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Front cover:
Dead standing black box Culturally Modified Tree along Kromelak *(Outlet Creek) (Photo: Darren Griffin)*

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Editorial note

The papers included in this ninth issue of *Excavations, Surveys and Heritage Management in Victoria* were presented at the annual Victorian Archaeology Colloquium held at La Trobe University on 1 February 2020. Once again we had over 150 participants whose attendance testifies to the importance of this fixture within the local archaeological calendar. It continues to be an important opportunity for consultants, academics, managers and Aboriginal community groups to share their common interests in the archaeology and heritage of the State of Victoria.

The papers published here deal with a variety of topics that span Victoria's Aboriginal and European past. While some papers report on the results of specific research projects others focus on aspects of method, approach, education and the social context of our work. and approach.

In addition to the more developed papers, we have continued our practice of publishing the abstracts of other papers given at the Colloquium, illustrated by a selection of the slides taken from the PowerPoint presentations prepared by participants. These demonstrate the range of work being carried out in Victoria, and we hope that many of these will also form the basis of more complete studies in the future. All papers were refereed by the editorial team. This year Elizabeth Foley managed this process and the sub-editing of this volume under the guidance of Caroline Spry. Layout was again undertaken by David Frankel.

Previous volumes of *Excavations, Surveys and Heritage Management in Victoria* are freely available through La Trobe University's institutional repository, Research Online < www.arrow.latrobe.edu.au:8080/vital/access/manager/Repository/latrobe:41999 >. We hope that this will encourage the dissemination of ideas and information in the broader community, both in Australia and internationally.

We grateful to the Colloquium's major sponsors ACHM, Ochre Imprints, Ecology and Heritage Partners and Heritage Insight; sponsors Biosis, ArchLink, Christine Williamson Heritage Consultants and Extent; and to la Trobe University for continuing support. We would like to thank them, and all others involved for their generous contributions towards hosting both the event and this publication. Yafit Dahary of 12 Ovens was, as always, responsible for the catering.

Preparation of this volume was, like so much else in 2020, undertaken during the severe restrictions imposed because of the COVID-19 pandemic. We hope that 2021 will be a better year for all and that even if we are unable to hold our Colloquium at the usual time we will be able to do so later in the year.

The editors and authors acknowledge the Traditional Owners of the lands and heritage discussed at the Colloquium and in this volume, and pay their respects to their Elders, past and present.

'Scarred for life too': measuring girth and estimating ages of culturally modified trees using comparative examples from Wotjobaluk Country, Western Victoria

Darren Griffin[1] and Abby Cooper[2]

Abstract

*Barengi Gadjin Land Council Aboriginal Corporation, Cooper Heritage Management and the Wimmera Catchment Management Authority recorded 172 culturally modified trees (CMTs) during the initial archaeological survey stage of the Lower Wimmera River Aboriginal Water Project, along a section of the Wimmera River (*Barringgi Gadyin*) between Lake Hindmarsh (*Guru*) and Lake Albacutya (*Ngalpakatia/Ngelpagutya*), known as Outlet Creek (*Kromelak*), on Wotjobaluk Country, western Victoria. This paper examines the role of tree girth in the study of CMTs, which is the most common CMT attribute recorded by archaeologists, and is often applied in assessments and interpretations of this place type. Tree-girth measurements and their use in estimating biological tree age is discussed, as well as the accuracy and expediency of other CMT age estimation techniques employed by archaeologists. The paper concludes by presenting five steps that could be adopted by archaeologists to improve the quality of CMT data collected in the field, and subsequently the registration, assessment and interpretation of CMTs in Victoria.*

Introduction

In 2017, the Wimmera Catchment Management Authority (WCMA) received funding from the Victorian Government's Aboriginal Water Program to facilitate the Lower Wimmera River Aboriginal Water (LWRAW) Project, which was developed, managed and delivered by Wotjobaluk Traditional Owner's (TOs) working at the WCMA and Barengi Gadjin Land Council Aboriginal Corporation (BGLC), in collaboration with Cooper Heritage Management (Cooper HM). The LWRAW project assessed the Aboriginal cultural values of the Wimmera River (*Barringgi Gadyin*) through recording, collating and mapping of TO stories, values and connections to the waterway central to Wotjobaluk culture, Country and identity.

A comprehensive description of the aims, methods, results and functional analyses of CMTs recorded during the LWRAW project is detailed in Griffin and Cooper (2019:97–130). The objective of this paper is to provide suggestions for methods of field data collection for CMTs in Victoria to generate more reliable information about the age and interpretation of these trees.

Tree girth

Tree girth is one of the primary pieces of quantitative data required on the Victorian Aboriginal Heritage Register (VAHR) scarred tree component form, determined by measuring circumference at 1.5 m height above ground (HAG) (AAV 2008:78). Other than the radius of the canopy, the remainder of quantitative data required relates specifically to the cultural scar or modification. Other information required relating to the tree itself is subjective, such as the tree's condition (AAV 2008:78–80; AV 2019). Long (2003:36) explains the reason for collecting the girth attribute is simply ' ... to allow comparisons to be drawn between different trees'. This attribute appears to have been adopted from the diameter at breast height (DBH) measurement, which is the universal standard for expressing the size of the trunk or bole of a standing tree, and the most common data collected in dendrometry (the field of botanical research concerned with the measurement of the various dimensions of trees).

