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May 7, 2008

TO: Joaquin Ruiz
Dean, College of Science

Tom Swetnam
Director, Laboratory of Tree-Ring Research

FROM: George H. Davis
Executive Vice President and Provost

RE: Academic Program Review Final Report and Next Steps for the Laboratory of Tree-Ring Research

Enclosed, please find a copy of the report from your academic program review internal/external review team. The report may be shared with members of your program.

The next step in the review process is to discuss the report's findings and future plans for the Laboratory of Tree-Ring Research at a meeting that will be scheduled shortly. On occasion program directors and department heads have elected to prepare an initial response to the APR final report to share at our meeting. Please feel free to use this option if you find it appropriate.

I look forward to working with you to bring this review process to a fruitful conclusion.

Enclosure

GHD/mat

ACADEMIC PROGRAM REVIEW 2007:
LABORATORY OF TREE-RING RESEARCH
UNIVERSITY OF ARIZONA, TUCSON, ARIZONA

EXTERNAL REVIEW REPORT

Review Committee (Team)
Drs. Lonnie Thompson, The Ohio State University (Chair), Richard Ahlstrom, HRA, Inc., Debbie Colodner, Arizona-Sonora Desert Museum, Karl Flessa, University of Arizona, Connie Millar, USDA Forest Service, Pacific Southwest Research Station, John Olsen, University of Arizona and John (Mike) Wallace, University of Washington

INTRODUCTION

The University of Arizona's Laboratory of Tree-Ring Research (LTRR) is widely regarded both nationally and especially internationally as the premier institution of its kind. In the 70 years since its inception under the leadership of the astronomer A. E. Douglass, the LTRR has come to be recognized as peerless in terms of the breadth, depth, and eminence of its research, the quality of its student training at both undergraduate and graduate levels, and its commitment to public outreach. Today, The University of Arizona's LTRR focuses its efforts primarily in the areas of dendrochronology, dendroarcheology, dendroclimatology, and dendroecology, especially with respect to the role of fire. Although other institutions in the U.S. and abroad pursue parallel aspects of the LTRR's current mission, none combines its strengths across such a broad spectrum. In fact, the exceptionally interdisciplinary character of the Laboratory's research division is a template for such endeavors. Both faculty appointments and the recruitment of students reflect the explicitly interdisciplinary character of the Laboratory's mandate, drawing from the Colleges of Science, Social and Behavioral Sciences, Agriculture, and Engineering. We consider the LTRR to be one of the University of Arizona's hidden treasures; "hidden" in the literal sense due to its isolated, inadequate location tucked beneath the University's stadium, and figuratively since for a variety of reasons we believe that its continuum of contributions to the University is not fully communicated or appreciated. Our interactions with the LTRR constituencies, including faculty, staff, students and peers within and outside the University of Arizona, lead us to make the recommendations that follow below, emphasizing the University's need to invest substantial resources for the archiving of the LTRR's supremely important reference collection of archaeological and modern wood samples.

The team's foremost recommendation is that steps be taken as soon as possible to re-house the unique collection of dendrochronological specimens, including the modern and ancient wood, fire scar, and increment-core samples, as well as the archaeological collections in a custom-designed facility and that this be coordinated with filling the need for space of all types (administration, offices, labs, meeting rooms, and class rooms). We believe that these needs can ultimately only be met by the Earth and Natural Resources Building of which the LTRR would be a part **(A)**.

We strongly recommend the creation of the position of a full-time (1.0 FTE) collection manager within the LTRR. This individual will oversee the reorganization of the collection, design of a computerized database system to document accessions, raise funds via collections management grants to manage the archive, and provide on-going oversight of the material. The team sees this as the top priority near-term action item **(B)**.

We recommend that LTRR PIs amplify their research program by expanding collaborations with other departments and colleges at the University of Arizona. Well-established LTTR research efforts in documenting temporal variations in climate, fire frequency and water availability address issues of central concern to campus units such as the Institute for the Study of Planet Earth (ISPE), Geosciences, Atmospheric Sciences, Hydrology and the School of Natural Resources **(C)**.

