KEYWORDS: ***Bushfire – Rockshelter – Pictogram – Arnhem Land – Australia***

BUSHFIRE-INDUCED HEAT AND SMOKE PATTERNS WITHIN AN ABORIGINAL ROCK ART SHELTER

R. G. Gunn and R. L. Whear

Abstract. A controlled burn in a gully housing a large rockshelter in southern Arnhem Land permitted the observation of heat and smoke behaviour within the shelter and its inferred impact on rock art and other Aboriginal cultural heritage. It was found that, due to air currents created by the fire, that heat was unlikely to be a major agent in the deterioration of the rock art unless burning vegetation was in contact with or very close proximity to the art panel. Smoke contamination of the pigments was possible but considered to be minor at most. Similarly, other items of cultural heritage, including the floor deposits, are unlikely to be effected by bushfires unless they are in contact with burning vegetation (including tree roots).

Introduction

The role of fire has long been recognised as a major agent in rock weathering (Blackwelder 1926; Twidale 1980; Dorn 2003; Twidale and Campbell 2005). The intense heat necessary, however, appears to require burning vegetation to be either in direct contact or immediately adjacent to the rock surface to cause exfoliation (Gunn 1999). The potential threat by fire to petroglyphs on open sites is well documented (Rosenfeld 1988: 33; Bednarik 2001: 62, 89–90), particularly where wooden boardwalks are involved. Fire is also often mentioned as a threat to rockshelter artwork (e.g. Edwards 1979: 197), but there has been little study of the problem. The Aborigines of western Arnhem Land have been producing rock art of outstanding quality for many thousands of years (Watchman and Jones 1992; Gunn and Whear 2008). The area is also well known for its seasonal bushfires (Press et al. 1995). How is it then that these two incompatible elements have co-existed for so long?

In southern Arnhem Land, the climate is typically monsoonal with an annual rainfall of around 1000 mm, almost all of which falls over the Wet season from October to March (Jawoyn season of *Jiyowg*). Humidity is high during the Wet, with rapid vegetation growth, including many tall grasses that die and dry off; these become highly flammable over the subsequent Dry, which is low in humidity (*Malabbarr*). In discussing the role of fire in maintaining vegetation regimes in the south-west of Western Australia, Hallam concluded that

> most of our virgin bush is fire climax vegetation and that Aboriginal firing of the bush must have been an important factor in the establishment and maintenance of this vegetation pattern (Hallam 1979: 7).

A similar conclusion can be drawn for the important contribution of regular Aboriginal burning practices throughout Australia, particularly in the well-grassed areas (Gould 1980: 81–82; Walsh 1987; Press et al. 1995; Wiynjorrotj et al. 2005).

Following the movement of Jawoyn people from their traditional lands into central Aboriginal community settlements such as Maranboy, Barunga and Wugularr (Beswick), traditional burning practices have no longer been possible in many outlying areas. Consequently, the Jawoyn Association, Katherine, which is charged with managing Jawoyn lands, has instigated a program of systematic mosaic burning (mostly by helicopter) to imitate traditional practices and prevent the build-up of high fuel loads. Even these 'controlled' fires, however, may have the potential to damage or destroy Aboriginal cultural heritage.

During burning operations in southern Arnhem Land, a small controlled burn of a gully housing a well-known rockshelter at Yimigronggrong permitted the ad hoc observation of the behaviour of heat and smoke within the shelter, and allowed a superficial assessment of its impact on the site's cultural heritage.

Yimigronggrong

The Yimi.grong.grong shelter is within the Beswick Aboriginal Land Trust, some 10 km NE of Barunga, in southern Arnhem Land (Fig. 1). It lies in a tight and deep gully on a tributary of Dook Creek,

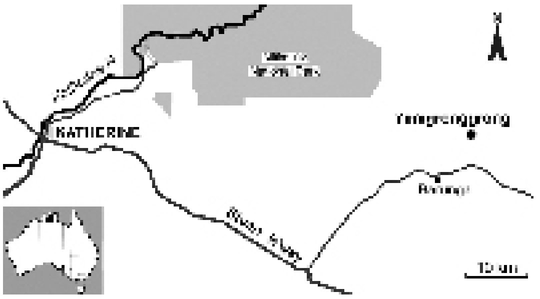

Figure 1. Location of the rockshelter Yimigronggrong.

