Eucalypt Woodland in *Cape York Peninsula* as Habitat for Arboreal Marsupials: Responses of the Common Brushtail Possum

John W. Winter

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Cover Photographs:

(Front) Historical photograph of the common brushtail possum *Trichosurus vulpecula eburacensis* from the Coleman River region of Cape York Peninsula., taken by Eric Mjöberg, September 1913, at the time when he collected the type specimen for the subspecies *T. v. eburacensis* (Plate 160 in Mjöberg 1918).

(Left) Typical eucalypt woodland on Cape York Peninsula, Melon Yard, Strathgordon. Photographer A. B. Freeman.

(Back) Eucalypt woodland with diverse understorey, Eric Yard, Rokeby Road, Mungkan Kaanju National Park, Cape York Peninsula. Photographer A. B. Freeman.

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1. Summary

Introduction
Populations of many species of frogs, reptiles, birds and mammals are declining throughout the tropical woodlands of northern Australia and this is attributed to changes occurring in this woodland habitat. Amongst the mammals there is evidence in declines of ground dwelling species, such as the northern quoll and northern brown bandicoot, but also of the arboreal common ringtail possum and common brushtail possum. Evidence of decline in the last two animals in some areas of Cape York Peninsula initiated this project.

Funding and Outputs
The project was partly funded by the Cape York Natural Heritage Trust through the community ‘Tree Kangaroo and Mammal Group’ based on the Atherton Tablelands. Outputs emanating from the project include this report and a ten-minute video titled ‘Are Woodland Possums Disappearing from Cape York Peninsula?’, which was circulated to all stakeholders.

Aims and Emphasis
The project examined the eucalypt woodlands of Cape York Peninsula with the aim of enhancing them as suitable habitat for arboreal marsupial possums and gliders. Emphasis was placed on the common brushtail possum because of the historical data available for the possum on the Peninsula, the biology of the species is well known, it is widespread across northern Australia and it is relatively easy to study in the field.

Methods
The main methods used in the study were:

- Resampling of localities previously sampled for possums;
- Seeking information from past and present residents of Cape York Peninsula;
- Searching the early scientific and exploration literature; and
- Assessing the woodland habitat.

Findings
Resampling of localities and information obtained from residents revealed that the common brushtail possum has not undergone a general decline throughout the Peninsula. Whilst significant declines have taken place at some localities, populations elsewhere appear to have remained constant over decades, even recovered from low densities or made an appearance where they were previously thought to be absent. The general population structure of the common brushtail possum on Cape York Peninsula as determined in this project is one of very low densities, often difficult to detect using standard sampling techniques, with extremely localised areas of much higher densities. Population fluctuations occur such that in the low density areas they appear to come and go, whereas in the high density areas the possums persist, but changes in numbers occur over a span of years.

Insufficient evidence was obtained for the other woodland arboreal marsupials – the common ringtail possum, squirrel glider, sugar glider and feathertail glider – to determine their population structures on the Peninsula.

The journals of early European explorers and naturalists highlight the paucity of game on Cape York Peninsula indicating that the low population levels currently present are not indicative of a recent decline, but are the norm, probably reflecting low soil fertility levels on the Peninsula.

Density Modifiers

It is postulated that common brushtail possums are sensitive to changes in their woodland habitat, particularly to changes that affect the understorey. In the tropical woodlands the brushtail's diet is a mixture of leaves and fruit and much of the fruit is obtained from understorey plants. Consequently, any environmental process that reduces the diversity, not necessarily the density, of the understorey will have impacts on the possum.

The two factors most likely to affect the understorey are fire and the intensity of grazing by cattle. Grazing modifies the shrub layer and particularly the ground vegetation in relation to its intensity, and this can affect the brushtail possum which spends much of its time on the ground. On Cape York Peninsula the level of grazing has been relatively light compared to other areas and at the present intensity may not have greatly affected the possum populations. Fire, by contrast, is thought to have a major impact on possum numbers through its influence on the structure of the woodland understorey. There is evidence from the Northern Territory that possum numbers increase the longer the time between fires, because of the better developed understorey resulting from the longer fire interval.

High Density Nodes

Relatively high density brushtail possum population nodes were identified in restricted areas. Elsewhere, the density of possums has been shown to increase on higher fertility soils. Soil fertility was not tested, but broad-scale mapping of soils indicates that these nodes may be related to higher soil fertility.

Resource Bottle-neck

A late dry season 'bottle-neck' of resources is identified as potentially a critical time for brushtail possums because of high temperatures and low moisture levels in the environment, which is likely to be reflected in low water levels in foliage, the main source of water for the possums. Should a fire also eliminate the ground vegetation and understorey foliage at this time, the possums may not be able to survive.

Issues

Enhancing woodland on Cape York Peninsula as suitable habitat for arboreal marsupials is achievable primarily through fire management. This project recommends that the most appropriate fire strategy is one that enhances the diversity of the understorey and shrub layer in a relatively small mosaic pattern such that there is a patchwork of areas, some left unburnt for periods of five or more years. Also of importance to the brushtail possum, because of the time it spends on the ground, and to other ground dwelling native mammals such as the bandicoots, is the management of grazing to ensure the diversity of native grasses and plants is retained. Broad-scale tree clearing is a major issue only in the very tall eucalypt forests on aluminous laterite mined for bauxite.

Measures taken to enhance woodland will also apply to the other woodland arboreal marsupials with some slight differences for the species. The common ringtail possum rarely comes to the ground so is unlikely to be affected by changes to the ground cover, but extensive clearing of woodland will have a greater impact on its movements. Likewise the three gliders rarely come to the ground so clearing will have a greater impact on their movements than on the movements of the common brushtail possum. The gliders are susceptible to becoming entangled on barbed-wire fences.

Detailed recommendations emanating from this project for the management of woodland habitat and its arboreal marsupials are contained in Section 7, and suggested lines of future investigation are outlined in Section 8.

2. Introduction

2.1 Background

Eucalypt woodland is common and widespread across tropical northern Australia (Figure 1). Because it is so common there is a tendency to view it as requiring little attention regarding its conservation, particularly as little broad-scale clearing has occurred in the north. To the casual eye the woodland habitat looks healthy with its continuous tree cover and good ground cover of grass.

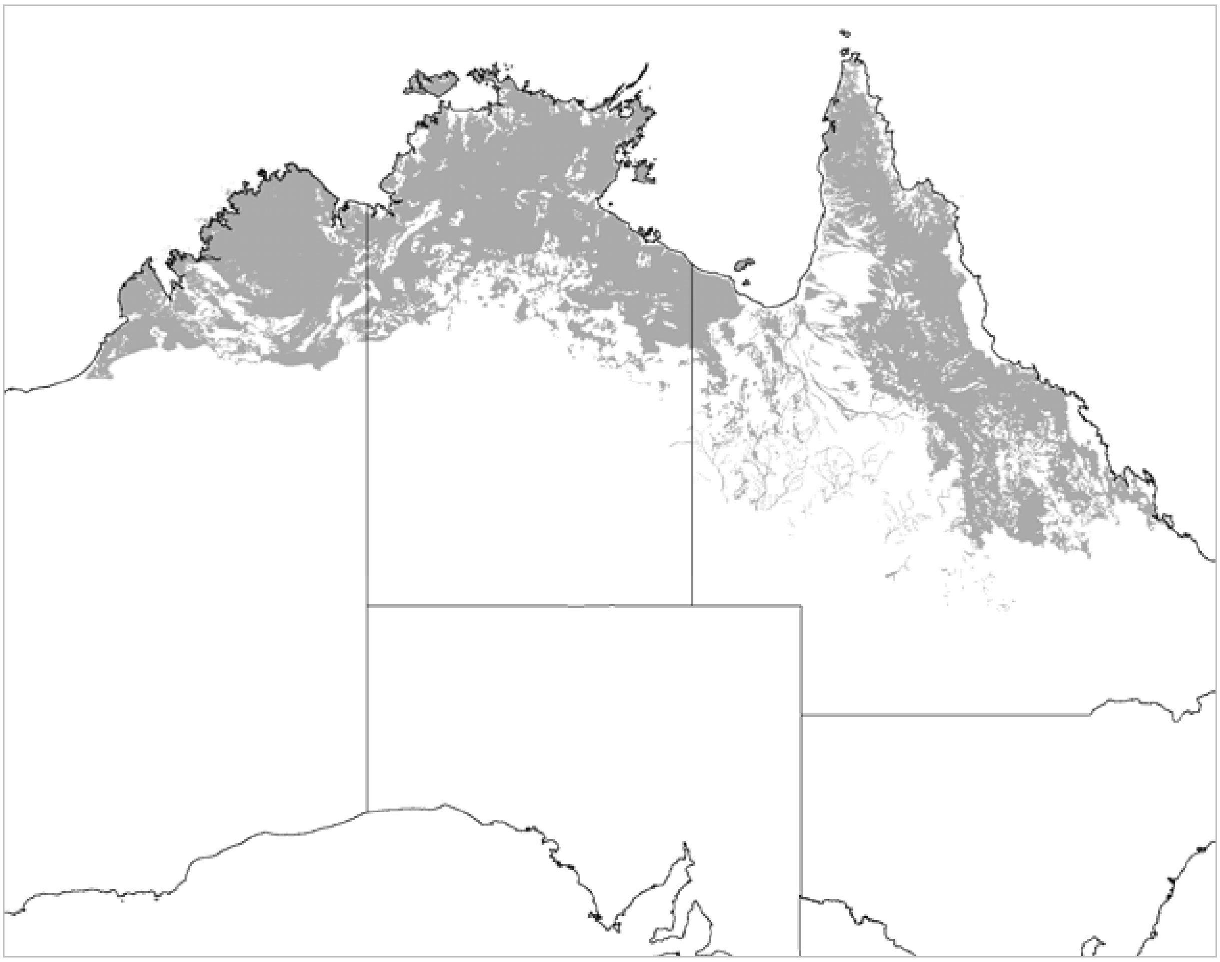

Figure 1. Eucalypt woodland across tropical northern Australia (Modified from Fox *et al.* 2001).

There are signs, however, that elements of the woodland fauna are declining, with evidence documented for birds and mammals. Franklin (1999) attributes a decline in ground dwelling fauna, and in particular the granivorous bird fauna, to a change from Aboriginal land management to European pastoralism and alternative fire regimes. Even in areas subject to extensive vegetation clearing, the decline coincides with the pastoral era prior to clearing (Franklin 1999). The woodland dwelling northern quoll *Dasyurus hallucatus* has suffered a seventy-five percent range reduction since the arrival of Europeans in northern Australia, with cattle, cane toads and exotic disease as possible contributing factors (Braithwaite and Griffiths 1994; Burnett 1997). A mammal decline is documented for the relatively intact woodland habitat of Kakadu National Park, originally thought to be a response to a period of extremely dry years (Braithwaite and Muller 1997). Despite a run of unusually good wet seasons the population densities of seven species (northern quoll, fawn antechinus *Antechinus bellus*, common brushtail possum *Trichosurus vulpecula*, northern brown bandicoot *Isoodon macrourus*, dusky rat *Rattus colletti*, black-footed tree rat *Mesembriomys gouldii* and pale field rat *Rattus tunneyi*) of the eleven species sampled did not recover (Woinarski *et al.* 2001). In the woodlands of Cape York Peninsula the common ringtail possum appears to have declined since the late 1940s, based on museum records and journals of early naturalists (Winter and Allison 1980). Likewise, there is evidence of a decline of the common brushtail possum in some, but not all, areas of the Peninsula (J. W. Winter unpub.).

The common brushtail possum, once extensively distributed throughout the woodlands of Australia, appears to be sensitive to changes to this habitat, and has undergone a radical decline over much of its distrib

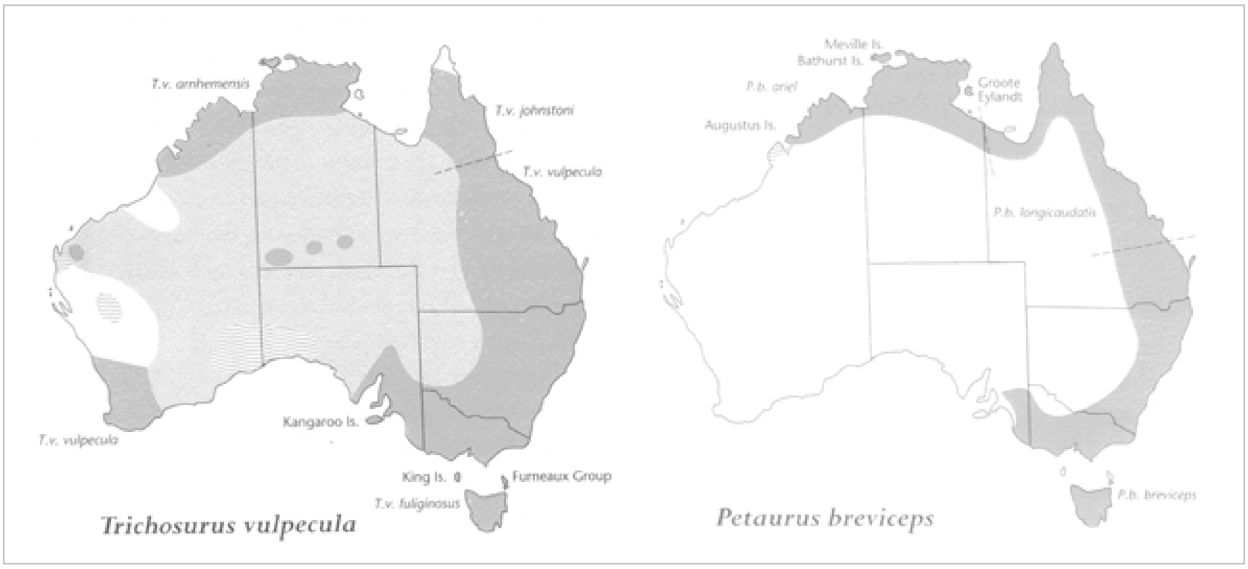

Figure 2. Australian distribution of the common brushtail possum (left) and the sugar glider (right) (Strahan 1995). Dark areas show present distribution, lighter areas previous distributions.

This decline is attributed to a combination of environmental factors, particularly drought, fire, predators and domestic stock. In the semi-arid and arid environments of central Australia it is hypothesised that the possum populations managed to survive in localised refugial areas of relatively high soil nutrition and water content (Kerle *et al.* 1992). However, degradation of these refugial areas from increased pressure of domestic stock, and the increased predator pressure from introduced feral cats and foxes, has led to widespread local extinctions of the possum when it was most vulnerable because of drought years (Kerle *et al.* 1992). There have also been significant declines and local extinctions of the common brushtail possums in the wetter box/ironbark woodlands of inland eastern Australia from Queensland to Victoria (Kerle 2004). Although much of this decline is a result of clearing of this habitat (seventy percent in New South Wales) a change in the structure of the woodland, which includes a ninety percent reduction in the proportion of large trees for nest hollows and the loss of shrubby understorey, is considered to be a major contributing factor (Kerle 2004).

2.2 Purpose and Aims of the Project

The primary purpose of this project was to assess the eucalypt woodlands of Cape York Peninsula as habitat for arboreal marsupials and to suggest guidelines as to how this woodland habitat can be managed to enhance its capacity to sustain populations of these marsupials.

The woodlands of Cape York Peninsula support five arboreal marsupials – two possums and three gliders; the common brushtail possum, common ringtail possum *Pseudocheirus peregrinus*, sugar glider *Petaurus breviceps*, squirrel glider *Petaurus norfolcensis* and the feathertail glider *Acrobates pygmaeus* (see Plates 1 and 2). In northern Australia the common ringtail possum, squirrel glider and feathertail glider are restricted to north-eastern Queensland, whereas the common brushtail possum and sugar glider extend throughout the tropical woodlands of Australia (Figure 2). The wide geographical spread of the last two species means that ecological and management findings for the species in Cape York Peninsula can be applied well beyond the Cape York Peninsula study area.

The project had two aims:

- The first was to assess the population status of the common brushtail possum on Cape York Peninsula and whether it is a species in decline within its woodland habitat on the Peninsula; and
- The second, much more difficult aim was to determine the factors which control the population status of the possum.

2.3 Choice of the Common Brushtail Possum

All five species of arboreal marsupial are widely distributed throughout the woodlands of Cape York Peninsula (Figure 3), but by far the most frequently seen is the common brushtail possum. The other four have either much lower populations – the common ringtail possum – or are more difficult to find because of their smaller size and more elusive behaviour.

Because the common brushtail possum is widespread in eucalypt woodland, any findings regarding the possum in the woodlands of Cape York Peninsula will be applicable to this habitat right across northern Australia. It is generally considered a robust species as it has good populations in the wetter forests and woodlands of the east coast and adapts readily to the urban environment where it frequently interacts with people. Thus, for such a robust species to be in decline over much of its woodland range indicates that substantial changes are taking place in this habitat. Because the common brushtail possum is widespread and relatively common it is likely to be a good indicator species of arboreal marsupial habitat quality, as population densities will vary according to habitat quality (Dickman and Steeves 2004).

The brushtail possum also has the advantage that:

- It is an easy species to census by means of spotlighting, thus relatively good comparative data is available at certain localities over many years;
- It is a species that most people recognise and are aware of, which means additional information on changing population numbers can be obtained from the general public;
- There are good historical records obtainable from museum collections and from the literature;
- Its biology – ecology, behaviour and digestive physiology – is well known, which enables a more informed interpretation of the results obtained from a study such as this; and

- It is a species very familiar to the principle investigator who studied its behaviour in the wild for his doctoral degree.

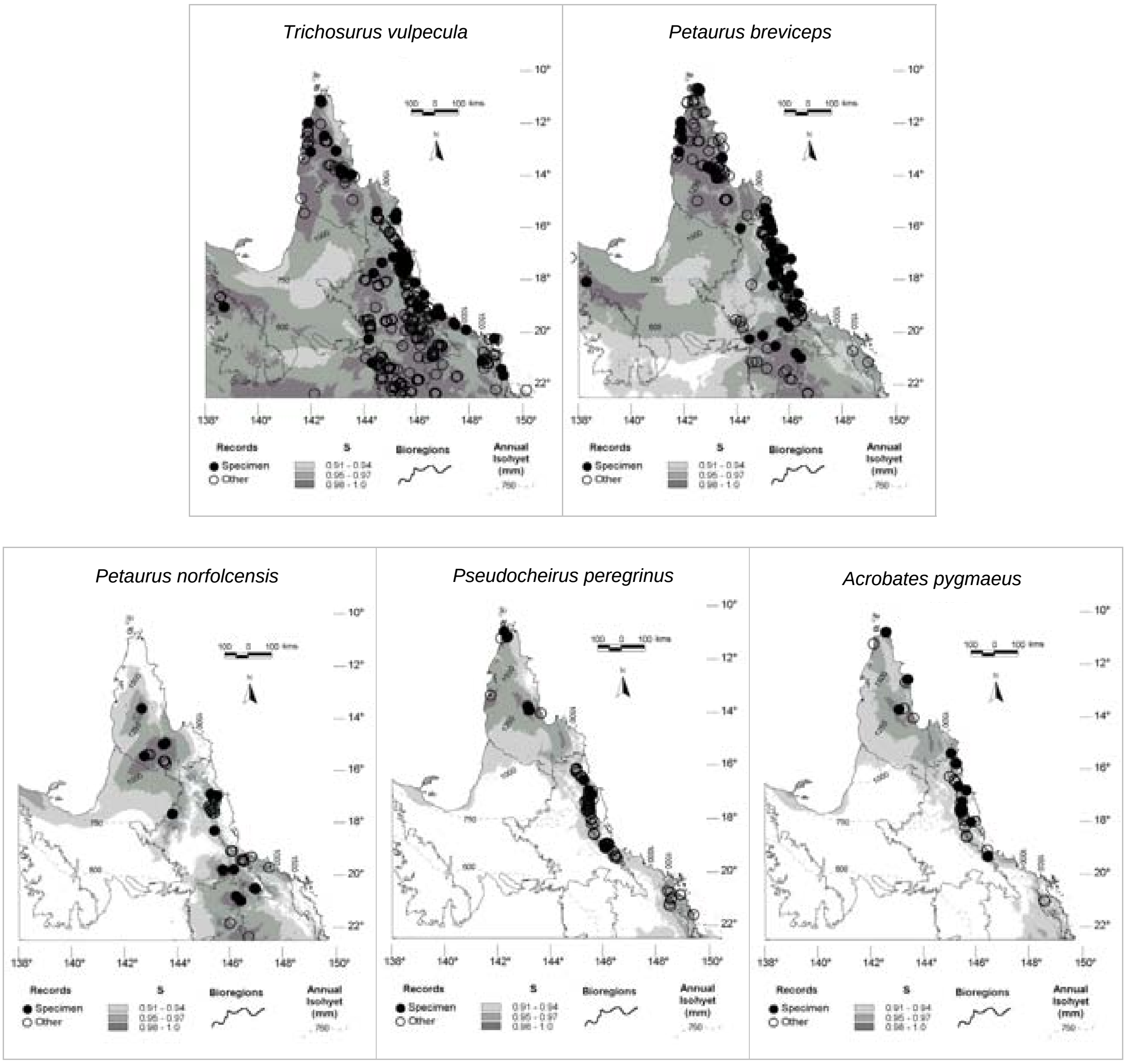

Figure 3. Distribution of the five arboreal marsupials living in eucalypt woodland on Cape York Peninsula. After Winter *et al.* 2004. Solid circles are records backed by specimens; open circles are observational records; shading indicates predicted distribution based on suitable climate – the darker the shading the more suitable the climate.

3. Methods

The first aim of the project was to determine the status of the brushtail possum throughout Cape York Peninsula, and in particular whether the species was in general decline throughout the region.

The general strategy of assessing population changes to brushtail possum numbers was to compare present day numbers with those recorded in the past. This was done by:

- Revisiting locations which had been sampled for the possums in the past three decades by either the author or his colleagues. This included returning to locations where possums were not found in the past, as well as locations at which they had been previously recorded. The purpose of revisiting past possum-deficient locations was to avoid biasing the results towards a conclusion of a general possum decline;
- Collating museum and scientific literature records to compare the geographical spread of records from the past with those obtained recently;
- Seeking information on the possums from past and present residents of Cape York Peninsula to complement the information obtained through direct searching;
- Searching for mention of possums in early written accounts of explorers and others.

At each of the sites revisited the woodland habitat was assessed in order to obtain an understanding of what constitutes healthy woodland for arboreal marsupials. This in turn provided the basis for recommendations for its management to enhance its ability to support the possums and gliders.

3.1 Resampling of Localities

3.1.1 Selection of Localities and Searching Methods

Localities were selected which had previously been searched for possums during fauna surveys of Cape York Peninsula between 1973 and 1993 (Table 1). The records suggested that the common brushtail possum had disappeared from three localities (Mapoon Road, Embley Range and Laura), but was still present at Rokeby and Coen, at least into the 1990s, and the common ringtail possum had disappeared from Vrilya Point. In addition, four localities (Strathgordon, Cockatoo Creek, Massy Creek and Kimba Plateau) were selected at which possums had not previously been recorded during previous surveys, despite the presence of apparently suitable habitat.

The sampling technique used to search for possums was spotlighting at night along a transect, either on foot or from a vehicle, using Lightforce 30 watt 12 volt spotlights without filters.

Walking transect: Two observers walking parallel to each other along a route through woodland habitat for a minimum period of one hour and over a distance calculated from the GPS route feature.

Vehicle transect: One or two observers from a slow moving vehicle (approximately ten kilometres per hour) for a minimum distance of five kilometres. Early into the project this was standardised to multiples of 5.0 km where possible.

Drive-by Spotlighting: The use of a spotlight from a vehicle travelling at normal driving speed to obtain opportunistic records of possums.

The position of every possum seen was recorded using a Garmin GPS 76 12 channel geographical positioning system and later downloaded and incorporated into a Microsoft Access database. Other information recorded for each possum included perpendicular distance (m) from transect line, height of possum above ground and height of tree, identification of tree, and where possible sex, age (adult, juvenile, at-heel) and whether females had young evident in the pouch. A large, young at-heel which made no attempt to climb onto its mother's back was counted as an independent sighting.

Carried out concurrently with the present project was a Savanna Cooperative Research Centre (Savanna CRC) project on resampling for all non-volant mammals on Cape York Peninsula, including possums, undertaken by the Queensland Parks and Wildlife Service and which involved the author. It used a broader suite of techniques based on sampling quadrats (Woinarski and Fisher 1995). These additional methods were employed at the following locations sampled in this project – Vrilya Point, Cockatoo Creek, York Downs, Rokeby, Massy Creek and Strathgordon. Each location contained six sites.

Walking census: Two observers searched a one-hectare site for fifteen minutes on three consecutive nights using a 30 watt spotlight and a 4.5 volt headlight. The latter light was to locate the weaker eye shine of the smaller gliders.

Trapping: Four wire cage traps (two measuring 60x29x29cm and two measuring 55x20x20cm) were set at the four corners of a 50x50m grid at six sites at each of the above locations. They were baited with a peanut paste/rolled oats/honey mix, sometimes with apple, and set for three consecutive nights.

The detection of possums at a locality is a function of both their density in the area and the time spent searching for them. For example, a failure to find possums at a locality could mean that they are locally absent (to claim 'local extinction' would require a much greater effort over an extended period than was possible in this project) or that insufficient time was spent in searching for what may be relatively low densities of possum. If possums are present at high densities, their presence can be detected with significantly less search effort. To overcome this bias of greater ease of detecting possums at greater densities, proportionally greater effort was spent in searching for possums at localities at which they were not detected.

Consequently, a number of simple rules were used to determine the status of possums at a locality:

Based on Spotlighting Transect of 5.0 km by vehicle or one or more hours on foot:

1. Sample for at least three consecutive nights at a locality to accept an ***absence*** result;
2. Determine as a ***high density*** population if,
   - One possum seen along three or more passes along the same transect; or
   - Three or more possums seen on any one pass of a transect.
3. Determine as a ***low density*** population if,
   - Possums were seen, but they did not meet the criteria for a high density population;
4. Determine as a ***sub-sampling density*** population if possums were not recorded during systematic sampling but were known to be present as a result of opportunistic observations.

Table 1. Localities previously surveyed and selected for resampling.

Locality	1970s				1980s					1990s				
Common Brushtail Possum														
Rokeby (Eric Yard)								1986[7]	1988[7]			1993[4]		
Coen – North				1979[2]						1991[7]		1993[4]	1996[8]	1997[8]
Embley Range Plateau							1985[8]			1991[8]				
Laura (Split Rock)			1978[2]	1979[2]								1993[4]		
Mapoon Road					1980[3]	1981[5]				1991[6]		1993[4]	1996[8]	1997[8]
Jardine River (Bridge Creek)	1973[1]	1975[1]												
York Downs						1981[3]								
Strathgordon (Melon Yard)												1993[4]		
Vrilya Point						1981[3]					1992[8]			
Cockatoo Creek (Atambaya)		1975[1]												
Massy Creek (Silver Plains)			1978[2]	1979[2]										
Kimba Plateau												1993[4]		
Common Ringtail Possum														
Vrilya Point						1981[3]					1992[8]			

Recorded ☐ Not recorded ☐ Disappeared ☐

Sources: [1] Jardine River and Heathlands fauna survey (J. W. Winter unpub.); [2] McIlwraith fauna survey (Winter and Atherton unpub.); [3] Weipa fauna survey (Winter and Atherton 1985b); [4] CYPLUS fauna surveys (Winter and Lethbridge 1994); [5] A. Kerle (pers.comm.); [6] W. Foley, S. Ward and R. Gegg (pers. comm.); [7] M. Delaney (pers. comm.); [8] J. W. Winter (unpub.).

3.1.2 Site Description

At each locality sampled, two sets of environmental parameters were recorded.

Tree characteristics were recorded using the point-quartile method. From a fixed point the five closest trees with a diameter-at-breast-height (DBH) of fifteen centimetres or greater were selected in each quarter, to give a total of twenty trees. Recorded for each tree was the species of tree, DBH measured with a DBH tape, height to the nearest metre estimated after the height of the tallest tree was determined using a Dendrometer II (Institut für Forsteinrichtung und Ertragskunde der Universität Göttingen), distance from the centre point using a Bushnell Yardage Pro laser range finder, the canopy layer it occupied (T1, T2, T3), and the number of potentially suitable hollow entrances for gliders (less than about ten centimetres in diameter) and for brushtail possums (greater than about ten centimetres in diameter).

These site characteristics were recorded on a standard proforma also used for the Savanna CRC project.

4. Results

4.1 Presence of Possums at Sampled Localities

The presence or absence of possums at the resampled localities was assigned to five categories according to the results over the period of sampling (Table 2). Possums were considered to have:

Disappeared if not found at localities where they were previously known to occur. This included two localities for the common brushtail possum, Mapoon Road and Jardine River (Bridge Creek), and one for the common ringtail possum at Vrilya Point.

Reappeared if found at localities where previous sampling indicated their presence and subsequent disappearance over the past three decades. This included two localities for the brushtail, Embley Range and Laura (Split Rock).

Continuously present if present at all previous and present sampling sessions. This included two localities for the brushtail, Coen and Eric Yard on the Rokeby Road in Mungkan Kaanju National Park.

Appeared if found during the present sampling at localities where they were not found during previous sampling sessions. This included two localities for the brushtail, Strathgordon (Melon Yard) and York Downs (Jump-up and Myall Creek).

Never seen if not recorded during previous and present sampling sessions. This included four localities for the brushtail, Vrilya Point, Cockatoo Creek (Atambaya), Massy Creek (Silver Plains) and Kimba.

Table 2. Results of resampling at selected localities.

Locality	1970s				1980s					1990s					2000s		
Common Brushtail Possum																	
Rokeby (Eric Yard)								1986[7]	1988[7]			1993[4]				**2003**	**2004**
Coen – North				1979[2]						1991[7]		1993[4]	1996[8]	1997[8]	**2002**	**2003**	
Embley Range Plateau							1985[8]			1991[8]					**2002**		
Laura (Split Rock)			1978[2]	1979[2]								1993[4]					**2004**
Mapoon Road					1980[3]	1981[5]				1991[6]		1993[4]	1996[8]	1997[8]	**2002**		
Jardine River (Bridge Cr)	1973[1]	1975[1]													**2002**		
York Downs						1981[3]											**2004**
Strathgordon (Melon Yard)												1993[4]				**2003**	
Vrilya Point						1981[3]					1992[8]				**2002**	**2003**	
Cockatoo Creek (Atambaya)		1975[1]														**2003**	
Massy Creek (Silver Plains)			1978[2]	1979[2]												**2003**	
Kimba Plateau												1993[4]				**2003**	
Common Ringtail Possum																	
Vrilya Point						1981[3]					1992[8]				**2002**	**2003**	

Recorded   Not recorded   Disappeared   Still present   Appeared

Table 3. Mapoon Road Transect sampled in 2002 from the Batavia Outstation Landing to "Small Scrub", north of Myerfield. Transect divided into 5.0 km sections. Where necessary, kilometres were adjusted to equate with Batavia Outstation Landing as starting point. Dark shading indicates original section of road, the remainder undertaken along widened road, except for diversions from main alignment (light shading).

AMG Coordinates WGS84	Batavia Outstation Landing to 'Small Scrub'		Batavia Outstation Landing to 'Small Scrub'			Clough's Landing to Small Scrub turn-off			Small Scrub turn-off to Clough's Landing			Features Along Transect
Easting/Northing	16/09/1980		18/11/2002			19/11/2002			20/11/2002			
	J. W. Winter, R. G. Atherton		J. W. Winter, H. V. Myles, J. Charger			J. W. Winter, H. V. Myles, R. Barkley			J. W. Winter, H. V. Myles, L. Booth, C. Woodley			
	km	Observation	Adj. km	km	time	Adj. km	km	time	Adj. km	km	time	
534600 / 8945600	0.0	B. O. Landing	0.0	0.0	20.03							Batavia Outstation Landing
			2.0	2.0	20.19							Main Mapoon Road
	3.0	Dingo										
			5.2	5.2	21.01							Clough's Landing turn-off
				6.5	21.10		0.0	19.40		23.2	22.25	Clough's Landing
			5.2	7.7	21.20	5.2	1.2	19.53	5.2	21.9	22.17	Clough's Landing turn-off
	7.0	*T. vulpecula*										
			7.8	10.3	21.33	7.9	3.9	20.07	7.8	19.3	22.08	Main Mapoon Road
	8.2	Block Fence	8.5	11.0	21.40	8.5	4.5	20.15	8.4	18.7	22.03	Block Fence
			9.4	11.9	21.48	9.4	5.4	20.22	9.3	17.8	21.55	Block Fence south turn-off
	10.1	*T. vulpecula*				9.4	5.4	20.24				
	10.2	*T. vulpecula*									21.40	
	11.7	*T. vulpecula*										
	12.3	*M. antilopinus*										
	13.3	*T. vulpecula*										
	14.8	*P. breviceps*										
	15.2	*T. vulpecula*							15.1	12.0	21.22	
	18.8		18.4	20.9	22.21	18.5	14.5	21.26	18.5	8.6	20.28	Telstra tower
	19.1	*M. antilopinus*										
	20.0	*M. antilopinus*										
	20.0	*T. vulpecula*										
	20.0	*T. vulpecula*										

AMG Coordinates WGS84	Batavia Outstation Landing to 'Small Scrub'		Batavia Outstation Landing to 'Small Scrub'			Clough's Landing to Small Scrub turn-off			Small Scrub turn-off to Clough's Landing			Features Along Transect
Easting/Northing	16/09/1980		18/11/2002			19/11/2002			20/11/2002			
	J. W. Winter, R. G. Atherton		J. W. Winter, H. V. Myles, J. Charger			J. W. Winter, H. V. Myles, R. Barkley			J. W. Winter, H. V. Myles, L. Booth, C. Woodley			
									20.6	6.5	20.48	Main Mapoon Road
	22.1	*T. vulpecula*										
	22.5									5.5	20.40	Water hole
	22.6	*T. vulpecula*							20.6	4.4	20.30	Pennefather turn-off
			25.0	27.5	22.59	25.0	21.0	21.50	25.0	0.0	20.13	Turn-off to Small Scrub
	27.2	*M. antilopinus*										
	29.2	Small Scrub	30.2	32.7	23.59							Small Scrub
Length km	**29.2**			32.7			21.0			23.2		
Along original km				8.6			1.5			1.5		

4.2 Disappeared Populations

4.2.1 Mapoon Road

Of the two brushtail possum populations in this category, the one sampled along the Mapoon Road between Batavia Outstation Landing and a small patch of scrub 29 km south is the best documented. Ten brushtail possums were sighted in 3.0 hours of spotlighting along this section of road on 16 September 1980 (Winter and Atherton 1985b) (Figure 4).

The following year, Anne Kerle and Dick Whitford (Kerle pers. comm.) spent twelve nights (22 June to 3 July) in the area, camped about halfway along the transect close to the present-day Telstra tower. They recorded a total of seventeen brushtails in 7.75 hours of spotlighting (Figure 5) and trapped a further nine individuals in 26 wire cage traps set for twelve nights. This showed that the density of possums was still high in 1981. However, ten years later when a party of zoologists – Simon Ward, Bill Foley and Bob Gegg – sampled the area in 1991, they failed to find any possums despite spending two nights searching along the road (S. Ward, pers. comm.). This was an alert to the possible decline of possums in the woodlands of Cape York Peninsula. Between 1993 and 1997 this transect was repeated a further three times by the author and no possums were found (Figure 5). The transect, or major parts of it, was repeated on three consecutive nights during this project and again no possums were recorded (Figure 5).

In the early 1980s the road was a single-lane bush track with canopy gaps little more than the natural gap size between trees. During the 1990s the road underwent both widening and some realignment such that by 2002 only 8.8 km of the original road remained unaltered and the other 20.4 km had been upgraded to a major two-lane highway along an approximately fifty-metre wide cleared swathe through the woodland. Nine of the ten possum observations were made along what is now a greatly widened road (Table 3).

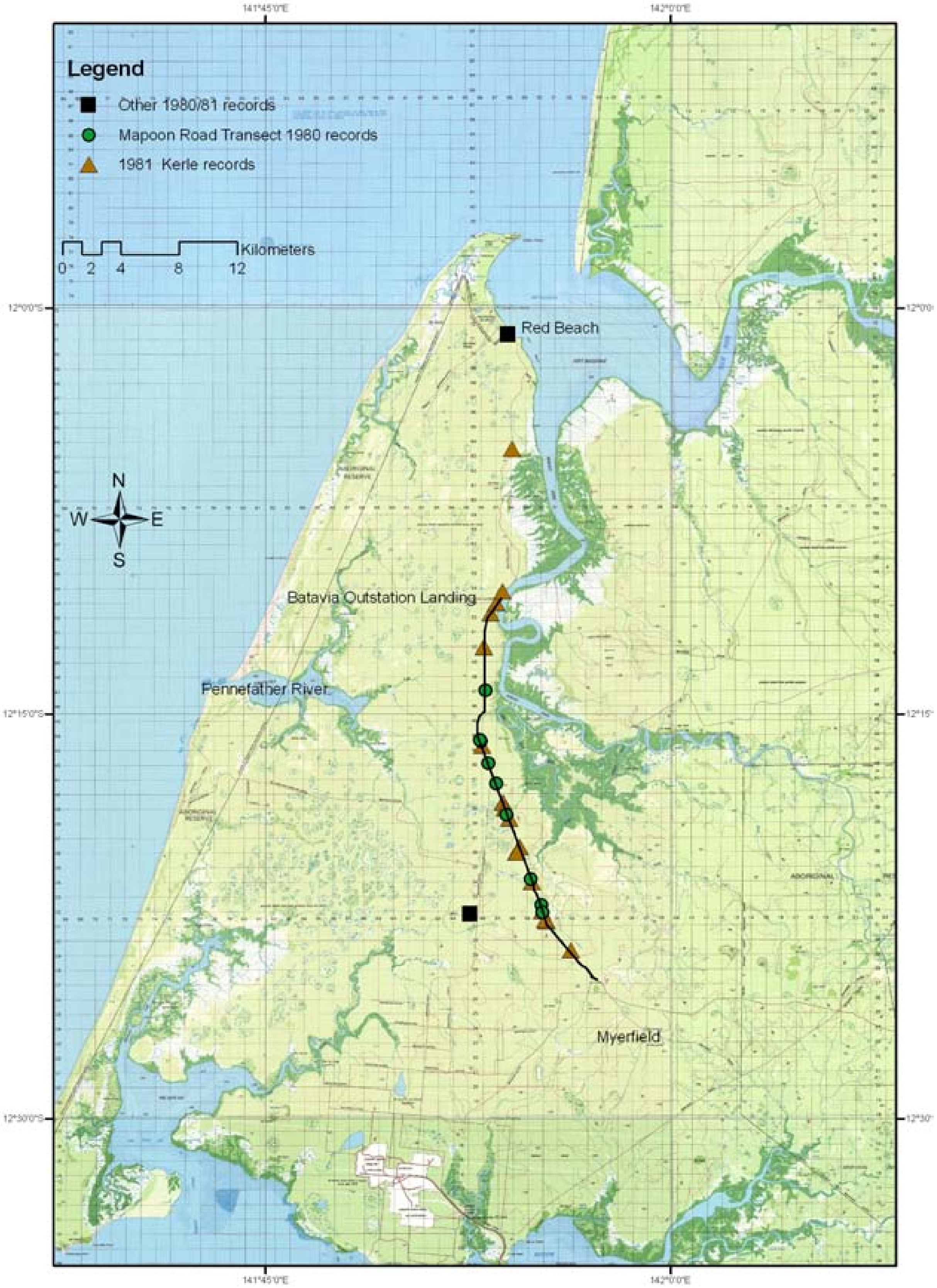

Figure 4. Common brushtail possums recorded along the Mapoon Road Transect (solid line) by Winter and Atherton in 1980 and by Kerle and Whitford in 1981.

