A SURVEY OF THE LIZARD FAUNA OF MAQUIS FOREST HABITAT ON THE VALE INCO MINE SITE (10 TO 20 YEAR PLAN OF DEVELOPMENT)

Cygnet Surveys & Consultancy

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Frontcover: *Bavayia sauvagii* – photo Ross A. Sadlier

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1. INTRODUCTION

This report is from the second of two studies undertaken to determine the species diversity of lizards in canopied maquis habitats, primarily maquis paraforestier and maquis preforestier, across the area encompassed by the Vale Inco mine site on the Goro Plateau. An earlier study undertaken in 2008 (Sadlier and Swan, 2009b) investigated the lizard fauna of canopied maquis in the area of the 5-10 year plan of development, and the study presented here investigated the area of the 10-20 year plan of development in 2009.

The 2008 study of the lizards of canopied maquis habitats on the Vale Inco mine site recorded a moderately rich fauna of 10 species, which included seven skinks (*Caledoniscincus austrocaledonicus*; *Caledoniscincus cf. atropunctatus*; *Lioscincus nigrofasciolatus*; *Marmorosphax tricolor*; *Sigaloseps deplanchei*; *Simiscincus aurantiacus* and *Tropidoscincus variabilis*) and three geckos (*Bavayia cf. sauvagii*; *Bavayia septuiclavis*; *Rhacodactylus auriculatus*). Earlier studies (Sadlier and Shea, 2004) identified an additional species of skink (*Nannoscincus mariei*) and gecko (*Bavayia goroensis*) in canopied maquis habitats in the region, and recent work by Vale Inco biologists has found an additional gecko (*Eurydactylodes symmetricus*). In total 13 species of lizard have been recorded from this habitat type on the Goro Plateau. This is a level of diversity approaching that recorded for humid forest in New Caledonia, the habitat with the greatest diversity of lizard species (~20 species – Sadlier, 2006), and far greater than maquis shrubland which generally has a relatively low diversity (~5-7 species) and abundance of lizards. A high proportion of the species recorded from canopied maquis habitat (9 of 13) are regional endemics, that is, species restricted to the southern ultramafic ranges. Of these two (*Simiscincus aurantiacus* and *Bavayia goroensis*) are identified as of particular conservation significance under a system using modified IUCN criteria (Sadlier and Bauer, 2003).

The study presented here on the lizard fauna of the 10-20 year plan of development was undertaken to examine in detail the relationship between the local lizard fauna and canopied maquis habitats and in the area to be impacted by the mine, and complements an earlier study on the 5-10 year plan of development.

2. STUDY SITES AND METHODS

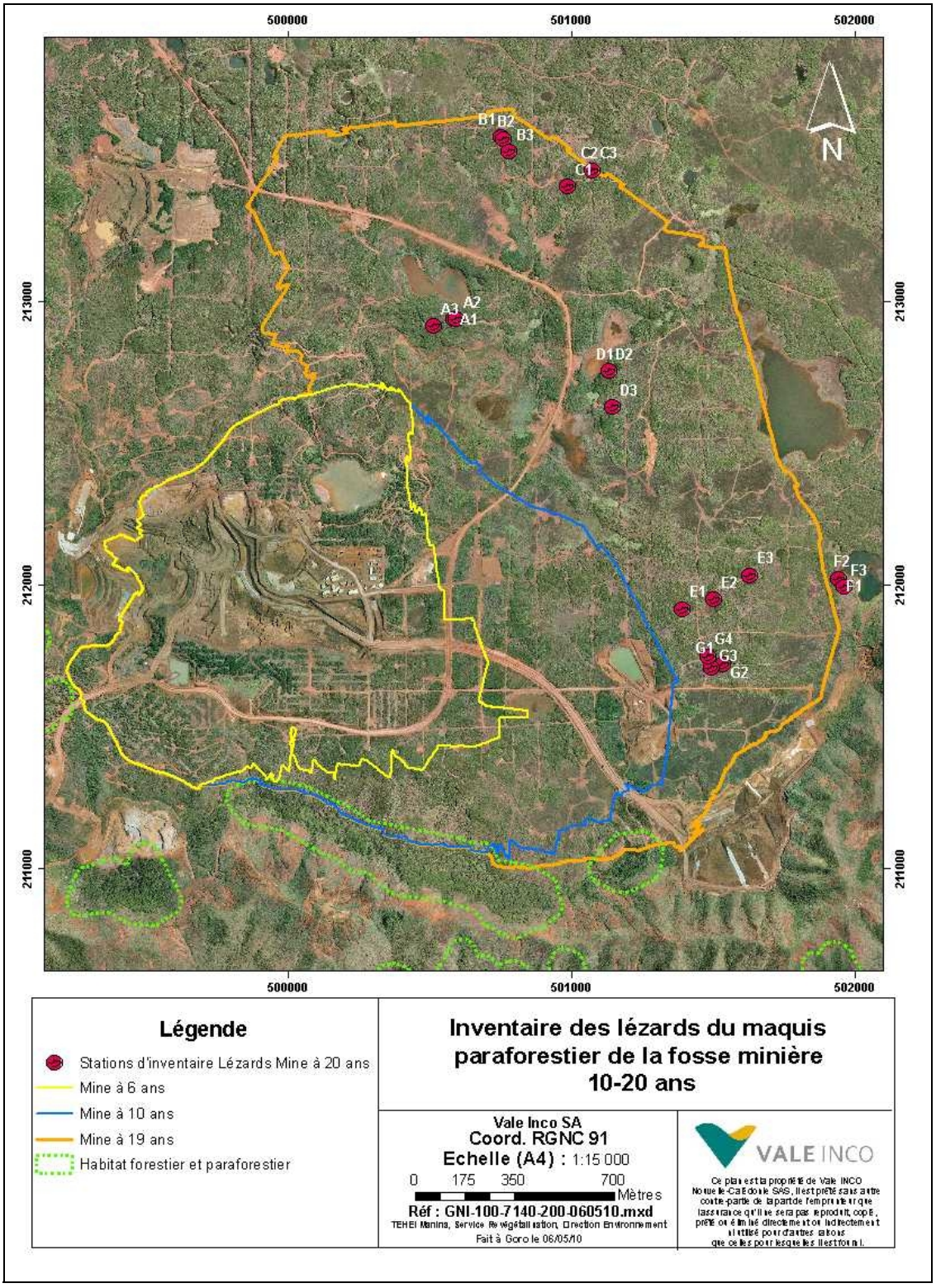
The study was conducted within the projected 10 and 20 year mine boundaries in the dry season of November 2009. Conditions during the survey were considered to be average with respect to temperature and below average with respect to clear weather. The sites selected for survey work were areas of canopied maquis identified by Vale Inco botanists. The sites were selected on the basis of size, relative homogeneity of habitat type, and access. In all, seven separate sites were investigated, with three replicates at each site (four at site G).

