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A review of vegetation associated with records of the Masked Owl *Tyto novaehollandiae* in north-eastern Queensland

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Abstract. In north-eastern Queensland, the Masked Owl *Tyto novaehollandiae* is a rare and taxonomically complex species in apparent decline. It has typically been recorded in open sclerophyll forest and woodland, often adjacent to cleared areas, but current records suggest a patchy distribution. We used all available high-veracity records of the Masked Owl in north-eastern Queensland to examine habitat associations based on regional ecosystem data, and present a spatial model of its potential distribution within the Cape York Peninsula, Wet Tropics and Einasleigh Uplands bioregions. We conclude that the currently disjointed distribution is probably because of a lack of systematic surveys and that this species might be more widespread than previously thought.

Introduction

The successful conservation and management of any species requires information about habitat preferences and spatially explicit predictions about where it does, or might, occur. Masked Owls *Tyto novaehollandiae* occurring in north-eastern Queensland are considered scarce, poorly known and in apparent decline (Garnett *et al.* 2011). Previous descriptions of Masked Owl habitat in north-eastern Queensland are disparate, and include open sclerophyll forest and woodland, or isolated stands of large trees within clearings, with either sparse or dense ground-cover (Debus 1993, 2012; Fitzsimons & Rose 2008; Debus & Searle 2014). Descriptions also include areas adjacent to remnant woodland including cleared areas, grassland, heath or sugarcane fields (Hollands 1991, 2008; Young & de Lai 1997; Garnett *et al.* 2011; Debus 2012).

The taxonomic treatment of Masked Owls in north-eastern Queensland is contentious, complex and potentially hampering the ability to conserve and manage the species. Some authorities treat the north-eastern Cape York Peninsula population as Cape York Masked Owl *T. n. galei*, with those on southern Cape York Peninsula and the Atherton Tablelands (as well as in north-western Australia) as Northern Masked Owl *T. n. kimberli* (Mees 1964; Clements *et al.* 2019; Bruce & Marks 2020). Others consider *T. n. galei* inseparable from *T. n. kimberli*, preferring to treat all populations on Cape York Peninsula as the latter (Schodde & Mason 1980; Higgins 1999; Woinarski 2004; Garnett *et al.* 2011; Gill *et al.* 2020), while Mason (1983) argued that all populations on Cape York Peninsula were morphologically distinct from *T. n. kimberli* of north-western Australia, and subsequently reinstated *T. n. galei*.

Adding to the uncertainty is an unclear understanding of the northern limit of the Southern Masked Owl *T. n. novaehollandiae*, which ranges, according to different authorities, as far north as south-eastern Queensland (Higgins 1999), Townsville (Schodde & Mason 1980; Clements *et al.* 2019), or the Daintree (Schodde & Mason 1997). With *T. n. galei* or *T. n. kimberli* yet to be sampled in genetic studies to clarify their taxonomic status (Uva *et al.* 2018), biogeographical approaches have attempted to imply distributional delineations. Schodde & Mason (1980) proposed the possibility of an abrupt intergradation zone of *T. n. kimberli* and *T. n. novaehollandiae* at the foot of the Cape York Peninsula, between the Torresian Barrier and Burdekin Basin (Gap). Ford (1986) suggested that either a potential range gap exists between *T. n. galei* and *T. n. novaehollandiae*, or birds intermediate between these taxa remain uncollected, perhaps extant on the northern margin of the Burdekin-Lynd Divide.

Despite taxonomic and distributional uncertainties, the conservation status of the Masked Owl (i.e. *T. n. galei*, *T n. kimberli*) in north-eastern Queensland remains consistent, with the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the Queensland *Nature Conservation Act 1992* recognising a single taxon (i.e. *T. n. kimberli*) and listing it as Vulnerable (Department of Agriculture, Water & the Environment 2020; Department of Environment & Science 2020).

For the purposes of this study, we have tried not to assume knowledge of subspecific distributions but consider habitat associations of historical Masked Owl records within three bioregions that encompass the generally accepted distribution of Masked Owl taxa in north-eastern Queensland: the Wet Tropics, Einasleigh Uplands and Cape York Peninsula. We collated all available high-veracity records of Masked Owl within these bioregions to determine if records were associated with specific regional ecosystem (RE) classifications (Neldner *et al.* 2019). In order to inform future survey effort, we developed a spatial model of the potential distribution of Masked Owl populations in north-eastern Queensland.