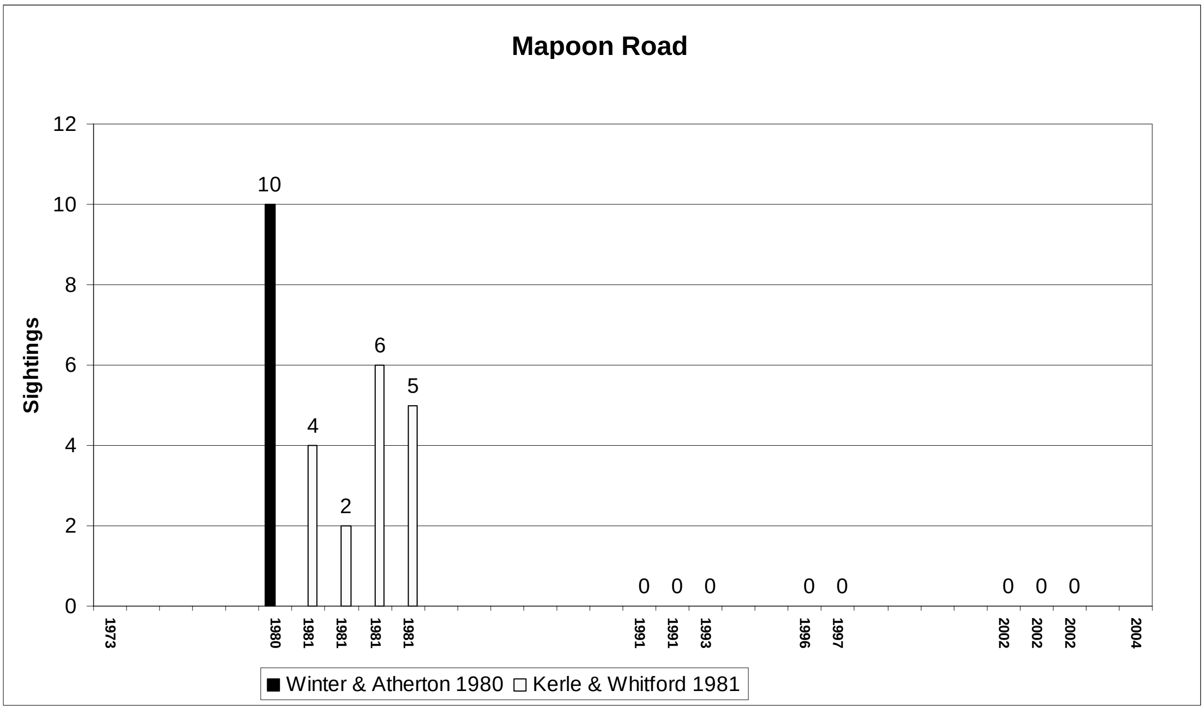

Figure 5. Number of common brushtail possums recorded along the Mapoon Road Transect.

Three factors may have contributed to a drop in the numbers of possums recorded:

1. Reduced ability to see the possums because of the greater distance to the forest edge from the road;
2. Retreat of the possums from the road because of disturbance from increased traffic noise; and
3. Retreat of the possums from the road because of less palatable foliage as a result of dust from the road covering it.

Reduced ability to see the possums was not considered to be a significant issue because of the very open nature of the woodland with its extremely sparse shrub layer and no growth of denser vegetation along the edge. As a result the spotlight beam penetrated well into the woodland. In addition, the road did not run down the middle of the cleared swathe but close to one edge, thus the increased distance to the woodland edge applied to one side only.

Nor is traffic noise or dust considered sufficient to force the possums back from the road because of the evidence from the arterial Peninsula Development Road immediately south of Coen along which possums were seen in good numbers and often close to the road (see the Coen transects for details). The main road at Coen has a higher volume of traffic than the Mapoon Road, has a similar width swathe cleared through the woodland and the section south of Coen was unsealed resulting in a heavy dust load on the bordering vegetation.

In addition the apparent 'crash' in possum numbers along the Mapoon Road Transect had taken place by 1991, before major road works had taken place. Consequently, these results are taken as strong evidence that possum numbers had declined substantially along this transect between 1981 and 1991 and had not recovered.

4.2.2 Jardine River (Bridge Creek)

The second locality within this category was the stretch of road along the old telegraph line, through eucalypt woodland each side of Bridge Creek, south of the Jardine River (Figure 6) (Appendices 1 and 2). In the course of three vehicle transects, one in 1973 and two in 1975, possums were seen every time (Figure 7). Although numbers could be low (only one brushtail during the first 1975 transect), it is the consistency of sightings that is important. In 2002 no possums were found despite spotlighting for 6hr 34mn by vehicle and 3hr 34mn on foot over three nights.

A significant change in the habitat along the track could have affected the results. During the early transects the telegraph line was still functioning with a 25-30 m wide swathe kept cleared. By the time of the recent transects the telegraph line had long since been demolished and the original open swathe was now filled with regrowth of eight- to ten-metre tall trees, which significantly curtailed the ability to see into the forest each side of the transect. To negate this difficulty, a walking transect was undertaken to supplement the vehicle transects. Two observers walked parallel to the road, one person fifty metres from the road, the other one hundred metres distance from the road, both beyond the influence of regrowth. One sugar glider was seen, but no possums. Again, this is taken as good evidence that possum numbers have crashed at this locality between 1975 and 2002.

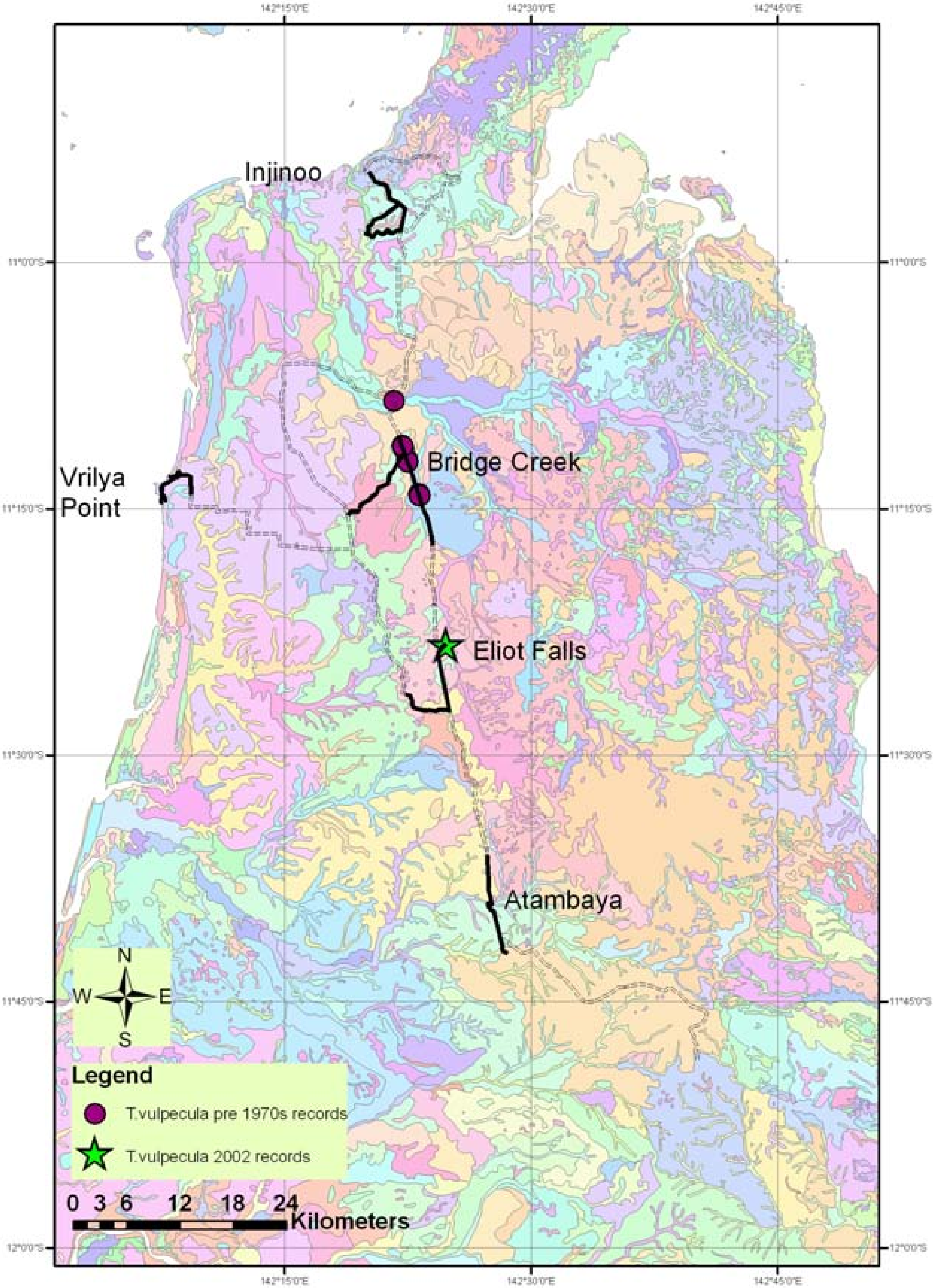

Figure 6. Most northerly localities sampled for possums during the 2000s. Jardine River (Bridge Creek), Vrilya Point, Eliot Falls and Atambaya; depicting roads traversed during spotlighting (solid lines), and brushtail possums recorded in the 1970s (solid circle) and 2002 (star), on a background of vegetation units.

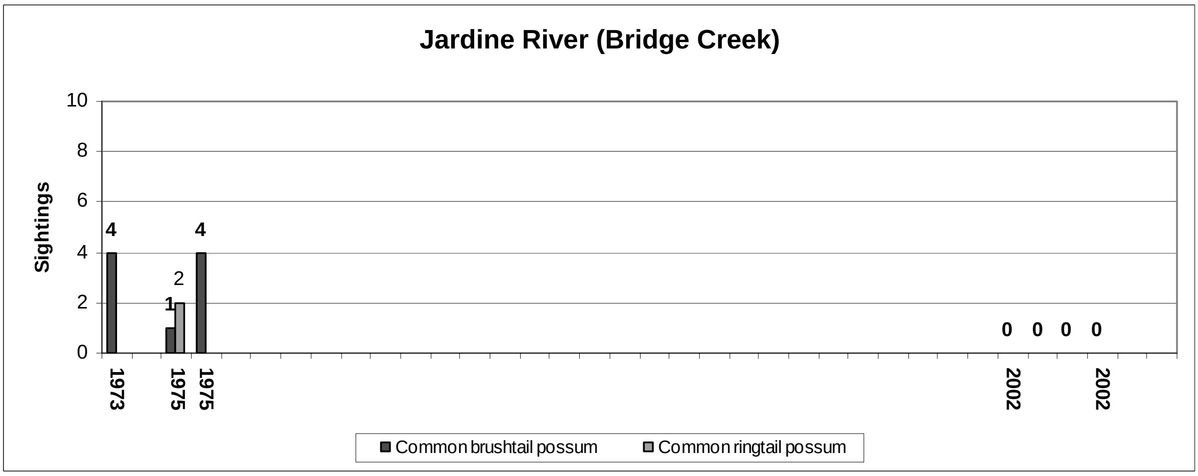

Figure 7. Number of common brushtail and common ringtail possums seen along the Jardine River (Bridge Creek) Transect.

4.2.3 Vrilya Point

Vrilya Point is the only locality at which sufficient observations of the common ringtail possums had been made in the past to make resampling for this species worthwhile (Figure 6 and Figure 8).

As part of the Weipa regional fauna survey the eucalypt woodland on Quaternary sediments, immediately south of the creek 1.5 km south of Vrilya Point, was sampled in August 1981 over a period of nine nights (Winter and Atherton 1985b) (Table 4). Although sightings of common ringtails per spotlighting session were usually of a single animal, once only of two, the fact that one was seen on most nights, and over different routes, indicates more than one individual was present. At the time it was estimated that at least four were sighted (J. W. Winter pers. obs). On the night of 9 July 1992, two consecutive transects were made by the author and others between the beach and the creek approximately seven hundred metres inland. The total of 4hr 18min failed to find any possums, strongly suggesting a decline in numbers, if not total disappearance of the species at Vrilya Point. Vrilya Point was visited twice during the present project, first in September 2002 as part of this project and again in October 2003 during the Savanna CRC project (Table 4, Appendices 1, 2 and 3). No ringtails or brushtails were recorded.

The only possum reported over about the past decade was one seen by the Traditional Owners (Sandra Woosup pers. comm.). It was white, in a casuarina tree backing the beach south of the point. The most likely identity of this possum is a spotted cuscus *Spilocuscus maculates*, based on its colouring and on a sighting made of one in an adjacent vine forest patch during sampling for this project in 2003. No brushtail possums have been recorded at Vrilya Point.

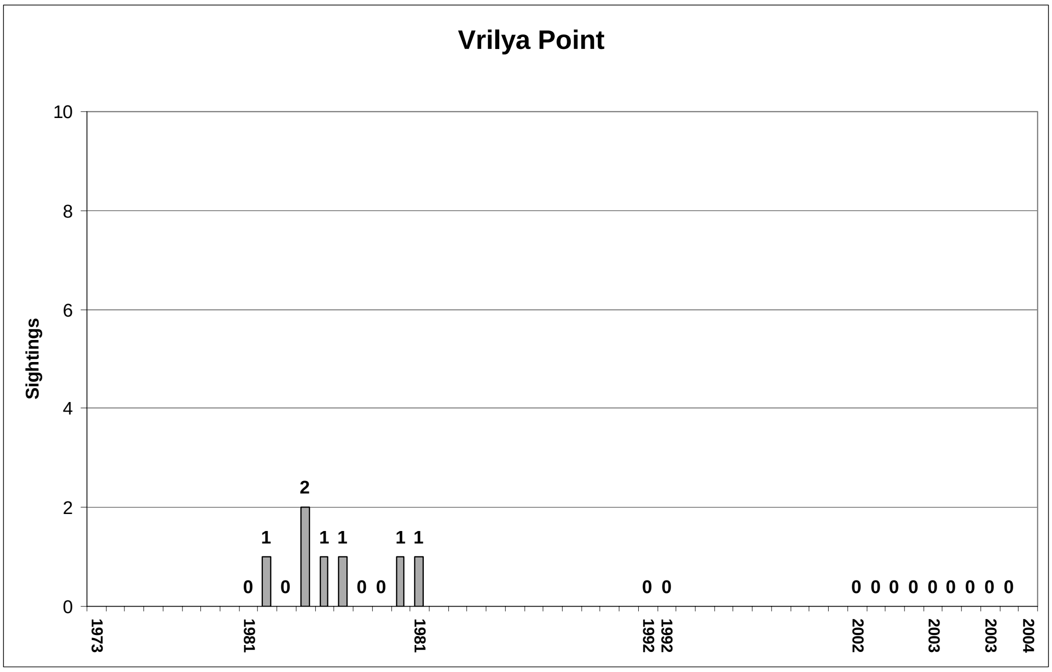

Figure 8. Sightings of common ringtail possums south of Vrilya Point.

4.3 Reappeared Populations

These are populations in which the initial recording of possums was followed by a later negative result, only to be found again during the present project.

4.3.1 Laura (Split Rock)

In May of 1978 and 1979 two transects were made from a moving vehicle, faster than the usual spotlighting speed, along the main road south of Laura with eight and five possums seen respectively on the box and bloodwood flats between Hells Gate Creek and Cattle Creek (Figure 9). In June 1993 the road was traversed from Laura to the Telstra tower at the saddle between Hells Gate and Redbank Creeks, which included the flats where possums were seen in the 1970s, this time at the usual slow spotlighting speed of ten to twelve kilometres per hour to allow a thorough search by two observers (c.21km). No possums were observed during this more thorough search, strongly suggesting that their numbers had significantly declined since the late 1970s. During the present project two spotlighting transects were undertaken in March 2004 from Laura Roadhouse to 3.7km east of Kennedy Creek (20.0km) (Appendix 1). Three brushtail possums were seen on the first night and one the next, all on the box and bloodwood flats between Cattle and Kennedy Creeks (Figure 9). This indicates a recovery of the population, but not to the earlier densities.

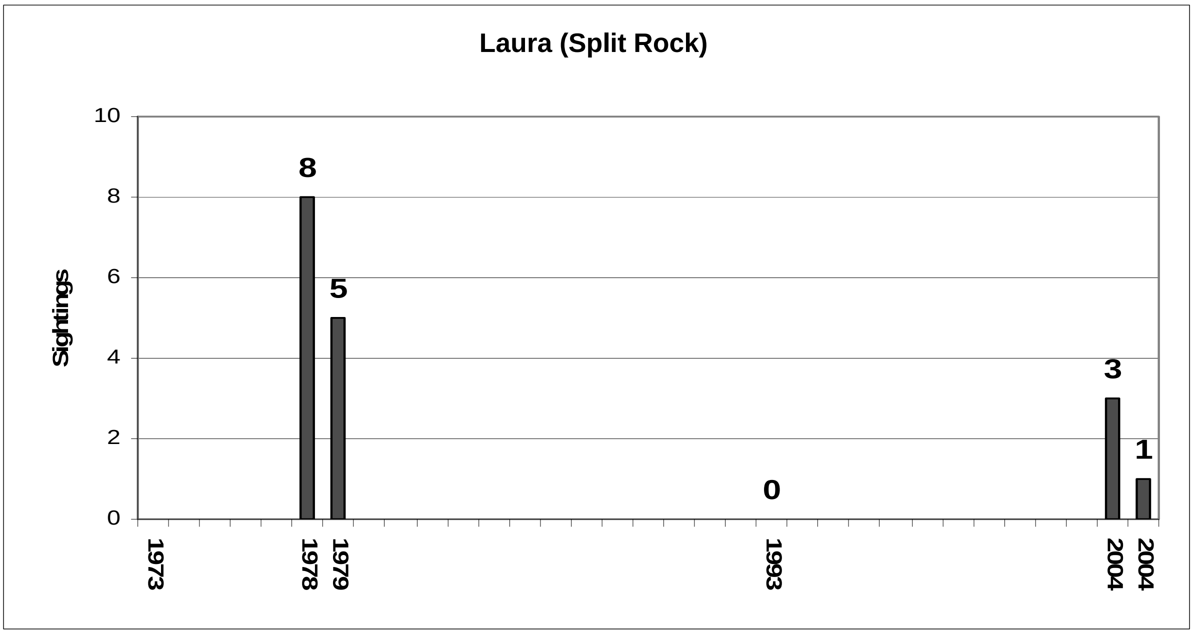

Figure 9. Number of common brushtail possums seen along the Laura (Split Rock) Transect.

4.3.2 Embley Range

The northern end of the plateau of the Embley Range was the second locality at which this pattern was repeated. In 1985 spotlighting was undertaken (1.9hrs, 6.1km from a vehicle, 0.8hrs walking) along the access tracks of two sleeper cutters who were active at the time, to give a tally of six brushtail possums (Figure 10). None were found in 1991 when the area was traversed by two observers, walking fifty metres apart for 3.0hrs. Yet in 2002 during the present project, again with two observers walking fifty metres apart for 3.0hrs and 2.1hrs on consecutive nights, six and four brushtails were observed, plus one common ringtail possum (Figure 10) (Appendix 3). The search effort involved in all three sampling sessions is considered to be sufficient to indicate that there was indeed a reduction in population density of the brushtail in the early 1990s with a subsequent recovery by 2002.

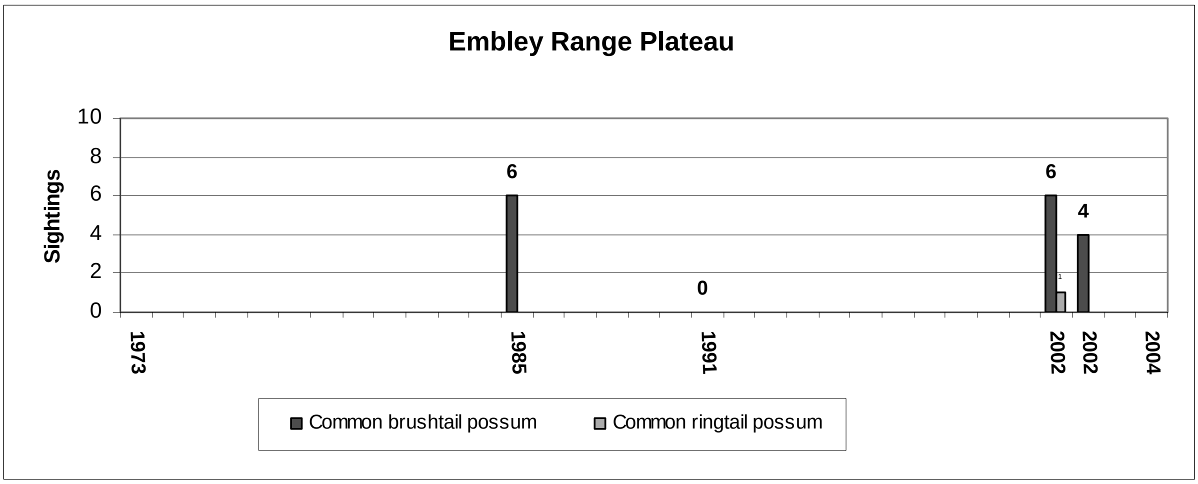

Figure 10. Number of common brushtail and common ringtail possums seen on the northern end of the summit plateau of the Embley Range.

4.4 Continuously Present

4.4.1 Coen North

The Coen North Transect is evidence of a continuous, but peaking population over a period of thirty years (Figure 11). The transect was along the main road from the Coen River bridge, northwards for 5.8km to a cattle grid (removed in 2006). In 1979 one possum was seen when spotlighting along the old telegraph line parallel to, but two- to three-hundred metres to the east of the road (Figure 11). It was the late Mick Delaney who alerted the author to the numbers along this stretch of road when discussing the disappearance of the brushtails along the Mapoon Road. In 1990 and 1991 he had sighted thirteen and seventeen brushtails respectively along this section of the road. The author subsequently repeated the transect three times between 1993 and 1997 and obtained the highest densities recorded for Cape York Peninsula, with a maximum of thirty-one brushtail possums seen on any one pass of a transect (Figure 11). During the project the transect was repeated seven times (including three by Colin Dollery, pers. comm.) in 2002 and 2003 with a maximum of five brushtails seen on any one night (Appendix 1). This indicates that the brushtails were still present, but at considerably lower densities. The results demonstrate that the Coen North population was low in 1979, peaked in the 1990s and has subsequently declined.

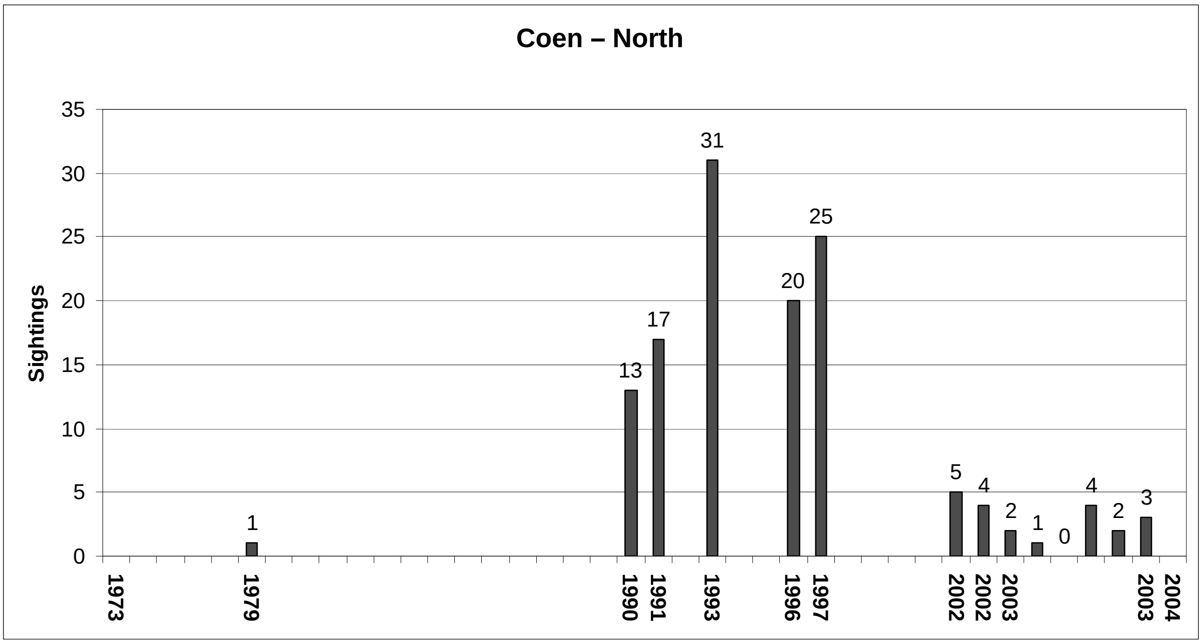

Figure 11. Number of common brushtail possums seen along the Coen North Transect.

That such a peak in numbers in the 1990s occurred elsewhere in the Coen district is supported by the following set of observations made along the Port Stewart Road each side of the Stewart River crossing. On 17 August 1978, when spotlighting from a vehicle from the southern crossing of the Stewart River north for 9.6km to the old Port Stewart turn-off, three brushtails were seen in 1.5hrs (J. W. Winter and R. G. Atherton unpub.). On 16 July 1995, Matthew Shaw spotlighted on foot from the Stewart River, travelling north along the road for one hour, covering 1.2km (paced) and saw six brushtails. Although not strictly comparable with the 1978 results because of the different method of spotlighting, it does suggest that the brushtails were in higher densities than in 1978. During this project on 5 September 2003 a 5.0km transect was undertaken, straddling the river and beginning 2.4km north of the river, i.e. including the section of road spotlighted by Matthew Shaw, and one brushtail possum was sighted. Bearing in mind the different technique, it does suggest a drop in numbers back to the 1978 level, which mirrors the pattern seen along the Coen North Transect.

4.4.2 Rokeby Road (Eric Yard)

The Rokeby Road (Eric Yard) location in Mungkan-Kaanju National Park also has a continuous record of brushtail possums sighted over a nineteen-year period (Figure 12). The 1986 and 1988 records were "all restricted to one kilometre of road at Eric Yard" (M. Delaney pers. comm.) and the 1993 records obtained by the author during the Cape York Peninsula Land Use Strategy (CYPLUS) were also within one kilometre of Eric Yard. The 2003 to 2005 records obtained in the course of the present project were from two five-kilometre sections either east or west of Eric Yard. The high numbers, twelve to thirteen, were from the eastern five kilometres and the lower numbers from the western five kilometres. The results indicate a continuous presence of the possum, but suggest an increased sighting rate during 2004 and 2005 (Figure 12) (Appendices 1 and 2).

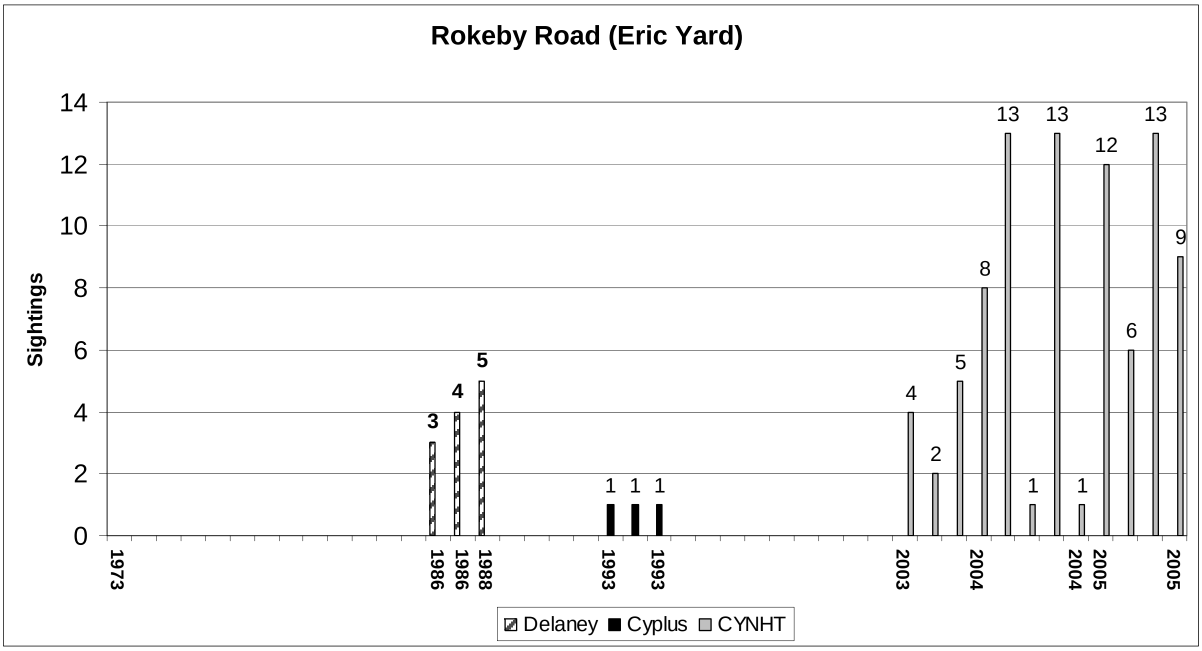

Figure 12. Number of common brushtail possums seen along the Rokeby Road Transect. In five-kilometre sections either centred on (1986-1993), or each side (2003-2005) of Eric Yard.

4.5 Appeared

At two localities, where considerable search effort over three to four nights had failed to find possums in earlier surveys, substantial numbers were recorded during the present surveys.

4.5.1 Strathgordon (Melon Yard)

Melon Yard, on the Edward River, Strathgordon was a CYPLUS fauna survey locality at which trapping (eighteen large wire trap-nights) and spotlighting (2hrs at sites and approximately 3hrs along 26km of road over three nights) was undertaken over a five day/night period in June 1993. No possums were recorded (Figure 13). In this project in August 2003 common brushtail possums were recorded along a 5.0km transect parallel to Edward River on three separate nights, thus categorising it as a *high* population (Figure 13) (Appendix 1). In addition, four brushtails were recorded during the one-hectare site surveys (three sightings, one trapped, seventy-two wire trap-nights) and seven seen opportunistically elsewhere at the locality. Thus, a total of nineteen records of brushtail possums were obtained in 2003, compared with the negative result in 1993 indicating a substantial population increase.

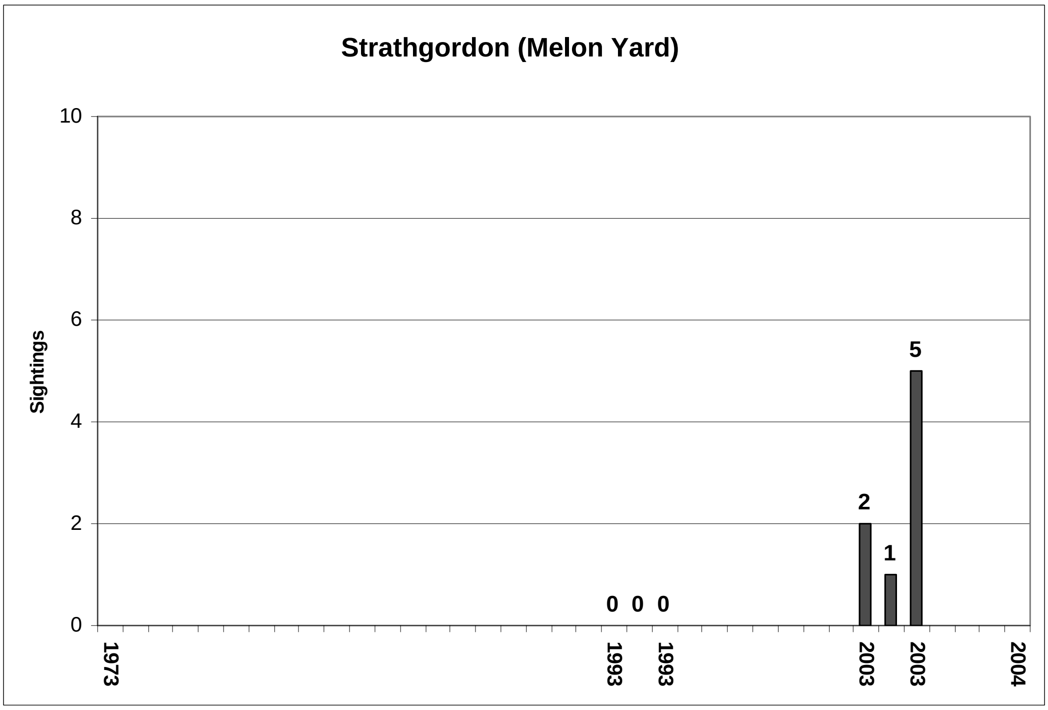

Figure 13. Number of common ringtail possums recorded along the Strathgordon (Melon Yard) Transect in 1993 and 2003.

4.5.2 York Downs

A similar pattern was obtained for York Downs. In May 1981, as part of a fauna survey of the Weipa region (Winter and Atherton 1985b), a base camp was established for nine nights at the site of the old homestead on Myall Creek. A total of twenty-three person-hours spotlighting (eighteen hours on foot and five by vehicle) took place in the vicinity of the camp and a further 8.5 person-hours by vehicle on the bauxite plateau of the Jump-Up to the west. No possums were recorded (Figure 14). In 2004 along four of the five 5km transects (one repeat) brushtails were recorded, both in the woodland centred on Myall Creek and the one transect on the Jump-Up (Figure 14). In addition to the transect records, five individual brushtails were captured seven times and three seen during foot searches of the one-hectare sites, all on the Jump-Up (Appendices 1 and 2). Thus, a total of twenty-one observations of brushtails were made compared with the negative result in 1981, indicating a substantial population increase.

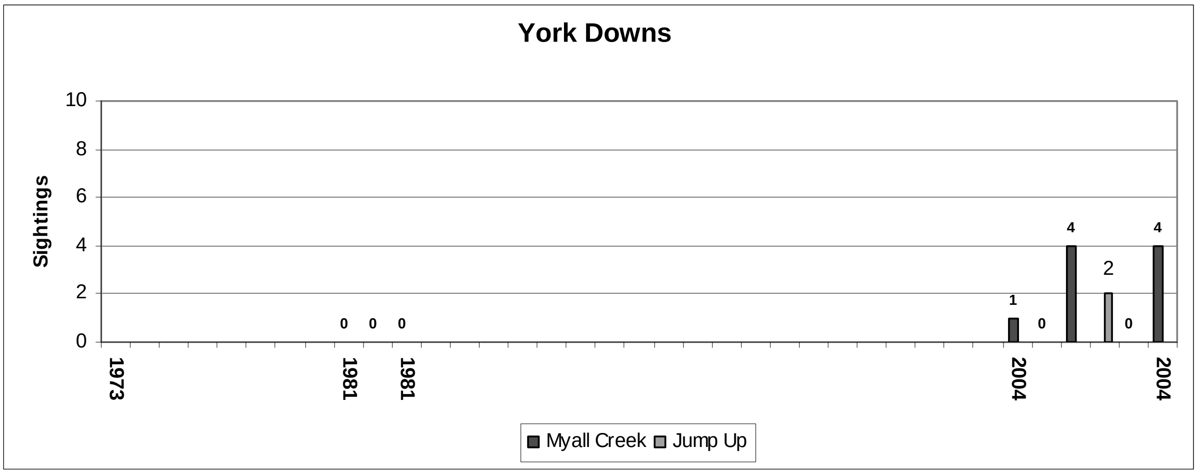

Figure 14. Number of common brushtail possums recorded at York Downs.

4.6 Never Seen

At four of the localities with apparently suitable eucalypt woodland habitat for possums, common brushtail possums have not been recorded either in past surveys or during the present resampling. This is despite considerable search effort involving more than one night and sometimes cage trapping (Table 4).

4.6.1 Kimba

The Kimba Plateau of very tall messmate *Eucalyptus tetrodonta* woodland, between the Pinnacle and Kimba homesteads, was sampled during CYPLUS in May 1993 (Table 4). No possums were recorded, but squirrel gliders were frequently seen. In July 2003 the area was resampled (Table 4, Appendix 1). Again no possums were recorded on the plateau. The absence of possums from the very tall woodland on the plateau was confirmed by the Raymond brothers. Rodney Raymond has lived on Kimba Station for forty years and has never seen a possum, nor has Bill Raymond who has lived on Pinnacle Station for the same amount of time. Squirrel gliders *Petaurus norfolcensis*, on the other hand, were relatively common during both surveys. Fourteen were recorded in 1993 and in 2003 three were seen. Rob and Robyn Raymond were raising a young glider, which enabled measurements to be taken thus confirming the species.

The closest a brushtail possum was seen during these two surveys was one on the Pinnacles-King Junction Road about 22km south of the plateau in 2003.

Table 4. Localities at which common brushtail possums were not recorded during previous or present surveys.

Locality	Year	Spotlight Hrs		Cage Trapnights	Possum/Glider Sightings	
		Vehicle	Foot		Common Brushtail	Other
Atambaya	1975				0	1 sugar glider
	2003	2.6	4.5	72	0	2 sugar gliders
Massy Cr	1977-1979	9.5	28.6	122	0*	3 sugar gliders 4 spotted cuscuses
	2003	2.3	6.2	72	0	1 sugar glider 4 spotted cuscuses
Kimba	1993	4.0	2.0	18	0	14 squirrel gliders
	2003	6.4	-		0*	3 squirrel gliders
Vrilya Pt	1981		41.6	xxx	0	9 common ringtails 10 sugar gliders 1 feathertail glider
	1992	-	4.3	-	0	-
	2002	1.5	5.7	-	0	1 sugar glider
	2003	2.0	8.3	72	0	2 sugar gliders 1 spotted cuscus

* One brushtail seen outside defined sample area (see text).

4.6.2 Vrilya Point

No common brushtail possums were recorded during four sampling periods at Vrilya Point. See Section 4.2.3 for details.

4.6.3 Cockatoo Creek (Atambaya)

Atambaya, at the crossing of the Telegraph Road over Cockatoo Creek, c.60km south of the Jardine River crossing (Figure 6), was first sampled in September 1975 (Table 4). It was also sampled as a Savanna CRC site in October 2003 (Appendices 1 and 2). The only arboreal marsupial seen was a sugar glider, one in 1975 and two in 2003.

4.6.4 Massy Creek

Massy Creek on Silver Plains Station was visited several times between 1978 and 1979 in the course of the McIlwraith Fauna Survey, where sampling was centered at the lower crossing (Table 4). The lower crossing was again sampled as a Savanna CRC locality in June 2003 (Appendices 1 and 2). No brushtail possums were recorded either during the 1970s or in 2003, but a single sighting was made in eucalypt woodland on 11 May 1978 along the road south of the Silver Plains homestead, about nine kilometres south-south-west of the Massy Creek location.

4.7 Population Nodes

It was apparent before the commencement of this project that brushtail possums were not uniformly distributed throughout the eucalypt woodlands of Cape York Peninsula but tended to be concentrated at relatively confined localities (J. W. Winter pers. obs). To determine whether the possums were in fact clumped, the numbers of possums seen during the 5.0km vehicle spotlighting transects were compared with the expected numbers using the statistical Poison Distribution (Table 5).

Table 5. Number of brushtail possums seen along five-kilometre vehicle spotlighting transects in eucalypt woodland.