2.1 Study sites.

The type of canopied maquis habitat varied between sites across the study area, ranging from low canopied maquis arbustif through to relatively tall canopied maquis paraforestier and preforestier, with intermediate stages of development occurring within and between the replicates. Surrounding the patches of canopied maquis are areas of low maquis shrubland of varying density. Sites D-G were located on a plateau with an extensive exposed cuirasse cap, and sites A-C on a low ridge that generally lacked extensive exposed cuirasse rock.

The vegetation of each replicate at each of the major sites was characterized by a visual assessment made at each of 10 transect stations (5-8 metres apart) located along a transect of approximately 50-80 metres in length as follows:

- Maquis: open shrubland, no canopy.
- Maquis arbustif: low canopy to 3 metres in height
- Maquis paraforestier: low canopy to 5 metres in height
- Maquis preforestier: canopy height greater than 5 metres



Location of sites examined November 2009. Blue outline represents 10 year mine boundary, orange line the 20 year mine boundary. Survey sites (alphabetic) and replicates (numeric) are in white and approximate location of each replicate is encompassed by the adjacent red circle.

Site	Co-ordinates	Habitat
A1	-22.170064865S 166.583366991E	maquis arbustif/paraforestier 10%; paraforestier 20%; preforestier 70%
A2	-22.170070940S 166.583402008E	paraforestier 100%
A3	-22.170149102S 166.583123652E	maquis arbustif/paraforestier 40%; preforestier 60%
B1	-22.163967536S 166.583938307E	maquis arbustif 50%; paraforestier 50%
B2	-22.163993284S 166.583959627E	maquis arbustif/paraforestier 20%; paraforestier 50%; preforestier 30%
B3	-22.164141866S 166.584038565E	maquis arbustif 10%; paraforestier 30%; preforestier 60%
C1	-22164532935S 166.584760148E	maquis arbustif/paraforestier 100%
C2	-22.16435.370S 166°585068459E	paraforestier 30%; preforestier 70%
C3	As for C2	paraforestier 70%; preforestier 30%
D1	-22.170649432S 166.58528510E	paraforestier/preforestier 40%; preforestier 60%
D2	As for D1	maquis arbustif 10%; maquis arbustif/paraforestier 20%; paraforestier 30%; paraforestier/preforestier 20%; preforestier 20%
D3	-22.171064971S 166.585330288E	maquis arbustif/paraforestier 100%
E1	-22.173372296S 166.590197756E	maquis arbustif 30%; maquis arbustif/paraforestier 20%; paraforestier 50%
E2	-22.173263454S 166.590590972E	maquis arbustif 40%; maquis arbustif/paraforestier 60%
E3	-22.172981785S 166.591027156E	maquis arbustif 30%; maquis arbustif/paraforestier 30%; paraforestier 20%; preforestier 20%
F1	-22.173010600S 166.592124482E	maquis arbustif/paraforestier 10%; paraforestier 40%; preforestier 50%
F2	As for F1	maquis arbustif 50%; maquis arbustif /paraforestier 20%; paraforestier 30%
F3	-22.173107297S 166.592192226E	maquis 10%; maquis arbustif 70%; maquis arbustif /paraforestier 20%
G1	-22.174009760S 166.590706322E	maquis arbustif 100%
G2	As for G1	maquis arbustif 80%; maquis arbustif /paraforestier 20%
G3	-22.174050389S 166.590574146E	maquis 90%; maquis arbustif 10%;
G4	-22.173914514S 166.590519824E	maquis 70%; maquis arbustif 30%;

Table 1: Location of sites and replicates surveyed with total percentage of habitat type for each.

There was a level of heterogeneity in habitat between and within the replicates at most sites:

- Site A replicates A1-A3 were primarily tall maquis paraforestier and maquis preforestier, with some habitat transitional between maquis arbustif and maquis paraforestier at A1 and A3, while replicate A2 was a homogeneous stand of maquis paraforestier.
- Site B replicates B2 and B3 were primarily tall maquis paraforestier and maquis preforestier with some habitat transitional between maquis arbustif and maquis paraforestier, while at replicate B1 maquis arbustif and taller canopied maquis paraforestier were equally represented.
- Site C replicates C2 and C3 were primarily tall maquis paraforestier and maquis preforestier, while C1 was a stand transitional between maquis arbustif and maquis paraforestier.
- Site D replicates D1 and D2 were primarily tall maquis paraforestier and/or maquis preforestier, while D3 was a stand transitional between maquis arbustif and maquis paraforestier.
- Site E all replicates were a grade from moderately low maquis arbustif through to higher canopied maquis.
- Site F replicate F1 was primarily taller canopied maquis with little transitional lower canopied maquis. At replicate F2 maquis arbustif and taller canopied maquis paraforestier were equally represented, while replicate F3 was predominately low canopied maquis arbustif.
- Site G replicates G1 and G2 were predominately maquis arbustif while sites G3 and G4 were predominately maquis with some small patches of maquis arbustif.

