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Feline Encounters Down Under: Investigating the Activity of Cats and Native Wildlife at Sydney's North Head

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Simple Summary: Cats are a common sight across Australia, freely roaming not only through urban areas but also within natural habitats, including protected areas like national parks. This unrestricted movement raises concerns due to potential impacts on native wildlife populations. North Head, Manly, located in New South Wales, serves as a prime example, boasting a rich biodiversity that includes endangered populations of Long-nosed Bandicoots and Little Penguins. Recent observations by wildlife officers within Sydney Harbour National Park and the North Head Sanctuary highlighted the presence of cats, prompting a deeper investigation into their spatial and temporal distribution. Cameras were installed across the headland over a five-week period to capture cat and native fauna activity. Cats were frequently observed at the interface with the urban area of Manly. Moreover, cat activity primarily occurred during the night, coinciding with periods of heightened native mammal activity. These findings underscore the potential for direct and indirect interactions between cats and native wildlife within the headland, with implications for species conservation efforts. This study emphasises the importance of implementing proactive management strategies to mitigate the potential impact of feline predation on local biodiversity while also highlighting the need for further research in this area.

Abstract: Cats (*Felis catus*) are widespread across Australia, including within natural and protected areas, and in many areas, cats, including owned domestic cats, are not restricted in where or when they can roam. In Australia, cats have contributed to the decline of many native species and continue to be a problem for governments. North Head, Manly, is home to an endangered population of Long-nosed Bandicoot (*Perameles nasuta*) and the only mainland breeding colony of Little Penguin (*Eudyptula minor*) in New South Wales (NSW). Camera traps were installed for a 5-week period across North Head to determine the spatial and temporal distribution of cat activity. As well as capturing instances of cats, the cameras detected native animals such as birds, possums, Long-nosed Bandicoots and other small mammals. An analysis of the camera images showed cats could be found within protected areas of the headland (where cats are prohibited) and along the boundary with the adjacent suburban area of Manly. Cats were mostly detected during the night. There were high occurrences of overlap between cats and Long-nosed Bandicoots (Dhat 0.82), possums (Dhat 0.88) and other small mammals (Dhat 0.67). These findings indicate that cats are active across the Manly headland at the same time as native animals, both within protected areas where cats are prohibited and in adjacent residential areas, and this could have implications for these populations.

Keywords: *Felis catus*; free-roaming; containment; camera trap; wildlife; conservation

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1. Introduction

Cats are popular companion animals in Australia and are also widespread across the continent, including within natural and protected areas. Australian wildlife, particularly small mammals, are uniquely vulnerable to cat predation. Cats are thought to

2. Materials and Methods

2.1. Setting

This study was conducted at North Head in NSW, Australia. The suburb of Manly has a population of approximately 83,208 people in 35,282 private dwellings with a density of approximately 5496 people per square kilometre (83,208/15.43 km^2) [16].

North Head includes a variety of land tenures (Figure 1). Cats are prohibited within the Sydney Harbour National Park and North Head Sanctuary (managed by the Sydney Harbour Federation Trust), which are adjacent to the residential area of Manly and include sclerophyll forest and littoral rainforest remnants and coastal areas. There are no residential dwellings within the Sydney Water Treatment Plant. The coastal areas are made up of small shrubs and heath that lead into sandy beaches and tall cliffs on the east and south faces of the headland. The headland includes the largest extant occurrence of the Eastern Suburbs Banksia Scrub, a critically endangered ecological community [17–19].

Figure 1. Map detailing the different land tenures at North Head, including the Sydney Harbour National Park and North Head Sanctuary (managed by the Sydney Harbour Federation Trust), where cats are prohibited. Numbered white dots indicate where monitoring cameras were located.

captured 60 s or longer apart from the previous event, and this counted as one observation. The events were counted, with any unidentifiable images and those with missing data removed. A clean dataset was compiled into a csv. file by camera number, date, time and tag.

After a simple count of the data, the overlap package in R Studio was used to determine the coefficient of overlapping of 'CAT' and 'BAN', 'POS', SMLMAM' and 'BIRD'. The Dhat4 estimator was used due to the large sample sizes.

Using all the images tagged 'CAT', individual cats were identified and monitored across all cameras. Cats were identified via their body markings by B.P.AK. Cats that were unable to be identified were listed as 'Unknown' and not counted as individuals in case the cat was captured elsewhere. Therefore, the number of individual cats presented is the minimum number of cats in the area at the time the research was conducted. Cats wearing collars or of identifiable breeds were also noted. The breed was determined by a visual appraisal of images by G.C.M. Occupancy modelling in R Studio was used to predict the occupancy and detection rates of cats within the national park.