No. of possums per 5km	Frequencies		Chi-sq value
	Observed	Expected	
0	77	23.63	120.546
1	13	38.40	16.799
2	7	31.20	18.769
3	2	16.90	13.136
4	6	6.87	0.109
5	3	2.23	0.265
6-12	12	0.60	214.903
Total	**120**	**119.82**	**384.527**

Chi-square = 384.527, 6 d.f., $p<0.005$

The highly significant difference between the observed and expected numbers seen in a five-kilometre transect indicates that the possums are not evenly distributed throughout the eucalypt woodland. It is apparent from the contributions from the Chi-square value in Table 5, and depicted in Figure 15, that there were a significantly greater number of times when no possums were seen or when six or more possums were seen. This indicates that the possums were indeed clumped.

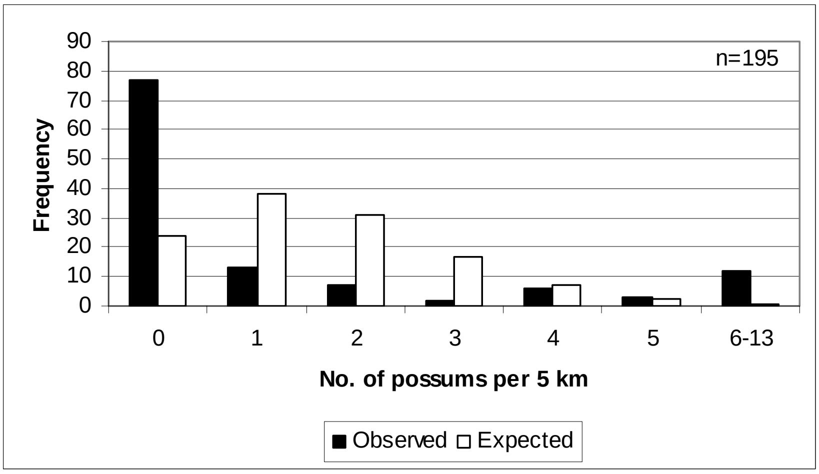

Figure 15. Frequency of common brushtail possums seen along five-kilometre spotlighting transects.

The two resampled localities which showed this clumping most clearly were Coen and Eric Yard. These concentrations of populations are referred to as population nodes.

4.7.1 Coen

To examine the apparent concentration of brushtail possums centred on Coen, 5.0km vehicle spotlighting transects were undertaken along roads radiating out from Coen township (Figure 16). The average number of brushtail possums observed per hour was significantly different for the transects and ranged from none to a high of 6.3 per 5.0km (Table 6). The higher densities of possums were clustered about the town, except for the Wire Yard Transect to the north-east of the town where no possums were seen even close to the town.

In this project it was not possible to totally discount the effect of the town on the surrounding population of the brushtail possums. There may have been a higher density of possums in the town because of the better food supply provided by house gardens and food scraps and thus the higher densities surrounding the town were the result of possums dispersing out from the town.

Two pieces of evidence suggest that the town did not have a significant influence on the surrounding population of brushtails. One was the lack of possums along the Wire Yard Transect from Wire Yard to the Lankelly Road on the outskirts of Coen, along which no possums were recorded. The forest along this transect was generally much taller, reflecting slightly wetter conditions, than elsewhere round Coen, indicating that habitat rather than proximity to the town is the main influencing factor. The other piece of evidence was the lack of brushtail possums in and around Weipa township even though they were known to occur in the surrounding messmate *Eucalyptus tetrodonta* forest (Reeders and Morton 1983; Winter and Atherton 1985a;b). This indicates that towns in themselves on Cape York Peninsula do not necessarily boost the possum population.

Common brushtail possum sightings appeared to be related to broad environmental features, despite sampling not being designed to test for this. The transects occurred within three distinct Land Zones – Zone 5, old loamy and sandy plains to the north and west of Coen, Zone 11, hills and lowlands on metamorphic rocks south of Coen and Zone 12, hills and lowlands on granitic rocks along the Wire Yard Transect (Satler and Williams 1999) (Figure 17). The Wire Yard Transect, along which no possums were seen, was the only one through woodland on the granites of Land Zone 12, which suggests that woodlands on granite may be poor habitat for the possums. Two opportunistic sightings of possums along the Port Stewart Road may be on granite, but they occur right on the boundary with the metamorphics of Land Zone 11. However, this does not explain why possum sightings fall away dramatically within a land zone (5 and 11) away from Coen (Figure 17). There does, however, appear to be a close relationship between sightings and soil on the northern and southern Coen transects, along which the possum sightings are restricted to the ‘Drop’ (Dr) soil type which is described as ‘moderately deep gradational yellow soils formed on hillslope of ademellite or granite’ (Biggs and Philip 1995) (Figure 18). The occurrence of Drop soils on metamorphic rocks of Land Zone 11 south of Coen could result from outwash from the adjacent granitic hills. The lack of possum sightings along the Wire Yard Transect and the western end of the Coen River Transect, both on ‘Drop’ soils, do not make for a perfect fit with soil type.

Table 6. Frequency of common brushtail possums observations along five-kilometre transects in vicinity of Coen, sampled 2002/2003. Adjusted to five kilometres and ordered in increasing straight-line distance from Coen.

Transect	Distance from Coen (km)	No. Brushtail Possums	Transect Length (km)	Total Hours	Possums per Hour
Coen-River, 0-5 km	0.5-4.5	10	5.0	1.6	6.3
Coen-North, 0-5 km*	0.5-5.5	17	5.0	4.5	3.8
Coen-South, 0-5 km	0.5-5.5	11	5.0	2.1	5.2
Wire Yard (Pandanus Cr)	0.5-6.5	0	7.4	1.8	0.0
Emily Yard	4.5-6.5	3	2.8	0.7	4.3
Coen-River, 5-10 km	4.5-9.0	9	5.0	1.5	6.0
Coen-South, 5-10 km	5.5-10.5	6	5.0	1.3	4.6
Coen-North, 5-10 km*	5.5-10.5	1	5.0	1.1	0.9
Coen-River, 10-15 km	9.0-13.5	0	5.0	0.8	0.0
Coen-South, 15-20 km	10-20	0	5.0	0.5	0.0
Stewart River	20-22	1	5.0	1.2	0.8
Coen-South, 25-30 km	22-30	0	5.0	0.6	0.0

* Coen-N Transect adjusted from 5.8 km to 5.0 km.

G test = 35.4577 (P <.005,11 d.f. 26.757) ***

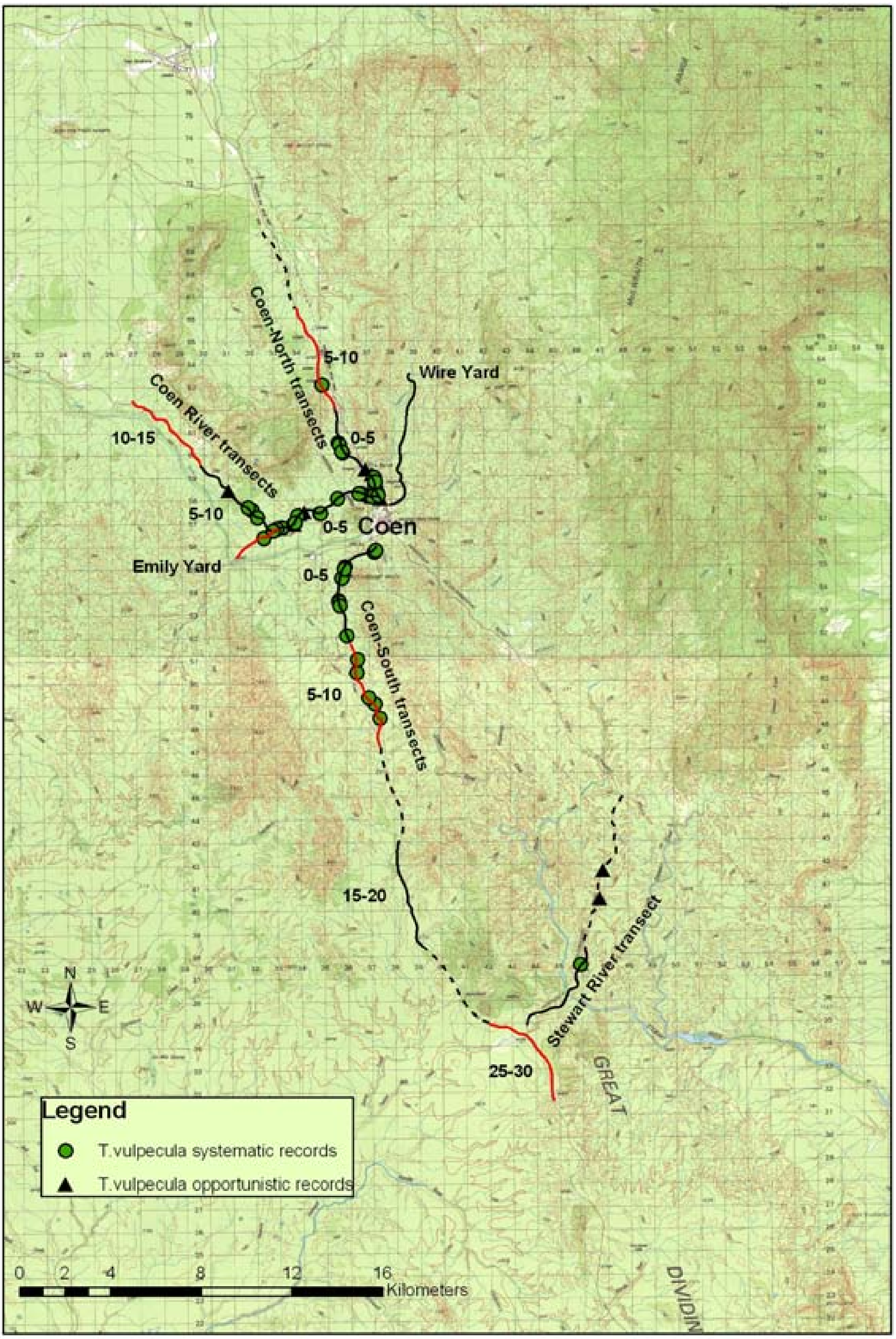

Figure 16. Vehicle spotlighting transects centred on Coen. Systematic five-kilometre transects (solid dark and red lines) and drive-by spotlighting along dashed sections of road.

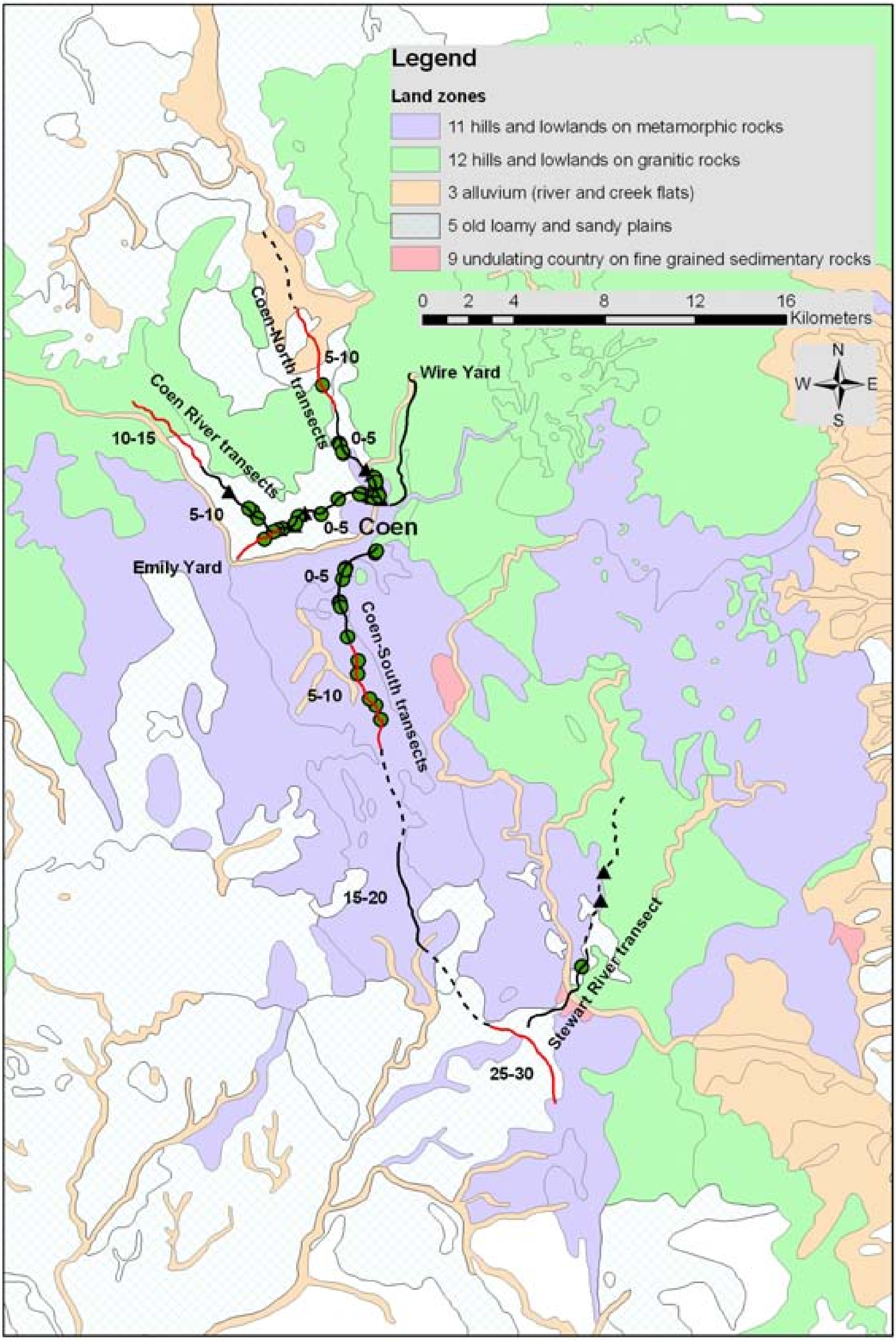

Figure 17. Coen five-kilometre spotlighting transects in relation to Land Zones. See Figure 16 for details. Land Zone Mapping obtained from Queensland Environmental Protection Agency.

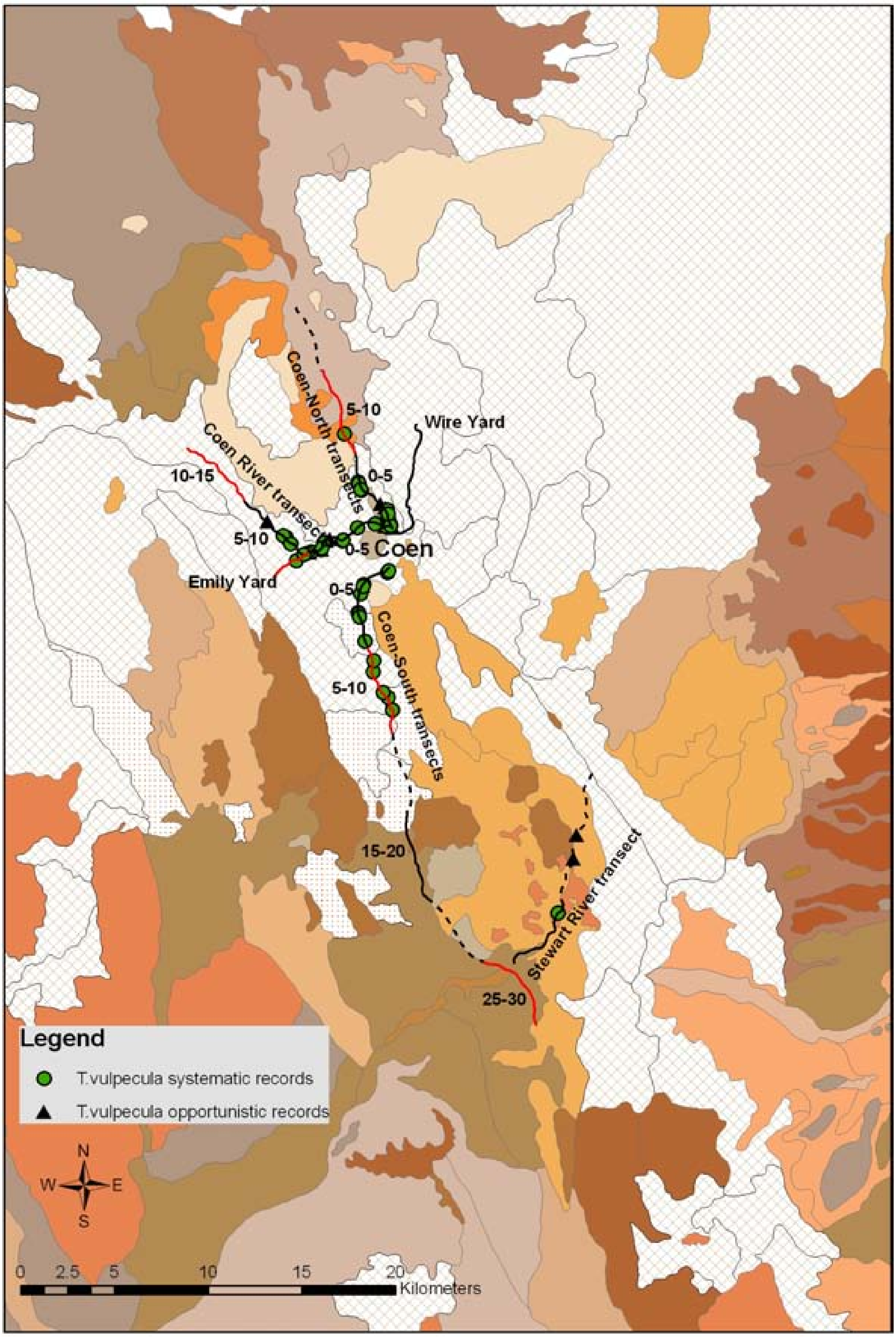

Figure 18. Coen five-kilometre spotlighting transects in relation to soil types. 'Drop' soil type crosshatched. See Figure 16 for further details. Map obtained from CYPLUS Soils (Geology) GIS layer, Queensland Environmental Protection Agency.

4.7.2 Rokeby (Eric Yard)

A second node clearly present was centred at Eric Yard along the road into the Rokeby ranger station in Mungkan Kaanju National Park (Figure 19). Early records tended to be clustered about Eric Yard (see Section 4.4.2) which was confirmed during the first session of resampling in 2003. In the second session in May 2004 a forty-kilometre section of the road was spotlighted repeatedly from a vehicle as 5.0km sections. In June 2005, Mike Ahmet and Christiane Roetgers repeated the two five-kilometre transects immediately to the east and west of Eric Yard. In November 2005, five-kilometre sections of the road, from five kilometres east to ten kilometres west of Eric Yard, were traversed between one and two times.

It is obvious from the numbers seen in each five-kilometre transect that there is a concentration of common brushtail possums in the section immediately to the east of Eric Yard and to a lesser extent in the five-kilometre section immediately to the west (Figure 20), and the greatest concentration is along the two kilometre sub-sections of the transect immediately to the east of Eric Yard (Figure 21).

There is an even better relationship between brushtail possum sightings at Eric Yard and soil type than that found at Coen (Figure 22). All the sightings within the five-kilometre section to the west of Eric Yard and most within the five-kilometre to the east, certainly all within the first two kilometres (Figures 20 and 21) were on soils mapped as Clark (Cr) (Figure 22). This soil is described as “deep bleached gradational yellow massive soils formed on residual sands” (Biggs and Philip 1995).

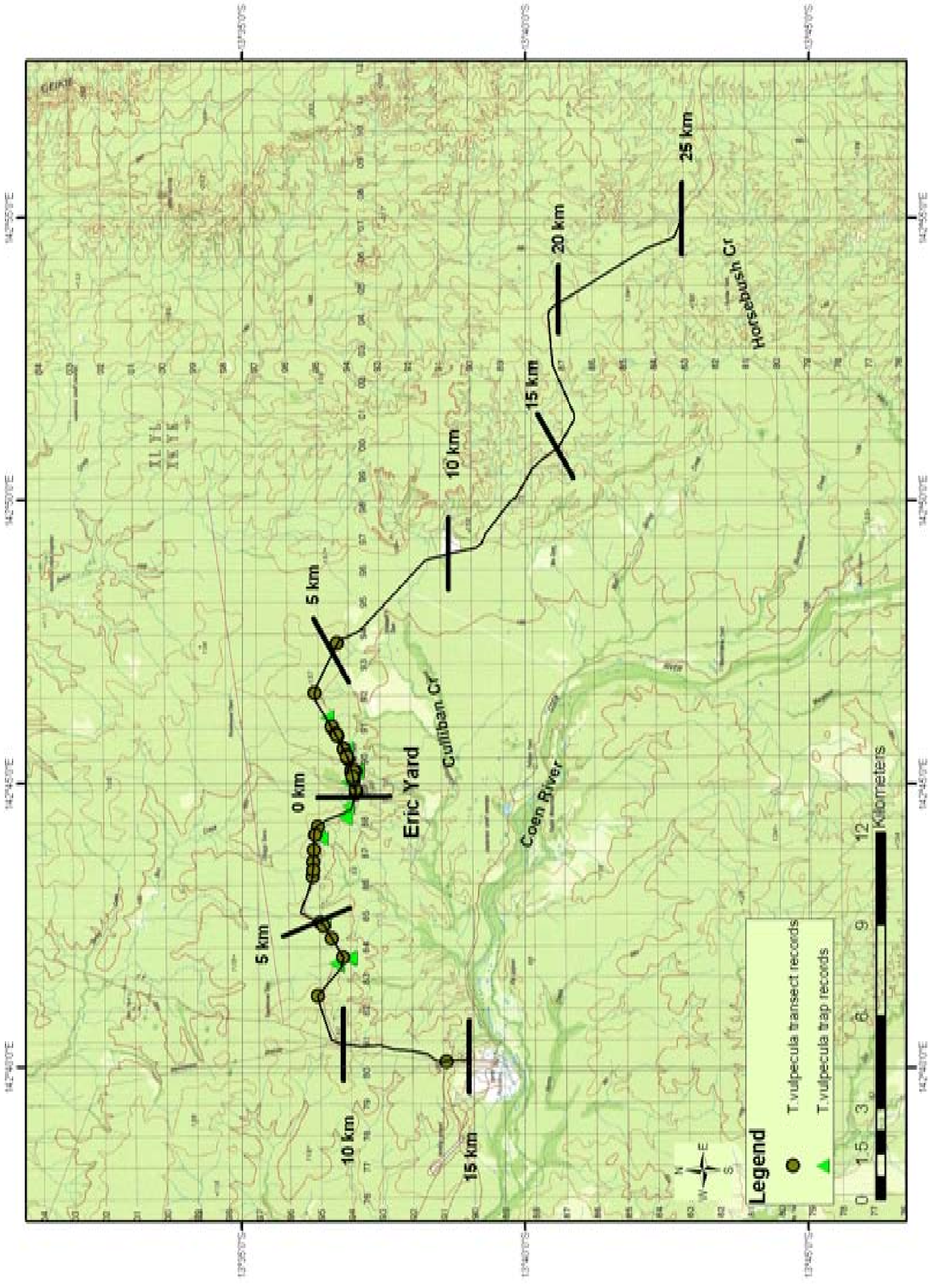

Figure 19. Location of common brushtail possums along the five-kilometre transects centred on Eric Yard. Trapping was restricted to between 5km E and 10 km W of Eric Yard.

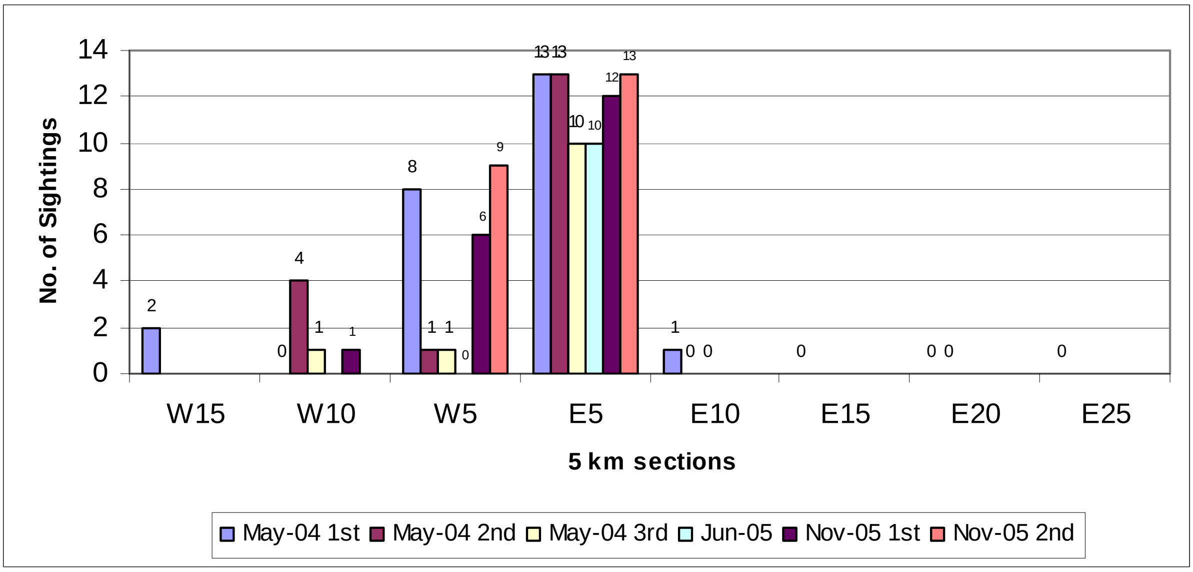

Figure 20. Common brushtail possums seen along five-kilometre spotlighting transects centred on Eric Yard. Each section was traversed between one and six nights. Zeros represent five-kilometre sections traversed without seeing possums.

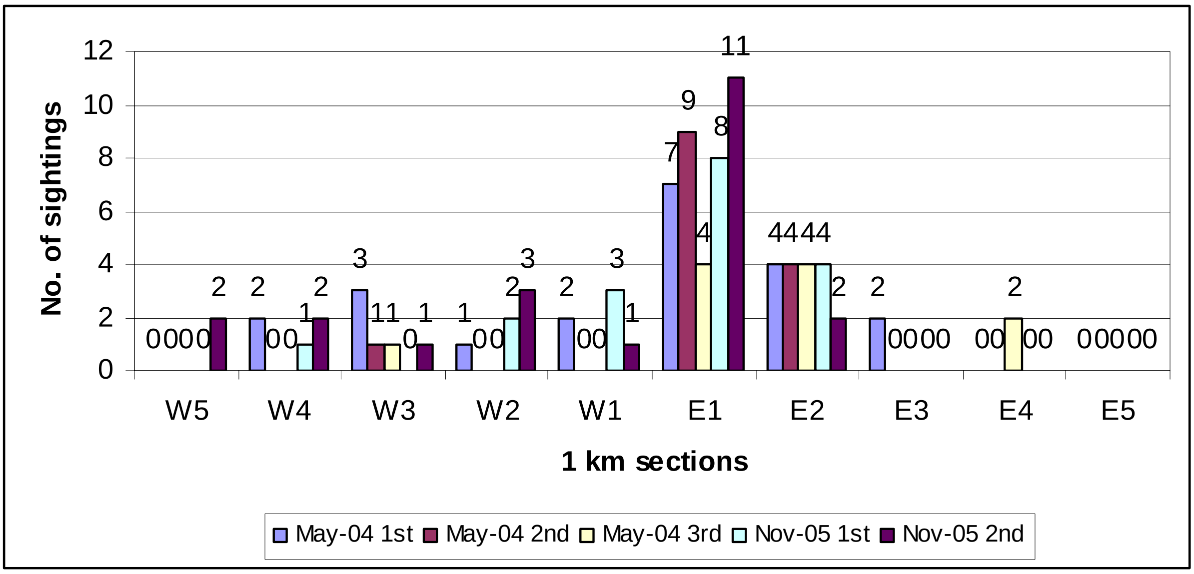

Figure 21. Number of common brushtail possums seen along one-kilometre sections of the five-kilometre sections immediately to the east and west of Eric Yard. Zeros represent one-kilometre sections traversed without seeing possums.

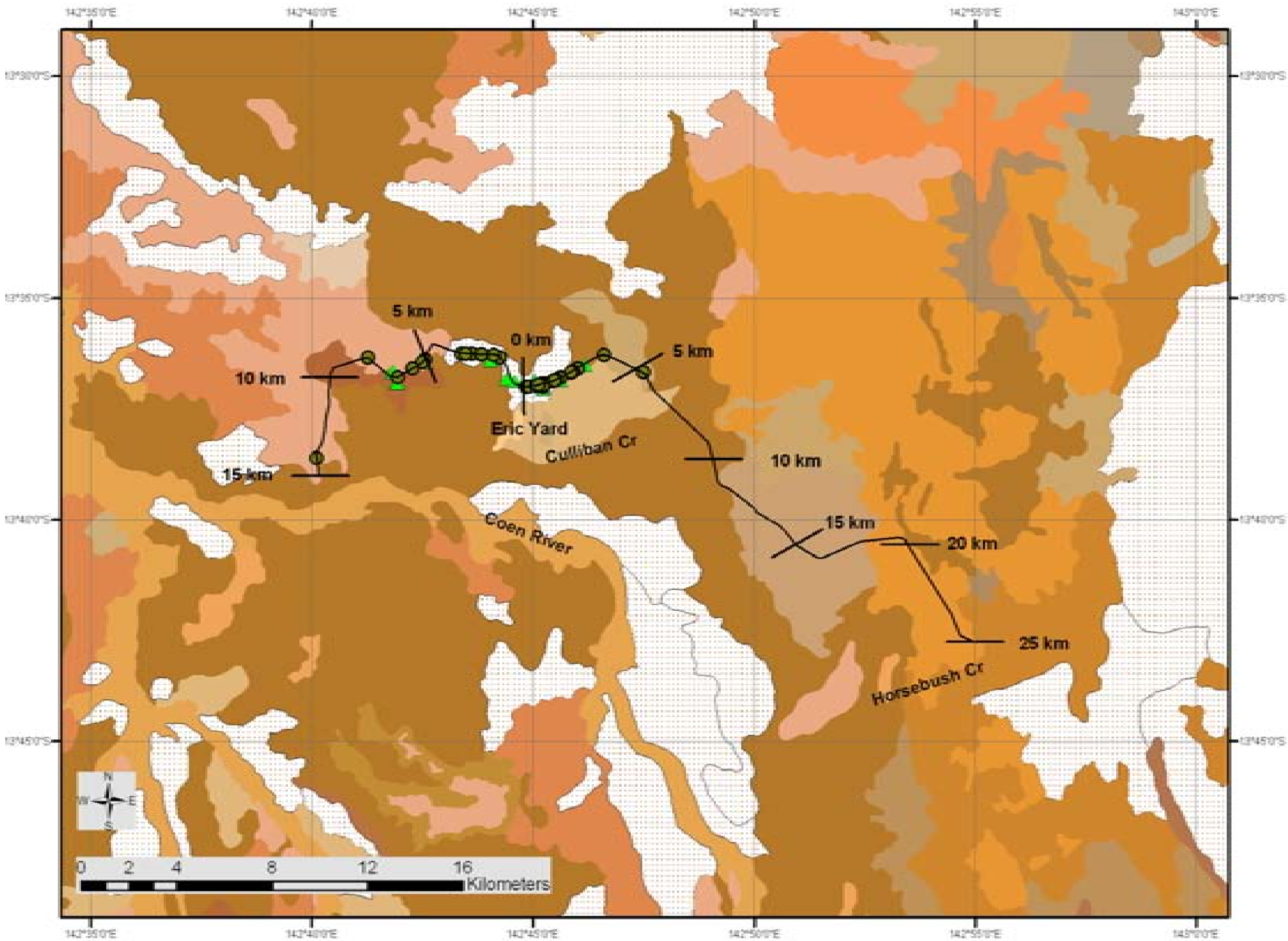

Figure 22. Eric Yard Transect in relation to soil types. Clark soil type stippled.
Map obtained from CYPLUS soils (Geology) GIS layer, Queensland Environmental Protection Agency.

4.7.3 Conclusion

The distribution of brushtail possums within the two nodes identified appear to be most strongly related to soil types based on broad-scale mapping. However, this relationship needs to be verified by more systematic sampling which was beyond the scope of the present project.

4.8 Woodland Types Used by Common Brushtail Possums

It is self evident that an arboreal species such as the common brushtail possum requires trees, although they are known to be capable of successfully living in almost treeless areas such as on Kangaroo Island, South Australia (Troughton 1962), in New Zeeland (Pracy 1974) and of denning in caves in Western Australia (Jones 2004). Throughout northern Queensland the common brushtail possum is known to mainly inhabit rainforest, eucalypt open forest, eucalypt woodland and mixed woodland (which includes a mixture of species, though eucalypts may dominate) (Winter *et al.* 2004). Its occurrence in rainforest in northern Queensland is confined to the Wet Tropics bioregion where it is represented by a subspecies, the coppery brushtail possum *Trichosurus vulpecula johnstonii*, and the Forty Mile Scrub (Stocker *et al.* 1961). On Cape York Peninsula there are no known instances of the common brushtail possum in rainforest, where its place is taken by the common spotted cuscus *Spilocuscus maculatus* and the southern common cuscus *Phalanger intercastellanus* (Winter *et al.* 2004).

It is apparent from any initial examination of the records that the common brushtail possum is generally found in eucalypt open forests or woodlands of Cape York Peninsula, but as any acute observer knows these open forest and woodlands are far from uniform in character. They vary in structure with differing heights, canopy density, amount of shrub layer and the main trees they contain. These include the Darwin stringybark or messmate (*Eucalyptus tetrodonta*), bloodwoods (*Corymbia sp.*), box trees (e.g. the Malloy box *Eucalyptus leptophloeba*), ironbarks (*Eucalyptus sp.*), Cooktown ironwood (*Erythrophleum chlorostachys*), wattles (*Acacia sp.*), paperbarks (*Melaleuca sp.*) and greener, softer leaved trees such as the white lady apple (*Syzygium suborbiculare*), kurrajongs (*Brachychiton sp.*) and almonds/damsons (*Terminalia sp.*).

This variation in open forest and woodland types is primarily determined by rainfall, soil and geomorphology (geology and terrain). Mapping available for this project that characterises the forest types are the Broad Vegetation Types (BVG) (Neldner and Clarkson 1995) and Land Zones (LZ) based on geomorphology which is a combination of geology and topography (Satler and Williams 1999).

To determine the extent to which the common brushtail possum may be restricted to a particular type of open forest or woodland, records were allocated to the combined Broad Vegetational Types and Land Zones. This was done by overlaying the geographical point at which a record was obtained on a map of the vegetation types and land zones, using computer stored information. Consequently, results are subject to the accuracy at which a possum sighting was recorded and the accuracy of the mapping. Possum sightings were nearly always located using a Geographical Positioning System (GPS), and were considered to be accurate to within one hundred metres. In the few cases where a locality was determined from a map, only those records with an accuracy of 250m or better were used. Another source of error was the 1:250,000 scale at which vegetation was mapped. At this scale the smallest unit that can be represented is twenty-five hectares (Neldner and Clarkson 1995). Conversely, certain plant communities such as narrow riverine communities, isolated rainforest patches and small swamps may have been exaggerated in extent so as to be shown on the map (Neldner and Clarkson 1995).

To overcome possible bias that the presence of brushtail possums merely reflects those areas sampled, two sets of records were considered. One is the records of the common brushtail possum obtained from 2000 to 2004 inclusively. The other set is of other vertebrate species recorded in the same time period during spotlighting searches or trapping with large wire cage traps capable of capturing possums (Table 7). This second set is used as a measure of the areas sampled and includes localities at which no possums were recorded.

To determine whether the number of possum records obtained from a particular combination of Land Zone and Broad Vegetation Type, the actual number recorded is compared with the expected number based on the ratio of other vertebrates recorded from that combination:

Expected no. of possums for location *y* =
total possums ÷ total other vertebrates x number of other vertebrates at location *y*

A total of 269 brushtail possum records and 508 other vertebrate records were available for the determination of possum numbers in the range of LZ/BVGs sampled (Table 8).

There was a significant difference between the number of possums recorded and expected in a particular combination of Land Zone and Broad Vegetation Type (LZ-BVG) (Table 8). When graphed in order of the contribution made to the Chi-square value, there is a group at the upper (right) end of the scale in which the difference between the observed and expected is substantial (Figure 23).

The greatest difference, and one in which the number of possums observed was higher than expected, was for the messmate woodlands on old sand plains (LZ-BVG 5-16). Land Zone 5 is the old (Cainozoic) erosional loamy and sandy plains and includes those with either ferric or aluminous lateritic surfaces. Broad Vegetation Type 16 is defined as ‘woodlands and tall woodlands dominated by messmate *Eucalyptus tetrodonta* on deeply weathered plateaus and remnants’ (Neldner and Clarkson 1995). Although the messmate may be the most common tree, others, particularly the Melville Island bloodwood *Corymbia nesophila* and Cooktown ironwood *Erythrophleum chlorostachys* may also be common. The possums do not necessarily occur in higher than expected numbers throughout this type of woodland as illustrated by the lower than expected number recorded from messmate woodland on sandstones (LZ-BVG 10-16, Table 8).

The next greatest difference was for lower than expected numbers of brushtail possums recorded from closed gallery forests with large paperbark trees on alluvia along watercourses (LZ-BVG 3-6) (Table 8, Figure 23). This is perhaps not surprising as this is the habitat occupied by the common spotted cuscus. Other habitats in which numbers of possums were lower than expected were poplar gum (LZ-BVG 3-12) and broad-leaved paperbark (LZ-BVG 3-18) woodlands on alluvia, and ironbark woodlands on granite (LZ-BVG 12-9).

Table 7. Species recorded during spotlighting searches or trapped at localities where large wire traps set.

	Common name	Scientific name
Frogs		
	Rocket Frog	*Litoria nasuta*
	Wood Frog	*Rana daemeli*
Reptiles		
	Estuarine or Salt-Water Crocodile	*Crocodylus porosus*
	Burton's Legless Lizard	*Lialis burtonis*
	Diamond Python	*Morelia spilota*
	Northern Death Adder	*Acanthophis praelongus*
	Brown Tree Snake	*Boiga irregularis*
Birds		
	Australian Bustard	*Ardeotis australis*
	Large-tailed Nightjar	*Caprimulgus macrurus*
	Papuan Frogmouth	*Podargus papuensis*
	Tawny Frogmouth	*Podargus strigoides*
	Barking Owl	*Ninox connivens*
	Southern Boobook	*Ninox novaeseelandiae*
	Barn Owl	*Tyto alba*
Mammals		
	Short-beaked Echidna	*Tachyglossus aculeatus*
	Brown Bandicoot	*Isoodon macrourus/obesulus*
	Common Brushtail Possum	*Trichosurus vulpecula*
	Common Ringtail Possum	*Pseudocheirus peregrinus*
	Striped Possum	*Dactylopsila trivirgata*
	Sugar Glider	*Petaurus breviceps*
	Squirrel Glider	*Petaurus norfolcensis*
	Agile Wallaby	*Macropus agilis*
	Antilopine Wallaroo	*Macropus antilopinus*
	Black-footed Tree-rat	*Mesembriomys gouldii*
	Little Red Flying-fox	*Pteropus scapulatus*
	Cat (feral)	*Felis catus*
	Cattle	*Bos* sp.
	Pig (feral)	*Sus scrofa*
	White-tailed Rat	*Uromys caudimaculatus*

Table 8. Observed and expected numbers of common brushtail possums and other vertebrates in relation to Land Zones and Broad Vegetation Types.

