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Management of Amphibian Populations in Booderee National Park, South-Eastern Australia

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Abstract

Often land set aside for conservation becomes a multiple use area, which forces land managers to balance biodiversity values against competing needs. Booderee National Park is an important conservation reserve for a range of amphibian species in south-eastern Australia. The Park includes a number of townships, defence facilities, and recreation areas, as well as land for conservation. We examined amphibian communities in the area and related these to broad habitat features and identified potential threats to the long term viability of these populations. Two distinct assemblages occurred within the Park that could be related to broad habitat features of the breeding site (i.e., wet heath and open water wetlands). There are three potential threats to the viability of these populations: (1) inappropriate fire regimes; (2) introduced predators; and (3) infection by the chytrid fungus. While fire regimes and predators can be managed, the chytrid fungus cannot and therefore represents the primary concern for amphibians in the area.

Keywords

populations, management, booderee, amphibian, national, park, south, eastern, australia

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MANAGEMENT OF AMPHIBIAN POPULATIONS IN BOODEREE NATIONAL PARK, SOUTH-EASTERN AUSTRALIA

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***Abstract.*—Often land set aside for conservation becomes a multiple use area, which forces land managers to balance biodiversity values against competing needs. Booderee National Park is an important conservation reserve for a range of amphibian species in south-eastern Australia. The Park includes a number of townships, defence facilities, and recreation areas, as well as land for conservation. We examined amphibian communities in the area and related these to broad habitat features and identified potential threats to the long term viability of these populations. Two distinct assemblages occurred within the Park that could be related to broad habitat features of the breeding site (i.e., wet heath and open water wetlands). There are three potential threats to the viability of these populations: (1) inappropriate fire regimes; (2) introduced predators; and (3) infection by the chytrid fungus. While fire regimes and predators can be managed, the chytrid fungus cannot and therefore represents the primary concern for amphibians in the area.**

Key Words.—anuran, conservation, forest, *Heleioporus australiacus*, *Litoria aurea*

INTRODUCTION

One of the primary goals of conservation reserves is to protect and maintain biodiversity including populations of threatened species. For many reasons, this can be an extremely difficult task. First, the distribution of threatened species are often poorly understood due to the species being either rarely encountered or rarely abundant (e.g., Penman et al. 2004). Second, the responses of individual species to natural disturbances and management actions vary widely between and within species groups (e.g., Goldingay et al. 1996; Law and Dickman 1998; Lemckert 1999; Kavanagh and Stanton 2005), forcing land managers to select practices that will inevitably favor some species, or groups of species, over others. Third, conservation reserves are often multi-purpose areas that require a range of management actions that may at times conflict with conservation management goals. For example, the use of natural areas for recreational activities often results in ecological impacts (e.g., Sun and Walsh 1998; Kutiel et al. 1999; Hadwen et al. 2007).

Booderee National Park is a high profile conservation reserve on Bherwerre Peninsula on the east coast of Australia (Fig. 1). The Park is a multiple use area supporting the Wreck Bay Aboriginal community (the traditional landowners of the area), an Australian Navy base (including a large airfield), a number of designated recreation areas, a botanic gardens complex, a small township, and large tracts of natural areas set aside for the conservation of marine and terrestrial ecosystems. A plan of management has been developed (Booderee National Park Board of Management and the Director of National Parks. 2002. Booderee National Park Plan of Management. Commonwealth of Australia, Canberra, ACT), which attempts to balance the demands placed on the Park administration by this complexity. The plan also identifies research and monitoring strategies to test the efficacy of the proposed management approaches.

A diverse range of amphibian species occur within the Park, including two threatened species: the Giant Burrowing Frog (*Heleioporus australiacus*) and the Green and Golden Bell Frog (*Litoria aurea*). The region is particularly important because it represents the southern limit of a range of amphibian species (Littlejohn 1967; Cogger 2000). The importance of this region will only increase under predicted global climate change scenarios (Suppiah et al. 2007), which are expected to drive species distributions south or to higher elevations (Brereton et al. 1995), as it may represent the climatic refugia for these species. It is therefore important to ensure that the management of this area ensures the successful conservation of these species into the future.