Methods

Study area

The study area included in this review is predominantly based around bioregions defined in the Interim Biogeographic Regionalisation for Australia (IBRA) (Thackway & Cresswell 1995). The three IBRA bioregions selected in this review [Cape York Peninsula (CYP), Wet Tropics (WET) and Einasleigh Uplands (EIU)] include those encompassing the distribution of Masked Owl taxa (i.e. *T. n. kimberli* and/or *T. n. galei*) in north-eastern Queensland (e.g. Mees 1964; Mason 1983; Ford 1986; Schodde & Mason 1997; Higgins 1999; Woinarski 2004) (Figure 1). Bioregions to the west and south of these selections were excluded, because of insufficient regional Masked Owl records of determinable veracity, and lack of knowledge as to whether Masked Owls occur through the Gulf Plains bioregion. The Gulf Plains bioregion contains the 'Carpentaria' barrier, a recognised divide separating species on Cape York Peninsula from the Top End region (Edwards *et al.* 2017). With no definitive records of Masked Owls from the Gulf Plains bioregion, this barrier thus provides an appropriate western boundary of the study area (Figure 1).

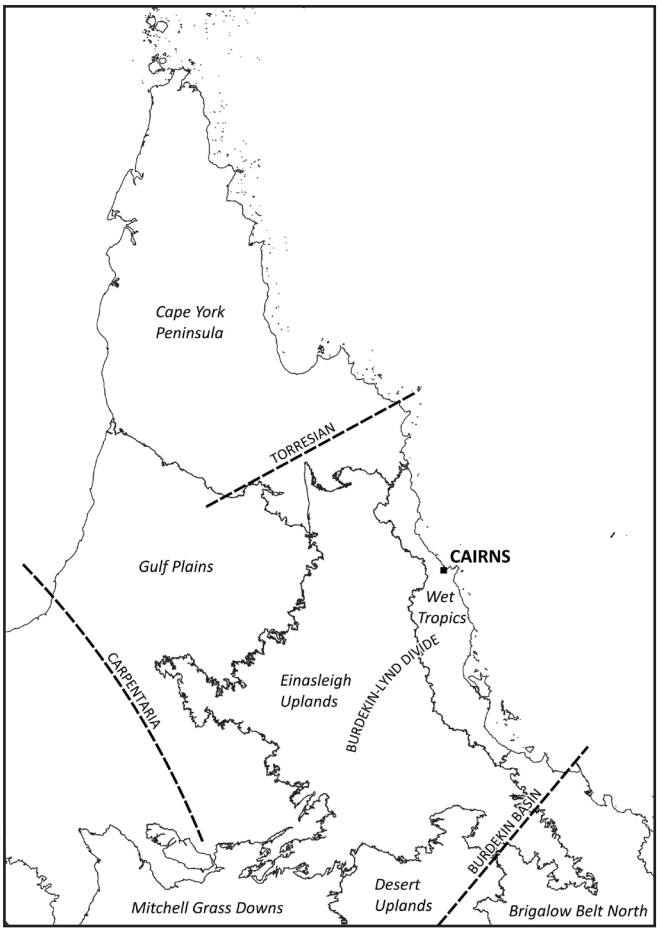

Figure 1. Bioregions and biogeographical barriers relevant to the distribution of the Masked Owl in north-eastern Queensland.

Nature of occurrence records

Masked Owl records were sourced from online databases, as well as published reports and journal articles. Online database records were sourced from OZCAM (Online Zoological Collections of Australian Museums 2019), WildNet (Queensland Government 2019), Birdata (BirdLife Australia 2019b) and eBird (Sullivan *et al.* 2009) for all dates up until 30 June 2019. From these sources, 96 records of the Masked Owl were collated.

The Masked Owl occurs sympatrically with the superficially similar Eastern Barn Owl *T. alba delicatula* throughout its range, including north-eastern Queensland, and records of each species are often mistakenly attributed to the other (Higgins 1999). To ensure that the records used in this study were Masked Owl, each of the 96 records was qualitatively assessed for spatial accuracy and available corroborating evidence, the latter including museum specimens, photographic evidence, or adequately described encounters relating to either the physical appearance of the owl, or its vocalisations. Of these, 16 records had sufficient spatial accuracy and corroborating evidence to be treated as high-veracity records; 80 were considered plausible, but lacked available corroborating evidence, and were treated as undetermined-veracity records. The temporal range of the high-veracity records spanned from 1905 to 2020, with eight of these records post-2000.

