The distribution of Long-nosed Potoroo *Potorous tridactylus tridactylus* habitat on the far north coast of New South Wales

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ABSTRACT

The Long-nosed Potoroo *Potorous tridactylus tridactylus* has declined substantially on the far north coast of New South Wales. In this study, the known and potential habitat of the Long-nosed Potoroo on the coastal sandplain in the region is mapped in detail for the first time. A total of 3,613 ha of potential habitat is distributed in 10 areas from 24 ha to 1,423 ha in size. Heathy Scribbly Gum *Eucalyptus signata* woodland was considered to be particularly significant habitat in the region. While there is evidence that eight of the areas mapped once supported potoroos, their presence has only been confirmed in four of them since 2000. Targeted survey at known sites where the Long-nosed Potoroo has not been recently confirmed is urgently required, as well as a thorough reassessment of its conservation status in the region. Ecological research into threats and food preferences, and implementation of targeted conservation management actions is also needed.

Key words: Long-nosed Potoroo, endangered marsupials, mammal conservation, threatened species

Introduction

Potoroids (Marsupialia: Potoroidae) have fared poorly in Australia over the last two centuries. Of the 10 modern species, two are presumed to be extinct and all others have suffered declines, most of them severe (Claridge *et al.* 2007). The Long-nosed Potoroo *Potorous tridactylus* has declined on the Australian mainland (Claridge *et al.* 2007; Johnston 2008; Martin and Temple-Smith 2010; Frankham *et al.* 2012) and there has been a number of local population extinctions (Claridge *et al.* 2007; Martin and Temple-Smith 2010). It is listed as a Threatened species under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and also under State legislation in New South Wales (NSW), Queensland, Victoria and South Australia. One population at Cobaki Lake on the NSW far north coast is listed as an Endangered Population and declines are considered to be occurring elsewhere in the State (Lunney 1989; Mason 1997).

Frankham *et al.* (2012) recommend that the mainland population of the Long-nosed Potoroo be managed as three separate subspecies, including *Potorous tridactylus tridactylus*, the subspecies assigned to its occurrence in southeast Queensland and northeast NSW. The eastern escarpment of the Great Dividing Range in northeast NSW is the stronghold for this subspecies, with a series of relatively regularly spaced populations from the Barrington Tops region to the Border Ranges (Schlager 1981; NPWS 1994). In contrast, along the coastal margin the distribution is extremely fragmented (Schlager 1981), with populations separated by wide gaps. Notwithstanding the limited number of targeted surveys that have been conducted in the coastal margins, between the Richmond and Hunter Rivers there are only four locations where potoroos have been reliably observed: Limeburners Creek, Old Bar, Forster and Port Stephens. In Queensland, mainland coastal populations once occurred on the Gold Coast and Sunshine Coast (Amos 1982), and the species is apparently extant on Fraser Island (Martin and Temple-Smith 2010).

The far north coast of NSW (defined here as the coastal plain north of the Richmond River) may once have been a coastal stronghold for the species. A string of localities where the Long-nosed Potoroo was known to occur span the region, from Wardell on the Richmond River to Cobaki Lake near the Queensland border. Early records from far north coast populations came from a road-kill near Lennox Head in 1971, a juvenile animal killed by a domestic cat at Wardell in 1980 and a pouch young found dead at the same Wardell locality in 1981 (Schlager 1981).

During a terrestrial vertebrate survey of coastal Byron Shire in 1985, three Long-nosed Potoroos (adult male and adult female with young at heel) were trapped at one site (Fig. 1a) in what is now Tyagarah Nature Reserve (Milledge *et al.* 1986; Milledge 1991). The species was also recorded in surveys of the vertebrate fauna of the Cudgen Lake (Fig. 1b) and Brunswick Heads areas in 1988 and 1992 (Milledge 1988; Milledge and McKinley 1992). The ongoing presence of the Cudgen

Figure 1. Long-nosed Potoroos trapped at (a) Tyagarah in 1985 and (b) Cudgen Lake in 1988, and (c) camera-trap photo from Wardell in 2009. Photos, (a) and (b) D. Milledge and (c) M. Andren.

Lake population was confirmed in 2004 (Callaghan *et al.* 2004). However, in 2006 the species was not found in a targeted survey of Cudgen Nature Reserve by Goldingay *et al.* (2006). Following a similar trend, the Brunswick Heads population was confirmed in 2000 (Milledge 2000) and again in 2004, but camera trap surveys in 2009 (D. Scotts unpubl. data 2012) and 2011 (N. Graham pers. comm. 2012) failed to detect the species.

The Long-nosed Potoroo population in Tyagarah Nature Reserve was assessed by Mason in 1992, who estimated a minimum population size of 80-90 individuals within the Nature Reserve (Mason 1997). Mason concluded that the small number of individuals in the population does not "…augur well for its indefinite persistence" (Mason 1997). Parker (2005) also surveyed this population at its southern extent in 2004, when four individuals, including two females were trapped within an area of approximately 12 ha. However, a number of recent surveys in Tyagarah Nature Reserve have failed to detect potoroos; cage trapping in 2009 (Goldingay and Lindsay 2009), and camera traps in 2009 (D. Scotts unpubl. data 2012), 2010 (N. Graham pers. comm. 2012) and 2012 (Lake 2012).