DBH and other dendrometric measurements are primarily used globally by the forestry industry for estimating timber volume. The theory that DBH can also be used to estimate age in large and veteran trees also appears to have originated from the forestry industry, based on the fact that trunk diameter increment is the only constant non-reversible feature of tree growth (White 1998:2).

In Victoria, the concept of relating DBH to tree age is used by ecologists determining the assessment pathway of applications to remove native vegetation (DELWP 2017a). However, this is only used in relation to large tree offset requirements, incorporating other data such as tree height and maturity. DBH benchmark

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measurements are listed for every large tree species in corresponding bioregional Ecological Vegetation Classes (EVCs) (DELWP 2017b) and are never used to suggest the biological age of individual trees.

Bennetts and Jolly (2017:12) state that it is generally true that the larger the tree's girth, the older it is, although there are many exceptions to these rules. Trunk diameter growth varies, depending on a range of factors including tree species, soil type, climate, rainfall, and tree density. Evidence indicates growth rates of *Eucalyptus* spp. are not linear, changing from height-oriented to width-oriented once trees reach around 15 cm DBH, and with trunk growth declining at a greater rate once matured, after about 100 years (Beesley 1989:12; Bennetts and Jolly 2017:13; Klaver 1998:234). Therefore, making direct correlations between trunk diameter and tree age is problematic. For example, as Roberts and Marston (2011:8) note:

> *Black box trees are assumed to be long-lived; however, only a few have been reliably dated or aged. Two large trees ... with DBH of 65 and 143 cm respectively, were estimated to be about 250 years by radiocarbon dating (George et al. 2005), showing that size is not a reliable measure of age.*

Scientific methods for estimating tree age

CMT research in Australia continues to be undervalued and underrepresented (Dardengo et al. 2019:34; Morrison and Shepard 2013:158; Rhoads 1992:202). The primary reason, according to Morrison et al. (2012:19), is the difficulty in easily assessing the age of CMTs. The only accurate way to determine tree age is through the application of scientific methods, such as dendrochronology and radiocarbon dating (Long 2003:33).

Dendrochronology involves the study of data from ring-tree growth to determine the calendar age of a tree. It is based on the principle that each growth season, a tree will create a new ring that reflects the weather conditions of that season. However, ring counting does not ensure the accurate dating of every ring because '...each ring must be precisely dated to its year of formation before a chronology can be constructed' (Ogden 1978:340).

To assign absolute calendar ages to each ring without error, dendrochronology must account for the occasional presence of 'false rings' (multiple growth layers in a single year) and 'missing rings', known as standardisation (Dietrich and Anand 2019:4815; Leavitt and Bannister 2009:374–375). The frequency of false and missing rings depends on tree species and their climatic environments, with trees not forming annual growth rings when subject to severe climatic conditions, such as drought, or when located on 'sensitive' sites close to their limits of tolerance, such as steep rocky sites, shallow soil profiles and/or with soil moisture stress (Brookehouse 2006:438; Leavitt and Bannister 2009:374–375; Ogden 1978:340). These conditions are common for most Australian trees, making them difficult to age (Dunwiddie and LaMarche 1980:130). Cross-dating or cross-matching ring-tree sequences against other samples provides absolute dating control in these instances, however, in Australia, there is a general lack of regional chronological sequences to facilitate cross-dating (Brookehouse 2006:437; Spry et al. 2020:7).

Radiocarbon helps assign more accurate ages to wood that has not or cannot be effectively dendro-dated because of these issues. One of the main obstacles using radiocarbon dating for CMTs, is that in many cases, part or all of the tree has to be destroyed to obtain an appropriate sample. Tree coring can be used, not only as a method for investigating tree rings, but also to provide wood samples for dating that avoids tree death (Long 2003:33; Morrison et al. 2012: 19; Spry et al. 2020:7). Few examples exist in Australia where these scientific techniques have successfully provided absolute dates for CMTs (Long 2014; Long et al. 2002, 2005; Spry et al. 2020).

One example is located on Wotjobaluk Country. The CMT was a bark removal scarred black box (VAHR 7324-0495) near *Barringgi Gadyin* at *Bogambilor* in Horsham. Tree ring and radiocarbon data were combined, providing an estimated calendar date of 1714±70 BP for the original scar face, meaning it predated European colonisation of the region by at least 52 years (Long et al. 2002:19). This date was estimated by calculating the radiocarbon date for a sample of wood close to the tree centre (330±70 cal. BP, ANU-11816) and then adding tree ring data to obtain an estimate of the calendar date for the weathered scar face (Long et al. 2002:15–16).

