Science for Saving Species

Research findings factsheet

Project 1.1.1

Threatened Species Recovery Hub

National Environmental Science Programme

Cyclones, fire and termites: Tree hollow abundance in the tropical savannas of northern Australia

In brief

Large hollow-bearing trees are key habitat structures in the tropical savannas of northern Australia, as they are in other savannas globally. It is important to understand the relationship between the abundance of tree hollows and the decline of hollow-dependent mammal species.

Of the nine mammal species that have declined markedly in northern Australia since European settlement, six are arboreal (including semi-arboreal and climbing species) and all use hollows either by necessity or opportunistically. Many of these species have now contracted to the higher rainfall parts of their range where large trees (and therefore larger hollows) are most abundant.

This study is the first of its kind in Australia's tropical savannas. It aims to quantify hollow abundance to form a foundation for assessing whether there is a causal relationship between arboreal mammal decline and hollow abundance. The key questions it seeks to address are how hollow abundance varies across this environment, the factors that affect that abundance, and how this may affect hollow-dependent species and their management.

Hollows in savanna woodlands

Woodlands comprise the main vegetation type in the monsoonal tropics of northern Australia. One of the most distinctive forms of these woodlands are those dominated by one or both of Darwin woollybutt (*Eucalyptus miniata*) and Darwin stringybark (*E. tetrodonta*), and collectively such woodlands extend over about 445,000 km^2, including 180,000 km^2 in the Northern Territory.

Like other savannas around the world, the vegetation structure and composition in these woodlands is controlled by a highly seasonal wet–dry climate. Some particularly notable features of the northern Australian savannas are high monsoonal summer rainfall, low soil fertility, low human population density and frequent disturbance by cyclones and fires.

These woodlands share with the better-studied woodlands and forests of temperate Australia a co-evolution of eucalypts and a diverse set of hollow-using fauna, and an abundance of hollows.

However, their hollow-bearing differs in important ways from that of temperate woodlands and forests in its environmental and disturbance factors. Hollow-bearing trees are generally smaller in the savannas than in the forests of temperate Australia. Despite this, the trees of the tropical savannas support greater densities of hollows than those in many temperate eucalypt woodlands and forests, and the densities of larger hollows may be similar to that of long unburnt, unlogged, intact temperate forests. One of the reasons for this is the abundance of arboreal termites

Australia's northern savannas experience frequent disturbance by fire. Photo: Leigh-Ann Woolley

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Hollows in savanna woodlands (continued)

in the savanna woodlands, which results in a high degree of piping, or the hollowing of the cores of eucalypt species, and therefore the forming of tree hollows.

Another difference between savanna and temperate woodlands is that less than 5% of the savanna woodlands in the region have been cleared – much less than Australian woodlands and forests generally. The limited timber harvesting has focused almost exclusively on two tree species, Cypress pine (*Callitris intratropica*) and ironwood (*Erythrophleum chlorostachys*), both favoured for timber because they are relatively termite-resistant.

However, these savanna woodlands are now subject to increasing intensification of land use and marked changes to fire regimes. These factors could be expected to affect hollow availability and hence habitat suitability for the many hollow-dependent fauna species, including threatened species. Across the large area of the Northern Territory's 'Top End' sampled in this study, at any site there are fires approximately every two to three years, with many of these fires occurring in the late dry season, when fires are of highest intensity and impact.

What we did

The team counted tree hollows of 1809 trees on 43 sites in savanna eucalypt woodlands across the monsoonal tropics of the Northern Territory. All sites were in woodlands dominated or co-dominated by the two tree species *E. miniata* and *E. tetrodonta*. The sites were selected to sample across broad rainfall, soil type, topography and disturbance gradients. None of the sites had experienced timber-harvesting.

We included all trees with a diameter at breast height (DBH; approximately 1.3 m from the ground) of greater than 20 cm and identified them to species or species group. Trees smaller than 20 cm DBH were excluded because they were unlikely to bear hollows. We defined hollows as any entrance that may have depth exceeding the minimum entrance diameter. Every hollow was categorised into one of four size classes based on minimum entrance diameter: Small (<5 cm); Medium (5–10 cm); Large (10–20 cm); and Very large (>20 cm). These hollow size categories broadly match the requirements for different types of animal species: for example, cockatoos need very large hollows; parrots and possums large hollows; gliders and arboreal goannas medium hollows, and geckoes, pardalotes and tree frogs small hollows.

Image above: The brush-tailed rabbit rat nests in hollow trees in northern savannas. Photo: Leigh-Ann Woolley

Our findings

Hollows are abundant in this system by Australian and global standards, with an average of 207 hollows per hectare. We found a significant relationship between hollow abundance and tree characteristics (size, species) and broad environmental factors (annual rainfall, soil depth).

The main predictor of hollow abundance was the abundance of eucalypts and their size: eucalypts had the most hollows per tree. As the dominant species, *E. miniata* and *E. tetrodonta* were the most commonly sampled: they had a mean 2.3 and 1.7 hollows per tree, respectively. These two eucalypts also had the highest frequency of larger (>10 cm) hollows.

