Conservation status of New Caledonia palms

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An assessment of the conservation status of the palm species occuring in New Caledonia is provided, based on the new IUCN Red List categories. To determine the conservation status of each species, their extent of occurrence was determined using locality data on herbarium collections. Area of occupancy, number of adults, regeneration, and threats were evaluated on 62 localities throughout the Territory, including all types of palm habitats and all localities of species occurring at less than five sites. Among the 37 palm species known in New Caledonia, all are endemic and 13 are in a threatened category, including four critically endangered, one endangered, and eight vulnerable. Only four of the threatened species are represented in a reserve. Six species are listed as LRcd since they are adequately protected in a reserve despite an acute restriction of their range. Recommendations are given to improve the network of protected areas to include more threatened species.

Key words: New Caledonia, Palms, Reserves, Conservation.

INTRODUCTION

THE New Caledonia palm flora is remarkable for its diversity and uniqueness (Guillaumin 1961; Thorne 1965; Good 1974; Schmid 1981; MacKee *et al.* 1985). This palm flora consists of 16 genera, 15 of which are endemic, and 37 species, all endemic (Moore and Uhl 1984; Pintaud and Hodel 1998a,b). New Caledonia has the highest number of endemic genera of palms, and especially monotypic genera, in the world (Johnson 1996). Most New Caledonia palms are noteworthy for their limited distribution: twelve species are known from a single locality and 22 occur in only one phytogeographical sector as defined by Jaffré and Veillon (1989). Moreover, nearly all species are confined to primary forest ecosystems and are consequently very sensitive to habitat disturbance.

Jaffré and Veillon (1989) provided an account of the degree of rarity of New Caledonia palms, and Jaffré *et al.* (1998) gave a preliminary assessment of their conservation status in a checklist of the threatened endemic New Caledonia plant species. Also, five species of New Caledonia palms are listed in the most threatened categories, and most of the others are listed as rare in the WCMC database (Johnson 1996). All these previous data are in great need of re-evaluation due to recent and extensive field study of the New Caledonia palms. Pintaud and Hodel (1998a,b) assessed the conservation status of the four species of *Kentiopsis* and three species of *Burretiokentia*. Here, a comprehensive study of the conservation status of the New Caledonia palms is provided, and is an addition to the efforts made in recent years to asses the *in situ* conservation status of palms in the South-West Pacific (Dowe and Cabalion 1996; Dowe *et al.* 1997; Fuller *et al.* 1997).

MATERIALS AND METHODS

Information about the distribution of species was collected from nearly all herbarium collections of New Caledonia palms. Moore and Uhl (1984) listed nearly 600 collections and we made almost 300 additional ones since 1980, especially during a two-year extensive survey (1995–96). Also, a survey of palm communities, including all species, was made in 62 localities throughout the Territory from sea level to the highest summits (over 1 600 m). There were 28 localities in southern New Caledonia, 16 in the centre, 17 in the north and one on Lifou Island. There were 42 localities below 800 m elevation and 20 above. Thirty-five localities were on ultramafic rocks and 25 on schists, with one each on limestone and basalt. There were 18 localities included in botanical reserves, while the others were outside reserves. In each locality, the following information was recorded: elevation, substrate, vegetation type, threats on habitat and protection status. For each palm species, density, regeneration, microhabitat preferences, and specific threats were evaluated. A special effort was made during the course of this field work to evaluate the area of occupancy of species having a limited occurrence. All localities of the species known from four or fewer sites were included in the survey and the extension and size of each population evaluated. The conservation status of each species was determined from these data according to the IUCN Red List Categories (1994).

RESULTS

Among the 37 species, 13 are threatened (Table 1). Of these, four species are critically endangered (CR), one is endangered (EN), and eight are vulnerable (VU). Also, six species adequately conserved in a reserve (which would be threatened otherwise) are included in the

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Table 1. Criteria for conservation status of the 19 palm species occuring in less than five localities in New Caledonia (13 threatened and 6 LRcd).

