A manual of techniques to create simulated natural cavities in Slender Cypress Pine (*Callitris gracilis murrayensis*):

for use by Major Mitchell's Cockatoo (*Lophochroa leadbeateri leadbeateri*)

Department of Environment, Land, Water & Planning

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Report Title: "A manual of techniques to create simulated natural cavities in Slender Cypress Pine (*Callitris gracilis murrayensis*) for use by Major Mitchell's Cockatoo (*Lophochroa leadbeateri leadbeateri*)"

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Cover photographs: Hauling new cavity cover plate with the elevated work platform (Grant Harris ©).

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Introduction

This manual provides illustrated details of several techniques developed to create simulated natural cavities (SNC) in standing Slender Cypress Pine (*Callitris gracilis murrayensis*) (or simply *Callitris*). Further, a decision matrix is provided to direct choices in the most appropriate SNC technique depending upon the status of the candidate tree. The creation of tree cavities in this project addresses a high priority action listed in the Department of Environment, Land, Water and Planning's (DELWP) Action for Biodiversity Conservation (ABC) database for implementation in 2014 and 2015 and was funded by the Victorian Government in 2014-15. These excavated tree cavities are designed for use by the *Flora and Fauna Guarantee Act* 1988 listed Major Mitchell's Cockatoo (MMC) (*Lophochroa leadbeateri leadbeateri*) (MMC) for nesting and may also be used for night roosting (Hurley, 2006a). However, the techniques described here are equally applicable as conservation actions for other cavity dependent fauna.

The novel technique of excavating cavities in trees to create SNC has not been previously undertaken on such a scale in *Callitris*. The dimensions for constructing SNCs are based on the median dimensions of measurements taken from 55 natural cavities used for breeding by MMC at Pine Plains in Wyperfeld National Park (Hurley, 2006a). The feasibility of some of the techniques applied here were initially trialled on 12 *Callitris* at Pine Plains in 2009 (Hurley, 2009). This manual provides a detailed description of recent advances in these techniques and is intended to act as a user's manual for others wishing to undertaken similar conservation actions.

This manual accompanies the report "Simulating natural cavities in Slender Cypress Pine (*Callitris gracilis murrayensis*) for use by Major Mitchell's Cockatoo (*Lophochroa leadbeateri leadbeateri*)" by (Hurley & Harris, 2014). That full report may be read for further information on the background to why this manual was prepared. As such this manual has been designed for use in the field by practitioners intending to undertake similar actions.

Methods

A quick summary of the definitions and terms used will assist with the reading and field application of this manual. **Heartwood** is non-living solid inner tissue which no longer conducts vascular fluids, whereas **sapwood** comprises the outer layers of living tissue and is involved in vascular transport including the **xylem** vessels which transport water from the roots to the leaves. The **cambium** layer is also living tissue and this layer separates the sapwood from the **phloem** which transports nutrients generated in the leaves to other parts of the tree. The **periderm** is the outer bark layer of the tree. This serves to protect the connective tissue from infection and the extremes of weather, in some cases even fire (Figure 1). During SNC creation, removal of sapwood layers on live trees is kept to a minimum so as to protect and retain the integrity of the tree.

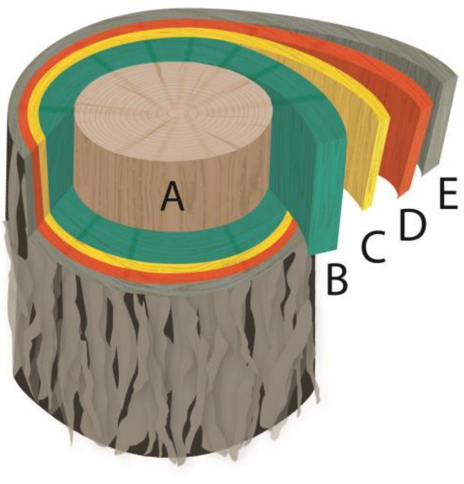


Figure 1. Anatomy of a tree trunk in cross section. A = Heartwood, B = Sapwood, C = Cambium, D = Phloem and E = Periderm or bark. Adapted from Campbell et al. (2008).

Simulated Natural Cavity (SNC) is a collective term applied to distinct processes developed in this project. The processes for cavity formation developed in this project were grouped into five distinct categories depending upon the developmental stage (i.e. age) and health of the tree and the condition or existence of any cavity within the tree:

Excavate: Create entrance and new cavity by carving out heartwood in a standing tree.

Augment: Accelerate natural processes through the removal of decayed material and heartwood to produce a secure cavity. Augmentation works may include enlarging entrance and cavity dimensions or modifying nest entrance to protect from rainwater run-off.

Restore: Reinstate old degraded cavities through the re-establishment of nest chamber floor and covering of large cracks to secure cavity walls.

Nest-box: Construction of a nest-box made from a single salvaged Callitris log by excavation of heart wood and carving an entrance to mimic a natural cavity for nesting. Mounting, in a tree, a nest-box in a position considered suitable to Major Mitchell's Cockatoo.

Initiate: Removing a branch or creating a scar to expose heartwood, to initiate/accelerate natural cavity formation.

This last action is intended to encourage natural processes to initiate cavity formation. It is undertaken by branch removal or scar creation that so as to expose the heartwood. Freshly exposed heartwood is very pale compared to the grey of the outer bark layer. This contrast forms a strong visual stimulus that attracts large cockatoo species such as Galahs and MMC to start excavating an entrance and cavity. This technique may be considered for live mature trees approaching a size of 30 cm diameter at breast height (DBH).

Tree selection

The site selection of candidate trees for SNC works is to target trees of ≥ 50 cm (DBH) and a trunk height of ≥ 8 m (Hurley, 2006a). Consideration need also be given to the proximity of candidate trees and any existing cavity-bearing trees. The average distance between active MMC nests was found to be 400 m (n = 63) and the minimum recorded distance was 50 m (Hurley unpublished data 2001). Where possible, candidate trees should be selected from areas where nest trees had previously been known to occur in order to offer a new cavity within the breeding territory. Also preference is to be given to sites assessed to have low human visitation rates. If suitable candidate trees in such areas cannot be found, GPS coordinates are to be collected for trees that could potentially support a nest-box.

SNC technique selection

Each SNC technique is most appropriate at certain stages of tree development. Cavity initiation is the first technique to be applied to early mature trees prior to having formed any cavities naturally. SNC excavation can begin for mid-mature trees and augmentation is a method for accelerating the formation of a trunk already in the early stages of cavity formation. Restoration is most required for collapsed cavities in large old trees. The following timeline may assist in guiding which technique to use (Figure 2).

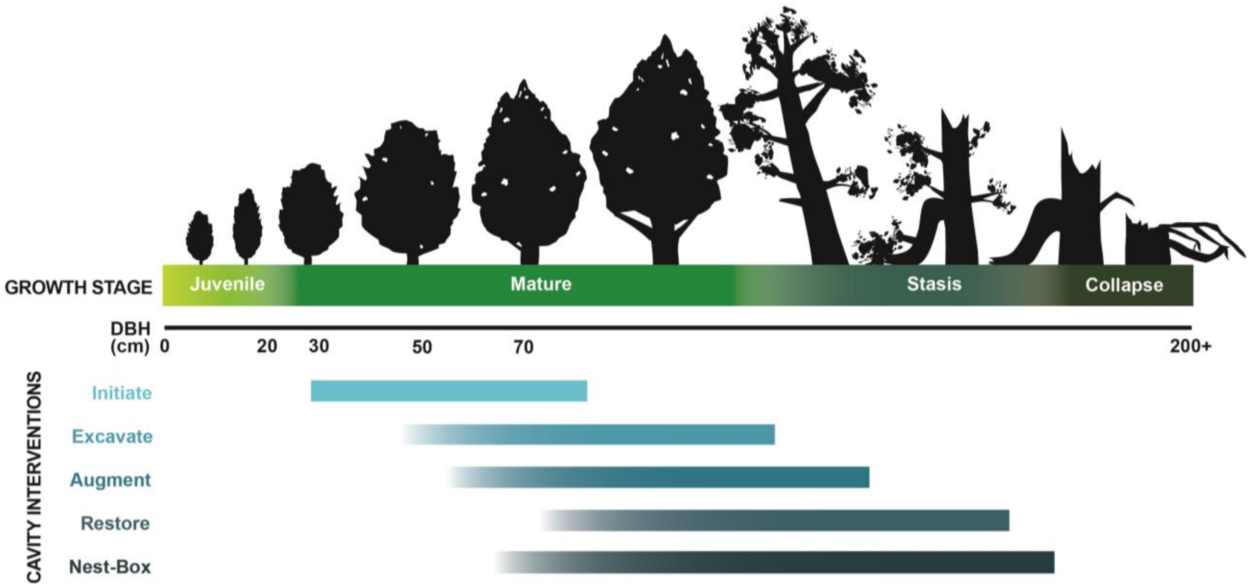


Figure 2. Time line of tree growth and appropriate growth stages for SNC intervention. Letters represent SNC techniques in the temporal sequence of tree development and loss. I = Initiate, E = Excavation, A = Augmentation and R = Restoration.