Collectively paraforestier, preforestier and transitional habitat between these made up 47.7% of the habitat covered by the transects. Canopied maquis arbustif and transitional stages of this toward a lower (maquis/maquis arbustif) or taller (maquis arbustif/paraforestier) canopy comprised 44.6% of habitat, with only occasional areas of open maquis shrubland included on the transect lines (7.7% - , mostly at replicates G3 and G4).

Maquis preforestier - Site C2.

2.2 Field methods.

The previous study in 2008 to assess the diversity and abundance of lizard species in canopied maquis habitats showed that strategically placed glue-traps were equally (or more) effective at detecting the presence and providing a measure of abundance of most day active species, and even more effective at detecting the presence of secretive species when placed at the entrance to likely sheltering sites where logs and rocks rest on the ground. For these reasons this technique was employed as the primary method to detect lizard species in the present study at the seven sites surveyed. Records were also kept of lizards encountered opportunistically on transects during the course of checking glue-traps.

For detecting the presence of secretive species and diurnal surface dwelling species of skink, glue-traps were strategically placed at each station (5-8 metres apart) located along each transect line for each replicate. Traps were placed in the crevices and cracks created where outcropping cuirasse boulders contact the ground, under and next to logs, and in areas of litter or amongst surface debris. For each trap placed at each station along a transect line the basic microhabitat attributes of the station were recorded with regard to potential sheltering sites:

- located within or at the edge of a crevice between the rock and the forest floor (1).
- located next to an outcropping piece of rock/cuirasse (2).
- under vegetation and/or debris on the forest floor (3).
- in the open with no obvious cover or proximity to a sheltering site (4).
- under a log where there is a gap between the forest floor and log or in an opening in a fallen log (5).
- at the base of a tree (6).

Geckos are usually the less diverse of the two lizard groups present, and are usually encountered active at night foraging in low shrubs, small trees, or the forest canopy, or sheltering by day in vegetation or under cover on the ground. Nocturnal searches were usually undertaken in the first three hours after sunset. The method used to search for geckos detects the reflection from the eye when a beam of light is directed towards the lizard or, by scanning vegetation with a powerful light at closer range to

observe geckos moving along twigs or branches. Binoculars modified to carry a torch and emit a light beam from below the eyepieces of the binocular were used to detect eye reflection. This method readily detects both the larger and smaller geckos, but to be effective it generally requires a minimum search distance of 10 -15 m., and a co-worker is required to collect the gecko for positive identification while the first observer keeps the animal in sight from a distance. Night searches were run along a 100 metre transect through forest habitat with a relatively open understory.

The previous study in 2008 trialed the effectiveness of glue-traps placed around the trunks of trees to detect the presence of arboreal skinks and geckos active at night – the results were considered to be of limited success and for this reason were not employed in the present study.

***Search effort and conditions*:** At each site replicate one glue-trap was laid at each of the 10 stations along the transect line. A total of 220 trap stations were operational throughout the survey period, usually for a period of three full days and nights after being established, representing approximately 660 trap days/nights in total. The distribution of traps by habitat along transects in each replicate is given in Table 2.

Timed nocturnal searches consisted of walking the road edge in the general vicinity of each major site, or through a transect of the site where there was insufficient road edge to survey. Usually three persons participated in night searches of sites, and in all a total of ~21 hours and 30 minutes of person search hours were undertaken primarily along road verge habitat as follows: sites **B**, **C** and **G** each 1 hour and thirty minutes per site (total 4 hours 30 minutes); sites **D**, **E** and **F** each 3 hours per site (total 9 hours); site **A** four separate searches totaling approximately 8 hours. Day time temperatures ranged from 21.5-25.8°C ($\bar{x}$ 23.4°), the humidity was consistently high at 74.5-98.5% ($\bar{x}$ 87.7%), and cloud cover was 50% or more ($\bar{x}$ 89.5%) for 9 of the 10 survey days with one relatively clear day with 5% (am) to 65% (pm) cloud cover. The temperature on the eight nights during which night searches were conducted ranged from 20.7-23.3°C ($\bar{x}$ 22.°), the humidity was consistently high at 82.5-97.5% ($\bar{x}$ 89.7%), and cloud cover was 50% or more - rain prevented searches on two nights.

Sites & replicates	maquis	maquis/ arbustif	arbustif	arbustif/ paraforest	paraforest	paraforest/ preforest	preforest
A1 (10)				1	2		7
A2 (10)					10		
A3 (10)				4			6
B1 (10)			5		5		
B2 (10)				2	5		3
B3 (10)			1		3		6
C1 (10)				10			
C2 (10)					3		7
C3 (10)					7		3
D1 (10)						4	6
D2 (10)			2	1	3	2	2
D3 (10)				10			
E1 (10)			3	2	5		
E2 (10)			4	6			
E3 (10)			3	3	2		2
F1 (10)				1	4		5
F2 (10)			5	2	3		
F3 (10)	1		7	2			
G1 (10)			10				
G2 (10)			8	2			
G3 (10)	9	1					
G4 (10)	7	3					
Count 220	17	4	48	46	52	6	47
%	7.7	1.8	21.8	21	23.6	2.7	21.4

Table 2: Number of ground traps placed in each habitat in each replicate – bracketed number is traps per replicate.

The number of individual lizards encountered at each station was recorded and voucher specimens taken of each species for future taxonomic studies.

3. RESULTS

A total of 12 species of lizard are recorded for the survey period for all sites combined - 7 species of skinks and 5 geckos. Four species of skinks *Caledoniscincus cf. atropunctatus*, *Caledoniscincus austrocaledonicus*, *Marmorosphax tricolor* and *Sigaloseps deplanchei*, and the geckos *Bavayia septuiclavis* and *Rhacodactylus auriculatus* were widespread across the study area and constituted 95% of records for the survey.

The skink *Sigaloseps deplanchei* - widely distributed across canopied maquis habitat of the study area.

