Frieda River

Frieda River Limited

Sepik Development Project

Environmental Impact Statement

Appendix 8c – Terrestrial Biodiversity Impact Assessment

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coffey

A TETRA TECH COMPANY

SEPIK DEVELOPMENT PROJECT

TERRESTRIAL BIODIVERSITY IMPACT ASSESSMENT

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A report prepared for Coffey Services Australia Pty Ltd and Frieda River Limited

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EXECUTIVE SUMMARY

This report presents an assessment of the potential impacts of the Sepik Development Project on terrestrial biodiversity values. The assessment first defines the values of the Study Area, it then assesses the potential impacts on them using a mitigation hierarchy of avoid, mitigate, rehabilitate and offset. Biodiversity values have been defined at four scales: broad, intermediate, fine and individual.

Broad Scale: six values were recognised at the broad scale of the entire Study Area:

- Extensive intact habitats. The Study Area Lowland Zone, as part of the Sepik River Basin, is in one of the few floodplains in the world largely unaltered by human activity.
- High biodiversity. The Study Area has high biodiversity: Project surveys recorded a total of 1,418 species of plants, 86 species of mammals, 234 species of birds, 60 species of frogs, 46 species of reptiles, 116 species of odonates and 359 species of butterflies. A further 64 mammal species and 123 bird species could occur. Overall the Study Area Hill and Montane Zones have higher and more specialised biodiversity than the Study Area Lowland Zone, but all Zones are considered to be of high value.
- Species new to science. A range of species new to science were recorded by Project surveys.
- Endemic species. The area is rich in species endemic to New Guinea. Mammals, in particular, have high levels of endemism with over 70% of the species recorded being endemic to mainland New Guinea or smaller areas.
- Migratory and/or congregatory species. The Project surveys recorded small groups of migratory waders in the Study Area but the amount of habitat available is large and suggestive of an area that could accommodate large numbers. Until such times as systematic surveys along the entire Sepik River demonstrate otherwise, the Study Area Lowland Zone must be considered of high value for migratory and other congregatory waterbirds, particularly the off-river waterbodies consisting of shallow lakes and their associated floodplains. Large camps of flying foxes also occur.
- Habitats and biodiversity of cultural significance. Local communities are linked to biodiversity through their largely subsistence lifestyles. The forests and rivers provide the bulk of their needs.

Intermediate scale: five 'Priority Ecosystems' were recognised at this intermediate scale – Peat Forest, Nena Karst, off-river waterbodies of the Study Area Lowland Zone, Montane Forest above 1,000 m asl and the North Coastal Ranges.

- The record of Peat Forest vegetation was the first of this type in PNG. It shows all the features of Peat Forests that are widespread in Southeast Asia.
- The karst habitats in the Study Area stand out as being of particular value. The largest block, the Nena Limestone Plateau, contains large-scale karst features including at least two large dolines that may house the IUCN Critically Endangered Bulmer's Fruit Bat.
- Off-river waterbodies along the Sepik River provide the major habitats for waterbirds and are important nesting and refuge sites for crocodiles and freshwater turtles.
- The Montane Forest above 1,000 m asl supports isolates of a montane mammal community with a highly restricted distribution in New Guinea.
- The North Coastal Ranges are part of a complex of isolated ranges that support a large endemic fauna, particularly mammals and frogs.

Fine Scale: at the finest habitat scale, four 'focal habitats' are singled out as having particular significance:

- Riparian and gallery forests, which act as refuges for fauna in dry times.
- Hilltops, which act as sites for breeding congregations of butterflies.
- Upland streams, which support torrent-dwelling frogs, butterflies, odonates, semi-aquatic rodents and birds.
- Caves, which are critical for survival of cavernicolous bats and swiftlets.

Species Scale: A range of threatened species occur or have the potential to occur in the Study Area including nine species listed as Critically Endangered by IUCN, seven listed as Endangered and 15 listed as Vulnerable. Eleven of these are also protected under the PNG *Fauna (Protection and Control) Act 1966*. A further 26 are protected under the Act but listed as Least Concern or Near Threatened by IUCN.

