropology, Louisiana State Univ.
- 1984 – 1984: Visiting Assistant Professor, Department of Geography, Univ of Oklahoma

PROFESSIONAL ACTIVITY AND RECOGNITION (selected items)

- Member: American Meteorological Society; Association of American Geographers; Tree-Ring Society; American Geophysical Union; American Water Resources Association; Association of State Floodplain Managers; Geological Society of America
- Offices held: Association of American Geographers, Water Resources Specialty Group Chair, Secretary/Treasurer; American Quaternary Association, Councilor for Paleoclimatology
- Editorial/ review service for numerous journals/agencies, e.g.: J. of Hydrology, J. of Hydrometeorology, Bull. of the Amer. Meteorological Society, Arctic and Alpine Res., The Prof. Geographer, Annals of the Assoc. of Amer. Geographers, Nat. Academy of Sciences
- Appointed to National Academy of Sciences' (NAS) Committee on Geography, Board on Earth Sciences and Resources of the Commission on Geosciences, Environment, and Resources
- Awards: Provost's General Education Teaching Award; American Meteorological Society Editor's Award*;* Project Kaleidoscope - Faculty for the 21st Century (PKAL), Association of American Geographer's Warren J. Nystrom Award for best dissertation.

RESEARCH SUMMARY

Hirschboeck's research is concentrated in two main areas: *flood hydroclimatology* and *synoptic dendroclimatology*. Her work involves the climatology and hydroclimatology of extreme events – especially floods, paleofloods, and droughts -- which she analyzes from the perspective of their meteorological and climatological causes and their long-term variability. She also uses synoptic climatology and dendroclimatology to link tree-ring responses to anomalous atmospheric circulation patterns. Her research has progressed from the theoretical examination of the underlying atmospheric mechanisms that produce extreme hydroclimatological events in statistical time series, to analyses of the synoptic circulation patterns that produce frost rings and drought signals in tree-ring records, to new applied stakeholder-driven research on synchronous high and low extreme streamflow episodes detected from tree-ring reconstructions.

Publications (career):

- peer-reviewed book chapters
- 10 papers in refereed journals

- non-reviewed technical reports
- multiple abstracts / presentations each year at national/international conferences

Research Grants and Contracts since 1989 (1999-2006 in parentheses):

- Lead or sole PI on 11 (6) / Co-PI on 6 (2) funded research projects
- Total funding as lead/sole PI through LTRR: $1,170,493 ($451,266)
- Total funding -- all grants: $1,940,526 ($473,726)
- Funding from: NOAA, NASA, U.S. Bureau of Reclamation, ILAC, Institute for Aegean Prehistory, The Salt River Project, NSF, DOE, USGS

TEACHING SUMMARY (since 1999)

Hirschboeck places a major emphasis on teaching and pedagogy at both the undergraduate and graduate levels and since 1999, she focused especially on teaching development and promoting the use of learning technologies on campus. She is a longstanding contributor to the University of Arizona's General Education program, and received the Provost's General Education Teaching Award in 2003. She also prepares future college teachers through her GEOG 595c College Teaching Practicum course. In addition to mentoring her own graduate students, as Chair of the Global Change GIDP she interacts closely with all the students in the GIDP, has revised the GC-GIDP's curriculum and has developed a new GC 695g Global Change Toolkit course. She has been a highly sought member on numerous university committees focused on improving teaching effectiveness and implementing learning technologies at both the undergraduate and graduate course levels. In the LTRR, she serves as Curriculum Coordinator and shares the duties of unofficial graduate student coordinator.

Courses taught (since 1999)

- NATS 101 Introduction to Global Change (award winning course; taught every Fall 1999 through 2006) (150 students, plus embedded honors sections and accompanying weekly preceptor training class for 6-10 students)
- GEOS 595e Dendrochronology Colloquium: Journal Club (Fall 1999), Synoptic Dendroclimatology (Spring 2000, 2004), Synoptic Sense (Spring 2004), Presentation and Display of Analytical Results (Spring 2005)
- GEOG 431/531 Global and Regional Climatology (Spring 2001 2003, 2005)
- GEOG 695c College Teaching Practicum, Fall 2004, Spring 2005
- ARL 595a Arid Lands Resource Sciences Colloquium - Current Research (Spring 2004)
- UNVR 197a & 597a General Education Preceptor Training Workshop & Graduate Asst. Training Workshop; co-taught with the Univ. Teaching Teams Program (Fall 1999, 2000, 2001)
- GEOG 498 Senior Capstone (Summer 2000)
- 1-2 independent studies courses per year

Graduate students (since 1999):

- Dissertation chair for 4 Ph.D. students (1 completed as of 12/06, 1 ABD, 1 withdrew)
- Thesis director for 2 M.S. & 1 M.A. students (1 completed as of 12/06)
- Service on 15 Ph.D. exam/dissertation committees (8 completed as of 12/06)
- Service on 7 M.S. thesis committees (4 completed as of 12/06)

Undergraduate students (since 1999)

- Honors thesis advisor for 1 B.A. undergraduate in Latin American Studies (student graduated in 2000)
- Faculty mentor for 1 Native American Geography & Regional Development undergraduate enrolled in the Graduate College's Summer Research Institute (student graduated in 2001 & was admitted to a graduate program)
- Senior research project advisor for 1 B.S. undergraduate in Plant Sciences (student graduated in 2004)

SERVICE SUMMARY (since 1999)

Hirschboeck's service commitments at the departmental and university levels have been substantial. Most notable is her (unpaid) administrative role as Chair of the Global Change Ph.D. Minor Graduate Interdisciplinary Program since 2004. Under Hirschboeck's administrative guidance the program has expanded in depth and breadth, undergone a curriculum revision, and developed new vigor via scholarly exchange and funding opportunities for the students, many of whom are LTRR graduate students. At the national level, Hirschboeck's most significant service has been her appointment to the National Academy of Sciences' Committee on Geography, Board on Earth Sciences and Resources (1980-2000).

Departmental Committees (selected -- since 1999)

- Chair, Five-Year Review Committee for LTRR Director (2005-2006)
- Post-Tenure Review Committee, LTRR (2003 -present)
- Tree-Ring Day Organizer and Coordinator (2005)
- Chair, Search Committee for LTRR faculty position (2000, 2001) & Search Committee member for LTRR faculty position (1999-2000)
- LTRR Graduate Student Program Assessment Committee (2002-2003)

University Committees (selected -- since 1999)

- General Education Assessment Committee, Chair, Natural Sciences Team (1999)
- College of Science Awards Committee (2003-2005)
- College of Science Millennium Project Committee (2003-present)
- Learning Technologies Advisory Board (2005 - present)
- Re-Envisioning TA Training Task Force (2006)
- ISPE Executive Committee member (2005- present)

MALCOLM K. HUGHES

EDUCATION

- University of Durham, B.Sc. (Honours), 1965, in Botany and Zoology
- University of Durham, Ph.D., 1970, title of thesis: 'Investigations of the ecosystem energetics of an English woodland'. Supervisor; Dr. J. Phillipson.

EXPERIENCE

- 1992-93 Visiting Fellow, Cooperative Institute for Research in Environmental Sciences, University of Colorado-Boulder
- 1992-present Professor of Watershed Management, School of Renewable Natural Resources, University of Arizona

- 1986-present Professor of Dendrochronology, University of Arizona
- 1986-1999 Director of the Laboratory of Tree-Ring Research, University of Arizona
- 1982-1986 Reader in Ecology, Liverpool Polytechnic (now Liverpool John Moores University)
- 1971-1982 Lecturer II, Senior Lecturer and Principal Lecturer in Ecology, Biology Department, Liverpool Polytechnic
- 1969-1971 University Research Fellow, Botany Department, University of Durham
- 1968-1969 Research Fellow, Soil Biology Institute, University of Aarhus, Denmark

PROFESSIONAL ACTIVITY AND RECOGNITION IN LAST TEN YEARS

- 1998 Fellow, American Geophysical Union.
- 2000 Bullard Fellow, Harvard University
- 2006 Galileo Circle Fellow, University of Arizona
- 1996-1999 Member, joint working group between the PAGES core project of the International Geosphere-Biosphere Program and the CLIVAR project of the World Climate Research Program
- 1999-2005 Member, steering committee, National Science Foundation PARCS (Arctic paleoclimate).
- 2000-2004 Vice-President, International Tree-Ring Society
- 2001-present Member, Advisory Board, Dendrochronologia
- 2003-2004 Chair, Organizing Committee, international conference "Tree Rings and Climate: Sharpening the Focus", Tucson, Arizona, April 2004.
- 2005-2006 Member, Advisory Committee, 7th International Conference on Dendrochronology, Beijing, PRC, June 2006.
- 2005-2006 Member, International Scientific Committee, International Conference Climate changes and their impact on boreal and temperate forests, Ekaterinburg, Russia, June 2006.

Reviews of grant proposals for US National Science Foundation, US National Oceanographic and Atmospheric Administrations, US Department of Energy National Institute of Global Environmental Change, agencies in Austria, Germany, New Zealand, India, the UK and the EU. Reviews of manuscripts for journal including Nature, Proceedings of the National Academy of Sciences (PNAS), Geophysical Research Letters, Canadian Journal of Forest Research, The Holocene, Quaternary Research, Journal of Climate, Climate Dynamics, Climatic Change, Tree Ring Research, Dendrochronologia.

RESEARCH SUMMARY

Dr. Hughes' research is designed to address the question "How and why does climate vary on interannual to century time scales?" His strategy is to contribute to the building of large scale (continental to global) networks of instrumental and 'proxy' climate records with defined chronology, temporal resolution and climate signal. He does this by: 1) establishing new kinds of tree-ring record (new species, new regions, new variables from cell-size to combined ring width, density and isotope) in order to better 'thencast' the behavior of the climate system; 2) using these networks and 'thencasts' to raise questions about the behavior of the climate system. 3) improving understanding of the mechanisms forming natural archives such as tree rings.