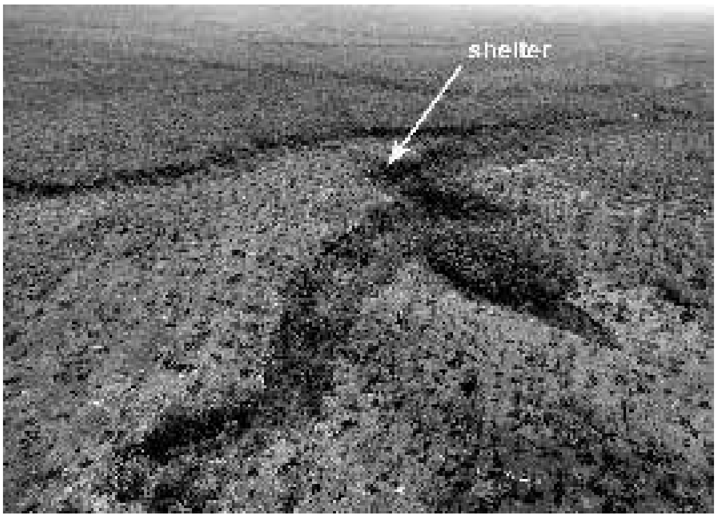

Figure 2. Situation of the Yimigronggrong shelter.

upstream from the favoured fishing place of Dordluk. The shelter is well known to the people of Barunga as an olden-times camping place. Its traditional name, Yimigronggrong, was provided by Jawoyn elder Sybil Ranch. The shelter has been the subject of several archaeological studies by Flinders University (Wilson n.d.; Claire Smith, pers. comm., 2007)

The bedrock is an undifferentiated flat-lying Early Cretaceous lacustrine sandstone and local conglomerate (Kruse et al. 1994). These beds form a flat tableland that is scoured by deep, steep-sided drainage channels (Fig. 2). The sandstone at the shelter is a poorly cemented yellow quartz sandstone, with minor lenses of yellow jasper and conglomerate. It is assumed that this coarser sandstone, while more readily eroded by water, will be less affected by fire heat than the more closely cemented quartzose sandstones, due to its greater porosity allowing freer air movement within the stone.

The vegetation on the lateritic gravel plateau is primarily open woodland (NTG 2007), consisting of *Eucalyptus miniata* (woolybutt: *yiwal*), *E. bleeseri* (bloodwood: *kalarr*) and *E. tetrodonta* (stringybark: *porrorlorl*), with tall sorghum grass (sorghum sp.) and spinifex (Triodia sp.: *jalkwarak*). The gullies have similar trees and grasses with the addition of *Melaleuca viridiflora* (large-leafed paperbark: *pirtij*), turkey bush (Calytrix sp.: *wij)* and dense thickets of *Acacia shirleyi* (lancewood: *kumpij*) (Robinson et al. 1975; Wiynjorrotj et al. 2005). When the grass in this area dries off fully, it becomes extremely flammable and bushfires can burn for many days and cover large distances. Wildfires on the tablelands can remove all understorey vegetation and, if hot enough, run as crown fires that denude the trees of their leaves. However, the vegetation is generally very fire resilient and has adapted to, and often requires, regular burning (Russell-Smith 1995). The principal threat of fire is to rainforest pockets, wildlife, cattle and property.

The Yimigronggrong shelter is situated within a low cliff at the top of a steep scree slope (Figs 1 and 2). It is composed of two alcoves: a large spacious alcove (A), and an adjoining long but shallow overhanging cliff wall (B). Alcove A is 52 m long, 10 m deep and 6 m high at the dripline, with a north-easterly aspect (Figs 3 and 4). The rear wall is vertical and two to three metres high, while the ceiling is stepped upwards from the inner wall to the dripline (Fig. 5). Sections of the rear wall are heavily water-washed during the Wet season. The alcove is a major Aboriginal site, with both rock art and occupation deposit. The artwork consists of over 350 motifs (including 330 paintings and 19 hand stencils, and dominated by representations of large snakes; Fig. 6). Most, however, are now in poor condition due to the pigments' poor adhesion to the bedrock. The floor deposits, excavated by Flinders University in 1997, are less than 30 cm deep and have a near-basal date of around 1500 BP (Wilson n.d.).

Figure 3. Alcove A profile.