We recommend that the LTRR develop a coherent plan for how this unit could develop over the next 10 years, with a view to obtaining a major new facility on that time-scale. We recommend that the unit plan one or more retreats that will deal with the issue of strategic planning, develop a pithy, 2-5 page strategic plan document that includes a readily-amendable appendix list of action items. This document can then serve as a baseline and collective memory on what had been discussed and agreed upon, and a useful yardstick against which to judge what actions might or might not advance goals of strategic planning, and/or when a new vision or direction might be called for, as well as setting the standards by which success can be measured **(D)**.

We recommend that efforts be made to restore the state funding for the support staff who do the day to day development of the tree ring chronologies that are the backbone of the entire tree ring effort. One of the expert technicians who has served the Lab for several decades has already retired and is working part time on a volunteer basis, and another is approaching retirement age. It is important that younger people are hired and trained while these experts are still available to mentor them. State funding could be leveraged by using it to partially fund positions currently funded 100% by federal grants. Having partial state support for these positions would make them more secure and more attractive to individuals whom the Lab would very much like to retain in the face of competitive offers **(E)**.

We recommend that the LTRR continue to expand its breadth of contributions to teaching at the undergraduate and graduate levels. To attract a critical mass of classes requires close coordination with the Laboratory's partner departments (Geosciences, Geography, Anthropology and Atmospheric Sciences) and with units in other colleges. The committee strongly endorses the appointment of a full-time graduate program coordinator **(F)**.

We commend the LTRR for a tremendous amount of outreach, given its relatively small staff and resources, but we feel the energy currently devoted to outreach might be focused more strategically in "training trainers." Given the limited technical staff and the high demands on their analytical skills, their time may be better allotted **(G)**.

We highly recommend that the LTRR director, the College of Science Development Office and the University endowment program, encouraged by the University's central administration, actively pursue endowment funds.

(A) FACILITIES

The physical facilities of the LTRR remain dismal in spite of previous APR committees' recommendations that this problem be addressed and rectified as quickly as possible. The committee's foremost recommendation is that the University take the necessary steps to build an Earth and Natural Resource Building to house the Tree Ring Laboratory, atmospheric sciences, the Institute for the Study of Planet Earth, Arid Lands Resource Sciences, and related programs so that the University can better compete for large coordinated federal grants while maintaining the uniqueness of individual units. Increasingly large numbers of campuses across the country, including those with which the University of Arizona competes in Earth and Environmental Sciences, are adopting sustainable or "green" technologies to save water, energy and other resources, and to create a smaller environmental footprint in general. The University of Arizona needs to set a better example for the community and also for students. For instance, new buildings (e.g. ENRB2) should be explicitly "green" by design. We must highlight the poor physical facilities at the LTRR with respect to offices, laboratories, class and conference rooms, and collection archives, and stress that these are completely inadequate for a world class university. Of most concern is the space available to store and manage wood samples. The LTRR has a unique archive of wood collected (including increment cores as well as cross-sections and timbers) from the American Southwest as well as sites throughout the world over the last century. These include the invaluable bristlecone pine samples which are used to calibrate the radiocarbon calendar, as well as priceless archeological samples from early sites throughout the Southwest. This collection is of international importance and yet it is poorly organized, inadequately cataloged and largely unprotected from the risk of fire. A near term solution currently under consideration is to remodel the stadium offices of the present Printing Department to house both the Lab and the archive, with hopes of eventually raising ($4-5 million) in external funding to construct a new building nearby that would provide more secure housing for the archive. While we agree that this proposed solution would relieve the present acute shortage of space and that a dedicated archive building would provide much greater security for the collection of tree ring samples, we believe that the University of Arizona departments and programs would derive greater benefit from LTRR if it were relocated closer other environmental sciences units.

(B) RECOMMENDATION TO HIRE A COLLECTIONS MANAGER

The LTRR houses a unique collection of dendrochronological specimens obtained from both ancient and modern trees and from archaeological contexts. The collection comprises tens of thousands of specimens, including cross-sections and cores from living and dead (ie. bristlecone

pine samples) trees, extensive fire-scar specimens, cross-sections and cores from construction timbers incorporated in prehistoric and historic buildings, and samples of charcoal recovered in the course of archaeological excavations. These samples have been amassed over a period approaching a century in length, by dendrochronologists and archaeologists conducting research primarily in western North America, but in other parts of the world as well.

