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Long-Term Preservation of Dendroarchaeological Specimens and *In Situ* Preservation: Problems and Practical Solutions

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Dendrochronology offers a unique opportunity to address archaeological questions with minimal invasiveness. Often, archaeological tree-ring sampling, and occasionally analysis itself, can be performed while the larger structure or object remains *in situ*. In comparison to the costs and benefits of excavation (complete or partial) and a growing international call for *in situ* preservation, dendrochronology provides an effective compromise for the interpretation of wooden material culture.

The current number of archaeological tree-ring specimens worldwide probably exceeds 2,000,000. These specimens have been obtained from thousands of historic buildings, shipwrecks, and other sites and artefacts. These specimens are housed by a variety of public and private entities: museums, universities, governments, private corporations, and individuals. Despite their importance as vouchers for archaeological dates and great potential for future use and new applications, generally little attention has been paid to the long-term curation of tree-ring specimens. This paper identifies some pressing curation problems and suggests that the value and nature of dendroarchaeological research is compatible with international calls for *in situ* preservation. Some practical suggestions, provided here, could drastically improve the long-term curation of dendroarchaeological specimens, further demonstrating the methodology as a viable and valuable partner to *in situ* preservation.

KEYWORDS dendrochronology, dendroarchaeology, conservation, preservation, specimens, archives

Introduction

Dendrochronologists study the annular rings and other growth features of trees as natural chronometers and as recorders of change in the environment with which all

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biological life and human cultures are inescapably linked. Tree rings provide access to a pre-industrial perspective on cultures and environment that is otherwise unattainable and is of great importance to the public and academics alike.

The value of dendrochronology to archaeology is difficult to overstate: over the past eighty years, it has become the gold standard for referencing chronological, behavioural, and environmental events when wood is found on archaeological sites (Dean, 1996; 2009). With its origins rooted in the south-western region of the United States, dendroarchaeology has spread to much of the rest of the world and has been a mainstay of European archaeology for at least four decades (Kuniholm, 2001; Baillie, 2002; Čufar, 2007; Dean, 2009; Eckstein and Cherubini, 2012).

Archaeological tree-ring studies are especially valuable for yielding absolute, single-year dates for past events and processes. Cultural and natural history insights from this kind of work have arisen worldwide. To cite an early example, A. E. Douglass (1929), founder of the discipline in the United States, used architectural timbers and archaeological charcoal to date the rise and fall of pre-European populations of the US South-west (Robinson, 1979). They also have shed light, for example, on the historic and pre-historic record of Europe (e.g. Billamboz, 2004; in which waterlogged timbers from Neolithic and Bronze Age settlements in the northern Alps were used to understand bog and lake-shore occupation over time). Knowledge gained from tree rings in archaeological contexts has been central to revealing and understanding cultural and environmental change over time, with valuable lessons for the present and future. Such studies continue today and have expanded to include virtually all periods of history, cultures, and a variety of wood-use behaviours worldwide (e.g. see Nash, 2002 for a review of archaeological tree-ring dating methods and applications; see Creasman, 2010a for applications of dendrochronology to better understand human/environment interactions based on ship and boat timbers).

Dendrochronology is often compared to the assembly of a jigsaw puzzle. The pieces, gathered from a wide variety of independent sources, are assembled over a period of years. Long-term preservation and continued access to specimens are thus crucial to this field, as an individual sample may prove to be significant only decades after its collection, when sufficient others have been obtained for comparison, allowing completion of the 'puzzle'. Despite this necessarily far-sighted scope, practitioners and stakeholders alike have largely neglected development of a comprehensive solution for the long-term needs of expanding collections.