Publications:

- 2 co-authored books by major presses
- 2 edited books by major presses
- 1 edited issue of a journal

- 83 peer reviewed journal papers and book chapters (41 since 1999)
- 39 other journal papers and book chapters
- 4 reports
- several presentations each year at national and international meetings 1 coauthored book

Research Grants and Contracts since 1988 (with 1999-2006 in parentheses):

- PI or coPI on 39 (20) funded projects
- Lead PI or sole PI on 28 (16) funded projects
- Total funding $8,766,296 ($6,084,340), as lead or sole PI $3,331,176 ($1,730,876)

TEACHING SUMMARY (since 1999, but on sabbatical leave calendar 2000)

Courses taught:

- Biology of Tree Rings, BIOC497c, Spring 1999, 2004;
- Introduction to Dendrochronology, GEOS/ANTH/WSM 464/564, fall 2001, 2002, 2003, 2004, 2005, 2006;
- Practical dendroclimatology, GEOS 597I, presession 2002, 2003, 2004, 2006;
- Dendrochronology colloquium, Spring 2005, 2006.

Graduate Students:

- Ph.D. Committees since 1999 -9 (5 graduated); Ph.D. major advisor since 1999 -2;
- M.S. committees since 1999 –2 (both graduated); M.S. major advisor since 1999 – 1 (graduated)

UNIVERSITY SERVICE SUMMARY (SINCE 1999)

- 1993-present Member, Executive Committee, Institute for the Study of Planet Earth
- 1994-2004 Member, Interdisciplinary Committee on Global Change
- 2006 Member, Search Committee for Director of School of Natural Resources.
- 2006-present Chair, Departmental promotion and tenure committee.
- 2006 Member, continuing status committees, ISPE and Arid Lands
- 2005-2006 Member organizing committee, College of Science theme semesters on “Evolution and “Global climate change”

STEVEN W. LEAVITT

EDUCATION

- University of Illinois, B.S. Geology, 1971
- University of Virginia, M.S. Environmental Sciences, 1977
- University of Arizona, Ph.D. Geosciences, 1982

PROFESSIONAL EXPERIENCE

- 1996 to present Prof. of Dendrochronology, U. of Arizona
- 1990-1996 Associate Prof. of Dendrochronology, U. of Arizona
- 1989-1990 Associate Prof. of Geology, U. of Wisconsin-Parkside
- 1984-1990 Assistant Prof. of Geology, U. of Wisconsin-Parkside

- 1982-1984 Post-doctoral Research Associate, U. of Arizona, Geosciences

PROFESSIONAL ACTIVITY AND RECOGNITION

- Member- The Geochemical Society; American Geophysical Union; The Tree-Ring Society; American Quaternary Association; Ecological Society of America
- Editor- *Tree-Ring Research* (elected, 2002-present)
- Editorial Board- *Radiocarbon* (1994-present)
- Editorial Advisory Board, Dendrochronologia (2000-2005)
- Executive Committee, American Quaternary Association- (elected to represent Paleoclimate 2002-2006)
- Review Panelist, DSCCRS (Dissertation Initiative for the Advancement of Climate Change Research), Washington (16-18 December 2002)
- Panelist, Biocomplexity LWI/CC Workshop: Designing a Capstone Experience for Recent PhDs, Embarking on Interdisciplinary Careers, Catalina Island (Oct 3-6, 2003)
- Outside program reviewer, USDA Water Conservation Lab, Phoenix (2003)
- Personnel reviewer of four researchers at governmental agencies and other universities (2000-present)
- Ad hoc review- 55 proposals for 10+ funding agencies and 72 manuscripts for 25+ journals since 2000
- CIRES (University of Colorado-Boulder) Visiting Fellow (2006)

RESEARCH SUMMARY

Dr. Leavitt's research generally involves light stable-isotope geochemistry applied to geological and environmental problems, the global carbon cycle in geologic time and the recent imbalance from anthropogenic effects, environmental and climate reconstructions, dendrochronology, soil organic carbon. Recent research has involved reconstructing environment from 10,000-year old wood from the US Midwest, tree-ring stable-carbon isotopes as in indicator of changing plant water-use efficiency as atmospheric [CO_2] has increased, tree-ring stable-carbon isotopes as drought indicators, soil sequestration of carbon under elevated [CO_2], and C_3-C_4 vegetation distribution in the Great Plains over the past 10,000 years reconstructed from stable-carbon measurements of soil carbon.

Publications:

- 1979-1999, author/co-author of 72 publications (including 46 in peer-reviewed journals (viewable at http://www.ltrr.arizona.edu/~sleavitt/CVallPubs02.htm)
- Since 2000, author/co-author of 57 peer-reviewed journal publications

Research Grants and Contracts:

- Principal investigator or co-principal investigator on projects totaling ca. $3.5M worth of grant and contract support (>$10K) since 1984, including ca. $1M since 2000
- Lead PI or sole PI on 9 of (17) funded projects (>$10K)

TEACHING SUMMARY (sabbatical leave Fall 1999/Spring 2000)

Dr. Leavitt teaches through formal University of Arizona courses for graduates and undergraduates and through mentoring and advising of graduate students. In addition to University of Arizona students, he has also served on graduate committees of students from Università degli Studi di Palermo, University of Sydney, UC-Santa Barbara and University of Wales-Swansea since 2000. In addition to contributed lectures

in other LTRR academic-year courses, he has delivered lectures to LTRR summer presession courses and to the Stable-Isotope Ecology summer course at the University of Utah almost every June. Dr. Leavitt was the primary on-site organizer for 1-week short course on "Wood Anatomy of Tree Rings" taught by Fritz Schweingruber of Switzerland, Holger Gaertner of Germany, and Alex Wiedenhoeft of the USDA Forest Products Laboratory, at UA on May 16-21, 2005, and is serving in the same capacity for planned summer 2007 offering.

Courses taught:

- Nats-101 Introduction to Global Change (general ed. science for non-science majors) Spring 2001, 2002, 2003, 2004, 2005, 2006
- GC/GEOS/HWR 572 Global Biogeochemical Cycles (co-taught with Prof. Paul Brooks) Fall 2000, 2001, 2002, 2003, 2004, 2005
- GEOS/WSM 595e Isotope Dendrochronology, Fall- 2000, 2002, 2004
- GEOS/WSM 595e Journal Club, Fall 2001

Graduate students (since 2000):

- Dissertation thesis committee chair for 3 Ph.D. students (2 completed)
- Dissertation exam committee for 1 Ph.D. student (did not serve on thesis committee)
- Service on 1 M.S. students' exam and/or thesis committees (1 completed)
- Service on 7 Ph.D. students' exam and/or dissertation committees (1 completed)

SERVICE SUMMARY (SINCE 2000)
University/College/Department

- New Faculty Position Search Committee (Fall2000/Spring2001)
- Award for "Excellence and Innovation at The University of Arizona" as Chairman of the Global Change IDP, 1997-1999 (Nov. 20, 2002).
- Faculty Host for Haury Visitors Iain Robertson and Zewdu Eshetu (July-August 2000)
- Co-organizer of "Tree-Ring Day" (Held March 28, 2003)
- P&T Annual Review Committee (each year)
- Committee for evaluation of LTRR Director (2005/2006)
- Grad Student Annual Report coordinator (Fall 2004- present)

DAVID M. MEKO

EDUCATION

- Pennsylvania State University, B. S., 1972, Meteorology
- University of Arizona, M. S., 1974, Atmospheric Sciences
- University of Arizona, Ph.D., 1981, Hydrology and Water Resources

EMPLOYMENT (since 1986)

- 2004-Present: Associate Research Professor, Laboratory of Tree-Ring Research (LTRR)
- 1994-2004: Principal Research Specialist, Laboratory of Tree-Ring Research
- 1991-1994: Adjunct Assistant Professor of Dendrochronology, Laboratory of Tree Ring Research
- 1988-1991: Research Associate, Laboratory of Tree-Ring Research, University of Arizona.

- 1986-1988: Hydrologist/Assistant Director, Water Resources Department, Tohono O'odham Nation, Sells, Aizona

PROFESSIONAL ACTIVITY
- Member of American Meteorological Society
- Member of American Geophysical Union

RESEARCH SUMMARY

Dr. Meko uses tree-ring data and instrumental climatic/hydrologic data to study the natural variability of climatic and hydrologic systems. The spatial scale of these studies ranges from the small watershed to the continent The ultimate goal of Dr. Meko's research is to contribute to the ability of society to make intelligent choices in the management of its natural resources. Current research topics include riparian dendrohydrology, temporal stability of the Mexican Monsoon, long-term water supply reliability in the Colorado River Basin, dendrohydrologic signal in blue oak (*Quercus douglasii*), and time series methods for extracting low-frequency climate signals from tree rings. Dr. Meko's early research dealt with the tree-ring evidence for a link between solar variability and drought. His more recent work has focused on hydroclimatic variability and strategies for helping water resource planners cope with climate uncertainty and climate change. Collaborators include scientists from the Arizona Water Institute, several University of Arizona Departments (Office of Arid Lands Studies, Hydrology and Water Resources, Agricultural Economics), the U.S. Geological Survey, Scripps Institution of Oceanography, NOAA, the University of Arkansas, and the Desert Research Institute (U. of Nevada).

Publications (career totals):
- 1 co-edited book/conference proceedings
- 5 peer-reviewed book chapters
- 32 papers in refereed journals
- 57 papers or presentations at conferences
- 4 peer-reviewed technical reports
- 12 non-reviewed technical reports
- 1 article in popular magazine

Research Grants and Contracts (Since 1999):
- 12 funded research projects
- Total funding at $1,269,102 (as PI & Co-PI)
- Grant funding $ 394,444, as lead PI with grant administered through LTRR
- Funding for current projects comes from NOAA, CALFED, the U.S. Bureau of Reclamation, the Salt River Project, and the California Department of Water Resources.