3.1 Distribution and abundance: Two species were equally widespread and abundant across the study area, *Marmorosphax tricolor* constituting 34% of records for this group and *Caledoniscincus cf. atropunctatus* 31% of records. *Marmorosphax tricolor* is a secretive species only rarely seen active by day, and all records are from captures on glue-traps, with approximately half (50 = 49%) of the total number of individuals recorded in the first 24 hours of trapping. The species was recorded in both tall and low canopied maquis habitats, including maquis arbustif and more open transitional maquis/maquis arbustif habitat. Although widely distributed across the study area *Caledoniscincus austrocaledonicus* was infrequently recorded, constituting only 11.3% of records for the group with no clear pattern as to distribution by habitat type.

The skinks *Lioscincus nigrofasciolatum* and *Tropidoscincus variabilis* were also infrequently recorded but are still expected to be widespread in canopied maquis habitat across the study area. The absence of records for *Tropidoscincus variabilis* from some sites and the low numbers recorded at others most likely reflects genuinely low densities for this species in canopied maquis habitats. *Lioscincus nigrofasciolatum* is primarily arboreal in habits and extremely wary, it was rarely observed and nearly all records came from glue-trap captures. Hence, the distribution and abundance of this species is difficult to interpret other than it was trapped in consistently low numbers across the study area indicating it is probably widespread in distribution but present in relatively low densities.

The skinks *Sigaloseps deplanchei* and *Simiscincus aurantiacus* are generally considered to be associated with humid forest habitat. *Sigaloseps deplanchei* is largely fossorial in habits, though it is occasionally observed active in leaf litter in forest habitats. The species is widely distributed across the study area and was recorded in moderately high densities, including sites with a relatively high component of maquis arbustif (F3; G1 & G2), and even in open maquis (G4). *Simiscincus aurantiacus* is a poorly known species, it has not been observed active and is thought to have a biology specialised for occupying a subterranean niche. In the past three years it has been recorded during the course of surveying and monitoring of humid forests and canopied maquis habitats on the Goro Plateau, indicating it is widespread in these habitats in the region, but infrequently detected because of its secretive behaviour. During the 2008 canopied maquis survey a single individual was recorded from a matrix of cuirasse boulders in maquis preforestier, representing the first record of the species from this habitat type. The individual recorded during the 2009 canopied maquis study was also from preforestier habitat, but the study area this year lacked an extensive cuirasse cap compared to the 2008 survey.

Two gecko species, *Bavayia septuiclavis* and *Rhacodactylus auriculatus*, were widespread in distribution across the study area, each being recorded from six of the seven sites surveyed. By contrast *Bavayia cf. sauvagii* had a scattered distribution

and was recorded at low densities. Two species, *Bavayia goroensis* and *Eurydactylodes symmetricus*, were only recorded from a single site, the tall canopied maquis habitat at site A.

The gecko *Bavayia goroensis* – a local endemic to the Goro Plateau region

The gecko *Bavayia septuiclavis* – an endemic to the southern ultramafic ranges

The gecko *Eurydactylodes symmetricus* – an endemic to the southern ultramafic ranges

Table 3: Distribution of species by site across the study area within the 10 and 20 year mine plan boundaries – numbers represent total records for each species from all detection methods combined – sites A to D

		Site A1	Site A2	Site A3	Site B1	Site B2	Site B3	Site C1	Site C2	Site C3	Site D1	Site D2	Site D3
SKINKS	*Caledoniscincus cf. atropunctatus*	2	-	3	4	7	4	1	5	3	7	8	3
	Caledoniscincus austrocaledonicus	-	-	-	3	1	-	1	2	-	-	-	-
	Lioscincus nigrofasciolatum	-	-	-	1		-	-	-	-	-	-	-
	Marmorosphax tricolor	4	-	7	5	8	2	3	8	9	7	4	2
	Sigaloseps deplanchei	1	-	6	1	3	1	-	4	-	5	4	7
	Simiscincus aurantiacus	-	-	-	-	1	-	-	-	-	-	-	-
	Tropidoscincus variabilis	-	1	-	2	-	1	-	-	-	-	-	-
	Bavayia goroensis	--------- 2 ---------			----------			----------			----------		
	Bavayia cf.sauvagii	--------- 1 ---------			----------						----------		
GECKOS	*Bavayia septuiclavis*	--------- 8 ---------			--------- 7 --------			--------- 5 ---------			-------- 8 --------		
	Eurydactylodes symmetricus	--------- 1 --------			----------			----------			----------		
	Rhacodactylus auriculatus	--------- 7 ---------			--------- 9 ---------			--------- 5 ---------			----------		
	No. Species	**9**			**9**			**6**			**4**		

Table 3 cont'd: Distribution of species by site across the study area within the 10 and 20 year mine plan boundaries – numbers represent total records for each species from all detection methods combined – sites E to G.

Site E1	Site E2	Site E3	Site F1	Site F2	Site F3	Site G1	Site G2	Site G3	Site G4		
8	7	10	4	-	3	6	6	2	1	*Caledoniscincus cf. atropunctatus* n = 94	SKINKS
2	4	4	1	6	4	2	-	3	1	*Caledoniscincus austrocaledonicus* n = 34	
1	-	-	-	-	-	-	-	-	1	*Lioscincus nigrofasciolatum* n = 3	
3	-	2	12	4	7	3	6	3	3	*Marmorosphax tricolor* n= 102	
1	6	-	4	-	3	9	3	-	4	*Sigaloseps deplanchei* n = 62	
-	-	-	-	-	-	-	-	-	-	*Simiscincus aurantiacus* n = 1	
-	-	-	-	1	-	-	-	-	-	*Tropidoscincus variabilis* n = 5	
----------			----------			----------				*Bavayia goroensis* n = 2	GECKOS
2			----------			3				*Bavayia cf. sauvagii* n = 6	
----------			1			1				*Bavayia septuiclavis* n = 30	
----------			----------			----------				*Eurydactylodes symmetricus* n = 1	
1			1			3				*Rhacodactylus auriculatus* n = 26	
7			**7**			**8**					

3.2 Distribution by habitat: One of the main aims of the surveys was to assess the importance of the different canopied maquis habitats for different species of lizard. For this purpose the results will focus on comparing low canopied maquis (transitional 'maquis/maquis arbustif' through to transitional 'maquis arbustif/paraforestier') habitat that constitutes approximately 44.6% of the habitat sampled on the site transects, with tall canopied maquis (paraforestier through to preforestier) that constitutes approximately 47.7% of habitat, and to a lesser extent open maquis (shrubland) that constitutes approximately 7.7% of habitat surveyed.