Mason (1993) also carried out a survey of the Long-nosed Potoroo at Cobaki Lake near Tweed Heads after the species had been recorded on Crown land in the area (Warren 1992). A substantial amount of survey and radio-tracking has subsequently been conducted on this population as part of the environmental assessment for the Pacific Highway Tugun Bypass (Bali *et al.* 2003). The size of this small and isolated population was estimated to be 55-85 individuals (Bali *et al.* 2003; Lewis and Freestone 2009). Additionally, Parker (2006) described the presence of suitable potoroo habitat and recorded numerous apparent diggings (P. Parker pers. comm. 2011) at Cobaki Lake during a survey to the west of the Tugun Bypass study area, although a substantial amount of this habitat has now been cleared (D. Milledge pers. obs. 2012). Elsewhere, camera-trap surveys on Jali Local Aboriginal Land Council land from 2009 to 2012 (Graham and Morrison 2009; M. Andren unpubl. data 2012) have confirmed that a population remains extant in the Wardell area (Fig. 1c). However, small scale camera-trap surveys at Lennox Head and Billinudgel in 2012 (80 trap-nights at each location) failed to re-locate potoroos in those areas (M. Andren unpubl. data 2009-2012).

It is important to maintain populations of Long-nosed Potoroos for their valuable role in ecosystem functioning. They are considered to be significant dispersers of hypogeal (underground) fungi species, which in turn are likely to be important for host-plant vigour and survival through their mycorrhizal associations (Malajczuk *et al.* 1987; Claridge *et al.* 1992; Claridge *et al.* 1993; Johnson 1995). Although Long-nosed Potoroos are omnivorous, consuming plant tissue and invertebrates (Bennett and Baxter 1989), the consumption of sporocarps of hypogeal fungi is a large and extremely important component of their diet (Guiler 1971; Langer 1980; Bennett and Baxter 1989; Seebeck and Rose 1989; Claridge *et al.* 1993; Claridge and Cork 1994; Tory *et al.* 1997 Claridge *et al.* 2007). In Victoria, Claridge *et al.* (1993) recorded 58 different fungi species in the diet, with mycophagy prominent in the cooler, wetter months and less important at other times of the year (Claridge *et al.* 1993).

Potoroos locate the sporocarps by smell and use the claws on their forepaws to unearth them, resulting in their characteristic diggings (Fig. 2). Soil quality may be improved through the turnover and aeration from these diggings (Frankham *et al.* 2011). Localised loss of potoroos may therefore be detrimental to ecosystem functioning through the loss of their fungi dispersal role and decreased soil turnover.

Figure 2. Mark Graham examining Long-nosed Potoroo diggings in a dried-out swale in wet heathland in the Ngunya Jargoon Indigenous Protected Area, Wardell in 2013. Photo, D. Milledge.

Knowledge of habitat and its distribution is fundamental to an assessment of the conservation status and management of a species. On the far north coast, the Long-nosed Potoroo generally occurs in heathy woodland or shrubland (Mason 1997). The species rarely moves far from dense vegetation (Kitchener 1973; Bennett 1993; Long 2001) and uses well-defined runways through thick undergrowth and well-hidden "squats" for resting (Kitchener 1973; Seebeck *et al.* 1989; Long 2001). However, it also prefers small patches of open habitat for foraging (Bennett 1993). Structurally diverse microhabitats are therefore characteristic of individual potoroo home ranges (Bennett 1993; Claridge and Barry 2000; Norton *et al.* 2010).

Although there is some knowledge of the habitat occupied by the Long-nosed Potoroo on the far north coast, there are relatively few reliable and spatially accurate records in the region. Modelling the habitat distribution using statistical methods was therefore not considered likely to result in a reliable prediction. Instead, we combined knowledge of the habitat requirements with detailed geological and vegetation mapping (available for many parts of the far north coast), as well as local knowledge of areas occupied by the species to produce a detailed map of potential habitat.

Methods

Study area

The study area comprises part of the coastal plain from Tweed Heads on the NSW / Queensland State border south to the Richmond River and is 87,265 ha in size (Fig. 3).

The natural habitats of the study area have become highly fragmented due to vegetation clearing, initially for agriculture and currently for urban development and associated infrastructure. Approximately 72.5% of the original vegetation has been cleared and only 23,992 ha remain. The study area includes approximately 95 km of coastline of which about 57 km (60%) is heavily urbanised. This includes a nearly continuous urban strip for the 33 km from Tweed Heads to Pottsville. About 26 km (27%) of the coastline is contained in conservation reserves managed by the NSW National Parks and Wildlife Service (NPWS). The remaining 12 km (13%) is mostly comprised of small rural holdings.

Habitat mapping

Long-nosed Potoroo observations and habitat descriptions were collated, including those from Bali *et al.* (2003), Callaghan *et al.* (2004), Goldingay and Lindsay (2009), Goldingay *et al.* (2006), Lewis and Freestone (2009), Mason (1993, 1997), Milledge (1988, 1991, 2000), Milledge and McKinley (1992), Milledge *et al.* (1986, 1995) and Parker (1993, 2005, 2006). The NSW Office of Environment and Heritage's *Atlas of NSW Wildlife* contained 37 records that were considered to be reliable and accurately located, including records from most of the above studies.