Criteria were developed for selecting the most appropriate SNC technique. A logical consequence of this process was the development of a decision matrix to provide clarity in SNC technique selection (Figure 3). SNC techniques may be applied to either live or dead standing *Callitris* as the status (live or dead) of the *Callitris* appears not to deter MMC breeding. For example, in 2006, 46% of *Callitris* used by MMC for nesting were dead and by the spring of 2010 this proportion had grown to 86% dead at Pine Plains (Hurley, 2011).

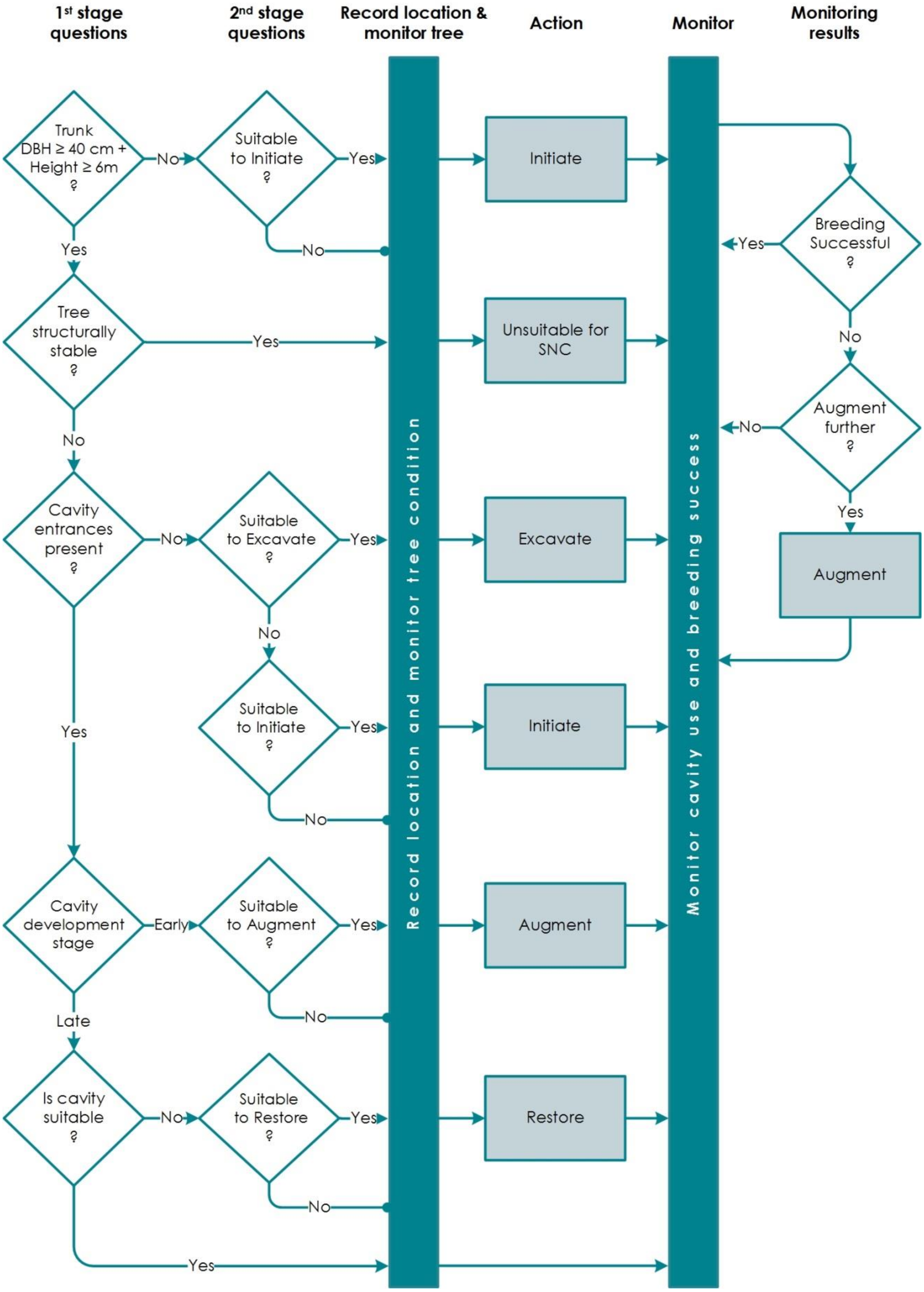


Figure 3. Decision matrix for the selection of the appropriate technique in simulated cavity formation in Slender Callitris Pine (*Callitris gracilis murrayensis*). Diamonds are decision points and light teal boxes are actions. The dark decision strips represent recording and monitoring activities.

Structural Stability

The structural stability of potential trees is first assessed by external visual examination of the buttress, trunk and canopy (Mattheck & Breloer, 1997; and Lonsdale, 1999). Cavities weaken trunks and the risk of tree collapse increases when the residual wall thickness (t) is less than ⅓ of the radius (R) of the trunk (Mattheck & Breloer, 1997). The longevity of trees in which SNC have been created is an important consideration in the SNC technique selection. The applicability of the t/R ratio has been contested and following the recommendations of Bond (2006) it was considered acceptable to reduce the residual walls of dead trees during SNC construction to less than ⅓ but not less than ¼ of the trunk radius when undertaken in conjunction with pruning for weight reduction of dead canopy branches. We also recommend retaining ¾ of the trunk circumference where the face plate is removed. SNC are to be installed in trees that pose minimal risk to surveyors working in accordance with best practice guidelines (Forbes-Laird, 2008; and DSE, 2011; and SWA, 2011).

Timber from *Callitris*, can resist degradation by termites and decay for between 15 to 25 years and as such is valued for its durability as a construction and fence post material (FWPRDC, 2004; and Boland *et al.*, 2006). SNC installed in standing dead *Callitris* of mature size (DBH ≥ 50 cm DBH) that have been stabilised through crown pruning can be expected to remain standing for > 15 years in absence of fire or extreme winds. In living trees, SNC can be expected to last the life-span of *Callitris*, which can be 130 years or more after cavity formation (Gibson *et al.*, 2008).

Cavity dimensions

The dimensions and shape of the cavities to be created are shown in Figure 4. These comprise an entrance of 13 cm wide (A) and ~22 cm tall (B) in the side of a trunk. The bottom lip of the entrance should be 60 cm (C) above the nest chamber floor, which should in turn be ~19 cm (D) x 19 cm (E) in diameter (Figure 4). The actual dimensions to be applied to each SNC are summarised in Table 1.

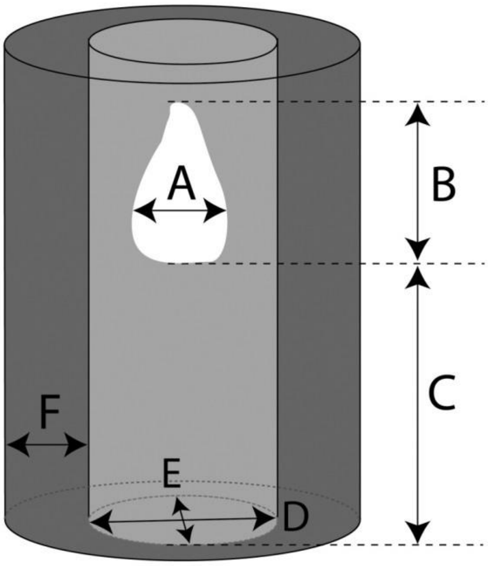


Figure 4. Measurements of naturally occurring Major Mitchell's Cockatoo nest cavities in Callitris tree trunks (*n* = 55) (figure adapted from Hurley (2006a)). A = horizontal entrance diameter or width, B = vertical entrance diameter, C = cavity depth to nest chamber floor, D = maximum diameter of nest chamber floor, E = minimum diameter of nest chamber floor and F = nest chamber wall thickness.

