A Survey of the Lizard Fauna of the Proposed Goro Nickel Mine Site

Goro Nickel

Final Report

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1 Introduction

1.1 Background

New Caledonia has a rich and diverse lizard fauna. Currently 65 species of lizard are recorded from the Grande Terre, and a significant number of new species await description as a result of recent field and laboratory research. In particular genetic studies currently being undertaken show an exceptional number of cryptic species exist. Aside from a few species of geckos that are widespread in the Pacific region most of the lizard species recorded from New Caledonia are endemic to the island.

The endemic lizard fauna comprises two families, the Gekkonidae and the Scincidae. On the main island and Ile des Pins species richness of skinks (44 described species) is double that of geckos (21 described species). These figures are expected to increase substantially, possibly by as much as 25% with the description of new species. A number of species are relatively widespread throughout the remainder of the island, but others show varying levels of regional to localised endemism. Some of these local and regional endemics have very restricted distributions and specific habitat preferences, and are likely to be of particular conservation concern. The extensive ultramafic block in the south of the island is recognised as a distinctive zoogeographic sub-region with a suite of endemic lizard species (Bauer & Sadlier, 2000).

Some species are highly specialised in their biology and are likely to require special management. Conservation of the giant geckos in the genus *Rhacodactylus* is particularly problematic given that virtually nothing is known of population densities, home range, or diet for the majority of species. Other species are highly dependent upon moist forest habitats.

Previous field research in the survey area is limited to brief and opportunistic collections made at Foret Nord, and a single site in maquis preforestier habitat at Route de la mine as part of a study of maquis fauna by IRD biologists. Elsewhere in southern New Caledonia opportunistic (non-structured) collections of lizards have been made on the east coast at Goro and near Yate, in the central mountain chain at Riviere Bleue, and at various sites near Noumea and Mon Dore.

At the request of Goro Nickel a survey of the proposed Goro Nickel mine site was undertaken in December 2003. The aim of this survey was to identify the composition of lizard species in a broad range of habitats within and adjacent to the proposed mine and its operations (hereafter survey area). In particular it attempted to identify the degree to which individual lizard species relied on the different microhabitats present in or adjacent to the survey area.

1.2 Sites Surveyed

IRD botanists have identified a suite of up to seven habitat types in the survey area. These habitat designations (listed below) also form the basis upon which I.R.D. biologists will undertake an invertebrate survey focusing on the myrmecofaune:

1. forêt rivulaire
2. forêt à *Arillastrum gummiferum*
3. maquis paraforestier à *Arillastrum gummiferum*

4. maquis paraforestier à *Gymnostoma deplancheanum*
5. maquis arbustif ouvert et fermé sur sol ferralithique
6. maquis ligno-herbacé sur pentes érodées et de piedmont
7. maquis de sols hydromorphes ou à hydromorphie temporaire

Where possible two sites for each of the major habitat types were surveyed (Table 1). The location of these survey sites in most instances corresponds to those sites already identified by I.R.D. biologists for survey work on the myrmecofaune.

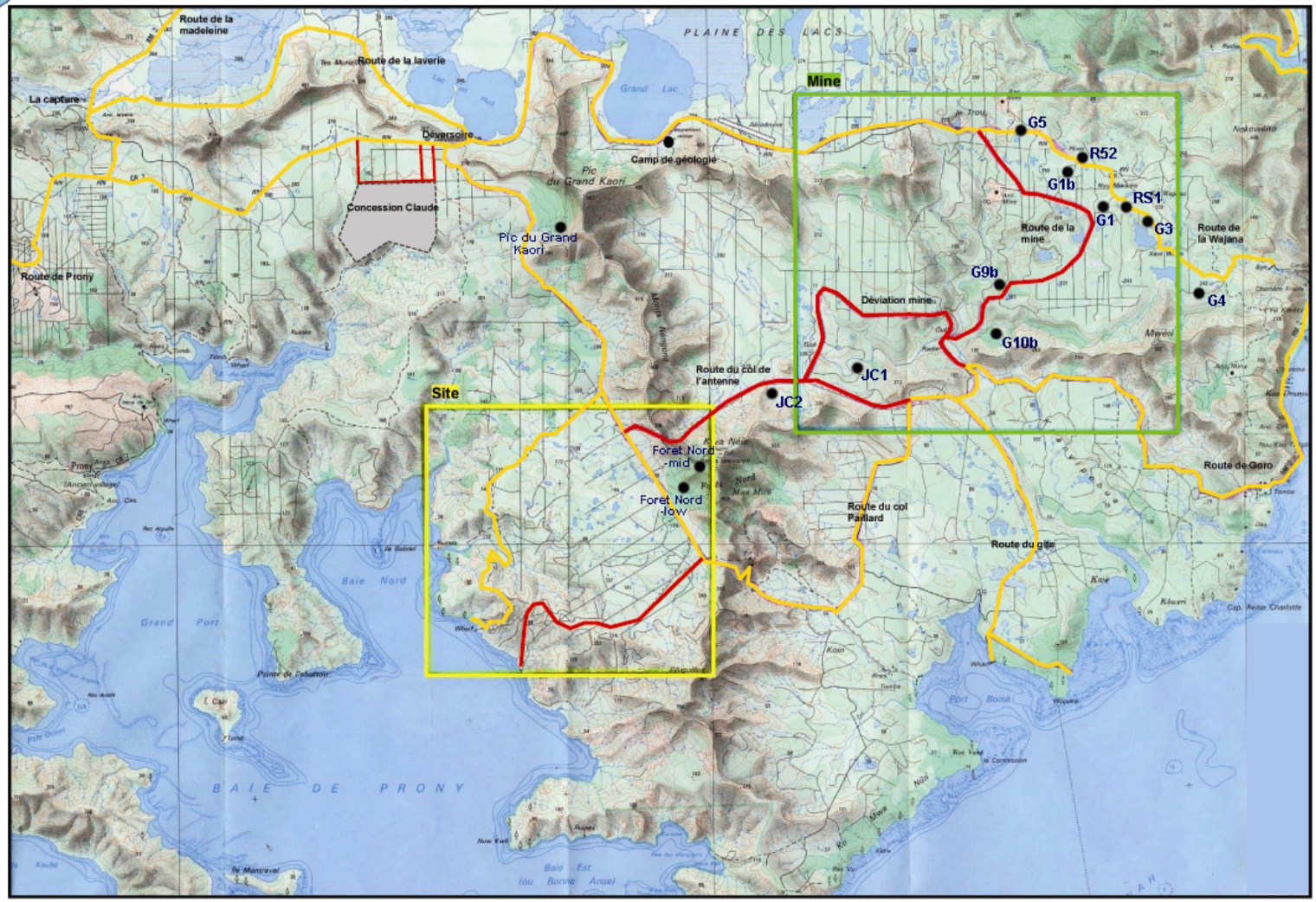
Closed forest habitat on Foret Nord adjacent to the proposed area of mining activity (upper slopes of Foret Nord; lower slopes of Foret Nord;) and at Pic du Grand Kaori were also surveyed – these may not necessarily correspond to sites identified by IRD but were identified as significant sites for lizards in the region.