There are no protected areas in the Study Area.

Potential Project disturbances may mimic natural processes, interfere with them or provide an entirely novel situation. The dynamics of all the vegetation in the Study Area is determined by disturbance. In the Study Area Hill and Montane Zones gap phase dynamics is the major ecological driver of forest composition. While gap phase dynamics operates in all the forests of the Study Area Lowland Zone, hydrology is a major driver there. Fire is a major ecological force throughout PNG and is a significant factor in closed forest dynamics; during droughts even wet forests can burn. The forests most sensitive to fire are: Lower Montane Forest on high ridges, and Swampy Forest in the Study Area Lowland Zone developed on peat substrates.

The role of disturbance in tropical forests tends to make them resilient to disturbance, but the extent, type and duration of disturbance is critical. Short-term, small-scale disturbances can mimic natural gap phase or small-scale catastrophic dynamics. However, major changes to natural dynamics result in system collapse or forest conversion and can be brought about by large scale clearing, continuous small clearings fragmenting the forest, disturbances being too frequent, fire, exotic species invasions, or hydrology being altered. Human activities promoting clearing and fire are the single biggest factor influencing forest loss in PNG.

A range of direct and indirect impacts may occur as a result of the Project development and have the potential to act synergistically on flora and fauna populations and their habitats. Sources of impacts to terrestrial biodiversity values assessed in this report are predicted to occur from: clearing and subsequent edge and barrier effects, habitat loss as a result of creating the reservoir of the integrated storage facility (ISF), contamination of waterways and forests, introduction and spread of invasive species and diseases, and, indirect effects resulting from increased land clearing and hunting as a result of from increased access, increased frequency of fire, and of the effects from implementing social development projects.

Some potential impacts were avoided at the design stage through the choice of concentrate export route, the location of a hydro-power reservoir, the location of sites for mine waste and tailings disposal, airports and transport routes.

A broad range of management measures will form the Biodiversity Management Sub-plan of the Environmental Management and Monitoring Plan. The measures that will be adopted by the Project include specific measures for focal habitats and IUCN Critically Endangered species. In addition, a broad range of measures for other environmental elements are relevant to protecting biodiversity. While forest loss may appear to be the most important change effecting terrestrial biodiversity values, in the longer term, in-migration, invasive species and fire are likely to be the most important processes to control as they can have broad-scale ecosystem-wide effects.

The Project is large and it is estimated that the total footprint of approximately 16,000 ha will result in the clearing or inundation (forest loss) of about 15,400 ha of forest, the remainder being cleared areas, roadside vegetation and river surface. 91% is likely to be permanently lost. This forest loss is concentred in the Frieda and May River Catchments. In total 80% of the total forest losses are of intact or only lightly disturbed forest and mostly Hill Forest. Indirect impacts are predicted to be more severe than direct impacts as a result of in-migration which can be controlled to only a limited extent. This could be further exacerbated by patterns of resettlement should large numbers of people move to higher elevations in the Frieda and May River catchments.

PART 1 INTRODUCTION AND DATA CONSOLIDATION

1. Introduction

This report presents an analysis of the potential impacts of the Sepik Development Project on terrestrial biodiversity and ecology. Figure 1 shows the location of the Sepik Development Project and it is described in more detail in section 11. It consists of four intimately interrelated components: the Frieda River Copper-Gold Project (FRCGP), the Frieda River Hydroelectric Project (FRHEP), the Sepik Power Grid Project (SPGP) and the Sepik Infrastructure Project (SIP). The FRCGP and the FRHEP will produce copper-gold concentrate and electricity respectively from a complex of facilities in the catchment of the Frieda River (Plate 1). They share the largest single element, area-wise, of the Sepik Development Project – the Integrated Storage facility (ISF) - a reservoir used to store water for the generation of electricity and to provide a disposal system for mine waste rock and tailings. They also share, as necessary, internal roads, some of which loop into the neighbouring Saniap catchment, a road connection to a port to be built on the Frieda River and an upgraded Frieda River airstrip to be used in construction. Plate 2 shows the Frieda River flowing into the lowlands near the Frieda River airstrip.

