PREDICTING IMPACTS OF FUEL REDUCTION FOR ASSET PROTECTION ON THREATENED SPECIES

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Abstract
Fuel reduction in bushland adjacent to urban development is an important component of bushfire management to protect lives and properties. In many urban areas, the objective of property protection by fuel reduction conflicts with biodiversity management objectives. Conserving threatened species in such situations will require information on spatial distributions of these species in the landscape. We used GIS modelling to predict the likely impacts of strategic fire advantage zones (SFAZs) on two threatened species in the Shoalhaven region of NSW: the eastern bristlebird and the glossy black cockatoo. We used current knowledge of the association between these animals and vegetation to predict habitat suitability. We overlaid residential areas on this habitat-suitability map, and then applied buffers around the residential areas to represent minimum (250m) and maximum (450m) SFAZs scenarios. For eastern bristlebirds, 4000 ha of suitable habitat occurred in the study area, and nearly 15% of this would become unsuitable with 450m SFAZs. For the cockatoos, approximately 9% of 30,000 ha of suitable habitat would be altered with 450m SFAZs. The GIS models provide the information needed for more creative bushfire mitigation activities that could deliver both the conservation of endangered species and protection of human assets.

Additional keywords: fire, eastern bristlebird, glossy black cockatoo, GIS, habitat model

Introduction
Conflicts occur between biodiversity conservation and the need to protect life and property against bushfire at the urban/bushland interface, making it the focal point of much debate (Nature Conservation Council, 1999; 2002; 2004). A risk management approach is an increasingly common strategy for dealing with this conflict (Ellis *et al.* 2004) and defining bushfire risk zones in bushland surrounding urban areas is a key part of this approach. In NSW, risk to property is addressed largely through Asset Protection Zones (APZs) and Strategic Fire Advantage Zones (SFAZs), which are managed so that fuel loads remain below defined levels (RFS, 2003).

Specifications for APZs in the Shoalhaven region allow a maximum width of 100 m, with mechanical clearing usually between 20-40 m to maintain fuel loads below 4 t ha^{-1}. Specifications for SFAZs vary. Generally, the combined width of SFAZ plus APZ would be 400 m, but may extend further, depending on local conditions. Fuel loads in SFAZ are to be kept to a maximum of 7-10 t ha^{-1} over 60-80% of the area, by prescribed burning.

Clearing of native vegetation can have dramatic impacts upon native flora and fauna, causing loss of species locally, fragmentation of habitats, and disruption of ecosystem processes (Saunders, 1977; Saunders, 1990; NPWS, 2006). Similarly, prescribed burning can have negative effects upon native biota (Brooker, 1998; Baker, 2002; Brown et al., 2003; NPWS, 2004). The detrimental ecological impacts of clearing and altered fire regimes have led to these being listed as Key Threatening Processes under NSW threatened species legislation (TSCA 1995).

A number of species listed as vulnerable and endangered under NSW legislation are identified as being at risk of extinction when exposed to high frequency fire, as it may disrupt their life cycle processes and alter the vegetation structure of their habitat (NPWS, 2004). Four characteristics in particular appear to make animal species susceptible to high-frequency fire and resultant habitat chance: ground dwelling, cover-dependant, poor disperser and low fecundity (Keith *et al.* 2002).

The Shoalhaven region encompasses 4,660 km^2, and is a very important area ecologically due to its wide range of habitats and high biological diversity. The Shoalhaven LGA is under significant pressure for further development but significant parts of the landscape are dedicated to conservation. In addition to the city of Nowra, there are many small urban and rural settlements, which create long urban/bushland perimeters. Within the Shoalhaven region there are 36 species of plants and 89 species of animals listed in Schedules 1 and 2 of the *TSCA*, 1995 (SCC, 2004).