Table 1. Sites surveyed December 2003

Habitat	SiteCode	Location	Co-ordinates
Closed Forest (3 sites surveyed)		Pic du Grand Kaori Foret Nord - low Foret Nord - high	22°17'05"S 166°53'42"E 22°19"28"S 166°54"51"E 22°18"55"S 166°54"47"E
Forêt Rivulaire (1 site surveyed)	G4	Route de la Wadjina	22°17'35"S 166°59'33"E
Arillastrum Forest (2 sites surveyed)	G6 G10B	Route de la mine Route de la mine	22°16'52"S 166°57'13"E 22°18'10"S 166°57'39"E
Maquis paraforestier of *Gymnostoma* (3 sites surveyed)	G3 G5 G5B	Route de la Wadjina Route de la Wadjina Route de la Wadjina	22°17'04"S 166°58' 57"E 22°16'26"S 166°57'43"E 22°16'09"S 166°57'35"E
Maquis paraforestier of *Arillastrum* (1 site surveyed)	G9B	Route de la mine	22°17'47"S 166°57'33"E
Maquis arbustif (2 site surveyed)	G1 G1B	Route de la Wadjina Route de la Wadjina	22°17' 06"S 166° 58' 44"E 22°16'35"S 166°58'38"E
Herbaceous maquis (2 sites surveyed)	JC2	Route de la col de l'antenne Foret Nord - mid	22°18"29"S 166°55"35"E 22°18"55"S 166°54"47"E
Maquis on cuirasse (3 sites surveyed)	JC1 RS1 RS2	Route de la col de l'antenne Route de la Wadjina Route de la Wadjina	22°18'18"S 166°56'25"E 22°16'49"S 166°59'01"E 22°16'26"S 166°58"32"E

The maquis paraforestier à *Gymnostoma deplancheanum* sites G5 and G5B chosen by IRD along Route de la Wadjina were a special form of this habitat and are identified on detailed botanic maps as maquis preforestier à *Gymnostoma* et *Metrosideros* and will be referred to as maquis preforestier hereafter.

Sites d'activités Goro Nickel 2003




Closed forest - Forêt Nord


Closed forest - Forêt Nord

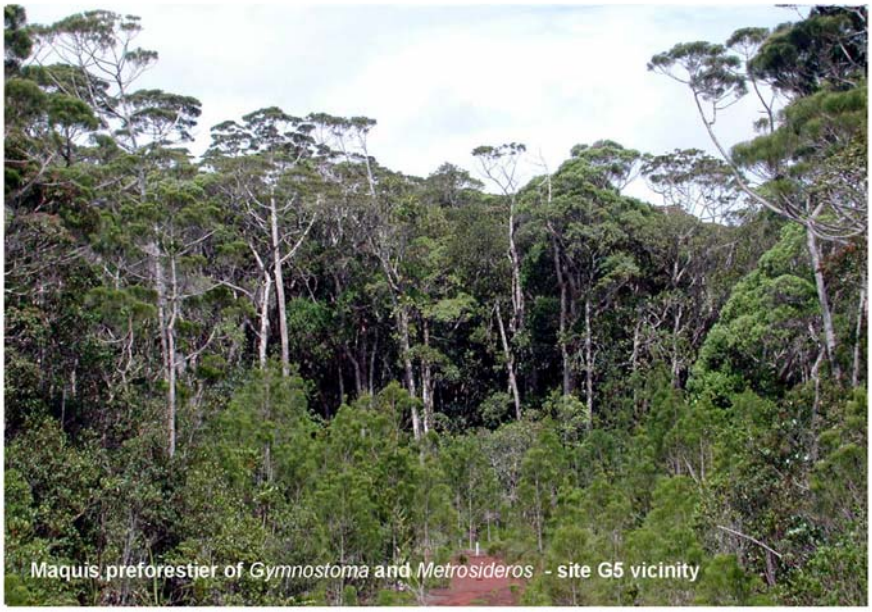

Closed forest - Pic du Grand Kaori


Forêt Rivulaire - Site G4


Arillastrum forest - site G6 from distance


Arillastrum forest - site G10b


Arillastrum forest - site G10b


Maquis preforestier of *Gymnostoma* and *Metrosideros* - site G5 vicinity


Maquis preforestier of *Gymnostoma* and *Metrosideros* - site G5


Maquis paraforestier of *Arillastrum* - site G9b


Maquis arbustif - site G1


Maquis arbustif - site G1b


Herbareous maquis on ridges, habitat for *Lacertoides pardalis*


Maquis on cuirasse

2 Search Methodology

Most lizard species can be assigned to one of four very broad groups based on behaviour and habitat preference:

- secretive species that shelter and forage below the surface of the ground cover.
- diurnal surface active species that tend to forage and bask on the surface of the ground cover.
- diurnal surface active species that are arboreal in habits and tend to forage and bask on the trunks and foliage of trees, occasionally being active on the surface of the ground cover.
- nocturnal species that forage by night in low shrubs, small trees, or the forest canopy (sheltering by day in vegetation or under ground cover).