All measurements can be taken using a metal tape measure except tree diameter and wall thickness. Tree DBH was measured at 1.4 m above ground level using a diameter tape measure. Wall thickness was calculated by measuring the diameter of the trunk using a diameter tape at the level of the nest chamber floor, then subtracting from this the average of the two internal diameters of the nest chamber floor. This figure was then halved to give the average thickness of the nest chamber wall. To assist in selecting the appropriate measurements for SNC creation, data from 55 natural cavities are provided in Table 1.

Table 1. Dimensions of naturally occurring *Callitris* cavities used by Major Mitchell's Cockatoo breeding in Pine Plains (n = 55). The 'Key' values relate to the labels in Figure 4. Listed are the median, mean and the standard deviation (SD) of the mean. All measurements are in cm. Raw data obtained from Hurley (2006).

Cavity dimensions	Key	Range	Median	Mean	SD
Tree DBH	N/A*	34-149	69.5	72.5	± 24.5
Entrance – Horizontal diameter	A	8-30	13	13.3	± 4.1
Entrance – Vertical diameter	B	9-80	22	27.6	± 13.7
Depth to nest chamber floor	C	19-180	51	53.9	± 25.8
Nest chamber floor diameter	D & E	9-34	19	18.0	± 4.1
Nest chamber wall thickness	F	6-20	9	10.1	± 4.0

**Tree DBH not illustrated in Figure 5. #Calculation for nest chamber floor area describe in text above.*

Equipment

The installation of SNC requires the use of high performance power-tools in unconventional positions and challenging environmental conditions. To undertake this work safely the following guidance is provided.

Qualifications and Experience

Operators must have demonstrated competency in the skills that they require to undertake SNC construction in a safe manner. The following units of the *Certificate III in Arboriculture* (AHC30810) provide a framework for assessment of these competencies:

- *Remove trees in confined spaces* (AHCARB305A)
- *Undertake complex tree climbing* (AHCARB307A)
- *Perform aerial rigging* (AHCARB310A)
- *Undertake aerial rescue* (AHCARB306A)

Tools

Building on the methods of Carey and Gill (1983) and Kenyon and Kenyon (2010), a combination of chainsaws and two angle grinders equipped with two different sized timber carving blades (Arbortech©) were used in the creation of all SNC, including nest-boxes.

The use of the *Stihl 020t* top handled chainsaw is recommended. Compared to rear-handled chainsaws, it provides the operator with greater flexibility and more nuanced movements when excavating cavities. A robust angle grinder is essential for efficient cavity excavation and carving of walls and cavity entrances. The *AEG 2200W 9"* angle grinder has sufficient power and it includes an automatic safety cut-off switch and movable cutting guard. Angle grinders are to be fitted with *Arbortech* 6" disks with replaceable tungsten carbide teeth. A smaller *Arbortech 710W Mini Grinder* was also used for finer work such as carving cavity entrances and initiating excavation in augmented SNC (Figure 5 & Figure 6). In the field, these need to be powered by a diesel generator of 4Kv or greater capacity.

To limit saw dust clogging the air vents clamp a flexible plastic tube ~ 45 cm long over the handle of each angle grinder to act as a dust guard (Figure 6 and Figure 7). Without this dust guard, the whole motor and electrical system would become clogged with fine wood dust and chips within minutes, which would lead to the motor overheating. The tubing allows the working grinder to draw in clean, relatively dust-free air from outside of the dust-filled tree cavity work area. As an added precaution, remove this dust guard, dismantle and clean out the angle grinder after every hour of use (Figure 7). To reduce "down-time" a second grinder can be used as a back-up to allow one to be cleaned while the other remains in use. A vacuum cleaner with a nozzle directed inside the cavity work area further decreased sawdust accumulation and the amount of dust that can impact on the grinder motor. The vacuum is also useful in cleaning out the grinder motors. For these tasks use the industrial Festool Cleantec© FT17E.

Figure 5. Large Arbortech© blade attached to AEG Angle grinder used to sculpt internal surfaces of nest-box. Note gray dust cover extending beyond the work area to protect the angle-grinder motor.

Figure 6. Arbortech© mini grinder with improvised dust cover (light grey) fitted to cover the handle and air intake. The dust cover is 45 cm long and held in place with a large hose clip.

Figure 7. Arbortech© mini grinder with improvised dust cover (light grey) and handle removed. The red tape holds a rubber strip fitted to ensure an airtight fit.

Personal Protective Equipment (PPE)

SNC formation generates high volumes of particulate dust in close proximity to the operator so eye, ear and respiratory protection are essential. To avoid eye damage full wrap-around goggles in accordance with *AS/NZS 1337.6:2012* personal eye protection must be worn when using power-tools. Dust-masks designed for airborne particulates in accordance with *AS/NZS 1716:2003* respiratory protective devices must be worn to avoid inhalation of dust and chainsaw exhaust. The use of hearing protection in accordance with *AS/NZS 1270:2002* acoustics - hearing protectors is essential when using power-tools.

PPE for safe work at height in trees must be in accordance with the access method used, for example climbing or elevated work platform (EWP), and be in compliance with the *Safe Access In Tree Trimming And Arboriculture Draft Code of Practice* (SWA, 2011) and the *Draft Climbing Guidelines* (VTIO, 2010).

Installation techniques

The base of all SNC were lined with a 5-10 cm thick layer of fine *Callitris* woodchips (Figure 8A) replicating that found in active MMC nests (Figure 8B) (Rowley & Chapman, 1991; and Hurley, 2006b). These *Callitris* woodchips were cut from solid clean heartwood devoid of rot, termite damage or other disease. To mimic materials created by MMC to line their nests, a hand mattock was used to chop woodchips from the solid timber to dimensions of ~3 cm x 0.5 cm. The cuts used to remove canopy branches or stems were made to simulate natural fractures (coronet cuts), which are thought to facilitate colonisation by invertebrates and fungi (Curtis *et al.*, 2000; and Fay, 2002) (Figure 9). These coronet cuts also provide a more natural “splintered” profile to the cut edge and thus attracting less unwanted human attention.

Figure 8. Fresh Callitris woodchips, cut with an axe (A). Callitris woodchips, cut by Major Mitchell Cockatoo, lining nest cavity (B).

Cavity creation techniques

As the decision matrix illustrates there are several techniques available depending upon the size of the tree and the state of any cavities in the tree. Each of the four techniques for creating a cavity ready to use by MMC are described in full detail with images to illustrate each of the key steps in sequence.

Excavate

Excavation involves the creation of an entirely new cavity. This technique is generally only suited to dead wood as it involves removal of a faceplate which would cause extensive damage to sapwood if undertaken on a living tree. Also in some dead trees it may be necessary to remove some of the canopy to reduce wind drag in order to increase the longevity of the remaining trunk and cavity (Figure 9). In some cases a natural scar may already exist following the loss of a branch exposing the heartwood. The resulting scar may be used as an entry point to excavate a new cavity.

The first step is to use a chainsaw to cut out a faceplate. This is best done by first cutting two cross cuts ~70 cm apart and not more than ¼ the diameter of the tree at the height of the cuts. Then make two longitudinal cuts with the chainsaw bar held at a 90^0 angle for each on either side of the face plate starting one at a time from just below one end of the top cut and continuing down to the lower cut. Repeat this on the other side. The angling and depth of the longitudinal cuts should allow the cuts to meet in the middle of the trunk all the way along the cuts (Figure 10). The faceplate should naturally fall loose once the final cut is complete. The faceplate should be set aside for further work later.

