

Guidelines for collecting and conserving dendrochronology samples from Tasmanian public reserves

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Abstract

In the last 30 years there has been increasing recognition of the potential for dendrochronological studies on Tasmanian trees. This research is likely to provide information that can be used for historical, palaeoclimatic and palaeogeographical reconstructions. Research to date in Tasmania has focussed on the endemic conifers, in particular Lagarostrobos franklinii and Athrotaxis spp., although other species have been used. Most available evidence indicates that properly conducted tree coring does not have any adverse effect on the health of conifers. Hardwoods, however, are susceptible to staining and fungal attack and Nothofagus cunninghamii is particularly prone to damage by myrtle wilt. As some dendrochronology field practices have the potential to cause damage, there is a need to establish appropriate guidelines in this area. Much dendrochronological work occurs in reserves where scientific collecting permits are required. This paper provides a set of proposed guidelines and conditions for the issue of such permits in Tasmanian public reserves.

Introduction

Dendrochronology is a science based on the examination of tree rings and other aspects of dateable wood in predominantly long-lived trees. Dendrochronological studies have especially favoured long-lived gymnosperms, notably the bristle-cone pines (*Pinus longaeva*) of the south-western United States (e.g. Ferguson 1970; Fritts 1976), and have largely been located in the mid- to high latitudes of the northern hemisphere. The concentration of work in the northern hemisphere has thrown light on questions about global environmental change (e.g. Jacoby & D'Arrigo 1989). Dendrochronological studies are diverse in scope but aim to answer questions about local, regional or global climatic changes, changes in the composition of atmospheric and environmental isotopes, local or regional ecological history, and geomorphology. Data is obtained from interpreting discs or core samples of tree wood.

In the southern hemisphere, pioneering work was conducted in the 1970s and 1980s (Ogden 1978; Dunwiddie and LaMarche 1980; Norton and Ogden 1987). Work has increased in the last 30 years, partly because of the realisation that excellent signals for climatic reconstruction (Cook *et al.* 1991) can be gained from several long-lived southern hemisphere gymnosperms (Norton *et al.* 1989; Villalba 1990), notably Huon pine (*Lagarostrobos franklinii*) in Tasmania (Cook *et al.* 1991) and *Fitzroya cupressoides* in Argentina (Lara and Villalba 1993). *Phyllocladus aspleniifolius* has also been shown to have good potential in Tasmania (Allen *et al.* 2001). Climate reconstructions developed using dendrochronological methods have been enhanced by the use of information regarding the role of the El Niño-Southern Oscillation (ENSO) on southern hemisphere and global weather systems.

Drought events and monsoonal penetration into Asia have been investigated using dendrochronological methods (D'Arrigo *et al.* 2006a, 2006b), as has fire history (e.g. Banks 1999; Grissono-Mayer and Swetnam 2000; Drobyshev and Niklasson 2004; Bowman 2007). Dendrochronological techniques can also assist understanding of stand structure and dynamics (Alcorn *et al.* 2001, Simkin and Baker 2008).

While other palaeo-records, such as from corals and speleothems (cave deposits), offer information on past environments, analysis of tree-ring records can provide unique sets of data that record annual variation in growth. Dendrochronology has a central place in climate change research given its annual resolution and ability to track anthropogenic climate change since 1750. The year 1750 is the year that the Intergovernmental Panel on Climate Change has established as the beginning of industrial emissions (IPCC 2001). Dendrochronological studies can also provide important insights into the dynamics of forests, as well as climate systems.

In the southern hemisphere, Tasmania, New Zealand and Patagonia have yielded the brightest prospects and results for dendrochronologists, while mainland Australia has yielded relatively little. The most extensive Australian conifer genus is *Callitris*, but it is relatively short-lived and has rings that are difficult to interpret (Pearman 1971), although the genus is being re-evaluated with some promising results (Baker *et al.* 2008; D'Arrigo *et al.* 2008). Success in establishing *Callitris* chronologies would be significant because of the continent-wide distribution of this genus.