Four species of skink, *Caledoniscincus cf. atropunctatus*, *Caledoniscincus austrocaledonicus*, *Marmorosphax tricolor* and *Sigaloseps deplanchei* were all widespread across the three major habitat types surveyed (maquis arbustif, paraforestier and preforestier) and the transitional stages between these, and were also present in areas of open maquis where these constituted part of transects, but generally occurred in low abundance. The skink *Tropidoscincus variabilis* was recorded from transitional maquis/maquis arbustif, paraforestier and preforest habitats but is also likely to be widespread in the region and to occur in more open maquis habitats.

During the 2008 survey of the 5-10 mine plan both timed observations and glue-traps were used at each replicate to detect skinks. During that survey timed day searches were conducted under ideal conditions of relatively cloud free skies and yielded a similar, but lower, number of individuals proportionally per unit area (0.62 *vs* 0.75) to that obtained by glue-trap captures during the same period. The results of the 2008 survey clearly indicated that the efficiency of glue-traps in detecting the presence of *Caledoniscincus cf. atropunctatus* was equal to (or greater than) that of timed searches, and for this reason the latter method was not undertaken during the 2009 survey of the 10-20 mine plan. The results from the 2009 survey using glue-traps only recorded a slightly higher number of individuals of *Caledoniscincus cf. atropunctatus* proportionally per unit area from all (1.01) canopied maquis habitats combined than the 2008 survey, despite weather conditions that included a number of

days with extensive cloud cover and several periods of rain, indicating this method is still effective at detecting this day active species under less than optimal conditions.

Table 4: Distribution of lizard species by habitat.

M maquis
M/MA maquis/maquis arbustif
MA maquis arbustif
MA/PAR. maquis arbustif/paraforestier
PAR. paraforestier
PAR./PRE. paraforestier/preforestier
PRE. preforestier

		M	M / MA	MA	MA / PAR.	PAR.	PAR. / PRE.	PRE.	Total
SKINKS	*Caledoniscincus aff atropunctatus*	1	22	-	20	24	3	24	94
	Caledoniscincus austrocaledonicus	3	14	-	11	3	-	2	34
	Lioscincus nigrofasciolatum	1	-	-	-	2	-	-	3
	Marmorosphax tricolor	7	21	-	17	17	6	33	102
	Sigaloseps deplanchei	2	21	-	15	6	2	16	62
	Simiscincus aurantiacus	-	-	-	-	1	-	-	1
	Tropidoscincus variabilis	-	3	-	-	1	-	1	5
	Total skinks	14	82	-	63	55	11	76	301
GEKCOS	*Bavayia goroensis*		-		-		2		2
	Bavayia aff.sauvagii		3		2		1		6
	Bavayia septuiclavis		1 (1)		-		27(1)		30
	Eurydactylodes symmetricus		-		-		1		1
	Rhacodactylus auriculatus		3		1		22		26
	Total geckos		8		3		54		65

NB: - For skinks the numbers represent captures from ground glue-traps. For geckos numbers night observations except for those in brackets which represent captures from ground glue-traps.

The return of captures per unit area from glue-traps gives a proportional estimate of the occurrence of each of the more widespread species of skink in each of these broad habitat types (no. of records as a proportion of effort for each habitat, where effort equates to the number of transect stations for a particular habitat type as a % of total number of stations assuming equal duration of trap effort at all stations). The occurrence of *Caledoniscincus cf. atropunctatus* and *Marmorosphax tricolor* in low canopied maquis was proportionally slightly lower than that recorded in tall canopied maquis (0.94 *vs* 1.07 records per unit area for *cf. atropunctatus*, and 0.85 *vs* 1.17 for *tricolor*) using the glue-trap detection method. Limited sampling of open maquis resulted in a level of occurrence of *Marmorosphax tricolor* (0.90 records per unit area) proportional to that found in canopied maquis habitats, though this pattern is not considered to persist with more widespread sampling.

The occurrence of *Sigaloseps deplanchei* was proportionally higher in low canopied maquis than that recorded in tall canopied maquis (0.81 *vs* 0.50 records per unit area), and the species was recorded also at a low level of occurrence (0.28 records per unit area) from open maquis habitat. The occurrence of *Caledoniscincus austrocaledonicus* in low canopied maquis was significantly greater (five-fold) that recorded in tall canopied maquis (0.56 *vs* 0.10 records per unit area).

Placement of glue-traps at the stations with respect to proximity of microhabitat or sheltering sites had several clear impacts on rate of detection of the secretive skink species *Marmorosphax tricolor* and *Sigaloseps deplanchei* (Table 5):

- proportionally the highest number of *Marmorosphax tricolor* per unit area were recorded from glue-traps placed at sheltering sites, with traps placed at the entrance of a rock crevice recording nearly 40% more individuals than those placed next to a rock or under a log.
- glue-traps placed in leaf litter away from obvious sheltering sites recorded proportionally fewer *Marmorosphax tricolor* per unit area than were recorded from traps placed next to sheltering sites.
- unexpectedly, proportionally as many *Sigaloseps deplanchei* were recorded from glue-traps placed under overhanging vegetation, next to a tree or in the open as were recorded from traps placed next to rock sheltering sites.