The dendrochronological specimens held by the LTRR represent a cumulative and active collection of objects that has been, and will continue to be, revisited to address current and emerging research issues. In other words, the collection is valuable not simply as a record of past research. The "traditional" approach to dendrochronological analysis has involved the cross-dating of tree-ring sequences on the basis of patterned variability in the widths of individual growth rings. Those width measurements have, in turn, provided a substantial portion of the data used by dendrochronologists to reconstruct past climatic and other environmental conditions. Fire scars that interrupt the ring sequence have played an important role as well. In recent decades, however, new methods of measurement have been developed, e.g. involving variability in wood density, in isotopes that are incorporated in the wood, in chemical composition of toxics incorporated from soil and air, and in different portions of individual growth rings (early wood vs. late wood). There is tremendous potential to apply these and other new approaches to specimens that are already in the LTRR collection, particularly though not exclusively in the case of samples whose ring sequences have already been cross-dated.

Particularly in the case of archaeological specimens, the development of tree-ring chronologies that apply to specific time intervals, tree species, and locations is an ongoing process. Simply stated, there is a good chance that specimens that are not datable today will become so in the future and that new research applications will emerge that will warrant novel assessments of archived samples. This potential can be realized only if specimens with appropriate characteristics (involving for example counts of rings and sensitivity of ring sequences) are retained in the collection for future re-analysis.

There is also a great potential for students to use the collections as source data for master's theses and doctoral dissertations. The collection of new specimens pursuant to specific research projects will always be an important component of dendrochronological research. On the other hand, the expenditure of resources, both in time and money, for field collection and processing of new samples may not be practical or necessary in the case of many student projects. This potential for re-study can be satisfied only if the collections are both properly curated and physically accessible.

Portions of the LTRR's specimen collection are currently well-cataloged and controlled. This includes the archaeological collection, which has been managed under a system that was developed in the 1960s and maintained to the present as additional material has been submitted by archaeologists for tree-ring analysis. An effort is also currently underway to catalog the bristlecone pine collection. Overall, however, the LTRR's specimen collection is not managed or maintained in a manner that is consistent with modern curation standards or with the collection's

continuing value for dendrochronological research. Too much information relating to the nature, research potential, and storage location of individual samples and sub-collections is held in the memories of staff members, some of whom are approaching retirement age, and too little is maintained in well-organized and accessible databases.

To overcome this shortcoming in the current status of the LTRR's dendrochronological collections, we strongly recommend the creation of a position for a permanent, full-time (1.0 FTE) collections manager within the LTRR. Because of the specialized knowledge required to adequately address collections needs, this should be an academic professional position eligible for continuing status. A permanent position is recommended, because the LTRR's collection of dendrochronological specimens will continue to grow into the future. Not only it would be both inefficient and unrealistic to expect the institution's scientific staff to dedicate the time and effort required to maintain even a well-organized collections management system, but these individuals lack the specialized knowledge required to manage such a large and varied collection.

The individual hired to fill this position should minimally possess a master's degree which includes training in the management of museum collections, plus experience in the management of natural science collections, computerization, and database construction for accessing specimens and cataloging records. Among the responsibilities of the collections manager would be the development (in consultation with pertinent members of the LTRR staff) of a sophisticated system to manage the collection of dendrochronological specimens, to incorporate the existing collections into this system, and to integrate newly collected specimens into the system. This individual would be responsible for conducting conservation assessments of the collection, as well as for preparing grant proposals for the enhancement of systematic collections to be submitted to the NSF and other appropriate funding agencies. It is anticipated that the collections manager could also make valuable contributions to the planning of storage facilities to be incorporated into a new building, including identification of appropriate archival and museum storage of specimens and records. This individual would also assist LTRR faculty with its collections and document retention needs.

Two additional benefits of hiring a collections manager and implementing a well-organized curation system can be mentioned. First, it will simplify the task of moving the collection to a new facility, when one becomes available. Second, the establishment of a true "systematic collection" will provide the necessary platform for convincing sponsors of dendrochronological research projects that grants and contracts should include a "line item" to support the addition of newly collected samples to the curated collection.