All dendrochronological studies require obtaining one or more samples of wood from a tree. When the process of obtaining wood samples from trees is poorly regulated, the health and well-being of the trees may be compromised. Permits to conduct scientific research in Tasmania are issued for many reserves by the Parks and Wildlife Service on advice from the Department of Primary Industries, Parks, Water and Environment, and by Forestry Tasmania. The lack of clear guidelines governing dendrochronology field research has resulted in inconsistencies in providing permits by permitting agencies in the past and some uncertainty in the research community.

At an invited workshop in late 2007, the collection and curation of material for dendrochronological research was discussed. This paper, building on the workshop, reviews past practices and proposes dendrochronology field protocols and conditions. It provides a guide to conditions that may be included in permits issued to conduct dendrochronological research in Tasmania.

Dendrochronological research involves the direct or indirect participation of several key groups: dendrochronologists, resource managers, and curatorial experts. Each of these groups has its primary focus and area of expertise. In some situations these may overlap; in other situations they may

not. Tasmania requires guidelines for the collection, storage and curation of its dendrochronological resources to avoid conflicts. To this end, we address here several areas of particular concern to one or more of these key interest groups, and append guidelines for dendrochronology sampling (Appendix 1) and a decision tree for permit-giving authorities (Appendix 2).

Past and current dendrochronology research practices

A review of collection permits between 1974 and 1997 (Ilowski 1997) found that 44 collection permits were issued by the Tasmanian Parks and Wildlife Service over that period for the collection of tree cores in Tasmania. Unfortunately, many permits, particularly those issued in the earlier years, rarely specified the number

of trees that could be sampled. Where numbers were given, around 20 trees was a commonly specified limit on collection permits. During the period 1974-1995, eight permits issued for dendrochronology field work at Mt Field National Park specified a restriction on the number of trees to be cored; the mean number was 24 trees (Ilowski 1997). Instances of coring within reserves, without permits, are also suspected but the extent of this practice is not clear. In some cases, permits issued for coring were not used. There is also no record of activities of Tasmanian Government agency staff, since their permits allowed a wide range of research activity and do not single out the collection of tree cores or cross-sections. A number of staff are known to have collected tree discs as part of tree aging work to determine the number of years since fire at various sites.

Target species indicated on the 44 collection permits issued by the Parks and Wildlife Service between 1974 and 1997 were typically the conifers *Athrotaxis cupressoides*, *Athrotaxis selaginoides*, *Lagarostrobos franklinii* and *Phyllocladus aspleniifolius* but also included other conifers as well as hardwood species, particularly *Nothofagus cunninghamii*.

The felling of live trees to take cross-sections is rarely permitted in Tasmanian reserves so tree coring is the main sampling technique dendrochronologists can use within reserves (Figure 1). Dendrochronologists often have a strong interest in sampling within reserves due to the coincident distribution of target species and reserves. An advantage of carrying out the research within reserves is the enhancement of the scientific importance of sites within reserves and the consequent elevated value of such reserves as long-term reference or study sites.

As with any scientific collections from reserves, there is also a standard clause



Figure 1. Coring *Athrotaxis* at Lake McKenzie in Tasmania's Central Highlands.

on permits to the effect that specimens must be lodged in a recognised institution following the work. Currently, a suitable Tasmanian repository to archive all Tasmanian dendrochronological material does not exist; however, investigations to determine the feasibility of establishing such a repository are ongoing.

Permits are currently required for sampling (including the taking of discs or tree cores) on reserved lands by virtue of the National Parks and Reserves Management Act 2002. These permits are issued with attached conditions that specify for example, approved localities, a maximum number of samples and the reporting requirements. Forestry Tasmania has a policy that requires permits be sought for any research carried out in State Forests.

Some of the Parks and Wildlife Service permits also allowed the taking of sections and cores from dead trees and from buried dead material. A flora collection permit is required for the collection of dead wood, buried or otherwise. However, in practice, applications to collect buried material from reserves managed by the Parks and Wildlife Service are referred to the Earth Science Section of the Tasmanian Department of Primary Industries, Parks, Water and Environment (DPIPWE), as the wood may be important in its geomorphological context. This paper does not deal with sampling from buried wood.

Field botanists often need to determine an age since fire of plant communities. One of the commonly used methods is cutting young stems in dense stands of *Leptospermum* or *Melaleuca*, to obtain a ring count (Jarman *et al.* 1988). This routine field ecology method is considered to be outside the scope of these protocols.