Spatial data

Masked Owl high-veracity records were converted to a shapefile using QGIS 3.6.3 (QGIS Development Team 2018). Regional ecosystem (RE) data were examined from the dataset Biodiversity Status of 2017 Remnant Regional Ecosystems – Queensland (Department of Environment & Science 2018). Regional ecosystems combine three major attributes: bioregions, land zones (geology, soils and landforms), and vegetation community (Neldner *et al.* 2019). REs are represented as three-digit, alpha-numerical, identification codes reflecting these attributes.

In order to generate a list of RE associations, a buffer with a radius of 500 m was created for all locations of high-veracity records. This radius was selected to allow all REs surrounding records centred on roads or cleared areas (e.g. paddocks) to be easily captured. The aim of the buffer was not to encompass the entire home-range of an individual Owl but to intersect and identify any REs within the immediate vicinity of a record. We expected that most captured REs fell within a home-range of a Masked Owl and therefore comprised potentially suitable habitat, but accepted that some captured REs were perhaps rarely, if ever, used purposefully by the Owls. RE identification codes were linked to the Regional Ecosystem Description Database (Queensland Herbarium 2019) to extract attributes of vegetation communities.

All REs intersecting or contained by a 500-m buffer were classified as primary associations, which were considered to most accurately represent areas of potentially suitable habitat for the Masked Owl. To complement the primary associations, REs that did not occur within a 500-m buffer but shared similar attributes (e.g. vegetation community)

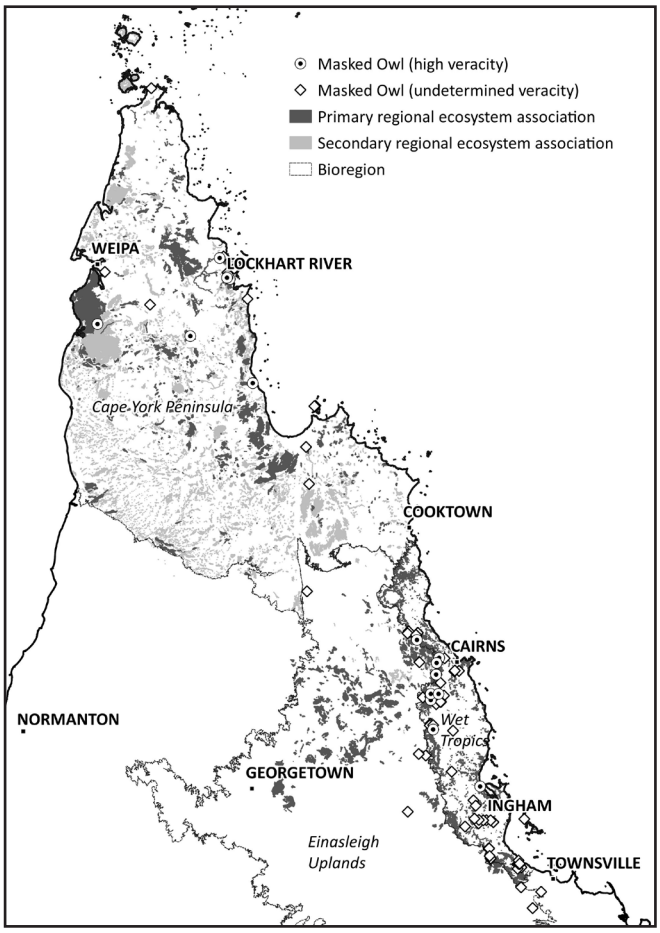

Figure 2. Regional ecosystems associated with high-veracity Masked Owl records in the Cape York Peninsula, Wet Tropics and Einasleigh Uplands bioregions.

were mapped as secondary associations. For example, a primary association with RE code of 3.3.31a would generate a secondary association of 3.3.31 (if this RE were not already a primary association) indicative of a similar vegetation community, and therefore potentially suitable for the Masked Owl. All resulting primary and secondary association polygons were extrapolated across bioregions.

Results

A total of 55 REs occurred within the 500-m buffer of the 16 high-veracity Masked Owl records. The conservation status and threats to each RE are listed in Table 1. Primary and secondary RE associations are shown in Figure 2.

The dominant trees at Masked Owl locations varied across bioregions (Table 2). Those consistently present at Owl locations throughout the bioregions included Clarkson's Bloodwood *Corymbia clarksoniana*, Moreton Bay Ash *C. tessellaris* and Broad-leaved Paperbark *Melaleuca viridiflora*. Some species were most dominant at the regional level [e.g. Darwin Stringybark *Eucalyptus tetrodonta* in the Cape York Peninsula (CYP), Forest Red Gum *E. tereticornis* in the Wet Tropics (WET) bioregion: Table 2).