Skinks make up the first three groups, while geckos make up the fourth group.

Species in the first group are found by day by searching beneath potential sheltering sites, or by pitfall trapping. The success of active day searching for secretive species is highly dependent upon the quantity of sheltering sites that can be investigated. Pitfall trapping has not been used widely in lizard surveys in New Caledonia to date. However, lizards collected as 'by-catch' from invertebrate surveys that have used pitfall traps indicate that in some areas this technique will detect secretive species. Where such sites have also been searched for reptiles by examining shelter sites, the catch from pitfall traps often indicates a greater abundance than suggested by the day searches. Pitfall traps do require an investment of time to establish (the greater the size of the trap used the greater the time to install it), and require monitoring on a regular basis.

Previous experience in the survey area and elsewhere in maquis habitat indicated that pitfall trapping would be logistically very difficult in most maquis habitats because of the very shallow depth of soil into which to place the traps. Deep traps are required to collect a full range of reptiles. Also very few species of secretive of lizards were expected to occur in maquis habitats other than moist maquis preforestier. For this reason searching for secretive species was limited to opportunistic searching of shelter sites where and when such opportunities presented themselves.

Day searches for diurnal surface active and arboreal species can only effectively be undertaken during reasonable weather conditions, preferably warm with some periods of direct sunshine. The presence of some sunshine was particularly important in habitats with an extensive tree canopy cover such as maquis preforestier, maquis paraforestier, or *Arillastrum* forest. Diurnal day searches consist of the observer quietly moving through the survey site to detect the presence of active or basking lizards.

Nocturnal searches are usually undertaken in the first three hours after sunset. The technique used is to detect the reflection from the eye of a gecko when a beam of light is directed towards the animal, or at closer range to visualise 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 is particularly suitable for detecting smaller geckos of the genus *Bavayia*. However, to be effective it generally requires a minimum search distance of 10 -15 m and is best used along road verges or in more open

habitats. At this distance it is often not possible to accurately identify the species of gecko, and a co-worker is needed to collect the gecko while the first observer keeps the animal in sight from a distance.

2.1 Timing

The optimal period for reptile survey work is when reptile activity is high ie. the early to mid summer months when temperatures are warm. For this reason the survey was conducted in December, the first available period for both the principal investigator and assistant to the investigator.

2.2 Search Effort

Survey sites generally consisted of a relatively homogenous block of habitat approximately 50 m x 25 m or less in area.

Most sites received a standard search effort as follows:
Timed diurnal searches 2 persons x 1 hour x 2 occasions = 4 hours per site.
Timed nocturnal searches 2 persons x 30 minutes x 2 occasions = 2 hours per site.

Timed diurnal searches involved two people moving through a survey site of relatively uniform habitat. The search by each person would involve a number of independent walks over the site, trying to cover new areas on each transect. The number of individuals observed was recorded and where possible voucher specimens for each species observed were collected.

Timed nocturnal searches involved two people moving along an open area of the survey site (often a track or path).

3 Results

Seventeen species of lizards (ten skinks seven geckos) were recorded from the survey area during the course of the December survey, and an additional species of gecko is known from previous research.

3.1 Distribution of species by habitat

3.1.1 Widespread species - five species (*Bavayia septuiclavis, Caledoniscincus atropunctatus, Caledoniscincus austrocaledonicus, Lioscincus nigrofasciolatum,* and *Tropidoscincus variabilis*) were widespread in the study area, in that they were recorded from a range of both maquis and forest habitats. The gecko, *B. septuiclavis*, is a regional endemic being restricted the very south of the island (Bauer & Sadlier, 2000). The other four species are widespread on the Grande Terre.

3.1.2 Species recorded mainly from closed forest habitats - one species, the skink *Marmorosphax tricolor*, was widespread across the various forest habitats being recorded from closed forest, *Arillastrum* forest, and maquis preforestier. Another species, the gecko *Bavayia* cf *sauvagii*, was also recorded mainly from these forest habitats during the course of the survey, but was also recorded from a single individual in maquis sur cuirasse habitat.

The giant gecko *Rhacodactylus sarasinorum* was recorded only from the taller more structurally diverse closed forest and *Arillastrum* forest, and the gecko *Bavayia robusta* and one skink *Sigaloseps deplanchei* were recorded only from closed forest. Another species of gecko, *Bavayia geitaina*, was recorded mainly from closed forest on the upper slopes of Foret Nord. This habitat characteristically has steep slopes with numerous outcropping rocks on the forest floor. *Bavayia geitaina* was also recorded in adjacent maquis habitat that similarly had numerous outcropping rocks. The geckos' *R. sarasinorum* and *B. robusta* are regional endemics. Both species are restricted the very south of the island (Bauer & Sadlier, 2000).

3.1.3 Species recorded mainly from maquis habitats - one gecko, *Rhacodactylus auriculatus*, was widespread in the study area, being located in nearly all maquis habitats surveyed. This species is also found at or within the edge of closed forest habits. Two species of skink, *Lioscincus tillieri* and *Lacertoides pardalis*, recorded only from maquis shrubland in this survey, are highly restricted in their habitat preference and distribution. *Lioscincus tillieri* is restricted to maquis but has been recorded from a variety of types of open maquis at a number of locations of different elevations in the south of the island. During the survey *L. tillieri* was found only in herbaceous maquis and maquis on cuirasse habitats. *Lacertoides pardalis* appears to be highly habitat specific. It is known only from herbaceous maquis on ultrabasic rocks habitat on the crest of the range of Foret Nord – the only confirmed localities being along the track to the antenna.

3.1.4 Species recorded from atypical or unusual habitats - two small species of skink, *Nannoscincus mariei* and *Cryptoblepharus novocaledonicus*, were each recorded from only a single survey site in maquis habitat. Their occurrence in this habitat type is regarded as unusual given the known preferred habitat type of each species.

Nannoscincus mariei was only recorded from maquis arbustif habitat. It is a secretive burrowing species that is usually found only in moist forest habitat. However, the site from which it was recorded has a low, relatively continuous canopy, a deep layer of leaf litter, and extensive layer of jumbled rocks at and below ground level that provided the appropriate microhabitat requirements for this species. Curiously, it was not found in moist closed forest sites in the survey area.