Alcove B, to the immediate east of alcove A, is 42 m long and 4 m high but has

Figure 4. *Freehand sketch plan of the shelter (not to scale).*

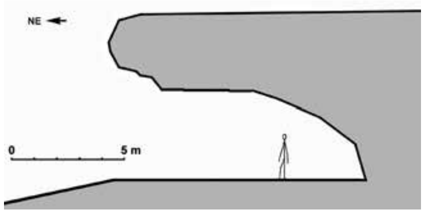

Figure 5. *Measured profile of the deepest section of the shelter.*

Figure 6. *Section of the alcove A artwork.*

a maximum depth of only two metres (Figs 4 and 5). The alcove has a northerly aspect. It contains over 50 paintings, 10 drawings and three hand stencils. Again, however, most of these are in poor condition and the floor, which is mostly bedrock, has only a very shallow floor deposit over bedrock.

The observations

The site was visited on the 11 August 2007, near the end of the Dry season but before the grass had completely dried off. At the time of the burn the daytime temperature was in the mid-30s (Celsius), and the wind a very light breeze from the north-east.

Tall grass and dead passion-vine (*Passiflora foetida*; an introduced weed) were thick on the talus and along the dripline, with the passion-vine encroaching into the sheltered area. The fire was lit from the base of the scree and burnt at a walking pace (say 4 km/hr) up and westwards along the slope. The flames reached maximum heights of around three metres, but for most burnt around 1–2 m high. The opposite gully wall was also ignited. During the burn, one of us (RG) remained in the shelter to observe the fire's behaviour and effects, and experience the radiant heat. The fire continued down the adjacent gullies until it burnt itself out.

Figure 7. *Fire approaching the shelter.*

As the fire progressed up the slope it became larger due to greater availability of fuels and its heat radiated directly into the shelter (Fig. 7). However, because of the ten-metre depth of the main alcove (A), it was at no time uncomfortable. Also, when the fire was at its maximum at the shelter, fire-generated air movement passed along the rear wall from east to west, in the direction of the fire's advancement. This current of cooler and fresher air formed a barrier preventing both smoke and heated air from filling the

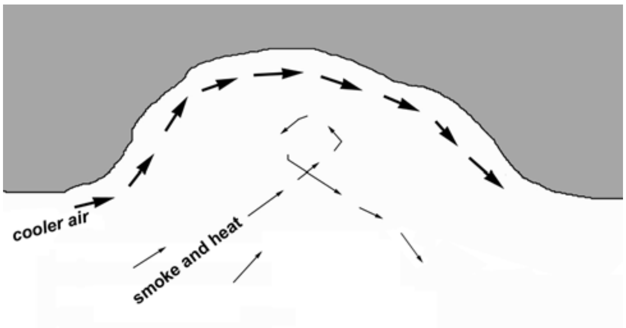

Figure 8. *Generalised shelter plan showing smoke and air movement.*

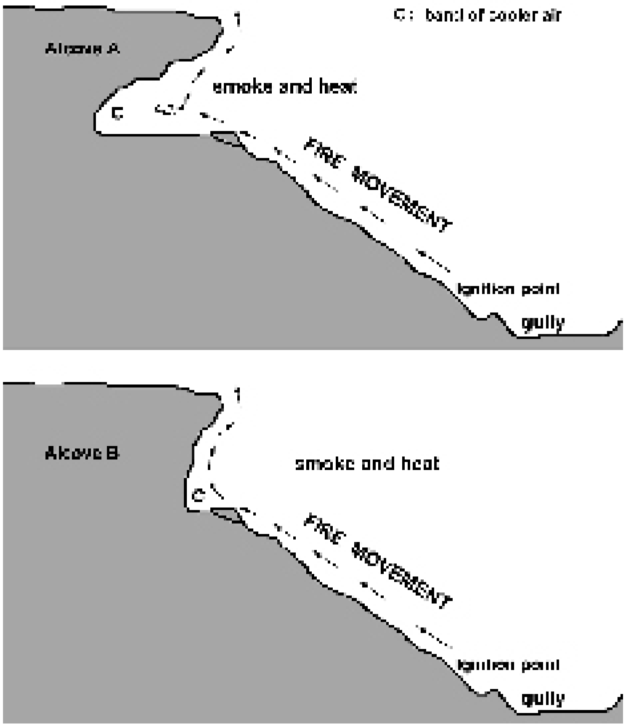

Figure 9. *Generalised alcove sections showing observed smoke and air movement.*

shelter. The smoke swirled into and around the central area and then, rising and passing the outer lip of the dripline, ascended beyond the cliff top (Figs 8 and 9). At no time did the smoke or heated air reach the rear wall. Burning embers and grass stalks were similarly conducted up and above the shelter. None landed at the rear or centre of the shelter, and only a small number fell back from the burning passion-vine at the front of the shelter. The passion-vine, which covered areas of the floor of alcove A (Fig. 10), burnt quietly and continued to burn after the fire front had passed.