We identified seven of the listed animal species that are likely to be sensitive to high frequency fire: Spotted Tailed Quoll (*Dasyurus maculatus*), Ground Parrot (*Pezoporus wallicus*), Long-nosed Potoroo (*Potorous tridactylus*), Southern Brown Bandicoot (*Isoodon obesulus*), Squirrel Glider (*Petaurus norfolcensis*), Eastern Bristlebird (*Dasyornis brachypterus*) and Glossy Black Cockatoo *Calyptorhynchus lathami*). In this study, we focus on the last two species, because they are present in the Shoalhaven region in sufficient numbers to develop models of habitat suitability and explore the spatial relationships between suitable habitat and SFAZs. We focused upon the north eastern part of the Shoalhaven LGA, between Nowra in the north and Manyana in the south, because this area contains a significant number of records of Eastern Bristlebirds and Glossy Black Cockatoos and a large number of urban/bushland interfaces.

Materials and Methods

Study species

The Eastern Bristlebird is a small, semi flightless terrestrial bird, with a sparse distribution that is confined to south east Queensland and lower parts of south east Australia (Baker, 1997). Two of the largest and most significant populations occur in south east NSW at Jervis Bay and Barren Grounds-Budderoo (Baker, 2002). The Eastern Bristlebird occupies a broad array of vegetation communities, each characterised by dense ground cover, which appears to be an important habitat requirement (Baker, 2000; 2002). This species displays all of the attributes of a fire sensitive bird, which hinders its ability to escape fire (ground dwelling, poor flier) and recover afterwards (cover dependant, poor disperser, low fecundity). The suitability of habitat post fire for this species will be dependant upon the time it takes for vegetation to recover and attain an appropriate structure.

The Glossy Black Cockatoo is the smallest of the Black Cockatoos, and is patchily distributed along the coast between Eungella in Queensland to Mallacoota in Victoria, with scattered populations being located in central south Queensland and NSW, and an isolated population located on Kangaroo Island South Australia (Higgins, 1999). The main habitat requirement for this species is the presence of *Allocasuarina* species for food, with the preferred *Allocasuarina* species in coastal south east NSW being *A. littoralis* (Clout, 1989; Mills, 1996). The presence of hollow bearing *Eucalyptus* trees for nesting is also very important (Joseph, 1982). The response of the Glossy Black Cockatoo to fire has not been the subject of detailed study, but Collins (2005) found that the number of trees showing evidence of foraging, and the number of cones consumed per tree increases with time since fire, peaking between 15 and 20 years post fire. The number of trees per hectare with evidence of feeding has been shown to be highly correlated with the number of Glossy Black Cockatoos in an area (Pepper, 1997).

GIS modelling

The use of GIS as a management tool is becoming increasingly common in conservation biology and land management planning, as it allows real world phenomena to be approximated using spatial relationships between geographical data in the computer based environment (Delaney, 1999), and for the effects of various scenarios to be tested at a landscape scale. For each species, the area of suitable habitat that would be affected by the fuel-reduction burning was calculated in two simulations, one assuming a 250 m wide SFAZ and the other 450 m wide.

In each case, the appropriate SFAZ layer was intersected with a 'suitable habitat' layer constructed for each species. Suitable habitat layers were created by (i) identifying key habitat requirements of each species from literature and (ii) selecting appropriate vegetation units from the vegetation map layer obtained from the NSW DEC based on these suitable habitat types and key habitat requirements using descriptions of each vegetation unit, which contained information about groundcover and shrub density and dominant plant species (Tindall *et al*., 2004; Table 1).

Table 1. Vegetation units in Shoalhaven GIS layer that were classed as suitable habitat in habitat modelling.