TEACHING SUMMARY (Since 2004)

Dr. Meko is not part of the teaching faculty, but does teach a course in applied time series analysis, gives guest lectures, and actively assists faculty members in course design and implementation. His primary goals in teaching are to help build a successful curriculum at the Laboratory, and to assist students and visiting scholars become acquainted with modern methods of time series analysis of paleoclimatic data. He also offers his Applied Time Series Analysis course online through the University of Arizona's Continuing Education Program.

Courses Taught:

- GEOS 585A: Applied Time Series Analysis – 7 students on campus, 4 online in Spring 2005 (offered in Spring Semester every other year)
- Guest Lectures: GEOS 464/564 (Introduction to Dendrochronology); GEOG 696C (Surface Moisture in Arid Lands: Mechanisms, Models, and Mediations); GEOS 497I/597I (Practical Dendroclimatology)
- International: with Dr. Ramzi Touchan, presented a short course on water resources and dendrochronology at Hashemite University, Jordan. Preparation included approximately one week for a manual and organization of lecture material.

Graduate Students and Post-Docs:

- Currently serves on 6 dissertation committees
- Funds 2 graduate students with research assistantships

SERVICE SUMMARY (Since 2004)

Dr. Meko regularly reviews research proposals for the NOAA Global Change Program and the Earth System History section of NSF, and for several scientific journals: The Holocene, the Canadian Journal of Forest Research, the Journal of the American Water Resources Association, and the Journal of Climate. He serves on a six-member science forum committee overseeing scientific work associated with the Gila River and New Mexico's benefit from the 2004 Arizona Water Settlement Act. He has serves as a member of the Global Change Minor Committee. He has given presentations to water management groups on the importance of considering climate variability and climate change in resource planning. He frequently gives newspaper and television interviews, and in 2005-06 was interviewed on water supply issues by a number of papers, including the Arizona Daily Star, Arizona Republic, Los Angeles Times, New York Times, and the Albuquerque Journal. He has appeared twice in the past year as a guest on the local PBS program "Arizona Illustrated". Dr. Meko also serves as a member of a 6-person science panel on Gila River water issues related to science projects aimed at optimizing New Mexico's benefits from the 2004 Arizona Water Settlement Act.

IRINA P. PANYUSHKINA

EDUCATION

- State Teacher Training University (Krasnoyarsk, Russia), B.S. & M.S., 1990, Geography, Biology
- V.N. Sukachev Institute of Forest, Siberian Branch of Russian Academy of Sciences, Ph.D., 1997, Forest Ecology

EMPLOYMENT (since 1990)

- 2006 to Present: Adjunct Assistant Professor of Dendrochronology, Laboratory of Tree-Ring Research
- 2002-2006: Research Associate, Laboratory of Tree-Ring Research
- 1999-2002: Research Scholar, Laboratory of Tree-Ring Research
- 1999: Associate Professor of Geography, Department of Geography, State Teacher Training University, Krasnoyarsk, Russia
- 1997-1998: Research Associate, Laboratory of Dendrochronology, V.N. Sukachev Institute of Forest, Siberian Branch of Russian Academy of Sciences, Krasnoyarsk, Russia, and Senior Lecturer, Department of Geography, State Teacher Training University, Krasnoyarsk, Russia

- 1990-1996: Adjunct Assistant Professor, Department of Geography, State Teacher Training University, Krasnoyarsk, Russia

PROFESSIONAL ACTIVITY AND RECOGNITION

- Member of American Geophysical Union and Tree-Ring Society
- J. W. Fulbright Fellow, CIES (1998)
- Awards: Siberian Branch of Russian Academy Sciences (1996, 1997, 1998, 1999)

RESEARCH SUMMARY

Dr. Panyushkina's research applies to dendroclimatology and dendroarchaeology, and involves LTRR faculty. She studies Holocene climate variability in Eurasia and North America by reconstructing climate and environment from tree rings. The research incorporates and advances our understanding of atmosphere-ocean-land interaction at different time scales (from millennial to decadal). Her newly developed network of subfossil tree rings around the US Midwest retains tree growth response to environmental changes during the Late Pleistocene - Early Holocene transition. The Siberian network of tree rings includes regional climatic proxies for the Late Holocene (last 2700 years). Dendroarcheological studies are located in Central Asia and focus on Iron Age and Bronze Age archaeological cultures of Eurasian steppe. The main goal of these studies is to develop precise calendar ages combining tree-ring crossdating with radiocarbon wiggles, and utilize the archaeological timbers for environmental reconstruction.

Publications:

- 3 nonreviewed technical report
- 3 peer reviewed book chapters
- 1 nonreviewed book chapters
- 14 papers in peer-reviewed journals
- 29 conference abstracts

Research Grants (since 2002):

- PI on 2 funded NSF research projects
- Total award $479,888

SERVICE SUMMARY

Dr. Panyushkina's professional service includes reviewing research grant proposals for a governmental agency, manuscripts for peer-reviewing journals and Ph.D. theses for dissertation committees of foreign universities. Outreach includes representing research groups to other universities and museums, providing interview and assistance to foreign broadcast media, and presenting talks on on-going research to academic communities. Panyushkina has also assisted in departmental activities such as organizing Tree-Ring Day.

PAUL R. SHEPPARD

EDUCATION

- Ph.D. (1995); University of Arizona, Department of Geosciences; major: Paleoenvironmental-Quaternary Studies with an emphasis in Dendrochronology; minor: Soil and Water Sciences; dissertation:

Reflected-light image analysis of conifer tree rings for dendrochronological research; dissertation director: Dr. Lisa Graumlich.

- M.S. (1984); Cornell University, Department of Natural Resources; major: Forest Science; minor: Statistics; thesis: Fire regime of the lodgepole pine (*Pinus contorta* var. *murrayana*) forests of the Mt. San Jacinto State Park Wilderness, California; thesis director: Dr. James Lassoie.
- B.S. (1982); Humboldt State University, California, Department of Forestry; major: Forest Resources Management; secondary emphasis: vocal performance; graduated magna cum laude.
- A.S. (1980); Long Beach City College, California, lower division general science.

EMPLOYMENT (since 1999)

- Assistant Professor, Laboratory of Tree-Ring Research, University of Arizona (since Aug. 2001): Conducting research, teaching, advising, and extension in dendrochronology.
- Research Specialist and Adjunct Professor, Laboratory of Tree-Ring Research, University of Arizona (Sep. 1997 to Aug. 2001): Developed web-based teaching modules for dendrochronology, conducted research in environmental sciences using dendrochronology, and taught.

PROFESSIONAL ACTIVITY AND RECOGNITION

- University of Arizona College of Science Distinguished Early Career Teaching Award (2005)
- Accepted as Associate Investigator into the Arizona Cancer Center (2005)
- University of Arizona College of Science Staff Recognition Award of Excellence (2000)

RESEARCH SUMMARY

Dr. Sheppard has devoted himself to exploring relatively open research areas, particularly (1) geomorphology and inorganic chemistry, which has resulted in new insights into tree-growth responses to the historic eruption of Parícutin as well as the prehistoric eruption of Sunset Crater, (2) unusual locales such as urban areas with public health issues, which has lead to important understandings of chemical environments around cluster areas of childhood leukemia using multiple techniques of environmental studies in novel ways, and (3) emergent techniques such as image analysis, which has advanced the general use of these techniques throughout the dendrochronological community.

Publications:

- 34 peer-reviewed articles in scientific journals.
- 1 co-authored book chapter
- 1 book review
- Numerous scientific conference abstracts and presentations

Research Grants and Contracts (since 1999):

- PI on several small funded grants for exploratory research
- Co-PI on 2 large funded grants
- Total funding ~$400,000
- Funding sources: NSF, EPA, Cancer Research and Prevention Foundation, Gerber Foundation, UA Imaging Program, UA Learning Enhancement Program

TEACHING SUMMARY (since 1999)

In addition to teaching courses, Dr. Sheppard emphasizes three philosophies for teaching and advising college-level students–transference of knowledge, breadth and depth, and life-long learning. Sheppard's teaching includes a wide variety of course and learners, including college professors in NSF Chautauqua Short Courses, graduate students in advanced seminar topics, undergraduates in basic environmental science course, and even high school learners in Arizona Envirothon.

Courses taught:

- NSF Chautauqua Short Course on teaching Dendrochronology at the College Level.
- Geosciences 487C/587C, Dendrochronology Workshop, upper division/graduate level quantitative chronology building and assessment, since 1998
- Geosciences 220, Environmental History of the Southwest, Tier 2 Natural Sciences General Education, since 2000.
- Geosciences 195D, Sense of Place, Freshman Colloquium, since 1998.
- Arizona Envirothon, High School academic competition in environmental sciences.

Graduate students:

- Ms. Elizabeth May, MA/Ph.D., Anthropology, since 2004.
- Ms. Christine Hallman, Ph.D., Geography, since 2006.

SERVICE SUMMARY (since 1999)

Dr. Sheppard fulfills the typical obligations of intramural service (e.g., departmental committees, college activities, and university commitments) and extramural service (e.g., peer review of manuscripts for journals and of proposals for funding agencies, professional society participation, and collegial collaborations). A notable activity has been co-leading the annual Dean's College of Science Galileo trip up and down the Catalinas, a natural history tour for potential financial donors to the College.