No other Australian state appears to have defined protocols for dendrochronological research, and the extent to which this is

currently an issue for all other Australian flora collecting permit authorities is not investigated here.

Potential risks associated with dendrochronological techniques

The effects of coring on the health of target trees have been of interest to land managers. Few studies have investigated the impacts of tree-coring on long-term growth and mortality of trees. The most recent, and comprehensive, study to address this question examined mortality of two coniferous species in the western USA, and found no difference between cored and un-cored trees after 12 years of observations (Van Mantgem and Stephenson 2004). Work by Shigo (1984, 1985) on the response of trees to wounding or other damage suggests tree coring would not cause harm due to compartmentalisation, a process which isolates a wounded area and seals it off from the living wood.

In conifers, the risk of decay is considered to be minor. A review of dendrochronological studies conducted by Grissino-Mayer (2003) found that conifers suffered little injury in the way of discolouration or fungal infection in the northern hemisphere, while hardwoods can be considerably affected by coring. Hardwoods have been seen to be quite variable in their response to injury by coring (Kube 2005). This would raise some concern when dendrochronological studies propose to involve rare eucalypts in Tasmania, or *Nothofagus*.

In eucalypts, or at least the Tasmanian species, and *E. obliqua* in particular, coring would be expected to lead to the establishment of decay columns in a high proportion of instances. Fungicidal paints offer partial protection against the establishment of decay (Mercer *et al.* 1983; Lonsdale 1984) and such an application followed by plugging the core hole with a suitable size piece of dowel will minimise decay. A wound treatment is recommended

in the proposed guidelines (Appendix 1). In the absence of a suitable fungicidal wound treatment, there will be a risk of decay developing from the coring wound. Decay is not generally lethal to trees and, particularly from coring wounds, would have minimal adverse effects on amenity or conservation values but may impact upon the commercial value of some timber. Nevertheless, minimising the risk of decay incursion should be considered in conducting sampling.

From the perspective of diseases associated with the coring of hardwood tree species, the main concerns are wood decay and vascular wilts/stains. The latter is the most significant problem to be considered in areas with high amenity or conservation value, including heavily visited areas such as the Tahune Forest Reserve. Myrtle wilt is the only significant vascular stain disease in Tasmanian native forests and only myrtles (*Nothofagus cunninghamii*) are susceptible. Myrtles should be avoided as target taxa for coring if at all possible.

“Black heart”, a fungal staining caused by a suite of fungi including *Penicillium echinulatum*, has been introduced to *Atherosperma moschatum* through coring wounds. However, the stain is non-lethal and actually increases the commercial value of trees.

As we are becoming increasingly aware of a suite of *Phytophthora* diseases in native forests, general hygiene also needs to be considered. A canker disease is known from *Diselma archeri* but its aetiology is poorly understood. Preventing the transmission of such diseases by cleaning instruments between cores is important.

Informal observations by the authors on trees and stands that have been subject to coring in Tasmania over the last 30 years suggests that there may be no discernable impact upon tree health by coring. Nonetheless, where data on the impacts of tree coring are lacking, such as for

Tasmanian tree species, it is reasonable to establish precautionary protocols that weigh the potential benefits against the potential risks. This is particularly justified because sampling targets tend to be on sites that are easily accessible and in some cases are easily visible to visitors to reserves.

Archiving of collected material

While most dendrochronologists maintain their sample collections with great care, there are many anecdotal accounts of core and disc collections being destroyed or dissipated. This has been due to research organisations moving to different buildings, shifts in focus of research due to staff changes, the principal investigator leaving the research organisation, or research not being pursued or completed. Thus potentially valuable research material has variously been dumped, burnt, given away and lost. The cores from long-lived trees are an important resource that should be made available for further studies. As the dendrochronological field expands in Australia, new chemical and analytical techniques are becoming available. Recent developments include techniques for efficient analysis of various isotope ratios, as well as new dating and analytical tools. If cores and discs are stored correctly they will be available for further analysis as techniques develop, and could lessen the need to take new cores and discs. Additional storage of high-resolution scanned images of cores and discs will allow for convenient reassessment of the tree ring data.