Once the faceplate is removed, use a chainsaw to make a series of long, deep vertical, parallel cuts into the exposed heartwood (Figure 11). The cavity walls being created should be ≥10 cm thick. Furthermore, check the required blade depth to ensure that no holes are made through to the other side of the tree trunk. This is critical as large parrots, such as Galahs, will chew-out and enlarge even the smallest of holes until they have created a further entrance-sized opening (Hurley, 2009). Following the chainsaw cuts the resulting slabs can either be prised-out with a pinch bar or horizontal cross cuts can be made to further speed up the removal of the bulk of the trunk's heartwood (Figure 12). Then use the Arbortech© to clean out the trunk cavity and form contours to the desired dimensions. It is important to leave some rough surfaces or small grooves in the walls of the cavity to provide climbing holds for birds to easily enter and exit the cavity.

If the height of the hole left by the faceplate does not match the desired cavity depth it is relatively straightforward to use the Arbortech© to deepen the cavity in the tree trunk. The measurements provided for this dimension should be regarded as a minimum as cavities up to 1.8 m deep have been used successfully by MMC at Pine Plains (Hurley, 2006a). It is critical that the proposed nest chamber floor is relatively flat with minimum diameters of 18 cm x 19 cm. In addition to cavity depth, this is the single most important aspect of the SNC construction (Korpimäki & Higgins, 1985). Smaller nest chambers will either deter MMC from nesting in them or limit the clutch size laid. A nest chamber with a larger diameter may be used by MMC and may be excavated if the trunk diameter is of sufficient size to accommodate it.

Now, the inside face of the faceplate must be carved-out so it has internal concave contours to match the curvature of the cavity being carved from the inside of the tree trunk. The cavity entrance can also be carved from the faceplate (Figure 13-14). These carving tasks are best done with an Arbortech© blade attached to an angle grinder. Refitting the faceplate is a critical stage for long-term viability of SNCs. Gaps and/or air flow between the remaining trunk cavity walls and the faceplate must be eliminated. The kerf width from the chainsaw creates a 1 cm gap between the faceplate and cavity walls and requires in-filling. Use plywood strips cut to suit or *Callitris* lengths custom made to fit each joining surface of the faceplate. Regardless of which timber is used, these infill or caulking strips should be glued and tacked to the joint edges of the trunk and then trimmed with the Arbortech© so that they sit flush with both the external and internal contours of the trunk and cavity. The contouring of theses strips will help to camouflage them from the prying beaks of Galahs and other cockatoos. A standard builder's glue can be used to bulk up any minor cracks between the jointed surfaces. Tech screws may also be used to strengthen the join between faceplate and tree. Remember to use a standard angle grinder blade to grind off or disfigure the tech screw heads, then paint them matt black and grey. This last action is recommended so as to not to attract undue attention from people or predators. The external surfaces of the caulking strips must also be painted a mottled matt dark-grey and black to protect from the weather. Alternatively thick strips of bark may be attached using silicone glue to cover the caulking strips. Once the face plate has been reattached fine Callitris woodchips must be placed in the base of the new cavity. One or two handfuls is enough (Figure 15). Following this the face plate should be camouflaged with bark from the same tree the work is being done. Entrances should look as natural as possible (Figure 16 and Figure 17).

Initially allow a half to one full day (4-8 hours) for the excavation of new cavities. With experience a team of two chainsaw operators will be able to an average excavate two cavities per day.

Excavate

Figure 9. The top section of this dead tree has been removed to reduce wind drag and provide stability in order to prolong the standing 'life' of the tree.

Figure 10. Removal of the face plate reveals that the heartwood has not begun to rot. Allow four hours to complete the excavation of this cavity.

Figure 11. The early stages of heartwood removal to create a cavity..

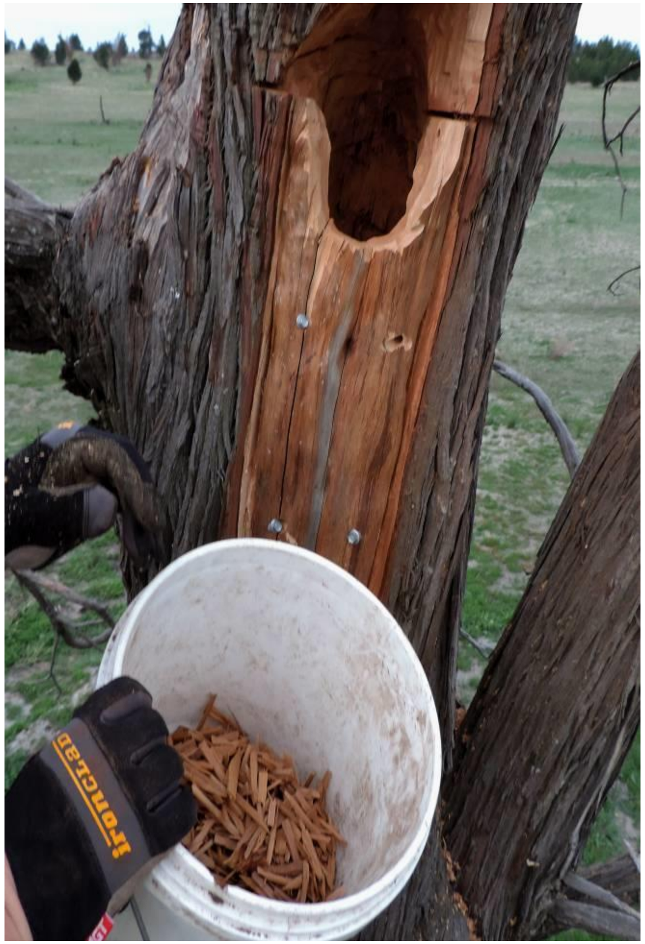
Excavate

Figure 12. The narrower the face plate the stronger the cavity section of the tree trunk. The face plate should not be wider then 25% of the trunk circumference.

Figure 13. Replacement of the face plate should include some sealing of gaps between the trunk and the face plate. Long tech screws should be used to secure the face plate.

Figure 14. The cavity entrance can be excavated from both the face plate and the trunk section above the face plate to form a natural looking entrance..

Excavate



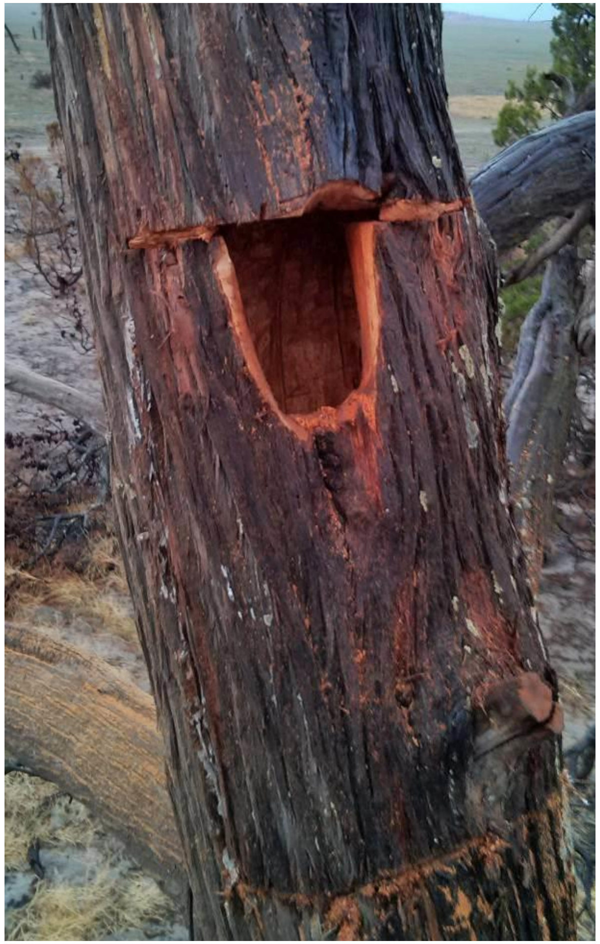


Figure 15. Once the face plate has been secured and the entrance has been fashioned fine Callitris chips must be placed into the cavity to form a layer not more than 10 cm thick.

Figure 16. After replacing the face plate, the bark layer is glued and screwed back in place to cover the tech screws.