Selected Activities:

- Session Chair, 7th International Conference on Dendrochronology, Beijing, June, 2006
- Instructor, 1st Central American Dendrochronological Workshop and Fieldweek, Chiquimulas, Guatemala, March, 2006 (all in Spanish)
- Annual Meeting of the Ecological Society of America, Tucson, August, 2003, organized and led tours of the Laboratory of Tree-Ring Research
- Session Chair, 6th International Conference on Dendrochronology, Québec City, August, 2002
- Instructor, 11th Annual North American Dendroecological Fieldweek, Saltillo, Coahuilla, Mexico, August, 2001 (in Spanish and English).

THOMAS W. SWETNAM

EDUCATION

- University of New Mexico, B. S., 1977, General Biology, Chemistry
- University of Arizona, M. S., 1983, Forestry-Watershed Management
- University of Arizona, Ph.D., 1987, Watershed Management, Dendrochronology

EMPLOYMENT

- 2000 to present: Director, Laboratory of Tree-Ring Research; Professor of Dendrochronology; joint appointments in School of Natural Resources, Geography & Regional Development, Ecology & Evolutionary Ecology
- 1994 to 2000: Associate Professor of Dendrochronology, Laboratory of Tree-Ring Research
- 1988-1994: Assistant Professor of Dendrochronology, Laboratory of Tree Ring Research
- 1987-1988: Research Associate, Laboratory of Tree-Ring Research, University of Arizona.

- 1980-1987: Graduate Assistant in Research, subsequently Graduate Associate in Research, Laboratory of Tree-Ring Research, University of Arizona.
- 1978-1980: Forestry Technician, Gila Wilderness, New Mexico, U. S. Forest Service.
- 1976-1977: Park Technician, Grand Canyon National Park, Arizona, National Park Service.

PROFESSIONAL ACTIVITY AND RECOGNITION

- Member of Sigma XI, Ecological Society of America (Annual Meetings Program Chair 2003-2004), American Quaternary Association, American Geophysical Union, Tree-Ring Society (Editor 2000, Treasurer 2002-present), Arizona Academy of Arts, Sciences & Technology, American Academy for the Advancement of Science, Society of American Foresters
- A. E. Douglass Scholarship, University of Arizona (1983)
- Visiting fellow at Aldo Leopold Wilderness Research Institute, Missoula Montana (1994)
- Walter Orr Roberts Lecturer, Aspen Global Change Institute, Aspen Colorado (1999)
- Weaver Lecturer, School of Forestry and Wildlife Science, Auburn University (2000)
- William Skinner Cooper Award, Ecological Society of America, with Julio Betancourt (2001)
- Henry Cowles Award, The Association of American Geographers, Biogeography Specialty Group, with James Speer (2002)

RESEARCH SUMMARY

Dr. Swetnam studies natural and cultural disturbances of forest and woodland ecosystems across a broad range of temporal and spatial scales. He uses tree rings and documentary sources to reconstruct the histories of fire, insect outbreaks, human land uses, and climate. He also studies demographic patterns of forest and woodland tree species in relation to disturbance and climate histories. A central goal of this research is to improve our understanding of the historical range of variation of ecosystems, and the causes of this variation. His research is funded in part by land management agencies, with the purpose of providing historical perspectives for informed resource planning. Recent foci of his work include investigations on the fire climatology of the western United States, and the role of past and recent climate variations in driving synchroneity in regional forest and woodland disturbance events and trends.

Publications (career):

- 2 co-edited, multi-author books (1 since 1999)
- 13 peer-reviewed book chapters (6 since 1999)
- 46 papers in refereed journals (17 since 1999)
- 28 papers in conference proceedings volumes (approx. half were peer reviewed, 4 since 1999)
- 7 other publications (opinion-editorials, summary articles)

Research Grants and Contracts (since 1999):

- 26 funded research projects
- total funding as PI: $1,507,355, accounts managed in the LTRR
- total funding as PI and Co-PI: $8,241,908
- funding from U. S. Forest Service; National Park Service; USDA/USDI Joint Fire Sciences Program; U. S. Geological Survey, Biological Resources Division; National Science Foundation; National Oceanic and Atmospheric Administration

TEACHING SUMMARY (Since 1999)

Since his appointment as Director of LTRR in 2000 Dr. Swetnam's course instruction has primarily involved colloquia, workshops, short courses, and invited lectures in courses on and off campus (about 5 or 6 lectures per year). His mentoring as major advisor has typically included 6 to 8 graduate students, and service on committees of another 6 to 9 students. His teaching goals are to (1) educate students about the basic principles, methods, and applications of dendrochronology in the environmental and earth sciences, (2) to train future dendrochronologists and environmental scientists in advanced methods and applications of dendrochronology in ecology and related fields, and (3) to impart historical knowledge and understanding of the temporal variability and functioning of climate and ecosystems.

Courses Taught (since 1999):

- Environmental History of the Southwest, GEOS 220, Tier II undergraduate course, 50 and 90 students, respectively in Fall 1999 and Fall 2000 (I designed and team-taught this course with Julio Betancourt and Jeff Dean in 1999, and then team-taught it with Paul Sheppard in 2000)
- National Science Foundation Chautauqua course on Using Tree-Rings in Environmental Education, for Science teachers in small colleges and universities, at Tree-Ring Lab, approximately 15 students/year, for 3 days in May, 2001 and 2002 with Paul Sheppard.
- Dendrochronology Colloquium (Journal Club, Fire Ecology, Fire Climatology, Entomology), GEOS 597E, Spring 2002, Spring 2003, Spring 2004, Fall 2005, Fall 2006 (3 to 8 students per semester)
- Dendroecology GEOS 595J, summer pre-session course (co-taught with Don Falk), 2005, 2006 (15 to 20 students per semester)

Graduate Students and Post-Docs (since 1999):

- dissertation committee chair of 10 PhD students -- 5 completed, 3 ABD, 2 others in progress as of 12/06
- service on 5 PhD dissertation committees -- 5 completed as of 12/06
- thesis committee chair of 4 MS students -- 4 completed as of 12/06
- service on 7 MS theses committees -- 7 completed as of 12/06
- collaboration with 2 post-doctoral associates

SERVICE SUMMARY (Since 1999)

In addition to his administrative service to LTRR as Director, and numerous service contributions to the College of Science and University (various search and review committees, etc.), Dr. Swetnam carries out extensive outreach aimed at communicating his research findings to other scientists, land and resource managers, and policy makers. These efforts include regular invited lectures at ecosystem management training workshops sponsored by government agencies and other universities, and frequent invited presentations to science and management leadership of federal and state resource and environmental agencies. He has provided expert testimony to Congress on two occasions, and he has provided information and consultation to Congressional staff members and the Arizona Governor's staff. He has served on the various state, national and international advisory and editorial boards listed below. Swetnam speaks regularly to public groups, including elementary and high school students and various clubs and organizations. He has been a frequent interviewee of regional, national and international print and television media, including the Arizona Daily Star, Arizona Republic, Albuquerque Journal, New York Times, Washington Post, Los Angeles Times, Time magazine, ABC News, Canadian Broadcasting Corporation, PBS Lehrer News Hour, Discover Channel, and many others.

Advisory (since 1999):

- Member, Board of Trustees, Valles Caldera National Preserve, appointed by President William J. Clinton (2000-2004)
- Member, Governor's Forest Health Advisory Council, appointed by Arizona Governor Janet Napolitano (2003-2006)
- Member, Governor's Climate Change Advisory Group, appointed by Arizona Governor Janet Napolitano (2005-present)
- Member, Science Advisory Board, Malpais Borderlands Group, New Mexico (2003-present)
- Member, Board of Advisors, Institute for Natural Resource Management, NSF-EPSCOR Program, New Mexico (2003-present)
- Member, Board of Advisors, NSF-EPSCOR Ecology Program, Wyoming (2005-present)
- Member, Board of Advisors, International Multiproxy Paleofire Database, National Climate Data Center, NOAA (2002-present)
- Member & Chair, Board of Advisors, NOAA Paleoclimatology Program (2004-2005)

Editorial (since 1998):

- Associate Editor, International Journal of Wildland Fire, 1993-present
- Editor, Tree-Ring Research (formerly Tree-Ring Bulletin) 2000-2001
- Associate Editor, *Ecoscience*, 1994-1998
- Associate Editor, Canadian Journal of Forest Research, 1998
- Editorial Board, Ecological Applications, 1998-1999
- Associate Editor, *Dendrochronlogia*, 2005-present
- Co-Editor with J. Dean and D. Meko on special issue of *Radiocarbon*, 1996

RAMZI TOUCHAN

EDUCATION

- University of Arizona, Ph.D., 1991, Watershed Management
- University of Arizona, M. Sc., 1986, Watershed Management
- University of Aleppo, B. Sc., 1977, Agriculture Engineering

EMPLOYMENT

- 2004-to present Associate Research Professor, Laboratory of Tree-Ring Research, The University of Arizona, Tucson, Arizona, joint appointment Associate Professor, School of Natural Resources.
- 1997-2004 Research Specialist Senior, Laboratory of Tree-Ring Research, The University of Arizona, Tucson, Arizona.
- 1993-97 Research Specialist, Laboratory of Tree-Ring Research, The University of Arizona, Tucson, Arizona.
- Postdoctoral Fellow, Laboratory of Tree-Ring Research, The University of Arizona.
- 1987-91 Graduate Student Assistant, Laboratory of Tree-Ring Research, The University of Arizona, Tucson, Arizona.
- 1983-84 Research Assistant, Department of Forestry, University of Aleppo, Aleppo, Syria.
- 1977-83 Technical Manager, Union of Syrian Agriculture, Aleppo, Syria.

PROFESSIONAL ACTIVITY

In collaboration with Drs. Dave Meko and Nizar Abu Jaber, Dr. Touchan conducted a workshop in Jordan on Sustainable Water Resources Management: the Role of Proxy Records in Understanding Drought and its Influence on Reclaimed Water Resources. In 1997 and 1999 he collaborated with Drs. M.K. Hughes, P. F. Ffolliott in conducting two training courses in the Near East, focusing on the role of dendrochronology in natural resource management. The participants were Jordanians, Israelis, and Palestinians. 1999 Dr. Touchan was awarded by the Minister of Agriculture in Jordan the highest medal of honor for his research and for conducting the training courses.