In this paper, we examine the amphibian communities of Booderee National Park and relate these to habitat features of the breeding sites. From this information, we identify potential threats to the long term conservation of amphibian diversity in the Park. We also discuss which management practices may aid the conservation of these populations.

METHODS

We conducted surveys in Booderee National Park between 1 March 2008 and 12 March 2008. The Park covers approximately 7,700 ha on the Bherewere peninsula in south-eastern Australia (Fig. 1). Natural

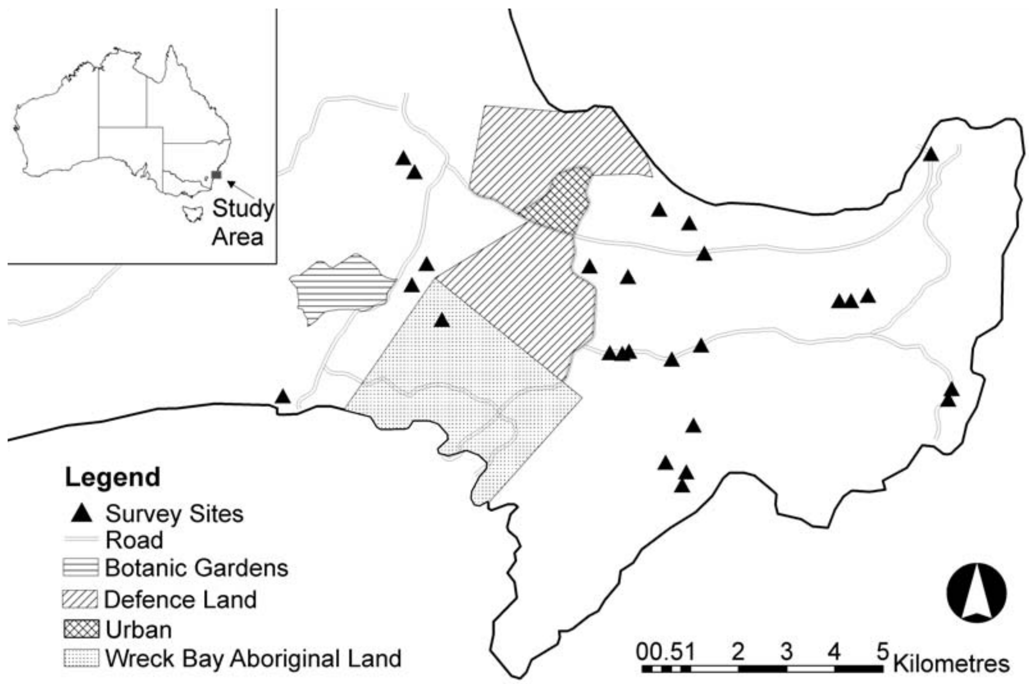

FIGURE 1. Location of Booderee National Park, Australia and the survey sites used in this study.

areas within the Park are generally Eucalypt forest, dominated by *Eucalyptus pilularis*, *Corymbia gummifera* and *E. botryoides*, interspersed with low (< 2 m) open wet heath areas, dominated by *Hakea sericea*, *Acacia sophorae*, *Banksia ericifolia* and *Leptospermum laevigatum* (Booderee National Park Board of Management and the Director of National Parks 2002. *op. cit.*).

We assessed the frog communities and their breeding habitats at 26 sites across the Park. Survey sites were a mixture of open water pond habitats, wet heaths, and drainage lines. White (White, A.W. 1999. Monitoring plan for the Giant Burrowing Frog, Booderee National Park. A report prepared for the Commonwealth National Park Service. Biosphere Environmental Consultants. Sydney, Australia.) identified the majority of sites that we used, although we included additional sites if they appeared to provide suitable habitat for any of the threatened amphibian species in the Park. We surveyed all sites using auditory surveys on two separate occasions separated by a minimum of seven days. We recorded the number of calling males of each species during a 5 min period in each survey. The timing of surveys meant that we would not have recorded two species: *Litoria nudidigitus* and *L. fallax*, which call in the spring and summer (Lemckert and Mahony 2008). Similarly, we did not encounter three species during our auditory surveys that are explosive breeders and only call under certain climatic conditions: *L. freycineti*, *L. dentata*, and *Heleioporus australiacus*. We conducted breeding habitat assessments following the methods of Penman et al. (2005) and Penman et al. (2006a). At each site, we took measurements of the size and depth of the water body, area of open water, aspect, slope, and vegetation within and adjacent to the water body and water body substrate. We estimated (to the nearest meter) the height of the vegetation within and surrounding the water body and the percentage shading of the water body.