Figure 17. Cavity entrances are typically carved out of the face plate.

Augment

Cavity formation is normally associated with older mature or senescent trees (Gibbons & Lindenmayer, 2002). It is estimated that Slender Cypress Pine do not reach a sufficient size to support a cavity suitable for MMC (i.e. 50cm DBH) until trees are >80 years of age (Gibson *et al.*, 2008). A variety of methods involving the exposure of heartwood and manipulation of tree health have been proposed to accelerate cavity development (Gibbons & Lindenmayer, 2002). The exposure of heartwood provides an entrance for fungi, bacteria and saprophytic insects which cause decay and, in conjunction with the trees adaptive growth response, leads to cavity formation (Mattheck & Breloer, 1997; and Lonsdale, 1999; and Taylor *et al.*, 2002). The rate at which wounding techniques are able to accelerate the processes of natural cavity formation is on a temporal scale unsuited to the rapid provision of cavities for threatened species recovery (i.e. formation will take place over decades). Cavity augmentation involves accelerating the formation of a cavity or improving the function of an existing cavity. Accelerating cavity formation for this purpose is based on many of the techniques required to excavate a cavity in a tree without an existing cavity.

In addition to accelerating cavity formation, cavity augmentation also involves making improvements to an existing cavity. This may be as simple as enlarging the entrance to an existing cavity or may involve more extensive works to enlarge the internal dimensions of a small cavity. Furthermore, augmentation often is in the form of inserting carved timber sections to deflect rainwater from flowing into a cavity or repairing cracks in cavity walls.

The primary augmentation process involves mechanically removing the decay and heartwood associated with wounds caused by natural processes. A pre-existing scar, revealing advanced rotting of the heartwood is slightly enlarged to allow use of Arbortech blades to excavate the rotten timber (Figure 18A & B). Once the rot has been removed to sufficient dimensions for an SNC a faceplate is carved from a single piece of timber and glued and screwed in place (Figure 18C).

Augmentation can also include modifications to an existing cavity to improve cavity function. These may be in the form of simply enlarging the entrance or other features of a cavity to suitable dimensions (Figure 19). In some cases augmentation may involve strategically placing a plug of timber to block water from flooding into a cavity (Figure 20 and Figure 21).

Augment

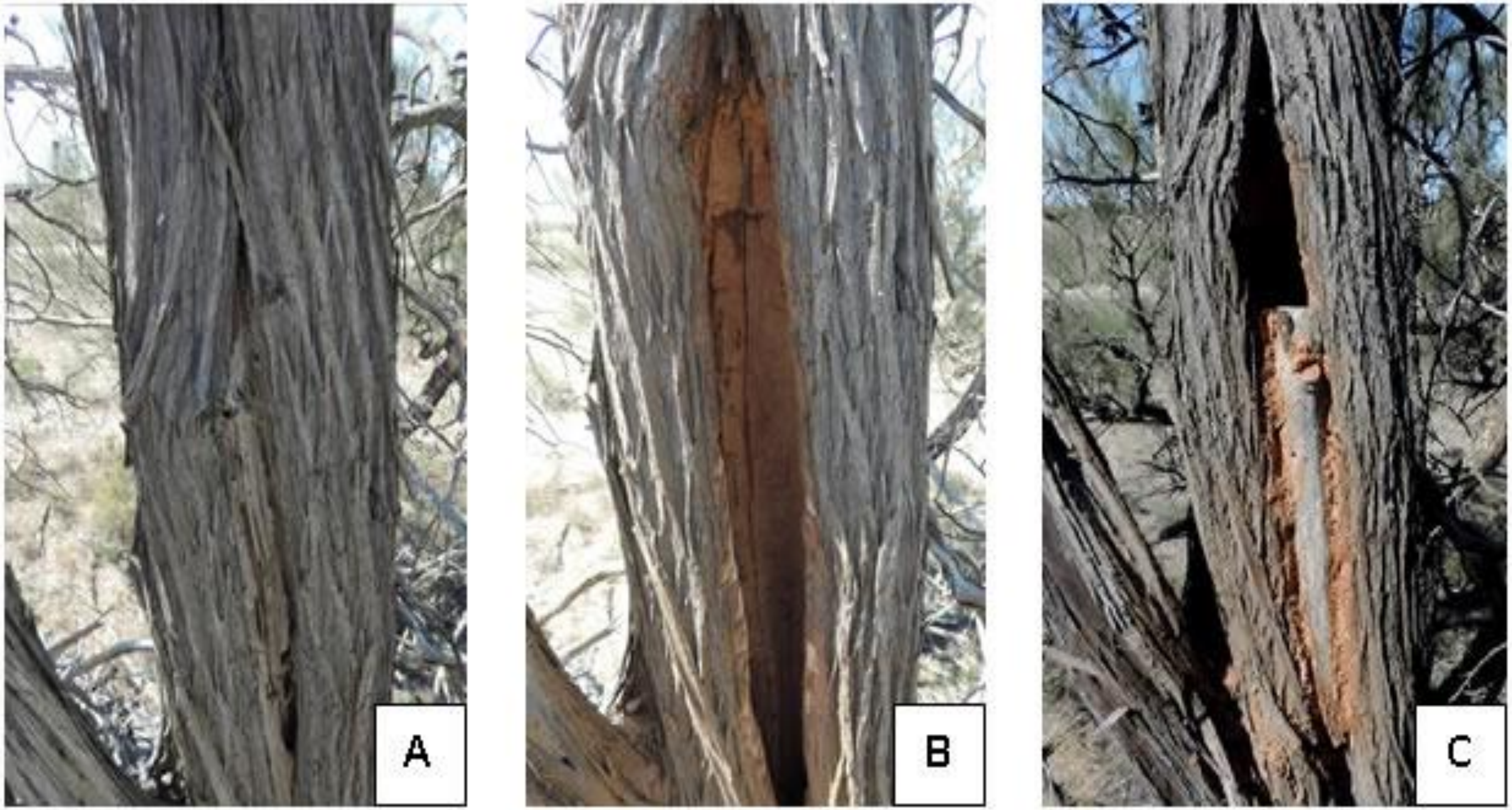


Figure 18. Three stages of tree augmentation to create a simulated natural cavity in a live Callitris. A = A narrow slit in the bark layer revealing extensive rot through the cambium layer to the heartwood. B = Rotten wood has been removed to establish a suitable cavity for use by Major Mitchell's Cockatoo but the entrance opening is too large, exposing the centre of the cavity. C = A piece of Callitris has been carved and used as infill for the cavity wall.

Augment

Figure 19. Enlargement of cavity entrance and internal cavity dimensions to make an existing cavity suitable for nesting by MMC.

Figure 20. Callitris branch carved to form a perch above a cavity entrance and to deflect rain from pouring into the cavity.

Figure 21. A cut section of branch wedged in place to limit water run-off from pouring into an existing cavity.

Restore

The deterioration of cavities can reduce their quality to a point where they are no longer suitable for nesting by cockatoos long before they are lost to tree fall or fire (Hurley, 2009; and Saunders *et al.*, 2014). Collapse of the nest chamber roof and walls due to decay and weathering exposes the nest chamber to rain, reducing the insulating quality of the cavity and exposing eggs and nestlings to the risk of drowning from flooding (Hurley, 2006a). The accumulation of wood debris and decayed material can result in cavities becoming too shallow to provide suitable shelter or protection from predators (Saunders *et al.*, 2014).

We used a method similar to that of Saunders *et al.* (2014) and Hurley (2009) to restore collapsed cavity floors by placing rounds of timber into the cavity, followed by a layer of coarse chip and finally a layer of fine clean *Callitris* woodchips of a texture mimicking that produced by the MMC. Missing cavity roofs or walls were replaced using a *Callitris* section carved to fit the cavity spout and sealed into place with wedges of timber and silicone sealant and tech screwed. Another strategy is to replace a collapsed cavity floor by screwing in place a sub floor of wire mesh. On top of this build up a stable cavity floor of Callitris chips to the desired depth (Figure 22). Cracks in the nest chamber wall were also filled with wooden wedges and silicone sealant; or for larger sections, replaced by affixing sections of timber carved to provide a firm fit (Figure 25 and Figure 26). It is imperative that these sections are well fitted to prevent gaps and are glued and secured in place with long wood screws or coach bolts where necessary.