Member of Society of American Foresters, 1985-1994; Member of the Tree-Ring Society, 2005-present.

RESEARCH SUMMARY

Dr. Touchan's research integrates dendrochronology into natural and water resources management in the Middle East, Eastern Mediterranean, and North Africa. Dr. Touchan in collaboration with Dr. Malcolm Hughes conducted the first large-scale systematic dendroclimatic sampling for the eastern Mediterranean region and the Middle East (Turkey, Syria, Lebanon, Jordan, Cyprus, and Greece). Dr. Touchan and his colleagues developed the first standardized precipitation index (drought index) reconstruction for the eastern Mediterranean region is the first known reconstruction of this climatic variable anywhere in the world. Dr. Touchan current research programs include establishing a multi-century network of climate records for the North Africa based on tree rings by extending and enhancing existing tree-ring datasets, and by developing new tree-ring chronologies geographically and temporally. This network is being, and will continue to be, used to study interannual to century scale climate fluctuations in the region and their links to large-scale patterns of climate variability. Dr. Touchan is also involved in the European Union project entitled "European Climate of the Last Millennium**"** to determine whether the magnitude and rate of 20th Century climate change exceeds the natural variability of European climate over the last millennium by using the best documentary, biological and sedimentary archives available across Europe to extract palaeoclimate signals. Approximately thirty-eight European Institutes and only Dr. Touchan from the US is involved in this extensive project.

Publications (Since 1999):

- 1 coauthored book
- 7 peer-reviewed articles in scientific journals
- 2 papers in conference proceedings volumes (were peer reviewed)

Research Grants and Contracts (since 2000):

- PI on 2 funded research projects
- Sub-Contract on funded research projects
- Total funding $674,850
- Grant funding is from National Science Foundation and the European Union

TEACHING SUMMARY

Dr. Touchan is not part of the teaching faculty, but does teach three courses every year in collaboration with different colleagues at the LTRR and School of Natural Resources.

Courses Taught:

- Practical dendroclimatology, GEOS 597I, presession 2002, 2003, 2004, 2006

- Dryland Forest Management, WSM531
- Agroforestry, WSM532

SERVICE SUMMARY

Dr. Touchan regularly reviews research proposals for the NOAA Global Change Program and for several scientific journals: *Climate Dynamics*, *Arid Environments, International Journal of Climatology, International Journal of Biometeorology, International Journal of Environment and Pollution, Dendrochronologia,* and *Methods and Applications of Absolute Chronology "Geochronometria"*. He serves as a member of the Technical Assistance Team for the Sustainable Development of Drylands Project at the International Arid Land Consortium at the University of Arizona. He was assigned the Chairman of the Scientific Committee for the conference entitled "Can Water Resources be Sustained in Drylands? *Challenges: Present and Future*" that will be held in Amman, Jordan between December 10-12, 2007. He was interviewed several times in local and international newspapers and journals discussing drought issues in the Middle East and North Africa. He also carries out extensive outreach and service aimed at communicating his research findings to other scientists, land and resource managers, and policy makers in the Middle East, Eastern Mediterranean, and North Africa. He developed three workshops in the Middle East on the role of dendrochronology in natural and water resources management.

RONALD TOWNER

EDUCATION

- University of Arizona , Ph. D., 1997, Anthropology
- Washington State University, M.A., 1986, Anthropology
- Lewis & Clark College , B. A., 1979, History

EMPLOYMENT

- 1998-present Adjunct Assistant/Visiting Professor Professor/Research Associate (Non-tenure track, part time), Laboratory of Tree-Ring Research, University of Arizona
- 1999-2007 Acquisitions Editor, Kiva, Arizona Archaeological and Historical Society, Arizona State Museum, University of Arizona
- 2004 Visiting Assistant Professor, The Colorado College, Colorado Springs, CO
- 1996-1998 Instructor, Pima College, Tucson, AZ
- 1990-1997 Graduate Student, Department of Anthropology and Laboratory of Tree-ring Research, University of Arizona, Tucson, AZ 85721

PROFESSIONAL ACTIVITY AND RECOGNITION

Dr. Towner's major research interests include examining human/environment interaction at various temporal and spatial scales, expanding dendrochronology and dendroarchaeology beyond the US Southwest, Navajo archaeology and ethnogenesis, conflict during the Protohistoric and Historic Periods in the US Southwest, and social and behavioral consequences of the transition to pastoralism

Publications (since 1995):

- 1 authored book
- 1 edited book
- 1 monograph

- 5 papers in refereed journals
- 10 nonreviewed technical reports
- 8 peer reviewed book chapters
- 1 public article
- 2 book reviews

Research Grants and Contracts (since 1998):

- PI on 4 funded research projects
- Co-PI on 4 funded research projects
- Total funding $897,000
- Funding from NSF, New Mexico State Historic Preservation Office, Western National Parks Association, Colorado Historical Society, UA Water Resources Research Center Technology and Research Initiative Fund, and various archaeological and geological projects.

TEACHING SUMMARY (since 1999)

Dr. Towner teaches undergraduate and, primarily, graduate students in a variety of contexts. Specific educational objectives include (1) conveying the place of dendrochronology in the study of human behavior, (2) teaching students how to apply advanced tree-ring methods to social science questions, and (3) imparting knowledge of the complex interrelationships among environmental, cultural, and demographic variables, especially in the American Southwest.

Courses taught:

- GEOS 220, General Education Tier II, Natural Sciences Course, Environmental History of the Southwest, Fall 2001, 2003, Spring 2000, approximately 100-150 students per semester
- Geos 479J/597J, Dendroarchaeology Field School, Spring Pre-session 2001, 2002, 2003, 2004, 2005, 2006. Usually 8-10 students per semester.
- Prehistory of the Southwest, The Colorado College, Colorado Springs, CO. Approximately 27 students.

Graduate students:

- Service on 2 M.A. thesis committees at BYU and ENMU (refuse to sit on UA committees)

SERVICE SUMMARY (SINCE 1998)

- Acquisitions Editor, *Kiva, The Journal of Southwestern Anthropology and History*, 1999-2006. Solicited and handled approximately 375+ manuscripts, published 32 issues of the quarterly journal.
- Publications Committee member, 1994-present, Arizona Archaeological and Historical Society
- Awards Committee member, 2001-present, Arizona Archaeological and Historical Society
- Board of Directors member, 2004-2005, Southwest Ceramics Research
- Board of Directors member, 2001-2002, Old Pueblo Archaeology
- Laboratory of Tree-ring Research, co-chair of Certificate in Dendrochronology efforts

Joint Appointed Faculty

Jointly appointed faculty members are professors whose main appointments are in other UA departments, and they have joint appointments in LTRR by virtue of their close collaborations and strong common interests with LTRR.

PETER F. FFOLLIOTT

EDUCATION

- University of Minnesota, 1958, B.S. (Forest Management)
- University of Minnesota, 1959, M.F. (Forest Management-Wildlife Management)
- University of Arizona, 1970, PhD (Watershed Management)
- Other graduate-level coursework taken at Colorado State University and Northern Arizona University

EMPLOYMENT

- 1961-1967: Research Forester, Rocky Mountain Forest and Range Experiment Station, USDA Forest Service, Flagstaff, Arizona
- 1967-present: Lecturer, Assistant Professor, Associate Professor, Professor, School of Natural Resources, University of Arizona, Tucson, Arizona

PROFESSIONAL ACTIVITY AND RECOGNITION

Member Professional Societies and Organizations: Society of American Foresters; International Society of Tropical Forestry; American Water Resources Association; Arizona Hydrological Society; Indian Association of Hydrologists; Forest Products Research Society; Arizona-Nevada Academy of Science; Society for Range Management; The Wildlife Society; IURFRO Working Parties S1.03.02, S1.05.06, S4.07.03; Sigma Xi; Xi Sigma Phi

Recognition:

- Fellow, Society of American Foresters
- Fellow, Indian Association of Hydrologists
- Fellow, Arizona-Nevada Academy of Sciences
- Certificate of Appreciation for Advancement of the Science, Education, Technology, and Practice of Professional Forestry in the Southwest (Awarded in 1994, 1997, and 2006)

RESEARCH SUMMARY

Areas of Research:

- Holistic ecosystem management practices in forest and woodland ecosystems
- Improving yield, quality, and distribution of water resources in forest and woodland ecosystems
- Strategies and tactics for management and sustainable utilization of renewable natural resources
- Effects of fire on ecosystem and hydrologic processes
- Assessments and evaluations of integrated ecosystem management practices
- Hydrologic simulation procedures
- Growth and yield models of tree and shrub species and related stand structures

- Economic assessments and evaluations of natural resources management programs
- Applications of decision support systems in the management of natural resources
- Policy issues and evaluation in relation to conservation, sustainable development, and management of natural resources

- Papers in refereed journals - 29
- Peer-reviewed books - 5
- Peer-reviewed book chapters - 12
- Conference proceedings - 56
- Other publications - 23

Selected Research Grants and Contracts Since 2000:

- Increasing Productivity of Semi-Arid Shrub-Grassland Communities (U.S. Forest Service)
- Hydrology of Oak Woodlands (Arizona Agricultural Experiment Station)
- Updating Time-Trend Response functions of Fire Impacts (U.S. Forest Service)
- Savannization: Demonstration in Chile (International Arid Lands Consortium)
- Characterization and Evaluation of Natural Resources in Encinal Savannas (U.S. Forest Service)
- Sustainable Development of Dryland Regions (U.S. Agency for International Development)
- An Ecosystem Approach to Prescribed Burning in Oak Savanna (Arizona Agricultural Experiment Station
- Impacts of Salvage Logging and Fuel Reductions Following Wildfire (U.S. Forest Service)