The detailed coastal Quaternary geology mapping of Troedson *et al.* (2004) was an important resource for mapping Long-nosed Potoroo habitat. The Pleistocene coastal barrier sand deposits comprise wind-blown and marine-deposited sands that were created during periods of high sea level (before 10,000 years ago). Twenty-seven of the 37 *Atlas of NSW Wildlife* records (73%) are located directly on Pleistocene beach ridges and backbarrier flats mapped by Troedson *et al.* (2004), highlighting the significance of this geology for the potoroo in the region.

Holocene barrier sands have been deposited in the active depositional coastal zone and have accumulated over the last 10,000 years following post-glacial marine transgression (Troedson *et al.* 2004) and appear to be of lesser importance as Long-nosed Potoroo habitat. While seven of the potoroo records were located on Holocene deposits, these were mostly closely associated with broader Pleistocene deposits (e.g. Holocene swamp deposits within the Pleistocene dune complex). There were no records of the species from the Holocene sand dunes. Three records were located on bedrock, but again these were within close proximity to the Pleistocene sandplain.

Vegetation communities found on the Pleistocene sands on drier sites include Wallum Banksia *Banksia aemula* dry heathlands, Scribbly Gum *Eucalyptus signata* heathy woodlands, Coastal Blackbutt *Eucalyptus pilularis* heathy woodlands and Coast Cypress Pine *Callitris columellaris* open forests. Heath-leaved Banksia *Banksia ericifolia* wet heathlands and shrublands, Broadleaved Paperbark *Melaleuca quinquenervia* wet shrublands and sedgelands are found on wetter sites (Sheringham *et al.* 2008).

Scribbly Gum woodland with a heathy understorey appears to be a particularly significant habitat for the Long-nosed Potoroo in the region. It has been identified at Cobaki Lake (Bali *et al.* 2003), Wardell (M. Andren unpubl. data 2012) and other areas (D. Milledge pers. obs. 2012, D. Scotts pers. obs. 2009) as a key habitat (Fig. 4). Scribbly Gum growing on the sandplain has a distinctive signature in the aerial photography available (ADS40 50 cm digital aerial photography on the Tweed Heads, Lismore and Ballina 1:100,000 mapsheets) and was rapidly digitally mapped using ArcView GIS software.

Figure 3. The study area on the NSW far north coast. An approximation of the 50 m elevation contour was chosen as the inland boundary to the study area as it encompassed the sand plain and all of the potential Long-nosed Potoroo habitat near the coast.

Figure 4. Long-nosed Potoroo habitat in Scribbly Gum-dominated heathy forest and woodland in the Ngunya Jargoon Indigenous Protected Area, Wardell where many potoroo diggings were observed in 2013. Photo, D. Milledge.

Two existing maps of potoroo habitat were available, one for Tyagarah Nature Reserve (Mason 1997) and one for Cobaki Lake (Bali *et al.* 2003). In Tyagarah Nature Reserve the potoroos were considered to favour dry and moist shrubland in the early to middle seral stages with emergent Wallum Banksia and a mosaic of dense understorey and open areas (Mason 1997). Mason estimated a density of 0.23 – 0.26 animals/ha, or 80-90 individuals, within 340 ha of the Nature Reserve. Prime habitat at Cobaki Lake was found to be Scribbly Gum mallee heathland and Tree Broom-heath *Monotoca elliptica* heathland (Bali *et al*. 2003). The density of potoroos was estimated at 1.1 animals/ha in the former habitat and 0.9 in the latter (Bali *et al*. 2003).

In addition, a number of general vegetation maps were also used; recent reliable and detailed mapping for two local government areas (Tweed and Byron), a detailed map of Tyagarah Nature Reserve, as well as coarse regional mapping of less reliability covering the entire area (NPWS 1999).

The existing potoroo habitat mapping, Scribbly Gum woodland mapping and the general geology and vegetation coverages were combined to produce a preliminary map of likely Long-nosed Potoroo habitat across the study area. We qualitatively categorised habitat into four quality classes; Class 1 (High Quality potoroo habitat), Class 2 (Intermediate Quality), Class 3 (Low Quality) and Class 4 (Very Low Quality). Table 1 shows how the geomorphology and vegetation data were combined to assign areas to classes for the preliminary habitat map.

We then thoroughly reviewed the preliminary map of likely Long-nosed Potoroo habitat and adjusted boundaries and classes according to local knowledge of potoroo distribution, disturbance, habitat quality and accuracy of the vegetation mapping. In some places where the underlying data was inaccurate, the adjustments occasionally resulted in significant changes to the preliminary map. Finally, to account for the use by Long-nosed Potoroos of areas adjacent to their primary habitat, native vegetation within 100 m of mapped Class 1 habitat was assigned to Class 2, and within 50 m of Class 2 assigned to Class 3.