Ideally, Tasmania should house a repository for Tasmanian material. The present situation is that material is scattered across a range of institutions on different continents, held in various conditions, and subject to a range of curatorial expertise and security arrangements. Distributed networks of museum collections have the advantage of dispersing risks and maintenance costs. On the other hand, there would be advantages in having a recognised, locally held

collection. At the time of writing there was no Tasmanian institution that was able to identify the funding for long-term curation of such a collection, although the potential for such arrangements is being investigated. The desirable option presently is to ensure that researchers properly house material in an institution regardless of where it is located. Protocols outlining standard storage techniques are not considered in detail in this paper, but some basic requirements are suggested in Appendix 1.

Summary

Tasmania is one of the outstanding locations in the Southern Hemisphere for dendrochronology research and significant contributions have been made in this field to our understanding of palaeoclimatic changes (Banks 1999). Researchers have used differing approaches to acquiring and curating their collected material, while the understanding of dendrochronology research requirements has varied across government agencies responsible for permitting this activity, resulting in an inconsistent approach to permits.

Available evidence suggests that tree coring is unlikely to harm conifers because of the compartmentalisation response of trees to injuries; however, hardwoods are more likely to be susceptible to damage by fungal attack. To put this in perspective, there is a background level of disturbance and infection by pathogens in any forest stand. Across the landscape there are disturbance events ranging from small to major. Natural landslides (Cullen 1991), fires (Brown 1988), myrtle wilt (Packham 1991) and floods occur at a background level as a normal part of the cycle of death and regeneration in a forest.

This paper is, to the best of our knowledge, the first to attempt anywhere to provide guidelines for dendrochronology sampling (Appendix 1), as well as a decision tree to assist and guide the permit-

issuing authority (Appendix 2). While not completely removing the need for subjective judgements (what constitutes a “well-reasoned case for collecting within a reserve”?), the process laid out in this way introduces a transparency that has previously been lacking. These guidelines should cover the needs of the land manager and permitting authority whilst not inhibiting the conduct of appropriate scientific investigation.

It is recommended that the feasibility of a study be examined, to assess the occurrence or otherwise of damage to cored trees. Forestry Tasmania has already carried out monitoring of *Nothofagus cunninghamii* canopies in areas where coring has occurred.

Dendrochronological studies of Tasmanian trees are likely to contribute important information on past climate conditions and their variability, as well as historical ecological dynamics. Such research is therefore to be actively encouraged, but needs to be conducted within guidelines such as those described here, as this will allow for scientific advancement while protecting the health of Tasmania’s native species and communities.

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The permit application and minimum information

Applicants for scientific research permits in Tasmanian reserves are required to provide some basic information as part of their request. Similarly, scientists interested in conducting dendrochronological research in Tasmania should be able to provide responses to questions such as the following before being granted permission to conduct their research:

1. Where and when will you sample?
2. What are the species you will be sampling?
3. How will you minimize the impacts of your sampling? (e.g., fewer samples, phytosanitary measures)
4. Could the proposed research be carried out on existing stored material in any collection known to the applicant?
5. How will you communicate the results of your research?
6. How will you communicate the relevance to the long-term management and interpretation or understanding of Tasmania's natural resources?
7. From what approximate date will other researchers be able to access the sample you have taken? ("After 3 years" would be an acceptable response, allowing a window for your exclusive research on the samples.)
8. How and where will your collected material be stored and curated while you are working on the material?

Risk minimisation and species protection

The type of sample collection will be influenced by the area in which the sampling occurs. For example, felling trees to collect stem cross-sections will generally not be permitted in reserve areas. In contrast, non-destructive sampling with manual tree corers (6 mm diameter or less) would be permitted in most reserves, if all sampling conditions (e.g. phytosanitary precautions) are met. Where a tree species is considered rare or threatened (Tasmanian Threatened Species Protection Act 1995), tree coring may be prohibited, restricted to dead trees or restricted to a small number of living individuals. The recovery plan or listing statement will help to determine whether a permit is issued for a listed threatened species.

The conditions provided below relate to the species-level impacts of dendrochronology sampling on individuals. They are considered independently of the conservation status of the species or vegetation community within which sampling targets occur.