TEACHING SUMMARY

Courses Taught:

- Undergraduate - RNR 384 - Natural Resources Management Practices
- Graduate-level - RNR 631 - Dryland Forest Management, RNR 532 - Agroforestry, and WSM 602 - Snow Hydrology

Graduate Students (2006):

- Master's Students, Major Advisor – 4, service on committee -- 3
- PhD Students , Major Advisor – 1, service on committee -- 4

SERVICE SUMMARY

Selected Intramural Services:

- 1997-present - Member, Core Curriculum Subcommittee,, School of Natural Resources
- 2001-2002 - Member, Post-Tenure Review Committee, School of Natural Resources
- 2003-present - Member, RNR Studies Committee, School of Natural Resources
- 2003-2005 - Member, Search Committees for Faculty Positions, School of Natural Resources
- 2004-2005 - Member, SNR Seminar Series Committee, School of Natural Resources
- 2004-present - Member, SNR Space Committee, School of Natural Resources
- 1996-present - Member, Research Project Review Committee, Arizona Agricultural Experiment Station
- 2000-present - Member, Board of Directors, Kel M. Fox Scholarship Fund

- 1999-2004 - Advisor, Forestry Career Development Event, FAA Field Day

Selected Extramural Services:

- 1978-1989 - Chairman, Temperate Forest Directorate, U.S. Man and the Biosphere Program
- 1984-1990 - Member, Panel on Rehabilitation and Management of Semi-Arid and Marginal Rangelands, National Research Council, National Academy of Sciences
- 1986-1996 - Chair, Dryland Forestry Program, School of Natural Resources
- 1993-2001 - External Faculty, Programa de Edstudios de Posgrado, Centro de Investigaciones Biologicas de Baja California Sur, La Paz, B.C.S.
- 1994-present - Member; Research and Demonstration Advisory Committee, International Arid Lands Consortium
- 2002-present - Member, Technical Advisory Committee, International Arid Lands-Agency of International Development Project on Sustainable Development of Drylands in Asia and the Middle East
- 2004-2005 - Member, Science Advisory Board, Bureau of Land Management
- 2002-present - Member, Science Advisory Committee, Malpai Borderlands Group
- 2005-2006 - President - President, Arizona-Nevada Academy of Science
- 2006-present - Member, Panel on Hydrologic Impacts of Forest Management Practices, National Research Council, National Academies

LISA J. GRAUMLICH

EDUCATION

- University of Wisconsin-Madison , B.S., 1975, Botany
- University of Wisconsin-Madison , M.S. 1978, Geography
- University of Washington, Ph.D., 1985, Forest Resources

EMPLOYMENT

- 2007-present Director, School of Natural Resources, The University of Arizona
- 2001-2006 Executive Director, Big Sky Institute for Science and Natural History, Montana State University
- 1999-2006 Professor, Land Resources & Environmental Sciences, Montana State University
- 1999-2001 Director, Mountain Research C enter, Montana State University
- 1998 Deputy Director and Dean of the Earth Learning Center, Biosphere 2 Center, Columbia, University (on leave of absence from University of Arizona)
- 1993-1999 Associate Professor, Laboratory of Tree-Ring Research, University of Arizona
- 1993-1997 Director, Institute for the Study of Planet Earth, University of Arizona
- 1988-1993 Assistant Professor of Dendrochronology, Laboratory of Tree-Ring Research, University of Arizona
- 1986-1988 Assistant Professor, Dept. of Geography, University of California, Los Angeles
- 1986 Research Associate, Dept. Ecology and Behavioral Biology, Univ. of Minnesota

PROFESSIONAL ACTIVITY AND RECOGNITION

- Co-Organizer, Integrated History and Future of People on Earth, Dahlem Conference, June 2005

- Scientific Advisory Board, National Center for Ecological Analysis and Synthesis, 2003-2006
- Co-Chair, Land Project Transition Team, International Geosphere Biosphere Program and International Human Dimensions Program, 2000-2003
- Vice-Chair, Land Use and Land Cover Change Core Project, International Geosphere Biosphere Program and International Human Dimensions Program, 2000-2005
- Member, Steering Committee, Mountain Research Initiative, International Geosphere Biosphere Program and International Human Dimensions Program, 2000-present
- Steering Committee, 1999 Open Meeting of the Human Dimensions of Global Environmental Change Research Community. IGES, Japan.
- Steering Committee, 1997 Open Meeting of the Human Dimensions of Global Environmental Change Research Community. Vienna.
- Member, Global Energy and Water Cycle Experiment (GEWEX) Panel, National Research Council, 1993-1995
- Member, Working Group on Terrestrial Ecosystems and Global Change, subcommittee of Committee on Global Change, National Academy of Science, 1991-1993
- Member, Working Group on Earth System History and Modeling, subcommittee of Committee on Global Change, National Academy of Science, 1990-1991
- Delegate, PAGES Workshop, High Resolution Records of Past Climate from Monsoon Asia: The Last 2000 Years and Beyond, International Geosphere Biosphere Program (IGBP), Taipei, Taiwan, May 1993
- Delegate, Climate Studies Workshop, United States-Peoples' Republic of China Cooperation in the Field of Atmospheric Sciences and Technology, National Science Foundation, May 1992
- Editorial Boards: *Ecological Applications*, 1995-1997, *Physical Geography*, 1989-present
- Ecological Society of America (Secretary 1998-2000); Association of American Geographers; American Geophysical Union; American Association for the Advancement of Science; Tree-Ring Society (Treasurer 1992-1998)

RESEARCH SUMMARY

Publications (since 1999):

- peer reviewed journal articles – 12
- peer-reviewed book chapters -- 4

SERVICE SUMMARY

- As Vice-Chair of the Scientific Steering Committee of the Land Use and Land Cover Core Project of the International Geosphere Biosphere Program (IGBP) and member of the Land Transition Team of IGBP, I worked to define the role of land-use/cover research in the newly reformulated IGBP and to enhance the linkages with global change scholars working from paleoecological and ecological perspectives (1997 – 2005).
- As Executive Director of the Big Sky Institute, I developed a professional development program for K-12 teachers in which MSU researchers work with teachers to incorporate wildlife biology data and concepts into standards-based curriculum. This work is done in partnership with several local school systems and teachers and was recently awarded an NSF GK12 grant $1.8M.

CONNSTANCE A. WOODHOUSE

EDUCATION

- Ph.D. (December 1996) Department of Geosciences, The University of Arizona, Tucson, Arizona
- MS (March 1989) Department of Geography, University of Utah, Salt Lake City, Utah
- BA (May 1979) Prescott College, Prescott, Arizona

PROFESSIONAL POSITIONS

- Associate Professor (Jan. 2007 - present), Department of Geography and Regional Development and Laboratory of Tree-Ring Research, University of Arizona, Tucson, AZ
- Research Affiliate (Jan. 2007-Present), Institute of Arctic and Alpine Research, University of Colorado, Boulder. CO
- Physical Scientist (Apr. 2000-Dec. 2006), Paleoclimatology Branch, NOAA National Climatic Data Center, Boulder, CO
- Research Scientist III, Fellow (Mar. 2004-Dec. 2006), Institute of Arctic and Alpine Research, University of Colorado, Boulder
- Research Scientist II (Mar. 1999-Mar. 2004), Institute of Arctic and Alpine Research, University of Colorado, Boulder
- Visiting Scientist (May 1998-Apr. 2000), Paleoclimatology Program, NOAA National Geophysical Data Center, Boulder, CO
- Research Scientist I (Jul. 1997-Feb. 1999), Institute of Arctic and Alpine Research, University of Colorado, Boulder
- National Research Council Associate (Jan. 1997- Apr. 1998), Paleoclimatology Program, NOAA National Geophysical Data Center, Boulder

AWARDS

- Administrator's Award, National Oceanic and Atmospheric Administration (2006)
- Bronze Award, Department of Commerce (2005)
- National Research Council Fellowship (1997-1998)

RESEARCH GRANTS and CONTRACTS

- National Science Foundation, lead PI on 1 grant, co-PI on 2 grants
- National Oceanic and Atmospheric Administration lead PI on 5 grants/contracts, co-PI on 2 grants
- US Geological Survey, lead PI on 3 contracts
- National Park Service, lead PI on 1 grant

RECENT PUBLICATIONS (since 2002)

- Lead author on 7 peer-reviewed journal articles and 1 book chapter
- Co-author on 4 peer-reviewed journal articles

PROFESSIONAL ACTIVITIES

- Member of American Geophysical Union, American Meteorological Society, American Quaternary Society, Association of American Geographers, Tree-Ring Society
- Tree-Ring Society, Vice President
- International Tree-Ring Data Bank, chairperson of advisory board

- International Multiproxy Paleofire Database, advisory board member
- Board of Trustees, Rocky Mountain Hydrologic Research Center
- Associate Editor, *Dendrochronologia*
- Member, National Academy of Sciences, Committee on the Scientific Bases of Colorado River Basin Water Management

Non-Core Adjunct Faculty

Non-core adjunct faculty are scientists who closely collaborate with LTRR, but whose employment is not with LTRR or the University, and their offices are off campus (except Dr. Ann Lynch).