Species	No. of locations	Extent of occurrence	Area of occupancy (estimated)	No. of adults (estimated)	Natural regeneration	Status of habitat	Decline	Threats (past causes in brackets)	Category and criteria
Cyphophoenix nucele	1	1 km²	10 ha	*ca* 100	good	unprotected	yes	shifting cultivation	CR (B 1–2)
Kentiopsis pyriformis	2	70 km²	50 ha	*ca* 100	very low	unprotected	yes	fire, erosion (logging)	CR (B 1–2)
Lavoixia macrocarpa	1	0.1 km²	10 ha	30	very low	protected	yes (low)	seed(-lings) harvesting	CR (D)
Pritchardiopsis jeanneneyi	1	0.1 km²	0.5 ha	1	no (seeds harvested for propagation)	protected	yes	removal of juveniles (palm hearts extraction)	CR (D)
Kentiopsis oliviformis	4	700 km²	<1 000 ha	>1 000	very low	unprotected	yes	farming (palm logging)	EN (B 1–2)
Actinokentia huerlimannii	2	50 km²	<1 000 ha	?	very low	main loc. protected	no	(bush fires, logging)	VU[1] (D2)
Basselinia iterata	1	4 km²	400 ha	>1 000	low but sufficient	unprotected	no	bush fires	VU (D2)
Basselinia tomentosa	2	60 km²	<1 000 ha	>1 000	good	unprotected	no	bush fires	VU (D2)
Basselinia vestita	1	4 km²	400 ha	>1 000	low but sufficient	unprotected	no	bush fires (mining)	VU (D2)
Burretiokentia hapala	3	260 km²	<1 000 ha	>1 000	2 good, 1 very low	unprotected	yes	bush fires, grazing	VU (D2)
Burretiokentia koghiensis	1	4 km²	200 ha	>1 000	good	partly protected	yes (low)	localized clearance	VU (D2)
Cyphophoenix elegans	1	50 km²	<1 000 ha	>1 000	good	unprotected	yes (low)	bush fires, farming	VU (D2)
Kentiopsis magnifica	1	20 km²	<1 000 ha	>1 000	good	unprotected	no	bush fires	VU (D2)
Basselinia favieri	1	2 km²	200 ha	>1 000	good	protected	no	none	LRcd
Basselinia humboldtiana	4	2 600 km²	<1 000 ha	>1 000	good	1 protected	yes	mining in 1 location	LRcd
Basselinia porphyrea	2	100 km²	<1 000 ha	>1 000	low but sufficient	1 protected	no	bush fires (mining)	LRcd
Burretiokentia grandiflora	1	10 km²	<100 ha	?	good	protected	no	none	LRcd
Burretiokentia dumasii	1	<40 km²	<1 000 ha	>100	good	protected	no	none	LRcd
Kentiopsis piersoniorum	1	5 km²	500 ha	>1 000	good	protected	no	none	LRcd

[1]*Actinokentia huerlimannii* and *Burretiokentia koghiensis* are considered vulnerable rather than LRcd despite occuring partly in a reserve, the first because regeneration is low and population size probably small, and the second because the main population is outside the reserve and prone to habitat disturbance.

Table 2. Distribution and ecology of New Caledonia Palms. Sector: phytogeographical sector(s) of occurrence of the species: S: South; C: Centre; N-E: North-East; N-W: North-West. Subst.: geological substrate: B: basalt; L: limestone; S: schist; U: ultramafic rocks. Veg.: vegetation type: RF: rainforest; S-HF: semi-humid forest; M: maquis. No loc: number of localities of occurrence recorded; in brackets, number of localities included in reserves.

Classification of species according to their status	Sector	Elev. (m)	Subst.	Veg.	No. loc.
Critically endangered species					
Cyphophoenix nucele H. E. Moore	LIFOU	50	L	S-H F	1 (0)
Kentiopsis pyriformis Pintaud and Hodel	S	10–200	U	RF	2 (0)
Lavoixia macrocarpa H. E. Moore	N-E	500–550	S	RF	1 (1)
Pritchardiopsis jeanneneyi Becc.	S	250	U	RF	1 (1)
Endangered species					
Kentiopsis oliviformis (Brongn. and Gris) Brong.	C	10–300	S, B, U	S-H F	4 (0)
Vulnerable species					
Actinokentia huerlimannii H. E. Moore	S	850–880	U	RF, M	2 (1)
Basselinia iterata H. E. Moore	N-E	900–1 000	S	RF	1 (0)