We suggest adopting the precautionary principle and minimising both the number of cores taken from a tree and the number of trees sampled. Tree cores are valuable because they are a primary source of data and have a restricted availability. If correctly stored, they can remain equally valuable for multiple studies, thus reducing the need to sample more individuals in the wild. When many cores are taken from one site they form a statistically valid collection, and it is therefore undesirable to separate the collection. A basic requirement/condition of permit will be that they are stored and curated as a collection in a responsible institution.

A substantial amount of time is devoted by the dendrochronologist to preparing, measuring, and analysing tree-ring data. Provision for archiving tree-cores and the tree-ring data associated with them is also important for ensuring that the potential for further information gain is available to land management agencies and other researchers. There are already protocols for storing voucher specimens of botanical collections. Recommended conditions for storing dendrochronology samples obtained from Tasmanian forests are included below.

The suggested permit conditions recommended here relate specifically to the dendrochronology sampling itself, and permitting agencies reserve their right to impose other conditions or prescriptions appropriate to the site or the circumstances. They may cover a range of factors including access arrangements or *Phytophthora* hygiene measures.

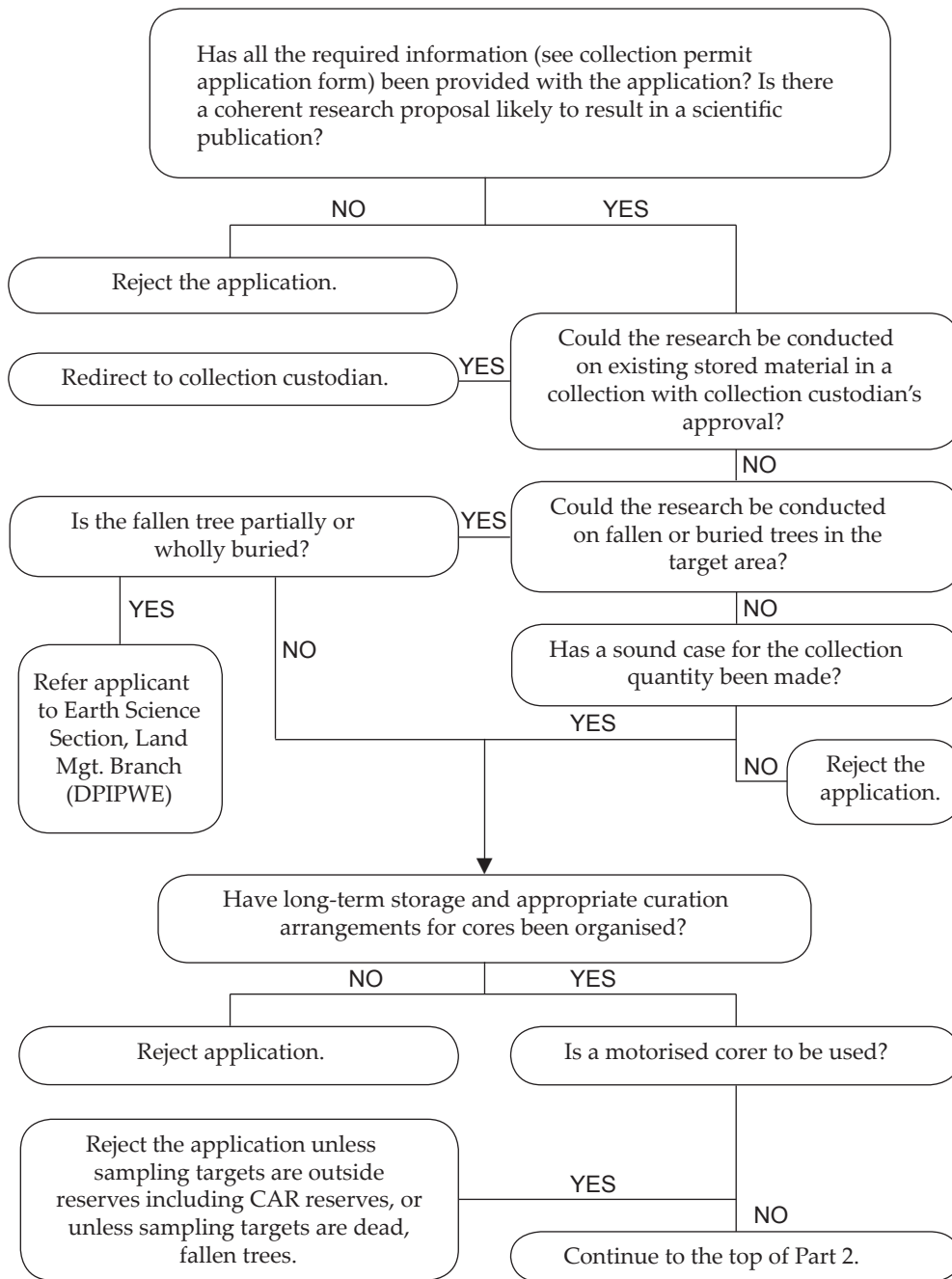
Suggested permit conditions

1. No more than three cores to be taken per tree.
 - Three cores per tree allows for a sample sufficient to account for the problem of missing and false rings. Greater than this number of cores may increase the risk of long-term damage

to the tree. As studies suggest it is best to implement the precautionary principle when considering tree coring (Van Mantgem and Stephenson 2004), three cores poses an acceptable risk in terms of long-term damage to the tree.

