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Loss of habitat for a secondary cavity nesting bird after wildfire

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ABSTRACT

Tree cavity dependent animals are sensitive to changes in cavity availability in forests. Fire is important in the long-term dynamics of cavity creation and loss, but there are few data on how fire impacts nesting resource availability for animals. We assessed the survival of 189 trees and 191 cavities used for nesting by an endangered secondary cavity nesting bird, the swift parrot *Lathamus discolor*, over a decade. A subset of monitored trees were burned in an uncontrolled fire. At the site of that fire, we compared swift parrot habitat quality before and after burning. We also evaluated the risk of total tree collapse due to stem destabilisation from basal scarring by calculating the critical failure stress for all monitored trees. Modelled persistence of unburned swift parrot nest cavities was more than twice that of scorched cavities over ten years. Likewise, unburned nest trees were more likely to still be standing at the end of the ten years than scorched trees. Fire caused an acute local increase in cavity and tree collapse. At the site of the fire, 62.8% of scorched nest cavities were destroyed compared to only 9.1% over the unburned remainder of the study area. Likewise, 48.6% of scorched nest trees collapsed at the fire affected site, compared to only 3.8% of unburned trees elsewhere. Burning associated tree collapse led to a significant decrease in tree diameter at breast height and number of potential cavities at monitored plots. This destroyed most of the existing nest cavity resource for swift parrots at the local scale and cavity abundance is unlikely to be replenished quickly. Loss of nesting resources may outweigh longer-term benefits of fire as an agent of cavity creation if animals miss opportunities for reproduction in locations where habitat is diminished by cumulative stochastic events and anthropogenic changes.

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1. Introduction

Mature forests support unique habitat features like cavities in trees, which are a critically important resource for animals that use them for shelter and nesting (Newton, 1994). Tree cavities form either by animal excavation (eg. woodpeckers) or wood decay (via fungal or insect attack, weather damage and fire), but compared to the rapid creation of excavated cavities, decay-formed cavities form relatively slowly (Gibbons and Lindenmayer, 2002). Many animals that utilise cavities either cannot or infrequently excavate them, and instead rely on primary excavators and decay to provide cavities (Aitken and Martin, 2007). Nonetheless, these secondary cavity nesters are selective of cavity morphology, and sensitive to changes in availability of their preferred cavities (Aitken and Martin, 2008). Cavity abundance can be reduced by anthropogenic change (Gibbons et al., 2002), which often occurs in tandem with natural stochastic events like storms and fire (White et al., 2005; Clark et al., 2013). Cumulative disturbance events can cause the rate of cavity loss to exceed replacement, which is a serious threat for secondary cavity nesters (Lindenmayer et al., 2013).

Fire is particularly important in the creation and loss of tree cavities in forests. Fires create cavities by killing limbs or entire trees and allowing wood decay to proceed (Gibbons and Lindenmayer, 2002). Burned forests eventually experience a pulse of cavity formation after fire (Haslem et al., 2012), but given enough time and successive disturbance events, cavity bearing limbs and trees are prone to collapse because they are structurally compromised (Newton and Brockie, 1998; Gibbons et al., 2000). For instance, basal scarring due to repeated burning is common in old, cavity bearing trees (Whitford, 2002) and is an important cause of collapse in some landscapes (Gibbons et al., 2000). Cavity bearing trees are also disproportionately affected by anthropogenic change, so that in some landscapes their abundance is dramatically reduced (Lindenmayer et al., 2012). Older trees produce more cavities, and in disturbed landscapes cavity recruitment can be minimal (Manning et al., 2013). In these circumstances, the potential benefits of fire in creating cavities may be offset by the cost of fire as a driver of cavity loss, particularly if over-frequent fires kill trees

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before they grow old enough to produce cavities (Newton and Brockie, 1998).

Studies in areas where primary excavators occur have shown that although fire can destroy existing nest cavities, burned areas are attractive to excavators who quickly replenish cavity numbers (Wiebe, 2014; Nappi et al., 2015). But in areas where primary excavators are absent, data on the fate of cavities and the trees that support them are only available for some forest types and species (Lindenmayer and Wood, 2010; Saunders et al., 2014; Taylor et al., 2014). Secondary cavity nesters are threatened by cavity loss (Gibbons and Lindenmayer, 2002), so there is a need to better understand how stochastic events like fire impact their availability. We present data from a decade of monitoring cavities and trees used for nesting by an endangered secondary cavity nesting bird. Swift parrots *Lathamus discolor* are selective about the types of decay-formed tree cavities they use for nesting (Stojanovic et al., 2012; Webb et al., 2012) but suitable cavities are uncommon (Stojanovic et al., 2014a). Although swift parrots rarely nest in the same place in consecutive years (Stojanovic et al., 2015), old nest cavities can eventually be reused (Stojanovic et al., 2014b). The availability of suitable nesting sites for swift parrots across their breeding range is likely to influence their population viability (Heinsohn et al., 2015). Our objective was to: (1) estimate persistence of burned and unburned swift parrot nest trees and nest cavities over their entire breeding range over ten years, (2) compare forest characteristics before and after fire to evaluate the effect of burning on swift parrot habitat quality, and (3) estimate the likelihood of collapse of our sample of swift parrot nest trees using basal scarring as an indicator of previous fire damage. We discuss our results in the context of the management of tree cavities for populations of cavity dependent animals in landscapes already degraded by anthropogenic change.