We used non-metric multidimensional scaling (nMDS) to represent graphically the amphibian community groupings within Booderee National Park using the Bray-Curtis dissimilarity measure (Bray and Curtis 1957). We then made comparisons between groups that the nMDS identified using an analysis of similarity (ANOSIM; Clarke 1993). We conducted all analyses with the R-package v 2.6.2 (R–Development Core Team. 2007. R: A language and environment for statistical computing. R Foundation for Statistical Computing, http://www.R–project.org. Vienna, Austria. Accessed 21 March 2010) in association with the VEGAN library (Oksanen, J., R. Kindt, and R.B. O'Hara. 2005. Vegan: Community Ecology Package version 1.6–10. http://cc.oulu.fi/~jarioksa/. Accessed 21 March 2010).

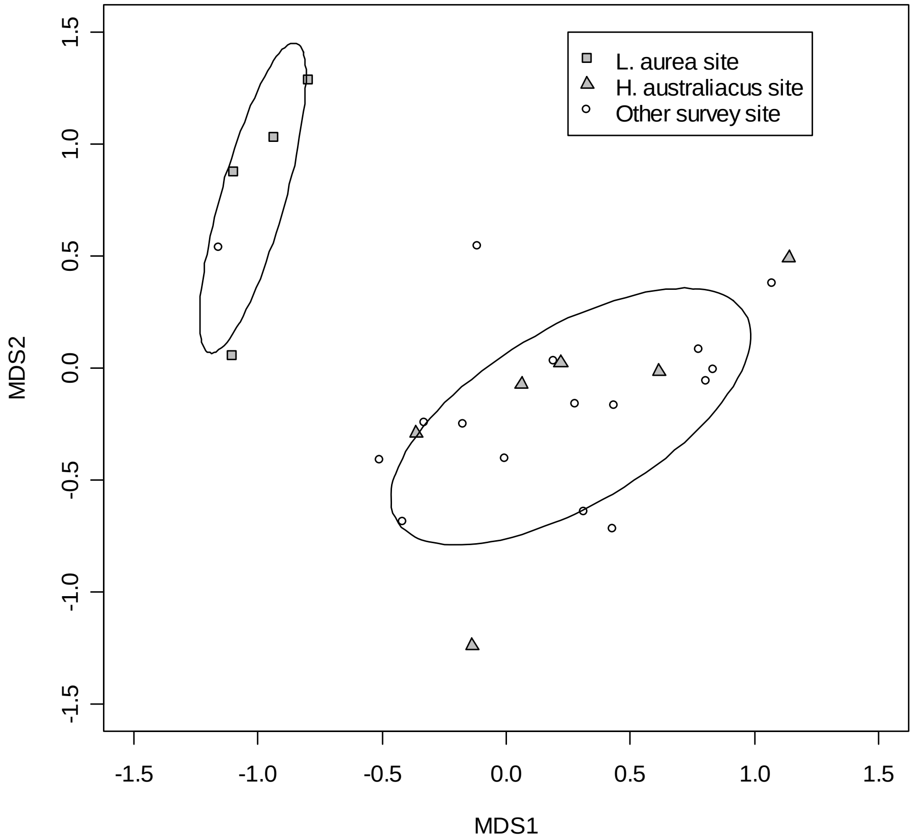

FIGURE 2. Results of the nMDS analysis comparing the recorded frog communities at the 26 survey sites within the Booderee National Park, Australia. Two dimensional stress = 0.07.