An ANOVA statistical analysis was run to determine any difference between the number of cats seen on the different cameras.

3. Results

A total of 171,669 camera trap images captured 23,218 true events (Table 2) and 34,005 NIL or UNK events over 963 trap nights. Of the 23,218 events, 34% (n = 8134) were animals tagged under the 10 categories (Figure 2), and the remaining 66% (n = 15,268) were humans (Table 2).

(a) (b)

Figure 2. Images of wildlife: (a) Long-nosed Bandicoot (BAN) and (b) Brushtail Possum (POS) captured on camera at North Head, Manly.

Table 2. Number of events by species recorded on camera traps at North Head, Manly, NSW.

Camera	Land Tenure	BAN	BIRD	CAT	DDOG	ECH	FOX	HUMN	LIZ	POS	RAB	SMLMAM	Total	Trap Nights
1	NBC	123	354	1	13	1	0	21	0	40	87	8	648	56
2	NBC	34	219	15	0	0	0	2	0	47	29	20	366	56
3	SPCCM	119	129	2	0	1	0	2	1	3	584	1	842	56
4	SHNP	31	98	11	15	0	2	2914	0	268	134	2	3475	44
5	SHNP	4	56	0	14	0	0	2728	0	2	12	1	2817	41
6	NBC	1	60	2	8	0	0	44	0	3	21	0	139	56
7	ICMS	3	102	0	0	0	0	19	0	3	44	2	173	56
8	NBC	51	796	0	0	0	0	1	0	45	5	0	898	56
9	NBC	25	173	0	0	0	0	9	0	16	214	3	440	42
10	SHNP	0	1	0	1	0	0	1072	0	0	0	0	1074	8

Table 3. Individual cat events and the number of times each cat was observed per camera.

Camera	Land Tenure	Cats Prohibited?	Cat 1 # DSH	Cat 2 Unknown	Cat 3 DSH	Cat 4 # Burmese	Cat 5 # Ragdoll	Cat 6 DSH	Cat 7 Burmese	Cat 8 DSH	Cat 9 # Unknown	Cat 10 DSH	Cat 11 * Bengal	Unknown ^	Total
1	NBC	No						1							1
2	NBC	No	2	1	12										15
3	SPCCM	No										2			2
4	SHNP	Yes			2	6	2	1							11
5	SHNP	Yes													0
6	NBC	No											2		2
7	ICMS	No													0
8	NBC	No													0
9	NBC	No													0
10	SHNP	Yes													0
11	SHFT	Yes				3									3
12	SHNP	Yes				2								1	3
13	SHFT	Yes				2									2
14	SHFT	Yes							3						3
15	SHFT	Yes							1						1
16	SHFT	Yes				1									1
18	SHFT	Yes													0
19	SHFT	Yes													0
20	ICMS	No					1			4	1				6
Total			2	1	14	14	3	2	4	4	1	2	2	1	50

'DSH' (domestic shorthair), 'NBC' (Northern Beaches Council), 'SPCCM' (St Paul's Catholic College, Manly), 'SHNP' (Sydney Harbour National Park), 'ICMS' (International College of Management Sydney), 'SHFT' (Sydney Harbour Federation Trust), # Cats wearing collars. * Cats controlled by humans, i.e., on a lead. ^ Cat image that was too indistinct to identify individually.

(a)

(b)

Figure 5. View from (**a**) camera 2 and (**b**) camera 4, which detected the most cat events of 19 cameras distributed across North Head, NSW, Australia.

Cats were recorded at or between dusk and dawn, with peaks in cat activity recorded around 6.00 p.m. and 2.00 a.m. and a small peak at 12.00 p.m. (Figure 6). This temporal cat activity was plotted against wildlife and human observations to calculate the overlap (Figure 7). No analyses were possible for echidnas and lizards due to the small numbers observed. Long-nosed Bandicoot, possum and small mammal overlaps were high (Dhat 0.67, 0.68 and 0.67, respectively) with an overlap from dusk until dawn. The overlap of bird and human was low (Dhat 0.3 and 0.19, respectively), with most of the overlap occurring at dusk and dawn. One cat (Cat 7) was observed on camera 14 carrying something presumed to be a small- to medium-sized mammal—possibly a Long-nosed Bandicoot or rabbit—in its mouth (Figure 8).