In most cases, analysis in archaeological dendrochronology involves only a small portion of the parent timber, which can remain *in situ* (Figure 1). Although analysis and future reference might require removal of a portion of the specimen (a 'core'; Figure 2) (Bannister, 1963; Stokes and Smiley, 1968; Ferguson, 1970; Towner, 2001), this is not always the case. Various studies of art historical objects and structures demonstrate that there are effective techniques for the analysis of wooden archaeological remains *in situ* and/or without sampling: narrowing the origin and earliest possible dates of wood-panel paintings by several Dutch masters (Eckstein et al., 1986; Wazny, 1992; 2005; Haneca et al., 2005); identifying whether certain reputed Antonio Stradivari stringed instruments could have been crafted during his lifetime (Bernabei et al., 2009; Čufar et al., 2010; Grissino-Mayer et al., 2010); using digital methodologies to acquire tree-ring data and measurements from Buddha statues and other wooden artefacts that cannot be cored or sampled (NARA, 2004); and

FIGURE 1 A University of Arizona student taking a dendroarchaeological sample. *Photograph by R. H. Towner*

correlating photographs and terahertz reflection imaging to measure inaccessible tree rings (Jackson et al., 2009), to name but a few.

Given the inherently destructive nature of archaeological excavation, dendrochronological specimens collected from a site should be held to the same standards of care and preservation as any other component of material culture. Collecting and processing of specimens can be costly in time and funds, but, too few researchers possess the sense of urgency that leads to the development or execution of procedures that can support future use of the specimens and thus the maximization of resources (Creasman, 2011: 103). Lacking such resources or vision, development and implementation of non-invasive dendrochronological methods should be encouraged, as more *in situ* analysis may both mitigate growth of collections and help to better preserve archaeological sites and artefacts (Figure 3).

While anecdotes of the loss or destruction of valuable dendrochronological material are prevalent, few potent accounts can be confirmed (see Creasman, 2011). It seems the primary curation problems have been the result of a shortage of storage capacity, limited personnel resources, inadequate preservation technology, or lack of vision regarding potential future uses (see Baillie, 2002; Dean, 2006). Yet, the confirmed examples do not necessarily portend a dim future for dendrochronological collections, as most seem to have received adequate care. With greater education on the part of customers and researchers involved in dendroarchaeological analysis, curation problems should be a thing of the past.

FIGURE 2 Representative dendroarchaeological samples.

FIGURE 3 An historic American wooden farm structure, *in situ* after dendroarchaeological sampling: identical condition as prior to sampling.
Photograph by R. H. Towner; Towner and Creasman, 2010

Dendrochronological collections

The nature of dendrochronology, especially for chronology-building, often calls for the collection of a large volume or quantity of specimens and their long-term curation (Figure 4; Stokes and Smiley, 1968; Baillie, 1982; Creasman, 2011).[1] Because absolute dating is the 'backbone of all [archaeological] tree-ring research' (Kuniholm, 2001: 38) and an 'ample supply' of wood is one of Bannister's prerequisites for successful dendrochronology (1963: 164), it is not a coincidence that many large and diverse collections have been built during the past century (e.g. the University of Arizona's combined cultural and natural history dendrochronology collection includes approximately 2,000,000 specimens, of which approximately 700,000 are archaeological; Figure 5).

There are broad disparities in the significance placed on archaeological dendrochronology by national research agencies and agendas. For example, the Dutch

FIGURE 4 A small portion of the general dendrochronology collection of the University of Arizona.
Photograph by G. Mackender

FIGURE 5 Approximately 50 per cent of the boxed dendroarchaeology collection of the University of Arizona.
Photograph by G. Mackender

National Research Agenda for Archaeology has included dendrochronology in its scope (Jansma, 2006). While English Heritage outlined techniques for collection, preparation, and analysis of dendrochronological specimens (Laxton et al., 2001; Jones, 2010), it has not defined standards for storage and safekeeping, which is left to individual laboratories (Hillam, 1998). Consistency is also lacking in the United States: in the guide to responsible conduct in scientific research authored by the National Academy of Sciences et al. (2009), collections of all kinds are critically overlooked. However, the National Science and Technology Council (2009) have specifically addressed scientific collections.[2] As there is no national agenda or agency for archaeology in the United States, the protection of archaeological heritage is left to state and local governments.

This paper is not and should not be construed as an indictment of past practices within the fields, but as a call to arms. In all subfields, stakeholders need to deepen their commitment to collections, especially archaeological materials, and/or identify alternative practices for analysis that decrease collections growth, such as *in situ* analysis.