RESULTS

We recorded nine species across the 26 sites surveyed. The number of species recorded at each site ranged from one to six (mean = 2.5, median = 2) species. The most prevalent species were *Crinia signifera* (24 sites), *Pseudophyrne bibroni* (18 sites), and *Paracrinia haswelli* (6 sites). Other species recorded during the auditory surveys were *Uperoleia tyleri* (4 sites), *Litoria jervisiensis* (4 sites), *Limnodynastes peronii* (4 sites), *Litoria peronii* (3 sites), and *Limnodynastes dumerilii* (1 site). We made no auditory records of either of the threatened species known to occur in the Park, although we observed a female *Heleioporus australiacus* on a road within the Park during the surveys.

We identified two distinct frog communities in the nMDS (Fig. 2) and ANOSIM (r = 0.779, P < 0.001,). The first group included frog communities characterized by the presence of a range of species including *Litoria peronii, L. jervisiensis, Limnodynastes peronii*, *L. dumerilii*, *Paracrinia haswelli*, *Crinia signifera*, and *Uperoleia tyleri.* The assemblage occurred at five sites that were relatively large wetland/ponds with fluctuating but permanent water. They ranged in size from 50 m by 50 m up to 200 m by 70 m, and all had > 20% open water with some sites up to 95%. All sites occurred in *Eucalyptus pilularis/Corymbia gummifera* forests with a shrubby understorey. The presence of just two species, *Pseudophryne bibronii* and *Crinia signifera*, with the occasional presence of *Paracrinia haswelli*, distinguished the frog communities in the second group. The second group occurred at 21 sites, which were either small ephemeral drainage lines or large areas of low open heath (< 2 m height). These sites were throughout the Park and surrounded by either dry sclerophyll forest or open woodland. Historic sites for the threatened species fell neatly within the two groups with the *Litoria aurea* sites being within the first group and the *Heleioporus australiacus* sites being within the second group (Fig. 2).

DISCUSSION

Two distinct frog communities occurred at the sites surveyed within Booderee National Park. Differences in the communities appear to be related to coarse scale variation in the breeding habitat. Management of the amphibian biodiversity within the Park should focus on ensuring a number of these two broad habitat types are available with varying disturbance histories. Three main threats exist within the Park, the amphibian chytrid fungus (Berger et al. 1998), inappropriate fire regimes (DECC 2007. Ecological consequences of high frequency fires – key threatening process determination. http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Ecological+consequences+of+high+frequency+fires+key+threatening+process+declaration. Accessed 1 June 2008), and introduced predators (Environment Australia 1999a, 1999b), all of which have the potential to impact the ability to conserve amphibian diversity in the long term. Management strategies should be developed that consider these threats (see Muths et al. 2009).

Coarse scale differences in habitat appear to drive the variation in the frog communities at the Park. The two habitat types were large open water wetlands and small drainage lines/wet heath areas. Although *C. signifera* was the only species that occurred at the majority of the sites in both habitat types, the remaining species were largely restricted to one habitat. *Pseudophryne bibronii* was the main species in the small drainage line/wet heath areas. This species constructs nests in moist areas of leaf litter or under rocks and logs that hatch following rains when they get washed into small streams (Anstis 2002). Such habitats are not available around the large wetland areas. *Heleioporus australiacus*, which occurs in several of these sites, lay eggs under dense vegetation or in burrows (Harrison 1922; Mahony 1993) that flood following heavy rain. Breeding habitats within this group of sites are consistent with reports of breeding habitat for *H. australiacus* from elsewhere (Littlejohn and Martin 1967; Daly 1996; Penman et al. 2006a). *Crinia signifera* is an extremely versatile species, which is able to occupy both moist sites and open water wetlands, and it is not surprising that it occurs in all habitat types (Cogger 2000; Anstis 2002). Species that occurred in the large wetland areas, such as *Litoria aurea*, *L. peronii*, *Limnodynastes dumerilii*, and *Paracrinia haswelli* require open water to lay their eggs and for the tadpoles to complete development (Anstis 2002). The large wetland areas have similar habitat characteristics to published reports of breeding habitat for *Litoria aurea* throughout its range (e.g., Pyke and White 1996; Hamer et al. 2002; Goldingay and Newell 2005a, b)

Due to the close relationship between frog communities and habitat features, we recommend that management of the Park should ensure that management actions affect only a subset of each of these habitat types at any one time. This is particularly relevant for the two threatened amphibian species in the Park. Each of the threatened species is associated with one group of sites and there is imperfect knowledge about each species' distribution within the Park. The Park conducts routine monitoring for both these species. However, *H. australiacus* is a cryptic species that is difficult to detect as it is only active under certain climatic conditions (Penman et al. 2004; Penman et al. 2006b). In contrast, *L. aurea* is relatively easy to detect in sites where it occurs, but has not been seen for a number of years in the Park despite a routine monitoring program (Nick Dexter, pers. comm.).