Most recent is the investigation of bark removal scarred *Eucalyptus melliodora* (yellow box) CMT from Wiradjuri Country, Lachlan Tablelands, NSW (Spry et al. 2020). This study demonstrates the quality and quantity of information that can be obtained from CMTs using multi-disciplinary recording techniques, including photogrammetry surveys to record the CMT, and Accelerator Mass Spectrometry (AMS) dating of core samples to produce an absolute chronology. Results indicate the cultural modifications occurred after 1950, probably between 1966 and 1973, and the tree was approximately 97–108 years old when it died in 1998–1999 (Spry et al. 2020:14–15). This can be considered a relatively young age considering the tree-girth circumference at 1.7 m HAG was 4.8 m, once again demonstrating the problems with estimating tree age using girth measurements alone.

Growth-rate models

In the absence of scientific dating, growth-rate models have been used to provide relative age estimations for comparable CMTs. Growth-rate models rely upon a wealth of recorded dendrometric and environmental data, historical information, and comparison with known date measurements. The synthesis of this information creates a model where specific data can be extrapolated and correlated to a relative age (Morrison et al. 2012:41–42; White 1998:1).

Although no growth-rate models exist in the Wimmera-Mallee for the three CMT species recorded during the Stage 1 survey, there is a range of excellent models recently collated by Bennetts and Jolly (2017) for each species in the relatively comparable semi-arid environment of the River Murray region. Whilst the large amount of data containing numerous variables makes relevant comparative analyses difficult, Bennetts and Jolly's research is important because it highlights the problem of applying growth models to estimate tree age across different tree species. Bennetts and Jolly (2017) also demonstrate some of the many factors that affect growth rates in the two most common tree species in the Wimmera-Mallee: river red gum and black box. These factors include the effects of crown health (trees with healthy crowns generally had a higher annual increase in DBH than trees with poor crowns), flood frequency (red gum growth rates were affected by flood frequency, but this did not have a significant effect on growth rates of black box) and tree density (Bennetts and Jolly 2017:32–38). Their study also found that red gums grew faster than black box, because red gums are better at modulating their physical environment and resources (Bennetts and Jolly 2017:35). For example, over a seven year period, the mean annual growth rate (measured in change in DBH) for 584 red gum trees was 0.44 cm, whilst for 149 black box trees it was 0.15 cm (Bennetts and Jolly 2017:32) The slow growth rate of black box trees was also noted in a study by George (2004) located on the Chowilla floodplain, Lower Murray River, South Australia, where saplings remained approximately 150 cm high and 2 cm DBH for more than 50 years.

Klaver (1998:234-235) produced a growth-rate model for black box at Overland Corner on the River Murray by recording girth measurements of 12 trees with known ages, dated by recorded flood events to calculate radial growth per year for each tree. Klaver's (1998:234) results suggest black box trees in riverine environments with circumferences at breast height less than 1.5 m were unlikely to be sufficiently old to be related to traditional Aboriginal land use. However, Klaver (1998:234) recognises the model's limitations including small sample size, non-scientific absolute dating method, reliance on a single dendrometric measurement to calculate annual radial growth, and the presumption of linear growth. These limitations are highlighted when the model is applied to her survey results. Klaver (1988:236) claims that according to this model, six of the 155 black box CMTs recorded during her survey are too young to be of Aboriginal origin. However, she points out that other observational data collected from these trees, such as axe marks, indicate that all of them are likely to be Aboriginal CMTs (Klaver 1998:236).

These examples illustrate the main issues using comparative growth-rate models for estimating CMT age. Each model must be considered specific for each tree species and environmental context because of the various factors affecting individual trunk-diameter growth. They should be developed over time and well established for each tree species and relevant bioregional EVC before they can be used reliably. Therefore, archaeologists must be cautious applying comparative data from these models, as there are numerous variables to be considered and understood.

Survey area

Stage 1 of the LWRAW project involved four targeted archaeological surveys of Crown land within the Native Title determination area of the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagulk Peoples (the peoples of the Wotjobaluk Nations). The survey area comprised approximately 28.5 km of the riparian zone and floodplains along Outlet Creek (*Kromelak*), encompassing the northern extension of *Barringgi Gadyin* between Lake Hindmarsh (*Guru*) and Lake Albacutya (*Ngalpakatia/Ngelpagutya*) (**Figure 1**).

The survey area is covered by an Indigenous Land Use Agreement (ILUA) between the Wotjobaluk Peoples and the Victorian and Federal Governments and jointly managed as a national park reserve by BGLC and the Department of Environment, Land, Water and Planning (DELWP), through Parks Victoria (PV). The natural resources of the entire *Barringgi Gadyin* catchment area (Wimmera-Avon Catchment Basin) are managed at a broader level by the WCMA (BGLC 2017:7-8; BGLC 2020; WCMA 2020a, 2020b).