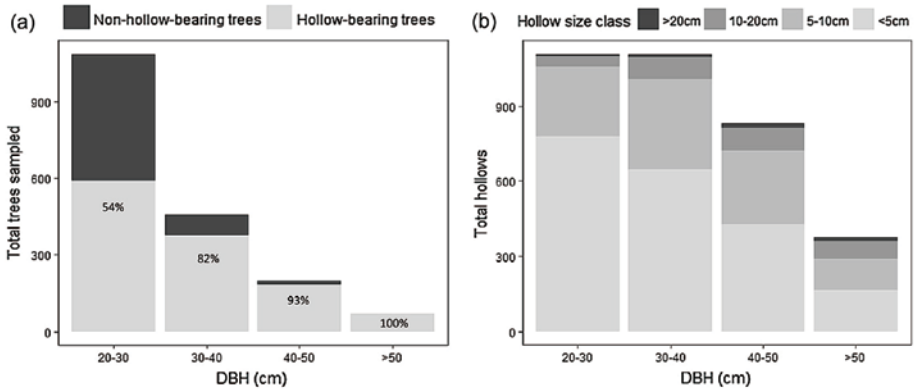
Large trees (> 40cm DBH) contained the most hollows of all sizes and were the only trees containing very large hollows. Even though large trees were not very common (only 17% of all trees were large), 95% of these trees contained hollows and they contained more than a third of all hollows in the ecosystem.

Tree hollows were also most abundant at high rainfall sites (>1300 mm) and sites with soils deeper than 10 cm. The findings support previous observations that savannas of the monsoonal tropics support greater densities of hollows than do many eucalypt woodlands and forest of the temperate regions of Australia: 88 medium to very large hollows per hectare (>5 cm diameter) and 23 large and very large hollows per hectare (>10 cm diameter).

Image right: The sugar glider, soon to be redescribed as the savanna glider. Photo: Leigh-Ann Woolley

Typical of studies that examine hollow abundance, most hollows found on the savannas were small (59%) or medium (31%) and were dispersed across tree sizes, and only 8% were large and 2% very large. The large and very large hollows were most often (80%) associated with large trees (>40 cm DBH) or entirely dead trees. Trees with a DBH of greater than 50 cm, the most likely to bear large and very large hollows, comprised only 4% of the sample, with the highest density of them found in high rainfall sites.

The predictable relationship between hollow abundance and tree species and size, rainfall and soil depth was substantially affected by three chief disruptors – cyclones, fire and termites, and interactions between them.



a) Total trees surveyed grouped by tree size (DBH = diameter at breast height) and showing what proportion were hollow-bearing. As trees get larger, the proportion that are hollow bearing increases. b) The total number of hollows surveyed grouped by tree size (DBH) and hollow size.

Eucalypts in savanna woodlands frequently have hollowed cores. Photo: Leigh-Ann Woolley

Cyclones

Higher rainfall areas (>1300 mm) with a greater abundance of tree hollows were also more likely to be affected by cyclones, which can severely alter that abundance. When trunks or large branches snap in cyclones, new large or very large hollows may be created, but when branches are lost, small hollows on these branches are also lost. Cyclone effects vary with intensity. Average hollow density at high rainfall sites was 236 hollows per hectare at sites unaffected by cyclones, but reduced to 179 at those with moderate cyclone impact, and 71 at severely impacted sites. At sites sampled after 33 years of regrowth following a severe cyclone, the abundance of hollows remained low.

Fire

Frequent late dry season high-intensity fires reduced the density of large hollows, which suggests that high intensity fires directly cause the loss of large trees. Where trees have more extensive fire scarring, indicating recent or more severe fires, they had fewer medium hollows per tree. There were also relatively few small hollows at sites exposed to frequent fire, due to branch loss.

Termites

Termite activity was strongly associated with a higher abundance of hollows. Most trees in northern Australian savannas have hollow cores or pipes due to termite activity, with this frequency significantly higher for eucalypts (97% of *E. miniata* and 82% of *E. tetrodonta*).

Interactions

1. Fire and cyclones: Fires after a cyclone can be exceptionally intense due to unusually high fuel loads on the ground from fallen limbs and trees. Fires can also become more frequent due to increased grass biomass where cyclones have reduced canopy cover. Wind or fire damage, or both, can increase the susceptibility of the tree to future damage.
2. Fire and termites: Fire may access the internal structure of the trees at termite mound entrances and cause external openings to extend, ultimately compromising the structural integrity of the tree and increasing the likelihood of the tree dying.
3. Cyclones and termites: Decreased structural integrity of the tree from termite impact can increase the likelihood of cyclone damage.

Recommendations and conclusions

Although this study has done much to characterise the abundance of hollows in the vast forests of northern Australia, and the factors influencing such abundance, targeted research is still needed to examine whether hollow availability is a limiting factor for hollow-dependent animals.

It has been estimated that there are more species of hollow-using mammals and reptiles in the northern Australian savannas than in the woodlands of temperate southern Australia. However, there is far less information available about the quality of habitat and the link to fauna occupancy for the tropical north than for the temperate south.

The abundance of hollow-bearing trees may be a critical resource to protect threatened mammal species from threats like introduced predators, and this calls for further research.

We recommend experimental studies to assess mammal survival and density at paired sites with and without artificial hollows. This could help establish whether reductions in numbers of hollows limit mammal survival and density, and therefore whether to manage the controllable factors, chiefly fire, to influence hollow availability. Our study also reinforces the need for better management of fire in these systems. Particular priority should be given to reducing the frequency of high-intensity, that is late dry season fires, especially where the risks of fire are higher.

The coastline of northern Australia is at significantly higher risk of frequent disturbance by storms and tropical cyclones during the monsoonal wet season than inland regions more than 100 km from the coast. Such severe disturbance places hollow-dependent fauna at particular risk of the potential consequences of a reduction in the number of hollows, and raises further concerns over the threats to the declining mammal populations in these coastal zones of northern Australia.

Arboreal termites are abundant in the northern savannas. Photo: Leigh-Ann Woolley

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