Table 2 — *continued*

Classification of species according to their status	Sector	Elev. (m)	Subst.	Veg.	No. loc.
Vulnerable species — *continued*					
Basselinia tomentosa Becc.	C	900–1 100	S	RF	2 (0)
Basselinia vestita H. E. Moore	C	900–1 000	U	RF	1 (0)
Burretiokentia hapala H. E. Moore	N-W, N-E	20–500	S	RF	3 (0)
Burretiokentia koghiensis Pintaud and Hodel	S	450–550	U	RF	1 (1)
Cyphophoenix elegans (Brongn. and Gris) H. Wendl. ex Sal.	N-E	50–550	S	RF	1 (0)
Kentiopsis magnifica (H. E. Moore) Pintaud and Hodel	N-E	400–550	S	RF	1 (0)
LRcd species					
Basselinia favieri H. E. Moore	N-E	300–500	S	RF	1 (1)
Basselinia humboldtiana (Brongn.) H. E. Moore	S, C	800–1 000	U	RF	4 (1)
Basselinia porphyrea H. E. Moore	S	700–1 000	U	RF, M	2 (1)
Burretiokentia grandiflora Pintaud and Hodel	S	250–1 000	U	RF	1 (1)
Burretiokentia dumasii Pintaud and Hodel	C	600	U	RF	1 (1)
Kentiopsis piersoniorum Pintaud and Hodel	N-E	400–1 000	S	RF	1 (1)
LRlc species					
Actinokentia divaricata (Brongn.) Dammer	S, C	10–1 100	U	RF	>4 (1+)
Alloschmidia glabrata (Becc.) H. E. Moore	N-E	10–1 200	S	RF	>4 (1+)
Basselinia deplanchei (Brongn. and Gris) Vieil.	S, C	400–1 500	U	RF, M	>4 (1+)
Basselinia gracilis (Brongn. and Gris) Vieil.	S, C, N-E	10–1 600	S, U	RF	>4 (1+)
Basselinia pancheri (Brongn. and Gris) Vieil.	S, C, N-W	10–1 100	U	RF, M	>4 (1+)
Basselinia sordida H. E. Moore	S, C	900–1 500	U	RF	>4 (1+)
Basselinia velutina Becc.	S, C, N-E	400–1 600	S, U	RF	>4 (1+)
Brongniartikentia lanuginosa H. E. Moore	N-E	700–1 300	S	RF	>4 (1+)
Brongniartikentia vaginata (Brongn.) Becc.	S	10–1 000	U	RF, M	>4 (1+)
Burretiokentia vieillardii (Brongn. and Gris) Pichi-Sermoli	S, C, N-E	400–1 300	S, U	RF	>4 (1+)
Campecarpus fulcitus (Brongn.) H. Wendl. ex. Becc.	S	10–1 000	U	RF	>4 (1+)
Chambeyronia lepidota H. E. Moore	C, N-E	400–1 500	S	RF	>4 (1+)
Chambeyronia macrocarpa (Brongn.) Vieil. ex. Becc.	S, C, N-E	10–1 000	S, U	RF	>4 (1+)
Clinosperma bracteale (Brongn.) Becc.	S, C	10–1 100	S, U	RF	>4 (1+)
Cyphokentia macrostachya Brongn.	S, C	10–800	S, U	RF	>4 (1+)
Cyphosperma balansae (Brongn.) H. Wendl. ex Salomon	C, N-E	10–1 000	S, U	RF	>4 (1+)
Moratia cerifea H. E. Moore	C, N-E	10–600	S	RF	>4 (1+)
Veillonia alba H. E. Moore	N-E	10–600	S	RF	>4 (1+)

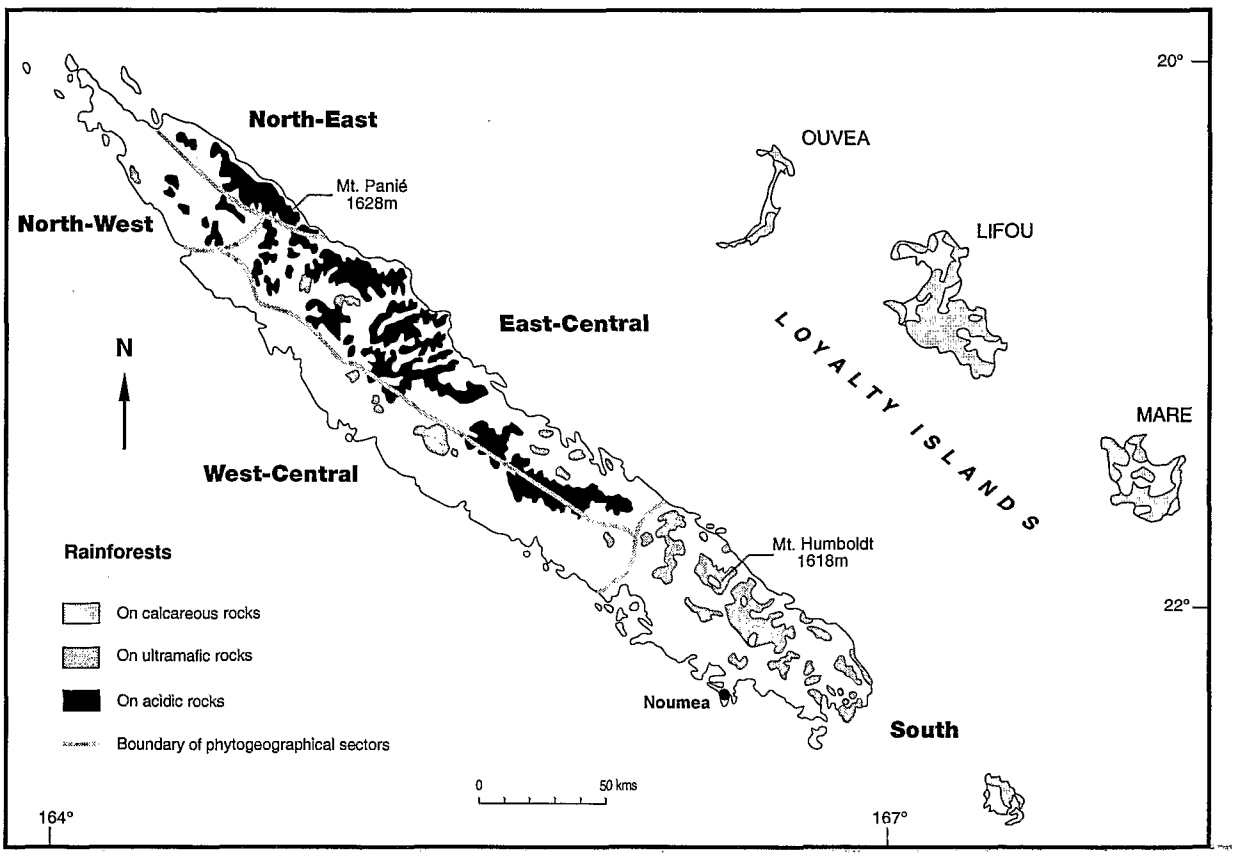

Fig. 1. Forests, substrates and phytogeographical units in New Caledonia.