The small skink, *Cryptoblepharus novocaledonicus*, was recorded from a single site in maquis on cuirasse habitat. The species is normally restricted to shoreline habitats. Its occurrence at this site appears to constitute a viable but isolated population of this species. Two similar sites were surveyed elsewhere in the survey area but the species was not recorded at either of these.

A small species of gecko, *Bavayia* cf. *cyclura*, was also recorded from a single individual in each of two different types of forest-like maquis. It is difficult to assess the preferred habitat of the small gecko, *Bavayia* cf. *cyclura*. It appears to be a member of the *Bavayia cyclura* species group new to science, and unknown outside of the study area. This group of geckos typically shelter under the bark of standing trees or in tree hollows. Its occurrence in two maquis habitats with a moderate to low canopy (maquis preforestier and maquis arbustif respectively) is compatible with what is known of the general habitat preferences for members of this species group. However, the low detection rate for *Bavayia* cf. *cyclura* (one individual from each habitat) does not permit a confident assessment of the species habitat preferences. Identification of the species involving both morphological and genetic analysis is currently being undertaken.

Table 2. Distribution of species by site.		G4	G6	G10 B	G3	G5	G5B	Foret Nord high	Foret Nord low	Pic du GK	G1	G1B	JC1	RS1	RS2	JC2	Foret Nord mid	G9B	Southern Endemics
SCINCIDAE	*C. atropunctatus*	*	*	*	*	*			*	*	*	*						*	
	C. austrocaledonicus	*	*	*	*	*		*	*	*	*	*			*	*		*	
	C. novocaledonicus												*						
	L. pardalis																*		*
	L. nigrofasciolatum	*				*			(*)		*	*							
	L. tillieri														*		*		*
	M. tricolor		*	*		*		*	*										
	N. mariei											*							*
	S. deplanchei								*	*									*
	T. variabilis	*	*			*		*		*						*			*
GEKKONIDAE	*B. cf. cyclura*					*					*								*
	B. geitaina							*									*		*
	B. robusta							*											*
	B. cf sauvageii			*					*	*					*				*
	B. septuiclavis		*	*	*	*	*	*	*	*	*	*							*
	R. sarasinorum			*				*	*	*									*
	R. auriculatus	*		*	*	*	*	*	*	*	*				*		*		
	R. leachianus							(*)											
	TOTAL	5	6	6	4	8	2	9	9	8	6	5	1	0	4	2	4	2	11

3.2 Species richness of habitats

3.2.1 Forest - the richest habitats in terms of number of species were three 'forest' types from which a total of 14 species are recorded, and included closed forest (13 species), *Arillastrum* forest (8 species), and maquis preforestier (8 species).

The skink fauna recorded from of all three 'forest' habitats was very similar. Only the distribution of one species remains problematic. The small and secretive species *Sigaloseps deplanchei* was only recorded from forest at the base of Foret Nord and Pic du Grand Kaori. The presence of another skink species dependant on moist forest, *Marmorosphax tricolor*, in all habitats indicates that suitable conditions exist. The species is usually detected by active searching beneath sheltering sites such as rocks and logs. The low number of suitable sheltering sites in *Arillastrum* forest or maquis preforestier and maquis paraforestier limited the opportunities to detect *S. deplanchei* in these habitats.

There are obvious differences in the distribution of some geckos between the 'forest' sites. Differences in structural diversity between the forests, particularly in the presence and structure of large emergent trees, is likely responsible for the presence or absence of the giant geckos and larger species of *Bavayia* in certain habitats. One species of gecko found mainly in forest habitat, *Bavayia geitaina*, was highly dependant upon the presence of extensive areas of jumbled rock, and was recorded only from the steep slopes of the ranges at Kwa Neie.

Nearly all the species of skinks and geckos recorded from all closed forest sites combined were also recorded at Foret Nord, and three species, the geckos *Bavayia geitaina*, *Bavayia robusta*, and *Rhacodactylus leachianus*, are so far only recorded from that location. Foret Nord offers access to forest at the base and mid to upper parts of the range. There are significant differences in the forest structure and the type of ground cover on the forest floor between forest at the base of the range and that situated on the steeper upper slopes. The distribution of certain lizard species at Foret Nord may reflect this diversity of habitat structure, as appears to be the situation between the two geckos *Bavayia* cf *sauvagii* and *Bavayia geitaina*. In Foret Nord *B.* cf *sauvagii* has only recorded from forest at the base of the range while *B. geitaina* has only been recorded from forest on the upper slopes where extensive rock outcropping dominates the forest floor. This is very similar to the situation on Mt Koghis where although the two species occur in the same general area *B. geitaina* occurs primarily in extremely rocky areas (Wright et al., 2000).

The *Arillastrum* forest sites were in some aspects structurally similar to the closed forest sites surveyed, but were significantly smaller in size. With only a few exceptions most of the species recorded from closed forest could be expected to occur in *Arillastrum* forest. The likely occurrence of the giant gecko *Rhacodactylus leachianus* in this habitat is particularly difficult to assess as this large species probably has a complex biology.

3.2.2 Maquis – species diversity within lower maquis habitats (excluding maquis preforestier and paraforestier) in the survey area appears to be highly influenced by the structural diversity of the vegetation.

The greatest diversity of lizards found in low maquis habitats was in the maquis arbustif (sites G1 and G1B) from which seven species in total were recorded. This total includes a small gecko (*Bavayia* cf. *cyclura*; site G1), that could represent a species new to science. This species is only known from another individual recorded in maquis preforestier (site G5). Both maquis arbustif sites surveyed had a mosaic of dense and open vegetation, the open areas having a sparse to moderate groundcover of shrubs while the more closed in areas had a moderately dense canopy, but fewer understory shrubs and relatively thicker leaf litter and debris coverage on the ground. Five of the seven species recorded from maquis arbustif were species widespread in both maquis and forest habitats, but one, *Nannoscincus mariei,* normally is associated with moist forest habitats.