Table 1. Primary regional ecosystem (RE) associations of the Masked Owl in north-eastern Queensland, listed by vegetation management (VM) class, biodiversity (BD) status and associated threatening processes.

Vegetation management class and biodiversity status	*Associated threatening processes*
Endangered	
VM class: 7.8.3a BD status: as VM class; plus 3.3.57, 7.3.26a, 7.3.43a, 7.8.7a, 7.8.15a	Habitat fragmentation, weed invasion
Of concern	
VM class: 3.3.57, 3.5.21, 7.3.14a, 7.3.14b, 7.3.19a, 7.3.21a, 7.3.26a, 7.3.43a, 7.3.49a, 7.8.7a, 7.8.15a, 7.8.18a, 7.11.44 BD status: as VM class except those listed 'Endangered'; plus 7.11.35a, 9.3.3c	Residential development, weed invasion, vine-forest invasion
No concern at present/Least concern	
VM class: 5.38, 3.5.39, 3.5.42, 3.7.4, 3.11.1, 3.11.3, 3.12.3b, 3.12.8, 3.12.11, 3.12.40, 3.12.45, 3.12.47, 7.3.5a, 7.11.5c, 7.11.21a, 7.11.35a, 7.12.22a, 7.12.24a, 7.12.34, 9.3.3c, 9.5.9b, 9.5.15a, 9.11.4a, 9.11.7a, 9.12.7a BD status: as VM class except 7.11.35a, 9.3.3	

Associations with vegetation by bioregion

1. Cape York Peninsula (CYP)

Within the CYP bioregion, records were predominantly associated with REs comprising low to tall open woodland or forest dominated by Darwin Stringybark ± Clarkson's Bloodwood ± New Guinea Bloodwood *Corymbia novoguinensis* ± Blotchy Bloodwood *C. stockeri* ± Melville Island Bloodwood *C. nesophila* ± Moreton Bay Ash ± Broad-leaved Paperbark. Primary RE associations are distributed throughout CYP (Figure 2). Non-remnant/cleared vegetation was associated with one high-veracity record (Table 2).

2. Wet Tropics (WET)

Within the WET bioregion, records were predominantly associated with REs comprising low to tall open woodland or forest dominated by Forest Red Gum ± Narrow-leaved Ironbark *E. crebra* ± White Mahogany *E. acmenoides* ± Poplar Gum *E. platyphylla* ± Molloy Red Box *E. leptophleba*

Table 2. Dominant woodland tree species (listed in >10% of identified REs) linked to primary RE associations for the Masked Owl in north-eastern Queensland. Bioregions: CYP = Cape York Peninsula, WET = Wet Tropics and EIU = Einasleigh Uplands.

	Bioregion		
	CYP	*WET*	*EIU*
No. Owl records (high-veracity/undetermined-veracity)	7/8	8/61	1/11
No. REs associated with high-veracity Owl records	22	23	3
	% of REs containing listed tree species		
Eucalyptus			
White Mahogany *E. acmenoides*		22	
Narrow-leaved Ironbark *E. crebra*		26	
Cullen's Ironbark *E. cullenii*			33
Granite Ironbark *E. granitica*		13	
Molloy Red Box *E. leptophleba*	14	22	100
Yellow Box *E. melliodora*			
Poplar Gum *E. platyphylla*		22	100
Forest Red Gum *E. tereticornis*		43	33
Darwin Stringybark *E. tetrodonta*	36		
Corymbia			
Lemon-scented Gum *C. citriodora*		17	
Clarkson's Bloodwood *C. clarksoniana*	55	26	100
Dallachy's Gum *C. dallachiana*		22	67
Pink Bloodwood *C. intermedia*		39	33
Melville Island Bloodwood *C. nesophila*	18		
New Guinea Bloodwood *C. novoguinensis*	27		
Blotchy Bloodwood *C. stockeri*	18		
Moreton Bay Ash *C. tessellaris*	18	26	67
Melaleuca			
Karnbor *M. dealbata*			33
Broad-leaved Paperbark *M. viridiflora*	45	13	33
No. high-veracity records associated with non-remnant or cleared habitat	1	7	1

± Clarkson's Bloodwood ± Dallachy's Gum *C. dallachiana* ± Pink Bloodwood *C. intermedia* ± Moreton Bay Ash. Primary RE associations are distributed throughout WET (Figure 2). Non-remnant/cleared vegetation was present within the 500-m buffer of seven of eight high-veracity records (Table 2).