Landform, climate and vegetation

The landscape surrounding the survey area comprises gently undulating dunefields, floodplains and alluvial plains, lakes, lunettes, and elongated dunes. The area is classified as belonging to the North Western Dunefields and Plains (DP) tier-one geomorphic unit (GMU), which occurs in the western part of the Murray Basin Plains, submerged by Late Tertiary seas (Agriculture Victoria 2020). The centre and north of this GMU is known as the Mallee, whilst the south is known as the Wimmera. Subsequently, the landscape is divided into two landform regions. These are generally known as the Mallee Dunefields, formed primarily by aeolian sediment redistribution processes in the mid-late Pleistocene to Holocene periods; and the Wimmera Plain, created by the deposition of Loxton/Parilla Sands

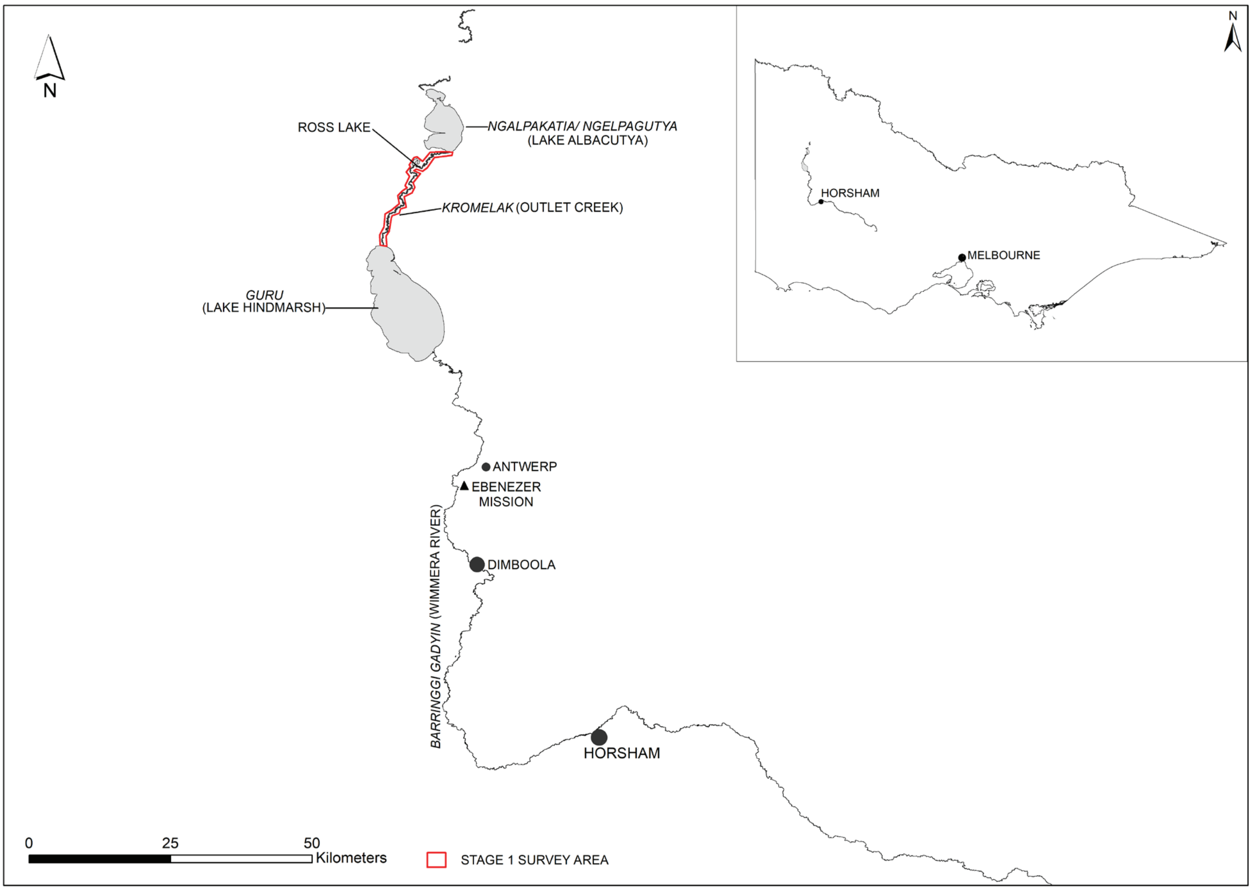

Figure 1. Stage 1 survey area, Targeted Archaeological Survey, Lower Wimmera River Aboriginal Water Project. Drawn by A. Cooper

during inundation and subsequent gradual shoreline retreat following sea level changes between 6 and 2 million years ago (Agriculture Victoria 2020; Bowler et al. 2006; MCMA 2018:16-17). Overall, this landscape is commonly referred to as the Wimmera-Mallee.

The Wimmera-Mallee's climate is semi-arid, ranging from almost arid in the north to sub-humid in the south. Average annual rainfall ranges from 1,000 mm in the south to 300 mm in the north (Agriculture Victoria 2020; WCMA 2020c). Rainfall is low and unreliable in the study area. The average maximum temperatures at the nearest recording station at Rainbow range from 14.4^{o}C in July to 30.8^{o}C in January, whilst temperatures of up to 46^{o}C have been recorded during summer (Cibilic and White 2010:43). Optimum temperatures for plant growth occur mainly in early autumn and late spring.