Land Zone – Broad Vegetation Type		Brushtail Possum		Other	Chi-square
Name	**Code**	**Observed**	**Expected**	**Verts**	**Value†**
Clay downs – messmate woodland	9-17	14	14.57	27	0.022
Metamorphics – Malloy box woodland	11-11	16	18.34	34	0.300
Alluvial plains – *Eucalyptus leptophloeba* woodland	3-11	3	4.32	8	0.401
Sand plains – messmate woodlands woodland	5-17	30	34.53	64	0.595
Clay downs – bloodwood woodland	9-8	1	2.16	4	0.622
Granite hills – messmate woodlands woodland	12-11	1	2.16	4	0.622
Metamorphics – ironbark woodland	11-9	23	17.27	32	1.904
Alluvial plains – heath	3-24		2.16	4	2.158
Sand plains – paperbark (narrow leaved) woodland	5-20		2.16	4	2.158
Sand plains – shiny-leaved / coolibah woodland	5-7		2.16	4	2.158
Sandstones – heath	10-24		2.70	5	2.698
Sandstones – messmate woodlands woodland	10-10		3.78	7	3.777
Sand plains – closed forest (rainforest)	5-3		4.32	8	4.316
Alluvial plains – bloodwood woodland	3-8	15	8.09	15	5.894
Alluvial plains – broad-leaved paperbark woodland	3-18	8	20.50	38	7.625
Sandstones – messmate woodlands woodland	10-16	2	11.87	22	8.207
Alluvial plains – box or poplar gum woodland	3-12		8.63	16	8.633
Granite hills – ironbark woodland	12-9		9.17	17	9.172
Alluvial plains – gallery forest and paperbark	3-6	7	24.28	45	12.298
Sand plains – messmate woodlands, woodlands	5-16	146	72.84	135	73.482
Total	**Total**	**266**		**493**	**147.0425**

Chi-sq = 147.0425, 19 d.f., p<0.005*** (highly significant)

† In ascending order of the contribution made to the Chi-square value.

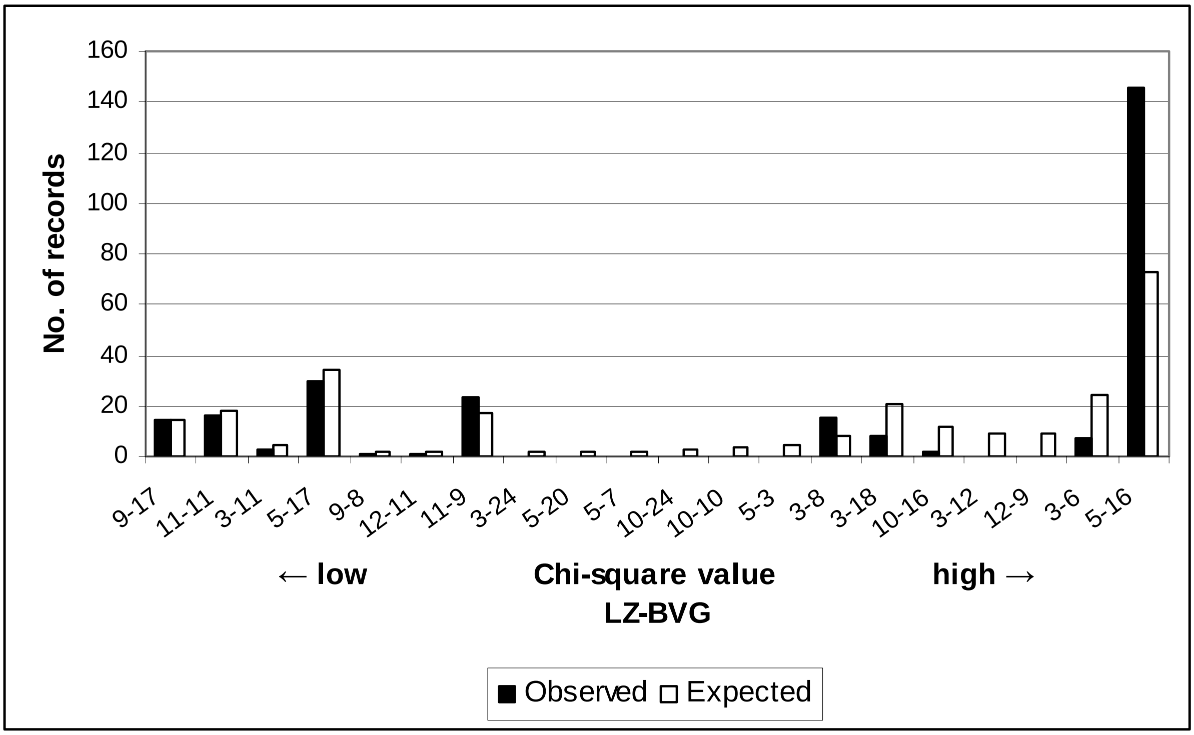

Figure 23. Observed and expected numbers of common brushtail possums in Land Zone-Broad Vegetation Type (LZ-BVG) units. Plotted in order of the contribution made to the Chi-square value (Table 8).

4.9 Tree Characteristics

4.9.1 Hollows

Shelter during daylight hours is important to the common brushtail possum. They are known to be extremely adaptable in what they use – rabbit burrows (Pracy 1974; Troughton 1962), rock crevices, fallen logs, bracken, large epiphytic ferns, forks of trees and house ceilings (Cowan 1989; Day *et al.* 2000; Green and Coleman 1987; Pracy 1974; Ward 1978, J. W. Winter pers. obs.). However, in the woodlands of Cape York Peninsula the sparse more exposed canopies of trees provide little shelter from either avian predators or high daytime temperatures, other than in tree hollows. There are no records of the possums denning on the ground on Cape York Peninsula.

Potential possum hollows were estimated using the point-quartile method. Potential brushtail possum hollows were recorded in 11.5% of the 820 trees examined, and 25% contained potential glider hollows (Table 9). Of the fourteen tree species occurring ten or more times in the sample, the Malloy red box had the highest percentage with possum hollows, 33%, followed closely by a bloodwood tentatively identified as Stocker's bloodwood with 25%. The remaining four species containing possum hollows in this group were the messmate, Clarkson's bloodwood and Melville Island bloodwood with relatively high percentages (19, 14, 14) and the Cooktown ironwood with a low 4%. Of this group of fourteen most common trees which accounted for 703 (85%) of the 820 trees measured, seven were eucalypts (genus *Eucalyptus* or *Corymbia*), and only one, the broad-leaved carbeen *C. confertiflora*, was without possum sized hollows. Of the seven non-eucalypt species, the Cooktown ironwood was the only one containing possum size hollows. The remaining six non-eucalypt species – nonda plum, lady apple, kurrajongs, wattles and broad-leaved paperbark – lacked hollows of either possum or glider size.

A caveat needs to be applied to these observations on potential possum dens. Namely, that the observation from the ground of an opening at the end of a branch, or an opening on the trunk of a tree, was not necessarily proof of a hollow suitable for use by a possum. This may apply to thinner trees, particularly the 30-45cm DBH class which have a reasonable proportion of suitable sized entrances for possums, but may lack any backing hollow (Figure 24). Hence the precaution of calling them potential den hollows.

Another precaution in interpreting these pooled results is that trees containing hollows are not necessarily evenly distributed between localities, and may therefore be limiting to possum numbers in some places.

Table 9. Percentage of trees measured in the point-quartile plots containing potential hollows for gliders and possums.

Trees				**Percentage with hollows**	
Common name	**Species**	**Number**	**Percentage**	**Glider**	**Possum**
Messmate	*Eucalyptus tetrodonta*	232	28.3	38.8	19
Clarkson's bloodwood	*Corymbia clarksoniana*	130	15.9	25.4	14
Cooktown ironwood	*Erythrophleum chlorostachys*	100	12.2	13.0	4
Melville Island bloodwood	*Corymbia nesophila*	79	9.6	41.8	14
Malloy red box	*Eucalyptus leptophleba*	24	2.9	41.7	33
Wattle species	*Acacia species*	23	2.8	0.0	0
Nonda	*Parinari nonda*	20	2.4	0.0	0
	Neofabricia mjobergii	19	2.3	0.0	0
Broad-leaved carbeen	*Corymbia confertiflora*	15	1.8	26.7	0
Ironbark	*Eucalyptus sp* (narrow-leaved)	15	1.8	46.7	20
Broad-leaved paperbark	*Melaleuca viridiflora*	14	1.7	0.0	0
Stocker’s bloodwood	*Corymbia stockeri?* (gum top)	12	1.5	50.0	25
Kurrajongs	*Brachychiton*	10	1.2	0.0	0
Lady apple	*Syzygium suborbiculare*	10	1.2	0.0	0
Swamp mahogany	*Lophostemon suaveolens*	8	1.0	0.0	0
a paperbark	*Melaleuca ?viridiflora*	8	1.0	0.0	0
a paperbark	*Melaleuca nervosa*	7	0.9	0.0	0
Bushman's clothes peg	*Grevillea glauca*	6	0.7	0.0	0
	Asteromyrtus	5	0.6	0.0	0
Kapok bush	*Cochlospermum gillivraei*	5	0.6	0.0	0
Rough-leaved bloodwood	*Eucalyptus setosa*	5	0.6	40.0	20
Brown cudgerie, Mango carrotwood	*Canarium*	4	0.5	0.0	0
a bloodwood	*Corymbia dallachiana*	4	0.5	50.0	25
Weeping paperbark	*Melaleuca leucadendra*	3	0.4	0.0	0
Emu-apple, Rose almond	*Owenia*	3	0.4	0.0	0
Quinine bush	*Petalostigma pubescens*	3	0.4	0.0	0

Trees				**Percentage with hollows**	
Common name	**Species**	**Number**	**Percentage**	**Glider**	**Possum**
an almond or damson	*Terminalia aridicola*	3	0.4	0.0	0
Cypress pine	*Callitris intratropica*	2	0.2	0.0	0
Red beech	*Dillenia alata*	2	0.2	0.0	0
a eucalypt	*Eucalyptus* (box)	2	0.2	50.0	0
Beefwood, silver oak	*Grevillea parallela*	2	0.2	0.0	0
Cabbage tree palm, fan palm	*Livistona*	2	0.2	0.0	0
	Siphonodon sp	2	0.2	0.0	0
Golden bouquet tree	*Deplanchea tetraphylla*	2	0.2	50.0	0
Bead tree	*Adenanthera abrospermoides*	1	0.1	0.0	0
	Allocasuarina littoralis	1	0.1	0.0	0
Milkwood	*Alstonia*	1	0.1	0.0	0
Wild orange	*Capparis canescens*	1	0.1	0.0	0
a bloodwood	*Corymbia nesophila?*	1	0.1	100.0	0
a bloodwood	*Corymbia novoguinensis*	1	0.1	0.0	0
Poplar gum	*Corymbia playphylla*	1	0.1	0.0	0
a bloodwood	*Corymbia* sp	1	0.1	100.0	0
	Erythroxylum ellipticum	1	0.1	0.0	0
a paperbark	*Melaleuca*	1	0.1	0.0	0
	Pogonolobus reticulata	1	0.1	0.0	0
	Syzygium eucalyptoides	1	0.1	0.0	0
Woody pear	*Xylomelum scottianum*	1	0.1	0.0	0
Unidentified species		11	1.3	0.0	0
Rainforest species		15	1.8	6.7	7
Total	**46 + unidentified species**	**820**		**25.0**	**11.5**

4.9.2 Tree Girth, Height and Spacing

As expected, the proportion of trees with potential possum dens increases with increased girth of the trees, which is assumed to be the older ones. The Malloy red box is the best hollow bearing tree with most trees 45cm DBH and above containing possum hollows (Figure 24).

There was a slight trend for possums to be more abundant in the shorter woodlands (Figure 25). These were often the woodlands with a greater mixture of species, particularly species such as white lady apple (*Syzygium suborbiculare*) or almonds/damsons (*Terminalia sp*.). The forests with a mean tree height over fifteen metres tended to be those dominated by messmate *Eucalyptus tetrodonta*, and were low in possum numbers despite this tree containing a high percentage of potential possum dens. That this is not a fixed relationship is demonstrated by the very tall stringybark forest on the Embley Range in which the common brushtail possum was found to be abundant and is possibly more related to other features in the forest such as the complexity of the understorey.

Tree spacing was quantified as the distance from the centre of the point-quartile sampling plot to the nearest five trees, 15cm or greater in diameter, in each quarter. This measure provided an index of spacing rather than the actual spacing between trees. There was no obvious relationship between the spacing of trees and the density of possums (Figure 25).

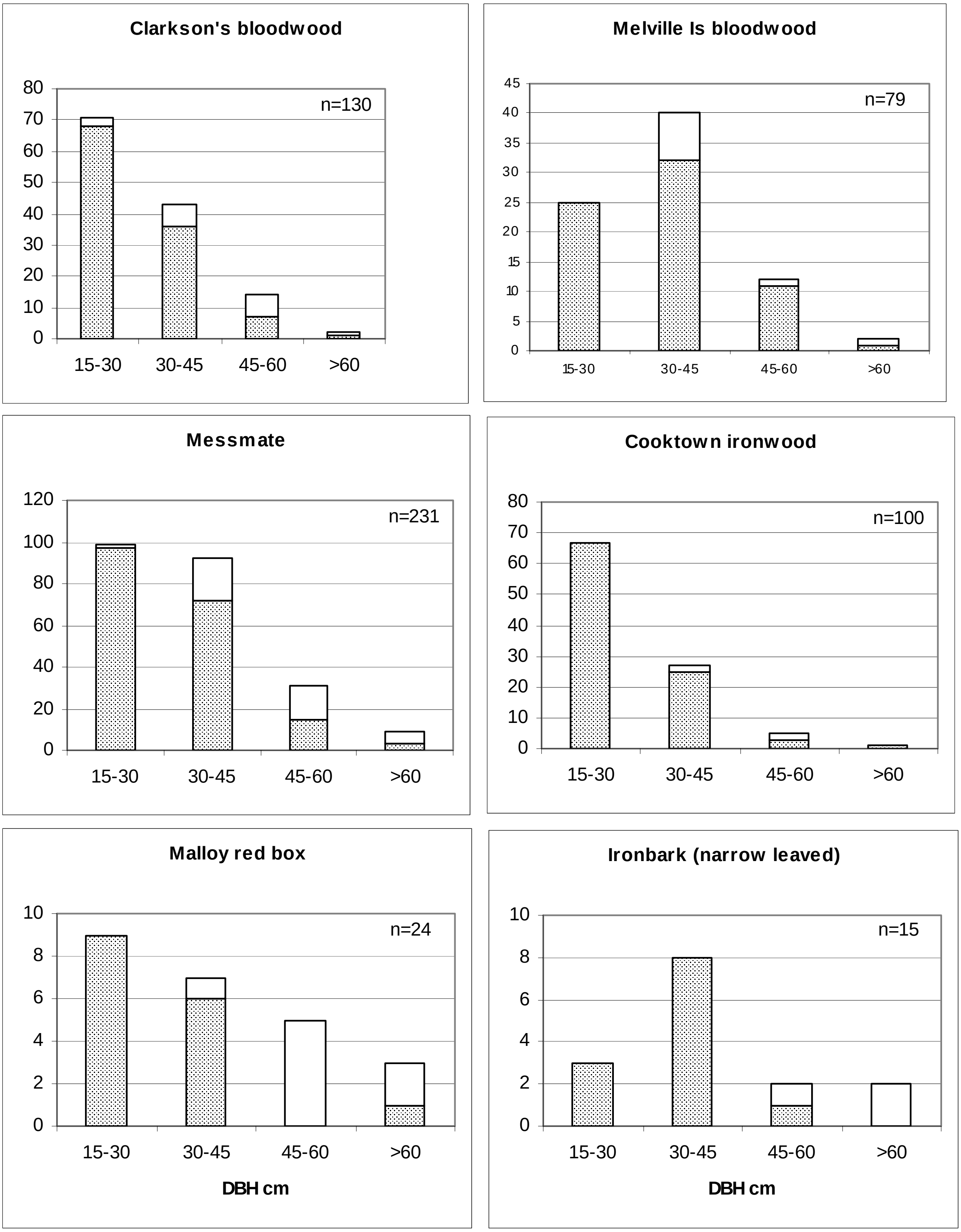

Figure 24. Proportion of trees containing tree hollows potentially suitable as common brushtail possum dens in relation to the girth (DBH) of the tree. Stippled = trees without hollows, plain = trees with hollows.

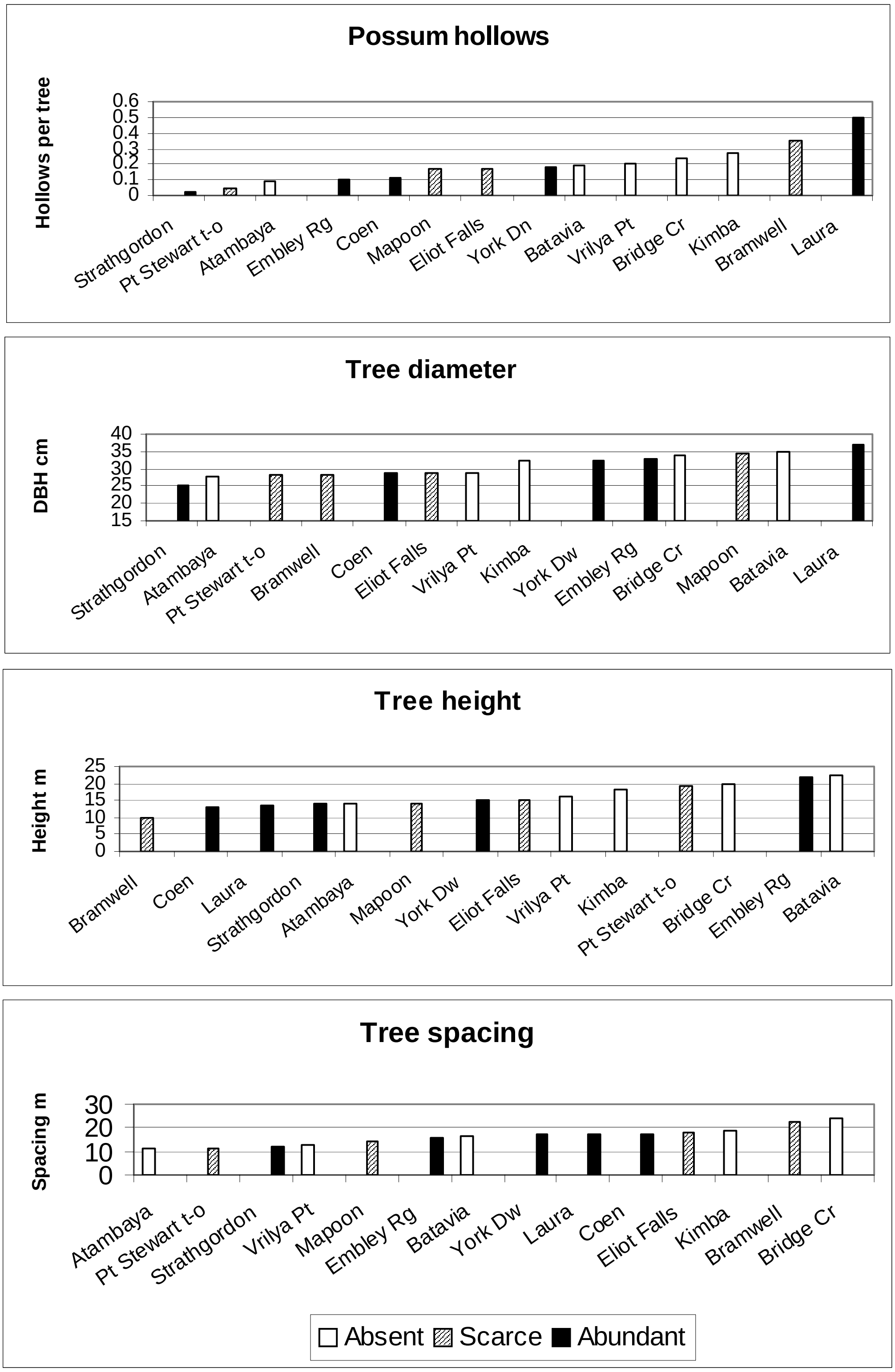

Figure 25. Average tree characteristics at a locality in relation to the density of common brushtail possums.

4.9.3 Conclusions

The main conclusion to be drawn from the structure of trees is that potential possum den hollows are common within the savanna woodland of Cape York Peninsula because they occur at reasonably high percentages in the most common trees, notably the eucalypts. They are unlikely to limit the number of possums at a locality as there was no obvious relationship between the number of hollows per tree and the abundance of possums (Figure 25).

Nor was there any apparent relationship between possum abundance and tree diameter or spacing, although there may have been a trend for possums to be more abundant in the shorter woodlands (Figure 25).

4.10 The Regional Population of Common Brushtail Possums

4.10.1 Supplementary and Anecdotal Data

The localities surveyed for possums and described above provide an insight, albeit a very restricted one, in to what is happening to the possum population regionally. To enhance this picture, other records often provided by local people or other visiting biologists are invaluable. These opportunistic observations are often crucial in understanding the situation, particularly where possum populations are extremely low, so become difficult to sample using the standard methods employed in this project. The examples described here illustrate the importance of incorporating all records in the understanding of a wildlife population at the regional scale.

4.10.1.1 Mapoon Road

Despite repeated resampling along the Mapoon Road Transect, possums have not been recorded in the *Eucalyptus tetrodonta* woodland that the transect traverses (Figure 26). However, in September 2002 a population of brushtail possums (four records, 13.5 hours spotlighting) was located only ten kilometres west of the Mapoon Road Transect in similar habitat in the vicinity of the Pennefather River (Kutt *et al.* 2005) (Figure 26). The Pennefather findings were made less than two months before the sampling of the Mapoon Road Transect in the present project which rules out the possibility of a significant population change between the two sets of data. Likewise, in December 2004, at a Savanna CRC locality centred on the Mapoon township at Red Beach, two sightings of the common brushtail possum were made in the course of 2.4 hours of vehicle spotlight transects (Figure 26). What these records demonstrate is that the brushtail possum is still present in the Mapoon/Pennefather area, but probably as a low density population which can often be missed by standard searching techniques. A low density population still present in the general area means that the possum population along the Mapoon Road Transect would have the capacity to recover to the 1980s densities under favourable conditions.

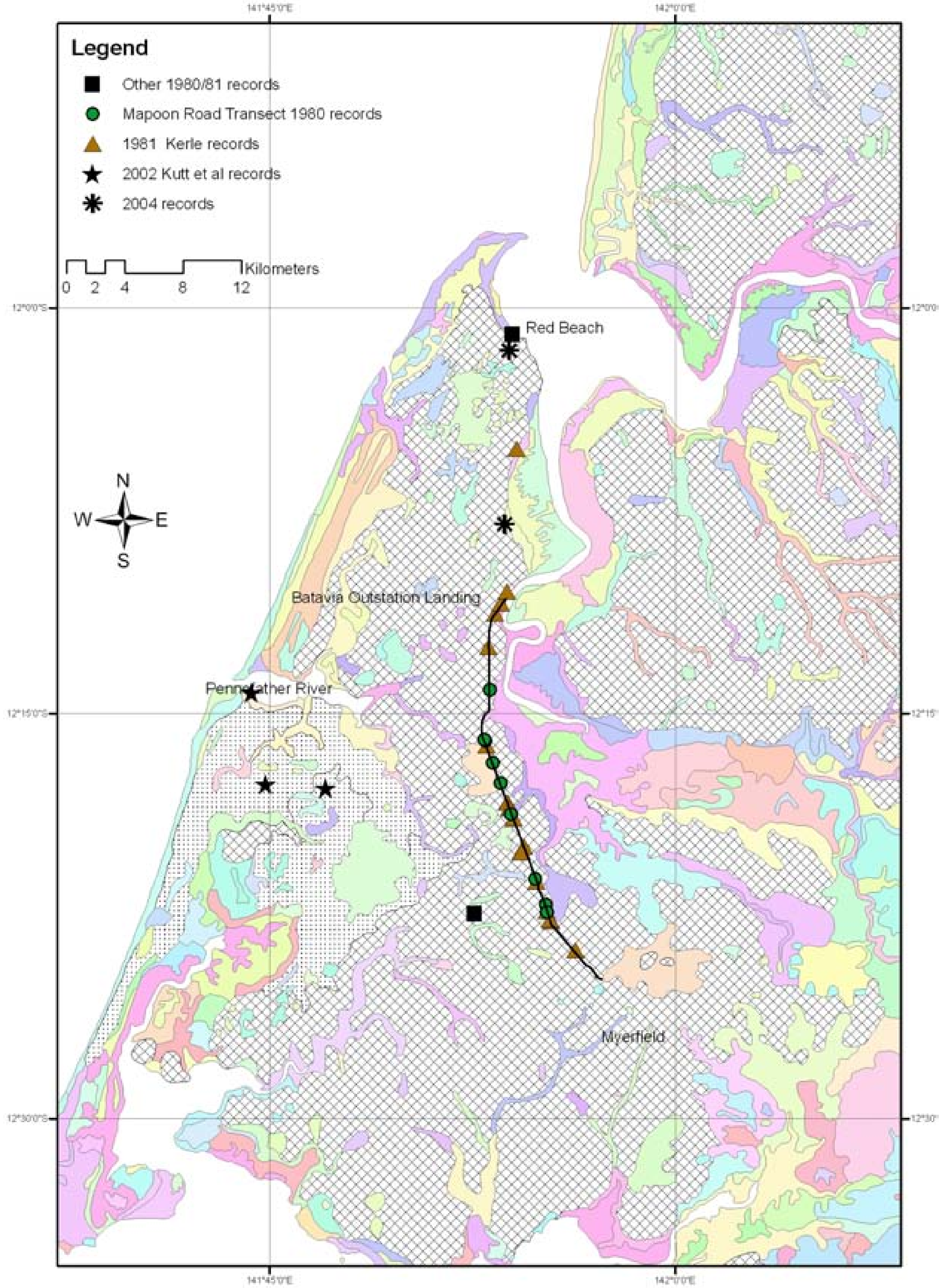

Figure 26. Mapoon Road Transect and recent (post 2000) records of the common brushtail possum in relation to Regional Ecosystems (REs). Cross-hatched = 100% RE 3.5.2 (messmate *Eucalyptus tetrodonta* and Melville Island bloodwood *Corymbia nesophila* tall woodland on aluminous laterite), stippled = 60% or greater of RE 3.5.2. Regional Ecosystem mapping obtained from Queensland Environmental Protection Agency.

4.10.1.2 Eliot Falls

Immediately following the resampling of the Bridge Creek area in this project, with negative results, two nights were spent at the Eliot Falls camping ground twenty kilometres further south. Expectations were to find possums because several months earlier Euan Ritchie (pers. comm. June 2002) had reported seeing one brushtail in the camping ground. After two nights spotlighting around the camping ground on foot (3.1 observer hours) and travelling the roads by vehicle (2.7 hours), the only arboreal marsupial seen was a sugar glider. However, Ingrid Schaefer, a camper at an adjacent site to that of the author, observed a brushtail possum at her camp site at 2:30 am. This highlights the impossibility of claiming the absence of possums from an area on the basis of a session of standard sampling. The Eliot Falls sightings are the most northerly records of the common brushtail possum on Cape York Peninsula since the Bridge Creek records obtained in the 1970s.

4.10.1.3 Other Possum Populations

Evidence of population fluctuations over a thirty year period was obtained from the Coen North Transect (see Section 4.4.1). Corroborating evidence for similar population fluctuations elsewhere on Cape York Peninsula was provided by Carol Shephard who lived at Mary Valley Station from 1962 to 1996. During this period the only time that brushtail possums were seen in and around the homestead was over a two year period in the mid 1980s. Her husband, Maurice Shephard, was seeing a similar increase in brushtail possum on neighbouring Lakefield National Park. She particularly remembered this because it was the first time that her teen age sons had seen possums. This suggests that there was a population increase during the mid 1980s possibly centred on the Morehead River, about ten kilometres north-west of the homestead, because information provided to her by the local Aboriginal people indicated that the possums were continuously present along the river. During this project, a night spent spotlighting at Mary Valley resulted in only one common brushtail possum seen, in a white apple at the Morehead River crossing (Appendix 1).

A similar increase in numbers was reported by Brian and Barbara McKenzie (pers. comm. 28/3/2004), who have lived three kilometres north of Laura since 1967 (37 years) and the first possums noted were in mid-1980s.

Boydii Heinemann (pers. comm. 16/11/2002), was raised on Bramwell Station north of the Wenlock River and told of seeing possums around rivers (Moreton) where the cuscuses were. He had been away from Cape York Peninsula for twenty years, but reported that in the last few years he had seen more possums and bandicoots on the roads than the whole of his life on the Cape, but conceded that the perceived increase may have been because he now travelled the roads more frequently.

Elsewhere, declines in possum numbers were reported. In the Muttee Head area between the Jardine River and Injinoo, Miriam Crowe (pers. comm. 12/9/2002), an elderly Injinoo Traditional Owner talked of hunting for possums with her father when she was a girl by looking for scratches made by possums on the trunks of the trees. In addition, Meun (Shorty) Lifu (pers. comm. 12/9/2002), Senior Community Ranger, Injinoo, said that possums lived in the area and were found in the iron bark trees because they liked the new shoots and used the hollows. Spotlighting in this area with Shorty from a vehicle on 12 September 2002 (17.3 km, 2.25 observer hrs) failed to find any possums. Shorty was unable to remember having seen a possum for many years, but had seen 'squirrel' gliders (either *Petaurus norfolcensis* or *P. breviceps*) regularly and a feathertail glider. These reports and observations, together with the total lack of any known records of brushtail possums north of the Jardine River, suggest numbers of brushtail possums, possibly always low, may have declined in recent years.

John Armbrust (pers. comm. 21/11/2002) came to Orchid Creek Station, north of the Archer, River in 1986. At the time he considered the possums to be plentiful judging by the number of gum trees with scratches on the trunks, and seeing possums and gliders when cutting timber. In the past three years, however, the scratches have disappeared which he attributes to a decline in possum numbers.

Some localities have had very low population densities of possums over extended periods of time. For example on Artemis Station, Sue Shephard (pers. comm. 15/11/2002), who has lived there continuously from the 1970s until the present, can remember seeing possums five times only; none around the homestead, four along the road into Musgrave at creek crossings and one dead beside a dam on the Dixie Road. Although described as 'just possums', it is probable that those on the road were brushtail possums. Jimmy Gordon (pers. comm. 30/7/2004) who lived at Rokeby for about twenty years up until the early 1980s, never saw a possum around the homestead nor in the bush, but emphasised that he did not go looking for them at night. His son James Gordon moved to Astrea Station, west of Musgrave, when they left Rokeby, and he has never seen brushtail possums on Astrea, even during a two month period of concentrated nocturnal pig control work.

Coen, on the other hand, appears to have a history of good numbers of brushtail possums going back many years. Paddy Shephard of Lochinvar Station (pers. comm. 4/9/2003) remembers possums as always being present around the homestead, for at least the past thirty years. Ann Creek (pers. comm. 24/7/2002) remembers as a young woman that ten miles north of Coen there were "…plenty of possums at Ten Mile Yard, opposite Mount Croll. When shining the light round we would see the eyes of possums in the trees."

The overall conclusion to be drawn from all these observations is that brushtail possums were probably never in high numbers over much of the Peninsula, that numbers may undergo changes over a period of years, and that in only a very few places, i.e. Coen, are numbers maintained at a relatively high level for periods of up to thirty years.

4.10.2 Observations in Relation to Time Spent Spotlighting

To overcome the possibility that the number of possums sighted at any one locality is a function of the number of hours spent spotlighting – the more hours searching will mean the more possums seen – the data for each locality can be expressed as the number of possums seen per hour. Apart from localities where no possums were seen the rate ranged from 0.16/hr at Kimba to 4.19 at Eric Yard (Table 10).

To determine whether the number of possums recorded at each locality is statistically different and therefore represents real differences in density and not just a matter of chance, the actual number of possums seen is compared with the number expected to be seen determined as follows:

$$\textbf{Expected number} = \frac{\textbf{total possums seen}}{\textbf{total hrs spotlighting}} \times \textbf{hrs spotlighting at the locality}$$

The difference between observed and expected numbers of possums was highly significant statistically (Chi-squared = 312.638, 16 d.f. <.005) (Figure 27), which means the differences are real. The substantially higher than expected number recorded at Coen and Eric Yard supports the contention that these two populations are indeed relatively high density nodes compared with the other populations. Numbers at Embley Range, Strathgordon and York Downs are also slightly higher than expected so may also represent population nodes, though less pronounced than the Coen and Eric Yard ones. All other populations are lower than expected and may therefore be indicative of low density populations.

Table 10. Common brushtail possum observations in relation to the time spent spotlighting.

Locality	Spotlighting effort				Brushtails	
	Vehicle		Foot hr	Veh. + ft	Seen	Per hr
	km	hr	hr	hr		
Eliot Falls	17.3	2.7	2.2	4.9	0	0
Atambaya, Cockatoo Cr	11.7	2.2	4.5	6.7	0	0
Rokeby, east of Cul 4	34.1	5.8	2.3	8.1	0	0
Mapoon Road	76.9	8.2	0.0	8.2	0	0
Massy Creek	14.9	2.3	6.8	9.1	0	0
Jardine River (Bridge Cr)	42.2	7.0	2.4	9.4	0	0
Vrilya Point	17.1	3.3	15.5	18.8	0	0
Kimba Plateau*	69.5	6.3	0.0	6.3	1	0.16
Pennefather**	?	?	?	13.5	4	0.30
Coen >10 km radius	20.0	3.0	0.0	3.0	1	0.33
York Downs	31.2	3.9	4.5	8.4	15	1.79
Bramwell	10.9	2.1	0.8	2.9	1	0.35
Mary Valley	22.5	1.9	0.2	2.1	1	0.48
Embley Range	0.0	0.0	7.8	7.8	10	1.28
Strathgordon (Melon Yard)	25.9	4.4	4.5	8.9	12	1.35
Coen, <10km radius	80.4	16.1	0.0	16.1	57	3.54
Rokeby, west of Culliban Cr	95.3	14.5	2.3	16.7	70	4.19
Total	**569.9**	**83.5**	**53.6**	**150.6**	**172**	**1.14**

The Rokeby locality is subdivided into the lateritic plateau area west of Culliban Creek (including Eric Yard) and the valley of Culliban Creek plus the lateritic plateau to the east.

* This includes the sighting on the Pinnacles to King Junction Road, 22 km south of the Kimba Plateau

** Kutt *et al.* 2005

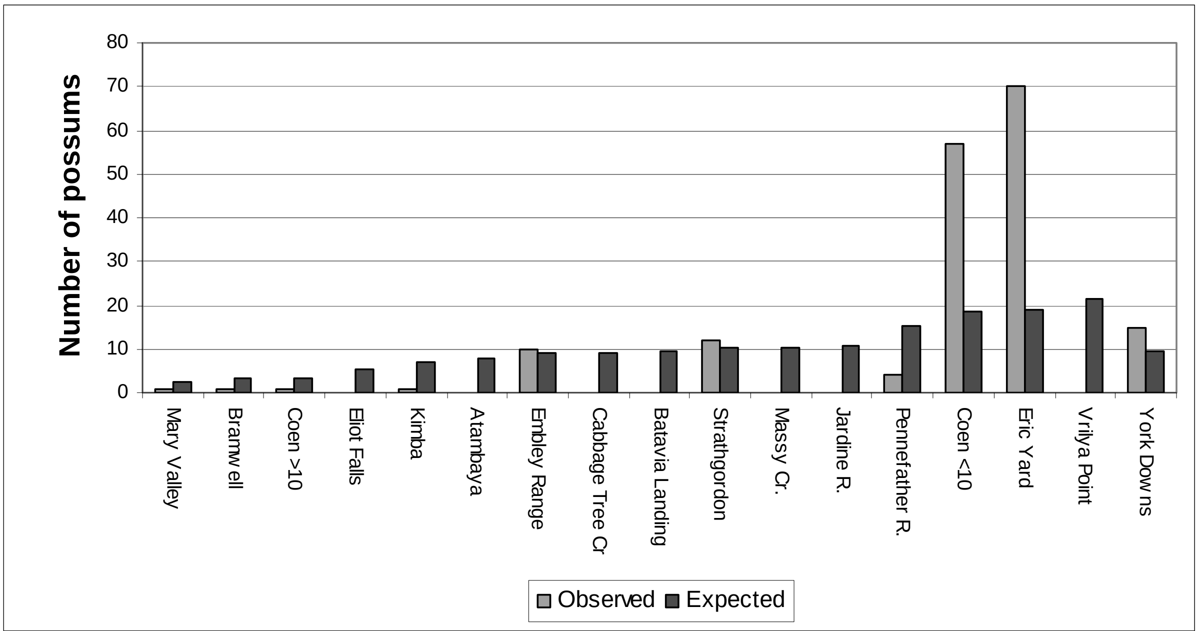

Figure 27. Observed number of common brushtail possums seen in relation to expected number.

4.11 Structure of the Cape York Peninsula Population

Population densities of the common brushtail possum on Cape York Peninsula are generally sparse, but with discrete relatively high density nodes, some of which are long-term others more ephemeral. There is evidence of at least one long-term decline in the population along the Mapoon Road, and of another decline at Bridge Creek, south of the Jardine River. However, at neither of these is there evidence of the extinction of the possum within the general locality as sightings were made of the possum in the general vicinity of the sampling locations during the project. At two localities, Strathgordon and York Downs, the possum was recorded in good numbers in the recent sampling but not during the earlier sampling ten and twenty-three years previously. This indicated that population declines at a locality are not necessarily permanent. Two long-term high density population nodes were recorded at Coen and at Eric Yard in Mungkan Kaanju National Park and at another two, Laura and Embley Range, where the populations may have been through a temporary decline.

In summary, the Cape York Peninsula common brushtail possum population is one that:

- Is widespread throughout the eucalypt woodlands of Cape York Peninsula, usually at extremely low densities that are often not detectable at the intensity of sampling employed in the present project, but the detection of which relies on opportunistic records, usually from other observers, or from more intensive sampling;
- Can fluctuate over time from very low density to relatively high density populations, such as those at Strathgordon and York Downs; or
- May be localised high-density populations, such as the Coen and Eric Yard nodes, which may fluctuate in density of over a period of years.

5. Possums: Declining or Not?

Over much of its range in Australia the common brushtail possum has experienced major declines in its numbers (Kerle 2004; Paull and Kerle 2004; Woinarski 2004b; Woinarski *et al.* 2001) and appears to have retracted from large areas, particularly in the semi-arid environment of central Australia (Kerle *et al.* 1992). Has there been a similar decline on Cape York Peninsula?

Based on the determination of numbers of the common brushtail possums on Cape York Peninsula in this project, population densities appear to be at extremely low levels throughout much of the eucalypt woodlands of the Peninsula, to the point where it is often impossible to find them using standard survey methods. In addition, at two localities, Jardine River and Mapoon Road, numbers have declined significantly. Does this low population density and significant drop in numbers represent a population in decline or is it the normal situation for the region? Are the relatively high density nodes relics of a once higher density population or are they indicative of mini population explosions in response to a combination of localised favourable environmental factors?

In this project, two approaches were used to elucidate these questions. One was to assess the state of the possum population at earlier times from the accounts of the first Europeans to visit the Peninsula and from earlier collectors for museums. The other was to assess any major geographical changes to the distribution of the common brushtail possum.

An obvious third source of information is that of the Indigenous people of Cape York Peninsula. This was not attempted in any systematic way as it was beyond the scope of this project to do so.