conservation-dependant category (LRcd). The remaining 18 species are not threatened, more or less widespread, and occur in at least one reserve (lower risk, least concern category, LRlc). There are 29 species which occur in lowland to medium elevation forest (below 700 m). Of these, 13 are restricted to that vegetation type, and among them, nine are threatened, including the four critically endangered species. Montane rainforest has 23 species. Of these, eight are restricted to it, and among them, four are vulnerable. Two species occur in semi-humid forest; *Cyphophoenix nucele* is critically endangered and *Kentiopsis oliviformis* is endangered. No species occur in dry sclerophyll forest or seashore vegetation. Five species occur outside forests, in open *maquis* vegetation. These five are primarily rainforest species surviving in disturbed vegetation. Thirteen species are restricted to schists (six threatened) and 15 to ultramafic rocks (five threatened). The only species occuring on limestone, *Cyphophoenix nucele* on Lifou, is critically endangered (Table 2, Fig. 1). Twenty-eight species have at least one population in a reserve. Two species, *Lavoixia macrocarpa* and *Pritchardiopsis jeanneneyi,* are critically endangered despite occuring entirely within a reserve, since the protection offered by the reserve does not prevent their decline. Nine of the 13 threatened species are not represented in reserves. Seven of the threatened species are located in the South Province, six in the North Province (one shared by both provinces) and one in the Islands Province (Lifou). Four of the six species listed in the LRcd category are in a reserve of the South Province and two are located in the only botanical reserve of North Province, at Mont Panié. (Table 3 and Fig. 2).

Nineteen of the 62 localities where the palm communities were studied are presently facing disturbance. Causes of disturbance include logging or clearing (seven localities), fire (five localities), grazing (four localities), and mining activities (three localities). Among the 43 remaining localities, 16 have been disturbed in the past, especially on ultramafic rocks (12 localities) where fires, logging, and mining were extensive during the end of the 19th and the first half of the 20th century. On non-ultramafic rocks, agricultural pressure is most important. There are 18 localities included in botanical reserves with palm communities of various richness (Table 4). Five of the eight richest areas for palms are in reserves and two others are partly included in reserves (Table 5).