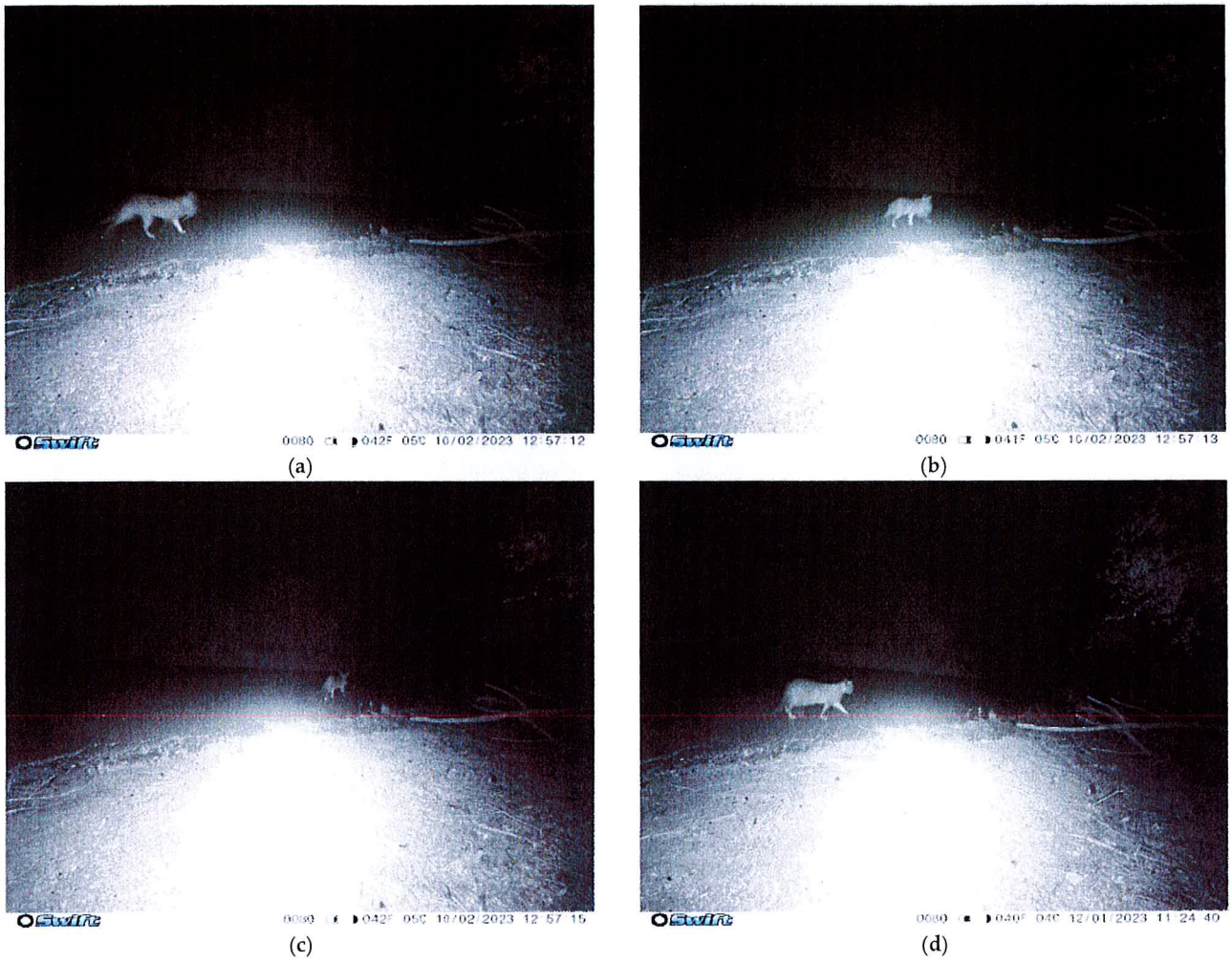

Figure 8. (**a**–**c**) Cat 7 with prey, presumed to be a Long-nosed Bandicoot or rabbit, captured on camera 14 at 1 a.m. within the North Head Sanctuary, Manly, NSW; and (**d**) the same cat two days prior in the same location without prey for comparison.