JULIO L. BETANCOURT

EDUCATION

- Univ. of Texas, B.A., 1975, Anthropology/Geography
- Univ. of Arizona, M.S., 1983, Geosciences
- Univ. of Arizona, Ph.D., 1989, Geosciences

EMPLOYMENT (since 1989)

- Project Chief, National Research Program, Water Resources Division, U.S. Geological Survey 1989-present; promoted to ST-16 (Senior Scientist) in 2004

PROFESSIONAL ACTIVITY AND RECOGNITION

- 1992-1998- USGS, Research Advisor, Ecology Discipline, National Research Program Water Resources Division 1992-1998
- Senior Fulbright Scholar, Argentina, 1994
- Department of Interior, Superior Service Award 1994
- 1993- USGS, Technical Advisory Group, Nuclear Hydrology Program, Nevada Nuclear Waste Storage Investigations, USGS
- 1994- USGS, Trends Committee, National Water Quality Assessment Program (NAWQA)
- 1995-1996- USGS, Global Change Program, Science Advisory Panel
- 1995-1997- NSF Earth System History (ESH) Panel
- 1996-1997- NSF, PAGES, Pole-Equator-Pole Paleoclimate Program, Steering Committee
- 1997-1999- Advisory Board, University of Arizona Press
- 1997-1998- Science Advisory Committee, Arizona District, Water Resources Division, USGS
- 2001, Founding Member of the International Biogeography Society
- 2001- William Skinner Cooper Award, Ecological Society of America, August 2001 (with Tom Swetnam)
- 2002- Department of Interior, Meritorious Service Award (2^{nd} highest honor award granted to career employees of the Department)
- 2005- W.R. Boggess Award, American Water Resources Association, November 2005 (with Steve Gray and Steve Jackson)
- Editorial Board, *Diversity and Distributions* (since 2005)
- Selection Committee, William McGinnies Scholarship, University of Arizona (since 2004)
- Adjunct Professor, Department of Geosciences, Department of Geography & Regional Development, Laboratory of Tree-Ring Research, University of Arizona, current

RESEARCH SUMMARY

Betancourt's research interests are diverse and encompass how physical and biological systems respond to climate variability on time scales from years to millennia. He is one of the leading experts on the late Quaternary vegetation and climatic histories of North and South American deserts. He has employed a battery of morphological, geochemical and genetic analyses of fossil plant and animal material to test long-standing hypotheses about ecophysiological and evolutionary responses to changes in atmospheric CO_2 levels and climate. A decade ago, his research on contemporary climate variability was key to recognizing how El Niño and La Niña influence flood and wildfire frequency, suggesting alternative strategies to traditional flood and wildfire management in the western U.S. In response to recent drought in the Western U.S., he is now helping define how decadal to multidecadal variability in ocean temperatures modulates U.S. climate and western ecosystems, and how this knowledge might be used to forecast landscape change and manage natural resources.

Publications (since 1999):

- 54 papers in refereed journals
- 6 peer-reviewed book chapters
- 1 non-reviewed papers in conference proceedings
- 3 book reviews

Research Grants and Contracts (since 1999)**:**

- PI on 4 funded research projects
- Co-PI on 7 funded research projects
- Total extramural funding $1,250,000
- Note: USGS also funds Betancourt's research, with an annual budget of ~$400,000

TEACHING SUMMARY

Courses taught (since 1999):

- Environmental history of the Southwest (GEOS 220), Univ. of Arizona, Fall-Spring 1999-2000, this is a General Education/Natural Science (Tier 2: Sophomore level) class that I developed with my long-term colleagues Tom Swetnam and Jeff Dean. The class now has an enrollment of ~125 students

Graduate students:

- Thesis Committee chair or co-chair on 7 M.S. students (7 completed)
- Thesis Committee chair or co-chair on 8 Ph.D. students (8 completed)
- Service on 14 Ph.D. students' exam and/or dissertation committees

Undergraduate students: I routinely support & mentor undergraduate students in my lab. They have tended to be top-notch ones; in the past few years, several of these undergraduates have been honored as the *outstanding graduating senior of their respective departments* (Leslie Parkinson, Mike Wall, and Ben Wilder, Ecol. & Evol. Biology, Bobby Gillis, Tim Fischer, and Erin Gleeson, Geosciences).

SERVICE SUMMARY (Since 1999)

For most of his career with USGS, Betancourt has been based at the University of Arizona and USGS

Desert Laboratory on Tumamoc Hill, a 370-ha ecological reserve and research institution with a 100-yr legacy in environmental studies located on Tucson's west side (http://wwwpaztcn.wr.usgs.gov/). He is an adjunct professor in Geosciences, Geography and Regional Development, and the Laboratory of Tree-Ring Research. He has a formal MOU, as well a Cooperative Agreement, with the University that allows USGS free space and access to laboratory facilities in return for primary management of the research on Tumamoc Hill and mentoring of undergraduate and graduate students. He bears responsibility for coordinating research on Tumamoc Hill, including monitoring of vegetation plots that have been measured since 1908. Because Tumamoc Hill is embedded in a major city, Betancourt spends a considerable amount of time representing the Desert Laboratory in direct interactions with the media, local government and the general public. For example, Betancourt has used the Desert Laboratory and Tumamoc Hill in launching a multi-year program to justify, inform, motivate, and organize invasive species management across mixed jurisdictions to reduce ecological and economic risks of buffelgrass (*Pennisetum ciliare*) invasion in southern Arizona (http://wwwpaztcn.wr.usgs.gov/buffelgrass).

In the past seven years, Betancourt has organized several workshops and conferences, including the Central Andes Paleoclimatology Workshop in January 2001 (http://wwwpaztcn.wr.usgs.gov/pcaw/), the Western Governor's Association Workshop on "Improving the Application of Science in Western Drought Management & Planning" in March 2004, the AIBS/NSF Workshop on the Role of NEON in studying ecological impacts of climate in August 2004 (http://ibrcs.aibs.org/reports/pdf/neon-climate-report.pdf), the NSF Workshop to Develop an Implementation Plan for a National Phenology Network in August 2005 (http://www.uwm.edu/Dept/Geography/npn/meetings/wkshop_2005_8.html); the Implementation Team Meeting for the National Phenology Network in March 2006 (http://www.uwm.edu/Dept/Geography/npn/meetings/itmeeting_2006_3.html); and the 2nd NPN Implementation Workshop in October 2006. As co-organizer of the National Phenology Network, in summer 2006 Betancourt convinced USGS and the University of Arizona to fund an Executive Director, Associate Director, and a National Coordinating Office located at the Office of Arid Lands Studies (http://wwwpaztcn.wr.usgs.gov/rsch_highlight/articles/200610.html)

Betancourt also served on the National Academy of Sciences-National Research Council Water Sciences Board Committee on *Scientific Bases of Colorado River Water Management*. He contributed to and reviewed National Academy of Sciences (NAS)/National Research Council- (NRC) Board on Atmospheric Sciences and Climate Report on *Earth-Atmosphere Interactions: Understanding and Responding to Multiple Environmental Stresses, Report of a Workshop.* He represented USGS on Climate Change Science Program Office (CCSP), US Government Review Subcommittee, Working Group I Contribution to Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report

HENRY DIAZ

EDUCATION

- B. S. (1971) Florida State University (Meteorology)
- M. S. (1974) University of Miami (Atmospheric Science)
- Ph.D. (1985) University of Colorado (Geography/Climatology)

EMPLOYMENT (since 1989)

- Research Meteorologist, Earth System Research Laboratory

PROFESSIONAL EMPLOYMENT:

- June 1974 - May 1975: Center for Experiment Design and Data Analysis, Environmental Data Service, National Oceanic and Atmospheric Administration (NOAA, U.S. Dept. of Commerce, Washington, DC.
- July 1975 - September 1983: National Climatic Center, Environmental Data and Information Service, NOAA, Asheville, NC. (Detailed to NOAA/ERL Sept. 1981-Sept. 1983).
- October 1983 - August 1986: Climate Research Program, Environmental Sciences Group, NOAA/ERL, Boulder, CO (Acting Director January 1984-August 1986).
- September 1986 - December 1989: Climate Research Division, Air Resources Laboratory, NOAA/ERL, Boulder, CO.
- December 1989-September 1993: Climate Research Division, Climate Monitoring and Diagnostics Laboratory, NOAA/ERL, Boulder, CO.
- October 1993 to September 2005: Climate Diagnostics Center, NOAA/OAR, Boulder, CO.
- October 2005 to present: Earth System Research Laboratory, NOAA, Boulder, CO

HONORS, AWARDS AND RECOGNITION

- NOAA awards for Outstanding Achievement (May 1977, 1983)
- NOAA fulltime scholarship to the University of Colorado (1980-81)
- Sustained Superior Performance (1978, 1988, 1989, 1992, 1993)
- NOAA Administrator's Award, May 2004
- Summer (1982) Visiting Scientist with the Climate Research Group, Scripps Institution of Oceanography, La Jolla, CA.
- Visiting Scholar, the University of Massachusetts, Amherst (September 1988 - June 1989)
- Summer Visiting Scientist (1994), Institute of Geography, Swiss Federal Institute of Technology (ETH), Zurich, Switzerland.
- Summer Visiting Scientist (1998) IGBP/PAGES Project Office, Bern, Switzerland
- Visiting Scientist, Climate Research Division, Scripps Institution of Oceanography, La Jolla, CA (2000)
- Visiting Scientist, Desert Laboratory, University of Arizona (Spring 2002)
- Visiting Scientist, Tree-Ring Laboratory, University of Arizona (January-May 2004)
- Visiting Scientist, Bermuda Biological Station for Research (August-October 2005)
- Visiting Scholar, The University of Arizona (January-September 2006)
- Visiting Scientist, Ecole Polytechnique Federale de Lausanne, Lausanne, Switzerland (June-August, 2006)

PROFESSIONAL ACTIVITIES AND MEMBERSHIPS

- American Meteorological Society (Committee on Climate Variations, 1982-1987; Committee on Applied Climatology, 1991-1993; Committee on Climate Variations and Change, 2001–2004)
- American Geophysical Union

- Publications Committee Member of the Journal *Arctic and Alpine Research* (term ended)
- Member of the Editorial Board of the *International Journal of Climatology*
- Member of the Editorial Board of the Journal *Arctic, Antarctic and Alpine Research* (term ended)
- Member of the Editorial Board of the Journal *Atmósfera*