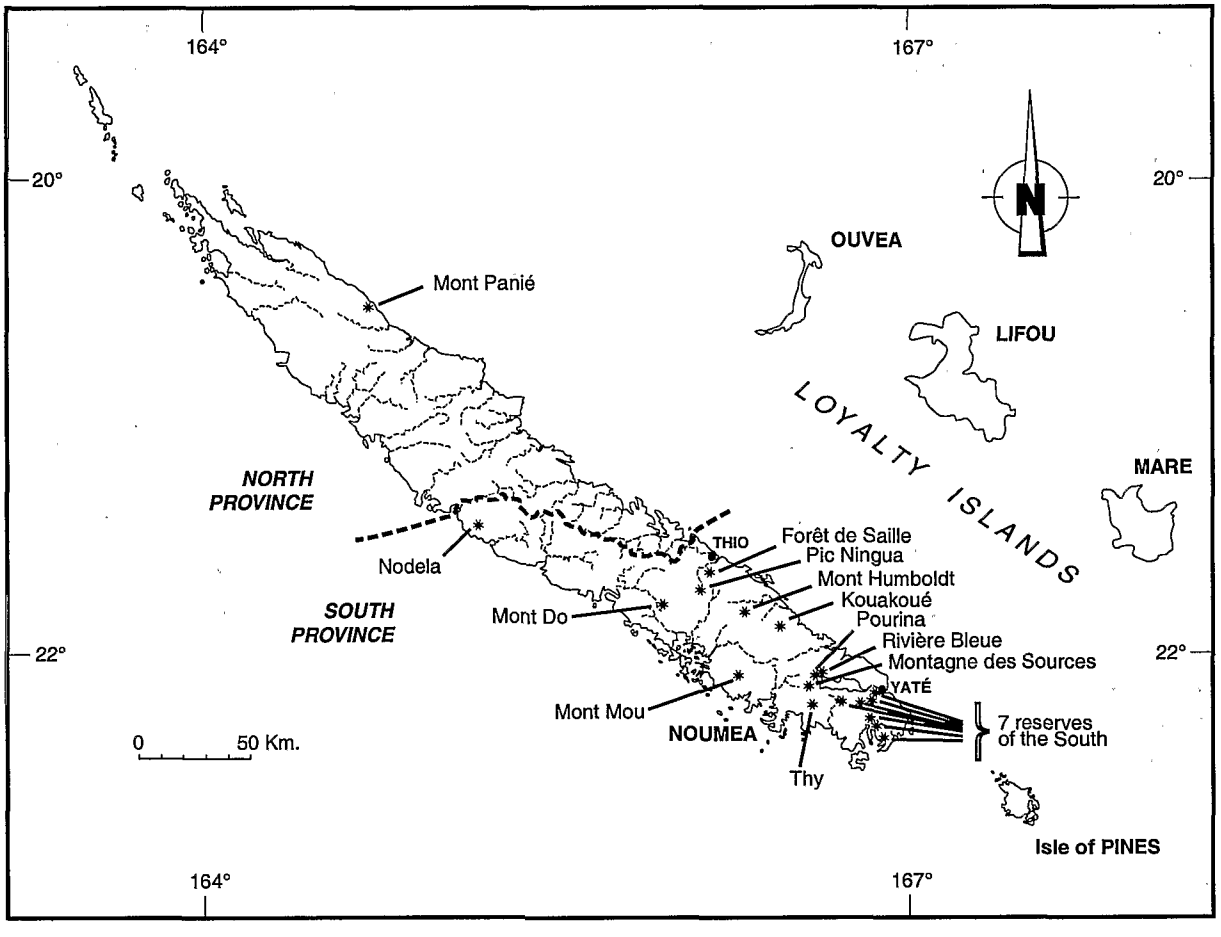

Fig. 2. Location of botanical reserves in New Caledonia.

Table 3. Characteristics of reserves and their palm flora (reserves of botanical value only included here).

Reserve	Location	Type of reserve	Area (ha)	Altitudinal range	Number of palm species	Number of threatened + LRcd spp.	Number locally endemic spp.[1]
7 reserves of the South	South Province	Botanical	4 466	0–700 m	10	1	1
Rivière Bleue	South Province	Provincial Park	9 045	150–1 100 m	8	0+1	1
Pourina	South Province	Special of fauna and flora	4 480	50–900 m	5	0	0
Montagnes des Sources	South Province	Inegral of nature	5 878	100–1 100 m	10	0+3	2
Thy	South Province	Provincial Park	1 133	300–1 100 m	8	1	1
Kouakoué	South Province	Special of fauna and flora	7 480	1 000–1 500 m	6	1	1
Mont Mou	South Province	Botanical	675	500–1 200 m	1	0	0
Humboldt	South Province	Botanical	3 200	1 200–1 600 m	1	0	0
Forêt de Saille	South Province	Special of fauna and flora	1 100	400–1 000 m	3	0	0
Pic Ninga	South Province	Special of fauna and flora	350	1 000–1 350 m	2	0	0
Mont Do	South Province	Special of fauna and flora	300	900–1 000 m	4	0	0
Nodéla	South Province	Special of fauna and flora	935	600–1 400 m	9	0+1	1
Panié	North Province	Botanical	5 000	300–1 600 m	13	1+2	3
All reserves	—	—	44 042	0–1 600 m	28	4+6	9
Total NC	—	— km²	19 100	0–1 600 m	37	13+6	37

[1]Extent of occurrence not exceeding 100 km².

Table 4. Characteristics of the 62 locations where palm communities were surveyed. Protect.: protection status, in a reserve (R) or outside. Disturb.: factor of disturbance acting at the present time or, in brackets, previously. No spp.: number of species. No. G.: number of genera. (Others as in Table 2).