Before European interference, the vegetation of the Wimmera-Mallee was a diverse, complex mosaic of ecological communities and habitats, including riverine forests and woodlands; plains grassy woodlands; Mallee Dunefield shrublands, heathlands and woodlands; non-eucalypt lunette woodlands; and herblands surrounding ephemeral lakes and wetlands (Agriculture Victoria 2020; WCMA 2020c; MCMA 2018:17).

Eucalyptus largiflorens (black box) and *Eucalyptus camaldulensis* (river red gum) are the main large tree species of the Pre-1750 EVC 813 'Intermittent Swampy Woodland' (Murray Mallee Bioregion). This EVC was distributed along the floodplains, terraces and lacustrine verges of *Kromelak*, *Guru* and *Ngalpakatia/Ngelpagutya* before European contact (DELWP 2019a, 2019b; DSE 2005). The elevated riverine terraces surrounding *Kromelak* and Ross Lake supported another Eucalypt woodland dominated by black box (EVC 103 'Riverine Chenopod Woodland'). *Eucalyptus macrocarpa* (grey box) is another large tree species found in this environment, although not typical of these EVCs (DELWP 2019a, 2019b; DSE 2005).

Methods

The survey was undertaken over 19 days between June 2017 and July 2019. The primary aim of the survey program was to assess the condition and location of previously recorded Aboriginal places, and record any new Aboriginal places, focusing on areas not previously archaeologically surveyed. Another important aim of the survey was to provide training and field experience for TOs in standard archaeological fieldwork techniques and Aboriginal Victoria (AV) site recording standards. In order to achieve this aim, nine local TOs and one Aboriginal resident participated in the survey.

Three of the participants had existing experience in archaeological site recording gained through employment as field representatives at BGLC and having completed the Certificate IV in Aboriginal Cultural Heritage Management delivered by La Trobe University. The survey and training was led by the authors with the assistance of Dave Johnston (Aboriginal Archaeologists Australia).

A standard archaeological pedestrian survey was employed across the entire activity area, with team members walking parallel to each other as described in Burke et al. (2017:89). The intervals between individual survey members (transect widths) were 20 m, with each surveyor effectively scanning 10 m either side of them. Observational data for each CMT was logged directly onto hard copies of VAHR recording form templates for scarred trees (AV 2019), per AV standards (AAV 2008:78-80). Hard copies of AV's 'Scarred Trees: An Identification and Recording Manual' (Long 2003) were used for reference in the field. Spatial data for each CMT was recorded using Trimble handheld DGPS devices (Juno 5 and GeoExplorer 7), post-processed with Trimble Pathfinder Office software for centimetre-level positioning accuracy.

Data recorded for each CMT included tree species and condition, trunk girth, canopy radius, scar height above ground, scar dimensions (length and width of the dry face), scar overgrowth dimensions (thickness on each side, top and bottom), scar orientation and condition, and the presence of other features, including type, number and pattern of any tool marks, epicormic stems and other modifications. Tree species and girth is analysed in detail below as these relate directly to tree age estimations. However, all of these attributes are relevant, as they should be used in combination to determine if a scar or modification is of Aboriginal origin (Spry et al. 2020:5).

Results

The landscape within the survey area is largely flat and open. Ground surface visibility during the survey, however, was low. This would have affected the identification of Aboriginal places on the ground, but not the standing CMTs. The main obstacle encountered during the survey was the logistics required getting the team in and out of the survey area; a large linear space, with numerous surrounding landowners/managers and limited access points. For this reason, the Stage 1 program was divided in to four separate surveys.

Another obstacle encountered was the relocation of the 96 CMTs previously registered within the survey area, the majority of which were recorded in 1992 as part of the Victorian Archaeological Survey (VAS) program. Information on the original site cards was often too brief and coordinates on the VAHR mostly inaccurate, as these locations were recorded prior to the use of GPS. It was decided a more effective method was to record all CMTs identified within the survey area and undertake a cross-check at the conclusion of the survey to determine which CMTs were already registered on the VAHR.

To determine whether scars or modifications noted on a tree were natural or cultural, the methods outlined in Long (2003) and AAV (2008) were adopted. In addition, these characteristics, and all the attributes recorded as outlined above, were discussed by the survey team to ensure a consultative approach to assessing CMT identification was adopted for each tree. If there was any ambiguity in the scars/modifications, and it could not be stated by all survey team members that they were of definite Aboriginal origin, then the tree was not recorded as a CMT. There were a number of these trees identified, but they were not recorded.

A total of 172 CMTs, 25 low density artefact distributions (LDADs) where there are fewer than 10 artefacts observed in a 10 x 10m area (AV 2014), five earth features (remains of pit-earth ovens with clay ball heat-retainers) and four shell middens were identified during the survey. Place inspections were also undertaken of two known places containing Aboriginal Ancestral Remains. Of the 172 CMTs, 28 had previously been registered on the VAHR. The survey included the re-identification and re-recording of these trees, and the new recording of 144 CMTs. The survey did not re-locate the remaining 68 previously registered CMTs. Therefore, a total of 212 CMTs (144 new and 68 existing registrations) have been recorded in the Stage 1 survey area (**Figure 2**).