4. Discussion

This study demonstrates the presence of multiple cats within critically important wildlife habitats on North Head, including within the Sydney Harbour National Park and North Head Sanctuary, where cats are prohibited. Several of the cats were observed wearing collars or were of identifiable breeds, and cats were most often detected using walking trails close to residential areas, suggesting that most, if not all, of the observed cats within the protected areas were owned pet cats roaming from adjacent suburban Manly. The time and location that the cats were observed overlapped with the activity of native animals known to be vulnerable to cat predation, such as Long-nosed Bandicoots, possums and other small mammals, with peaks in activity around dusk and in the early morning. While cats were the focus of this study, they were detected less frequently than foxes—another important introduced predator—and far less frequently than humans, and as such, their impact should be considered in proportion to the other interconnected threats to biodiversity on North Head.

Several cats were observed deep within the state and federally protected areas, including cats wearing collars, confirming that at least some pet cats roam long distances from home to access these areas. Of the five potential corridors cats might have used to access the protected areas of the headland, cats were more often detected using the walking

The biodiversity of North Head is subject to multiple and complex environmental threats, of which cats are only one. As noted by Brook, Sodhi and Bradshaw (2008) [38], environmental threats can interact to have worse conservation outcomes than simply adding the individual impacts. Ongoing habitat destruction and fragmentation are the primary drivers of contemporary extinctions [38]. Meanwhile, the impacts associated with invasive predators have been recognised to exacerbate the impacts of land clearing, grazing and fire [39]. As generalist mesopredators, cats are better suited to fragmented habitats than larger predators and their impacts can be amplified in environments where larger predators (e.g., dingoes) are no longer present [40]. Resource subsidies by humans (i.e., well-fed pet cats) can also facilitate human-mediated hyperpredation; owned domestic cats are no longer subject to home-range restrictions and competition for territory due to hunger; hence, there is no limit to the number of cats they can "support" [39]. Predation and fear effects caused by cats across North Head cannot be considered in isolation. Their impacts compound the ongoing habitat loss and fragmentation occurring on the headland, as well as threats from high levels of human activity and the impacts of other invasive predators such as dogs and foxes. As such, it is important to understand how threats interact to understand the conservation risks and determine appropriate management strategies [41].

Understanding which sub-populations of cats are roaming within protected areas of North Head has important implications for designing interventions to reduce their potential impacts. Approaches to managing owned domestic cats—the cat subpopulation most likely represented in this study—are different from those required to manage unowned or feral populations [42]. Containment of pet cats to their caregiver's property in NSW (the state where Manly is located) has steadily increased over several decades [43]. In addition, there is a growing evidence base on the design and implementation of cat caregiver behaviour change approaches to increase cat containment and reduce roaming [43–45]. However, evidence of their efficacy is limited. Previous research has indicated that individual cats vary considerably in their roaming and predation behavior [46,47]. Individual cats can also become specialist predators of a particular prey species and have been implicated in local extinctions [11]. As such, wildlife impacts associated with pet cats might not decrease without achieving very high rates of containment. Cats are already prohibited within Sydney Harbour National Park under the *National Parks and Wildlife Regulation 2019*. There are also prohibitions on cat and dog ownership imposed by the Sydney Harbour Trust on leasees of their properties at North Head. A similar restriction applies to the residents within the Spring Cove development to the North of Collins Beach. However, there are limited legislative provisions available to restrict cats from roaming within adjacent residential areas. As this study demonstrates, those residential areas also provide important habitat for endangered species, including the Long-nosed Bandicoot (*Perameles nasuta*). Increasing regulation of owned domestic cats roaming away from their caregiver's property and increasing resourcing of enforcement of cat regulations might be required to reduce the roaming of cats observed in this study, especially to reduce the impacts associated with individual high-risk cats such as cats 4 and 7. Our findings suggest that enforcement activities would be most effective if they prioritized identifying the small number of individual high-impact cats and working with their caregivers to keep them contained. However, further research into the efficacy and potential unintended consequences of such regulation is urgently needed.

The reliance on camera traps in this study has associated limitations. The cameras most likely did not capture every cat event at each camera location, and the cameras only covered a small fraction of North Head. This study was only conducted over a 3-month period; a longer deployment or camera deployment at other times of the year might have yielded different results. In addition, all images were manually tagged, introducing the potential for human error. Further research that incorporates other techniques, such as transects, spotlighting and scat testing, would be beneficial. The use of tracking or video collars on owned cats could also be enlightening and might additionally influence cat caregiver behaviour change.

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