The collapse of nest chamber floors caused by the progression of heartwood decay can also result in nest chambers becoming too small or exposing jagged wooden spikes of un-decayed wood (Figure 27 and Figure 28), both of which have been found to prohibit nesting of large cockatoo species. Saunders *et al.* (2014) did report successful breeding by Carnaby's Black-Cockatoo, in WA, after restoring cavities by in-filling collapsed nest chamber floors. We further developed this technique for application in *Callitris* in Pine Plains (Figure 29 and Figure 31).

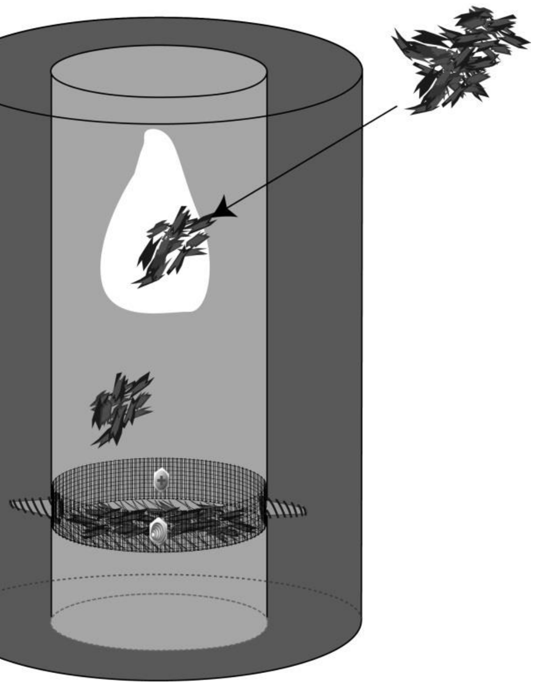


Figure 22. An old natural cavity where the floor has collapsed. A wire mesh false floor has been tech-screwed in place and fresh Callitris wood chips are being added.

Restore

Figure 23. An old natural cavity where a full length section of the cavity wall Has fallen away.

Figure 24. The cavity is cleaned out to expose fresh heartwood to release natural oils.

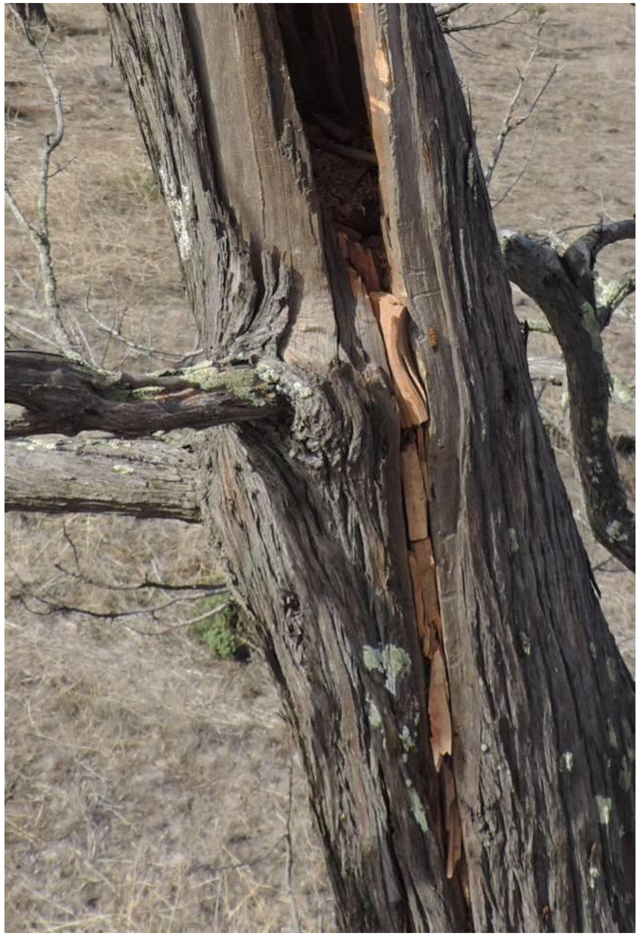


Figure 25. Wedging large Callitris chips into cracks to secure base of cavity.

Restore

Figure 26. Face plate installed to replace lost cavity wall.

Figure 27. Old cavity, following dry rot collapsing nest chamber floor. Note the high density branch anchors remain preventing access to the lowered floor level.

Figure 28. Internal cavity collapse does not always reveal branch anchors and cavity floors can collapse all the way to the base of the tree. Also at least three other side entrances need to be filled in.

Restore

Figure 29. Blocks (or coarse chips) of Callitris can be placed inside the cavity to fill it to the desired level of the proposed cavity floor. These are best supported by a sub-floor of wire mesh tech screwed into place.

Figure 30. Once packed down the coarse layer is covered with a finer layer of Callitris chips.

Figure 31. A restored cavity with Major Mitchell's Cockatoo feathers on a layer of fine Callitris chips lining the chamber floor of October 2014.

Nest-box

The creation of and installation of nest-boxes is a last resort action for the conservation of cavity dependent fauna. It is an admission that all other conservation and management actions have failed. Installing nest-boxes creates a requirement for ongoing maintenance and active management of these structures. In conservation reserves where wildfires have removed large numbers of cavity bearing trees it may be necessary to replace some with nest boxes.

Nest-boxes were made from salvaged windfall *Callitris* logs. For a safe work environment, a tension tie-down strap was used to secure the log in position when using power tools on each log. A biscuit was sliced from the top and base of each log using a chainsaw to provide a clean surface (Figure 32). Immediately after each cut was made the newly exposed end grain was painted with a log sealer to prevent the ends of the log from splitting (Figure 33). For this we used Mobil Log Seal©. Without an end-grain sealant, once cut, the timber tended to split very quickly (Figure 34). A second thick coating of log seal should be applied. As a further precaution strapping is placed around the top and bottom of each log to further reduce splitting (Figure 35).

Once the ends of the log have been secured the main cuts in the log can be made to create and remove the face plate (Figure 36 and Figure 37). This is best done by first cutting two cross cuts ~ 70 cm apart and not more than 1/4 the circumference of the tree at the height of the cuts. Then make two longitudinal cuts with the chainsaw bar held at a 45^0 angle for each on either side of the tree starting one at a time from just below one end of the top cut and continuing down to the lower cut (Figure 36). Repeat this on the other side. The angling and depth of the longitudinal cuts should allow the cuts to meet in the middle of the trunk at a right angle all the way along the cuts. The faceplate should naturally fall lose once the final cut is complete (Figure 37).

The wedged shape provides a more robust structure to the nest-box by leaving more of the nest-box intact as a single piece (Figure 38). Put the face plate to one side while working on the nest-box proper. To efficiently clear the large amount of material required to form the nest cavity, use a chainsaw to create longitudinal cuts along the internal length of the log (Figure 39). This creates internal slabs that can be further split with a pinch bar and lifted out (Figure 40).

The main cavity, can be worked with two Arbortech blades on separate angle grinders. Once the internal slabs have been removed to create a cavity use the Arbortech© to sculpt the interior walls and floor and deepen the cavity if necessary (Figure 41 to 42).

The inside face of the faceplate must be carved so it has internal concave contours to match the curvature and wall thickness of the cavity being carved from the inside of the tree trunk (Figure 44 and Figure 45). The cavity entrance can also be carved from the faceplate (Figure 46) or may be carved out of the nest-box on the opposite side to the face-plate (Figure 47 to Figure 49). These carving tasks are best done with an Arbortech© blade attached to an angle grinder.

Once the interior of the nest-box is nearing completion, the entrance can be made in the log on the side opposite to the faceplate (Figure 47 and Figure 49). It is recommended to carve the entrance to nest-boxes on the opposite side to the face-plate so the face-plate can be placed against a tree trunk and provide further protection from damage by large parrots (Figure 49) (Hurley, 2009)

Use the Arbortech© blade attached to an angle grinder to clean and smooth-off any rough edges to the cavity entrance from both within and outside the nest-box (Figure 50 and **Error! Reference source not found.**). Final adjustments can be made to the interior of the nest-box such as carving climbing holds for the birds and ensuring the caulking timbers cover all gaps between the walls and the faceplate. Ply wood fill in the gap created by the kerf width of the chainsaw blade (**Error! Reference source not found.**). It is recommended to use timber slats and then glue and screw the face-plate securely in place.