C) CONTRIBUTIONS AND IMPORTANCE OF THE LTRR TO OTHER CAMPUS PROGRAMS

The LTRR is in an excellent position to participate in leading the University of Arizona's growing focus on the earth and environmental sciences. Well-established LTRR research efforts

in documenting temporal variation in climate, fire frequency and water availability address issues of central concern to campus units such as ISPE, Geosciences, Atmospheric Sciences, Hydrology and the School of Natural Resources. The archaeological components of the Laboratory's efforts document how human societies in the Southwest have responded to environmental variability. Recent developments in using tree-ring data to provide baseline environmental information show great promise in understanding the role of emerging contaminants in public health while the development of techniques to extract environmental information from tropical trees has the potential to greatly increase the geographic scope and applicability of tree-ring studies. The Ph.D. minor in Global Change, chaired within the LTRR, has created a community of graduate students from many campus disciplines. In short, the existing and potential connections between the LTRR and campus units in the Colleges of Science, Engineering, Agriculture and Life Sciences, Social and Behavior Sciences, Law, and Public Health demonstrate the LTRR's centrality to the UA's emerging focused programs in the earth and environmental sciences.

In addition, just to highlight a few of the faculty, we note the leadership roles taken by Dr. Swetnam in the governor's task forces on forest heath and on climate change, by Dr. Hughes with the Intergovernmental Panel on Climate Change and other international efforts on global warming, and by Drs. Hirschboeck and Meko in documenting temporal variation in river flow in the Southwest. These efforts give the LTRR prominence in state, national and international efforts to address environmental issues of great relevance to society.

We sense, however, that the decision of LTRR faculty leadership to assign higher priority to state, national and international affairs than to University affairs, coupled with LTRR's almost hidden location on campus have resulted in the Laboratory's relative lack of prominence in on-campus efforts in the environmental sciences. While unfortunate, this situation can be easily addressed, and the results will be to the benefit of all concerned.

We suggest here that the Laboratory's faculty, post-doctoral fellows, and students develop efforts to reach out to other campus units. Such pro-active efforts will ensure that the Laboratory's programs and personnel play an appropriate role in new campus initiatives. These efforts could include greater participation by jointly appointed faculty in activities in their related departments, invitations to faculty from other departments for joint appointments in the LTRR, co-teaching courses offered with other departments, and volunteering for colloquia or seminar series in other departments. We do recognize that such broader participation with other departments exerts a cost: more committee work, more meetings, and more lectures take time away from more inward-looking LTRR activities or from opportunities outside the University. Building strong and effective interdepartmental collaborations requires more than an absence of institutional barriers: it is the face-to-face contacts between faculty and students that come about through teaching, student advising, and other shared activities that faculty come to know one another and discover their common and complementary interests.

The physical isolation of the LTRR from potential collaborators elsewhere on campus requires that the Laboratory's faculty and students take the initiative in developing such collaborations.

The Laboratory's great strength is in using its understanding of past environmental variability to manage for the present and for the future. We are certain that once the relevant campus units are continually informed of the LTRR strengths, it will be guaranteed to play a significant role in campus-wide environmental efforts. The new virtual School of Earth and Environmental Programs presents the LTRR with an opportunity for a greater role in shaping campus wide efforts in the environmental sciences.

(D) STRATEGIC PLANNING

The LTRR has a 70-year history of leadership in dendrochronological research, with current national and international prominence in climate, fire, and archeological sciences. Laboratory researchers have continued to develop innovative applications of tree-ring research to emerging key scientific and societal questions. Maintenance of this pioneering and leadership capacity for decades is testimony to the LTRR's unique resilience to inevitable challenges faced over time in budgets, facilities, academic and institutional changes, varying availability of faculty and student candidates, etc. We commend this strength.

As a result of Arizona's decades-long history of declining state budget support, and a resulting need to eliminate technical and support staff, the LTRR is now operating as a small academic unit with little buffer to accommodate further rescissions that might come in the future. Opportunities that may arise and pass quickly will need to be seized or lost; the potential of continuing budget cuts may require further and critical LTRR program reductions; and changes in Director and faculty appointments could have significant consequences on the unit. While small size may increase vulnerability, strategic planning would enable key decisions and tactics to be outlined relative to future scenarios, thus enabling greater stability and growth.