- Member of the Editorial Board, *Advances in Global Change Research*, Kluwer Academic Publishers Book Series.
- Intergovernmental Panel on Climate Change, Working Group I, Climate Observations and Trends
- Fellow of the Cooperative Institute for Research in Environmental Science (CIRES), University of Colorado (Boulder), 1987 - 2004
- CIRES Associate Director for Climate and Atmospheric Dynamics (1997–1999)
- Adjunct Associate Professor, Department of Geography, University of Colorado (Boulder)
- Adjunct Professor of Dendrochronology, Tree Ring Laboratory, University of Arizona, Tucson

RESEARCH GRANTS AND OTHER FUNDING SUPPORT IN THE LAST 10 YEARS:
- PI on 4 NOAA Research Grants ($463,000 total)
- Co-PI on 4 DOE Research Grants ($2,058,000 total)
- Latest Research Grant: DOE Contract (June 2004-May 2007, $510K) with R. S. Bradley, "Regional-Scale Climate Variability on Decadal to Century Timescales".
- Total Funding $2,641,000

PUBLICATIONS (since 1999):
- Edited 4 multi-author books
- Peer-reviewed journal papers -- 19
- Peer-reviewed book chapters -- 3

STEVEN GRAY

EDUCATION
- B.S. (Biology) University of Tulsa, 1994
- M.S. (Botany) University of Oklahoma, 1998
- Ph.D. (Botany) University of Wyoming, 2003

EMPLOYMENT
- 2006-Present Associate Research Scientist, Department of Civil and Architectural Engineering, University of Wyoming
- Director, Wyoming Water Resources Data System
- Wyoming State Climatologist
- National Research Council Post-Doctoral Research Associate, Desert Laboratory, U.S. Geological Survey
- Post-Doctoral Research Associate, Big Sky Institute, Montana State
- University

RESEARCH SUMMARY

Gray's research focuses on a variety of topics including: climatology and hydrology (instrumental and paleo); water resources and land management; environmental policy; human-environment interactions; global change.

Selected Publications:

Research Grants and Contracts (since 2003):

- National Science Foundation, Geography and Regional Science Program (Co-investigator with L.G. Graumlich and others). *"A novel approach for improving records of long-term, multi-scale snowpack variability in western North America."* ($98,000).
- National Park Service. *"Linking the monitoring of climate and ecosystems in the Greater Yellowstone Region."* ($21,000).
- National Research Council-Research Associate Program, U.S. Geological Survey Post-Doctoral Research Award. *"Assessing the Importance of Low-Frequency Climate Variability in Forecasting Ecological and Hydrologic Change Across the Rocky Mountain West."* ($157,000).
- National Park Service-Greater Yellowstone Network, Inventory and Monitoring Program. *"Development of climate-monitoring protocols for the Greater Yellowstone Network."* ($40,000).
- U.S. Geological Survey-Wyoming Water Development Commission Water Research Program (Co-investigator with S.T. Jackson). *"Combining modern and paleo-techniques for improved drought prediction and response."* ($57,479)

SERVICE SUMMARY

As Wyoming State Climatologist, Gray provides information on water and climate-related topics to a broad range of stakeholder groups. Gray serves on Wyoming's Drought Management Task Force, and he is involved in a wide variety of activities aimed at coordinating drought mitigation efforts across the region. Gray is a founding member of the *Journal of Service Climatology's* editorial board, and an active member in the CIRMOUNT coordinating group. Recent outreach activities, focused primarily on climate change impacts and water resources, have taken him to dozens of venues across the western United States. Gray is also a member of the University of Wyoming's Water Faculty Committee, a group challenged with integrating water resources research with the needs of agriculture and other water users throughout the region.

ANN M. LYNCH

EDUCATION

- Pennsylvania State University, B.S., 1977, Forest Science
- University of Michigan, 1981, M.S., Natural Resources (Entomology/Pest Management)
- University of Michigan, 1984, Master of Forestry, Biometrics
- University of Michigan, 1984, Ph.D., Natural Resources (Entomology/Pest Management)

EXPERIENCE

- 2005-present: GS-14 Research Entomologist, Rocky Mountain Research Station, U.S. Forest Service, Flagstaff & Tucson AZ (2006)
- 1989-2005: GS-13 Research Entomologist, Rocky Mountain Research Station, U.S. Forest Service, Fort Collins CO & Flagstaff AZ (1996)
- 1987-1989: GS-12 Research Entomologist, Rocky Mountain Research Station, U.S. Forest Service, Fort Collins CO
- 1985-1987: Assistant Professor of Watershed Management (Forest Resources Management), School of Renewable Natural Resources, University of Arizona

- 1980-1984: Research Assistant in Forest Entomology, School of Natural Resources, University of Michigan, Ann Arbor and Iron River MI
- 1978-1979: Regional Plans and Operations Forester, Oklahoma Region, Weyerhaeuser Company, Wright City OK
- 1978: Professional Intern/Scientist I (Entomology), Southern Forestry Research Center, Weyerhaeuser Company, Hot Springs AR
- 1977-1978: Professional Intern/Scientist I (Forest Regeneration), Western Forestry Research Center, Weyerhaeuser Company, Centralia WA

- 2006-present: Adjunct Associate Professor, The University of Arizona, Laboratory of Tree-Ring Research
- 1998-present: Adjunct Faculty, Northern Arizona University, School of Forestry, Flagstaff AZ
- 1989-present: Faculty Affiliate, Colorado State University, Department of Bioagricultural Sciences and Pest Management, Fort Collins CO

PROFESSIONAL RECOGNITION

- Certificate of Merit for outstanding technology transfer, with cash award, USDA Forest Service, Rocky Mountain Research Station, 1998
- Certificate of Merit for continuous dedication to excellence in forestry education, with cash award, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, 1988
- Distinguished Alumni Award, Alumni Society of the School of Resources, University of Michigan, 1986
- Donald M. Matthews Award in Forest Management, with cash award, Faculty of the School of Natural Resources, University of Michigan, 1984
- Samuel A. Graham Award for Outstanding Scholarship in Forest Biology and Superior Writing Capability, with cash award, Faculty of the School of Natural Resources, University of Michigan, 1983
- Traveling Scholar, Committee on Institutional Cooperation, 1982
- Xi Sigma Pi, elected Member, 1976

RESEARCH SUMMARY

Dr. Lynch conducts research on the ecological roles of insects in forested ecosystems, with emphases on high elevation coniferous ecosystems of the North American Southwest, the effects of climate change on forest insect disturbance ecology, and the interaction of fire, insects, climate, and anthropogenic effects. The long term goal of this research is to provide information needed for resource management and decision support for forest health and productivity. Dr. Lynch also conducts research on the ecology of *Elatobium abietinum*, an exotic aphid on *Picea* in North America. This research encompasses basic biology, ecology, and population dynamics of this insect as well as pest impact assessment and prediction in both Southwestern interior montane ecosystems and Pacific Northwestern coastal maritime ecosystems. The long term goal of this research is to minimize the impacts of this exotic to Southwestern forest health, productivity, and biodiversity.

Publications

- 12 senior or sole authored peer-reviewed
- 11 junior authored peer-reviewed journal articles
- 2 peer-reviewed book chapters

- 37 technical reports and conference proceedings
- 1 Forest Plan Revision analysis report

TEACHING SUMMARY

As an employee of the U.S. Forest Service, Dr. Lynch has no formal teaching responsibility. Teaching participation has included:

- Dendroecology Workshop (GEOS 479k/579k), including lectures, laboratories, and co-leader of the field session, 2006 & 2005
- Field Instructor for Oklahoma State University Forestry Field Camp, 1998 & 1995
- While an Assistant Professor at the School of Renewable Natural Resources (1985-1987): Forest Resources Management, Computer Applications Laboratory, Upper Level Seminar
- Service on 6 M.S. thesis and 1 Ph.D. committees
- 30+ guest lectures at University and Research Departments
- 10 guest lectures at Elementary and High School classes

PROFESSIONAL SERVICE

- Pinaleño Ecosystem Restoration Project Interdisciplinary Team, Coronado National Forest, 2004-present
- Pinaleño Partnership, 2006-present
- U.S. Forest Service Global Change Research Program, team member, 2004-present
- Flagstaff Laboratory Safety Committee, 2003-2005
- Rocky Mountain Research Station, Internal Communication Team, 1999-2000
- Rocky Mountain Research Station, Publications Merger Committee, 1998
- Rocky Mountain Research Station, Library Advisory Committee, 1995-1997
- Arapaho-Roosevelt National Forest Interdisciplinary Team, 1992-1993
- U.S. Forest Service, Forest Health Protection Modeling and Information Resources Steering Committee, 1994-1998

Elected appointments

- North American Forest Insect Work Conference: Steering Committee & Workshop Chair, 1991 & 1996
- Western Forest Insect Work Conference: Secretary 1994-1999; Proceedings and Conference Guidelines Committee, 1994-2000; Annual Conference Program Chair 1995; Annual Conference Steering Committee 1988
- Society of American Foresters, Entomology and Pathology Working Group: Chair 1999-2000; Chair-Elect 1997-1998; Secretary 1995-1996; Annual Convention Workshop Coordinator 1997-1998; Terminology Project Contributor 1997-1998
- Society of American Foresters, Colorado/Wyoming State Society, Science & Technology Coordinator 1995-1996

Current Professional Memberships

- British Ecological Society, 2005 to present (invited member)
- Ecological Society of America, 2002 to present
- Entomological Society of America, 1980 to present
- Entomological Society of Michigan, 1980 to present

- International Union of Forestry Research Organizations, 1992 to present
- North American Forest Insect Work Conference, 1991 to present
- Southwestern Entomological Society, 1985 to present
- Western Forest Insect Work Conference, 1988 to present