Nest-box

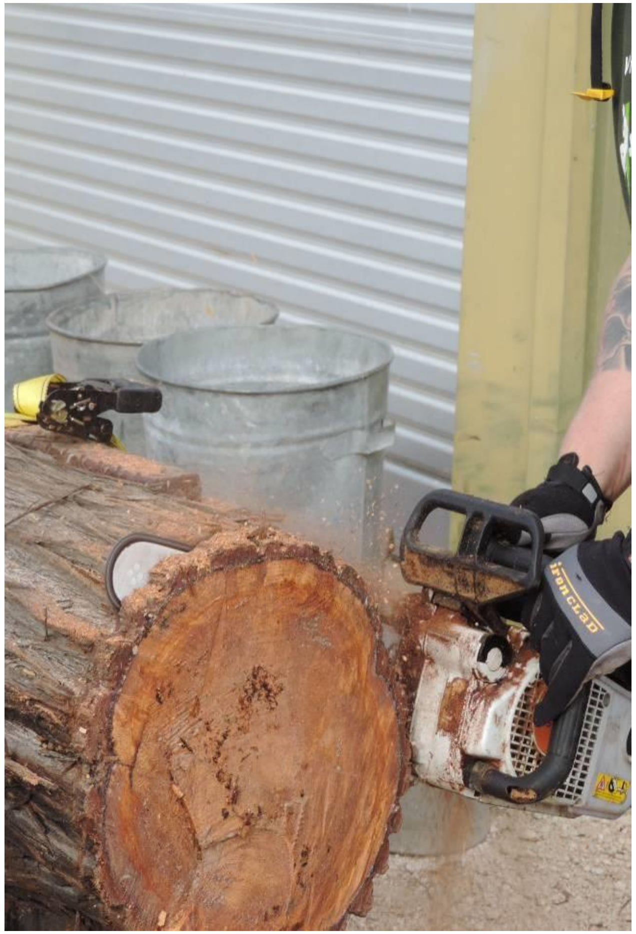


Figure 32. Cross-cut top and base of Callitris log for clean even surfaces.

Figure 33. Log sealer painted on end-grain immediately after cutting to reduce splitting of Callitris log.

Figure 34. Split end grain biscuit from Callitris log five minutes after cutting.

Nest-box

Figure 35. Strapping at end of *Callitris* log to further reduce splitting.

Figure 36. Longitudinal cuts angled at 45^0 to create a wedged section that will form the face plate.

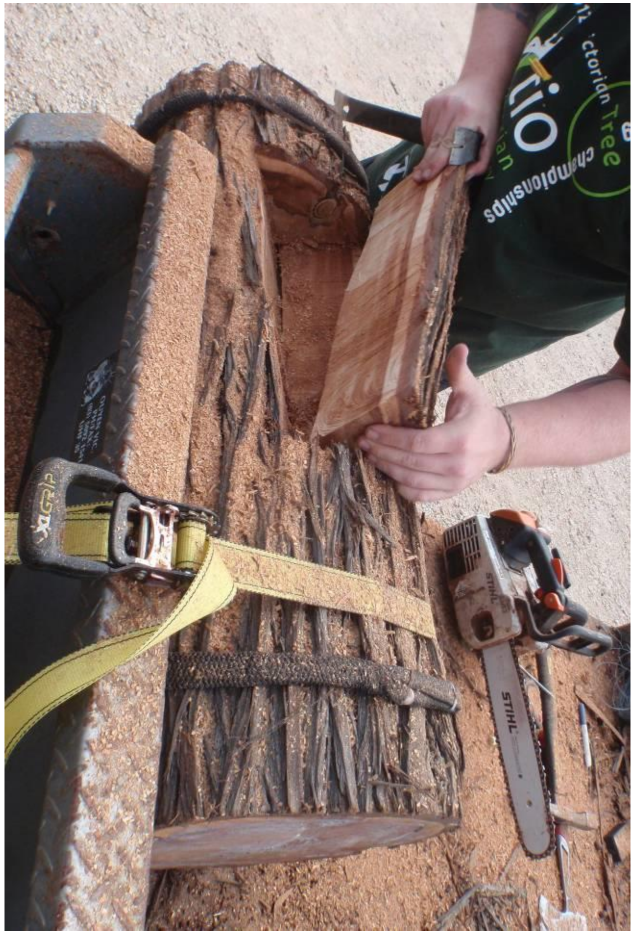
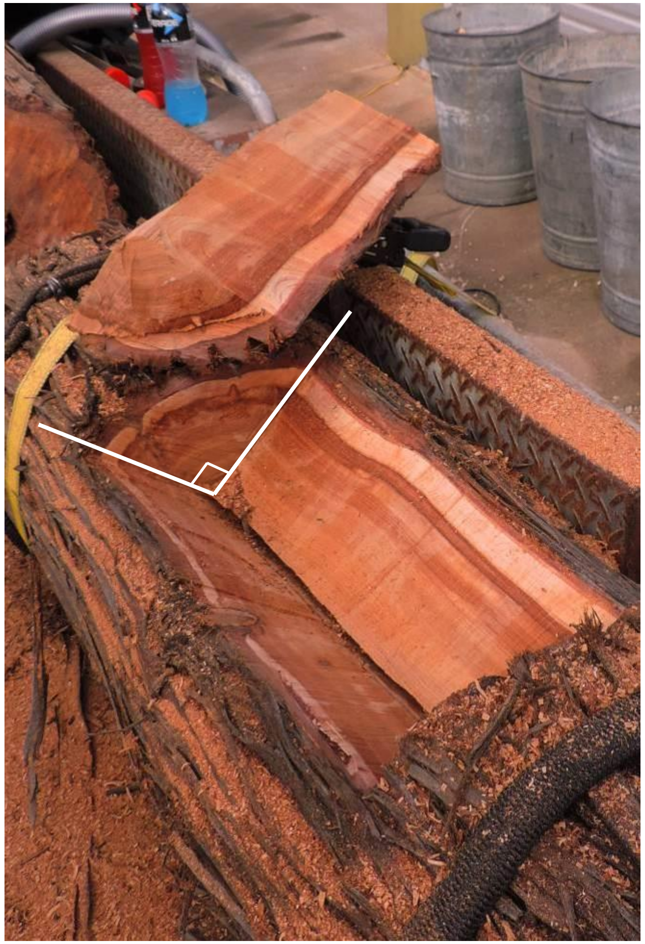


Figure 37. Removal of wedged faceplate.

Nest-box



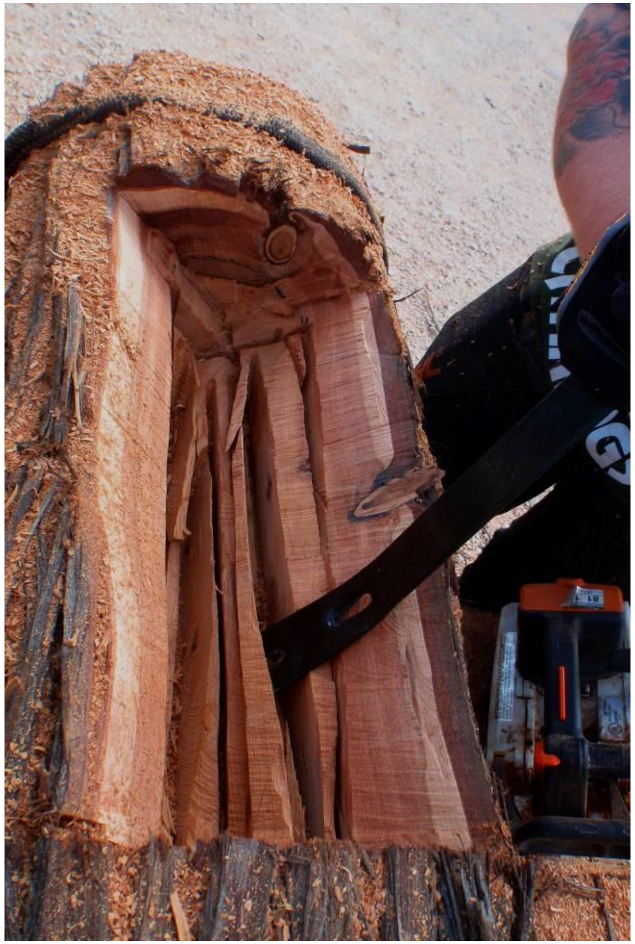


Figure 38. The wedge removed will later be carved to form a face-plate. Note the 90^{o} angle of the narrow section removed for the face plate.