Attribute	Eastern Bristlebird	Glossy Black Cockatoo
Suitable vegetation types	wet forest/rainforest, forest, open forest, woodland, open woodland, closed scrub, closed coastal scrub, closed shrub swamp, mallee, closed low to tall heathland, closed sedgeland and closed wet heathland (Higgins 1999, Baker 2000)	woodland or open sclerophyll forests (Higgins 1999)
Key habitat requirements	dense groundcover (Baker 2000; 2002)	presence of *A. littoralis* trees (Clout 1989; Mills 1996)
Requirements for habitat modelling	Any of the above vegetation units with >34% groundcover	Woodland or open sclerophyll forests with *A. littoralis*

We used records from the Department of Environment and Conservation (DEC) Wildlife Atlas to estimate the accuracy for the 'suitable habitat' models for each species. Each record within 500 m of a road (where most survey effort has been directed) was classified as being in predicted suitable habitat or not. For Eastern Bristlebirds, 70% of 263 records were in sites classed as suitable habitat; for Glossy Black Cockatoos, 65% of 253 records were in suitable habitat.

Minimum and maximum SFAZ layers were created by placing a 250m and 450m buffer around the villages in the study area. These buffers were edited so that they did not extend across significant water bodies. Habitat models were then intersected with an SFAZ data layer to identify the area of habitat affected by SFAZs for both the minimum and maximum widths. This was then exported as a new layer of suitable habitat impacted upon by SFAZs. The 'calculate perimeter and area' tool in X Tools Pro 2.0 (Data East, LLC) was then used to calculate the

total area of 'suitable habitat' in the study region, and the portion of suitable habitat that was within SFAZs for each simulation.

Results and Discussion

Habitat suitability

The habitat model predicted that there is 90,000 ha of habitat suitable for the Eastern Bristlebird, and 30,000 ha suitable for the Glossy Black Cockatoo within the 166,000 ha study region. This study region is particularly important for these threatened bird species. In particular, it represents one of the only two substantial, viable populations of the endangered Eastern Bristlebird remaining – from a species distribution that once spanned coastal areas from northern Victoria to southern Queensland (Baker 1997; 2000).

The habitat model was not perfect; a number of records for each species were in areas classified as 'unsuitable' habitat in the model. There are several possible reasons for such misclassification, some associated with habitat modelling and some with bird records. For habitat modelling, these include: (i) the information for the vegetation layer in the GIS is based on aerial photograph interpretation, limited field sampling and vegetation distribution modelling from environmental data layers, so some areas may have been identified as unsuitable when, in the field, they may have been suitable habitat; (ii) the scale and resolution of the mapping may have led to mis-identification of small (<1ha) remnant patches of suitable habitat as unsuitable, even though birds may have been able to use such small patches; (iii) estimation of % cover of low and mid-storey vegetation, which is critical for Eastern Bristlebirds, is subjective and this vegetation characteristic may change rapidly, especially as a result of fire. For bird records, sources of misclassification include: (i) the records for the two bird species in the DEC Wildlife Atlas represent an accumulation spanning many decades; (ii) older records that now appear to be misclassified may have actually been in what was then suitable habitat; (iii) some records may have been due of birds detected while moving through habitat, but not primarily using it; (iv) in the case of the Eastern Bristlebird, many may be in close proximity to suitable habitat, reflecting the fact that this species occurs at higher density in areas of vegetation transition (Baker *et al*., 2002) – the fact that records in unsuitable habitat are generally close to suitable habitat can be seen in Fig. 2(a).

Despite these various possible sources of misclassification, 70% of the Eastern Bristlebird records and 65% of Glossy Black Cockatoo records occurred within areas classed as suitable habitat. Thus, we consider that even the relatively coarse habitat modelling we conducted can give a good representation of the areas of potential conflict between fire management and biodiversity management for these two threatened species.

SFAZ impacts

The distribution of suitable habitat across the landscape in the study region results in varying amounts falling within SFAZs, depending both on the species and on the width of SFAZ in a particular scenario. The potential magnitude of the impact of habitat conversion from suitable to unsuitable as a result of maintaining SFAZs ranges from 1,343 to 2,500 ha for Glossy Black Cockatoos (4.5 to 8.3% of their total suitable habitat) and from 2,150 to 4,000 ha for Eastern Bristlebirds (2.4 to 4.5% of their suitable habitat) (Table 2).