A similar pattern of smoke behaviour was observed in the side alcove that is only one to two metres deep. Here however, the smoke passed more directly up the wall of the cliff and did not circulate as it did in the larger alcove. Again, no embers settled on the alcove floor. During the fire activity very little fine ash settled in either alcove. Also, at its peak the interior heat was nowhere intense enough to cause rock exfoliation, although minor exfoliation was later observed on a number of fully exposed boulders on the scree slope.

This pattern of fire behaviour continued for around half an hour until the fire had burnt all flammable vegetation around the shelter. After this, there was no further increase in heat within the shelter.

Figure 10. *Passion-vine burning on the shelter floor.*

Figure 11. *Smoke hanging in the gullies after the fire front had passed.*

However, about ten minutes after the fire had passed beyond the western extremity of the shelter and the larger patches of vegetation had been burned away, the air movement created by the fire subsided, and a heavy smoke blanket filled the gully and seeped into the shelter where it sat motionless (Fig. 11). The lack of air movement created a lack of fresh air, and a build up of thick smoke caused choking and copious eye watering, which finally became unbearable. This necessitated a rapid retreat to the top of the cliff where the smoke was significantly thinner and the air considerably more comfortable to breathe. It took another half-hour for the smoke to dissipate from the shelter. A final inspection of the shelter found no further impact from the fire.

From this experience it is apparent that rockshelters can be effective havens for people and wildlife while a bushfire front passes. However, for the weak or badly injured, the shelters could also be a place for a suffocating death. It is also clear that, for low-temperature fires at least, rock art is generally protected from the effects of radiant heat due to a protective flow of cooler air around the shelter wall.

To confirm these preliminary findings, quantified observations could be readily made with the appropriate electronic equipment during controlled burns in other areas of the country, and in a range of different shelter forms and rock types.

Conclusion

A controlled burn of a rocky gully in southern Arnhem Land permitted the ad hoc study of the behaviour of bushfire smoke and heat within a rockshelter. Overall, it appears that rockshelters can provide a safe repository for rock art against the threats of bushfire. Bushfire-generated heat is therefore not seen as being a major cause of their deterioration or a major threat to their continued preservation. This is supported by the high annual frequency of bushfires throughout Arnhem Land and the large quantity of high-quality rock art still extant within many rockshelters in the region (much of which is many thousands of years old; Lewis 1988, Chaloupka 1993). Also, if any artwork was produced on more exposed surfaces in Arnhem Land, water is more likely to have been the agent of its destruction, as the heavy wet-season rains would quickly flush away any unprotected pigments.

Bushfire smoke, however, may well impact on rock art if the housing shelter is in a gully or other area where the post-fire smoke is not dissipated by air movement. The significance of this impact is unknown but, presumably, some smoke particles will adhere to the wall surface and to the outer surface of the artwork.

While these casual observations are from a single example, there is no reason to assume that the findings will not apply to similar-shaped rockshelters elsewhere in Australia. Hence, it is proposed that rock art and other cultural heritage within rockshelters are essentially protected from the effects of bushfires. This conclusion cannot be held to be true if there is any flammable vegetation, including underground tree roots, in close proximity to the art panels or other items or features of cultural heritage.

From a management perspective, it is undoubtedly good practice to remove vegetation growing against any art-bearing surface and to prevent further regrowth. Such vegetation can be abrasive with wind action as well as providing fuel for fire. This removal, however, must be done sensitively and with full consent from custodians as, in some instances, the vegetation may be more significant than the rock art. For example, in central Australia, the rock fig invariably has mythological associations and hence is more important to the present-day culture than rock art that has long lost its meaning (pers. field notes). Also, from a conservation viewpoint, vegetation across the front of a shelter may well be beneficial to art preservation through providing a solar screen (Andrew Thorn, pers. com., 1998). As with all aspects of cultural heritage management, remedial actions must be undertaken with care and consultation, and with a wider view than simply the immediate problem in hand.

Acknowledgements

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APPENDIX

VEGETATION MANAGEMENT AND CULTURAL HERITAGE VALUES

(Draft only, as proposed to public agencies in Queensland)

MICHAEL J. ROWLAND

Background

Patterns of vegetation distribution in the landscape may be a significant indicator of the location of cultural heritage places. Most people, for example, will recall, while driving the highways of Queensland, seeing the occasional clusters of fruit trees in an otherwise open paddock. On closer inspection it is likely that there will be the remains of an old homestead in the same locality. In a similar way, on many middens in north Queensland exotic plants grow today where indigenous people dropped seeds, which have grown in the organically enriched soils of the middens. It is more generally known that the indigenous peoples of Australia modified much of the vegetation pattern of the continent over at least the last 40 000 years through their 'fire-stick farming' methods.