CMT species

Analysis of species for CMTs recorded within the Stage 1 survey area revealed black box comprised over half the total number of trees showing evidence of cultural modification, followed by grey box, and then river red gum (**Table 1**). The prevalence of black box, and similar representation percentages for grey box and river red-gum, has been observed in other archaeological surveys conducted in the Wimmera-Mallee (Bird 1990:27; Edmonds et al. 1997; Kamminga and Grist 2000:95-100; Rhoads 1992:207–209; Webber and Burns 2004:39–40; Webber and Richards 2004:56–58, 67).

CMT girth

Analysis of trunk girth for the three CMT species recorded during the Stage 1 survey is presented in **Table 2**. According to the relevant bioregional EVCs (Intermittent Swampy Woodland and Riverine Chenopod Woodland) black box are large trees with a DBH between 40–50 cm or more, and river red gum with a DBH of 70 cm or more (DSE 2005). The average DBH recorded for both these species are well above

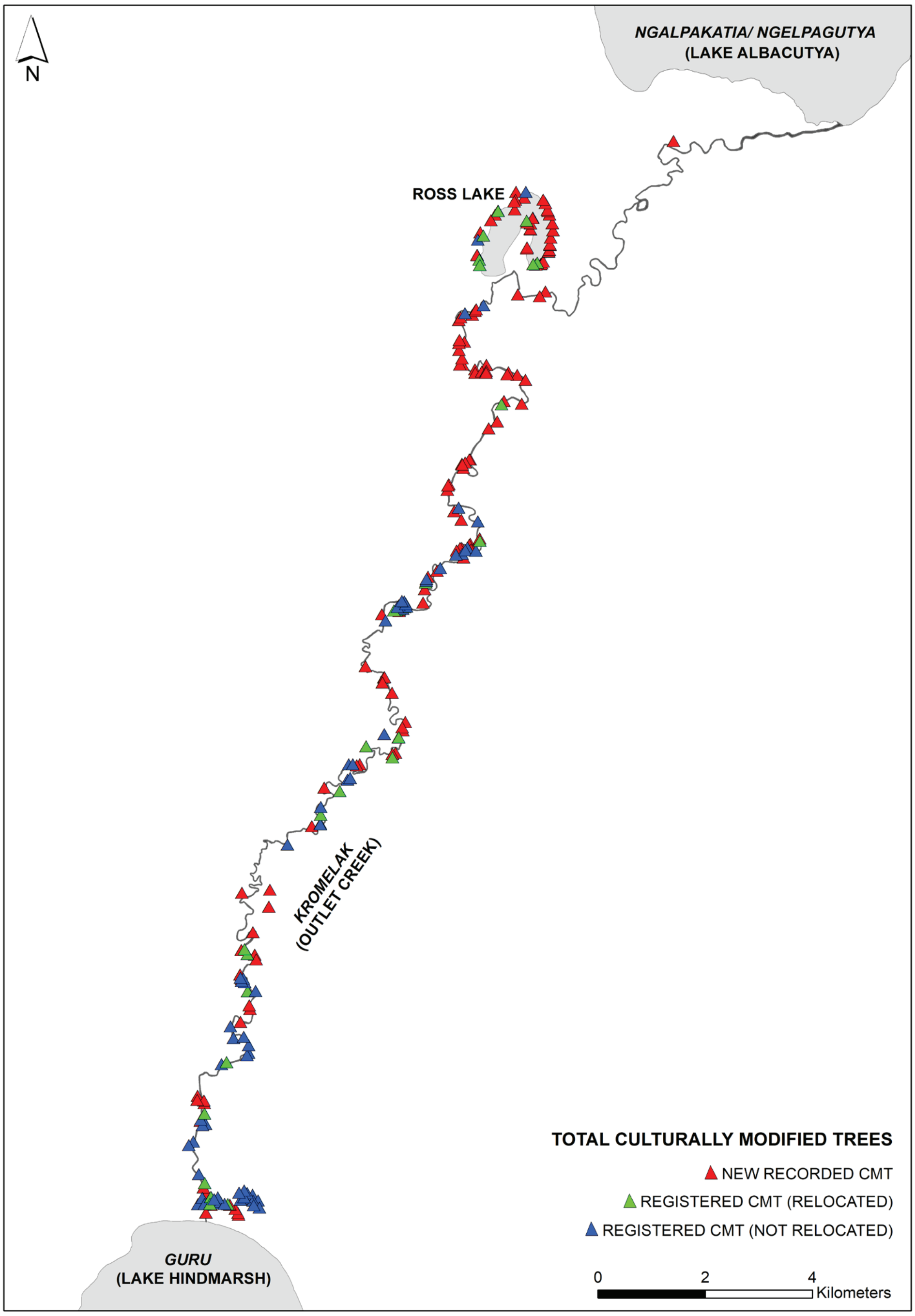

Figure 2. Total number of Culturally Modified Trees in Stage 1 survey area. Drawn by A. Cooper

Tree Species	Number	Percentage
black box	89	51.7
grey box	46	27.0
river red gum	13	7.5
other gum	1	0.6
uncertain	23	13.2
Total	**172**	**100**

Table 1. Species of Culturally Modified Trees within the Stage 1 survey area

these benchmarks, and only a few outliers are smaller.