Results

The far north coast map of potential Long-nosed Potoroo habitat is shown in Fig. 5 and detail of the particularly significant Tyagarah/Brunswick Heads area in Fig. 6. A total of 3,613 ha of potential habitat was mapped. This represents 15% of the remaining vegetation in the study area. Most (97%) is below 10 m in elevation. Only 969 ha of high quality habitat was mapped (4% of the remaining vegetation; 99% below 10 m elevation).

Over 99% of the 392 ha of Scribbly Gum woodland on the Pleistocene sands was considered to be potential Long-nosed Potoroo habitat. Only a few small, isolated and highly disturbed patches were excluded. Scribbly Gum woodland occurred at many of the historical Long-nosed Potoroo locations and few large patches were found to occur outside these locations. However, not all of the Scribbly Gum woodland was considered to be of the highest quality habitat, such as some examples in wetter areas that were downgraded to lower habitat classes. Additionally, some potoroo occurrences were not associated with Scribbly Gum woodland, such as many of the localities in Tyagarah Nature Reserve.

The area, tenure, status and historical summary of Long-nosed Potoroo habitat mapped in the 10 areas identified is listed in Table 2. Tyagarah/Brunswick Heads and Wardell together contain 70% of all mapped habitat and 80% of the high quality habitat.

Two of the Long-nosed Potoroo surveys undertaken on the far north coast are illustrated in Figure 7.

Discussion

Mapping the habitat distribution of vertebrate species is notoriously problematic due to the detailed complexity of natural systems and the coarseness of the information used to interpret them. Consequently, animals may be absent from some of the supposedly optimal mapped habitat, but present in areas not mapped at all. However, a reliable distribution is an invaluable tool for assessing and implementing conservation strategies for a species. Habitat mapping is therefore a worthwhile, if imprecise undertaking.

Based on our extensive experience with the species on the far north coast, we are confident that the Long-nosed Potoroo map of potential habitat presented here is relatively accurate and that significant tracts of habitat have not been omitted. Of course, inaccuracies remain such as those arising from the deficiencies and inconsistencies in some of the existing vegetation mapping. While subjective interpretations were often used to try and correct such problems, the results should not be adopted without further critical evaluation and, ideally, field validation.

Ten areas of Long-nosed Potoroo habitat were identified, eight of which have some historical evidence of occupation. The other two, Arakwal and Hastings Point, both appear to contain potential habitat but there is no evidence of occupation by potoroos and the areas are very small, at 45 ha and 46 ha respectively. Of the eight

Table 1. Initial assignment of Long-nosed Potoroo habitat quality classes based on geology and vegetation community. Numbers refer to the assigned habitat quality class: 1 is High Quality potoroo habitat, 2 is Intermediate, 3 is Low and 4 is Very Low.

Vegetation	Geology[1] (Coastal Barrier Marine Sand)				
		Pleistocene			Holocene
	Beach Ridge And Assoc. Strandplain	Backbarrier Flat	Beach-Ridge Swale	Other	All
Tweed Vegetation[2]					
Coastal Scribbly Gum Open Forest To Woodland	1				
Coastal Swamp Mahogany Open Forest To Woodland	2		2		
Banksia Dry Sclerophyll Open Forest To Shrubland	2		2		
Broadleaved Paperbark – Eucalypt Spp. – Swamp Box	2		2		
Dry Heathland To Shrubland	2		2		
Wet Heathland To Shrubland	2		2		
Blackbutt Open Forest Complex				4	
Byron Vegetation[3]					
Scribbly Gum	1	1			
Wallum Banksia – Scribbly Gum	1	1			
Scribbly Gum – Red Bloodwood				1	
Wallum Banksia – Coast Banksia – Dwarf Banksia	2		2		
Heathland - Shrubland	2			2	
Swamp Sclerophyll – Mixed Eucalypts	2				
Swamp Mahogany – Swamp Box		2			
Swamp Sclerophyll	2	2			
Paperbark		2			
Blackbutt		3			
Tyagarah Nr Vegetation[4]					
Scribbly Gum	1				
Wallum Banksia Dry Shrubland	1				
Wet Heathland	1/2		2		
Heathland	1/2		2		
Swamp Mahogany	2		2		
Paperbark – Swamp	2				2/3
Swamp	2				2
Npws Vegetation[5]					
Lowland Scribbly Gum	2				
Wallum Banksia Woodland	2				
Wallum Banksia Heathland	2/3				4
Heathland	2				4
Swamp – Heath	3/4				
Scribbly Gum[6]	1/2	1/2	1/2	1/2	1/2

[1] Troedson *et al.* (2004)
[2] Tweed Shire Council 2009 digital ArcMap coverage that includes Cobaki Lake, Cudgen Lake and Hastings Point
[3] Byron Shire Council 2007 digital ArcMap coverage that includes Billinudgel, Brunswick Heads, Skinners Shoot, Arakwal, and Ti-Tree Lake
[4] NPWS Tyagarah Nature Reserve digital ArcMap coverage
[5] NPWS regional vegetation digital ArcMap coverage (NPWS 1999)
[6] Rapid mapping of Scribbly Gum woodland (this project)