- proportionally nearly twice as many *Sigaloseps deplanchei* were recorded from traps placed under a log as from traps placed in the open or next to a rock or at the entrance of a rock crevice.
- proportionally fewer *Caledoniscincus cf. atropunctatus* per unit area were recorded from traps placed in the open or under vegetation as from traps placed next to objects on the forest floor (rock or tree trunk).

	Rock crevice [13.6%]	Next to rock [15%]	Under veg. [23.6%]	In open [20%]	Under log [9.8%]	Next to tree [18.2%]	Total
M. tricolor	22 (1.62)	18 (1.2)	16 (0.68)	20 (1.0)	13 (1.35)	13 (0.7)	102
S. deplanchei	8 (0.58)	4 (0.27)	14 (0.59)	10 (0.5)	12 (1.26)	16 (0.88)	64
C. cf. atropunctatus	15 (1.1)	19 (1.27)	16 (0.68)	14 (0.7)	9 (0.94)	21 (1.15)	94
C. austrocaledonicus	4 (0.29)	1 (0.07)	6 (0.25)	14 (0.7)	4 (0.42)	3 (0.16)	32
T. variabilis	-	1	2	1	-	1	5
L. nigrofasciolatum	-	1	1	-	-	1	3
S. aurantiacus	1	-	-	-	-	-	1
Total	50	44	55	59	38	55	301

Table 5: Number of individuals of each species recorded from glue-trap stations on transect lines through all replicates – numbers in brackets against each species for each microhabitat are the proportion of individuals recorded per unit of area as expressed by the number of records as a proportion of effort for each micro-habitat ie. number of records for M. tricolor recorded from traps placed next to a rock crevice was 1.62 per unit area, where effort equates to the number of transect stations for a particular micro habitat type as a % of total number of stations ie. next to rock crevice [13.6%].

3.3 Comparison of results: 5-10 *vs* 10-20 mine plan survey: *Species Diversity and Abundance*

overall a higher diversity of lizards (12 *vs* 10) was recorded during the survey of canopied maquis on the area of the 10-20 mine plan in 2009 than on the 5-10 mine plan in 2008. Both surveys recorded the same diversity of skink species, and both recorded the geckos *Bavayia cf. sauvagii*, *Bavayia septuiclavis* and *Rhacodactylus auriculatus*, but a further two species of gecko, *Bavayia goroensis* and *Eurydactylodes symmetricus*, were recorded during the 2009 survey, both from tall canopied maquis at site A.

Both surveys were of approximately the same duration at the same time of year. Conditions during the 2008 survey of the 5-10 mine plan were considered to be optimal, with extensive periods of cloud free weather conditions, whereas conditions during the 2009 survey of the 10-20 mine plan were less favourable with a number of days with extensive cloud cover and several periods of rain. Despite this the number of skinks recorded from glue-traps (301 *vs* 218) was greater during the 2009 survey than the 2008 survey. The main difference in abundance between the 2009 and 2008 surveys was in the greater number of *Caledoniscincus cf. atropunctatus* (94 *vs* 75) and *Sigaloseps deplanchei* (62 *vs* 23) recorded in the 2009 survey. Both species seem to prefer moist habitats and are most frequently encountered in forest and canopied maquis, and both utilize the leaf litter layer of the forest floor. The two species are different in behaviour, *Sigaloseps deplanchei* is secretive and not commonly observed active, whereas *Caledoniscincus cf. atropunctatus* is usually seen active in sunlit patches of the forest floor. The greater abundance of *Sigaloseps deplanchei* during the 2009 survey could be attributed to the overcast and moister conditions during (and before) the survey period, leading to increased surface activity by this species. Conversely the reduced amount of sunlight on the forest floor resulting from extensive overcast conditions would have been expected to lead to less activity in *Caledoniscincus cf. atropunctatus*, yet more individuals were recorded from the glue-trap stations in the 2009 survey, indicating the species to be equally active under these overcast conditions.

It is difficult to assess the difference in diversity of gecko species encountered in the 2008 *vs* 2009 surveys given both of the additional species encountered, *Bavayia goroensis* and *Eurydactylodes symmetricus*, have also been recorded from other canopied maquis habitats and humid forest habitat in areas adjacent to, and distant from, the mine site, indicating both species have a wide and scattered distribution across a range of habitat types in the region. There was a marked difference in the encounter rate and distribution of *Bavayia cf. sauvagii* between the 2008 *vs* 2009 surveys, with the species only recorded from three of the seven sites on the 10-20 year mine plan surveyed at night for geckos in 2009, compared to five of seven sites on the 5-10 year mine plan during the 2008 survey. Two of the sites from which *Bavayia cf. sauvagii* was recorded in the 2009 survey (E and G) are small patches

with a moderately high proportion of low canopied maquis compared to other sites and are located on areas of broken cuirasse, and in this respect are more similar to areas of canopied maquis on the cuirasse plateau surveyed in 2008 (sites A-C, F and G of 2008 survey). Also, encounter rates for the species during the 2009 were lower, with only 1-3 individuals encountered at any one site compared to 9-14 at four of the sites surveyed in 2008.

4. ASSESSMENT

4.1 Significant species: Significant species are those of particular conservation significance by virtue of having one or more aspects of their biology (habitat preferences, diet, home range, etc.) specialised, and which in combination with their extent of occurrence can determine the ability of the species to persist into the future.

One species, *Bavayia goroensis*, is a local endemic to the Goro Plateau and has previously been categorised as 'Endangered' under modified IUCN conservation criteria (Sadlier and Bauer, 2003). The species is known to occur in a range of open to canopied maquis habitats, including maquis arbustif and paraforestier adjacent to the mine site (Sadlier & Shea, 2004), more open maquis habitats (Bauer et al., 2008), and tall closed humid forest on the North Kwe range (Sadlier and Swan, 2009a). The more recent records, particularly those from humid forest and those reported here for preforestier habitats, indicate the species is more widespread in the region but difficult to detect. A more recent IUCN assessment that has taken these factors into account has lowered the level of perceived threat to the species to 'Vulnerable'.