Table 2. Vegetation units in GIS layer that were classed as suitable habitat in habitat modelling.

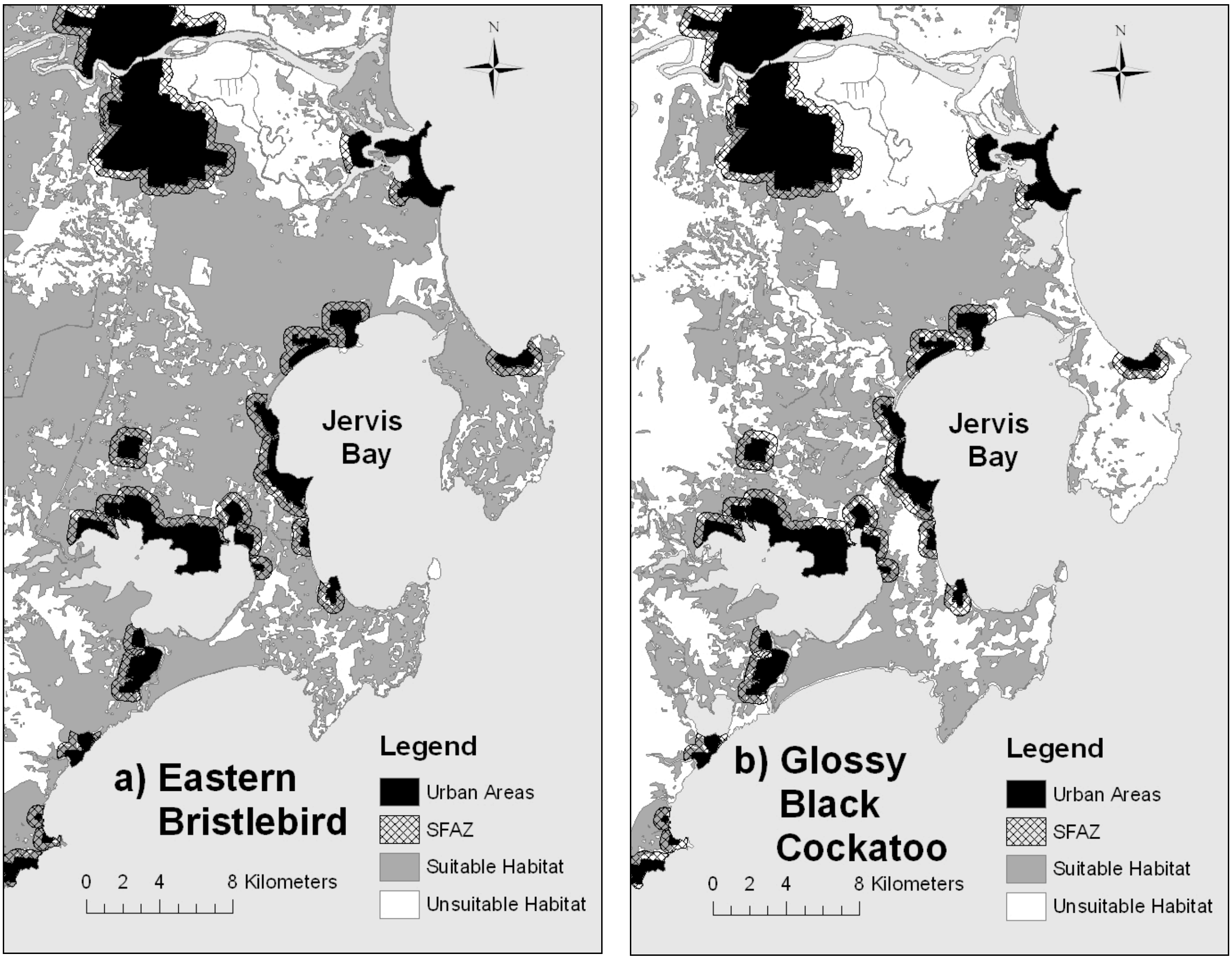
	Area of suitable habitat (ha)	**Area affected by SFAZ (ha)**		**% affected by SFAZ**	
Simulation		**250 m**	**450 m**	**250 m**	**450 m**
Eastern Bristlebird	90,117	2,150	4,095	2.4	4.5
Glossy Black Cockatoo	30,120	1,343	2,500	4.5	8.3