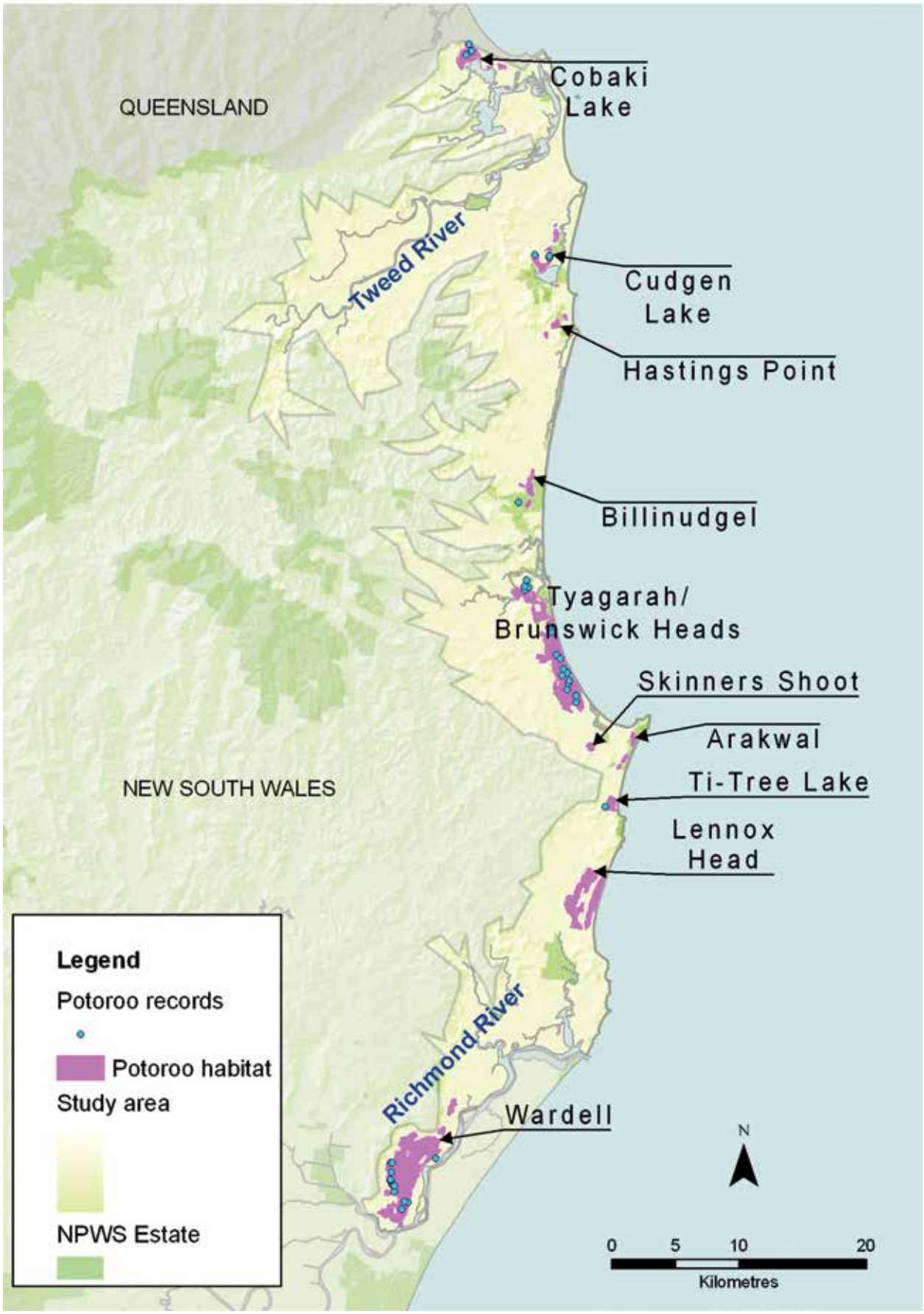

Figure 5. The 10 areas of potential Long-nosed Potoroo habitat mapped in the far north coast study area. All habitat qualities are displayed in purple with a thick outline so that the areas can be seen at the scale of the far north coast.