These facilities will be connected to the coast at Vanimo through an infrastructure corridor in which will be co-located a buried pipeline for copper-gold concentrate, a transmission line and road connections. The transmission line, together with associated infrastructure, forms the third component of the Sepik Development Project - the SPGP. The remaining component of the Sepik Development Project - the SIP - consists of the Vanimo Ocean Port, an upgrade of the Green River airstrip to a regional airport and a public road from Green River to Hotmin (the Hotmin Road) within the infrastructure corridor.

Road access between Vanimo and the production facilities will be within the infrastructure corridor firstly along a private newly built mine access road to Hotmin, thence along the Hotmin Road to Green River (which would be public) then along the existing public Vanimo to Green River road.

Henceforth all the FRGCP and FRHEP Project components within the Frieda and Saniap River catchments will be termed the “mine and ISF facilities”, excluding the infrastructure corridor within the catchment.

As Figure 1 shows, the mine and ISF facilities lie to the south of the Sepik River in the foothills of the Schatterburg and Thurnwald Ranges, part of the Central Cordillera of New Guinea. Compared to the ranges to the north the foothills are demarcated generally abruptly from the floodplain of the Sepik River (Plate 2). By contrast the ranges to the north, the Torricelli Mountains and Bewani Mountains, are not as high and there is a much more gradual gradient into the Sepik River floodplain. Plate 3 shows the kunai lowland forest complexes on the slopes leading up to the Torricelli Mountains. In the discussion that follows the Bewani Mountains and Torricelli mountains will be termed the “North Coastal Ranges”[1].

The infrastructure corridor tracks north west from the Frieda River catchment across the hills of the May River catchment (Plate 4) and thence into the Sepik River floodplain where it crosses the Sepik River south of Green River (Plate 5). From thereon it follows the route of the existing Vanimo to Green River road northwards to cross the Bewani Mountains (Plate 6) and descends into the Puwani River catchment (Plate 7) and into Vanimo.

From Vanimo the transmission line will eventually run for approximately a further 39 km to the Indonesian border, but this future section is not included in this impact analysis.

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[1] Technically the Oenake Range and Serra Hills are the “coastal ranges”. However, the term “North Coastal Ranges” has often been used in biodiversity discussions to include various combinations of the high isolated northern ranges of New Guinea and variously includes the Van Rees, Foya, Cyclops, Denake, Bewani, Torricelli and Prince Alexander Ranges.