Figure 1 illustrates both the distribution of suitable habitat modelled for these two species, and the overlap with the 450 m SFAZ buffer. This figure clearly illustrates the long urban/bushland perimeters that are associated with having a number of small urban settlements within a bushland landscape, and the large areas that need to be managed for fuel-reduction as a consequence..

Effect of landscape context

The modelling conducted in this project represents a snapshot in time. The landscape is not constant, however. First, large-scale phenomena such as climate change will alter the composition of vegetation communities and their distribution across the landscape, hence changing the amount and spatial distribution of suitable habitat. Second, further urban and other development will continue to reduce the total amount of suitable habitat in the region both directly, by conversion from bushland to urban, and indirectly, by further increasing the urban/bushland perimeter and hence to total area of the landscape in SFAZ. Third, periodic unplanned fires will temporarily convert suitable habitat to unsuitable; in fact, bushfires between 2000 and 2003 burned 88,500 ha in the study region (Loemker 2004), converting 60.6% of formerly suitable habitat to unsuitable for Eastern Bristlebirds. As a result, the percentage of remaining Bristlebird habitat that was contained within SFAZs increased from 4.5% to over 10%.

Figure 1. Maps showing intersection of suitable habitat and Strategic Fire Advantage Zones for (a) Eastern Bristlebird and (b) Glossy Black Cockatoo habitats.



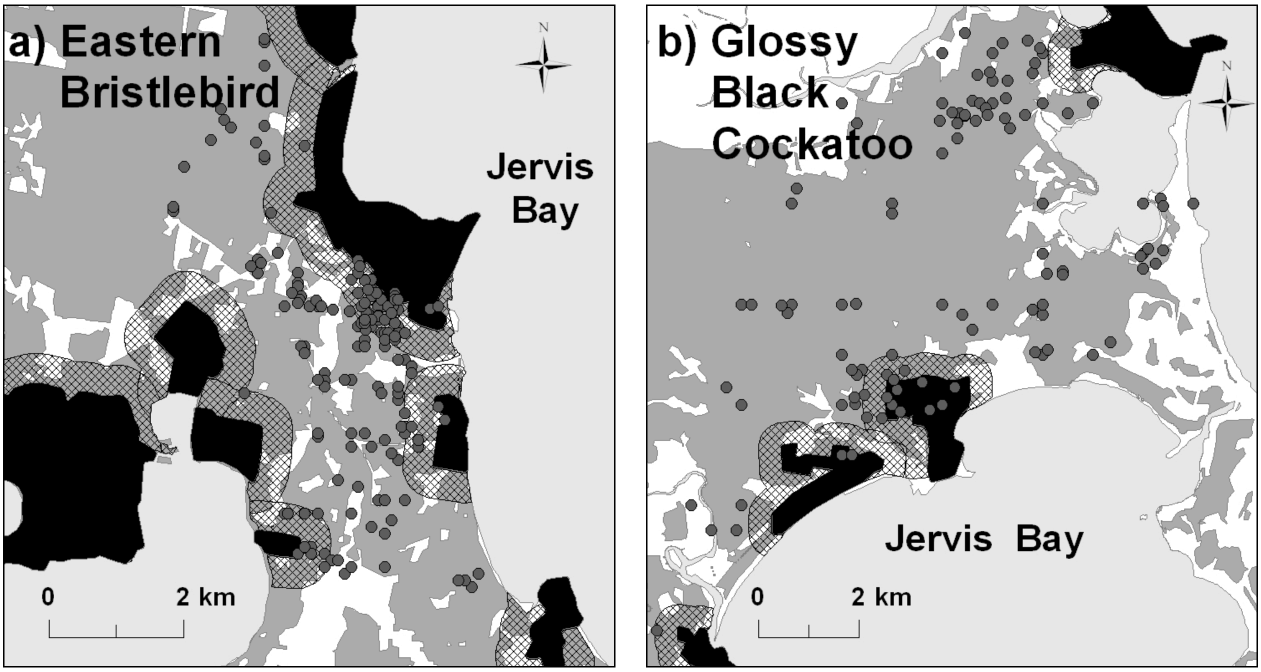
An important consequence of conversion of habitat from suitable to unsuitable, as a result of further development, bushfires, or SFAZ management, is increased fragmentation and separation of remnant patches of suitable habitat. For example, maintanance of the SFAZ around Wrights Beach (the small settlement in the middle-lower section in Fig. 2(a)), would separate suitable Bristlebird habitat to the south from a large tract to the north. The spatial arrangement of this remnant 'patchwork' will influence both viability of local populations in the remnants and their ability to recolonise patches that become suitable as post-fire regeneration occurs.