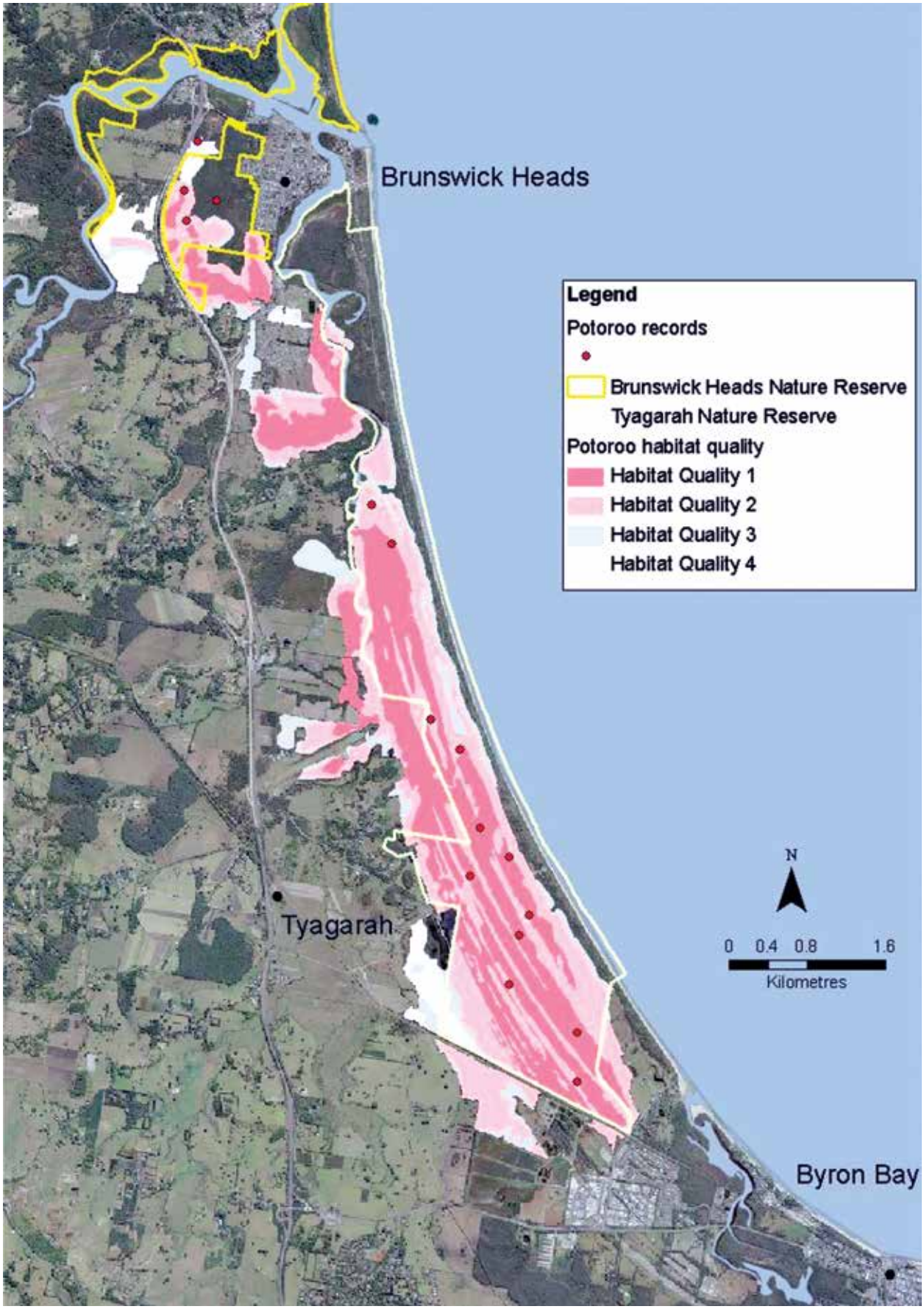

Figure 6. Detail of the Long-nosed Potoroo habitat mapping in the Tyagarah/Brunswick Heads area on the far north coast of NSW.

Table 2. The area, tenure, status and historical summary of the 10 areas mapped as potential Long-nosed Potoroo habitat on the far north coast.

Location	Hectares of total potential habitat (% of total)	Hectares of high quality (Class 1) habitat (% of high quality)	Tenure*	Status and history of observations
Arakwal	45 (1%)	0	100% Arakwal National Park	Unlikely to be extant. Small amount of suitable habitat; never recorded.
Billinudgel	87 (2%)	0	86% Billinudgel Nature Reserve 14% Freehold	Possibly extant. Only a small amount of suitable habitat; 1987 unconfirmed record (A. Benwell, G. Opit pers. comm.); 1994 road-kill record at South Golden Beach (B. Law pers. comm.); not recorded in small-scale camera-trap survey 2012 (M. Andren unpubl. data 2012).
Cobaki Lake	206 (6%)	106 (11%)	93% Crown Land 7% Freehold	Extant. Recorded 1992 (Warren 1992); 1993 trapping (Mason 1993); 2003 trapping and radio-tracking (Bali *et al.* 2003); possible diggings 2005 (P. Parker pers. comm.).
Cudgen Lake	135 (4%)	49 (5%)	83% Freehold 17% Cudgen Nature Reserve	Possibly extant. 1988 trapping (Milledge 1988); 2004 observation (Callaghan *et al.* 2004); not recorded in surveys since (e.g. Goldingay *et al.* 2006).
Hastings Point	46 (1%)	0	50% Freehold 46% Cudgen Nature Reserve 4% Freehold	Unlikely to be extant. Some suitable habitat; never recorded.
Lennox Head	499 (14%)	0	41% Freehold (JLALC) 35% Crown Land 24% Freehold	Possibly extant given large amount of habitat, but none known to be of high quality. 1971 road-kill (Schlager 1981); not recorded in small scale camera-trap survey 2012 (M. Andren unpubl. data 2012).
Skinners Shoot	24 (1%)	0	100% Freehold	Unlikely to be extant. Very small amount of habitat; 1995 possible diggings (Milledge *et al.* 1995).
Ti-Tree Lake	64 (2%)	35 (4%)	47% Crown Land 40% Freehold 13% Ti-Tree Lake Aboriginal Area	Possibly extant but only small amount of suitable habitat. 1993 possible record from hair analysis (Parker 1993).
Tyagarah / Brunswick Heads	1,098 (30%)	434 (45%)	54% Tyagarah Nature Reserve 33% Freehold 8% Crown Land 5% Brunswick Heads Nature Reserve	Tyagarah: Extant? 1985 trapping (Milledge *et al.* 1986); 1992 trapping (Mason 1997); 2004 trapping (Parker 2005); not recorded in recent surveys 2009 (Goldingay & Lindsay 2009, D. Scotts unpubl. data), 2011 (N. Graham pers. comm.) or 2012 (Lake 2012). Brunswick Heads: Probably extant. 1992 trapping (Milledge & McKinley 1992); 2000 trapping (Milledge 2000); 2004 trapping record (B. Taylor); not recorded in recent surveys 2009 (D. Scotts unpubl. data) or 2011 (N. Graham pers. comm. 2012).
Wardell	1,423 (39%)	345 (36%)	61% Freehold (JLALC) 35% Freehold 5% Crown Land	Extant. 1980 and 1981 specimens (Schlager 1981); Graham and Morrison (2009); 12 localities found in 2009-12 camera-trap survey (M. Andren unpubl. data).
TOTAL	3,613	969	32% Freehold 30% Freehold (JLALC) 23% NPWS Reserves 15% Crown Land	