3. Einasleigh Uplands (EIU)

Only a single high-veracity record was determined within the EIU bioregion. This record was associated with REs comprising woodland dominated by Molloy Red Box ± Poplar Gum ± Forest Red Gum ± Clarkson's Bloodwood ± Dallachy's Gum ± Moreton Bay Ash ± Pink Bloodwood ± Karnbor *Melaleuca dealbata* ± Broad-leaved Paperbark. Primary RE associations are located along the eastern boundary of EIU and patchily towards Georgetown (Figure 2). Non-remnant/cleared vegetation was also associated with the record (Table 2).

Discussion

In this paper, we have summarised REs associated with records of the Masked Owl in north-eastern Queensland, and presented a map of potential distribution. By doing so, we provide an indication about where Masked Owls might occur in the Cape York Peninsula (CYP), Wet Tropics (WET) and Einasleigh Uplands (EIU) bioregions regardless of taxonomic uncertainties.

The association of Masked Owl records with non-remnant REs (Table 2) supports earlier assertions of the species occurring in fragmented and/or open landscapes, with such areas potentially being important to the Owls' hunting success (Hollands 1991, 2008; Debus 1993). However, it should be stressed that some form of remnant woodland was also associated with all records, and the Owls' persistence in an area is probably dependent on the availability of such habitat (Debus 1993).

There was also no attempt in this review to describe vegetation used specifically for roosting or nesting, although it is likely that several tree species listed in

Table 2 are used for these purposes. The Forest Red Gum, which was linked to 43% of REs associated with Masked Owl records in the WET, is a known nest-tree for this species (Hollands 2008).

Most REs associated with Masked Owl records are currently of low conservation concern (Table 1). However, some REs present in the CYP, WET and EIU bioregions are of concern or endangered, primarily from invasion by weeds or vine-forest or fragmentation through agricultural or residential development (Queensland Herbarium 2019). Additional threatening processes within the identified REs include loss of the Owl's prey (small mammals) through relatively frequent fires, loss of ground-cover vegetation through grazing, and predation by introduced predators (Perry *et al*. 2015; Legge *et al*. 2019). How Masked Owls may respond to these additional threatening processing within potentially suitable habitat is unknown.

Although most Masked Owl records in this study are from north of the EIU and Burdekin-Lynd Divide (Ford 1986), it is apparent that suitable REs continue to at least the southern extremity of the WET bioregion (Figure 2). Furthermore, high-veracity records, as well as clusters of undetermined-veracity records, occur to a similar extent. Therefore, the distribution of the Masked Owl in the WET bioregion likely extends beyond the Burdekin-Lynd Divide, potentially as far south as the Burdekin Basin. The Burdekin Basin is a noted disjunction in the ranges of some subspecies of birds because of the drier vegetation communities present as a result of reduced rainfall (Edwards *et al.* 2017), but whether this is a subspecific barrier to Masked Owls remains unknown.

Improved documentation of future Masked Owl encounters would improve conservation efforts. Attempts should be made to record locations as spatially accurately as possible (e.g. through the use of GPS). Additionally, records would be further strengthened through photographic and/or sound-recording evidence, as well as a description of the surrounding habitat. When permissible, any Masked Owls found dead should be lodged in museums as comparative material for future taxonomic assessments of Masked Owl taxa.

Despite only high-veracity Masked Owl records being used in this review, spatial coverage was similar to the overall dataset (Figure 2). It is therefore expected that the vegetation associations described are representative of the Owl's habitat associations across its north-eastern Queensland distribution. Based on these associations, we conclude that the currently disjointed distribution of the Masked Owl in north-eastern Queensland, particularly in the CYP bioregion, is probably because of a lack of systematic surveys and Masked Owls might be more widespread than previously thought. Whether this finding ultimately affects the conservation status of Masked Owls in north-eastern Queensland (in particular the *T. n. kimberli*/*T. n. galei* complex) remains to be seen, and any review of their conservation status needs to be underpinned by stratified systematic surveys using proven techniques such as call-playback and focused initially on primary RE associations. Until such work can be undertaken, it is critical that development proponents and environmental regulators consider the habitat model that we have presented here as a precautionary approach, rather than simply considering historical point records in their assessments.

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