Species diversity in maquis habitats lacking multi-layered structural diversity in the vegetation is typically low at individual sites. It is, however, the preferred type of maquis habitat for the only maquis restricted species in the south of the island, *Lioscincus tillieri*.

Six species were recorded from the two herbaceous maquis sites, a habitat with a typically very dense understory of low shrubs and grasses but little emergent vegetation. Two of these species, the skink *Lacertoides pardalis* and the gecko *Bavayia geitaina*, have localised distributions on the survey area that are dependent upon the presence of extensive outcropping rock as sheltering sites. The remaining four species would be expected to occur in similar habitat throughout the region.

Five species were recorded from three maquis on cuirasse sites, but each was only recorded from a single survey site in this habitat. The record of the skink *Cryptoblepharus novocaledonicus* at site JC1 represents an atypical and unique population of what is normally a coastal species. The low number of observations for any particular species in cuirrase habitats and the differences in species composition between sites make it difficult to draw any conclusions of the lizard fauna in this habitat type, other than that most species appear to be represented in very low densities, and that the distribution of species in this habitat is likely to be discontinuous.

3.3 Significant species

3.3.1 Regional and local endemics - two species, the skink *Lacertoides pard*alis and gecko *Bavayia* cf. *cyclura*, are known only from within the vicinity of the study area.

Lacertoides pardalis is recorded only from herbaceous maquis on the upper part of the ridges on Kwa Neie. Information on the species biology is limited but indicates it is dependent upon the outcropping rocks on the ridges for shelter. Similar habitat in the region was located only on the crest of ranges in the immediate vicinity of the study area. Disturbance in the immediate vicinity of known populations is likely to have an adverse affect on local populations.
Bavayia cf. *cyclura* appears to represent a species of gecko new to science. It was recorded only from two sites, one located in maquis arbustif, the other in maquis preforestier. Its presence in an area proposed for development is likely to represent one of the most significant conservation issues for reptiles in the survey area. Activity

associated with mining has at this stage been limited to the incursion of roads and tracks. The route de la mine has already created a division in the maquis preforestier habitat. The impact of this road as a barrier to movement of reptiles between the two areas of maquis preforestier will become more pronounced as more intensive activity as mining operations accelerate. Extensive clearing of adjacent maquis habitat is likely to adversely affect the forest microclimate, and in turn affect the suitability of this habitat for the gecko.

A number of species of lizards have been identified as 'southern endemics', species restricted to forest or maquis habitats on ultramafic soils in the south of New Caledonia (see Table 2). Eleven of the species recorded from the study site (approximately two thirds the total number of species recorded) were southern endemics. Of these five species were recorded mainly from 'forest' habitat, three only from maquis habitat, and three from both maquis and 'forest' habitats (see Table 2).

Four of the southern endemic species (*Bavayia robusta*, *Bavayia* cf *sauvagii*, *Rhacodactylus sarasinorum*, and *Bavayia septuiclavis*) have distributions that are restricted to the far south of the island, with distributions only extending as far north as Mt Ouin or Mt Koghis. Disturbance to populations of these species within and adjacent to the survey area is likely to represent a more significant effect on the overall distribution than for the more widely distributed species.

3.3.2 Species of Particular Conservation Concern – a recent assessment of the conservations status of the endemic New Caledonian lizard fauna (Sadlier & Bauer, 2003) has identified those species most at risk, based on the extent and nature of a species distribution and perceived threats.

Three species of gecko recorded from the study site, *Bavayia geitaina*, *Rhacodactylus sarasinorum* and *Rhacodactylus leachianus*, are listed as 'Vulnerable', and one species of skink, *Lacertoides pardalis*, as 'Endangered'.

Bavayia geitaina is known from a limited number of locations each representing an isolated sub-population (Sadlier, R. A. and A. M. Bauer. 2003), and appears to have very specific microhabitat requirements, usually being recorded from areas of forest with extensive outcropping rock on the forest floor. The species is categorised as Vulnerable because of its small and fragmented distribution and the presence of a range of potential threats across its distribution. The population on Kwa Neie is the only known sub-population south of Bois de Sud.

The giant geckos *Rhacodactylus sarasinorum* and *Rhacodactylus leachianus* are regarded as at risk from a range of threats because of their large size and likely complex biology (Bauer & Sadlier, 2000; Sadlier, R. A. and A. M. Bauer. 2003). *Rhacodactylus sarasinorum* is known from a limited number of forest sites in the south of the island, each representing an isolated sub-population, whereas *R. leachianus* has a much broader distribution being widespread throughout the length of the island, but is rarely common at any locality on the Grande Terre. Because of their large size and low densities both species are likely to be affected by the presence of exotic species, in particular rats are likely to prey upon eggs and juveniles, and cats on juveniles and adults. The Little Fire Ant has been identified as significant threat to lizard diversity and abundance in forest habitats (Jourdan et al., 2001), and if introduced to closed forests in the survey area is likely to affect local populations of

both species. Adult and juvenile *R. sarasinorum* have been observed foraging low in the canopy and one adult was discovered sheltering in a small standing tree that was also a long-term nest site. Such behaviour would bring this species into frequent contact with ants, whereas adult *R. leachianus* tend to forage and shelter higher in the forest canopy (although nest sites at or near ground level have been recorded on several occasions). Most coastal closed forests in the region are heavily invaded by the Little Fire Ant, and the persistence or long-term viability of either species in these forests is doubtful. The closed forests and *Arillastrum* forests in the survey may represent the only areas of forest free of the Little Fire Ant, and the populations of *R. sarasinorum* from forests may be the only ones in the region likely to survive in the long-term.

The skink *Lacertoides pardalis* is categorised as 'Endangered' because of its highly localised distribution in combination with several high levels of threat to the only known population. The proximity of the mine activities and main access roads place this population at risk from increased occurrence of fire, disturbance, and the introduction of pest species. Elsewhere in the vicinity of mine operations disturbance to the species' preferred habitat could result in local extinction of other populations that might exist in the area.