The value of small patches of suitable habitat and the degree of impediment to recolonisation that is caused by converting habitat to unsuitable is dependent upon species. Glossy Black Cockatoos, for example, are more mobile and wide ranging than Bristlebirds and are less dependent on cover, though they are perhaps more dependent on a particular food source (*Allocasuarina* seeds). There mobility means that isolated food trees, even in urban areas (e.g. see the records in Callala Beach township, in the centre of Fig. 2(b)), may contribute significantly to the viability of remnant populations, as long as food resources are managed effectively.

Improving and applying the models

There are several refinements that should be made to the studies we report here. First, as outlined above, we need to improve vegetation classification and resolution, assessment of cover within each vegetation class, and testing of vegetation characteristics (composition and cover) representing good quality habitat for particular species. We expect that this would result in a significant amount of the landscape that we classified as 'suitable' being reclassified to unsuitable. Second, the buffers we used for the two SFAZ scenarios were generalisations. As the bushfire risk management process is refined, it should be possible to tailor SFAZ widths to particular locations. At the very least, the GIS could be designed to set the SFAZ buffers based on the intersection of terrain and vegetation layers in particular locations, rather than using a standard width, because slope, aspect and vegetation type are important determinants of the appropriate width of SFAZs.

Figure 2. Local records (dots), urban areas (black), the 450 m SFAZs buffer (cross hatching), and modelled suitable habitat (grey shading) for (a) Eastern Bristlebirds in the Vincentia - Erowal Bay area and (b) Glossy Black Cockatoos in the Callala Bay – Callala Beach – Huskisson area.



Third, the relationship between time since last fire and suitability of habitat is poorly known for most threatened species and is generally inferred from estimates of habitat. However, it is possible that, depending on local conditions of soil fertility and rainfall, vegetation in some sites could return to suitability rapidly. As a consequence, the impacts of fuel-reduction activities in the SFAZ may not be so severe. For example, *Allocasuarina* trees burned as part of fuel-reduction activities may recover and produce new cones after only a few years (Collins 2005) and rapid understorey recovery may make a site suitable for Eastern Bristlebirds soon after a fuel-reduction burn. Thus, further research on the relationship between fire and habitat will allow more precise predictions of the effects of SFAZs.

Even as it stands, the model we have developed will allow those responsible for bushfire management plans to tailor on-the-ground actions to particular circumstances. For example, fuel-reduction activities or SFAZ widths could be modified in particular locations where high quality habitat would be isolated or converted to unsuitable, and scheduling of fuel-reduction activities could be modified according to the impacts on the distribution of high quality habitat of a recent bushfire.

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