The skink *Simiscincus aurantiacus* has been categorised as 'Endangered' under modified IUCN conservation criteria (Sadlier and Bauer, 2003). The species has a very restricted distribution and prior to the studies of canopied maquis and humid forest habitats in the Kwe Nord basin had only been recorded from three sites in southern New Caledonia: Mt Koghis, Pic du Pin and Forêt Nord. Its presence in maquis paraforestier habitat at site G during the 2009 survey of the 10-20 year mine plan and from similar habitat during the 2008 survey of the 5-10 year mine plan, and humid forest of the Kwe Nord range clearly indicates it is likely to be more widely distributed over the Goro Plateau. *Simiscincus aurantiacus* appears to be a

specialised burrower that utilises the matrix of crevices beneath the forest floor, it has never been observed active, all records coming from searching beneath potential sheltering sites, pitfall traps or captured on glue-traps. Lizards dependent on humid forest habitats and with a predominately fossorial behaviour are usually susceptible to desiccation and require a humid microhabitat to survive. During extended periods of dryness larger areas of forest are likely to maintain the necessary conditions for species with high moisture requirements to persist. However, the recent field surveys of canopied maquis habitat on areas of broken cuirasse cap have shown that other habitat types can provide the required microhabitats for moisture dependent species. The extent of occurrence of *Simiscincus aurantiacus* in maquis preforestier habitat is most likely dependent on the suitability of the subterranean microhabitat produced by the cuirasse cap that underlies much of the canopied maquis habitat on the Goro Plateau.

The skink, *Caledoniscincus cf. atropunctatus* is a regional endemic to forested habitats in southern New Caledonia, primarily humid forest and canopied maquis on ultramafic surfaces. These forested habitats on ultramafic soils are typically present as isolated patches, often small in size, and as such are vulnerable to a range of threats that include:

- potentially high and widespread level of threat from infestation by the introduced Little Red Fire Ant (*Wasmannia auropunctata*).
- potentially high level of threat, particularly small isolated patches, through repeated firing of adjacent maquis habitat, leading to loss and degradation of the forest edge.
- localised threat to isolated forest patches and gully forests on ultramafic soils through loss or degradation of habitat from activities associated with mining.

Although widespread in canopied maquis on the Goro Plateau the extent and suitability of canopied maquis habitat outside the Grand Sud is likely to be more limited in extent, and the species distribution in the more northern parts of its range in particular is likely to exist in highly fragmented humid forest habitat. For these reasons it could be conservatively ranked as ‘Lower Risk– near threatened’ using modified IUCN conservation criteria of Sadlier & Bauer (2003).

4.2 Significance of canopied maquis on the Vale Inco mine site: Surveys of canopied maquis habitat located within the Vale Inco mine plan during 2008 and 2009 have examined a total of 14 individual sites in the area proposed for development of the mine. From these and other studies a total of 13 lizard species have been recorded in canopied maquis habitat. This is a diversity approaching that found in humid forest (~20 species expected - Sadlier, 2006). Nearly all the species recorded from canopied maquis also occur in humid forest, including a number of moisture sensitive species (*Marmorosphax tricolor, Sigaloseps deplanchei*; *Simiscincus aurantiacus*, *Nannoscincus mariei* and probably *Caledoniscincus cf. atropunctatus*). The distribution and abundance of these species in canopied maquis habitats on the Goro Plateau is most likely directly related to the presence of suitable moist microhabitat, with the humidity level in the microhabitat likely to influence susceptibility to desiccation, and the carrying capacity (availability) of invertebrate prey. The canopied maquis sites studied generally had abundant leaf litter and those on the plateau area of the mine plan sat on an extensive matrix of broken cuirasse. These attributes in combination provide humid sheltering sites for the secretive species and layers of ground debris for invertebrate prey to live in. In this way canopied maquis provides an extension of suitable habitat to a number of species that would otherwise be largely reliant on the scattered humid forest patches found in the Grand Sud.

The more common and widespread skink species on the study area, *Caledoniscincus cf. atropunctatus* and *Marmorosphax tricolor*, were proportionally widespread in both open to low canopied maquis habits and tall canopied maquis habitats at sites across the study area. The skink *Sigaloseps deplanchei* was also a common and widespread skink species on the study area. It showed a distinct preference for tall canopied maquis habitat on the 5-10 year mine plan but was more evenly distributed across both low and tall canopied maquis on the 10-20 year mine plan. The reason for this difference in distribution across low and tall canopied maquis habitat by *Sigaloseps deplanchei* is not obvious, but could be an artifact of the different weather conditions encountered in the two survey periods, with drier conditions during the 2008 survey limiting activity (and detection) in low canopied maquis habitat. The

records of the skink *Simiscincus aurantiacus* are both from tall preforestier habitat. The species has a limited distribution in the Grand Sud and has been categorised as 'Endangered' under modified IUCN conservation criteria (Sadlier and Bauer, 2003). *Simiscincus aurantiacus* is a specialised burrower that utilises the matrix of crevices beneath the forest floor, and the extent of its occurrence in canopied maquis habitat is most likely also dependent on the suitability of the subterranean microhabitat. The cuirasse cap that underlies much of the canopied maquis habitat on the Goro Plateau provides a subterranean environment that buffers desiccation and act as refugia during unseasonably dry periods. For the skinks *Marmorosphax tricolor*, *Sigaloseps deplanchei* and *Simiscincus aurantiacus* in particular canopied maquis not only extends the overall distribution of these otherwise primarily humid forest inhabiting species, but also provides a degree of connectivity between populations in the scattered and isolated humid forest patches in the region. The connectivity provided by canopied maquis could facilitate gene flow between populations in different humid forest patches, and assist in re-colonization of humid forest patches in the event of localized extinction or population crashes, such as it might occur with infestation by the Little Red Fire Ant or other invasive species.