Lacertoides pardalis - **local endemic**


Bavayia cf *cyclura* - **local endemic**


Rhacodactylus sarasinorum - **regional endemic**

3.4 Significant sites and habitats

Forest sites within the survey area are considered to be of significant conservation value for lizards. They contain a high diversity of lizard species including a number of species restricted to this habitat type. Collectively the closed forest habitats, *Arillastrum* forest, and maquis preforestier and maquis paraforestier within or adjacent to the survey represent some of the least affected forests in the region. They are generally present as small and scattered patches isolated from each other by more extensive areas of maquis habitat. This degree of fragmentation has effectively created 'island' situations, for which there are advantages and disadvantages to the resident lizard populations. Because of their geographic isolation from nearby coastal forests, the forest patches in the survey area have been subjected to a lower level of direct and indirect impact from human activity until recent times. In particular they are relatively free of the invasive Little Fire Ant that has infested most of the coastal forests in the south of the island. However, the populations in these forest patches are also highly susceptible to a number of problems such as invasion of exotic species, drought, and fire on the forest edge.

3.4.1 Closed Forest – closed forest at Foret Nord and Pic du Grand Kaori had the greatest diversity of lizard species. Several species of lizards were only recorded from this habitat during the course of the survey. At Foret Nord the 'Vulnerable' gecko *Rhacodactylus sarasinorum* were relatively abundant in forest, particularly on the upper parts of the range. The invasive Little Fire Ant has infested much of the coastal forest in southern New Caledonia and appears to have had a significant negative impact on lizards. Observations made during opportunistic survey work at Port Boise, Prony, and Yaté in recent times has shown lizard populations in general to be lower in abundance than expected. These trends need to be quantified, but given the probable loss or reduction in abundance of many lizard species inhabiting coastal forests affected by invasive ants the lizard populations of Foret Nord and Pic du Grand Kaori are likely to be particularly important for the long-term conservation of these species in the region. This is particularly the case for the giant gecko *Rhacodactylus sarasinorum*.

3.4.2 Maquis preforestier of Gymnostoma and Metrosideros – this unusual forest type has been identified on the survey area by IRD botanists in the area either side of Route de la mine near its intersection with Route de la Wajana and sampled at adjacent sites G5 and G5B. These sites contained a high diversity of lizards (8 species), including the gecko *Bavayia* cf. *cyclura* that possibly represents an undescribed species known only from one other survey site. Maquis preforestier (and maquis paraforestier) may also act as a both a refuge and partial corridor or 'stepping stone' for long term migration of moist forest dependent species between the larger blocks of isolated closed forest habitat.

3.4.3 Arillastrum forest – Structurally this forest type is similar to the closed forests at Foret Nord and Pic du Grand Kaori, but is less diverse than 'closed forest' in terms of the overall number of lizard species recorded. Two forest dependant species (*Rhacodactylus sarasinorum* and *Marmorosphax tricolor*) were recorded from *Arillastrum* forest. Populations of these species are also considered of significant conservation value for their long-term survival in the region (see 3.4.1).

3.4.4 Herbaceous maquis with outcropping rock – suitable habitat for the endangered skink *Lacertoides pardalis* was identified near the crest of the ranges south and north (Monts Nengone) of the col de l'antenne (Kwa Neie), on the ranges bordering the southern edge of Plaine des Lacs, and the range located between Route de Goro and Route de la Wajana. Suitable habitat was not observed to the north and west of the survey area along the road to Noumea or along the road north to Madelaine and the Lac de Yate, but did occur around Col de Yaté. Given the very limited distribution of suitable habitat on the study site and in the region, activities (roads or clearing) along or near the crest of the ranges that degrade the quality of the preferred habitat are likely to adversely affect populations in the immediate area of activities. The species appears to be very wary and continued disturbance, even in a small area, is likely to affect individuals in the area of activities.

3.4.5 Maquis on cuirasse (site JC1) - a population of the small skink *Cryptoblepharus novocaledonicus* was located in this habitat (site JC1 on Route de la col de l'antenne). This species is normally restricted to shoreline habitats, its occurrence 5km inland is significant in representing an unusual extralimital population of this species.

4 Recommendations

4.1 Primary objectives for conservation of the lizard fauna

The recommendations outlined below address the needs of species of conservation significance or habitats of conservation significance within and adjacent to the study area. These recommendations are aimed at maintaining reptile species diversity and the survival of significant species at a local and regional level.

It is important to note that we do not make specific recommendations for the conservation of individual species that are widespread and common in the survey area, or for habitats with low lizard species diversity or without significant lizard species. The impact of the proposed mining operations on these lizard species or habitats of lower conservation concern will be at a very localised scale and have minimal effect on the long-term survival of these species in a regional context. However, the cumulative impact of more than one mining operation in the region will have a greater negative impact on the long-term conservation of these species in the region.

It is the responsibility of the Service de l'Envonnement Province Sud and the various mining companies in the region (including Goro Nickel) to consult as to how to approach the problem of rehabilitation of mined areas, including reinstating the faunal diversity that existed prior to mining. Such rehabilitation of the maquis habitat for reptiles will require restoration of the structural diversity of the present before mining, including the soil and leaf litter structure, and rock configuration if any but the most common and widespread habitat generalists among the lizard fauna are expected to inhabit the restored mined area.

4.1.1 Foret Nord and Pic du Grand Kaori - conservation of these sites is crucial to maintaining overall lizard biodiversity within the study area, particularly for forest

dependant species. These sites are also important for conservation of the giant gecko *Rhacodactylus sarasinorum* in the region. Maintaining the integrity of the forest microclimate is essential to the structural diversity of the forest edge and the adjacent interior of the forest.

Because of their proximity to the main mining camp and access roads these forests are particularly susceptible to a range of threats with increased activity associated with the mining operation, and from increased access to the area by virtue of the improved roads. Prevention of fire, the prevention of introduction of invasive species, and the impact of dust or toxic air-borne by-products of ore extraction process are key issues in conserving the lizard fauna at these sites.