Location	Lat. S.	Lg. E.	Elev. (m)	Subst.	Sector	Protect.	Disturb.	No. spp.	No. G.	No. local endemic
Amieu	21°37'	165°48'	450	S	S		logging	6	5	0
Amos	20°18'	164°23'	500	S	NE		(fire)	4	4	2
Aoupinie	21°11'	165°16'	700	S	C		logging	4	4	0
Arago	21°15'	165°28'	600	S	C			6	6	0
Balade	20°20'	164°30'	500	S	NE			3	3	0
Col De Koh	21°30'	165°48'	300	B	C		grazing	1	1	1
Col De Ni	21°56'	166°25'	900	U	S			2	2	0
Col De Yate	22°10'	166°54'	300	U	S		logging	2	2	0
Col De Koinde	21°36'	165°58'	700	S	C		fire	2	2	0
Colnett	20°31'	164°42'	400	S	NE			5	5	0
Dalmates (sentier)	22°09'	166°54'	200	U	S		(logging)	5	5	0
Dalmates (vallon)	22°12'	166°40'	250	U	S		fire	3	3	0
Dent St Vincent	21°52'	166°14'	1 100	U	S			6	4	0
Djiaouma	21°26'	165°21'	900	U	C	R		3	3	0
Dogny	21°37'	165°53'	1 000	S	C			5	3	1
Dzumacs	22°02'	166°28'	1 000	U	S		(logging)	5	5	0
Eguillon Prony	22°21'	166°55'	100	U	S		(fire)	3	3	0
Gallieni (Mine)	21°55'	166°20'	600	U	S		(mining)	2	2	0
Grand Kaori (Pic)	22°17'	166°54'	200	U	S		logging	5	3	0
Haut Coulna	20°38'	164°44'	600	S	NE		fire	4	4	0
Humboldt	21°53'	166°25'	1 500	U	S	R		1	1	0
Ignambi	20°28'	164°36'	700	S	NE			3	3	0
Kaala	20°40'	164°23'	500	U	NW		mining	1	1	0
Kouakoué	21°59'	166°31'	1 000	U	S	R		6	4	0
Kuanopluenu	20°57'	167°21'	50	L	LOYT		clearing	1	1	1
Kuebini	22°16'	167°00'	50	U	S		fire	6	6	1
Levres (Massif)	20°50'	165°10'	800	S	C			5	5	0
Mandjelia	20°24'	164°32'	600	S	NE		(logging)	5	4	0
Me Ori	21°31'	165°40'	900	U	C		mining	5	2	1
Me Ori	21°31'	165°40'	600	S	C		(logging)	3	3	0
Menazi	21°27'	165°43'	1 000	U	C		mining	4	2	0
Mont Mou	22°04'	166°20'	600	U	S	R		2	2	0
Mont Mou	22°04'	166°20'	1 100	U	S	R		1	1	0
Mouirange	22°12'	166°38'	300	U	S		(logging)	4	4	0
Mont Do	21°45'	166°00'	1 000	U	C	R	(fire)	4	3	0
Mont Koghi	22°10'	166°30'	500	U	S		(logging)	5	5	1
Mont. Sources	22°08'	166°36'	900	U	S	R		7	4	2

Table 4 — *continued*

Location	Lat. S.	Lg. E.	Elev. (m)	Subst.	Sector	Protect.	Disturb.	No. spp.	No. G.	No. local endemic
Nakada	21°39'	166°02'	1 000	S	C			4	3	1
Nehoué	20°27'	164°19'	30	S	NW		grazing	1	1	0
Nékando	21°52'	166°27'	800	U	S			7	3	2
Nengone	22°20'	166°55'	200	U	S	R	(logging)	8	7	2
Neumeni	21°40'	166°16'	750	U	S			9	7	1
Neumeni	21°40'	166°16'	1 000	U	S			2	1	0
Ninga	21°45'	166°08'	1 000	U	S	R		4	5	0
Nodéla	21°26'	165°21'	600	U	C	R	(logging)	7	6	1
Ouaieme	20°39'	164°51'	600	S	NE		fire	6	6	0
Panié	20°34'	164°47'	500	S	NE	R		10	7	3
Panié	20°34'	164°47'	800	S	NE	R		6	5	1
Panié	20°34'	164°47'	1 500	S	NE	R		3	2	0
Parari	20°21'	164°29'	100	S	NE		grazing	1	1	1
Pic Du Pin	22°15'	166°49'	400	U	S	R		4	3	0
Poro	21°20'	165°43'	700	U	C		(mining)	1	1	0
Pourina	22°03'	166°40'	300	U	S	R		5	5	0
Rivière Bleue	22°06'	166°40'	150	U	S	R	(logging)	8	7	1
Forêt Saille	21°41'	166°14'	500	U	S	R		2	2	0
Tchit (Creek)	20°36'	164°50'	10	S	NE		clearing	6	6	0
Thy	22°11'	166°32'	400	S	S	R	(logging)	5	5	0
Tiebaghi	20°30'	164°12'	300	U	NW		mining	1	1	0
Tindea-Boghen	21°37'	165°40'	100	S	C		grazing	1	1	1
Tio	20°29'	164°39'	1 000	S	NE			5	4	1
Tio	20°29'	164°39'	600	S	NE			2	2	0
Touaourou	22°12'	166°58'	10	U	S		clearing	5	5	1

Table 5. Richest areas for palms in New Caledonia.

Location	Sector	Number of species	Number genera	Locally endemic species	Status
Mont Pannié	North-East	13	10	3	Protected
Forêt de Saille	South	11	7	1	Partly protected
Montagne des Sources	South	10	5	2	Protected
Nodéla	Centre	9	7	1	Protected
Thy	South	8	7	1	Protected
Rivière Bleue	South	8	7	1	Protected
Ongoné	South	8	7	2	Partly protected
Nékando	South	7	3	2	Not protected