* Although the tenure of most of the 368 cadastral polygons involved in this study was known, some were not. These figures are therefore not exact, but they are likely to be close to the true value. For each location, tenure was divided into: Freehold Land; Freehold Land owned by the Jali Local Aboriginal Land Council (JLALC); NSW National Parks and Wildlife Service (NPWS) reserves; Crown Land.

Figure 7. (a) David Milledge examining a Long-nosed Potoroo trapped on the edge of swamp sclerophyll at Tyagarah in 1985 (b) Mick Andren setting up a camera-trap in Scribbly Gum-Wallum Banksia heathy woodland (camera attached to Banksia trunk, centre image) in 2012. Photos, (a) P. Parker and (b) D. Milledge.

historically occupied areas, four cannot be assumed to currently support a population. These are Lennox Head (where there are no records since 1971), Billinudgel, Ti-Tree Lake (both of which only contain unconfirmed records) and Skinner's Shoot (indirect evidence from diggings). The amount of habitat at Billinudgel (87 ha), Ti-Tree Lake (64 ha) and Skinner's Shoot (24 ha) is very small and Ti-Tree Lake is the only one of the four areas considered to contain any high quality habitat (but only 35 ha). A significant amount of potential habitat, almost 500 ha, does occur at Lennox Head, but none is currently considered to be of high quality (although this does need to be confirmed through further survey). Therefore, six of the ten areas may be below the size and condition (in terms of the amount of high quality habitat available) required to support a resident population of the species in the long term.

Cudgen Lake is one of only four Long-nosed Potoroo populations that have been confirmed to be extant on the far north coast since 2000, with the most recent observation made in 2004. However, subsequent surveys have been unsuccessful in locating the species (Goldingay *et al.* 2006). Consequently, a proposal to list the Cudgen Lake population as Endangered under NSW legislation failed due to a lack of evidence that the population is still extant (NSW Scientific Committee 2007). The total amount of habitat mapped at Cudgen Lake is only 135 ha, of which only 49 ha is considered to be high quality; coastal development appears to have significantly reduced the size and quality of the habitat in the area. While some habitat is protected in Cudgen Nature Reserve (31 ha), a fire in September 2012 burnt 60% of this, including all the Scribbly Gum woodland habitat mapped in the Reserve. Additionally, a major development is planned immediately adjacent to the remaining habitat. This demonstrates the potential vulnerability of small and isolated populations and the area urgently requires further targeted survey for the species.

The key remaining populations therefore appear to be those located at Cobaki Lake, Tyagarah/Brunswick Heads and Wardell. The persistence of the small Cobaki Lake population (estimated by Bali *et al.* (2003) and Lewis and Freestone (2009) at only 55-85 individuals) in the long-term is uncertain given the likely direct and indirect impacts from the major development planned immediately adjacent to the small habitat area (190 ha). Recent impacts include the construction of a residential access road and realignment of the Pacific Highway, together with the loss of an area of high quality habitat (old growth Scribbly Gum woodland). However, there is now a Long-nosed Potoroo management plan for the area (Lewis and Freestone 2009) that provides some optimism for the persistence of this small population.

Tyagarah Nature Reserve is the most important reserve managed by the NPWS for Long-nosed Potoroo conservation on the far north coast, containing 54% of the habitat of the important Tyagarah/Brunswick Heads population. Potoroos were recorded in both reserves in 2004, but again, more recent surveys to confirm the presence of the species have been unsuccessful (Goldingay and Lindsay 2009; Lake 2012). Greater survey effort is still required to properly assess the status of this population.