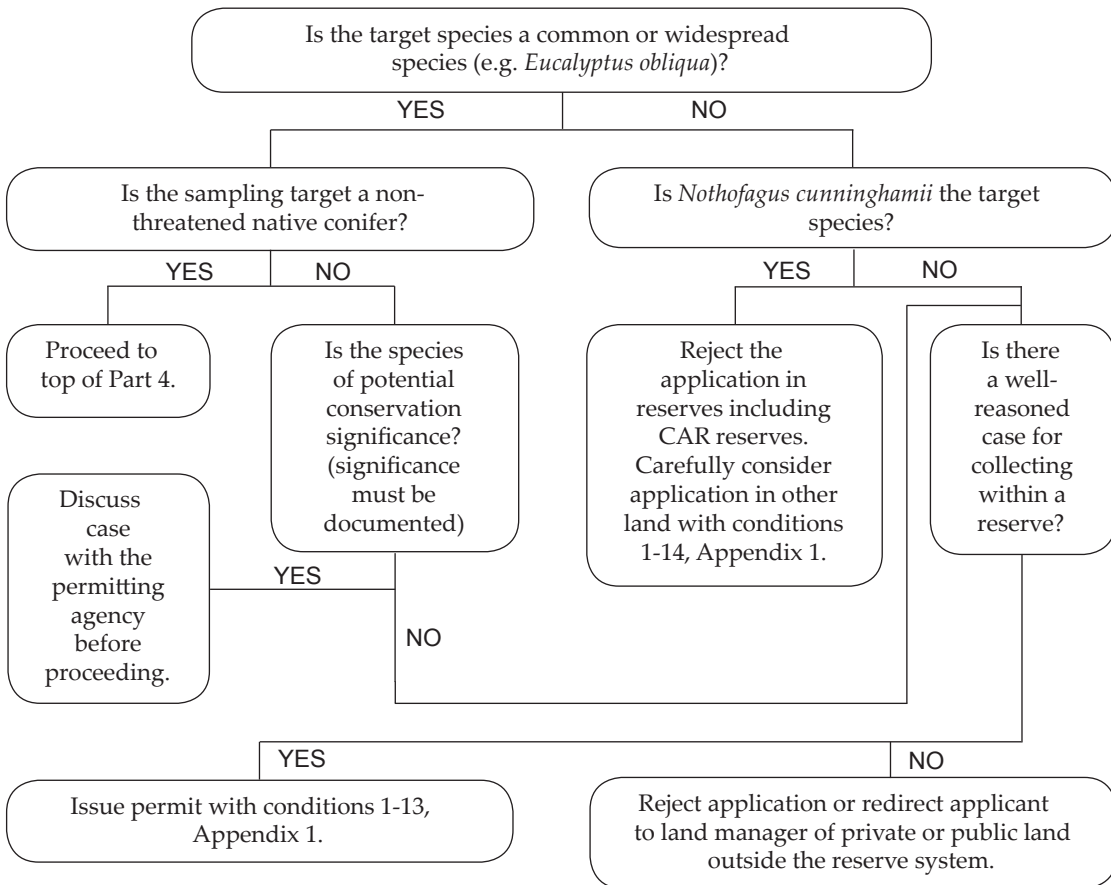
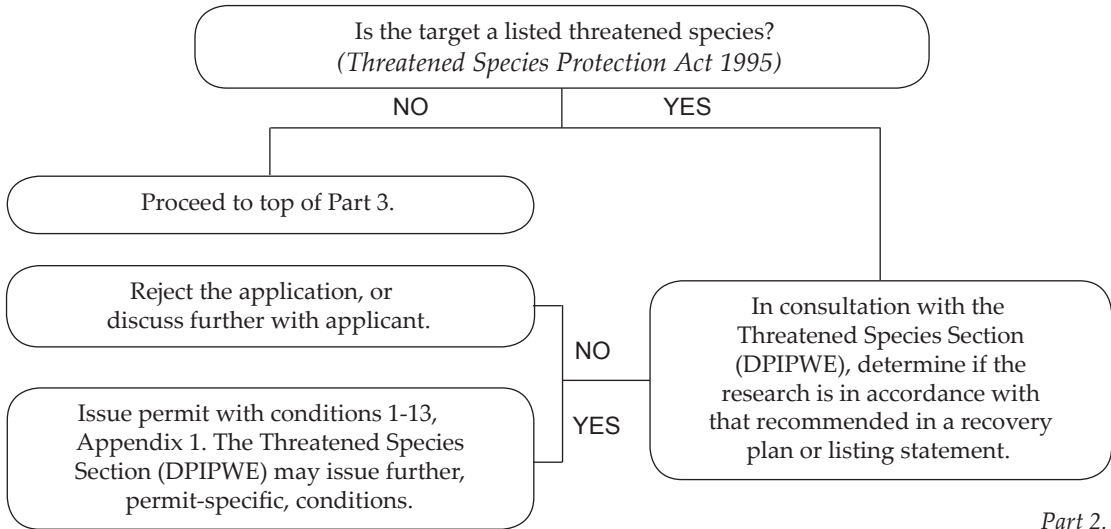
2. In a stand of trees, no more than 20% of the trees are to be cored.
 - May allow an opportunity for future analysis of the effect of coring on tree mortality if cored and un-cored trees remain.
3. Trees with a diameter of less than 10 cm should not be cored.
 - Some trees this size will suffer splitting when coring is attempted.
4. Cores must be inclined up towards the centre of the tree.
 - To prevent water accumulation which increases the chance of rot and infection; can also drain water from a tree where it may be already present.
5. Instruments are to be cleaned with a suitable product such as WD40 following field trips, and between cores are to be sterilised with alcohol to reduce pathogen transfer risk (Grissino-Mayer 2003).
 - The corer drill bit should be very sharp to reduce unnecessary injury to the tree.
6. A standard hand corer is to be used and not a motorised corer unless specifically permitted.
 - Most hand corers take a core 6 mm in diameter. There are several kinds of motorised corers which drill out an annulus of wood around a core sample of 12 mm diameter, leaving holes 25 mm in diameter. Motorised corers thus create a much greater level of damage to the tree, the long-term effects of which are unknown.
7. Cores must be glued on wood with water-soluble glue, in case cores need to be lifted and re-oriented. The type of glue used must be recorded.
 - Gluing to wood is an efficient method for storage and has been used for many years (Ferguson 1970).
8. Cores and discs must be kept in an institutional collection and not discarded. Material collected from public land remains the property of the Crown in right of the State of Tasmania.