DISCUSSION

Most palm species are threatened due to habitat disturbance. *Pritchardiopsis jeanneneyi* and *Kentiopsis pyriformis* are critically endangered and *K. oliviformis* is endangered, due to both habitat disturbance and past overexploitation for palm hearts or building material. Four other species suffering only limited habitat disturbance are listed as vulnerable due to acute restriction of their range *(Actinokentia huerlimannii, Basselinia iterata, B. tomentosa, B. vestita)*. One, *Lavoixia macrocarpa,* is critically endangered both for very limited occurrence and very low regeneration. However, considering the extensive habitat destruction (about 70% of the Territory is now covered by secondary vegetation, Jaffré *et al.* 1994) and the inherent fragility of the New Caledonia palms (many local endemic and monotypic genera with low ability to survive in disturbed vegetation), one might expect to find a more severely threatened palm flora. Among the 37 endemic palm species, just five are in the most threatened CR and EN categories, there are no extinct ones, and 24 are not threatened (including the 6 LRcd ones). The main reason for the relatively positive outlook is that nearly all species occur in rainforests disturbed or destroyed to a much lesser extent than semi-humid and dry forests. About 30% of the original rainforest remains, while only 2% of the dry forest still exists (Jaffré *et al.* 1993). Fortunately, no palms occur in the nearly destroyed dry forests. Montane wet forests are mostly undisturbed and hold more than 60% of the palm species, including several of very restricted distribution and which are listed as vulnerable for this reason. In contrast, there are only two species growing in semi-humid lowland forests affected by agriculture and both are threatened. *Kentiopsis oliviformis* is endangered and *Cyphophoenix nucele* is critically endangered.

Habitat disturbance remains the main threat to New Caledonia palms. An adequate network of well managed reserves can ensure the efficient conservation of palms by preserving their habitat. Existing reserves include six of the eight

richest areas for palms, but only two have permanent staff (Rivière Bleue and Nodéla). Expanding existing reserves would be sufficient to protect the eight richest areas for palms. The Ongoné reserve, for example, is located on steep slopes above 250 m elevation and includes the population of *Pritchardiopsis jeanneneyi,* but does not include the forest on flat ground between 200 and 250 m elevation where *Kentiopsis pyriformis* (critically endangered) is located. Logging and illegal removal of young plants is currently a threat to this forest. The eastern slope of Forêt de Saille, unprotected but the second richest area for palms with 11 species, is adjacent to Saille Reserve, which was created to preserve a population of large *Agathis lanceolata.* It contains only three LRlc palm species. A similar situation occurs on Mont Nékando which holds seven palm species including one vulnerable and two LRcd ones (protected elsewhere). The medium elevation slopes of Mont Nékando are unprotected, but adjacent to the Mont Humboldt Botanical Reserve, which contains only one LRlc palm species. However, eight threatened species will remain entirely outside reserves even if existing reserves are extended. Among these species, *Basselinia iterata* and *B. tomentosa* (vulnerable), despite their very limited extension, are not in immediate danger of extinction since they occur in undisturbed montane forests. *Kentiopsis pyriformis* (CR), *K. oliviformis* (E), and *Cyphophoenix nucele* (CR) mostly occur near Melanesian villages in severely disturbed forests often long used by local inhabitants. Conservation programmes involving local inhabitants should be undertaken for these species. Sustainable use through seed collecting and nursery activities is possible for these highly sought-after ornamental palms. Finally, *Basselinia vestita, Burretiokentia hapala, Cyphophoenix elegans,* and *Kentiopsis magnifica* occur in remnant forests of great biological interest (Mé Ori, upper Nehoué Valley, Amos Range), but threatened by bush fires. These forests are good candidates for new reserves.

White-waxy crownshaft of *Moratia cerifera* on Col d'Amos at 500 m elevation.

REFERENCES

Dowe, J. L., Benzie, J. and Ballment, E., 1997. Ecology and genetics of *Carpoxylon macrospermum* H. Wendl. and Drude (Arecaceae), an endangered palm from Vanuatu. *Biol. Cons.* **79:** 205–16.

Dowe, J. L. and Cabalion, P., 1996. A taxonomic account of Arecaceae in Vanuatu, with descriptions of three new species. *Aust. Syst. Bot.* **9:** 1–60.

Fuller, D., Dowe, J. L. and Doyle, M. F., 1997. A new species of *Heterospathe* from Fiji. *Principes* **41:** 65–69.

Guillaumin, A., 1961. Les palmiers de la Nouvelle-Calédonie. *J. d'Agricul. Trop. et de Botan. Appl.* **8:** 57–64.

Good, R., 1974. The geography of flowering plants. Longman Group Ltd, London.

IUCN, 1994. IUCN Red List Categories. Gland, Switzerland.

Jaffré, T., Bouchet, P. and Veillon, J.-M., 1998. Threatened plants of New Caledonia: is the system of protected areas adequate? *Biodiver. Conserv.* **7:** 109–35.

Jaffré, T., Morat, P. and Veillon, J.-M., 1993. Etude floristique et phytogéographique de la forêt sclérophylle de Nouvelle-Calédonie. Bull. Mus. Natn. Hist. Nat. Paris, 4è sér., section B, *Adansonia* **15:** 107–47.

Jaffré, T., Morat, P. and Veillon, J.-M., 1994. La flore, caractéristiques et composition floristique des principales formations végétales. Dossier Nouvelle-Calédonie. *Bois et Forêts des Tropiques* **242:** 7–30.

Jaffré, T. and Veillon, J.-M., 1989. Morphology, distribution and ecology of palms in New Caledonia. Pp. 158–68 *in* Palms of the South-west Pacific ed by J. L. Dowe. PACSOA, Milton, Australia.