Today vegetation growing near or on cultural heritage places may have both *positive* and *negative* effects on their conservation.

In the case of rock art sites, positive effects include the fact that vegetation encourages soil stabilisation, helping reduce the amount of dust or soil that may be windblown or kicked up by visitors. Negative impacts may be numerous and include physical damage caused by tree roots splitting the rock, direct rubbing of plants on pigments and of course direct damage by fire. Drastic changes to vegetation structures may also lead to alteration of the local microclimate (including greater runoff and higher or lower temperatures), which in turn may result in the growth of moss and algae, causing further damage.

There is probably little that can be done to manage fire damage to most open sites such as middens, artefact scatters and scarred trees. However, wherever these sites are known, firebreaks should be established around them.

Guiding principle

In all matters of cultural heritage management always work on the principle of doing *as little as possible but as much as necessary* to maintain the conservation and integrity of the place.

Prevention is better than cure

Removal of vegetation from the face of rock art is fairly straightforward. However, there are some important rules:

- Only undertake removal of vegetation where the damage or potential damage to the site is obvious (direct rubbing, potential fire damage etc.).
- Consider what the visual effects on the site will be.
- Consider whether the removal of the vegetation will give offence to the Aboriginal community (ask them).
- Assess the consequences of removing vegetation. For example, allowing considerably more light into the shelter may result in adverse impacts such as algal growth, or the microclimate of the shelter may be altered by permitting greater evaporation or increasing the likelihood of rain driving onto the rock surface. Microflora in the form of algae, fungi and lichens has been widely noted on paintings in shelters. Where microflora grows over images, it obscures and hides paint residues. In addition, it may act as catalyst for other weathering processes by retaining water and disintegrating the substrate.
- Identify the vegetation to be removed and determine if it is common to the area. If the plants are uncommon to the area, or food plants, they may have been planted accidentally or intentionally by Aboriginal people. Other rare types of plant should also not be removed and it may be necessary for a botanist to identify them.

Guidelines

Trees

In the case of rock face splitting and root damage the only solution is to cut down the tree and immediately paint the cut stump with a low-toxicity, low-volume tree killer chemical. If it is necessary to remove vegetation above the site this should be done so that material does not fall over the edge and all material should be removed.

Branch rubbing

It is generally sufficient to cut off the particular branch.

Other vegetation

- Where they present obvious fire damage risk and the site displays evidence of past fire damage, such as exfoliation, or where direct rubbing occurs, taller trees should be removed. Two methods suggested are hand pulling or cutting. For trees that are likely to re-sprout, cut stumps should be painted with tree killer chemical.
- Never leave cleared vegetation at the site as this

will provide fuel for future fires.

- Never walk unnecessarily on the floor of the rock-shelter as it may contain archaeological deposits which may be disturbed.

Other precautionary measures

Many rock art sites are fenced to prevent damage from animals and humans. Visually it is preferable to build fences some distance from the site as a whole. When building such fences please consider the following questions:

- Will the fence withstand bushfires.
- Will vegetation growth inside the fence pose a fire hazard to the images.

In the case of controlled or uncontrolled burns

- Establish a firebreak around the site.
- Determine the wind direction so that fire burns away from the site.
- Only experience with the nature and density of the vegetation will determine the extent of the fire break required as clearly some fires have much greater intensities than others (e.g. spinifex burns with intense heat, which may result in exfoliation of large flakes of rock). Nevertheless, a minimum of 100 m should be considered as a basic distance.
- If water is available do not direct it onto the rock art surface.

Reporting

Always record any damage that has occurred to a site. Report the damage to the regional manager (Cultural Heritage) in your region. Report any new sites discovered (vegetation burn-off often discloses sites not previously seen).

More information

The following reference will give a good insight into the range of conservation problems associated with rock art sites:

Lambert, D. 1989. *Conserving Australian rock art. A manual for site managers.* Aboriginal Studies Press, Canberra.

Gale, F. and J. M. Jacobs 1987. *Tourists and the National Estate: procedures to protect Australia's heritage.* Australian Government Publishing Service, Canberra.

The publications provide, however, only guidelines; in most cases expert advice must be sought on any major conservation issues.

Comments on this draft would be appreciated by:

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