 - Storage must be under appropriate conditions (acid-free) to allow for subsequent use and to reduce repeated sampling at sites.
 - Material to be properly marked and cross-referenced with metadata.
 - If the custodian of a collection intends to separate material from that collection, such as when changing jobs, retiring, or changing to other research interests, then the permitting authority must be notified to provide an opportunity for the repatriation of material to another institution in Tasmania.
9. Samples should be archived digitally.
 - Allows information to be shared and used by different institutions; also reduces unnecessary re-sampling.
10. Scientific papers and reports resulting from the research should specify which institution holds the physical material.
11. Information gathered must be stored on an international database.
 - This has been done for many years via International Tree Ring Data Bank (ITRDB), a web-accessible, electronic data-archiving system for storing tree-ring chronologies (National Climate Data Center, U.S. Department of Commerce). Metadata describing research site location and sampling dates are included with chronologies archived with the ITRDB.
12. High-resolution images are to be stored along with the accompanying metadata.
 - Images allow for re-assessment of rings/cores. Metadata is necessary to give samples context otherwise they are practically useless.
13. GPS coordinates or accurate map references for each sampling location must be recorded, along with any other metadata.
14. When coring *Nothofagus cunninghamii*, the core hole must be treated with "Garrison", a fungicide which prevents myrtle wilt. An off-label permit is required for the use of this chemical and the Agricultural Pesticides and Veterinary Medicines Authority (APVMA) should be contacted. Sufficient time should be allowed to obtain a permit.