Klaver's (1998) growth-rate model for black box suggests that CMTs with circumferences at breast height less than 1.5 m are too young to be of Aboriginal origin. Applying this model (and noting its numerous limitations, mentioned above) to the results of the survey would make these few outliers too young. However, these trees are likely to be Aboriginal CMTs based on the other observational data collected, similar to the six outliers in Klaver's (1998:236) survey.

The outliers in both studies may still be old enough to be Aboriginal CMTs, considering the numerous variables influencing trunk size, and more importantly, because the practice of culturally modifying trees has remained a continuing cultural practice amongst the Wotjobaluk Peoples, as it has for other Aboriginal peoples across Australia (Dardengo et al. 2019; Griffin and Cooper 2019; Griffin et al. 2013; Spry et al. 2020).

The results of the Stage 1 survey (**Table 2**) also correlate with previous studies, (e.g. Bennetts and Jolly 2017), which demonstrate that long-lived trees, such as the red gum, have larger average DBH measurements than black and grey box trees, even when subject to similar environmental conditions. Therefore, these results highlight the problem of using growth-rate models to determine the age of trees when recording CMTs, as DBH not only varies between different tree species, but also within the same species, depending on a range of factors discussed above.

Discussion

Despite the problems with tree-girth measurements and growth-rate models, their use to provide an estimate of tree age in CMT analyses persists (Dardengo et al. 2019:41, 54, 56). The notion that there exists a rapid and inexpensive model for estimating the age of CMTs remains seductive for archaeologists struggling to place this site type into a basic temporal context for management, reporting, and registration purposes. For example, one of the essential criteria required to demonstrate the authenticity of CMTs submitted to the VAHR is ' ... the tree must be of sufficient age to carry a scar caused by traditional Aboriginal techniques' (AAV 2008:77). This has perhaps led both the CMT recorder and the assessor to accept the flawed concept that trunk-diameter size is directly related to calendar age.

The results of the Stage 1 survey highlight the inadequacies in adopting this approach to assessing and registering CMTs. Determining whether a tree is of 'sufficient age' is not a simple process that can be undertaken by archaeologists in the field, or assessors in the registry office, using observational measurements alone.

Based on a synthesis of information gathered during the survey and studies referenced in this paper, we propose the following five steps be adopted by archaeologists recording CMTs in Victoria. Incorporating these steps when recording CMTs in the field replaces subjective estimations of tree characteristics with a systematic approach to recording CMT attributes and dendrometric measurements. This quantitative data can be used to compile more scientifically valid records of CMTs and as a meaningful basis for comparative analyses.

1. Record the relevant bioregional pre-1750 EVC category and large tree benchmark DBH measurements for CMT location and species

This information is easily accessible through the DELWP website (DELWP 2019a; DSE 2005) and NatureKit search tool (DELWP 2019b). It would be useful to record this data on the VAHR scarred tree component form because it adds essential contextual information to the observational data recorded for CMTs. Researching pre-1750s EVCs prior to fieldwork can also aid in species identification, although not all species recorded for CMTs are listed in every bioregional EVC. This includes trees that were not indigenous to a study area pre-1750, but are present in a historical or contemporary context, or indigenous species that did not reach a particular EVC benchmark threshold. For example, the grey box CMTs recorded during the Stage 1 survey do not appear in any of the bioregional EVCs listed for the survey area. DELWP (2017a:9) provides recommendations for assessing large trees not listed in the relevant bioregional EVCs.

The effective adoption of this step into routine CMT analyses would benefit from the addition of the pre-1750s EVC to the Aboriginal Cultural Heritage Register and Information System (ACHRIS), thus enabling archaeologists and researchers to export data relating to CMTs in particular EVCs for comparative purposes.

2. Improve the accuracy of CMT species identification

Accurate species identification is important because it forms the basis for all CMT assessments and interpretations, including age estimations and CMT validity. Archaeologists working in the field in Victoria can improve their CMT species identification knowledge by attending native vegetation identification field-trips and information sessions organised through regional DELWP offices, adding the standard published reference guides to their field-kit (e.g. Costermans 2006a, 2006b), and downloading relevant plant databases to devices

Species	Number	Mean circumference (m) (1.5m HAG)	Circumference range (m) (1.5m HAG)	Mean DBH (cm)	DBH range (cm)
black box	81	2.24	0.7–3.4	71.3	22.3–108.2
grey box	42	2.37	1–3.4	75.4	31.8–108.2
river red gum	11	3.56	1.5–5.4	113.3	47.7–171.9

Table 2. Girth measurements for Culturally Modified Trees within the Stage 1 survey area