Canopied maquis also provides habitat for two species of gecko, *Bavayia goroensis* and *Bavayia cf. sauvagii* which are so far only known from the Grand Sud, and a further two species, *Bavayia septuiclavis* and *Eurydactylodes symmetricus*, which are restricted to the southern ultramafic ranges. *Bavayia goroensis*, *Bavayia septuiclavis* and *Eurydactylodes symmetricus* are also known to occur in humid forest habitat and less frequently open maquis shrubland. In this respect canopied maquis again provides a habitat that contributes significantly to the overall distribution of these species in the Grand Sud. In the case of *Bavayia cf. sauvagii* the distribution of the species on the Goro Plateau (as well as in humid forest in Forêt Nord), and generally within the Grand Sud, seems to be linked with the availability of surface rock which provides sheltering sites. The extensive cuirasse broken cap on which much of the canopied maquis in the Grand Sud provides optimal habitat for this species, as reflected by the relatively high densities recorded in the 2008 survey of canopied maquis habitat on the 5-10 year mine plan. However, the forest dependent giant geckos in the genus *Rhacodactylus* (*R. ciliatus*, *R. sarasinorum* or *R. lechianus*) were

not recorded from canopied maquis habitat during the course of the 2008 or 2009 surveys of these habitats on the Vale Inco mine plan, despite the latter two being known to occur in nearby humid forest habitat at the Special Reserves Forêt Nord and Pic du Grand Kaori.

The importance of the humid forest and canopied maquis on the Goro Plateau for the conservation of the lizard fauna assumes a higher level of significance when viewed in a broader regional context. The humid forest and canopied maquis in the region are generally free of the introduced invasive Little Red Fire Ant that has infested much of the coastal forest in southern New Caledonia. The presence of this ant appears to have a significant negative impact on lizards (Jourdan et al., 2001). The lizard populations in the numerous canopied maquis fragments in the region represent a number of independent populations separated by areas of suboptimal (open maquis) habitat. While discontinuity of canopied maquis habitat in the region can be viewed in a negative context in limiting gene flow between populations, it may conversely reduce the potential for widespread infestation of the Little Fire Ant in the region, and leave some lizard populations unaffected. As such the canopied maquis habitats of the Goro Plateau operate to provide an extension of forest habitat and connectivity with and between humid forest patches, but in other cases isolated patches of canopied maquis can provide 'island' areas in which the lizard fauna may persist in the face of widespread impacts in the region by virtue of being refugia (though this also makes them very vulnerable to catastrophic events). In this way a mosaic of both interconnecting and discontinuous canopied maquis on the Goro Plateau can collectively contribute to the long-term conservation of forest-dependant lizards in the south of the island. In this respect maintaining a network of well managed canopied maquis habitat on the Goro Plateau may significantly enhance the overall ability of forest habitat in the region to maintain lizard diversity, and is likely to have similar benefits to other fauna.

5. RECOMMMENDATIONS.

5.1 Reestablishment of canopied maquis habitat on mined sites: The field studies in canopied maquis on the 5-10 year and 10-20 mine site have identified the importance of a diversity of sheltering and foraging sites on the ground floor utilised by secretive skink species *Marmorosphax tricolor*, *Sigaloseps deplanchei* and *Simiscincus aurantiacus*. In particular the broken cuirasse cap of the forest floor most likely plays a major role in providing sheltering sites buffered from extended periods of dryness. This microhabitat also provides sheltering sites for the locally restricted gecko *Bavayia cf. sauvagii* and for *Bavayia septuiclavis*. Re-establishment of canopied maquis or forested habitat on mined areas should also include re-establishment of sheltering sites at ground level for these re-vegetated sites to be suitable for re-colonization by lizard species from adjacent areas. Further, re-establishment of lizard populations on re-habilitated areas of the mine plan will require suitable source populations from habitat adjacent to the mine area. Such key sites need to be identified and a system of reservation, protection and management put in place to ensure that source populations persist and can be linked with re-habilitated sites in the future. To maintain viable source populations the sites selected should be monitored for invasive species and control measures put in place in the case of infestation. Also, corridors between source populations and designated for re-establishment of canopied maquis habitat on the mine site will be required to allow the movement of moisture dependent species to the areas to be re-colonised.

5.2 A Regional Reserve System for canopied maquis habitat: Canopied maquis habitats are poorly represented in the existing Provincial reserve system in the Grand Sud. Conservation of this habitat would assist in maintaining overall lizard biodiversity within the region, and in particular enhance the distribution and abundance of humid environment dependent species. A network of well managed canopied maquis habitat on the Plaine des Lacs/Goro Plateau would also provide similar benefits to other fauna. Surveys of canopied maquis throughout the Grand Sud are required to identify key areas suitable for reservation to maintain species diversity and abundance of the lizard fauna in the region. These surveys need to be accompanied by comparative studies on the key invertebrate resources in canopied

maquis habitat, particularly with respect to habitat with, and without, a broken cuirasse surface.

6. SUMMARY

Survey work on the canopied maquis of the Vale Inco year mine site and adjacent areas has identified a moderately rich lizard fauna of 13 recorded species, including several regionally significant species and one of high conservation concern. Most species found in canopied maquis will also be found in the interior of humid forest in the region, at similar or greater densities. In this sense canopied maquis extends the distribution of a large portion of the lizard fauna found in humid forest, and provides some connectivity between forest patches for these species. Nearly all the species of lizards found in canopied maquis on the Vale Inco mine area have also been recorded from humid forest on reserves in the Grand Sud; however, these reserves are small and separated, and reservation of intervening areas of canopied maquis would provide a greater potential for some level of connectivity between forests and potentially a more effective reserve system for forest dependent lizard species. Conservation and long-term management of areas of canopied maquis adjacent to areas to be re-habilitated is required to provide source populations for successful re-establishment of lizards on the mine area at the cessation of mining activities.

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