Appendix 2. Decision tree to assist in assessing permit applications.



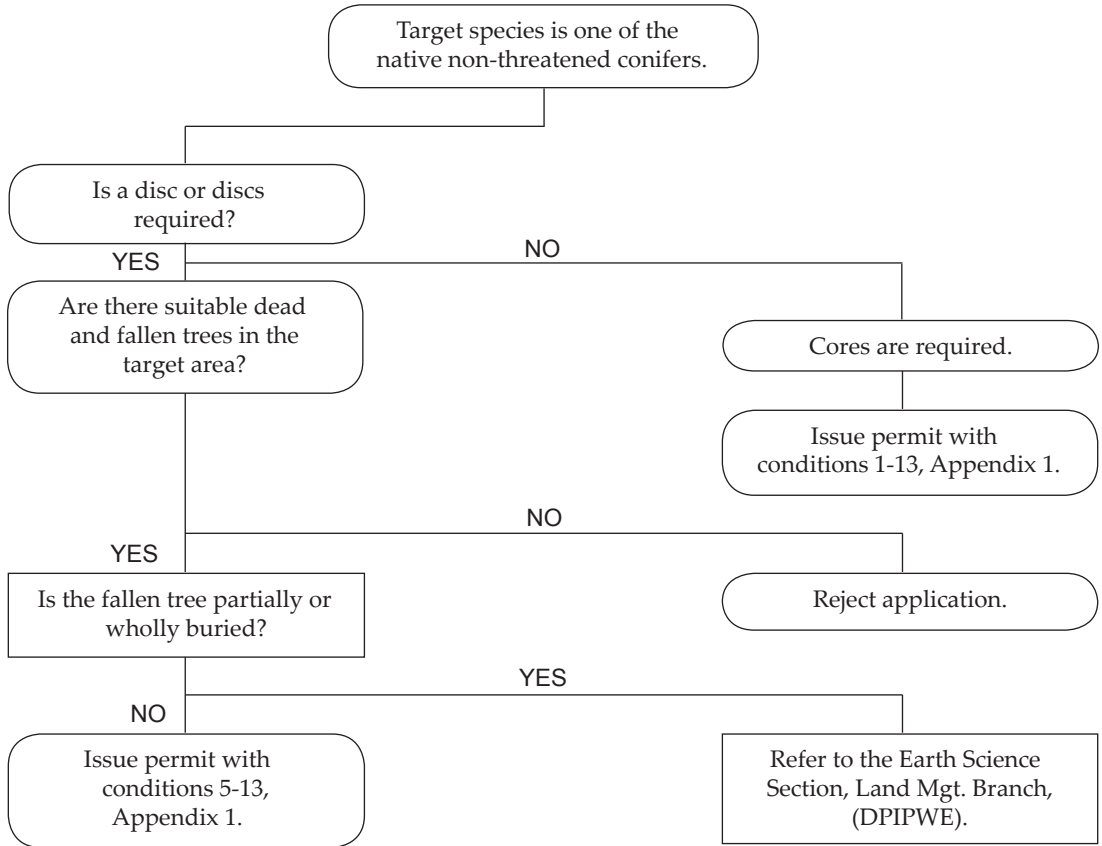
Part 1.

Appendix 2. Decision tree to assist in assessing permit applications (continued).



Part 3.

Appendix 2. Decision tree to assist in assessing permit applications (continued).



Part 4.