The external review found several situations that may become increasing opportunities or challenges in the next few years (i.e., before the next APR). The Laboratory's history of resilience suggests an ability to respond proactively; this capacity would benefit by advance discussion and planning within LTRR and with administrative leaders of other departments and associated colleges. Specific situations we noted include:

a) Declining Budgets. The trend of declining state budgets and limitations on traditional external funding sources over the past 10+ years may well continue in the future. We found that these budget cuts have necessitated LTRR making as many reductions as possible while attempting to maintain excellence and productivity. This process, however, has not been without impact on the Laboratory. As a result of cost reductions, the unit is now very lean with little opportunity left to cut in ways that wouldn't directly reduce its leadership and research prominence. The possibility of continuing rescissions, however, must be addressed and strategic plans developed to minimize undesired impacts on productivity. Where might reductions within LTRR occur that would least affect the unit's strengths? Are there cost-saving opportunities across departments worth investing in? Are non-traditional funding sources (foundations, endowments) appropriate to pursue and to what degree is useful assistance from the College of Science's Development Office

and the University of Arizona Foundation available? Are there ways to better promote the LTRR locally (i.e., within the University, community, federal, legislative, and corporate environments) so as to gain assistance and visibility in fiscal development?

b) Succession of the LTRR Director. We learned that the LTRR Director position is likely to be vacated during the upcoming APR period. This leaves open a critical question of succession. The Director's role has been tremendously important to the continuing success, prominence, and funding of the LTRR. The current and prior Directors have brought extremely high degree of prestige and competence to this job. Given the importance of the Director's position, and the demands for seniority, experience, and personality it entails, candidacy for the successor needs to be carefully evaluated. The University at present has a policy of not hiring Department Heads or Unit Directors externally; the availability of appropriate candidates within the LTRR, however, is not obvious. Thus, where will the LTRR look for a new Director? How might the Laboratory mentor or recruit an appropriate candidate within the University or through the use of any vacated faculty position that may arise (either before the Director steps down or as advance "debt")? What strengths and experiences might be sought in a new Director that will ensure the trend of continuing leadership and science excellence within what is likely to be increasingly unstable societal and budgetary contexts?

Given these situations, and the likely unstable and changing future opportunities and challenges, we recommend that the LTRR engage in an internal strategic planning process. In the same spirit that conducting the 7-year academic review catalyzes valuable internal discussion and integration, we believe that a conscious and reflexive strategic planning process would assist the unit in formally debating pros and cons of future options. In so doing, proactive decisions might be made that enable the LTRR to maintain and build strength in the future, averting potential crisis and reactive decision-making if undesired conditions arise, and consciously strengthening ties and collaborations that already exist. An effective approach to strategic planning asks the following reflective questions:

-- Who/what are we?
-- What do we do well now?
-- Where and what do we want to be...in the short term and the long term?
-- What opportunities and barriers exist to getting where we want to be?
-- What steps, including alternative paths, exist to get to our goals? (action items)

Strategic planning sessions could also explore what opportunities exist for seeking endowment funds to develop an archive facility, training an archivist, and/or collaborating with existing University Museum programs to achieve appropriate long-term housing for the invaluable LTRR wood collections.

(E) FACULTY AND SUPPORT STAFF

We found that the LTRR has a high caliber and productive faculty, with national and international renown. At present the disciplinary, gender, and age structure are relatively well balanced, especially considering the additions that LTRR has made with the use of non-core and

affiliate faculty. However, we understand that at least one member of the faculty may, for personal reasons, seek employment elsewhere, and thus a faculty line may become vacant during the next APR period. What expertise would the LTRR consider for this vacancy, should it, or other positions, unexpectedly arise? Might the University agree to support a senior scientist for such a vacancy, with the intent of transitioning to Director when that position becomes vacant? Is added support in any of the newly emerging discipline areas of LTRR needed? Might an advance campaign begin soon to train/recruit in non-traditional ways so as to enhance the diversity (Affirmative Action/EEO) of the LTRR's faculty? Continuing the innovative use of non-core faculty, might additional adjunct and affiliate roles be added to complement the current core faculty strengths?