Another approach would be to obtain a much better understanding of the relationship between population densities of the possum and its environment, from which specific causes of population changes can be isolated. By understanding this relationship it may become possible to know whether low numbers of possums are a result of fundamental aspects of the environment of Cape York Peninsula, such as soil fertility and climate, or the result of recent changes such as changes to the woodland as a result of changing patterns of land management. Again this falls outside the scope of the current project, other than the identification of possible factors that may be of importance to regulating possum numbers.

5.1 Early European Collectors/Expeditions

A difficulty with obtaining faunal records from early writings, particularly those not explicitly concerned with fauna, is whether a lack of records reflects a genuine absence of an animal or merely the chronicler’s lack of interest. However, the tone and general content of a piece of writing does help. Some early accounts provide no wildlife information because the authors were concerned primarily with the mineral and grazing potential of the country they traversed (e.g. Hann 1873; Jack 1921) or was a family account centred on the mining industry (e.g. Fisher 1998). Where earlier explorers attempted to live off the land, and treated wildlife as a food source, the availability or otherwise of wildlife was often noted in their journals (e.g. Byerley 1867; Carron 1849). As expected, the reliability of faunal information provided is greater in the accounts of collectors for museums, particularly as museum records provide a validation for the information (e.g. McLennan 1922; Mjöberg 1918; Tate 1952; Wilkins 1928).

The first written account of an overland expedition on Cape York Peninsula (Figure 28) is Carron’s journal of the ill-fated Kennedy 1848 expedition from Kennedy Bay just north of

Cardwell to Cape Weymouth – the furthest north reached by Carron (Carron 1849). Although they attempted to supplement their rations by hunting they were spectacularly unsuccessful as indicated by Carron's comment,

> "It is singular that the country here should be so destitute of game; we had seen a few wallabies and a few ducks, but were seldom able to shoot any of them; we had not seen more than four or five emus altogether since we started; a few brown hawks we occasionally shot, were almost the only addition we were enabled to make to our small ration. To-day we got an iguana and two ducks …" (Carron 1849 page 46).

In total, he records the shooting of one kangaroo and six wallabies as the only mammals obtained. Possums are never mentioned (Table 11), although Kennedy offered,

> "… Jackey five shillings each week if he would hunt possums for him, which, of course, Jackey did, though he would have done so without inducement." (Beale 1970 page 211).

The Jardine brothers, Frank and Alexander, during their cattle drive from Carpentaria Downs up the western side of the Peninsula and across to Somerset from September 1864 to March 1865, also hunted for game to supplement their diet (Byerley 1867). Along the Einasleigh River possums were present though scarce as indicated by the note,

> "At night, there being a fine moonlight, they went out to try and shoot opossums as an addition to the larder, but were unsuccessful. They appeared to be very scarce." (Byerley 1867 page 5)

However, they record shooting one possum along the river (Byerley 1867 page 16) and breakfasting off a possum found at a natives' camp (Byerley 1867 page 16). Along Cockburn Creek, a tributary of the Staaten River on two separate nights they were successful in obtaining three possums on each night (Byerley 1867 pages 17 and 19). North of the Staaten, however, their references to mammals are very few. They make no mention of possums, but record shooting a wallaby "... with which the vine scrubs were swarming", presumably either an agile wallaby or a red-legged pademelon, on the banks of the Mitchell River, and they saw 'red kangaroos' (antilopine wallaroos) at Kinlock Creek just south of the Archer River. Either they ceased to record these events or game did in fact become extremely sparse. It is more likely the latter because their food supplies were critically low and shooting of game would have been an eminently recordable event.

Somerset, also known as Port Albany, was established as a Government port of refuge at Albany Passage at the extreme north east of Cape York Peninsula in 1863. When its functions were transferred to Thursday Island in 1879, Frank Jardine, a former Government Resident, continued to occupy Somerset until his death in 1919 (Monteith 1987). Throughout this time it provided a base for naturalists and collectors for museums. However, no brushtail or ringtail possums are recorded from this early period of collection on Cape York Peninsula. John Jardine, the first Government Resident and father of the two Jardine brothers, in his account of the settlement in March 1865, states,

> "The animals afford small variety. The dingo, a native dog, four species of the smaller kangaroos, and two other marsupials are found. One, an elegant little squirrel-like opossum, striped lengthways with black and white, I believe to be new." (Byerley 1867 page 80)

This opossum is almost certainly the striped possum *Dactylopsila trivirgata*. Kendall Broadbent and Robin Kemp collected birds and mammals at Somerset during this period

(Brass 1953; Monteith 1987); the former for the Queensland Museum in 1874-1875 and again in 1884 and the latter for the American Museum of Natural History in 1912. Neither was successful in obtaining brushtail or ringtail possums.

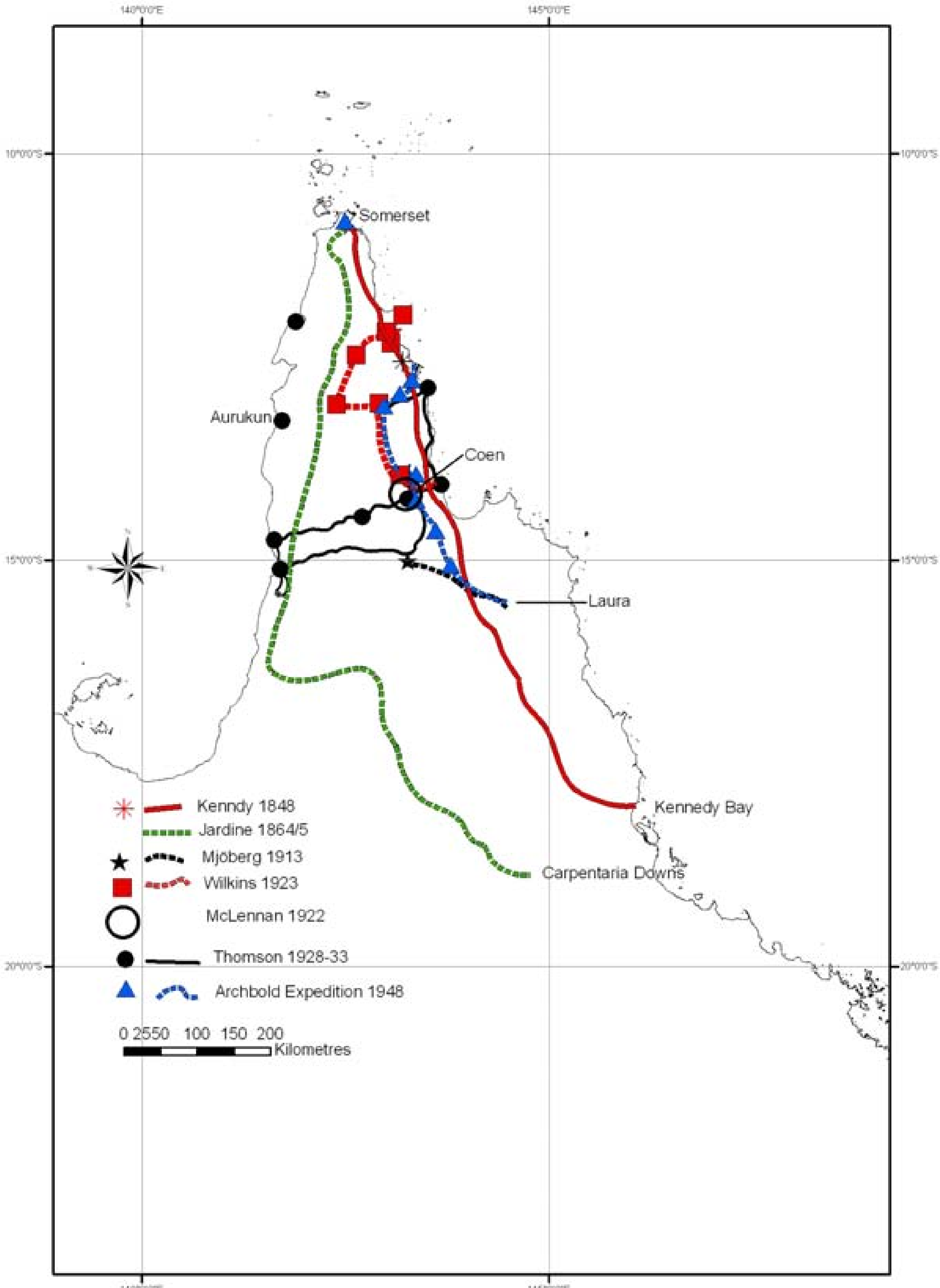

Figure 28. Routes traversed and localities inhabited (symbols) by the early European explorers, settlers, naturalists and scientists on Cape York Peninsula.

Eric Mjöberg, a Swedish explorer/naturalist, spent about a month between Laura and the headwaters of Alice River in September 1913 (Mjöberg 1918). With the help of the local Aboriginal people he collected four common brushtail possums at *Olen* (probably O'Lane) Creek in the headwaters of the Alice River (Lönnberg and Mjöberg 1916) about thirty-five kilometres west-north-west of New Dixie homestead, one of which was used as the type specimen for the description of the Cape York Peninsula subspecies of the brushtail possum, *Trichosurus vulpecula eburacensis*. In the account of his journey, Mjöberg (1918) stated that the Aboriginal people he was travelling with assured him that the common brushtail possum was quite common in this area.

The South Australian Museum houses a series of mammals collected by W. D. Dodd in April 1914 in the Coen district, which include two (plus one associated young) common brushtail possums from 'Stewart River' and four (plus one associated young) common spotted cuscuses from 'Coen River', but no common ringtail possums.

William McLennan (1922) spent eight and a half months based at Coen collecting birds' eggs for H. L. White from the end of August 1921 to May 1922. This involved him frequently searching tree hollows for nests. In all this time he mentions common ringtail possums twice, a glider (either a sugar or squirrel glider) once, and a hollow that "… was half full of gum leaves. Possums had evidently been using it". He may have come across possums more often and not mentioned them, but he seemed to mention other animals as a matter of course in his account, which suggests that possums were indeed scarce in the Coen district.

Captain Hubert Wilkins mounted an expedition to collect mammals and other animals for the British Museum (Wilkins 1928) and spent several weeks at Cape Grenville and along the Olive River on the east coast in 1928. He was bitterly disappointed in the scarcity of game:

> "We found the hills more barren and more destitute of game than the coastal areas. The longer we hunted and the more reports we heard, the greater was the evidence that Australian native life is rare in many places and extinct in parts. The six weeks which we spent in hunting in the vicinity of Cape Grenville and Temple Bay failed to add much to our collection of mammals. Many birds were collected, but of the few species of mammals that were known to exist in that area we saw but three or four individuals, and these were so elusive that we seldom had more than a glimpse of them as they dashed away through the bush. Natives who had lived in this area all their lives told us that they seldom saw an animal and did not depend on them at all for food." (Wilkins 1928 page 64).

He hoped to improve his luck by travelling inland from the Olive River to Moreton then down to Coen, but with no better success. At Moreton he writes,

> "For several days, with natives as companions, I hunted in the vicinity of Moreton, but failed to discover any animals." (Wilkins 1928 page 71).

In the caves at the Batavia gold fields he comments on the fact that there were many wallabies, wallaroos and dingoes and he collected a rock-wallaby. It was not until he reached Port Stewart that he commented on the area having the most game he had seen during the whole of his Cape York Peninsula stay. However, his hunting time in the vicinity of Port Stewart was limited to one day only.

Wilkins did not collect any common brushtail possums or common ringtail possums during his time on Cape York Peninsula (Thomas 1926) which together with his comments on the scarcity of game strongly suggests that these two possums were in short supply at his collecting localities. The only arboreal marsupials collected were a cuscus from the Olive River and sugar gliders from Cape Grenville.

Donald Thomson, the anthropologist and zoologist, made three long visits to Cape York Peninsula between 1928 and 1933. From May to the end of December in 1928 he worked from a base camp at Port Stewart and from there undertook a ten day journey north to the Lockhart River and a four month journey across the Peninsula to the west coast between the Mitchell and Edward Rivers. He returned for eight months in 1929, first to the Stewart River then after a few weeks moved to a base camp at Bare Hill near Cape Direction. His third visit commenced in May 1932 with a stay of about six months at Lloyd Bay, and then he transferred to Aurukun at the mouth of the Archer River. He was based at Aurukun from December 1932 to the end of August 1933, followed by a two month stay at Mapoon at the mouth of the Wenlock River (Thomson 1935).

Thomson collected an extensive range of mammals which are lodged in the National Museum of Victoria (Dixon and Huxley 1985). He collected ten common brushtail possum specimens, all from the lower Archer River in the vicinity of Aurukun. He obviously encountered them on the east coast as indicated by a photograph of a young brushtail from the Stewart River (Dixon and Huxley 1985). In a report to the Under Secretary, Department of Agriculture and Stock, Brisbane, 19 June 1930 after his 1928 and 1929 visits, he states that the common brushtail possum was "Well distributed, but moderately plentiful only, chiefly in Areas B, C and D." His 'Area B' was the coastal plains along the Stewart River, 'Area C' the escarpment country in the vicinity of Ebagoola, and 'Area D' the rolling wooded country along the upper and middle reaches of the Coleman and Edward Rivers. He did not record brushtails from his 'Area A', which is the coastal plains north of Breakfast Creek to Lloyd Bay, nor from 'Area E', the littoral plains of the west coast. His comments and the lack of specimens from his two earlier trips indicate that the common brushtail possum was not abundant in the Port Stewart area and hinterland. Based on his collection from the Aurukun area, the common brushtail possum may have been more plentiful along the lower Archer River and thus easier to acquire specimens.

Thomson collected just three common ringtail possums from Cape York Peninsula, all from the Aurukun area (Dixon and Huxley 1985). Two of them were young from the same mother, which escaped. In his notes he comments,

> "I cannot obtain another specimen though I offer plenty of tobacco etc. They tell me that the animals are very hard to find. The natives say that they do not inhabit scrub but are found in the open savannah woodland and not the scrub country … … They say that it builds nests in hollow trees and does not make nests in the open." (Dixon and Huxley 1985 page 63).

Thomson concluded that the common ringtail was,

> "…apparently not really rare but are extremely difficult to obtain. This is the only adult specimen that I have been able to secure in six months." (Dixon and Huxley 1985 page 65).

During 1932, P. J. Darlington Jr., collected beetles and mammals in the Coen area for the Museum of Comparative Zoology, Harvard. He obtained five common brushtail possums (three from Coen, two from the McIlwraith Range) and one common ringtail possum from Coen (Tate 1952). Soon after, in 1938, Gabriele Neuhäuser collected for the American Museum of Natural History from "inland localities north to Cape York" (Brass 1953). She did not collect any common brushtail possums, but obtained five adult and five young common ringtail possums for the museum (Tate 1952) plus a sixth which is lodged in the Queensland Museum, all from the Coen area.

The Archbold Expedition of 1948 made an extensive collecting trip through Cape York Peninsula for the American Museum of Natural History, New York (Brass 1953). It included two mammalogists, George Tate and Hobart van Deusen. From mid-April until mid-May they worked in the Lockerbie and Somerset areas at the northern tip of the Peninsula, but failed to collect either a common brushtail possum or common ringtail possum. They then shipped to Portland Roads, where they were joined by Donald Vernon from the Queensland Museum, and spent three weeks at Iron Range before gradually working their way by road across to Coen with collecting stops at Mount Tozer, Brown Creek and the Wenlock River. Coen was base camp for about a month while a trip was made to the Rocky Scrub in the headwaters of Peach Creek. At the end of August they traveled south to Laura with overnight collecting stops at Ebagoola, Musgrave and the Hann River. A total of twelve common brushtail possums were collected for the American Museum of Natural History, six at the Wenlock, one along the Coen River, four at Croll Creek north of Coen and one at Ebagoola (Tate 1952), and a further three for the Queensland Museum thirteen kilometres north-west of Coen (Queensland Museum records). None were collected in the Lockerbie/Somerset or Iron Range areas. The Archbold Expedition obtained three common ringtail possums, two at Coen and one at Port Stewart and Vernon collected one thirteen kilometers north-west of Coen. This indicates both the common brushtail possum and common ringtail possum were absent or extremely sparse north of the Jardine River and in the Iron Range area, but that the brushtail at least was relatively common at the Wenlock Crossing and around Coen.

Between 24 and 26 June 1960, Basil Marlow, Curator of Mammals of the Australian Museum, collected five common brushtail possums and one common ringtail possum in the Coen/Silver Plains area. This indicates a reasonable population density of common brushtail possums with the ratio in favour of the brushtails.

These early records suggest that the present day pattern of a generally low population throughout the Peninsula with some areas of relatively high density may have been that occurring at the time of the arrival of Europeans to Cape York Peninsula since 1848. The localities where brushtail possums may have been in relatively high densities were in the south-west, south of the Staaten River (Byerley 1867), the O'Lane Creek area west of Dixie (Mjöberg 1918), Wenlock on the Portland Roads Road and around Coen (Tate 1952). However, McLennan's (1922) and Wilkins' (1928) failure to record the common brushtail possum from Coen or its surrounds, suggests that the population density may have gone through fluctuations similar to that identified over the past three decades in the present project.

Common ringtail possum numbers have always been lower than those of the brushtails on Cape York Peninsula (Table 11). The difficulty of finding them because of their more retiring nature may partly account for this. The ratio, however, of ringtails to brushtails observed in the present project is significantly lower than in earlier years (Table 11) indicating a change in the ratio of the two possums, to the detriment of the common ringtail. Either the prevailing environmental conditions on Cape York Peninsula are having a greater impact on the common ringtail possum compared with the common brushtail possum, and that there may be a significant decline in numbers of the ringtail as previously suggested (Winter and Allison 1980); or prevailing environmental conditions are favouring the brushtails and there has been an increase in brushtail numbers in comparison to ringtail numbers.

Table 11. Numbers of common brushtail and common ringtail possums collected or mentioned by early European visitors to Cape York Peninsula.

Recorder or Collector	Year	Geographic Area and Animals	Source of Records	Common brushtail possum	Common ringtail possum
Kennedy Expedition	1848	From Cardwell to Escape River	Carron (1849) Beale (1970)	0	0
Frank and Alexander Jardine	1864/65	From Carpentaria Downs to Staaten River,	Byerley (1867)	7	0
		north of Staaten River		0	0
John Jardine	1865	Somerset	Byerley (1867)	0	0
Kendal Broadbent	1874/75 1884	Birds and mammals about Somerset	Brass (1953) Monteith (1987)	0	0
Robin Kemp	1912	Birds and mammals from near Cape York	Brass (1953) Monteith (1987)	0	0
Eric Mjörberg	1913	Mammals, Laura to Alice River	Lönnberg and Mjöberg (1916) Mjöberg (1918)	4	0
W. D. Dodd	1913	Stewart River	S.A. Museum	2	0
William McLennan	1922	Birds of Coen area	McLennan (1922)	0	2
Captain George Wilkins	1923	Cape Grenville, Temple Bay, Olive River and to Port Stewart via Moreton, Merluna, Wenlock and Coen	Thomas (1926) Wilkins (1928)	0	0
Donald Thomson	1928/29	Coastal plain between Breakfast Creek and Lloyd Bay,	Thomson (1930; 1935) Dixon and Huxley (1985)	0	0
		Stewart River plains, Ebagoola		Moderately plentiful	0
		Coleman/Edward River catchments,		Moderately plentiful	0
		Gulf coastal plains		0	0
Donald Thomson	1933	Aurukun area	Dixon and Huxley (1985)	7	3
P. J. Darlington Jr	1932	Coen and McIlwraith Range	Tate (1952) Brass (1953)	5	1
Gabriele Neuhauser	1938	Croll Creek, Coen	Tate (1952) Brass (1953) Queensland Museum	0	6 + 5 young
Archbold Expedition	1948	Lockerbie/Somerset,	Tate (1952) Brass (1953) Queensland Museum	0	0
		Iron Range,		0	0
		Wenlock,		6	0
		Coen/Croll Creek,		8	3
		Port Stewart,		0	1
		Ebagoola		1	0
Basil Marlow	1960	Coen/Silver Plains	Australian Museum	5	1
Total	**Pre 1970**			**45+**	**17**
	1970/99	CYP north of Laura	CYPLUS database	**187**	**5**
	Post 1999	CYP north of Laura	CYNHT and Savanna CRC projects	**386**	**5**
Ratios	**Pre 1970**			**3**	**1**
	1970/99			**37**	**1**
	Post 1999			**77**	**1**

G test for the brushtail:ringtail ratios for the three time periods – pre 1970, 1970-1999, post 1999 – G = 51.502, (P <.005, 2 d.f. 10.597) ***

5.2 Geographical Distribution

Population declines to the point of extinction are more likely to happen at the extremities of an animal's distribution where they are presumably experiencing progressively more unfavourable environmental parameters. An example is the Australian distribution of the common brushtail possum which has contracted its geographical range from the more arid central parts of Australia to the wetter coastal fringes (Figure 2). On a smaller scale this project compares the distribution of the brushtail possum throughout Cape York Peninsula prior to 2000 with more recent records.

Brushtail possums have been recorded from all bioprovinces of the Cape York Peninsula bioregion since 2000, except for the two most south-easterly, from which there are also no records prior to this time, almost certainly because of inadequate search effort rather than a true absence of the possum (Figure 29). This shows that there has not been any contraction in the range of the possums at the bioprovincial scale on Cape York Peninsula. The available records in fact suggest the opposite, that the possums have extended their range into the more northerly provinces of the bioregion. However, this is almost certainly a result of inadequate records, because Miriam Crow (pers. comm.), an Injinoo Traditional Owner, spoke of hunting for possums with her grandfather north of the Jardine River when she was a young girl, in about the 1940s. This is north of the most northerly records shown in Figure 29. It is curious though that no records of brushtail possums are known to science from so far north despite a considerable amount of collecting by naturalists since 1863, which was when the government settlement at Somerset was established (Monteith 1987).

5.3 Conclusion

The two lines of enquiry used here, old records and changes in geographical distribution, to assess changes to common brushtail possum numbers on Cape York Peninsula since the advent of Europeans do not indicate any major decline. Early records suggest that the possum was in very low population densities from the time of Kennedy's expedition up the east coast in 1848 and the Jardine brothers' cattle drive up the west coast in late 1864 to early 1865. There is also evidence that brushtail possums have been reasonably common in some areas, from at least the 1920s until the present, for example around Coen. In addition, there is no evidence of a geographical contraction of the possum's range on Cape York Peninsula.

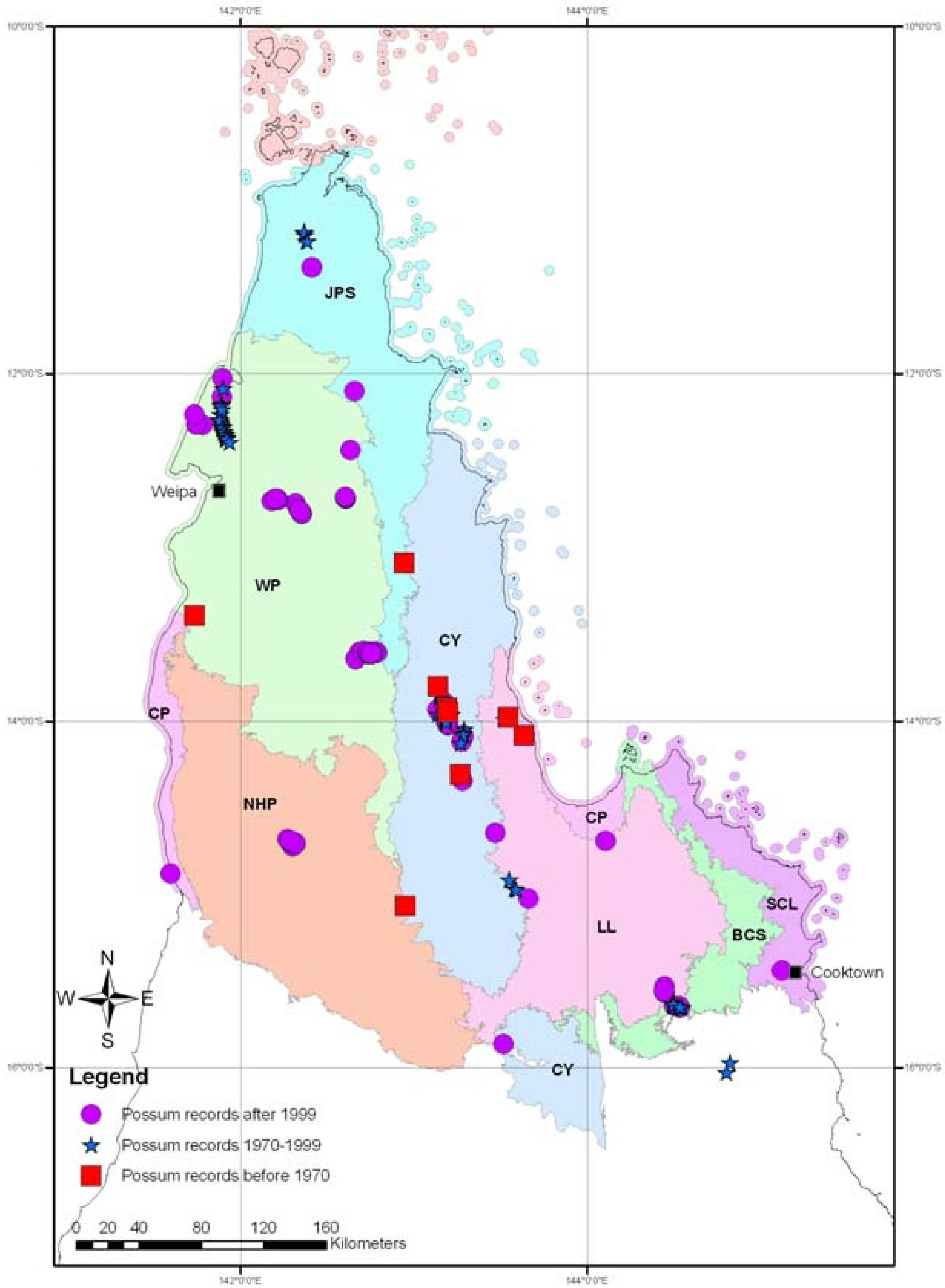

Figure 29. Distribution of common brushtail possum records in the Cape York Peninsula bioregion in relation to biogeographical provinces and categorised by years. Provinces: BCS = Battle Camp Sandstones, CP = Coastal Plain, CY = Coen-Yambo Inlier, JPS = Jardine-Pascoe Sandstones, LL = Laura Lowlands, NHP = Northern Holroyd Plain, WP = Weipa Plateau, SCL = Starke Coastal Lowlands. Bioregional mapping obtained from Queensland Environmental Protection Agency.

6. Influences on Population Structure

To manage eucalypt woodland in a manner which enhances it as suitable habitat for sustaining viable populations of arboreal marsupials, it is necessary to understand what factors influence population densities of marsupials. This is much harder to do in comparison to determining the population structure of the species which has been the focus of the earlier sections of this report. It is beyond the scope of this project to do little more than identify what these factors may be, and which are likely to be of greater importance to the well being of the common brushtail possum.

A number of factors impinge on the common brushtail possum. These can be broadly separated into:

- Those factors which directly affect the survival of the possum; and
- Those which do so indirectly through their effect on the possum's habitat.

6.1 Direct Stressors

Some stressors impinge directly on the individual possum and have the potential to affect the population density of the possums at a locality.

6.1.1 Hunting by Humans

The Aboriginal people of Cape York Peninsula undoubtedly hunted for possums and certainly were aware of the presence of the possums because many of the languages of the Peninsula have a word for possum (G. Wharton pers. comm.). Mjöberg (1918), on his expedition to the headwaters of the Alice River during which he collected the type specimen for the Cape York Peninsula subspecies of the common brushtail possum *Trichosurus vulpecula eburacensis*, gives an account of the different food gathering activities of men and women and states that the men were "… after more difficult prey, such as possums in the tree crowns ...'. Indeed the first common brushtail possum acquired by Mjöberg at O'Lane Creek was brought in by his Aboriginal guide following the inducement of a reward (Mjöberg 1918).

This project did not attempt to systematically seek information from Aboriginal people regarding hunting practices, but the information provided was sufficient to indicate that hunting for possums was no longer a major issue. Miriam Crow, an elder of the Injinoo people and Traditional Owner at Atambaya, Cockatoo Creek, spoke of hunting for possums with her grandfather, when she was a girl at Injinoo, by searching for possum scratches on the trunks of trees to determine the presence of possums in day time den hollows. However, she and Meun Lifu, Senior Community Ranger at Injinoo indicated that they no longer hunted for possums. Similarly, Ann Creek, an elder of Kaanju people and Land and Sea Coordinator at the Coen Region Aboriginal Corporation, stated that Aboriginal people in that area no longer hunted for possums. Laurie Booth, Senior Community Ranger, Mapoon Aboriginal Community, when speaking of the present day hunting practices of the local community indicated that arboreal marsupials were not sought.

Possums, mostly the common brushtail possum, were harvested for their skins in a fur trade that in Queensland was regulated from 1906 to 1936 (Hrdina and Gordon 2004). Although the Northern Possum District, centred on Townsville, included the Petty Session districts of Cook, Coen and Somerset (Gordon and Hrdina 2005; Hrdina and Gordon 2004), it is unlikely that possum harvesting was ever extensive, if it occurred at all, on Cape York Peninsula. In three years from 1923 to 1925, for which records are available, possum numbers were reported to be insufficient to support an open season in the Coen, Laura and Cooktown areas, but were considered to be sufficiently plentiful in the Maytown district. Mitigating against a Peninsula harvest was the smaller size and shorter fur on the pelts of the Peninsula possums which would have been given lower grades and returned lower prices. The lower quality of northern possums is evident from the price paid per dozen skins in Townsville in 1919 of 22 shillings, which was close to the bottom of the prices paid elsewhere in Queensland, where a top price of 160 shillings was paid in Warwick (Hrdina and Gordon 2004). Even if possums were harvested on Cape York Peninsula in the early 1900s, it is unlikely to have had any major long-term impact on their numbers. Gordon and Hrdina (2005) consider that the possum harvest in Queensland, though substantial in the years of regulated harvesting, was sustainable and that any population fluctuations were the result of natural eruptions and declines.

6.1.2 Disease

The only sign of diseased brushtail possums was the occasional observation of dermatitis on the rump. The worst case was of an adult male at Strathgordon in which a raw looking area of exposed skin covered an area about five centimetres in diameter. Less extreme cases display a matting of the fur on the rump. This is generally ascribed to lumbo-sacral dermatitis, which appears to be an allergic reaction associated with flea or mite infestations and there is no evidence that this condition is lethal to the possum (Cowan *et al.* 2000; Kerle 2001). In northern Australia, however, it is usually associated with a staphlococal infection as a result of stress related to land clearing or high population densities often as a consequence of artificial feeding (Wendy Bergen pers. comm.). 'Rumpers' fetched lower prices when brushtail possums were harvested for their pelts in Queensland between 1906 and 1936, and in some districts up to fifty percent of the pelts fell into this category (Hrdina and Gordon 2004). A tame adult female resident in the garden of Aileen Cross, Laura, exhibited weeping eyes and wet matted fur on the face and general poor condition of the body fur, but the female had had this condition for at least twelve months and it was probably an indication of old age.

A number of disease causing organisms have been identified from the common brushtail possum and include *Ixodes holocyclus*, the paralysis tick, *Toxoplasmosis*, *Leptospirosis* and *Tuberculosis* (Cowan *et al.* 2000; Presidente 1984). Although these organisms may be present in the possum population, generally wild populations are healthy. Disease problems of captive common brushtail possums are predominantly a consequence of stress associated with their capture and adjustment to their confinement (Presidente 1984). Stress as a result of capture-release studies can lead to increased mortality of adults and reduced survival rate of pouch-young in common brushtail possums in New South Wales (Clinchy *et al.* 2001). Stress has also been identified as a major cause of death in a wild population of the Herbert River ringtail possum (Speare *et al.* 1984) so is likely to be a factor in wild populations of the common brushtail possum, particularly when environmental factors may become extremely harsh towards the end of the dry season on Cape York Peninsula.

Anecdotal accounts of common brushtail possum numbers crashing over a short period of time do implicate disease. In the mid 1980s numbers of the common brushtail possum at Bakerville west of Herberton declined dramatically, and individuals encountered appeared to have flesh peeling off their faces suggestive of disease (B. Buckley pers. comm.). Common brushtail possums brought into animal carers in the Ravenshoe district with a cancerous type skin disorder which usually rapidly leads to death, has increased noticeably recently – mid to late 2004 (Harry Kunz pers. comm.). Possums exhibiting this condition, generally described as moist dermatitis, can respond to antibiotic treatment, but one, for which histopathology was obtained, was diagnosed with cancerous lymphosarcoma (J. McKenzie pers. comm.). On Woodleigh Station, south of Ravenshoe, Kate Waddell (pers. comm.) describes the numbers of common brushtail possums increasing over several years until abundant, by which time 'diseased-looking' individuals are common. This precedes a sudden decline in numbers. At Lyndhurst, west of Townsville, possum numbers went through a sudden crash in numbers in the mid 1980s (R. Delaney pers. comm.). The sudden decline suggests that disease may be implicated, but no obviously diseased animals were noted at the time.

No disease has been implicated in any of the population declines on Cape York Peninsula, but even if it was, it would be difficult to detect in remote areas where diseased animals may succumb quickly. Thus, disease can not be ruled out as a contributing factor to population declines on Cape York Peninsula. However, it is usually in stressful conditions, through adverse environmental factors, that disease becomes an issue in a population.

6.1.3 Predators

Potential natural predators of the common brushtail possum on Cape York Peninsula are the large lace monitor *Varanus varius*, scrub python *Morelia amethistina*, carpet python *Morelia spilota*, the larger owls – rufous owl *Ninox rufa*, barking owl *Ninox connivens* and masked owl *Tyto novaehollandiae* – and the dingo. The scrub python and rufous owl tend to be closely associated with rainforest so common brushtail possums over large areas of Cape York Peninsula will not be affected by these two predators. Under normal conditions predators and their prey establish equilibrium, although that may go through regular population fluctuations. For example, the powerful owl *Ninox strenua* in south-eastern Australia may deplete a local population of the greater glider *Petauroides volans* and then move their foraging activity to a different location in their large home range (Kavanagh 1988). However, neither the barking owl nor masked owl include a high proportion of larger vertebrates in their diet, consequently they are less likely to drastically reduce a brushtail possum population (Higgins 1999).

The feral cat *Felis catus* is the only recently introduced predator to Cape York Peninsula capable of preying on common brushtail possum (Edwards *et al.* 2004; Jones and Coman 1981; Paltridge *et al.* 1997). The feral cat had spread throughout Australia, including Cape York Peninsula by 1890 (Abbott 2002). It is widespread throughout the Peninsula and can be seen far from human habitation indicating that a truly feral population is established. A single feral cat has the potential to have a deleterious impact on an isolated colony of rock-wallabies (Spencer 1991) and because the possum frequently comes to the ground the young may be especially vulnerable to predation from cats. The amount of time that brushtails spend on the ground increases their exposure to predation by cats. In south-western Western Australia, where cats and foxes are introduced predators, '1080' baiting for foxes resulted in an increase in brushtail possums (How and Hillcox 2000).

During the project feral cats were seen at several of the localities sampled for possums, but no direct relationship between the presence of cats and the absence of possums was apparent. A single feral cat, however, is capable of impacting on a local population of a relatively slow breeding mammal such as the possum, and the impact will be greater when possum populations are under stress from other environmental factors such as drought.

6.1.4 Weather

Possums are known to suffer during times of high temperatures, particularly when associated with dry conditions. Pahl (1987) found that common ringtail possums in Victoria were seen to suffer from temperatures in excess of 36°C. They left their nests to sit in shade when the maximum temperature reached 36°C, were found on the ground and incapable of climbing on days with temperatures in excess of 39°C, and found dead on the ground following consecutive days with temperatures of 40°C or above. The ringtails also lost weight after extended hot periods. The green ringtail possum *Pseudochirops archeri,* restricted to elevations above about three hundred metres in the rainforests of the Wet Tropics region, north-eastern Queensland (Winter 1984), may also suffer from heat stress. Under laboratory conditions the green ringtail's body temperatures rises linearly above 30°C through an inability to produce sufficient water for evaporative cooling, which may become critical for its survival during the late dry season when the highest annual temperatures are experienced and the canopy is dry (Krockenberger 2002). Kanowski (2004) found that the green ringtail possum, together with two other Wet Tropics upland ringtail possums, the Herbert River ringtail possum *Pseudochilurus herbertensis* and the lemuroid ringtail possum *Hemibelideus lemuroids,* did not occur in lowland forests where the mean maximum temperature of the warmest week exceeded 30°C. Exceptionally high temperatures – seventeen days over 40°C in December 1979 – contributed to a crash in a koala population already under stress from drought in the Bolton region of south-western Queensland (Gordon *et al.* 1988).

It is during hot, dry periods that the availability of water may become critical for a possum's survival. Folivores derive much of their water from the leaves they ingest, but free water in the form of rain or dew may also be important. Common brushtail possums lick dew from leaves in the forest canopy (Winter 1976), licking of dew and rainwater is likely to be of considerable importance to the greater glider in the hottest months of the year (Foley *et al.* 1990), and the mist and dew may provide an important component of water intake during the dry season for the upland rainforest ringtails in the Wet Tropics region (Goudberg 1990). Koala numbers in the Prairie-Torrens Creek area west of Townsville increased with increased water content of leaves (Munks *et al.* 1996). Should the water content of leaves fall below a critical point, when they are rejected by a folivore – 65% for a koala (Pahl and Hume 1990) – the animal will need to switch to leaves with higher water content or rely more heavily on free water.

The smaller size of Cape York Peninsula common brushtail possums than those living further south is possibly advantageous for water balance during prolonged periods of dry weather (Williams and Turnbull 1983).

It is possible, therefore, that the common brushtail possum on Cape York Peninsula comes under maximum stress towards the end of the dry season, when temperatures reach their maximum and canopy leaves are probably at their lowest in water content. Whether this combination becomes lethal to the possum is not known and may depend on the quality of tree hollows providing shelter from the heat and the availability of moisture in the diet for the possum.

The climate of Cape York Peninsula is typically a tropical monsoonal one in which up to ninety-four percent of the rain falls during the summer wetter months from November to April, to be followed by a long six months dry season with virtually no rain (Figure 30). It is only on the east coast (Lockhart) and to a lesser extent on the northern tip (Cape York) that any appreciable rain falls during the dry season months of May to October.

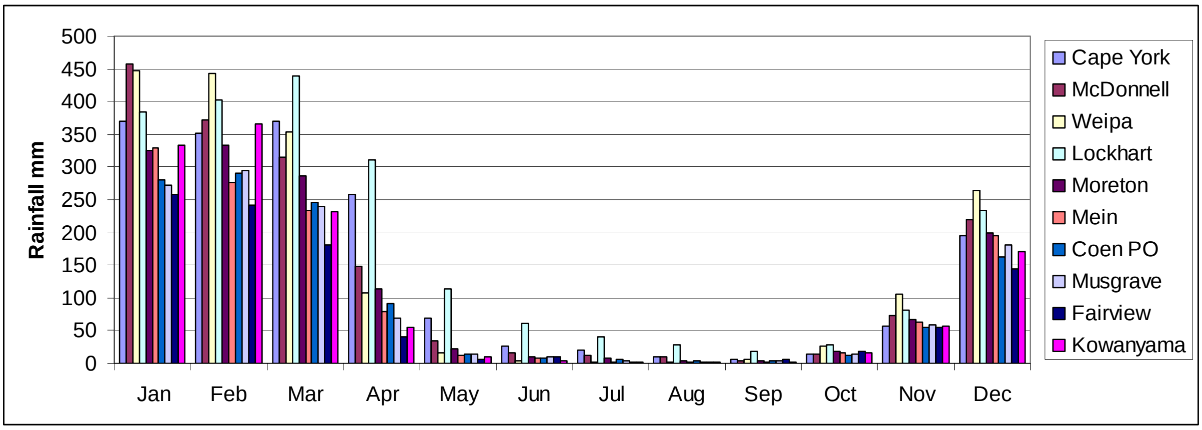

Figure 30. Mean monthly rainfall at ten localities on Cape York Peninsula in the general area of sampling for possums.