The protection of habitat on private property is clearly crucial for the conservation of the Long-nosed Potoroo on the far north coast, with approximately 62% of the total area of potential habitat occurring on private property across the region. The Jali Local Aboriginal Land Council owns approximately half of the total area on private property, including 61% of the highly

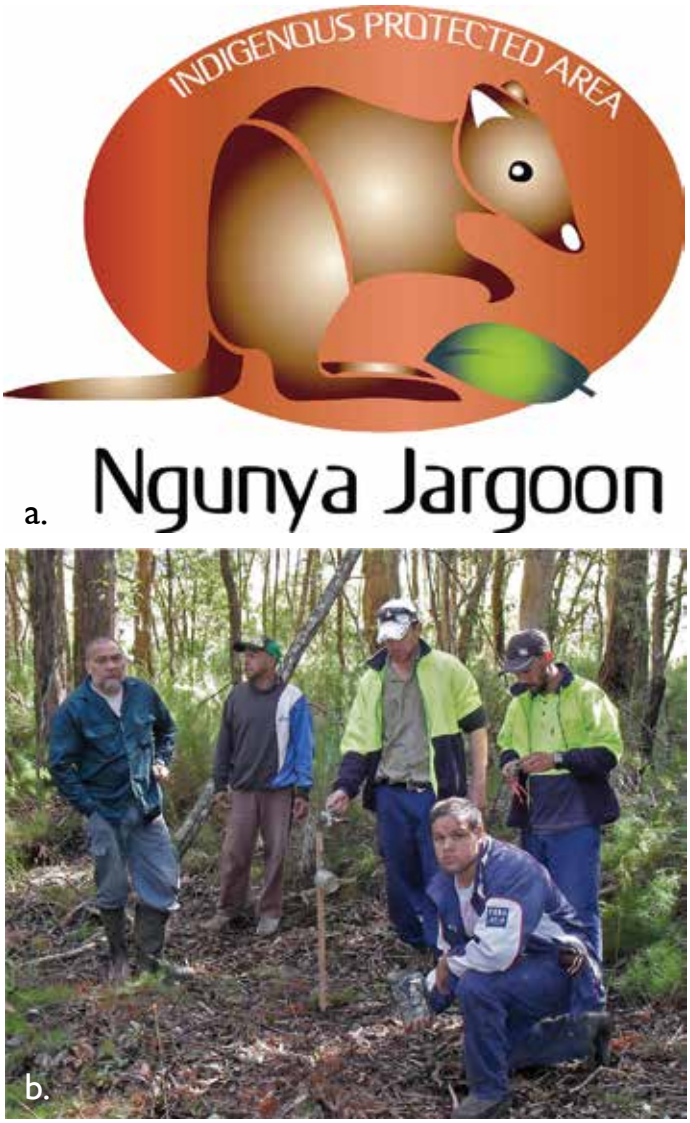

Figure 8. (a) The draft logo based on the Long-nosed Potoroo that has been adopted for the Ngunya Jargoon Indigenous Protected Area at Wardell. (b) Long-nosed Potoroo survey team employed by the Jali Local Aboriginal Land Council.

significant Wardell habitat. This area is also subject to impacts from coastal development, including increased fragmentation due to the upgrade of the Pacific Highway. However, the Long-nosed Potoroo is an icon of this area (Fig. 8a), where habitat is protected by an Indigenous Protected Area agreement (Ngunya Jargoon Indigenous Protected Area) finalised in 2013. The Land Council is employing the local community to continue potoroo surveys (Fig. 8b) in order to accurately establish the extent of the population on their land. With an informed approach to private land conservation, they are aiming to develop and implement a conservation management plan for the species.

The Long-nosed Potoroo is subject to numerous threats on the far north coast. Habitat loss, fragmentation and degradation from coastal development remains a fundamental threat to the species. Additional associated threats such as increased predation pressure when habitat is opened up and inappropriately applied fire removing vegetation cover too frequently or over large areas are also very likely to impact Long-nosed Potoroo populations. The complex and interrelated roles of these threats are recognised as key considerations for the conservation management of the species in the region.

Despite the small populations and prevailing threats, we believe that with concerted action in some key remaining areas, conservation of the Long-nosed Potoroo on the far north coast remains a realistic goal. Therefore, we urgently recommend (i) surveying all locations of historical records where potoroos have not been recently recorded (such as Billinudgel, Brunswick Heads, Cudgen Lake and parts of Tyagarah Nature Reserve) and (ii) undertaking a conservation assessment of the species in the region to re-assess its status. Research into the decline of the species (such as the role of predation and changed fire regimes), the genetic relationships of the populations on the far north coast (such as the possible divergent northern mainland lineage suggested by Frankham *et al.* (2012)) and local food resources are also needed, together with increased funding for the targeted conservation management of key populations.

Acknowledgments

The Ecosystems and Threatened Species Unit of the NSW Office of Environment and Heritage (OEH) at Coffs Harbour is thanked for providing the opportunity for Mick Andren and Jill Smith to participate in this study. The views expressed are those of the authors and not necessarily those of the OEH. Mick Andren is also grateful for the opportunity extended by the Jali Local Aboriginal Land Council to survey potoroos on their Wardell property. Marcus Ferguson and the rest of the Wardell field crew are particularly thanked. We also thank Ben Lewis and Mark Graham for their assistance in the mapping of habitat at Cobaki Lake and Wardell, Peter Parker for information relating to his records and Ernst Kemmerer for his comments on the draft manuscript.

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