One of the significant challenges facing Booderee National Park, and indeed most natural areas within Australia, is the management of fire regimes (*sensu* Gill 1975). Currently, the park manages fire for the protection and promotion of ecological assets and the protection of human assets and life. Despite active fire management strategies (Booderee National Park Board of Management and the Director of National Parks. 2002. *op. cit*.), wildfires will still occur within the Park. The impact of both wildfire and prescribed fire on Australian amphibians is poorly understood, with only a handful of studies conducted (Bamford 1992; Corbett et al. 2003; Woinarski et al. 2004). These studies suggest that individual species may be sensitive to the season and intensity of the burn (Driscoll and Roberts 1997; Corbett et al. 2003; Penman et al. 2006c), but at the community level fire may not be a major factor (Lemckert et al. 2004). The maintenance of a broad-scale fire mosaic across the Park is desirable for maintaining biodiversity (Bradstock et al. 2005), although large wildfire events have the potential to simplify such a mosaic. Recent wildfires (2001, 2003) do not appear to have reduced amphibian diversity at the sites considered in this study (White. 1999. *op. cit*.), but further research is needed. Such research is particularly important as predictions indicate that global climate change is likely to result in more frequent and intense fires (Hennessy et al. 2005).

Introduced mammalian predators are a threat to biodiversity throughout Australia. These risks have been recognized with "Predation by feral cats" and "Predation by the European red fox (*Vulpes vulpes*)," both being listed as key threatening processes under the Commonwealth *Environmental Protection and Biodiversity Conservation Act* 1999. The impacts of introduced predators on amphibians in Australia is largely unknown (e.g., Penman et al. 2004) with two threatened anuran species being listed as under threat by feral cats (Environment Australia 1999a), including *L. aurea*, and only one by the European Red Fox (Environment Australia 1999b). Currently, the Park has a comprehensive fox control program (Booderee National Park Board of Management and the Director of National Parks. 2002. *op. cit*.). Cats are also thought to occur in or around the Park, albeit at low numbers. Studies have been initiated to examine the density of both these predators throughout the Park in order to improve feral predator control in the Park. Provided the existing programs continue, it is unlikely that introduced predators will have a significant impact on the amphibian diversity within the Park.

Perhaps the most serious threat to amphibian diversity within Booderee National Park is infection by the chytrid fungus, *Batrachochytridum dendrobatidis*. This fungus has been linked to amphibian declines and extinctions worldwide (Berger et al. 1998; Lips et al. 2004). As a result, "Infection of Amphibians with Chytrid Fungus Resulting in Chytridiomycosis" is a key threatening process (Australian Government Department of the Environment and Heritage 2006). There are records of infected amphibians along the east coast of Australia, including the Jervis Bay area (Kriger et al. 2007) suggesting that the chytrid fungus may already be in the Park. Little is known about the nature of *B. dendrobatidis* infection on wild populations, beyond extinctions. Some recent studies suggest that populations of some species can survive with some level of infection (e.g., Burgin et al. 2005; Kriger and Hero 2006; Penman et al. 2008). There are no known management approaches for the control of chytrid fungus, which means Park mangers can only continue to provide large areas of habitat for amphibians and hope for the maintenance of diversity.

Amphibian communities in Booderee National Park fell into two broad groupings based on habitat type. Management of the Park requires consideration of not only conservation goals, but also a range of other competing land uses. Existing management strategies for fire and introduced predators appear to have maintained amphibian diversity at the sites (White. 1999. *op. cit*.) over a nine year period. Chytrid fungus represents the major threat to species at the sites; however, in the absence of any control mechanisms, conservation managers are unable to combat its effects.

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