The ability of possums to survive the dry season may be reduced during years of lower than average rainfall, particularly when two or more dry years occur in sequence, as for example in 1993-94, 1994-95 and again in 2001-02 and 2002-03 (Table 12).

Temperatures exhibit no yearly extremes and are generally warm (Figure 31). The east coast (Lockhart) and northern tip (Cape York) temperatures are buffered by proximity to the coast and have milder temperatures. Surprisingly, no such coastal influence is apparent on the west coast (Weipa, Kowanyama) of the Peninsula for maximum temperatures, as both localities have more extreme temperatures than the localities in the centre of the Peninsula (Moreton, Coen Post Office, Fairview). Temperatures reach their maximum towards the end of the dry season and the beginning of the storm season between October and December.

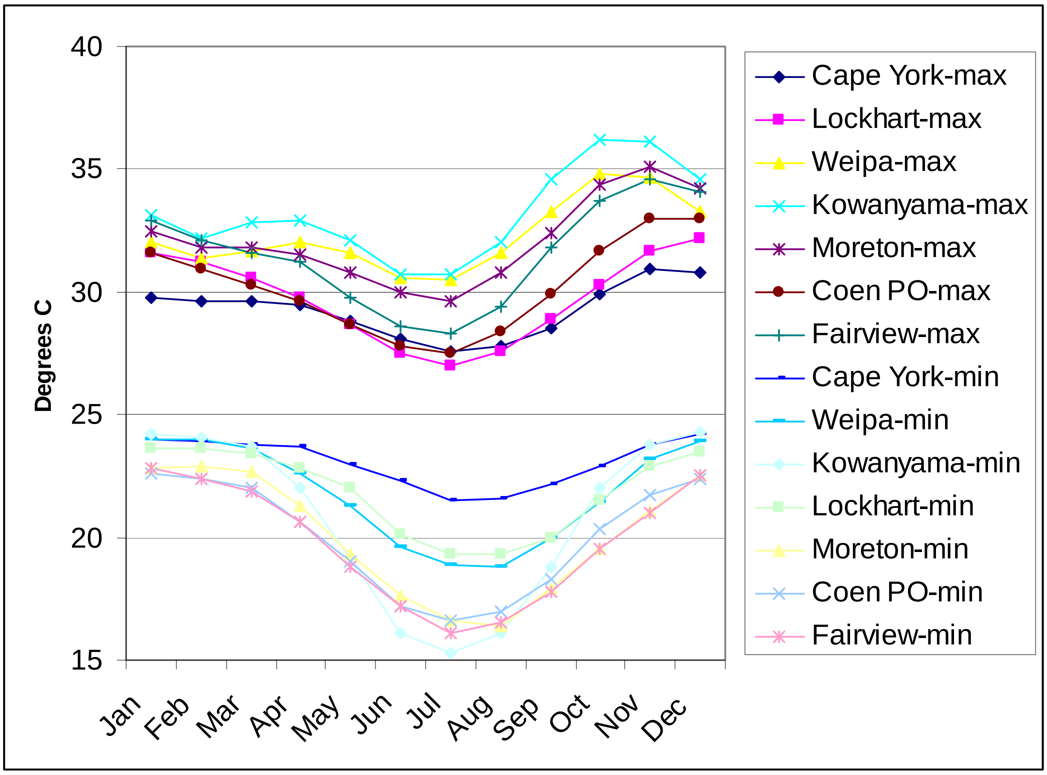

Figure 31. Mean monthly maximum and minimum temperatures for seven localities on Cape York Peninsula.

Table 12. Average rainfall on Cape York Peninsula between 1972 and 2004 depicted as being average, above average or below average. Where any one year is shown as having more than one category it is indicative of variation throughout the Peninsula. Data modified from Queensland Department of Natural Resources and Mines (2004).

Year	Rainfall		
	Above Average	Average	Below Average
1972-73			
1973-74			
1974-75			
1975-76			
1976-77			
1977-78			
1978-79			
1979-80			
1980-81			
1981-82			
1982-83			
1983-84			
1984-85			
1985-86			
1986-87			
1987-88			
1988-89			
1989-90			
1990-91			
1991-92			
1992-93			
1993-94			
1994-95			
1995-96			
1996-97			
1997-98			
1998-99			
1999-2000			
2000-01			
2001-02			
2002-03			
2003-04			

It is during these hot months that temperatures can frequently exceed 35°C, usually for more than five days a month, and at Musgrave and Kowanyama as often as twenty days a month (Figure 32a). Temperatures in excess of 40°C are not common and are confined to the months of October to December (Figure 32b).

The implication of this climate pattern for the common brushtail possums on Cape York Peninsula is that they come under their greatest stress from low water availability and high temperatures towards the end of the dry season when temperatures begin to rise in September and peak in October and November. A sequence of hot days over 35°C, particularly after a sequence of years with below average rainfall, may prove lethal to the possum. With global warming these stresses can only increase.

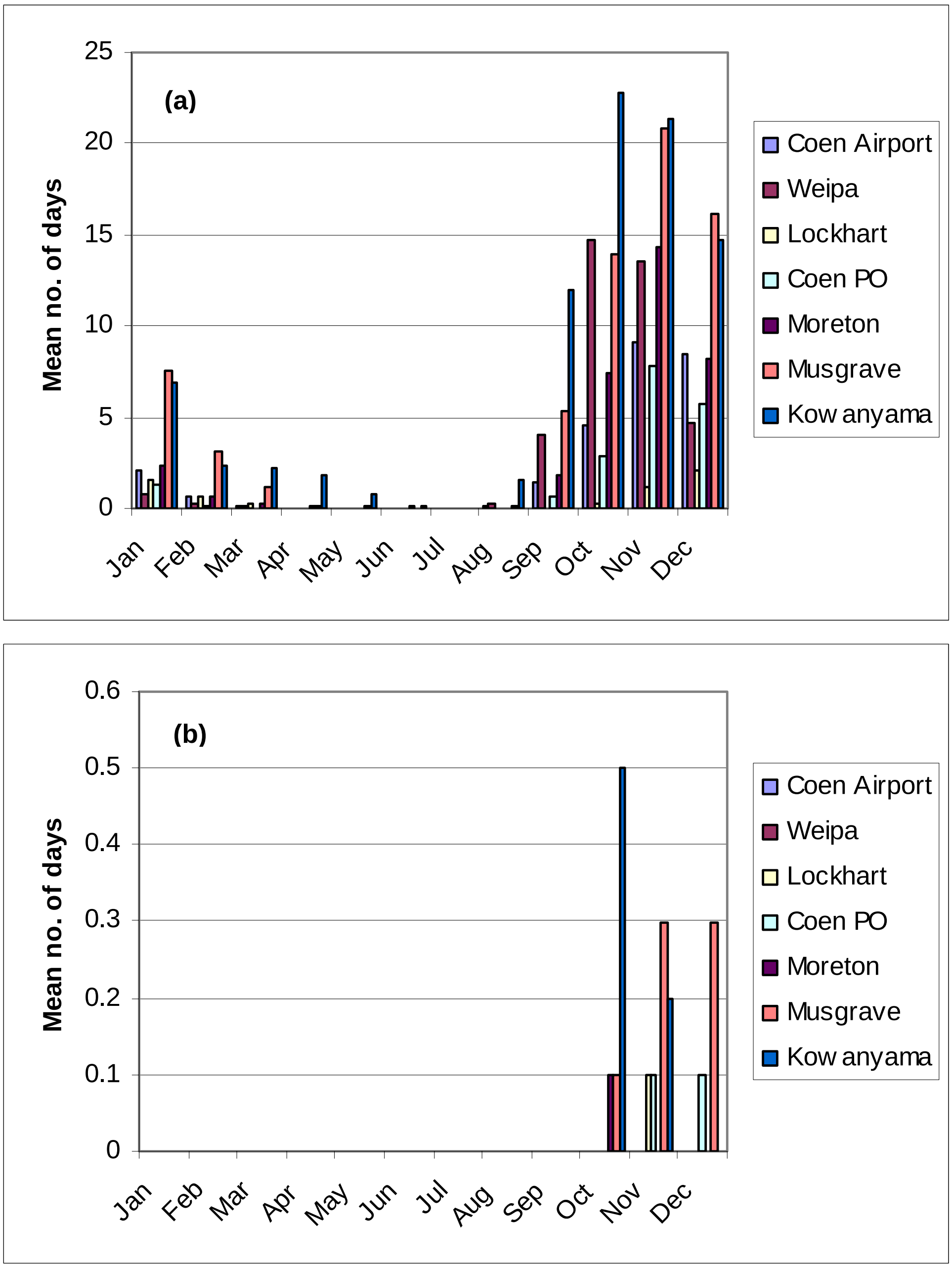

Figure 32. Mean number of days when the temperature was greater than (a) 35°C and (b) 40°C at seven localities on Cape York Peninsula.

6.1.5 Diet

The common brushtail possum is generally viewed as a folivore or leaf-eater, but with a high proportion of fruit and flowers included in the diet. Kerle (1984) summarised the known diet of the common brushtail which showed that the proportion of leaves in the diet varied from 38% to 100% and for eucalypt leaves only, from 0% to 95%. However, these figures are based on a wide range of studies, some of which relied on very small samples. If studies covering a reasonable selection of seasons only are considered, the proportion of leaves in the diet varies from 38% to 81%, and for eucalypts from 3% to 66%. Flowers and fruit ranged from a mere trace in Tasmania, a low 7% in Brisbane, to high proportions of 45% in the rainforests of the Atherton Tableland and 37.5% to 58.9% in the eucalypt woodlands of Kakadu. Feeding on the ground on grass and/or herbs was high in southern Australia, 10% to 60% in Tasmania and 23% in Brisbane, but much lower in northern Australia, 2% in the Atherton Tableland rainforest and 0% to 0.1% in Kakadu. It is not known whether the low proportions of flowers and fruit and high ground species in southern Australia and the converse in northern Australia is real difference associated with the climate or merely a reflection of the different techniques and emphasis in the different studies. Kerle's (1984) conclusion was that this variation in the diet indicated that the common brushtail possum is highly adaptable and is capable of varying the proportion of leaves and fruit and flowers according to availability.

Hume (2004), on the other hand, proposes that the digestive physiology of the common brushtail possum requires that its diet includes a high proportion of non-leaf matter. The common brushtail possum is a hind-gut fermenter, along with other possums and gliders, which means that much of its food is broken down into digestible components in the hind gut, particularly the caecum (Hume 1982; 1999). Of the four marsupial arboreal folivores studied in detail – the koala *Phascolarctos cinereus*, the greater glider, the common ringtail possum and the common brushtail possum – the brushtail is the least specialised for leaf eating. Its teeth emphasise tearing and crushing actions rather than the more cutting dentition of the other species, and unlike the other species it has no separation mechanism for particles of different sizes in its hindgut which allows more efficient processing of leaves relatively poor in nutrition. Thus the brushtail has only a limited ability to use *Eucalyptus* foliage as a sole dietary item (Hume 1999). It is likely that this limitation on the proportion of leaves in the diet extends to other tree genera in northern Australia such as Cooktown ironwood *Erythrophleum chlorostachys* and bloodwoods *Corymbia sp*. with high fibre content and low nutritional quality. Hume (2004) considers that it is the brushtail's inability to process foliage that dictates its less specialised diet and the need to include fruits and flowers rather than the flexibility of diet as suggested by Kerle (1984).

The common brushtail possum does have a high tolerance of plant secondary metabolites usually toxic to an animal, which can determine its diet in the wild (Hume 1999). This would explain the possum's ability to eat foliage of the Cooktown ironwood in northern Australia (see below) which is extremely poisonous to cattle and other stock (Everist 1974). Freeland and Winter (1975) argue that the brushtail needs to consume an average three different items a night to balance the intake of toxins.

Nutritional quality, essential oils and toxins, particularly recently discovered formulated phloroglucinol compounds, also influence choice of leaves (Foley *et al.* 2004; Moore *et al.* 2004). Within the eucalypts the common brushtail possum is highly selective of the leaves in the sub-genus *Symphyomyrtus* which includes gums, ironbarks and boxes and avoids those in the *Monocalyptus* group which includes many of the stringybarks (Moore *et al.* 2004). On Cape York Peninsula the abundant messmate *Eucalyptus tetrodonta* is in the sub-genus *Eudesmia* which is considered to have chemical properties similar to the *Symphyomyrtus* (Eschler *et al.* 2000) and is therefore available to the common brushtail possum. The chemical similarity of the bloodwoods in the eucalypt genus *Corymbia* with either

Symphyomyrtus or Monocalyptus is not clear (Eschler *et al.* 2000), but Moore *et al.* (2004) indicate that the bloodwoods may comprise about a quarter of the diet of the possum. The observations of Meun Lifu (pers. comm.), Chief Community Ranger, Injinoo, that brushtail possums north of the Jardine River favour the woodland containing iron bark, is consistent with this species being in the favoured *Symphyomyrtus* group. The concentration of formulated phloroglucinol compounds can vary significantly between individual trees at a locality to the point where one tree may be heavily browsed and the neighbouring tree of the same species left untouched (Moore *et al.* 2004). This merely emphasises that even in woodlands which appear to have an abundance of food for the possums, the chemical defences of the trees may drastically restrict what is available for the possum.

A wide variety of plant species are known to be eaten by the common brushtail possum in tropical and sub-tropical Australia (Table 13). It is apparent that food items are consumed from all layers of the forest, but that flowers and fruit tend to be more commonly taken from species in the lower layers of woodland (Figure 33).

In Kakadu, Northern Territory, in forest structures similar to those found on Cape York Peninsula, Kerle (1984) found that leaves constituted 41% and 49% of the possum diet at her two main sites of Jabiluka and Kapalga which were both classified as Darwin woollybut *Eucalyptus miniata* woodlands. However, despite the dominance of *E. miniata* in the canopy, eucalypt leaves did not feature prominently in the diet of the possums. At Kapalga, where the Cooktown ironwood *Erythrophleum chlorostachys* was common, it comprised the greatest proportion of leaves eaten. Whereas at Jabiluka, where the ironwood was scarce, the leaves of a broad range of species other than eucalypts were eaten. At both sites flowers and fruit constituted 58.9% (Jabiluka) and 50.3% (Kapalga) of the possum's diet, although there was considerable seasonal variation with the highest proportions of flowers and fruit eaten in the dry season months between August and November.

The common brushtail possum also includes ground cover plants in its diet (Table 13). In Tasmania the possum has been found to obtain more than half its food from ground cover plants, primarily dicotyledons (non grass herbs) (Statham 1984), or for grasses and herbs to form an important component of the diet (Fitzgerald 1984). In the Brisbane area common brushtail possums spent 8.9% of their time on the ground and males spent 15.8% of their feeding time on the ground which was significantly higher than 5% spent by females (MacLennan 1984). Whilst Kerle (1985) did not record which ground species were eaten, between about 5% and 25% of possums were on the ground when first spotted, which suggests that the time spent on the ground was more than moving between trees. Likewise, in the present project 11.5% of the 244 observations of brushtail possums were on the ground when first spotlighted or were head up on a tree trunk, no more than a meter off the ground, in the typical alert posture indicating that they had jumped onto the trunk from the ground (Winter 1976). Again this suggests that the possum is foraging on the ground.

Table 13. Plant species known to be eaten by the common brushtail possum in tropical and subtropical Australia

Layer	Species	Locality	Portion Eaten				Present on CYP	
			Leaf	Flower	Fruit	?	Species	Genus
Canopy tree	*Alstonia actinophylla*	Kakadu[1]	Yes				Yes	
	Corymbia maculata	Brisbane[3]	Yes					Yes
	Erythrophleum chlorostachys	Kakadu[1] & CYP[4,2]	Yes		Yes		Yes	
	Eucalyptus miniata	Kakadu[1]	Yes					Yes
	Eucalyptus crebra	Brisbane[3]	Yes					Yes
	Eucalyptus moluccana	Brisbane[3]	Yes	Yes	Yes			Yes
	Eucalyptus porrecta	Kakadu[1]	Yes					Yes
	Eucalyptus tereticornis	Brisbane[3]	Yes	Yes	Yes		Yes	
	Eucalyptus tesselaris	Brisbane[3]	Yes				Yes	
	Eucalyptus tetrodonta	CYP[2]	Yes				Yes	
	Acacia aulacocarpa	Kakadu[1] and Brisbane[3]	Yes					Yes
Understorey tree	*Acacia coriaceae*	C.Aust.[5]		Yes				Yes
	Acacia difficilis	Kakadu[1]	Yes	Yes				Yes
	Acacia dimidiata	Kakadu[1]	Yes					Yes
	Acacia estrophiolata	C.Aust.[5]		Yes				Yes
	Angophora subvelutina	Brisbane[3]	Yes	Yes				
	Brachychiton sp	CYP[2]		Yes			Yes	
	Buchanania obovata.	Kakadu[1]			Yes			Yes
	Calytrix exstupulata	Kakadu[1]	Yes	Yes				Yes
	Euroschinus falcatus	Brisbane[3]			Yes			
	Ficus sp	Brisbane[3]	Yes					Yes
	Lophostemon suaveolens	Brisbane[3]	Yes				Yes	
	Mallotus philippinensis	Brisbane[3]	Yes		Yes			
	Planchonella arnhemica	Kakadu[1]			Yes			Yes
	Syzygium suborbiculare	Kakadu[1]	Yes		Yes		Yes	
	Syzygium eucalyptoides	Kakadu[1]	Yes		Yes		Yes	
	Terminalia sp	CYP[2]				?	Yes	
Shrub or small tree	*Breynia cernua*	Mt Fox[6]	Yes				Yes	
	Bursaria spinosa	Mt Fox[6]				?	Yes	
	Capparis loranthifolia	C.Aust.[5]			Yes			Yes
	Carrisa lanceolata	C.Aust.[5]			Yes		Yes	
	Gardenia megasperma	Kakadu[1]				?		Yes
	Hakea eryeana	C.Aust.[5]		Yes				Yes
	Jacksonia dilatata	Kakadu[1]	Yes					Yes
	Lantana camara	Brisbane[3]		Yes				
	Petalostigma pubescens	Kakadu[1]	Yes				Yes	
	Pandanus spiralis	Kakadu[1]			Yes		Yes	
	Persoonia falcata	Kakadu[1]			Yes		Yes	
	Planchonia careya	Kakadu[1]	?		Yes		Yes	
	Tarenna dallachiana	Kakadu[1]				?		
	Verticordia cunninghamii.	Kakadu[1]		Yes				0
Ground cover	*Cucumis myriocarpus*	C.Aust.[5]			Yes			
	Eriachne triseta (grass)	Kakadu[1]	Yes				?	Yes
	Phyllanthus sp	Kakadu[1]	Yes					Yes
	Solanum ellipticum	C.Aust.[5]			Yes			Yes
	Solanum centrale	C.Aust.[5]			Yes			Yes
	Feeding on ground	CYP[2]				?		

Layer	Species	Locality	Portion Eaten				Present on CYP	
			Leaf	Flower	Fruit	?	Species	Genus
Mistletoe	*Amyema maidenii*	C.Aust.[5]			Yes			Yes
	Amyema miquelii	Brisbane[3]		Yes				Yes
Vine	*Ipomea cairica*	Brisbane[3]	Yes					Yes
	Citrillus lanatus	C.Aust.[5]			Yes		Yes	
	Mukia maderaspatana	C.Aust.[5]			Yes		Yes	
	Smilax sp	CYP[4]	Yes				Yes	

[1] Kerle (1985); [2] CYNHT project; [3] Winter (1976); [4] Kerle (1984); [5] Evans (1992); [6] Winter unpub.

The implications of the dietary habits of the common brushtail possum in tropical woodlands, including those of Cape York Peninsula, are that:

- The common brushtail possum's digestive physiology dictates that about fifty percent of its diet is non leaf matter, primarily flowers and fruit;
- Despite eucalypts (including the subgenus *Corymbia*) being the dominant tree in the possum's habitat they are a minor component only in the diet;
- The leaves of the Cooktown ironwood and a variety of understorey trees and shrubs form a major component of the leaves eaten;
- The flowers and fruits eaten tend to be from understorey trees and shrubs; and
- Ground plants feature in the diet and are probably more important than is indicated by the proportion of items recorded eaten, because of the amount of time the possum spends on the ground.

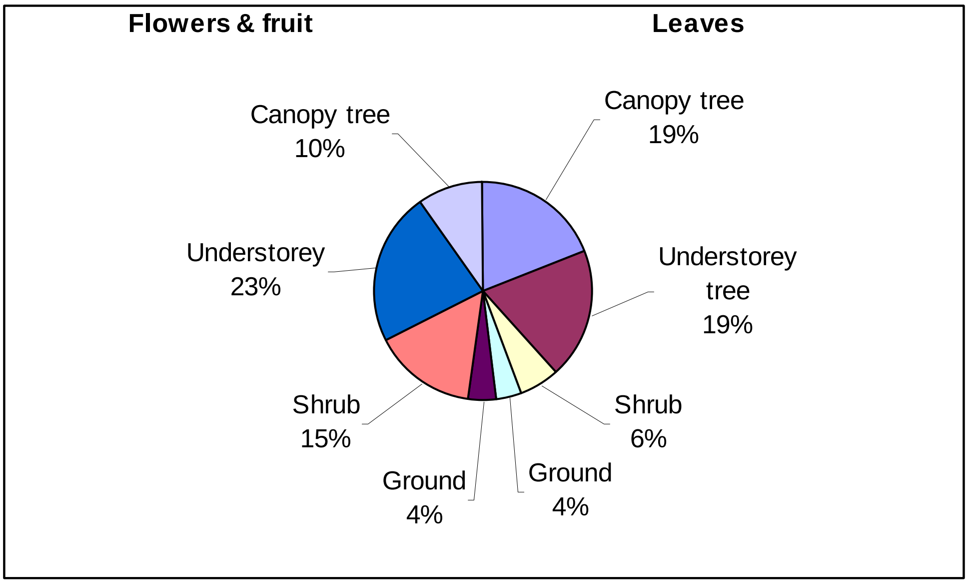

Figure 33. Proportion of plant species known to be eaten by common brushtail possum in tropical and sub-tropical Australia in relation to the vertical stratification of the species.

6.2 Indirect Stressors

Possum numbers can also be influenced indirectly through changes to their habitat and the most likely influential factors are climate, broad-scale clearing, fire and grazing by introduced stock.

6.2.1 Climate

Climate, notably rainfall, can impose relatively rapid changes to the woodland habitat, probably as a result of ground water levels which are closely linked to annual rainfall (Braithwaite and Muller 1997). Drought, particularly one lasting several years, can induce tree death (Fensham and Holman 1999) and conversely a series of wet years can contribute to an increase in tree density, commonly referred to as tree-thickening. Loss of trees as a result of drought was identified as a major contribution to a population crash of koalas in the Bolton region of south-western Queensland (Gordon *et al.* 1988).

While Cape York Peninsula over the past thirty years has experienced drought (1993/94 to 1994/95 and 2001/02 to 2002/03) and wet years (1972/74 to 1976/77 and 1995/96 to 2001) (Table 12), there is no documentation of either broad scale tree deaths or tree-thickening in the eucalypt woodlands. The possible exception is the noticeable increase in the broad-leaved paperbark tree *Melaleuca viridiflora,* which has invaded the open grasslands and woodlands on poorly drained soils – less so in the woodlands on better drained soils – and in which high rainfall years are identified as triggering seedling establishment (Crowley and Garnett 1998).

Longer term climatic changes associated with global warming will affect the possum through changes to their habitat.

6.2.2 Broad-scale Tree Clearing

Broad-scale tree clearing which destroys the habitat of arboreal marsupials has been limited on Cape York Peninsula to date, and under present day vegetation management regulations is unlikely to become a major issue, with the possible exception of woodland cleared for mining. ‘Home’ paddocks less than one thousand hectares in extent are common, but never large enough to disrupt continuity of woodland habitat, and little broad-scale clearing has taken place elsewhere on pastoral leases.

The exception to broad-scale clearing of eucalypt woodland on Cape York Peninsula is the destruction of messmate *Eucalyptus tetrodonta* very tall woodland on aluminous laterite (Type 2, Neldner and Clarkson 2000) in the course of open-cut bauxite mining. The mining occurs on the Weipa Plateau physiographic region which extends along the western side of Cape York Peninsula from approximately the Holroyd River in the south to the Jardine River in the north. Of the 846,064 hectares of Type 2 woodland on Cape York Peninsula, only 26,409 hectares or 3.1% is protected (extracted from J. Neldner and J. Clarkson reports by J. Clarkson pers. comm.). Virtually all the remaining 96.9% is under mining leases and destined to be cleared. Currently bauxite mining is concentrated in the vicinity of Weipa, but has the potential to cover a large area of the west coast of the Peninsula between Vrilya Point and Aurukun. In 2005, Comalco, currently the only company actively mining bauxite, cleared 922 hectares for mining (Comalco Weipa 2005).

6.2.3 Tree Hollows

All five of the arboreal marsupials living within the eucalypt woodland of Cape York Peninsula (three gliders, two possums) use tree hollows as their main day time shelter. An important function of hollows is the protection of the animals from extremes of temperature. In temperate Australia, hollows enable possums and gliders to form sleeping groups, the smaller the animal the greater the number that huddle together, as a means of conserving warmth during cold times (Gibbons and Lindenmayer 2002). In the tropics hollows are more likely to be important in reducing the animal's exposure to high day-time temperatures and low day-time humidity thus conserving the possum's water use, and from radiant heat during fires. Hollows also provide shelter from diurnal avian predators – eagles, goshawks, falcons – in the open canopy of the woodland.

Hollows are continually lost and formed in the woodlands and in the long-term the balance needs to be slightly in favour of hollow formation rather than hollow loss. Hollows are lost through storm damage to trees, felling of trees for timber and probably most commonly through fire destroying the tree to the point where it collapses. A combination of termites and fire are probably the major contributors to hollow formation, the termites through hollowing out trunks and limbs and fire by killing branches which then break off and expose their hollow centre (Inions *et al.* 1989; Mackowski 1984) In the temperate jarrah forest of south-western Australia Inions *et al.* (1989) found that a high intensity fire destroyed 38% of the trees previously inhabited by possums. Dead den trees were worst affected by the fire, comprising 44% of the destroyed den trees and 45% of those severely damaged. They found that a high intensity fire markedly reduced the number of large, old den trees, but that the possums adjusted by using hollows created by the fire in smaller, younger trees.

Eucalypts with thick bark, particularly those with a thick outer bark of dead tissue, are more resistant to fire than smooth barked species (McArthur 1968). On Cape York Peninsula this indicates that the messmate *Eucalyptus tetrodonta*, the iron barks, boxes (e.g. *E. leptophleba*) and bloodwoods (*Corymbia*) are likely to be the most fire resistant of the eucalypts. These tree species are also the main source of tree hollows for dens. While high intensity fires may contribute to the formation of tree hollows this is not necessarily an encouragement for the use of high intensity fires in the eucalypt woodlands. Not only is the formation of tree hollows likely to take place on a longer time scale than the destruction of hollows, hollows of sufficient size for possums may only develop in older trees which are the trees worst affected by fire. Nothing is known about the formation of hollows in tropical woodland, but in the forty-metre tall blackbutt *Eucalyptus pilularis* forests of northern New South Wales, Mackowski (1984) found that larger wildlife hollows suitable for brushtail possums did not develop in trees less than about two hundred years old.

The present project found that tree hollows were sufficiently common (11.5% of trees with potential hollows large enough for possums and 25% with potential glider hollows) not to be a limiting factor in possum numbers.

6.2.4 Soil Fertility

Arboreal marsupials occur at higher densities on nutrient richer soils within the eucalypt forests of New South Wales (Braithwaite *et al.* 1983; Braithwaite *et al.* 1984) and within the rainforests of the Wet Tropics bioregion of north-eastern Queensland (Kanowski 1999; Kanowski *et al.* 2001). The relationship between possum numbers and soil fertility is not a simple one as it can vary with the amount of rainfall and can be different for the different species of arboreal marsupial (Moore *et al.* 2004). Nevertheless, Moore *et al.* (2004) in their review of the nutrition of the arboreal marsupials concluded that common brushtail possum densities increase along soil fertility gradients, particularly in drier sites. They also concluded that common ringtail possum densities are higher on nutrient rich soils, but with some puzzling inconsistencies.

In a study of population densities of the common brushtail possum and rufous bettong *Aepyprymnus rufescens* within eucalypt woodland in the Townsville region of north Queensland, Johnson *et al.* (2005) concluded that soil fertility was the most important factor determining population density, over and above other factors such as size of trees suitable for dens.

The Cape York Peninsula Land Use Strategy (CYPLUS) found that low nutrient levels, particularly of phosphorus and sulphur, were a major restriction to the use of the region fore grazing purposes (Biggs and Philip 1995). Seventy five percent of their sampled sites had two parts per million or less of phosphorus and about 47% of their sites contained three parts per million or less of sulphur. These low soil fertilities are likely to be reflected in low possum and glider densities which appear to be a common feature over much of Cape York Peninsula.

6.2.5 Fire

6.2.5.1 Tropical Woodland

Fire is recognised as a major force in shaping tropical savanna woodland (Woinarski *et al.* 2004) and is identified as having a profound influence on the density of common brushtail possums. Two studies in the Northern Territory have shown that population densities of the possum are higher in areas with the longest interval since the last fire. Kerle (1985) in the course of a targeted study of the common brushtail possum in Kakadu National Park found that two factors accounted for 77.3% of the variation in possum numbers. The number of Darwin woollybut (*Eucalyptus miniata*) trees greater than twenty centimetres in diameter at breast height (DBH), accounted for 71.4% of the variation with more possums were found in areas with more of these trees. Although fire accounted for only 5.9% of variability, it was nonetheless statistically significant. Woinarski *et al.* (2004) in a study of vertebrates in eucalypt woodland at Solar Village near Darwin, compared woodland unburnt for twenty-three years with adjacent woodland burnt every year and found that the common brushtail possum numbers were significantly higher in the unburnt area.

What is it about unburnt woodland that favours the common brushtail possum? Because the possum uses tree hollows as shelters, only the hottest fires with a scorch height reaching into the canopy are likely to directly kill the possum (Kerle 1985). The immediate after effects, however, may pose a serious problem for the animal. A fire of sufficient intensity to burn the ground layer, shrub layer and scorch the canopy will drastically reduce the leaves and fruit available as food. The possum will then be dependent on canopy leaves, which at the time of the hottest fires in the late dry season may not contain sufficient moisture within the leaf to sustain a possum, which derives most of its water requirements from its food, or by licking dew or rain off leaves. The elimination of the understorey, even temporarily, following a fire is possibly the most significant factor because it is the understorey and shrub layer that contain a higher proportion of fruit eaten by the possum (Figure 33). If regrowth is not stimulated by rain following the fire, usually as thunder storms, the lack of new leaf growth may be insufficient to enable a possum to maintain enough body weight to survive. The length of time that a possum can survive in a severely burnt landscape may depend on how much of the animal's home range contains pockets of unburnt vegetation.

Apart from direct effects on the availability of food for possums immediately following a fire, fire has longer term implications in its influence on the structure of the woodland. A well developed shrub and understorey layer, rich in species diversity, appears to be conducive to higher densities of the common brushtail possum. Kerle (1985) attributes the higher density of possum in woodland at Kakadu with a longer interval of fire to structural differences of the woodland, in which the development of a shrub layer, substantial litter accumulation, reduction of tall annual grasses and the persistence of perennials were key factors. The full expression of plant life forms, through fire exclusion, not only produces a more diverse leaf diet for the possums but, more importantly, also enhances flowering and fruiting. Woinarski *et al.* (2004) in their Solar Village study in similar woodland closer to Darwin identified the unburnt woodland as having more diverse and denser shrubs and trees with a greater representation of rainforest-associated species. Eucalypts were still the dominant trees, but many other trees and shrub species had developed a dense tall understorey or sub-canopy in the unburnt area. It is in this diverse shrub and understorey that the common brushtail possums obtain a significant proportion of their diet of flowers and fruit (Kerle 1985). It is interesting to note that of the thirty-two plant species Bowman and Panton (1995) listed when comparing plots unburnt for twenty years with sites experiencing ambient fire histories in the same general area of Kakadu, fourteen are included in the diet of the common brushtail possum and all fourteen had greater number of saplings and trees in unburnt plots.

The total exclusion of fire from tropical woodland for twenty or more years is an unrealistic expectation and may not be desirable in the broader ecology of the woodland habitat. Consequently the frequency and intensity of fire in a locality may be of extreme importance to the brushtail possum. In the Northern Territory, where most of the studies on fire in woodland similar to that found on Cape York Peninsula, have been conducted, the late dry season burns (August-September) appear to be the most severe with the greatest scorch height, hottest fires and greatest amount of vegetation burnt compared with early dry season (April-July) and early wet season (October-December) burns (Braithwaite and Estbergs 1985). This is because moisture content in the vegetation is relatively high early in the fire season following the wet season and late in the season after the first rains (Lonsdale and Braithwaite 1991) Following a severe late dry season fire at Kapalga, tree and shrub mortality of 14.3% was recorded with different rates for species, which had the potential to change the species composition of the woodland (Lonsdale and Braithwaite 1991). Species mortality rates ranged from 4% (*Xanthostemon paradoxus*) to 90% (*Acacia sp*). Species known or thought to be important to possums suffered fairly high mortality (*Terminalia carpentariae* 25%, billy goat plum *Terminalia ferdinandiana* 25%, lady apple *Syzygium suborbiculare* 13%, cocky apple *Planchonia careya* 12%, quinine bush *Petalostigma pubescence* 57% and Cooktown ironwood *Erythrophleum, chlorostachys* 26%). Severe late dry season fires may prevent understorey species such as the shrub *Persoonia falcata* and the cocky apple *Planchonia careya* reaching maturity (Braithwaite and Estbergs 1985) and thus deprive the possums of their flowers and fruit as a dietary item. In another study of the effects of fire on savanna woodland at Kapalga, Williams *et al.* (1999) found that deciduous non-eucalypt species such as the Terminalias and Cooktown Ironwood *Erythrophleum chlorostachys* were particularly susceptible to fire, especially to late season fires which correspond to the main period of leaf flush for these deciduous species. Another affect of high intensity late-season fires is the loss of larger trees, less than thirty percent for trees within the 40-50 cm DBH category, possibly related to the high incidence of termite ‘piping’ of trunks and larger branches (Williams *et al.* 1999). It is these larger trees that provide day time dens for the possums.

In the Northern Territory the fire pattern may have changed in the tall eucalypt open forest, characterised by the presence of Darwin woollybut *Eucalyptus miniata* and messmate *E. tetrodonta*, from early dry season burns controlled by the Aboriginal people to more destructive late dry season burns as a consequence of less intensive management. In the more open woodland there may have been little change because it was considered less important to the Aboriginal people and was therefore not as carefully managed by them and burnt throughout the fire season (Braithwaite and Estbergs 1985). This shift in fire pattern could have a profound impact on the brushtail possum by reducing the shrub layer to ash at a time when it is most needed by the possum.

6.2.5.2 Cape York Peninsula

On Cape York Peninsula the journals of early Europeans indicated that Aboriginal people lit fires throughout the dry season (May-October) whereas contemporary burning in pastoral areas is more restricted to early dry season burns (Crowley and Garnett 2000). However, these early accounts do not indicate whether the Aboriginal people had a different burning strategy for open forest and woodlands comparable to that used by Aboriginal people in the Northern Territory. The shift to early dry season burns is considered to be a major factor in the increase of the broad-leaved paperbark *Melaleuca viridiflora* on open grasslands and as an understorey tree in woodlands on relatively poorly drained soils (Crowley and Garnett 1998). These authors detected little change in most plant taxa between 1966 and 1995, but increases tended to occur in other *Melaleuca* species too, in *Asteromyrtus symphyocarpa*, in *Thryptomene oligandra* and in a group of broad-leaved species, all possibly important for the brushtail possum – almonds/damsons *Terminalia sp.,* nonda plum *Parinari nonda, Erythroxylum ellipticum* and smooth-leaved quinine bush *Petalostigma banksii*. The present structure of the extensive dry eucalypt woodlands on Cape York Peninsula – a tree cover with dominant species of eucalypts and Cooktown ironwood, with a dearth of understorey shrubs and a ground cover of grasses – is attributed to regular burning that prevents smaller plants from reaching the canopy (Crowley 1995). It is this dearth of understorey shrubs, particularly ones that have edible flowers and fleshy fruits that may be a limiting factor in the carrying capacity of the woodland for possums.

At the preliminary level of sampling undertaken in the present study no simple relationship was detected between the absence of fire over a number of years and the presence of common brushtail possums at a locality (Table 14). Also there was no apparent relationship between early season low intensity fires and late season high intensity fires and possum presence. However, most sampled localities contained some areas which had not been burnt over the period 1999 to 2002, and it is this finer mosaic of burnt to unburnt areas that may be of importance to the possums. Even this, however, does not apply at Myall Creek on York Downs where for three years running the whole area was burnt, predominantly by late season fires, yet possum numbers were high a year later (Table 14). The complexity of the relationship between possum numbers and fire is highlighted by Isaac (2005) who found that when fire burnt half her woodland study site on Magnetic Island, there was an increase in both the number of young and population size in the burnt area. She suggests an increase in food quality and quantity resulting from regeneration of the vegetation led to an increase in the possum population.

The conclusion to draw from the known response of the common brushtail possum to fire elsewhere in northern Australia and from observations in the present study is that there is little doubt that fire has an effect on the possum numbers. This may be negative through the immediate reduction of foliage following a fire or through the reduction in biodiversity of the understorey and shrub layers of the woodland and the loss of large hollow-bearing trees. It may, however, also be positive because of an increase in food quantity and quality following a fire, although this assumes there is a residual population of possums that can take advantage of this increase.

The summary by Woinarski (2004a) of the needs of the common brushtail possum in the eucalypt woodlands of the ‘Top-end’ of the Northern Territory, apply equally to Cape York Peninsula. He states that the possum occurs preferentially in forest areas that are relatively long-unburnt, presumably because these support higher densities and larger crops of fruit-producing understorey plants, may have more hollows and large trees, and generally have understoreys with less dense grass, allowing for easier foraging and movement. He also notes that even within the intensively managed Kakadu National Park only about one percent of the eucalypt forest landscape has been unburnt for ten or more years, and only about five percent has been unburnt for five to nine years. This is likely to be replicated on Cape York Peninsula.

Table 14. Localities resampled for possums in relation to fire history, stock numbers and brushtail possum numbers. Occurrence of fire: 0 = none, 1 = early, 2 = late; / denotes part area, no mapping available. Fire mapping provided by Cape York Peninsula Development Association.