Buffer zones of undisturbed native maquis vegetation should be set aside where mining associated activities are proposed in the vicinity of closed forests, in order to prevent loss of humidity near the forest edge and increased penetration of light into the forest. Increased light penetration and at the forest edge promotes weed growth and overgrowth of the understory, while decreased humidity levels dry out the forest edge making it unsuitable for moisture sensitive species. Access to the forests should be limited by construction of effective barriers, and policed by security personnel.

The close proximity of the chemical nickel ore extraction plant to the forests and the presence of intensive vehicular activity on unsealed roads and near the forest will create dust and air-borne pollutants that will affect the quality of adjacent forest habitat. Most lizards rely on water droplets for moisture. Geckos in particular are likely to be affected as they forage amongst foliage and lick droplets of water on leaves for moisture. The suitability of leaves and tree stems for these activities will be reduced by the presence of high levels of dust or toxic air-borne by-products of ore extraction process. Measures to reduce or eliminate dust levels should be implemented before intensive mining activity commences. Goro Nickel needs to establish if areas of forest are likely to be subject to air pollution and the potential toxicity of those pollutants.
Regular monitoring of the forests for invasive ants is recommended during the life of the mining activities. The impact of cats or rats is also likely to become a problem with increased human occupation in the area, particularly for giant geckos. It is recommended that monitoring of the rat populations be undertaken and that appropriate control measures are undertaken in the event of increased numbers of pests. It is also desirable to monitor selected species of reptiles to track long-term trends in abundance should any of the invasive species problems identified become established in the forests.

4.1.2 Arillastrum forest and maquis preforestier of Gymnostoma and Metrosideros - conservation of these habitats will assist in maintaining overall lizard biodiversity within the study area. *Arillastrum* forest is particularly important for conservation of the giant gecko *Rhacodactylus sarasinorum* in the region. Maquis preforestier is a structurally diverse moist forest habitat. It is also one of two only known sites for the undescribed gecko *Bavayia* cf. *cyclura* which may be a local endemic.

Clearing close to the forest will affect aspects of the microclimate of the forest. Adequate buffer zones are required to maintain the integrity of the forest edge and the

adjacent interior of the forest. Fire breaks in the buffer area may also be required to ameliorate against the spread and intensity of fire.

It is recommended that the maquis preforestier of *Gymnostoma deplancheanum* et *Metrosideros* identified by I.R.D. botanists be reserved (with appropriate areas of adjacent vegetation to act as buffer zones), and that the impact from existing development in or near this habitat (roads and access tracks) be minimised. Significant large patches of *Arillastrum* forest in or adjacent to the survey area need to be identified and reserved, and buffer zones of native maquis vegetation should be set aside where mining associated activities are proposed in the vicinity of these forests. Access to the forests should be limited by construction of effective barriers.

4.1.3 Habitat for the endangered skink Lacertoides pardalis – the main threat to the endangered skink *Lacertoides pardalis* in the survey area is likely to come from mining associated activities on the crest of the ranges. The construction of new access roads through this habitat, or increased traffic on existing roads (including modification of Route de l'Antenne), could have an adverse affect upon individuals in the immediate area of development, particularly at the time of development (by blasting or mechanical disturbance to exposed rock outcrops or embankments). It is recommended that unspoiled areas on the crests of the ridges in survey area (and adjacent areas) be kept free from further development.

Fire, particularly high intensity fires or too frequent firing of the same area is likely to alter the structure and density of the thick ground-cover that typifies this habitat, and to reduce the suitability of the habitat for the species. Fires in the survey area need to be controlled before they reach the crest of the ridges.

4.1.4 Cryptoblepharus novocaledonicus population – it is recommended to preserve the area of maquis on cuirasse from which the population of the skink *Cryptoblepharus novocaledonicus* was recorded.

4.2 Ongoing studies

Ongoing studies are suggested where:

- knowledge of species of high conservation significance is insufficient to adequately assess the impact of potential developments on the species survival at a local and/or regional level. This study may take the form of targeted survey work.
- monitoring of likely indicator species could detect perturbations in the 'health' of populations (short-term fluctuations and/or long-term declines in abundance) in habitats of high conservation significance for lizards within or adjacent to the survey area.

4.2.1 Targeted Surveys Bavayia cf. cyclura and Lacertoides pardalis.

The most important subjects for further study are the preferred habitat and distribution of the two locally endemic lizards *Bavayia* cf. *cyclura* and *Lacertoides pardalis*.

Field research is required to fully assess the distribution and habitat preferences of the possibly undescribed gecko *Bavayia* cf. *cyclura* at three different topographic levels:

- in both maquis preforestier of *Gymnostoma deplancheanum* et *Metrosideros* and maquis arbustif habitats on the on the northern side of the study site from the area in which the species is known.
- in similar habitat within the survey area to identify other areas inhabited by this highly localised species that are likely to be impacted upon by proposed mining activities.
- in the preferred habitat (as determined by the results of the above surveys) in areas outside the survey area to determine whether the species has a wider distribution in the region.

Survey work is likely to require extensive hours of night spotting to obtain meaningful results. Over the period of the survey work undertaken by us only a single individual was observed in 4 hours of night searching at two maquis arbustif sites. The second individual was collected opportunistically during 8 hours of day searching in two maquis preforestier sites (though most day searching effort was put into observation of active lizards), but was not observed in 4 hours of night searching at these same two sites.

Field research to determine the distribution and habitat preferences of the skink *Lacertoides pardalis* is required to fully assess the significance of the only known population that occurs in rocky habitat on the ridge crests from near the col to the antennae. Extensive development is proposed for this area in the future. Field research is required in similar habitat within the survey area to identify other areas inhabited by this highly localised species, particularly sites likely to be impacted upon by proposed mining activities. If possible it would be useful to extend this study to determine the species potential distribution in a broader regional context. Suitable habitat outside the survey area might be identified from aerial photographs and depending on accessibility checked for the occurrence of the species. This survey work will need to be targeted and require use of specialised trapping techniques such as pitfall traps or small mammal traps.