We found that the LTRR relies heavily on the advanced experience of senior scientific staff, several of whom have decades-long tenure at the Laboratory. The knowledge and critical roles played by these professionals were highlighted by every group with whom we spoke. The Laboratory clearly would not function at its present high level and regard without the enduring tenure of these people and their knowledge. Unfortunately, budget cuts have been implemented within LTRR by reducing the number of technical staff, and several still are employed on soft funds rather than as permanent state employees. Further, whereas low turnover in this staff results in greater experience, historic memory, and enhanced capacity, there has been little opportunity to train new, younger individuals who would take over these roles as experienced staff retire. Thus, attrition of critical skills, memory, and capacity already threaten the foundations of the LTRR's productivity, and may become more pronounced as retirements ensue. What opportunities exist to maintain the current mix of faculty, both core and non-core, as well as advanced technical staff? How might the balance of outreach, education, and analysis be transitioned to younger individuals? What opportunities exist to secure the valuable skills of the present staff by developing permanent employment packages for them?

(F) TEACHING AND ACADEMIC PROGRAMS

We are pleased to note that the academic faculty members in the LTRR are playing a more important role in teaching courses than they were a decade ago, and that the courses taught by the LTRR faculty are well-attended and are receiving favorable ratings from the students. Exposing a broader group of students, including non-science majors, to the work of the Laboratory is beneficial to the LTRR and to the University as a whole. In view of the small number of LTRR academic faculty members and their heavy involvement in funded research and graduate research supervision, the contribution to undergraduate teaching is inherently limited. Therefore, it is important that it be put to the best use. More specialized course offerings at the advanced undergraduate and graduate levels also represent a valuable contribution to the University's academic mission. To attract a critical mass of students to these courses requires close coordination with its partner departments (Geosciences, Geography, Anthropology, and Atmospheric Sciences) and with units in other colleges.

The LTRR is in the process of designing a graduate-level certificate program that would serve as a credential for their graduates seeking employment in federal agencies and private companies

that have need for practical expertise in dendrochronology. In the absence of graduate degrees with an LTRR label, the certificate would be a way of recognizing the LTRR component of a student's graduate training. The Review Committee is supportive of the concept of a certificate, provided that it can be administered in such a way that it doesn't add significantly to the work load of the LTRR faculty.

The LTRR faculty members are deeply involved in graduate education through their partnerships with the departments of Geosciences, Geography, Anthropology, and Atmospheric Sciences. The fact that LTRR does not offer a degree of its own has not been a major impediment, but it does raise two minor issues that deserve consideration.

1) Graduate students supervised by LTRR faculty are affiliated with three different departments, each of which has its own policies with respect to the assignment of Teaching Assistantships and the degree to which they guarantee financial support for graduate students. Perceptions of inequity have sometimes been seen as detrimental to recruitment efforts of the LTRR faculty. Despite these inequities, student morale appears to be very high and the students that the Committee interviewed clearly value their dual identification with the LTRR and with their home department.

2) In proportion to the number of students that its faculty teaches, the LTRR receives its fair share of institutional support for teaching assistants. However, the LTRR enjoys a slightly smaller *de facto* "entitlement" of teaching assistantships than it would if it were a department, and this makes it appreciably more difficult for the Director and faculty to plan, on an annual basis, how graduate students will be supported.

Despite these obstacles, day-to-day interdepartmental coordination in graduate degree programs appears to be working very well. The Committee was favorably impressed with the excellent morale of the LTRR graduate students and with the prestige and good will that the LTRR enjoys among the faculty in the departments with which it partners in graduate teaching.

The Review Committee notes that the LTRR is considering appointing one of its faculty members as graduate program coordinator, who would oversee graduate student recruitment and work with individual students to ensure that they are progressing satisfactorily through their degree programs, and that they are receiving adequate financial support, to the degree that that's possible. The Committee strongly endorses such an appointment and recommends that it be implemented immediately.