Challenges

The potential exists for much greater use of the existing dendrochronological collections worldwide (e.g. Santiago-Blay et al., 2011), but this expansion depends upon their proper housing and management and upon improved knowledge of and access to them. Organized and readily accessible collections will encourage greater use of the materials by scholars, as well as for public outreach (e.g. primary school demonstrations and museum displays). Further, ongoing loss of tree-ring resources due to environmental and social changes means that existing collections will be increasingly valuable in coming decades and centuries for study by archaeologists, biologists, chemists, and a variety of earth scientists, among others.

With the increasing recognition of and demand for archaeological applications of dendro-analysis (e.g. Creasman, 2010b), collections are continually growing, thus compounding the challenges. For example, it is likely that thousands of unique wet palaeoecological and archaeological specimens spanning from 8000 BC to present have been amassed in the past few decades and are sitting on shelves throughout Europe without proper attention being paid to the specific conservation needs of waterlogged wood or their future utility (see Creasman, 2011).

Collecting and preparing a usable tree-ring specimen require a considerable initial investment of time and funds. Even thereafter, the physical specimens often remain largely inaccessible to those beyond the host institution/repository; in some cases, they are totally unavailable. Indeed, some tree-ring collections have been destroyed, in part or in full, following their initial use (for specific examples, see Creasman, 2011). As archaeological resources generally cannot be re-collected, any loss is significant.

Suggested solutions

The various methods offered by dendrochronology provide opportunities to balance the desire to preserve sites *in situ* with the desire to derive information. Often,

archaeological tree-ring sampling, and occasionally analysis itself, can be performed while the larger structure or object remains *in situ*. Given that standard sampling and analysis for dendrochronology is minimally invasive, especially relative to excavation, dendrochronology should be embraced by all those who wish to preserve our archaeological heritage for the future without sacrificing the ability to derive data about our collective past. However, as with any technique in archaeology that calls for *in situ* preservation, certain curation challenges are present and should be resolved before accelerating study.

While the suggestions provided here would, *ideally*, be applied indiscriminately across all sectors of the field, it must be acknowledged that a division exists between academic or public sector and commercial or private sector work. The fundamental differences between these two branches and their business models often result in drastically different standards of care. This division and its implications are outside of the scope of this manuscript and will be explored by the author in a future work.

Those seeking dendrochronological analysis for their site/artefacts, the organizations that fund the research and venues that publish such work should collectively and actively require confirmation of viable long-term management plans for the specimens in question. Perpetual institutional commitments are and will be critical to the future of dendrochronological specimens. Yet, after the primary researchers are gone or a discipline falls out of favour, institutions can unilaterally revise such agreements. If specimens remain *in situ* they can escape the pitfalls of such possibilities, but are, inevitably, exposed to other hazards. Perhaps the safest way to ensure preservation of specimens would be to build endowments exclusively for this purpose. It has been suggested that such resources could be secured through estate planning by those involved in the research (P. I. Kuniholm, International Tree-Ring Data Bank Forum, 6 May 2010), but how many people are dedicated enough to their work to support it in this way?

The practice of sampling should be predicated on a demonstrated ability to care for any material culture collected from archaeological contexts. If dendroarchaeological specimens are analysed with greater frequency *in situ*, there is far less likelihood of losing all or part of the critical associated data or other common collection problems. Whenever practical, *in situ* analysis of dendroarchaeological specimens should be practised, which will, in turn, help to reduce the stress on dendrochronological collections. The issue at hand is how to progress. It is hoped that this manuscript can be used to further advance the case for curation of dendrochronological specimens and greater application of the method even when the decision is made to preserve a wooden structure *in situ*.

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Notes

[1] Chronology-building is necessary for most dendroarchaeological analysis. 'Master chronologies' are the backbone upon which archaeological dating and other interpretations are based. However, chronology-building is not necessarily reliant only on archaeological material. It often incorporates a substantial component of living-tree or other non-archaeological material.

[2] It is important to note that in the United States archaeology is most often considered part of the humanities or a social or behavioural science and is less often included in discussions of the 'hard sciences'. For example, Hodder has posed and addressed the question: 'Is archaeology a soft science or an expensive humanity?' (1984; 2005).

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