Locality	Common brushtail possum numbers	Cattle/horse numbers	Date resampled	Fires				Area not burnt at least once over four-year period		Most intense fire
				1999	2000	2001	2002	Total area	Partial area	
Vrilya Point	Nil	Nil	Sep 02 Sep 03					?		?
Bridge Creek	Nil	Nil	Oct 02	-	-	0	-	?		?
Cockatoo Creek – Atambaya	Nil	Nil	Oct 03	-	-	2	-	?		2
Mapoon Road	Nil	Low	Nov 02	-	-	1	-	?		?
Massy Creek N	Nil	High	Jun 03	0	0	0	0	Yes		0
Massy Creek S	Nil	High	Jun 03	2	0	0	0/1	Yes	Yes	2
Kimba	Nil	High	Jun 03	0	0	1/0	0	Yes	Yes	1
Rokeby – Culliban Creek	Nil	Low	Jun 03	2/1	1/0	1/0	0	No	Yes	2
Laura	Medium	Low	Mar 04	0	2	0	2	Yes		2
York Downs – Jump-Up	Medium	Medium	Jun 04	2	1/0	2/0	1	No	Yes	2
York Downs – Myall Creek	Medium	Medium	Jun 04	2	2/1	2	1/0	No	Yes	2
Strathgordon	Medium	Medium	Aug 03	0/2	0/1	0	0/1	Yes	Yes	2
Embley Range	High	Medium	Nov 02	2	0	0	0/2	Yes	Yes	2
Rokeby – Eric Yard	High	Medium	May 04	1/0	1/0	1/0	1/0	No	Yes	1
Coen North	High	High	Sep 03	2/0	0	0	2/0	Yes	Yes	2
Coen South	High	High	Sep 03	0	0	0	2/0	Yes	Yes	2
Coen River	High	High	Sep 03	0	0	0/2	2/0	Yes	Yes	2

6.2.6 Grazing by Introduced Stock

Pastoralism in Australian tropical woodlands has an impact on the habitat with a substantial rearrangement of the native fauna. This was demonstrated when a one-hundred year history of pastoralism ceased in a military training area near Townsville, with a resulting increase in reptiles and those birds and mammals associated with the ground and understorey layers (Woinarski and Ash 2002). Likewise, cattle grazing practices in a sub-tropical eucalypt woodland in New South Wales significantly reduced vegetation complexity, altered species composition of the understorey and reduced the shrub layers to produce an open simplified and more grassy understorey structure (Tasker and Bradstock 2006). With a cessation of grazing in jarrah woodland of south-western Australia native perennial pasture species replaced exotic annual species to more closely resemble areas never grazed (Pettit and Froend 2001). It follows, therefore, that grazing by introduced stock, predominantly cattle and to a lesser extent horses, is likely to affect the ground and shrub cover on Cape York Peninsula.

The Jardine brothers were the first to introduce cattle onto the Peninsula in 1865 (Byerley 1867) and by the end of the 19th Century the cattle industry was well established on the Peninsula. Initially stock owners in northern Queensland used European cattle which were prone to stress under tropical conditions in that they succumbed to drought and ticks and performed poorly on the low nutrient forage (Gardner *et al.* 1990). Consequently, stock numbers remained low and impact on the environment was relatively light. However, with the introduction of zebu strains of cattle better adapted to drought conditions and resistant to ticks, the provision of feed supplements such as urea which allows cattle to feed on dry low nutrient vegetation and the provision of permanent watering points, stocking rates increased (Gardner *et al.* 1990). On Cape York Peninsula cattle numbers increased from 100,000 in 1965 to 150,000 in 1977 in response to change in breeds to Braham type, supplement feeding, vaccines and economic factors and have since remained at that level (Crowley and Garnett 1998).

Heavy use of native pastures leads to the progressive replacement of native perennial grasses with native annuals, then introduced annuals and in extreme cases introduced woody weeds (Gardner *et al.* 1990). Stocking rates on Cape York Peninsula appear to have been relatively light. Although the more sensitive of native perennial grasses to grazing pressure, kangaroo grass *Themeda triandra* and black spear grass *Heteropogon contortus* have declined, there has been no pasture degradation and the invasion of woody weeds indicative of excessive stocking, apart from sacrifice areas around dams or inside highly developed paddocks (Crowley and Garnett 1998).

Because the common brushtail possum spends a signification proportion of its time on the ground and includes ground cover plants in its diet, any alteration to the ground layer will affect the possum. Grasses can be an important component of the common brushtail possum's diet in southern Australia (Fitzgerald 1984), but were negligible in the diet of the possum at Kakadu (Kerle 1985) in similar habitat to the eucalypt woodlands of Cape York Peninsula. Of equal, or possible greater, importance to the possums are the ground cover or small shrubby broader leaved dicotyledonous herbs, a group that is reduced in species richness by cattle grazing (Fensham and Skull 1999).

Merely changing the species mix of the ground cover may not be deleterious to the possum. Improved pastures may include exotic species that are beneficial to the possum, for example, in New Zealand the possum is known to include up to 32% introduced grasses and clover in its diet (Nugent *et al.* 2000). Even extreme grazing pressure leading to the degradation of pasture and increase in woody weeds may not necessarily be deleterious for the possum, if woody weeds have flowers and foliage that can be eaten by them. Unfortunately little is known of the diet of the common brushtail possum on Cape York Peninsula, but with eleven percent of the possums on the ground when first sighted in this project, it is probable that the possum is obtaining a significant proportion of its diet from items – grass, forbs, fungi, insects – in the ground layer of its habitat, a layer that is impacted by grazing.

Relatively high numbers of cattle at a sampled locality for possums are not necessarily indicative of low numbers of possums, in that stock were present at all localities where possums were recorded and at Coen, a nodal locality for possum densities, stock numbers were high (Table 14). The relationship between stocking rates and possum numbers on Cape York Peninsula is obviously more complex than the mere presence of cattle, even in high numbers. This may be because what is considered to be high stocking rates on Cape

York Peninsula are relatively light compared with stocking rates experienced further south in tropical woodland.

6.3 Other Arboreal Marsupials

This project concentrated on the common brushtail possum, mainly because it is the possum most commonly encountered and for which there is the most information. However, many of the environmental impacts on the brushtail may also apply to the other woodland possums and gliders on Cape York Peninsula.

The common ringtail possum, like the brushtail, is an arboreal folivore and like the brushtail requires tree hollows for daytime shelter. It is therefore likely to be similarly affected by loss of den hollows, high temperatures, extremely dry conditions and by fire. There are, however, important differences between the two possums. The ringtail is a more specialised leaf eater with about ninety percent of its diet consisting of leaves, so it is less dependent on factors which may reduce flowering and fruiting, but it could be more sensitive to leaf moisture and fibre content. The ringtail rarely comes to the ground and if so does this to cross between trees rather than to feed on the ground. Consequently, grazing will have less impact on the more arboreal ringtail, other than through general changes imposed on the structure of the woodland, but tree clearing will have a greater impact. The ringtail is smaller, less than a kilogram in weight compared with the one to one and a half kilograms of the brushtail. This makes it more susceptible to cat predation although its more arboreal habits may negate this to some extent.

The sugar glider, squirrel glider and feathertail glider are all exudate (nectar and gum), pollen and insect feeders in complete contrast to the two possums. Thus, flowering patterns within the woodland will be important and fire reduction of flowering in the canopy trees could have an impact on the gliders. All the gliders are extremely arboreal and travel awkwardly on the ground, consequently tree clearing which fragments the habitat will have a profound effect. Even clearing for fire breaks and fence lines may act as substantial barriers to the gliders, unless kept sufficiently narrow to allow gliding between trees on each side. Furthermore, gliders may become entangled on barbed wire fences, particularly if clearings along fence lines force them low to the ground at the end of a glide. The glide angle of sugar and mahogany (*Petaurus gracilis*) gliders is about thirty degrees (Jackson 1999) so one would expect the similar angle for squirrel gliders. For these gliders track or fence line clearing should be no more than twenty metres wide, assuming an average height of trees each side of fifteen to twenty metres (Jackson 1999). This would allow the animals to land above fence height on the target tree. Cats are efficient predators on gliders, capable of plucking a low gliding animal out of the air and domesticated cats commonly bring in a catch to show to their owners.

6.4 Resource Bottlenecks

The term *resource bottleneck* is used to indicate a severe depletion or unavailability of an animal's resource for a finite time, but not a permanent loss of the resource (Karasov 1989). Resource bottlenecks can occur over different time scales. For example, the loss of tree hollows suitable for use by the common brushtail possum under inappropriate fire regimes is not necessarily permanent, but the bottleneck effect will have a time scale of decades. More relevant to understanding population changes of the common brushtail possum on Cape York Peninsula are bottlenecks of a much shorter duration, a matter of weeks, the most important of which are those pertaining to food and water.

A potentially serious bottleneck for the brushtail possum on Cape York Peninsula occurs at the end of the dry season when high temperatures, dry times and fire combine to cause extremely stressful times for the possum (Figure 34).

The critical time is towards the end of the dry season, when:

- Moisture content of the foliage is at its lowest, possibly too low in the canopy for the possum to obtain sufficient water and particularly if the storm season is late in coming; and
- Temperatures are at their highest and may begin to climb above 35°C and cause the possums to suffer heat stress, particularly if low water availability limits the ability of the possums to cool themselves by sweating.

The stressful climatic conditions are then exacerbated if a late hot fire reduces the ground and shrub vegetation to ash and scorches the canopy thus even further reducing the availability of foliage with sufficient moisture content for the possums to eat. Under these conditions the possums will loose condition and may well die.

It is not known how long the possums can survive such severe conditions. In a very different environment, but one with a similar bottle-neck of resources, wild rabbits in France when forced to fast due to harsh winter conditions, survived for an average of three to four days only (Boos *et al.* 2005). This suggests that the survival time for a possum in burnt woodland during hot dry conditions might be a matter of days only.

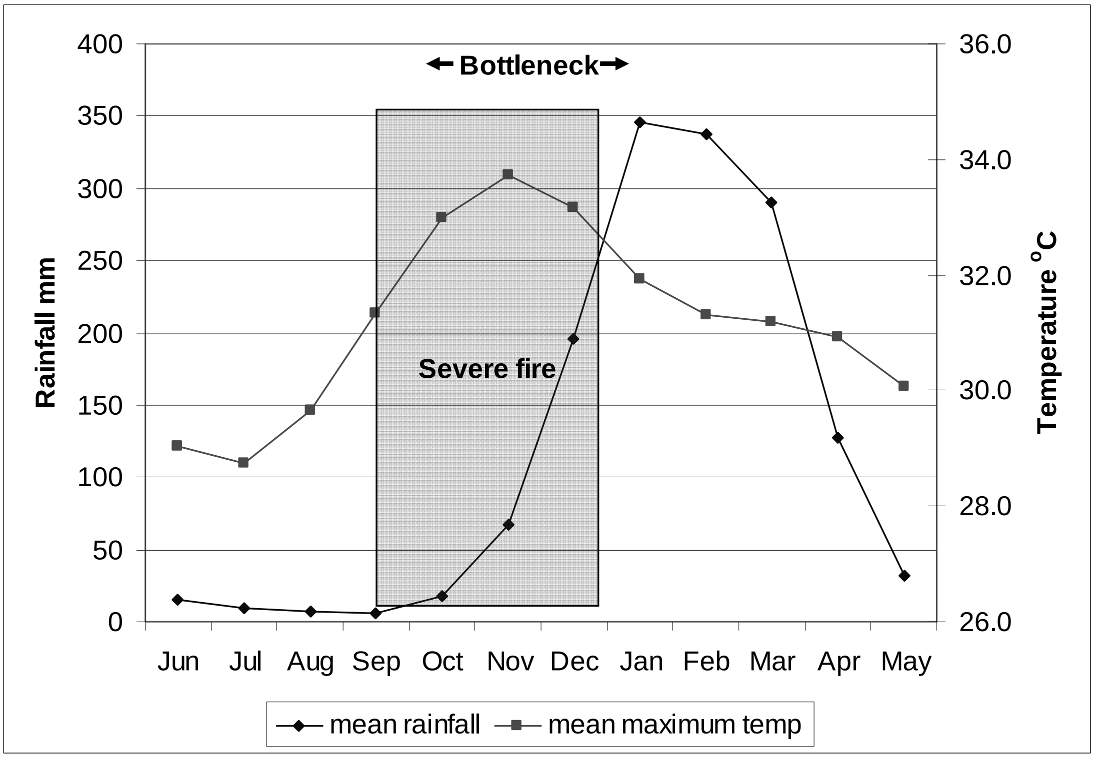

Figure 34. Postulated resource bottleneck for common brushtail possums resulting from severe fires, high temperatures and dry conditions. Monthly means for rainfall and temperature derived from localities in Figures 30 and 31 respectively.

6.5 Conclusion

The brushtail possum is maintaining a population structure on Cape York Peninsula that has changed little since the arrivals of Europeans. It is one of very low density generally, with the occasional node of relatively high density in restricted areas. Possum densities at these nodes may fluctuate over a time span of a few years to decades. It is not known whether they are the result of a number of environmental factors – rainfall, temperature, fire – converging to result in extremely favourable, though short lived, conditions, or whether some of the nodes reflect areas of relatively high soil fertility resulting in high possum densities. As stated by Kerle (1998) the brushtail possum in northern Australia, which has continuous rather than seasonal breeding and has two young a year, can recover rapidly when conditions are favourable.

In the Northern Territory the brushtail possum occurs patchily in the eucalypt tall open forest and mangroves and there is some evidence of an historical decline of the possum in the eucalypt forest (Woinarski 2004b). Woinarski (2004b) paints a rather bleak picture of habitat quality in these Northern Territory eucalypt forests, one of continuing degradation as a result of changing fire regimes, feral and domestic stock impacts (cattle, horses, donkeys, buffalo and pigs), increased fuel loads from introduced pasture species (principally the African gamba grass *Andropogon gayanus* and mission grass *Pennisetum polystachion*) and clearing for agriculture and forestry. These result in damaging changes which he considers to be ‘effectively unstoppable’, although he concedes that more intensive management associated with agricultural and forestry developments may be beneficial for possums by increasingly fragmenting the woodland in which fire control is easier.

The situation on Cape York Peninsula may not be as bleak. There are no populations of large feral grazers such as buffalo and donkeys, although feral horses and pigs may present problems; the introduced fuel-heavy grasses are not widely established; the pastoral industry is at a relatively low level of intensity; and little broad-scale clearing has taken place. Clearing caused by open-cut bauxite mining does have the potential to significantly affect the woodland on the west coast of the Peninsula. Perhaps we are at a cusp in the management of eucalypt woodlands on Cape York Peninsula, where habitat degradation could accelerate, but alternatively under careful management the extensive eucalypt woodlands could retain their natural biodiversity values, or even be improved.

However, low possum densities also indicate that it is at the limits of its geographical distribution in Australia and that relatively minor changes to its tropical woodland habitat may be sufficient to lead to its extinction in this habitat. If this is the case, then the fate of the possum on Cape York Peninsula may be at a cusp, where increased stresses to the woodland from human activity and global warming may tip the balance out of the possum’s favour. Consequently, complacency towards the management of eucalypt woodland on Cape York Peninsula is not an option.

7. Recommendations

7.1 Basis for Recommendations

The main aim of this project was to recommend measures for enhancing woodland on Cape York Peninsula as habitat for arboreal marsupials. This has been undertaken by examining the population structure of the common brushtail possum and identifying the environmental requirements of the possum and how these could be improved.

Recommendations made are based on two types of information engendering different levels of confidence. The most reliable information concerns the structure of the regional population of the common brushtail possum on the Peninsula determined by the number of possums recorded over time at various localities. Less confidence can currently be placed on the reasons for this structure as it depends largely on the knowledge of the possum derived from studies elsewhere. Nevertheless, these studies can be directly applicable to the situation on Cape York Peninsula, particularly those undertaken in the Northern Territory in the same monsoonal climatic zone as the Peninsula and in very similar woodland habitat. Likewise, studies of the brushtail possum in the Townsville region are from the same climatic zone, but in woodland with a slightly different mix of tree species.

Consequently, sufficient is known about the possum in tropical eucalypt woodland, based on both this project and studies elsewhere across northern Australia, to make preliminary management recommendations with the caveat that they are subject to change as a better understanding of the ecological processes of the woodlands of Cape York Peninsula is obtained.

7.2 Recommendations

The following management recommendations are grouped into the major factors impacting on the woodland habitat and most likely to affect its suitability as arboreal marsupial habitat.

The recommendations are based on the best currently available evidence, and will need to be modified with improvement in knowledge of both possum biology and eucalypt woodland ecology.

7.2.1 Fire

Rationale: Fire is apparently the most influential activity on possum densities, as studies in the Northern Territory have shown that longer intervals between fire favour possum numbers.

Fire can:

- Reduce the number of hollow-bearing trees that are essential as day time shelters for the possum;
- Reduce the species diversity of the understorey and shrub layer plants, particularly of softer leaved species which may be an essential component in the diet of the possum;
- Prevent or reduce flowering and fruiting of plants which is important to the possum as these items constitute about 50% of the diet; and
- Act as a critical component of the resource bottle-neck towards the end of the dry season.

The management of fire is a complex issue, however, with a range of opinions as to the most suitable frequency and seasonal timing of burning and largely depends on the outcome required. The outcome will differ according to the interests of the major stake holder at a locality, some of which may not be compatible with management to enhance the woodland as possum habitat.

Recommendation 1: That the fire regime most conducive to the survival of the possum in the eucalypt woodlands of Cape York Peninsula is one that:

- Aims for a relatively small scale patch burn which will result in a mosaic or woodland with differing fire histories;
- Aims to have a network of patches which have not been burnt for three or more years;
- Aims to encourage plant species diversity in the understorey and shrub layers; and
- Relies more on early season cool burns than on late season hot burns.

7.2.2 Grazing

Rationale: The level of grazing pressure currently sustained on the Peninsula appears to have had no serious deleterious effect on the common brushtail possum. However, any increased pressure or manipulation of the ground layer could have an effect particularly if it leads to the elimination of plants included within the diet of the possum, which has been shown to spend much of its time on the ground and is known to include ground cover plants in its diet elsewhere in Australia. Grazing pressure which reduces, or eliminates, non-grassy forbs in the ground cover is expected to have an adverse effect on possum numbers. However, without a more detailed examination of the use of the ground layer by the possum in Cape York Peninsula, it is impossible to know exactly how grazing pressure will impact on the possum.

Recommendation 2: That the retention of a component of native non-grass species as part of the ground vegetation be sought through appropriate pasture management.

7.2.3 Broad-scale Tree Clearing

Rationale: Generally, broad-scale tree clearing on Cape York Peninsula has not been extensive and where it has occurred it has not affected the overall connectivity of the woodland habitat. The exception is the potential for extensive areas of tree clearing of the very tall, predominantly messmate trees, and woodland on aluminous laterite as a result of open-cut bauxite mining. This woodland type occurs on the western side of the Peninsula from Vrilya Point in the north to approximately the Archer River in the south and currently only three percent is in protected areas. Whilst mining companies have environmental plans and constraints imposed on them these can differ between companies. There is no general conservation strategy for this woodland type which is in danger of being obliterated. Such a strategy would require the Queensland Government to work in close liaison with the mining companies.

Recommendation 3: That a general conservation strategy be developed for the tall eucalypt woodlands on aluminous laterite on Cape York Peninsula.

7.2.4 Linear Tree Clearing

Rationale: Linear tree clearing is undertaken for power lines, roads and fence lines. They are of little consequence to the common brushtail possum because of its propensity to spend time on the ground. However, the width of these linear clearings can have a detrimental impact on the movement of the remaining species of arboreal marsupials because of their reluctance to come to the ground. Most affected are the gliders which are clumsy movers on the ground, hampered by their gliding membranes. Furthermore, gliders are prone to becoming entangled on barbed-wire fences, usually on the top strand. The thirty-degree glide angle of the squirrel and sugar glider allows them to clear a twenty-metre gap from a fifteen- to twenty-metre tall tree.

Recommendation 4: That fire break, vehicle track and fence line clearings do not exceed twenty metres in width, assuming an average height of trees on each side of fifteen to twenty metres. This allows the gliders to land high enough up a target tree to clear any fences.

Recommendation 5: That the top strand of a fence be plain rather than barbed wire where a fence bisects glider habitat, to reduce the chance of a glider becoming entangled on the fence.

7.2.5 High Density Nodes

Rationale: Evidence was obtained of high density nodes of the common brushtail possum occurring in restricted areas over relatively long periods of time. The best examples were from around Coen and at Eric Yard in Mungun Kaanju National Park. In this project the nodes appear to be best explained by soil type, based on the available large-scale mapping of soils. These areas may be acting as refugia for fauna in addition to the possum. If so, they are important for the conservation of wildlife by ensuring the continuity of animal populations during difficult times. Accordingly, characteristics of the habitat occupied by these nodes need to be determined. This will enable further nodes to be identified, using broad scale mapping of environmental factors such as geology, soils, vegetation and climate. The nodes can then be managed for their wildlife values.

Recommendation 6: That the relationship between high possum densities and environmental factors be determined, in order to develop a predictive method for locating similar high densities.

7.2.6 Predators

Rationale: The recently introduced feral cat adds to the pythons, goannas, raptors, owls and the dingo already preying upon the possum. The cat is an extremely efficient predator on native animals including the possum, particularly on the young. Although the common brushtail possum population on Cape York Peninsula appears to co-exist with the cat, a single cat could seriously deplete a local population.

Recommendation 7: That the feral cat be treated as a serious additional predator of possums and other wildlife and measures be taken to reduce its numbers.

8. What Next?

The present project has provided a picture of the common brushtail possum population at a regional scale across Cape York Peninsula, but like most projects it has highlighted more questions than it has provided answers. Some future lines of investigation into ensuring that eucalypt woodland is suitable habitat for arboreal marsupials need to be considered.

While much is known about the common brushtail possum, considerable gaps in our knowledge of the animal still exist, particularly in respect to the population on Cape York Peninsula and how the possum responds to the environmental conditions of the region. This section outlines areas where further research would clarify the issues raised by this project.

8.1 Biology of the Common Brushtail Possum

8.1.1 Diet

More information about the diet of the possum is needed; the extent it relies on canopy, understorey and shrub plants and whether it is the leaves, flowers or fruits that are eaten. The amount of time the possum spends on the ground suggests that it feeds at ground level, but very little is known about which elements of this layer are included in the diet. In addition, water content of foliage may be extremely important in determining its availability as food for the possum. Lines of investigation could include:

- Determine the diet of the possum with emphasis on any seasonal changes related to the resource bottle-neck at the end of the dry season; and
- Ascertain the role of water content within the foliage of trees and shrubs used by the possum and how it may limit the inclusion of foliage within the possum's diet.

8.1.2 Population Ecology and Behaviour

The project identified the general structure of the brushtail possum population throughout the Peninsula – extremely low densities are the norm, but with high density nodes and evidence of both population crashes and recoveries. An understanding of these population fluctuations is essential if the woodland is to be managed for its biodiversity. Suggested lines of investigation include:

- Comparison of the population ecology of the brushtail possum at high and low densities, with emphasis on:
  - The ability of the possum to maintain and recover from extremely low densities; and
  - Whether the high density population nodes are essential in the reestablishment of the possum in areas of low density, i.e. do these nodes function as source populations?
- Study of social behaviour of the possum in the low density areas on Cape York Peninsula to determine whether:
  - There is a critical density below which individual possums cease to be part of a community in contact with each other; or
  - The high population nodes are merely a function of social cohesion which attracts possums to each other.

8.2 Environment of the Common Brushtail Possum

This study highlighted a number of environmental factors that undoubtedly had a profound influence on the population density of the common brushtail possum. Further study of these factors are suggested, many of which are also applicable to other arboreal marsupials in the tropical woodlands of Cape York Peninsula.

8.2.1 Habitat Structure

A diverse understorey and shrub layer is thought to be essential in the maintenance of a viable common brushtail possum population in tropical eucalypt woodland, based on two Northern Territory studies and on the knowledge of the possum's dietary requirements in the Northern Territory and on Cape York Peninsula. This hypothesis, however, needs to be rigorously tested as it is of considerable importance in determining the type of management required to maintain or enhance eucalypt woodland as possum habitat. A future study would:

- Test whether high species diversity of the understorey and shrub layer is necessary for a viable population of the common brushtail possum in tropical eucalypt woodland.

8.2.2 Soil Fertility

High leaf nutrient levels are known to be positively related to high densities of arboreal marsupials in eucalypt woodlands of south-eastern Australia and rainforest of the Wet Tropics of north-eastern Queensland. Likewise, high soil fertility is related to high population densities of the rufous bettong and common brushtail possum in tropical woodlands in the Townsville region. A study is required to:

- Examine the role of soil fertility in determining the density of brushtail possum populations on Cape York Peninsula, particularly in relation to the high density nodes.

8.2.3 Tree Hollows as Daytime Shelter

The present project found no relationship between the number of potential tree hollows and possum numbers, suggesting that the availability of hollows was not a limiting factor for the possums. However, the method of determining the presence of hollows by rapid scanning of a tree from the ground may have over estimated the number of hollows considered suitable as possum dens. Because tree hollows appear to be essential for the possums as protection from the climatic extremes of high temperatures and dry conditions, a more rigorous assessment of their presence in the woodland habitat is required. A future project could focus on:

- Assessing more precisely the availability of tree hollows as possum dens in eucalypt woodland of Cape York Peninsula; and
- Determining the degree of protection provided by hollows from high temperatures, low humidity and radiant heat of fires.

8.2.4 Fire

Fire is a major environmental factor in northern tropical woodland and numerous studies across northern Australia are studying fire's influence on the habitat, many of which are pertinent to the woodland on Cape York Peninsula and its suitability as arboreal marsupial habitat. Of particular relevance to the common brushtail possum on Cape York Peninsula and requiring further investigation is the role of fire in:

- Determining the structure of the understorey and shrub layer;
- Destroying trees, forming tree hollows suitable as possum dens; and
- Exacerbating the late dry season resource bottle-neck for arboreal marsupials in tropical eucalypt woodland.

8.2.5 Grazing

Grazing of domestic stock has an impact on ground cover which may also impact on the common brushtail possum, because of the amount of time it spends on the ground. There are numerous studies on the effects of grazing, with emphasis on the implications for a sustainable cattle industry in tropical Australia. The impacts of grazing on faunal biodiversity are also subject to a variety of studies, primarily focused on the correlation of grazing intensity and species diversity. It is not known, however, if grazing has a direct effect on the possum, although it is hypothesised that it does through the elimination of forbs in the ground layer. This requires testing by:

- Examining how grazing affects the use of the ground layer by the common brushtail possum.

8.2.6 Refugial Areas

This project found that common brushtail possum numbers are high in limited locations over many years, in what are referred to as population nodes. The project was insufficient in scope to confirm the nature of these nodes and to what extent they are correlated with specific habitat factors such as soil fertility, woodland structure, woodland type and soil moisture. However, if it was determined that a set of environmental characteristics favour the possums, these areas can then be treated as refugia.

If they are refugia for the possum they may also function in a similar fashion for other elements of the fauna and they would require special management. Should there be a clear association with a group of environmental factors these can be identified elsewhere on the Peninsula using Geographical Information Systems (GIS) and managed accordingly. A study is needed to:

- Determine environmental factors associated with high population nodes;
- Ascertain whether they are faunal refugial areas for possums other wildlife species such as bandicoots, spectacled hare-wallabies, black-footed tree-rats, birds and reptiles; and
- Locate other potential high population nodes on Cape York Peninsula using GIS techniques and test for common brushtail possum numbers.

8.2.7 Climate

If, as proposed in this project, the combination of high temperatures and dry conditions are lethal to possums, then the distribution of the possum on Cape York Peninsula may be determined partially by climate. Consequently, climatic modelling at both the short-term time frame of seasonality and at a longer time frame based on rainfall can be used to predict the possum's distribution within the region. A study would:

- Use climatic modelling to predict the distribution of the common brushtail possum on Cape York Peninsula and how it may be affected by global warming.

Plate 1. Common brushtail possum *Trichosurus vulpecula eburacensis* from Cape York Peninsula. (*Top*) From Melon Yard, Edward River, Strathgordon, sitting in a kapok tree *Cochlospermum gillivraei*. (*Bottom*) Mother with back-riding young from Port Stewart Road, Coen area. Photographer J. W. Winter.

Common ringtail possum
Pseudocheirus peregrinus

Photographs from The Mammals of Australia, 1995, (Ed) R. Strahan

Feathertail glider
Acrobates pygmaeus

Sugar glider
Petaurus breviceps

Plate 2. Other arboreal marsupials found in the woodlands of Cape York Peninsula. The common ringtail possum on Cape York Peninsula has a uniform grey, often dark grey, body and tan-coloured limbs. The feathertail glider is about the size of a mouse and has a distinctive feather-like tail. The sugar and squirrel gliders are very similar to each other and difficult to tell apart. The squirrel glider is slightly larger and has a fluffier tail.

Squirrel glider
Petaurus norfolcensis

Plate 3. Eucalypt woodland habitats in which common brushtail possums were found in good numbers. Eric Yard Site 5 with understorey containing numerous soft-leafed trees; Site 6 with fewer such trees; Coen River transect with species such as kurajong *Brachychiton*; and Strathgordon (Melon Yard) transect with Cooktown ironwood, but no obvious soft-leaved species. Photographer A. B. Freeman.

Plate 4. Eucalypt woodland habitats in which common brushtail possums were not found. All sites had co-dominance of messmate *Eucalyptus tetrodonta* and bloodwood *Corymbia* sp. trees in the canopy and a simple understorey. Photographer A. B. Freeman.

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Appendix 1: Vehicle Spotlighting Transects Undertaken During the Project

NB. Table reads across page spread. Datum WGS84 used for coordinates.
*Minutes spent spotlighting exclude significant stoppages during spotlighting.

Locality	Date	Observers	WP	Start of Transect Section						
				Description	Time	Zone	AMG		Decimal Degrees	
							Easting	Northing	Longitude	Latitude
Mary Valley	14/11/2002	J.W.Winter, H.V.Myles	5	Mary Valley homestead	2000	54	796974	8334853	143.76201	-15.04486
Morehead River	14/11/2002	J.W.Winter, H.V.Myles	11	Peninsula Development Road	2120	54	786392	8337476	143.66336	-15.02235
Bramwell	7/10/2002	J.W.Winter, H.V.Myles	Homest.	Bramwell Homestead	2100	54	676558	8657232	142.62255	-12.14187
Larua (Split Rock)	27/03/2004	J.W.Winter, H.V.Myles	35	Laura Roadhouse	2000	54	226044	8278254	144.44573	-15.55857
Larua (Split Rock)	28/03/2004	J.W.Winter, H.V.Myles	35	Laura Roadhouse	1945	54	226044	8278254	144.44573	-15.55857
Kimba Plateau	22/07/2003	J.W.Winter, A.B.Freeman	5	Kimba-Pinnacles short-cut Road, Kimba gate	2030	54	766970	8271892	143.48987	-15.61677
Kimba Plateau	23/07/2003	J.W.Winter, A.B.Freeman	18	Pinnacles-King Junction Road, gate	1940	54	775133	8262635	143.56699	-15.69951
Kimba Plateau	24/07/2003	J.W.Winter, A.B.Freeman	39	Kimba gate	1949	54	767019	8271950	143.49032	-15.61625
Kimba Plateau	24/07/2003	J.W.Winter, A.B.Freeman	45	Kimba main road, Pinnacles turn-off	2045	54	782280	8276323	143.63205	-15.57509
Atambaya	8/10/2003	J.W.Winter, A.B.Freeman	42	Cockatoo Creek crossing	1920	54	658878	8711601	142.45749	-11.65126
Atambaya	12/10/2003	J.W.Winter, A.B.Freeman	49	c.1 km N of Cockatoo Creek crossing	2140	54	659109	8712339	142.45958	-11.64457
Massy Cr, Silver Plains	19/06/2003	J.W.Winter, A.B.Freeman	Camp	Lower crossing of Massy Creek	2045	54	776362	8460042	143.55745	-13.91634
Massy Cr, Silver Plains	23/06/2003	J.W.Winter, A.B.Freeman	Camp	Lower crossing of Massy Creek	1900	54	776362	8460042	143.55745	-13.91634
Mapoon Road	18/11/2002	J.W.Winter, H.V.Myles, J.Charger	94	Batavia Outstation Landing	2003	54	597479	8653689	141.89601	-12.17722
Mapoon Road	19/11/2002	J.W.Winter, H.V.Myles, R.Barkley	96	Clough's Landing	1940	54	597406	8649017	141.89549	-12.21946
Mapoon Road	20/11/2002	J.W.Winter, H.V.Myles, L.Booth, C.Woodley,	90	6.5 km S of Telstra tower, turn-off old rd to Myerfield	2013	54	600405	8631181	141.92362	-12.38065
Rokeby Road	24/10/1993	J.W.Winter, P.J.Lethbridge, H.V.Myles,		Eric Yard	2055	54	689113	8493985	142.74810	-13.61670
Rokeby Road	24/10/1993	J.W.Winter, P.J.Lethbridge, H.V.Myles,		5.3 km W of Eric Yard	2145	54	685322	8495671	142.71295	-13.60170
Rokeby Road	24/10/1993	J.W.Winter, P.J.Lethbridge, H.V.Myles,		Eric Yard	2203	54	689113	8493985	142.74810	-13.61670
Rokeby Road	25/10/1993	J.W.Winter, P.J.Lethbridge, H.v.Myles,		O.6 km E of Eric Yard	2040	54	685022	8495171	142.71021	-13.60624
Rokeby Road	26/10/1993	J.W.Winter, P.J.Lethbridge, H.V.Myles,		Cabbage Tree Creek camp	2045	54	698185	8489439	142.83224	-13.65718
Rokeby Road	13/06/2003	J.W.Winter, A.B.Freeman	174	Cabbage Tree Creek camp	1910	54	698185	8489439	142.83224	-13.65718
Rokeby Road	14/06/2003	J.W.Winter, A.B.Freeman, F.Ford, E.Ritchie	175	Cabbage Tree Creek camp turn-off	1955	54	698069	8489096	142.83119	-13.66028
Rokeby Road	16/06/2003	J.W.Winter, A.B.Freeman	169	Eric Yard	2232	54	689113	8493985	142.74810	-13.61670
Rokeby Road	17/06/2003	J.W.Winter, A.B.Freeman	169	Eric Yard	2215	54	689113	8493985	142.74810	-13.61670
Rokeby Rd (Eric Yard)	12/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	21	Eric Yard	1940	54	689059	8493981	142.74760	-13.61674
Rokeby Rd (Eric Yard)	13/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	35	Eric Yard	1935	54	689052	8493976	142.74753	-13.61678
Rokeby Rd (Eric Yard)	14/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	33	5.0 km W of Eric Yard	1945	54	685034	8495426	142.71031	-13.60393
Rokeby Rd (Eric Yard)	15/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	36	Eric Yard	1955	54	689129	8493984	142.74824	-13.61671
Rokeby Rd (Eric Yard)	15/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	81	5.0 km W of Eric Yard	2025	54	685024	8495390	142.71022	-13.60427
Rokeby Rd (Eric Yard)	16/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	90	Eric Yard	2005	54	689099	8493981	142.74796	-13.61673
Rokeby Rd (Eric Yard)	16/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	100	5.0 km E of Eric Yard	2054	54	693541	8494691	142.78896	-13.61003
Rokeby Rd (Eric Yard)	17/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	107	5.0 km E of Eric Yard	1937	54	693636	8494644	142.78985	-13.61045
Rokeby Rd (Eric Yard)	17/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	110	10.0 km E of Eric Yard	2010	54	696642	8490841	142.81788	-13.64462
Rokeby Rd (Eric Yard)	17/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	115	15.0 km E of Eric Yard	2044	54	699988	8487390	142.84904	-13.67558
Rokeby Rd (Eric Yard)	18/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	150	Eric Yard	1942	54	689086	8493982	142.74785	-13.61672

WP	End of Transect Section							Minutes spent spotlighting*	Distance (km)	Mammals Seen	
	Description	Time	Zone	AMG		Decimal Degrees				*T. vulpecula*	Other
				Easting	Northing	Longitude	Latitude				
7	Peninsula Development Road	2038	54	792870	8331413	143.72426	-15.07639	38	6.0	0	None
14	Whisky Waterhole	2220	54	784425	8331629	143.64574	-15.07537	60	7.4	0	None
169	Bramwell road turn-off	2306	54	679577	8665130	142.64984	-12.07032	115	10.9	1	2 *Petaurus sp.*, 1 *F.catus*
22	Peninsula Developmental Road, 3.8 km SE Kennedy Cr	2248	54	239594	8267364	144.57082	-15.65836	168	20.1	3	None
47	Peninsula Developmental Road, 27.9 km from transect start	2235	54	244225	8261675	144.61339	-15.71022	179	27.9	1	1 *F.catus*
13	Kimba-Pinnacles short-cut Road, Pinnacles gate	2255	54	774467	8264062	143.56063	-15.68668	145	12.0	0	3 *P.norfolcensis*
32	Pinnacles-King Junction Road, gate	2135	54	769578	8243762	143.51731	-15.87056	115	27.5	1	None
43	Kimba main Road	2030	54	775480	8276348	143.56868	-15.57561	45	10.0	0	1 *M.agilis*, 2 *F.catus*
47	Pinnacles-King Junction Road, gate	2150	54	776034	8264097	143.57523	-15.68620	65	16.0	0	None
45	Telegraph line road 6.7 km S of Cockatoo Cr crossing	2040	54	660911	8706140	142.47640	-11.70053	80	6.7	0	None
53	Telegraph line road c.6 km N of Cockatoo Cr crossing	2237	54	658692	8717246	142.45552	-11.60023	57	5.0	0	None
305	Upper crossing of Massy Creek	2205	54	771880	8459395	143.51606	-13.92261	80	9.4	0	1 *M.agilis*, 1 *S.scrofa*
MA S6	Sand ridge N of Massy Creek mouth	2040	54	779889	8462591	143.58980	-13.89297	60	5.5	0	1 *C.familiaris*, 11 *B.indicus*
87	N side of little scrub patch	2359	54	603582	8627545	141.95296	-12.41343	219	32.7	0	2 *M.antilopinus*, 1 *F.catus*,
90	6.5 km S of Telstra tower, turn-off old road to Myerfield	2150	54	600405	8631181	141.92362	-12.38065	120	21.0	0	None
	Clough's Landing	2225	54	597406	8649017	141.89549	-12.21946	120	23.2	0	1 S.scrofa
	5.3 km W of Eric Yard	2145	54	685322	8495671	142.71295	-13.60170	50	5.8	0	None
	Eric Yard	2203	54	689113	8493985	142.74810	-13.61670	18	5.8	1	None
	Cabbage Tree Creek camp	2308	54	698185	8489439	142.83224	-13.65718	65	13.2	0	2 *Petaurus sp.*
	Rokeby Ranger Station	2217	54	680500	8489495	142.66879	-13.65783	97	16.0	1	1 F.catus, 1 *M.agilis*
	Near Horsebush Creek	2205	54	707522	8483071	142.91899	-13.71407	80	13.4	1	1 *P.breviceps*, 1 *S.scrofa*
189	Rokeby Rd, Archer's Bend turn-off	2250	54	680460	8491081	142.66832	-13.64349	220	26.5	4	2 *S.scrofa*, 1 *M.robustus*
210	Horsebush Creek crossing	2208	54	708007	8482669	142.92351	-13.71767	133	13.6	0	2 *M.antilopinus*, 3+ *P.scapulatus*
256	5.0 km W of Eric Yard	2328	54	685014	8495387	142.71013	-13.60429	56	5.0	2	1 *L.conspicillatus*
278	5.0 km W of Eric Yard	2316	54	685023	8495406	142.71021	-13.60412	61	5.0	5	2 *P.breviceps*
33	5.0 km W of Eric Yard	2115	54	685034	8495426	142.71031	-13.60393	95	5.0	8	1 *Petaurus sp.*, 1 *P.scapulatus*
46	5.0 km E of Eric Yard	2138	54	693551	8494688	142.78906	-13.61006	123	5.0	13	None
65	10.0 km W of Eric Yard	2030	54	681055	8494525	142.67360	-13.61233	45	5.0	0	None
81	5.0 km W of Eric Yard	2025	54	685024	8495390	142.71022	-13.60427	30	5.0	1	None
	10.0 km W of Eric Yard	2105	54	681055	8494525	142.67360	-13.61233	40	5.0	4	None
100	5.0 km W of Eric Yard	2054	54	693541	8494691	142.78896	-13.61003	49	5.0	13	1 *F.catus*
105	10.0 km E of Eric Yard (0.5 km E of Culliban Cr)	2132	54	696617	8490968	142.81764	-13.64347	38	5.0	1	1 *Isoodon sp.*
110	10.0 km E of Eric Yard (0.5 km E of Culliban Cr)	2010	54	696642	8490841	142.81788	-13.64462	33	5.0	0	1 *P.breviceps*
115	15.0 km E of Eric Yard	2044	54	699988	8487390	142.84904	-13.67558	34	5.0	0	None
118	20.0 km E of Eric Yard	2113	54	704555	8487305	142.89126	-13.67602	27	5.0	0	None
155	5.0 km W of Eric Yard	2017	54	685052	8495466	142.71047	-13.60358	35	5.0	1	None

Appendix 1 continued. NB. Table reads across page spread.