4.2.2 Monitoring of closed forest at Foret Nord and Pic du Grand Kaori.

These two forest sites have been identified as having an exceptionally rich lizard fauna of high conservation significance at a regional level, and includes two species of giant gecko identified as threatened at a national level. Monitoring of these sites for a suite of selected reptile species is required to track short-term and long-term changes in abundance of these species that could result from increased human activity in the area, and the proximity of the processing plant and roads.

Invasive species have been identified as a particular threat to the conservation of the lizard fauna of these closed forests. Cats, rats, and the Little Fire Ant are all known or suspected of having a deleterious effect on the abundance of a range of lizard species. Monitoring for invasive species should be pro-active and programs to monitor for these should be established as soon as possible – not once the problem becomes apparent.

Concurrent monitoring of a sufficiently broad range of lizard species to detect a range of potential threats should be carried out at both sites. Small geckos and the giant gecko *Rhacodactylus sarasinorum* are likely to be affected by excessive predation

pressure (and associated stress) from cats and/or rats, and by the presence of invasive ants. Night surveys are required to establish base-line levels of abundance for these lizards that will allow both the impact of these invasive species and the success of recovery actions to be measured. Similarly changes in abundance of the small and common forest dependant skink *Caledoniscincus atropunctatus* detected by day searches can provide another measure of the impact of invasive ants, should this occur. Alternatively a suite of both surface active and secretive skink species could be monitored by a programme of pitfall trapping. This technique, once the traps are established, is effective in obtaining objective measures of abundance free of the problems associated with observational data with regard to the skills of the surveyor.

Target species will differ with habitat type and objective of the monitoring – the advise of a consultant herpetologist should be sought when determining the species and approach to monitoring.

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Appendix A Consultant Details

ROSS A SADLIER – PRINCIPAL INVESTIGATOR

Museum Position Collection Manager/Herpetology Section of the Australian Museum, Sydney

Qualifications B.Sc. Macquarie University, Sydney 1986

Employment

1996 – present	Collection Manager, Herpetology Section of the Australian Museum
1980 – 1996	Technical Officer – Scientific, Herpetology Section of the Australian Museum

Research Interests

- Species diversity of New Caledonian lizards and relationships of New Caledonian lizards
- Regional surveys of the lizard fauna of New Caledonia
- Conservation of the lizard fauna of New Caledonia

Relevant Experience

Extensive field research experience in the region including more than 20 separate trips to New Caledonia (including the Loyalty Islands group) since 1979 (most of these since 1990).

Collaborative field research Conservation International and Province Nord Government) of 5 areas in Province Nord for assessment as to suitability for reservation (June and November 1996). This was the first such surveys to be conducted in the province.

Collaborative field research with I.R.D. Noumea (April & September 2000) on biodiversity and impact of introduced fire ants on the reptile fauna of endangered sclerophyll forests.

Collaborative field research with I.R.D. Noumea (February 2002) to inventory the fauna of maquis shrubland in the Tontouta Valley and Plaine des Lacs regions.

Collaborator with Whitaker Consultants on 'Research on the lizards of Province Nord, New Caledonia, with special reference to threatened species and the herpetofauna of threatened or restricted habitats' a project funded by Department of Economic Development and Environment, Province Nord. This project ran for 2 years investigating numerous areas not previously surveyed in the northwest of the Grande Terre and resulted in the discovery of a significant number of new species of lizards.

Publications

Over 25 scientific publications on New Caledonian lizards including the description of 26 new species of lizards from the region (approximately 40% of the known endemic lizard fauna).
Co-author in the recently published book 'The Herpetofauna of New Caledonia' with Aaron M. Bauer – the only complete monograph of the islands herpetofauna.

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DR GLENN M SHEA – ASSOCIATE INVESTIGATOR

Position

Senior Lecturer, Faculty of Veterinary Science, University of Sydney

Research Associate, Herpetology Section of the Australian Museum

Qualifications

Ph.D., University of Sydney, 1992

B.V.Sc.(Hons.), University of Sydney, 1983

Employment

2000 – present	Senior Lecturer, Faculty of Veterinary Science, University of Sydney
1993 – 1999	Lecturer, Department of Veterinary Anatomy and Pathology, Faculty of Veterinary Science, University of Sydney
1989 – 1992	Senior Tutor, Department of Veterinary Anatomy, Faculty of Veterinary Science, University of Sydney
1985 – 1989	Tutor, Department of Veterinary Anatomy, Faculty of Veterinary Science,University of Sydney

Research Interests

Species diversity and phylogenetic relationships of the lizards and snakes of Australia and surrounding regions, particularly the families Scincidae, Pygopodidae, Typhlopidae and Elapidae.

Distribution and habitat preferences of the lizards and snakes of Australia and surrounding regions.

Reproductive biology of the lizards and snakes of Australia and surrounding regions.

Relevant Experience

25 years of field research experience with the reptiles of Australia and surrounding regions, including two trips to Fiji, one to Papua New Guinea, and two to New Caledonia.

Reptile and amphibian surveys with Dr J. Broadbent for MacDonald-Wagner Pty Ltd (1984), Mr R. Sadlier for NSW Dept of Environment and Planning (1984), Dr J. Juvik (University of Hawaii) in Fiji (1990), Dr A. Greer for NSW Property Services Group (1993) R. Sadlier and G. Swan in reserves of Western NSW (1995-2003).

Publications

Over 120 scientific publications on the reptiles of the Australian region, including two on the New Caledonian herpetofauna (see below). Co-author of the recently published book "A Field Guide to Reptiles of New South Wales" (2004. Reed New Holland Publishers), co-editor of the book "Blauzungenskinke. Beiträge zu *Tiliqua* und *Cyclodomorphus*." (2000. Natur und Tier - Verlag, Münster), consultant editor of "Reptiles & Amphibians" (2002, Fog City Press, San Francisco) and of the reptile and amphibian chapters in "Animal Kingdom" (2000. Five Mile Press, Noble Park, Victoria. Contributed chapters to "Fauna of Australia. Vol. 2A. Amphibia & Reptilia" (1993. Australian Government Publishing Service, Canberra) and "Herpetology in Australia. A Diverse Discipline" (1993. Royal Zoological Society of New South Wales, Mosman).

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