Johnson, D. (ed), 1996. Palms: their conservation and sustained utilisation. Status survey and conservation action plan. IUCN, Gland, Switzerland.

Moore, H. E. and Uhl, N. W., 1984. The indigenous palms of New Caledonia. *Allertonia* **3:** 324–25.

MacKee, H. S., Morat, P. and Veillon, J.-M., 1985. Palms in New Caledonia. *Principes* **29:** 166–69.

Pintaud, J.-C. and Hodel, D. R., 1998a. A revision of *Kentiopsis,* a genus endemic to New Caledonia. *Principes* **42:** 32–33, 41–53.

Pintaud, J.-C. and Hodel, D. R., 1998b. Three new species of *Burretiokentia. Principes* **42:** 152–55, 160–66.

Schmid, M., 1981. Fleurs et plantes de Nouvelle-Calédonie. Editions du Pacifique, Nouméa.

Thorne, R. F., 1965. Floristic relationships of New Caledonia. *Univ. Iowa Studies Nat. Hist.* **20:** 1–14.

Effects of habitat and introduced mammalian predators on the breeding success of Yellow-eyed Penguins *Megadyptes antipodes*, South Island, New Zealand

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The endemic Yellow-eyed Penguin *Megadyptes antipodes* is threatened by habitat loss and introduced predators on mainland New Zealand. Nine colonies in the Catlins (south-east coast of South Island) were studied to measure breeding success, penguin abundance, and predator abundance in three successive breeding seasons (1991/92 to 1993/94). Nest numbers increased in all nine colonies in the three years despite predation (probably by Stoats *Mustela erminea*) being the most important cause of breeding failure. Larger colonies with higher breeding success were in small gullies with limited shrubs and bushes rather than in the most intact mature forest colonies hitherto assumed to be optimal habitat for the birds. Penguin nests were concentrated near the forest edge, but predators were not, so the predation risk was not elevated near the forest edge. Fragmentation of the original forest habitat had no observable adverse effect on breeding success. Stoats dominated the predator guild, while Ferrets *M. furo* and Feral Cats *Felis catus* were rare. Trapping to kill predators early in the season had no marked effect on subsequent predation losses, but trapping intervention when a predation outbreak occurred curtailed further chick deaths. A simple population model predicts that Yellow-eyed Penguins populations will grow provided the average total chicks loss is less than 43% per season, or at least 0.85 chick per nest fledges each year. This requires predation losses to be less than 34%.

Key words: Yellow-eyed Penguin, *Megadyptes antipodes*, Breeding success, Introduced mammalian predators, Habitat use, Fragmentation, Predation, Population model.

INTRODUCTION

THE Yellow-eyed Penguin *Megadyptes antipodes*, an endemic species to New Zealand, is threatened on South Island (Molloy and Davis 1992). It was estimated that there were less than 1 000 individuals in 1991/92, and that numbers were gradually declining (Triggs and Darby 1989; Marchant and Higgins 1990; Department of Conservation 1991). Two reasons are most often presented for this decline of the Yellow-eyed Penguin on South Island: the clearance of the native coastal forest and subsequent loss of breeding habitat (Darby and Seddon 1990; Department of Conservation 1991), and predation by introduced mammalian predators such as Stoats *Mustela erminea*, Ferrets *M. furo* and Feral Cats *Felis catus* (Darby and Seddon 1990; Department of Conservation 1991; Moller *et al.* 1995).

Most work on Yellow-eyed Penguins has been conducted in the Otago Peninsula colonies so there is little information to assess the risk of extinction of the more southern Catlins colonies, or to identify the optimal population management strategies there. Information about the trends and threats in the northern colonies may not apply in the Catlins colonies. This paper describes the breeding success, and causes of death of Yellow-eyed Penguin chicks in trapped and untrapped Catlins breeding colonies in three seasons (1991/92 to 1993/94). For this study a crude demographic model was constructed from our measures of breeding success, and survival and breeding estimates from other colonies to predict the level of predation control needed to conserve the Catlins subpopulation. This is used to establish an interim target to guide predator control efforts to help avoid wasteful overkill because predation control is expensive (Ratz 1997).

Coastal podocarp and hardwood forest is the preferred nesting habitat (Darby and Seddon 1990; Marchant and Higgins 1990) because the canopy provides shade, ensuring breeding success by avoiding thermal stress (Seddon and Davis 1989; Darby and Seddon 1990). These assumptions in the concept of habitat requirements may be misleading (Gray and Craig 1991). The original forest habitat may be suboptimal for Yellow-eyed Penguins even though still used widely, especially when there was a lack of alternative habitats in the past. This study investigated the habitat preferences of Yellow-eyed Penguins in the Catlins breeding colonies.

A potential interaction between habitat and predation threats involves the creation of habitat edges by forest fragmentation. Small mammalian predators have often been shown to frequent habitat boundaries (Erlinge 1977; Pounds 1981; King 1989). Predation of Yellow-eyed Penguins may be intensified if they choose to nest near the forest edges, and if predators do indeed favour such habitat edges in New

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