Figure 39. To hollow-out the cavity, first make outer cuts to allow the cavity walls to be at least 10 cm thick. Then further slits can then be cut to the appropriate depth.

Figure 40. Removing internal slabs by splintering with pinch bar.

Nest-box

Figure 41. The large Arbortech blade being used to carve the inside of the cavity being worked. Note the red tip of a vacuum cleaner above the work area.

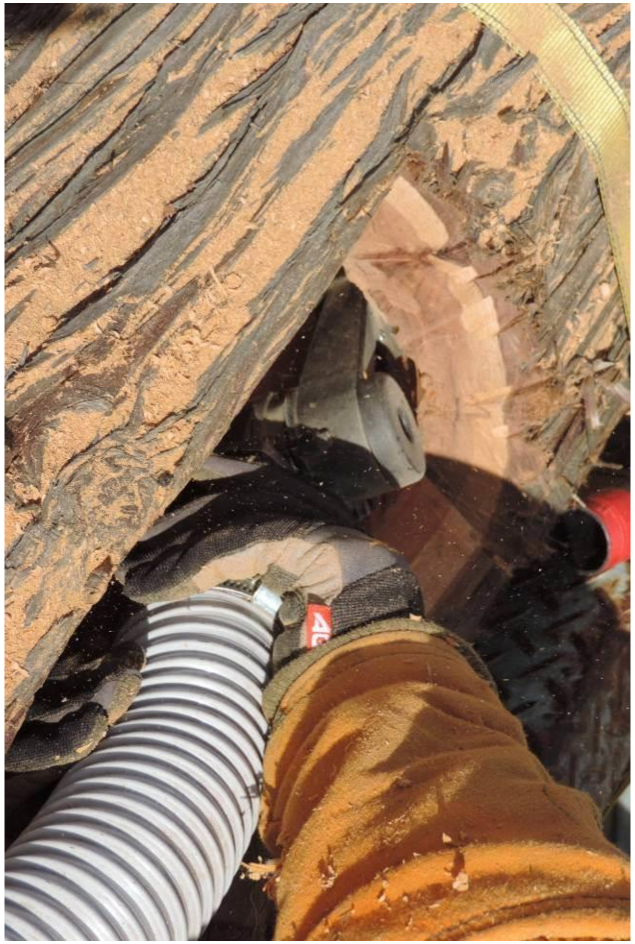


Figure 42. The confines of the work space demand that the dust guard is fitted to the angle grinder to prevent the motor over heating.

Figure 43. Once the cavity has been sufficiently enlarged the smaller Arbortech wheel can be used to smooth any rough edges and for finer scale carving and contouring.

Nest-box

Figure 44. The large Arbortech blade is to be used to carve the inside of the face-plate so it’s internal contours match those of the cavity being worked.

Figure 45. Where possible the face-plate is to be secured in a vice for ease of access and safety.

Figure 46. An entrance may be carved into the face plate.

Nest-box

Figure 47. Initial cut into back of nest-box to form entrance.

Figure 48. Marks on inside of nest-box indicating dimension of entrance.

Figure 49. Cavity entrance opened and ready for finishing off rough edges.

Nest-box

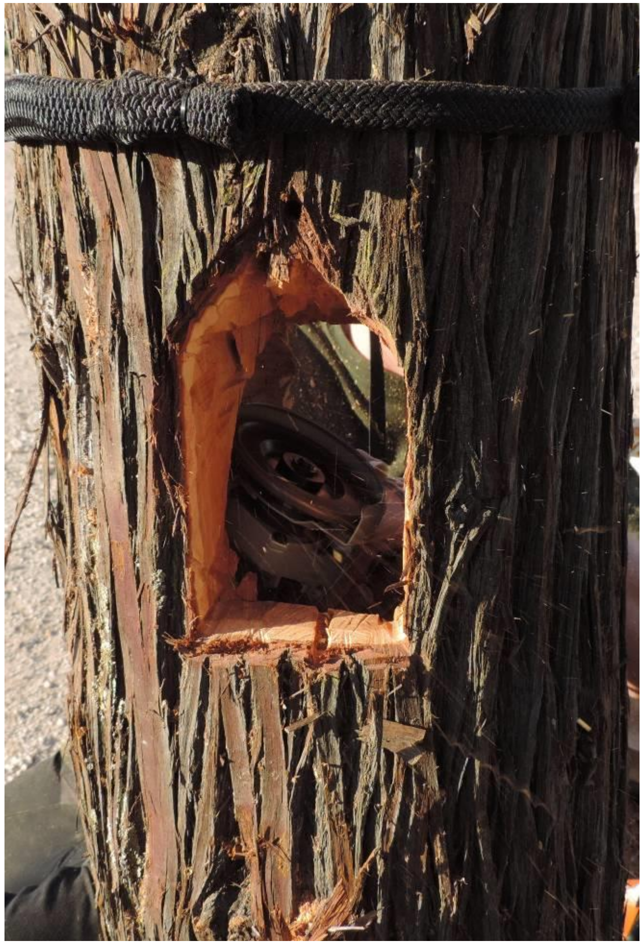


Figure 50. Arbortech being used to hollow out and form the cavity entrance.

Figure 51. Arbotech being used to smooth-off and from external entrance features.

Figure 52. Plywood caulking planks tacked and glued into place. Wood glue placed on interior gluing surface ready for attachment of face plate.

Nest-box

Figure 53. Face plate has been screwed into place and silicon glue is being used to further seal any remaining gaps.

Figure 54. This nest box has a metal plate, top and bottom to further protect timber from rotting and splitting. The nest box is resting on the stump of a cut branch.

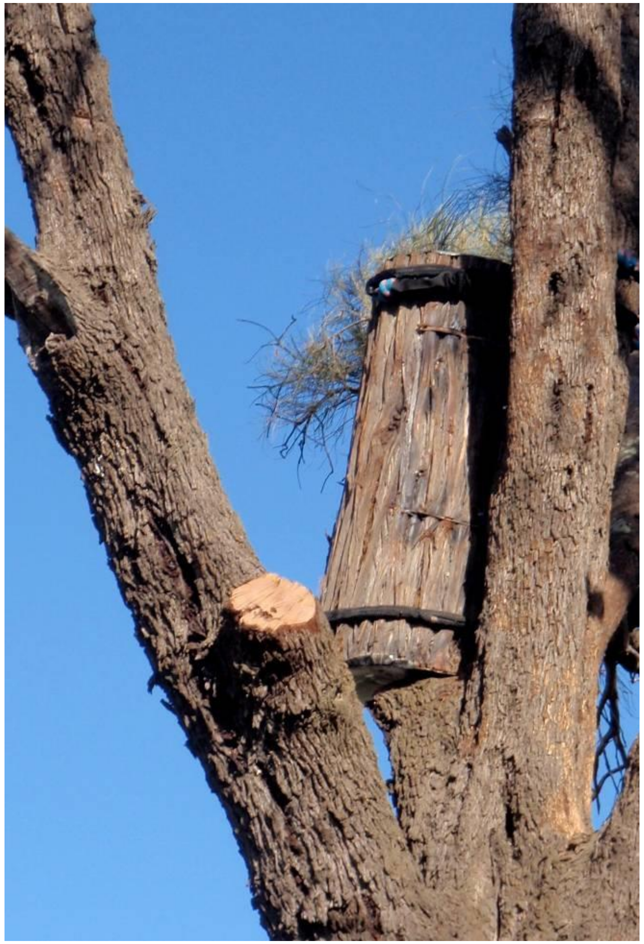


Figure 55. Note the face plate is facing into towards the tree trunk..

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