(G) LTRR OUTREACH

The LTRR does a tremendous amount of outreach, given its relatively small staff and resources. It appears that the quality of outreach is high, as measured by repeat requests by teachers, professionals and the interested public for tours and programs. Staff members divide their outreach activities in to three categories:

Educational Outreach:
K-12 community: We found that the LTRR makes an extraordinary contribution to community outreach, through hosting K-12 groups that tour the facilities, offering short- to longer-term educational opportunities for visiting students and scholars, and through extensive tours and talks in the community schools and museums to explain and demonstrate the role of the LTRR. While we commend this dedication, we find the energy currently devoted to outreach might be focused more strategically in "training trainers" in a few well-organized annual Open House events, or in strategically developed school visits. Given the limited technical staff and the high demands on their analytical skills, their time may be more efficiently used. Strategic development of focused outreach efforts may free up more staff time and energy without diminishing the impact and obvious commitment of LTRR employees to this important function. LTRR staff should also consider charging for their services (other outreach activities on campus charge fees) or working with local outreach professionals to increase grant funding for outreach. LTRR's website also has excellent resources for teachers.

Higher Education: Here LTRR's activities appear to be of high quality and have the direct outcome of helping them recruit graduate students, post-doctoral fellows and collaborators. However, graduate students felt that courses were not advertised widely enough on campus. Faculty should take advantage of existing campus networks to help advertise classes more widely.

Research Outreach: The collaborations being developed around the world are clearly a source of strength, growth, and new applications for tree ring research. Research Outreach should continue.

Public Outreach: The Public Outreach activities are excellent, and have resulted in very good publicity for the Laboratory, as well as some donations. Again, if they don't already exist, criteria could be developed for determining which of these invitations to accept, being very strategic about the potential for return on investment to the LTRR. Outreach to public agencies and decision-makers is extremely important for making the science useful to society, and should be continued. Some of the requests for help by teachers, school children, and the general public that take a tremendous amount of time could be diverted to a website "FAQ" section.

Donors/Media: Cultivating specific donors or media professionals by involving them more deeply in the research (especially the field work) could also result in higher visibility for the Laboratory. Unfortunately, the current facilities, and the egregious lack of investment and prioritization by the University, are an impediment to making the case that the LTRR is a world treasure.

SUSTAINABLE OPERATIONS, ENERGY CONSERVATION

As outlined already in our report, we found that the LTRR facilities are in very poor condition relative to modern standards and other campus departments. Further, we found that the LTRR has not collectively or proactively promoted the cause of reducing energy consumption, minimizing its ecological footprint, or intentionally modeling greenhouse-gas reducing behaviors. Given the leadership of the LTRR scientists as climate ambassadors in high-visibility national and international climate contexts, we believe there are opportunities and imperatives to establish significant key examples to reduce energy consumption, support alternative fuel and energy sources, and to accept choices in travel, consumption, and collective work lifestyles. The LTRR employees conduct considerable travel, mostly by vehicles and air, to many national and international meetings as well as for field work. Because of the Arizona climate, high-energy demands exist for air-conditioning, and old facilities appear to be poorly insulated and/or maintained.

We recommend that the LTRR commits to becoming a recognized academic and institutional leader and model in energy reduction, energy conservation, and use of alternative vehicles, fuels, and power sources as a means of "walking the talk" for climate mitigation. Examples of actions include: (1) demanding LEED certification standards for new building construction and renovation, including investigating solar and wind options as appropriate; (2) opting for hybrid- or high-mileage vehicle lease or rentals; (3) increasing the use of teleconferencing and work-at-home opportunities; (4) accepting and modeling power-conserving standards (thermostats set lower in winter and higher in summer; (5) setting standards for lights/computers off when inactive; (6) commuting/public transportation credits, etc.; (7) purchasing carbon-offsets (RECs) for non-renewable energy use and travel; and (8) supporting Green-certified businesses (including hotels for visiting external review committees), for example, Arizona Green Business Program: http://www.azdeq.gov/function/about/greenauto.html.

ACKNOWLEDGMENTS

The external review committee thanks the LTRR Director, faculty, staff, and graduate students for an exceptionally well-organized APR self-study and especially for their efforts during the review week. The schedule was efficiently conceived, enabling adequate time for the needed interviews and tours. We thank each participant for his/her time and commitment in meeting with us. The advance effort made our job enjoyable and easy.