Locality	Date	Observers	WP	Start of Transect Section						
				Description	Time	Zone	AMG		Decimal Degrees	
							Easting	Northing	Longitude	Latitude
Rokeby Rd (Eric Yard)	18/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	155	5.0 km W of Eric Yard	2017	54	685052	8495466	142.71047	-13.60358
Rokeby Rd (Eric Yard)	18/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	157	10.0 km W of Eric Yard	2048	54	681059	8494566	142.67363	-13.61196
Rokeby Rd (Eric Yard)	19/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	165	Eric Yard	1922	54	689077	8493980	142.74776	-13.61674
Rokeby Rd (Eric Yard)	19/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	181	5.0 km E of Eric Yard	2018	54	693509	8494706	142.78867	-13.60989
Rokeby Rd (Eric Yard)	19/05/2004	J.W.Winter, A.B.Freeman, K.Hegmann	118	20.0 km E of Eric Yard	2115	54	704555	8487305	142.89126	-13.67602
Rokeby Rd (Eric Yard)	9/11/2005	J.W.Winter, A.B.Freeman, H.V.Myles	11	Eric Yard	2018	54	689111	8493983	142.74808	-13.61671
Rokeby Rd (Eric Yard)	11/11/2005	J.W.Winter, A.B.Freeman, H.V.Myles	24	Eric Yard	2034	54	689113	8493980	142.74809	-13.61674
Rokeby Rd (Eric Yard)	11/11/2005	J.W.Winter, A.B.Freeman, H.V.Myles	29	5.0 km W of Eric Yard	2136	54	685043	8495447	142.71039	-13.60374
Rokeby Rd (Eric Yard)	12/11/2005	J.W.Winter, A.B.Freeman, H.V.Myles	21	5.0 km E of Eric Yard	2044	54	693677	8494624	142.79022	-13.61062
Rokeby Rd (Eric Yard)	12/11/2005	J.W.Winter, A.B.Freeman, H.V.Myles	11	Eric Yard	2207	54	689111	8493983	142.74808	-13.61671
Rokeby Rd (Eric Yard)	1/06/2005	M.Ahmet, C.Roetgers		Eric Yard	2000	54	689113	8493985	142.74810	-13.61670
Rokeby Rd (Eric Yard)	2/06/2005	M.Ahmet, C.Roetgers		Eric Yard	2000	54	689113	8493985	142.74810	-13.61670
Strathgordon	13/08/2003	J.W.Winter, A.B.Freeman	Camp	Base camp, Edward River	1925	54	637131	8376517	142.27359	-14.68148
Strathgordon	14/08/2003	J.W.Winter, A.B.Freeman	66	Junction of Access & River roads	2247	54	639802	8375052	142.29847	-14.69459
Strathgordon	17/08/2003	J.W.Winter, A.B.Freeman	66	Junction of Access & River roads	2300	54	639802	8375052	142.29847	-14.69459
Coen, North	18/10/1993	J.W.Winter, H.V.Myles, P.Lethbridge		Coen River bridge	2020	54	737667	8458276	143.19971	-13.93579
Coen, North	9/09/1996	J.W.Winter, H.V.Myles		Coen River bridge	2015	54	737667	8458276	143.19971	-13.93579
Coen, North	29/06/1997	J.W.Winter, H.V.Myles		Coen River bridge	1955	54	737667	8458276	143.19971	-13.93579
Coen, North	25/07/2002	J.W.Winter, H.V.Myles, P.Latch, B.Thompson		Coen River bridge	2010	54	737667	8458276	143.19971	-13.93579
Coen, North	15/11/2002	J.W.Winter, M.Lincoln		Coen River bridge	2006	54	737667	8458276	143.19971	-13.93579
Coen, North	2/09/2003	J.W.Winter, C.Edwards	26	Coen River bridge	2025	54	737667	8458276	143.19971	-13.93579
Coen, North	3/09/2003	J.W.Winter, C.Edwards	32	Grid on main road, 5.8 km E of bridge	2145	54	735373	8462895	143.17810	-13.89425
Coen, North	4/09/2003	J.W.Winter, C.Edwards		Coen River bridge	1938	54	737667	8458276	143.19971	-13.93579
Coen, North	8/11/2005	J.W.Winter, A.B.Freeman, H.V.Myles		Coen River bridge	2035	54	737667	8458276	143.19971	-13.93579
Coen, North	2/09/2003	J.W.Winter, C.Edwards	32	Grid on main road, 5.8 km E of bridge	2137	54	735373	8462895	143.17810	-13.89425
Coen, North	25/07/2002	J.W.Winter, H.V.Myles, P.Latch, B.Thompson		Grid on main road, 5.8 km E of bridge	2107	54	735373	8462895	143.17810	-13.89425
Coen, North	29/06/1997	J.W.Winter, H.V.Myles		Grid on main road, 5.8 km E of bridge	2127	54	735373	8462895	143.17810	-13.89425
Coen, South	5/09/2003	J.W.Winter, C.Edwards	143	Peninsula Development Rd, 30.0 km S of Oscar Cr Xing	2205	54	744835	8431823	143.26838	-14.17418
Coen, South	5/09/2003	J.W.Winter, C.Edwards	147	Peninsula Development Rd, 20.0 km S of Oscar Cr Xing	2250	54	739211	8438635	143.21570	-14.11312
Coen, South	18/10/1996	J.W.Winter, H.V.Myles		Peninsula Development Rd, Oscar Creek crossing	2200	54	737428	8455996	143.19770	-13.95641
Coen, South	18/10/1996	J.W.Winter, H.V.Myles		Peninsula Development Rd, 5.0 km S of Oscar Cr Xing	2240	54	736258	8452053	143.18722	-13.99213
Coen, South	2/09/2003	J.W.Winter, C.Edwards	37	Peninsula Development Rd, Oscar Cr Xing	2234	54	737428	8455996	143.19770	-13.95641
Coen, South	2/09/2003	J.W.Winter, C.Edwards	49	Peninsula Development Rd, 5.0 km S of Oscar Cr Xing	2400	54	736258	8452053	143.18722	-13.99213
Coen, South (old road)	18/10/1996	J.W.Winter, H.V.Myles		Power line crossing of old road	2010	54	737820	8456881	143.20126	-13.94838
Coen, South (old road)	18/10/1996	J.W.Winter, H.V.Myles		5.0 km S of powerline crossing	2100	54	740970	8453762	143.23067	-13.97629
Coen River Road	4/09/2003	J.W.Winter, C.Edwards	76	Road junction 2.8 km E of Emily Yard	2221	54	733619	8457077	143.16237	-13.94696
Coen River Road	4/09/2003	J.W.Winter, C.Edwards	120	Coen River road 5.0 km W of road junction	2352	54	729943	8459720	143.12815	-13.92338
Coen River Road	3/09/2003	J.W.Winter, C.Edwards	76	Turn-off from main road N of Coen River bridge	2240	54	737526	8458411	143.19840	-13.93458
Coen River Road	3/09/2003	J.W.Winter, C.Edwards	91	Road junction 2.8 km E of Emily Yard	0021	54	733619	8457077	143.16237	-13.94696
Coen, Wire Yard	3/09/2003	J.W.Winter, C.Edwards	61	Wire Yard, Coen River	1942	54	739044	8463855	143.21198	-13.88527
Port Stewart Road	5/09/2003	J.W.Winter, C.Edwards	136	2.4 km N of Stewart River crossing	2028	54	746240	8438444	143.28080	-14.11424
Vrilya Point	14/09/2002	J.W.Winter, A.B.Freeman, H.V.Myles		Camp, S side of lower creek crossing via upper crossing	2142	54	622947	8757647	142.12628	-11.23639
Vrilya Point	14/09/2002	J.W.Winter, A.B.Freeman		5.0 km along exit road from start	2237	54	624704	8759850	142.14229	-11.21641
Vrilya Point	2/10/2003	J.W.Winter, A.B.Freeman	29	S side of lower creek crossing via upper crossing	1924	54	622947	8757647	142.12628	-11.23639

WP	End of Transect Section							Minutes spent spotlighting*	Distance (km)	Mammals Seen	
	Description	Time	Zone	AMG		Decimal Degrees				*T. vulpecula*	Other
				Easting	Northing	Longitude	Latitude				
157	10.0 km W of Eric Yard	2048	54	681059	8494566	142.67363	-13.61196	31	5.0	1	None
162	14.25 km W of Eric Yard, Ranger Station top gate	2117	54	680543	8490501	142.66912	-13.64873	29	4.3	2	None
181	5.0 km E of Eric Yard	2018	54	693509	8494706	142.78867	-13.60989	56	5.0	10	1 *F.catus*
185	10.0 km E of Eric Yard (0.5 km E of Culliban Cr)	2051	54	696615	8490979	142.81762	-13.64337	33	5.0	0	1 *F.catus*
191	25.0 km E of Eric Yard	2145	54	707322	8483205	142.91713	-13.71288	30	5.0	0	None
21	5.0 km E of Eric Yard	2138	54	693677	8494624	142.79022	-13.61062	80	5.0	12	1 Dingo
29	5.0 km W of Eric Yard	2136	54	685043	8495447	142.71039	-13.60374	62	5.0	6	None
32	10.0 km W of Eric Yard	2210	54	681056	8494514	142.67360	-13.61243	34	5.0	1	None
11	Eric Yard	2205	54	689111	8493983	142.74808	-13.61671	82	5.0	13	1 Dingo
62	5.0 km W of Eric Yard	2318	54	685056	8495467	142.71051	-13.60356	69	5.0	9	None
	5.0 km E of Eric Yard	?	54	693677	8494624	142.79022	-13.61062		5.0	10	?
	5.0 km W of Eric Yard	?	54	685023	8495406	142.71021	-13.60412		5.0	0	?
51	15.0 km E of camp on Edward River Road	2150	54	648467	8368310	142.37932	-14.75506	145	15.0	2	1 *P.norfolcensis*, 16 *M.agilis*, 5 Bos
85	5.0 km E of junction on Edward River Road	2353	54	643865	8372388	142.33634	-14.71845	66	5.0	1	1 *P.norfolcensis*, 3 *M.agilis*
85	5.0 km E of junction on Edward River Road	2353	54	643865	8372388	142.33634	-14.71845	53	5.0	5	1 *P.norfolcensis*, 1 *M.agilis*, 1 *F.catus*
	Grid on main road, 5.8 km E of bridge	2136	54	735373	8462895	143.17810	-13.89425	76	5.8	31	1 *P.breviceps*, 2 ? (possibly T.v.)
	Grid on main road, 5.8 km E of bridge	2126	54	735373	8462895	143.17810	-13.89425	71	5.8	20	1 *M.agilis*, 1 dingo
	Grid on main road, 5.8 km E of bridge	2127	54	735373	8462895	143.17810	-13.89425	92	5.8	25	2 *Petaurus sp*, 1 dingo
	Grid on main road, 5.8 km E of bridge	2107	54	735373	8462895	143.17810	-13.89425	57	5.8	5	1 *P.breviceps*, 1 *T.aculeatus*
	Grid on main road, 5.8 km E of bridge	2113	54	735373	8462895	143.17810	-13.89425	67	5.8	4	None
32	Grid on main road, 5.8 km E of bridge	2137	54	735373	8462895	143.17810	-13.89425	72	5.8	4	1 *D.trivirgata*
26	Coen River bridge	2233	54	737667	8458276	143.19971	-13.93579	48	5.8	2	None
	Grid on main road, 5.8 km E of bridge	2052	54	735373	8462895	143.17810	-13.89425	74	5.8	3	None
	Grid on main road, 5.8 km E of bridge	2130	54	735373	8462895	143.17810	-13.89425	55	5.8	2	None
36	10.0 km N of bridge	2214	54	734121	8466612	143.16621	-13.86076	37	4.2	0	None
	12.8 km N of bridge, at water tank on left	2130	54	733641	8468683	143.16160	-13.84209	23	7.0	1	(at 6.0 km)
	10.8 km No of bridge	2215	54	734107	8466642	143.16609	-13.86049	48	5.0	3	1 *Petaurus sp*, 2 *P.scapulatus*
146	Peninsula Development Rd, 25.0 km S of Oscar Cr Xing	2238	54	742105	8435182	143.24280	-14.14407	33	5.0	0	None
149	Peninsula Development Rd, 15.0 km S of Oscar Cr Xing	2321	54	738300	8443205	143.20687	-14.07191	31	5.0	0	None
	Peninsula Development Rd, 5.0 km S of Oscar Cr Xing	2240	54	736258	8452053	143.18722	-13.99213	40	5.0	8	1 *P.breviceps*, 1 *Petaurus sp*
	Peninsula Development Rd, 7.4 km S of Oscar Cr Xing	2320		736866	8449731	143.19304	-14.01307	40	2.4	9	2 *P.breviceps*
	Peninsula Development Rd, 5.0 km S of Oscar Cr Xing	2400	54	736258	8452053	143.18722	-13.99213	86	5.0	9	1 *P.peregrinus*, 1 *P.breviceps*
60	Peninsula Development Rd, 10.0 km S of Oscar Cr Xing	0128	54	737472	8447729	143.19882	-14.03110	88	5.0	4	3 *P.peregrinus*, 2 *P.brevicips*
	5.0 km S of powerline crossing	2100	54	740970	8453762	143.23067	-13.97629	50	5.0	0	2 *P.breviceps*, 2 *M.agilis*
	Power line crossing of old road	2150	54	737820	8456881	143.20126	-13.94838	50	5.0	2	None
120	Coen River road 5.0 km W of road junction	2352	54	729943	8459720	143.12815	-13.92338	91	5.0	9	1 *P.breviceps*
122	Coen River road 10.0 km W of road junction	0042	54	727029	8462623	143.10095	-13.89738	50	5.0	0	1 *S.scrofa*
91	Road junction 2.8 km E of Emily Yard	0021	54	733619	8457077	143.16237	-13.94696	101	5.0	10	1 *M.gouldii*, 1 *D.trivirgata*
94	Emily Yard	0050	54	731479	8455704	143.14269	-13.95954	29	2.8	3	None
74	Coen township, Telstra tower	2127	54	738060	8457971	143.20338	-13.93851	105	7.4	0	None
141	2.6 km S of Stewart River crossing	2138	54	743769	8435139	143.25821	-14.14431	70	5.0	1	1 *M.agilis*
	5.0 km along exit road from start (Red Point turn-off)	2237	54	624704	8759850	142.14229	-11.21641	55	5.0	0	1 *P.breviceps*
58	Red Point (Welcome sign at swale)	2302	54	623829	8759735	142.13428	-11.21748	25	2.1	0	None
33	5.0 km along exit road from start	2020	54	624704	8759850	142.14229	-11.21641	56	5.0	0	1 *P.breviceps*

Appendix 1 continued. NB. Table reads across page spread.

Locality	Date	Observers	WP	Start of Transect Section						
				Description	Time	Zone	AMG		Decimal Degrees	
							Easting	Northing	Longitude	Latitude
Injinoo	12/09/2002	J.W.Winter, H.V.Myles, M Lifu	M1	Outskirts of Injinoo, via Muttee Head rd & pipeline	1950	54	646552	8792856	142.34103	-10.91715
Injinoo	12/09/2002	J.W.Winter, H.V.Myles, M Lifu								
Jardine (Bridge Creek)	2/10/2002	J.W.Winter, H.V.Myles		Bridge Creek crossing	1922	54	650295	8760738	142.37662	-11.20740
Jardine (Bridge Creek)	2/10/2002	J.W.Winter, H.V.Myles		Junction of Telegraph and Bypass access roads	2028	54	649812	8762320	142.37213	-11.19311
Jardine (Bridge Creek)	3/10/2002	J.W.Winter, H.V.Myles	133	Telegraph Road, 0.6 km S of Bridge Creek crossing	2149	54	650507	8760126	142.37859	-11.21291
Jardine (Bridge Creek)	4/10/2002	J.W.Winter, H.V.Myles	143	Telegraph Road, 0.6 km S of Bridge Creek crossing	2107	54	650507	8760126	142.37859	-11.21291
Jardine (Bridge Creek)	4/10/2002	J.W.Winter, H.V.Myles		Telegraph Road, creek 5.6 km S of Bridge Creek	2208	54	651961	8755646	142.39210	-11.25336
Jardine (Bridge Creek)	4/10/2002	J.W.Winter, H.V.Myles		Junction of Telegraph and Bypass access roads	2302	54	649812	8762320	142.37213	-11.19311
Jardine (Bridge Creek)	4/10/2002	J.W.Winter, H.V.Myles		4.0 km N of Bridge Cr (swamp edge)	2327	54	649215	8764088	142.36659	-11.17715
Eliot Falls	5/10/2002	J.W.Winter, H.V.Myles	149	Eliot Falls camping ground, S along Telegraph Rd	2030	54	654262	8740757	142.41383	-11.38788
Eliot Falls	6/10/2002	J.W.Winter, H.V.Myles		Telegraph Road, Scrubby Creek crossing	2118	54	654491	8734306	142.41622	-11.44618
Mapoon	8/12/2004	J.W.Winter, A.B.Freeman, K.Hegmann	23	New Road/old road intersection, NW of Batavia Out.Land.	1935	54	597081	8660324	141.89216	-12.11724
Mapoon	8/12/2004	J.W.Winter, A.B.Freeman, K.Hegmann	28	5.0 km along old rd to Batavia Outstation Landing	2012	54	598607	8655785	141.90632	-12.15824
Mapoon	9/12/2004	J.W.Winter, A.B.Freeman, K.Hegmann	34	Big Swamp Rd turn-off from Cullen Point Road	2015	54	596816	8672734	141.88936	-12.00503
Mapoon	12/12/2004	J.W.Winter, A.B.Freeman	MP5	Orchard Road	2134	54	598021	8670415	141.90049	-12.02596
York Downs	19/06/2004	J.W.Winter, A.B.Freeman	26	Myall Creek crossing	1934	54	642207	8589926	142.30998	-12.75204
York Downs	19/06/2004	J.W.Winter, A.B.Freeman	34	Road junction	2026	54	642855	8590266	142.31593	-12.74894
York Downs	19/06/2004	J.W.Winter, A.B.Freeman	37	Myall Cr road, 5.0 km S of road junction,	2100	54	645161	8586640	142.33734	-12.78161
York Downs	20/06/2004	J.W.Winter, A.B.Freeman	52	Road junction	2047	54	631257	8593460	142.20898	-12.72057
York Downs	20/06/2004	J.W.Winter, A.B.Freeman	52	Road junction	2151	54	631257	8593460	142.20898	-12.72057
York Downs	22/06/2004	J.W.Winter, A.B.Freeman	61	5.0 km W of Myall Creek crossing	2056	54	637720	8590866	142.26861	-12.74375
York Downs	23/06/2004	J.W.Winter, A.B.Freeman	72	Myall Cr road, 5.0 km S of road junction,	2153	54	645121	8586665	142.33697	-12.78139

WP	End of Transect Section							Minutes spent spotlighting*	Distance (km)	Mammals Seen	
	Description	Time	Zone	AMG		Decimal Degrees				*T. vulpecula*	Other
				Easting	Northing	Longitude	Latitude				
M4	Down Muttee Road to Burnbridge track		54	645667	8786885	142.33317	-10.97117				
M2	Back along pipeline to Injinoo Rd	2122	54	649326	8790242	142.36652	-10.94067	92	17.3	0	1 *Isoodon sp*
119	4.0 km N of Bridge Cr (swamp edge)	2005	54	649215	8764088	142.36659	-11.17715	43	4.0	0	None
	Junction with Bypass Road	2228	54	643486	8755255	142.31449	-11.25725	105	11.1	0	None
137	Telegraph Road, 9.8 km S of Bridge Creek	2324	54	652852	8751915	142.40043	-11.28705	95	9.2	0	1 *F.catus*
136	Telegraph Road, creek 5.6 km S of Bridge Creek	2151	54	651961	8755646	142.39210	-11.25336	44	5.0	0	None
	Telegraph Road, 0.6 km S of Bridge Creek crossing	2247	54	649215	8764088	142.36659	-11.17715	39	5.0	0	None
	4.0 km N of Bridge Cr (swamp edge)	2327	54	649215	8764088	142.36659	-11.17715	25	2.4	0	None
	Junction of Telegraph and Bypass access roads	2347	54	649812	8762320	142.37213	-11.19311	20	2.4	0	None
152	Telegraph Rd, 4.6 km S of Eliot Falls turn-off	2130	54	654235	8735570	142.41382	-11.43477	60	6.4	0	1 *P.breviceps*
159	Bypass Road, 9.9 km N of Telegraph Rd junction	2258	54	649436	8738255	142.36972	-11.41071	90	10.9	0	None
28	5.0 km along old rd to Batavia Outstation Landing	2012	54	598607	8655785	141.90632	-12.15824	37	5.0	1	None
32	Old road/new rd intersection 1.8 km S of Bat.Out.Landing	2058	54	596448	8652059	141.88659	-12.19199	31	4.4	0	1 *P.breviceps*
41	Edge of Big Swamp	2154	54	594583	8674542	141.86879	-11.98875	40	3.3	0	None
62	Mining survey road	2226	54	595006	8668211	141.87286	-12.04598	31	5.0	0	1 *P.breviceps*, 1 dingo
32	5.0 km east of Myall Creek	2011	54	646901	8590769	142.35317	-12.74420	37	5.0	1	2 *B.taurus*, 1 *E.caballus*
37	Myall Cr road, 5.0 km S of road junction,	2057	54	645161	8586640	142.33734	-12.78161	36	5.0	0	4 *M.antilopinus*
42	Myall Cr road, 10.0 km S of road junction,	2143	54	647823	8582409	142.36206	-12.81974	43	5.0	4	5 *B.taurus*
55	Old road, escarpment	2133	54	627844	8591454	142.17762	-12.73885	46	4.3	2	None
56	0.7 km NE of road junction	2200	54	630965	8594078	142.20626	-12.71499	9	0.7	0	None
62	10.0 km W of Myall Creek crossing	2123	54	633033	8592425	142.22538	-12.72986	27	5.0	0	None
78	Myall Cr road, 10.0 km S of road junction,	2228	54	647791	8582462	142.36177	-12.81926	35	5.0	4	1 *M.agilis*
TOTAL								6535	234.8	300	

Appendix 2
Large Wire Cage Trapping and Spotlighting at the Savanna CRC Sampling Quadrats

At each site, four traps set for three nights and fifteen minutes' spotlighting on three nights.

Locality	Site	Description	Zone No.	Easting	Northing	Longitude	Latitude	Date started	Trap nights	Mammals captured		Spotlight mins	Mammal sightings	
										T. vulpecula	**Other**		***T. vulpecula***	**Other**
York Downs	YD1	0.4 km by road E of Myall Creek; tall mixed woodland	54	642502	8590116	142.31269	-12.75031	21/06/2004	12	0	0	45	0	1 *Petaurus sp*, 1 *Isoodon sp*
York Downs	YD2	Myall Creek, W bank S of road crossing; riparian woodland	54	642240	8589819	142.31029	-12.75301	21/06/2004	12	0	0	45	0	0
York Downs	YD3	0.6 km by road W of Myall Creek; open grassy woodland	54	641590	8589889	142.30430	-12.75240	21/06/2004	12	0	0	45	0	0
York Downs	YD4	11.2 km by road W of Myall Creek, base of jump-up; grassy eucalypt woodland	54	631844	8592768	142.21441	-12.72680	21/06/2004	12	2	0	45	2	0
York Downs	YD5	11.8 km by road W of Myall Creek, on jump-up; shrubby eucalypt woodland	54	631486	8593252	142.21109	-12.72244	21/06/2004	12	1	1 *M.gouldii*	45	0	1 macropod
York Downs	YD6	12.4 km by road W of Myall Creek, on plateau; tall messmate woodland	54	631060	8593613	142.20716	-12.71920	21/06/2004	12	3	0	45	1	0
Mapoon	MP1	Big Swamp, 5.6 km SW of Cullen Point; open grassland with scattered trees	54	594527	8674652	141.86827	-11.98775	9/12/2004	12	0	0	45	0	4 *E.caballus*
Mapoon	MP2	Big Swamp access road, 5.7 km SW of Cullen Point; tall paperbark woodland on edge of swamp	54	594755	8674244	141.87038	-11.99143	9/12/2004	12	0	0	45	0	1 *E.caballus*
Mapoon	MP3	Big Swamp access road, 5.5 km SW of Cullen Point; mixed woodland 1.4 km E of Big Swamp edge	54	595591	8673687	141.87807	-11.99644	9/12/2004	12	0	0	45	0	1 *I.macrourus*
Mapoon	MP4	Outer beach 1.9 km W of Cullen Point; dune & swale mosaic of tall paperbark woodland and vine forest	54	597057	8678371	141.89140	-11.95405	9/12/2004	12	0	0	45	0	
Mapoon	MP5	1.2 km SW Red Beach Point, c.0.5 km along orchard road from Red Beach township;tall messmate woodland	54	598021	8670415	141.90049	-12.02596	9/12/2004	12	0	0	45	0	2 *I. macrourus*
Mapoon	MP6	3.3 km WSW Red Beach Point, c.2.7 km along orchard road from Red Beach township; tall messmate woodland	54	595727	8670330	141.87942	-12.02679	9/12/2004	12	0	0	45	0	3 *P.breviceps*, 1 *E.caballus*
Strathgordon, Melon Yard	ST1	Edward River, S bank, c.2.5 km downstream of Melon Yard; dune & swale riparian mixed woodland	54	637211	8376473	142.27434	-14.68187	15/08/2003	12	0	0	45	1	1 *M.agilis*
Strathgordon, Melon Yard	ST2	Edward River, S bank, c.0.65 km downstream of Melon Yard; grassy eucalypt woodland	54	638810	8375613	142.28923	-14.68957	15/08/2003	12	1	0	45	1	0
Strathgordon, Melon Yard	ST3	Access road, 3.0 km direct line SSE of Melon Yard; low grassy paperbark woodland	54	640262	8372550	142.30288	-14.71717	15/08/2003	12	0	0	45	0	0
Strathgordon, Melon Yard	ST4	Access road, 3.75 km direct line SSE of Melon Yard; grassy eucalypt woodland	54	640483	8371862	142.30497	-14.72338	15/08/2003	12	0	0	45	2	0
Strathgordon, Melon Yard	ST5	Access road, 5.3 km direct line SSE of Melon Yard; grassy eucalypt woodland	54	640810	8370297	142.30809	-14.73751	15/08/2003	12	0	0	45	0	0
Strathgordon, Melon Yard	ST6	Razor Grass Swamp, 5.6 km direct line S of Melon Yard; ecotone between grassy swamp & tall eucalypt woodland	54	639100	8369908	142.29222	-14.74112	15/08/2003	12	0	0	45	0	0
Vrilya Point, south	VP1	Beach 1.85 km SSE Vrilya Point; closed forest thickets on beach	54	622653	8757253	142.12360	-11.23996	4/10/2003	12	0	1 *U.caudimaculatus*	45	0	
Vrilya Point, south	VP2	Hind dunes, 2.0 km SSE Vrilya Point; mixed dune woodland	54	622772	8757150	142.12469	-11.24089	4/10/2003	12	0	1 *U.caudimaculatus*	45	0	1 *U.caudimaculatus*
Vrilya Point, south	VP3	"Wongai Scrub", vine forest patch, 2.2 km SSE Vrilya Point; tall vine forest on sand	54	622713	8756876	142.12416	-11.24337	4/10/2003	12	0	5 *U.caudimaculatus*, 1 *R.leucopus*	45	0	1 *S.maculatus*, 2 *U.caudimaculatus*

Locality	Site	Description	Zone No.	Easting	Northing	Longitude	Latitude	Date started	Trap nights	Mammals captured		Spotlight mins	Mammal sightings	
										T. vulpecula	Other		*T. vulpecula*	Other
Vrilya Point, south	VP4	Inland from beach, 1.9 km SE Vrilya Point; tall eucalypt woodland	54	622956	8757348	142.12637	-11.23910	4/10/2003	12	0	0	45	0	1 *U.caudimaculatus*
Vrilya Point, south	VP5	Southern bank of creek, 1.45 km SE Vrilya Point; narrow brackish riparian strip & grassy woodland on metasediments	54	622786	8757782	142.12480	-11.23517	4/10/2003	12	0	2 *U.caudimaculatus*	45	0	
Vrilya Point, south	VP6	North of creek, 1.65 km SE Vrilya Point; tall messmate woodland on laterite	54	622986	8757750	142.12663	-11.23546	4/10/2003	12	0	1 *U.caudimaculatus*	45	0	1 *P.breviceps*
Atambaya, Cockatoo Creek	AT1	Telegraph Road, 1.3 km SSE of telegraph line crossing of Cockatoo Creek; grassy eucalypt woodland on metasediment	54	659576	8710341	142.46395	-11.66262	10/10/2003	12	0	0	45	0	1 *P.breviceps*
Atambaya, Cockatoo Creek	AT2	Telegraph Road, 0.6 km S of telegraph line crossing of Cockatoo Creek; grassy eucalypt woodland on alluvium	54	659283	8710912	142.46123	-11.65746	10/10/2003	12	0	0	45	0	0
Atambaya, Cockatoo Creek	AT3	Telegraph Road, 0.25 km WSW of telegraph line crossing of Cockatoo Creek, south bank; mixed riparian forest	54	658987	8711456	142.45850	-11.65256	10/10/2003	12	0	0	45	0	0
Atambaya, Cockatoo Creek	AT4	Atambaya, 0.2 km N of telegraph line crossing of Cockatoo Creek; market garden	54	659148	8711680	142.45996	-11.65053	10/10/2003	12	0	3 *I.macrourus*	45	0	1 *P.scapulatus*
Atambaya, Cockatoo Creek	AT5	Telegraph Road, 0.4 km of telegraph line crossing of Cockatoo Creek; vine forest patch on metasediment	54	659239	8711949	142.46079	-11.64810	10/10/2003	12	0	0	45	0	0
Atambaya, Cockatoo Creek	AT6	Telegraph Road, 0.75 km of telegraph line crossing of Cockatoo Creek; shrubby tall eucalypt woodland on metasediment	54	659130	8712299	142.45977	-11.64493	10/10/2003	12	0	1 *I.macrourus*	45	0	1 macropod
Rokeby, Culliban Creek	CUL1	Rokeby Road, Eric Yard, 5.9 km WNW Ironbark Dam; grassy tall messmate forest on sand	54	689036	8493936	142.74738	-13.61715	15/06/2003	12	0	1 *I.macrourus*	45	0	1 macropod
Rokeby, Culliban Creek	CUL2	Rokeby Road, 4.5 km NNW Ironbark Dam; poplar gum woodland in grassy depression	54	690543	8494369	142.76128	-13.61313	15/06/2003	12	0	0	45	5	
Rokeby, Culliban Creek	CUL3	Rokeby Road, 2.0 km NW Ironbark Dam; grassy eucalypt woodland	54	693645	8494582	142.78993	-13.61101	15/06/2003	12	0		45	0	1 *Petaurus sp.*
Rokeby, Culliban Creek	CUL4	Rokeby Road, 0.3 km E Ironbark Dam; mixed paperbark and eucalypt woodland in linear drainage depression	54	695136	8492892	142.80382	-13.62618	15/06/2003	12	0	0	45	0	
Rokeby, Culliban Creek	CUL5	Rokeby Road, Culliban Creek, 2.2 km SE Ironbark Dam; grassy eucalypt woodland on high south bank of creek	54	696476	8491476	142.81630	-13.63889	15/06/2003	12	0	0	45	0	
Rokeby, Culliban Creek	CUL6	Cabbage Tree Creek, 4.8 km SE Ironbark Dam; sedge messmate woodland with quinine bush	54	698038	8489400	142.83088	-13.65754	15/06/2003	12	0	0	45	0	1 *F.catus*
Silver Plains, Massy Creek	MAS1	S side of swamp, 2.4 km SSW Massy Creek lower crossing, low paperbark woodland on swamp edge	54	776147	8457783	143.55568	-13.93676	20/06/2002	12	0	0	45	0	0
Silver Plains, Massy Creek	MAS2	1.9 km SSW Massy Creek lower crossing, grassy eucalypt woodland on alluvium	54	776146	8458317	143.55562	-13.93194	20/06/2002	12	0	1 *M.burtoni*	45	0	0
Silver Plains, Massy Creek	MAS3	Massy Creek, 0.25 km SW Massy Creek lower crossing; mewophyll vine forest on flood prone bank grading into shrubby woodland	54	776294	8459981	143.55682	-13.91689	20/06/2002	12	0	1 *U.caudimaculatus*, 1 *R.leucopus*	45	0	2 *S.maculatus*
Silver Plains, Massy Creek	MAS4	Coast road, 0.7 km NNE Massy Creek lower crossing; grassy eucalypt woodland	54	776733	8460786	143.56081	-13.90959	20/06/2002	12	0	0	45	0	1 *P.breviceps*
Silver Plains, Massy Creek	MAS5	Coast road, 3.3 km NE Massy Creek lower crossing; grassy open woodland + vineforest thicket	54	778777	8462555	143.57953	-13.89340	20/06/2002	12	0	0	45	0	
Silver Plains, Massy Creek	MAS6	Coast road, 4.2 km NE Massy Creek lower crossing, vine forest thickets on hind dune	54	779889	8462591	143.58980	-13.89297	20/06/2002	12	0	0	45	0	
Total									**504**	**7**	**0**	**1890**	**12**	

Appendix 3: Transects Spotlighted on Foot

*Minutes spotlighting takes into account significant stoppages, and excludes time spotlighted at Sites at Vrilya Point (see Appendix 2).

Locality	Date	Route	Time			Distance (m)	Mammals observed		Observers	ID	Starting Point (WGS84)		
			Start	Finish	Min*		*T.vulpecula*	Other			Zone	Easting	Northing
Bramwell	7/10/2002	Along creek line behind homestead	20.15	20.45	30		0	None	J.W.Winter, H.V.Myles	Homestead	54	676558	8657232
11 Mile Scrub	13/10/2003	Along SE edge and in vine forest	19.2	20.30	75		0	1 *S.maculatus*, 1 *T.stigmatica*, 3 *M.agilis*	J.W.Winter, A.B.Freeman		54	673425	8639537
Vrilya Point	13/09/2002	From camp to NE corner of 'Wongai Scrub', along inland edge to SE corner of scrub, circitous route via WP49, WP50 to top crossing of creek WP51, down creek to camp	19.30	21.37	127	1900	0	1 *U.caudimaculatus*	J.W.Winter, H.V.Myles	Camp	54	622947	8757647
										WP49	54	623097	8757173
										WP50	54	623145	8757188
										WP51	54	623117	8757387
Vrilya Point	14/09/2002	From camp to NW corner of 'Wongai Scrub' and return	19.18	20.57	99	1200			J.W.Winter, A.B.Freeman, H.V.Myles	Camp	54	622947	8757647
Vrilya Point	15/09/2002	From N end of 'Wongai Scrub', to SW corner WP60, then on bearing 50° to creek at WP61, north along creek to camp.	19.19	21.15	116	1400	0	None	J.W.Winter, A.B.Freeman, H.V.Myles	WP59	54	622694	8756970
										WP60	54	622804	8756832
										WP61	54	623279	8757091
Vrilya Point	3/10/2003	From camp to Sites 5, 1, 4 and back to camp via top crossing of creek	19.40	21.39	74	1400	0	1 *U.caudimaculatus*	J.W.Winter, A.B.Freeman	Camp	54	622947	8757647
Vrilya Point	4/10/2003	From camp to sites 4, 2, 3, 1, 5, 6 finished back at camp	19.35	22.58	113	2100	0	None	J.W.Winter, A.B.Freeman	Camp	54	622947	8757647
Vrilya Point	5/10/2003	From camp to Sites 6, 5, 4, 1, 3, 2 and back to camp.	20.06	23.04	90	2300	0	None	J.W.Winter, A.B.Freeman	Camp	54	622947	8757647
Vrilya Point	6/10/2003	From camp to Sites 3, 2, 6 and back to camp	20.12	22.07	70	1800	0	None	J.W.Winter, A.B.Freeman	Camp	54	622947	8757647
Embley Range	16/11/2002	From sleeper cutters camp on bearing 132° to WP57, then 210° to fence, 310° along fence to WP48 and back on 290° to camp	19.40	22.40	180	3100	6	1 *P.peregrinus*, 1 *P.breviceps*	J.W.Winter, H.V.Myles	WP43	54	674667	8593797
										WP57	54	674980	8593401
										WP48	54	674133	8593122
Embley Range	17/11/2002	From sleeper cutters camp on bearing 352° to edge of break-away, north along upper slopes of break-away to WP76, then compass bearing directly back to camp	19.35	22.17	130	2300	4	4 *M. agilis*, 1 *M. antilopinus*, 2 *S. scrofa*	J.W.Winter, H.V.Myles	WP43	54	674667	8593797
										WP76	54	673952	8594064
Bridge Creek	3/10/2002	From junction of Telegraph and Bypass Access roads, north along Telegraph Road to woodland edge at WP119 and return	19.35	20.58	80	3000	0	1 *P.scapulatus*	J.W.Winter, H.V.Myles		54	649812	8762320
										WP119	54	649215	8764088

Locality	Date	Route	Time			Distance (m)	Mammals observed		Observers	ID	Starting Point (WGS84)		
			Start	Finish	Min*		*T.vulpecula*	Other			Zone	Easting	Northing
Bridge Creek	4/10/2002	Parallel to and 50 m W of Telegraph Road from WP142 to WP141	19.10	20.10	60	810	0	1 *Petaurus sp*	J.W.Winter, H.V.Myles	WP142	54	649699	8762452
										WP141	54	649400	8763202
Eliot Falls	5/10/2002	Circuit of camp ground to Falls	19.10	20.12	62		0	None	J.W.Winter, H.V.Myles	WP149	54	654262	8740757
Eliot Falls	5/10/2002	Short circuit of camp ground	22.05	22.20	15		0	None	J.W.Winter, H.V.Myles	WP149	54	654262	8740757
Eliot Falls	6/10/2002	Circuit of camp ground to Falls	19.34	20.28	54		0	None	J.W.Winter, H.V.Myles	WP149	54	654262	8740757