Figure 3. Dead standing grey box CMT at Ross Lake with 22.3 cm DBH, view looking north-west, 16 June 2017 (Photo: Darren Griffin)

Figure 4. Dying black box CMT at Ross Lake with 31.83 cm DBH, view looking north-east, 16 June 2017 (Photo: Abby Cooper)

Figure 5. Dead standing black box CMT along Kromelak (Outlet Creek) with 42.97 cm DBH, view looking north-west, 1 December 2017 (Photo: Darren Griffin)

Figure 6. Dead standing red gum CMT at Ross Lake with 1.01 cm DBH, view looking east, 16 June 2017 (Photo: Darren Griffin)

used in field recording, such as those of the Royal Botaniocal Gardens Victoria (2020) and the Australian Virtual Herbarium (2020).

Identifying and distinguishing between some tree species can nonetheless remain difficult in the field, even for experienced ecologists and arborists. Two good examples, as noted during the Stage 1 survey, are black and grey box. Some individuals in these species are hard to differentiate, and further complicated in the Wimmera-Mallee by the presence of a hybrid box species. In these instances, samples including seeds, flowers, leaves, and bark can be removed; and a photogrammetry survey of the CMT undertaken, producing a detailed record for subsequent expert analysis. The addition of a tree specialist/aborist is therefore an important inclusion to the field or laboratory team.

3. Improve the accuracy and consistency of girth measurement recording

This study encountered numerous inconsistent girth measurements collected by archaeologists across Australia. These include the circumference at 1.5 m HAG (AAV 2008:79), 1 m (Dardengo et al. 2019:43; Long 2002:20, 26), and chest height, HAG not defined (Klaver 1998:234–235). The units used to present trunk growth rates in Australian models are also inconsistent.

While the current AV standard is presently acceptable, it is recommended that archaeologists move towards consistent girth measurement collection standards. This should comprise DBH (1.3 m HAG), as collected by ecologists in Victoria. This is the universal dendrometric standard for girth measurement. To facilitate this move to consistency DBH (1.3 m HAG) should also be recorded on the VAHR scarred tree component form, and in cultural heritage reports. Archaeologists in Victoria already use DBH when calculating place extent and root protection zones for dead CMTs (AV 2008:78, 82).

The addition and standardisation of this attribute will lead to improved analysis of CMTs with comparable growth-rate models and other dendrometric studies, thereby reducing errors that may occur when converting data. For example, using trunk-girth data from existing VAHR scarred tree registrations that are recorded in metres at 1.5 m HAG for comparison with a growth rate model where girth is presented in centimetres DBH (1.3 m HAG).

4. Increase and improve CMT dating

Estimating CMT biological age using only girth measurements or any set of observational data must cease immediately. Using age estimates based on this data as evidence that a tree is of insufficient age to contain a scar of Aboriginal origin must also cease. As this paper has outlined, archaeologists must be wary of using growth-rate models or any other comparative dendrometric data to estimate CMT age.

Radiometric dating of CMTs should be undertaken more frequently. The Victorian cultural heritage management industry should incorporate this procedure in all relevant projects, as has been done for radiocarbon dating of salvaged archaeological material. The methodology used by Spry et al. (2020) should be considered best practice for recording CMTs and adopted as far as practicable. Essentially this includes photogrammetry surveys, tree coring for wood samples and dendrochronological analysis, and AMS dating.

5. Undertake photogrammetry surveys

Photogrammetry surveys producing 3D models and photorealistic 3D visualisations are the optimal methods for recording highly accurate observational data for Aboriginal cultural heritage, especially CMTs (Almeida and Lovett 2016; Spry et al. 2020) This information can then be examined by other researchers and used for comparative analyses of CMTs. 3D photogrammetry data should become the standard format used in CMT registrations, in addition to photographs and sketches, and uploaded on the VAHR as part of a CMT registration. Photogrammetry also creates a permanent archive of a CMT, which has a finite life span and may be destroyed by fires, deforestation, vandalism and other processes.

Conclusion

This paper has examined the collection and application of tree-girth measurements in estimating tree age and has facilitated a review of some current standard practices and requirements associated with field recording, assessment and registration of CMTs in Victoria following the preliminary results of Stage 1 of the LWRAW Project. The review addresses assumptions regarding the expediency with which observational data is used to estimate the ages of CMTs. Information collected for CMT analysis, as described in this paper, should not be used in isolation to discount the authenticity of a CMT, but instead be combined to undertake a suitable comparative analysis, forming the basis for CMT assessments, interpretations and registrations. The culmination of this review is the presentation of five steps that could be adopted by archaeologists to improve the quality of CMT data collected in the field and subsequent future research.

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Note on terminology

'Wotjobaluk Nations' and 'Wotjobaluk Peoples' are contemporary terms used to collectively describe the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Japagulk Peoples (BGLC 2017:7; BGLC 2020). The authors acknowledge that not all people belonging to these five groups agree with the use of this collective terminology.

Wergaia words and names are used according to the orthography in Reid (2007).

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