2. Methods

2.1. Study site

Swift parrot nest trees and cavities were monitored at eight regions across their whole Tasmanian breeding range between 2005 and 2014 (Fig. 1). The study area supports a diverse range of *Eucalyptus* dominated forest types including woodlands, dry and wet forests. The study region has been extensively deforested (Hansen et al., 2013), and the impact of industrial logging on habitat availability for swift parrots has been highly controversial (Allchin et al., 2013). Regulation of these impacts is recognised as a management priority (Forest Practices Authority, 2010), but is complicated by the challenges posed by the life history strategy of swift parrots (Munks et al., 2004; Saunders and Tzaros, 2011; Webb et al., 2014; Heinsohn et al., 2015).

Region five (Fig. 1) was burned by an uncontrolled fire in March 2013. The fire burned 489 hectares of swift parrot important breeding habitat in the Meehan Range National Park and adjoining private land. Fig. 2 shows the distribution of swift parrot nests identified by Webb et al. (2012) at the 'Craigow Hill' site from Region 5 relative to the wildfire affected area. We addressed objective two (evaluate the effect of burning on swift parrot habitat quality at local scales) at Craigow Hill, which is predominantly dry, grassy, *Eucalyptus pulchella* and *E. globulus* dominated forest. A small number of nest trees elsewhere were burned in unrelated fires ($n = 5$), but only individual trees burned in those instances.

2.2. Nest cavity and tree fate

Swift parrot nest cavities were identified initially using behavioural cues (see Stojanovic et al., 2012; Webb et al., 2012). After 2010, when a likely nest was identified, trees were climbed using single rope techniques to confirm nesting (Stojanovic et al., 2014b, 2015). Nests discovered prior to 2010 were not climbed immediately after being found, but Stojanovic et al. (2012) found that using behavioural cues to identify nests from the ground was reliable 91.7% of the time. Nest cavities across the entire breeding range were revisited each year after their discovery for up to ten years. We recorded: (1) whether the tree and cavity had burned or not (determined by looking for fire scorching on any part of the tree, or close to the cavity), (2) whether the tree was standing or collapsed, (3) whether the nest cavity was standing or collapsed, (4) presence/absence of a concave basal scar and (if present), the ratio of wall thickness to radius of the basal cavity at breast height (the ratio t/r as described by Mattheck et al., 1994) to assess collapse risk.

2.3. Forest characteristics before/after fire

To evaluate whether fire changed habitat quality for swift parrots at the local scale after fire, we resurveyed vegetation plots at the Craigow Hill site established as part of another study in 2005 by Voogdt (2006). Plots were 28 m radius, non overlapping, and centred either on a randomly selected nest or non-nest tree ($n = 40$ plots: 19 nest plots and 21 random plots). For trees >60 cm diameter at breast height (DBH) and within 28 m of the central tree, we followed Voogdt (2006) and recorded: (1) tree species, (2) diameter at breast height (DBH), (3) basal fire scarring (where: 0 = no fire scarring, 1 = scorched bark, 2 = cambium scorched, 3 = small concave basal scar, 4 = large concave basal scar), (4) tree form (where: 1 = sapling, 2 = regrowth, 3 = advanced regrowth, 4 = mature crown, 5 = mature with major gaps in crown due to limb loss, 6 = senescent crown major gaps and major limbs dead/dying, 7 = tree alive but crown dead and mostly collapsed, dominated by epicormic growth, 8 = tree dead, 9 = collapsed tree), (5) tree species, and (6) number of potential cavities in the crown (counted from the ground using binoculars). Stojanovic et al. (2012) found that counting tree cavities using binoculars from the ground can only provide an index of cavity abundance, and we acknowledge that our cavity counts probably overestimate true cavity availability (Stojanovic et al., 2014a). Post fire surveys were undertaken in 2013 six months after the wildfire. All field techniques were calibrated between J. Webb nee Voogdt, D. Stojanovic and H. Cook so that Voogdt's (2006) methodology was followed.

2.4. Data analysis

To address our first objective (persistence of nest cavities and trees) we used known fate models in program MARK (White and Burnham, 1999) to model survival of swift parrot nest trees and cavities, and treated tree and cavity collapse, and cavity destruction (eg. enlargement or damage due to being burned so that the cavity was no longer suitable for swift parrots) as equivalent to tree and cavity mortality. Cavities that were scorched, but were not substantially changed in morphology were considered to have survived fire. We fitted models separately for trees and nest cavities because partial crown collapse can result in loss of nest cavities from a standing tree. We only included trees and cavities whose fate was known (i.e. no data were censored). For trees/cavities discovered after the study began, we assumed that their earlier (unmonitored) survival was not different to trees/cavities discovered in the first year of the study, i.e. 2005. We grouped trees and cavities depending on whether or not they had been burned in the study period. We used AICc ranking to select the models with the most support and used these to estimate burned and unburned tree and cavity survival over the study period.

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