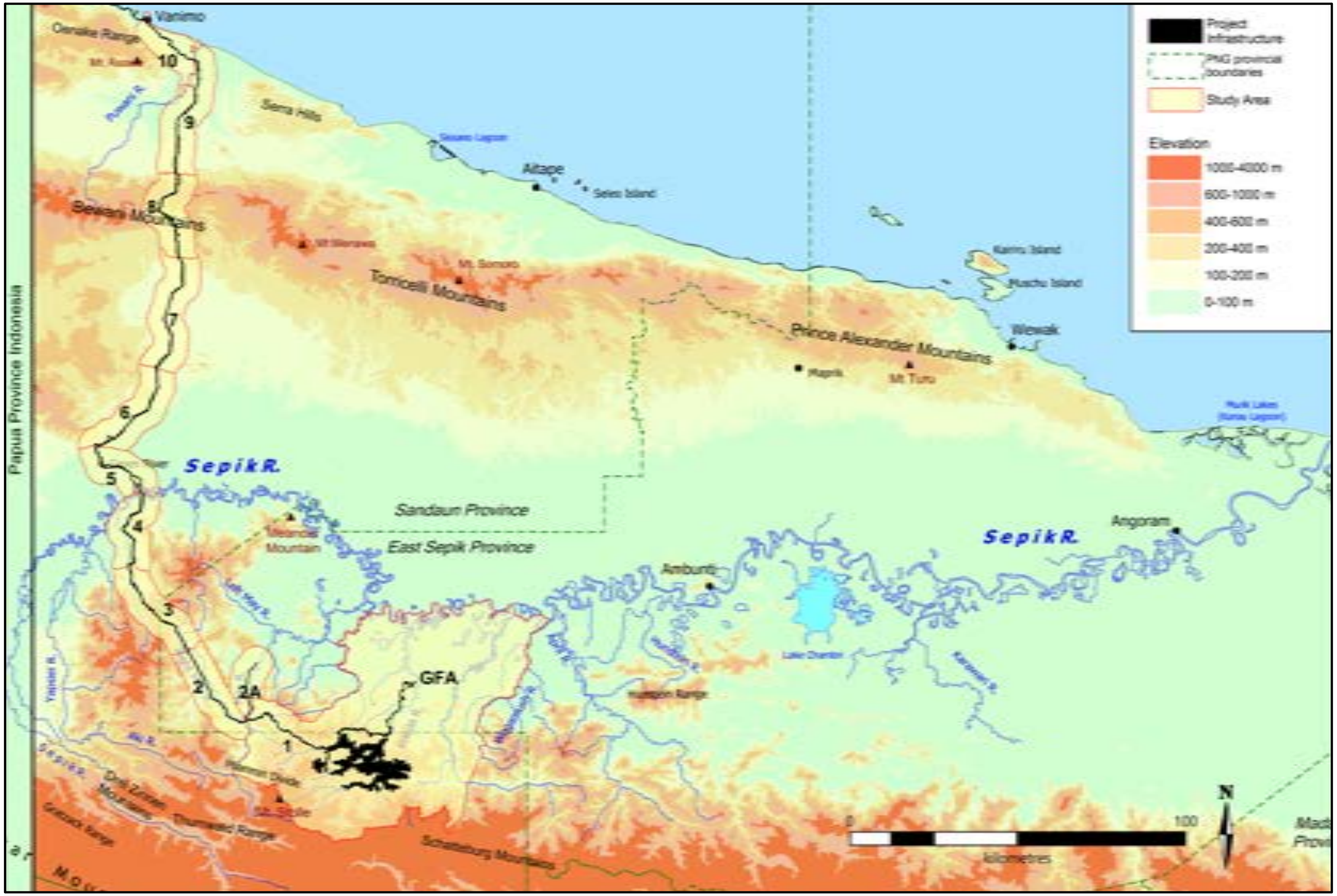

Figure 1 Location of the Sepik Development Project (GFA and numbers refer to Study Area sections (see section 3))

Plate 1 Hill Forests and the Malia River in the Frieda River catchment.

Plate 2 The Frieda River debouching into the lowlands.

Plate 3 Tongues of lowland forest and kunai grassland on the long shallow slope from the Sepik River floodplain to the Torricelli Mountains.

Plate 4 Hill Forests of the Right May River.

Plate 5 The Sepik River south of Green River.

Plate 6 The Vanimo to Green River road through the Bewani Mountains.

Plate 7 Settlements along the Vanimo to Green River road near Sereri Creek.

2. Consolidated Data for Impact Assessment

The impact analysis uses literature information and the biodiversity survey data presented in EIS Appendices 8A and 8B collected specifically for the Sepik Development Project.

EIS Appendix 8A presents results of a series of field surveys carried out between 2009 and 2011, hereafter termed “the 2011 surveys”, for what was then a stand-alone copper-gold project[2]. Surveys for mammals, birds, amphibians, reptiles, butterflies, odonates and flora were carried out at 24 sites and information from interviewing local people was gathered at a further 6 villages or sites (7 for mammals). The choice of biodiversity targets was specified by the then PNG Department of Environment and Conservation (now Conservation and Environment Protection Agency). The locations of the sample sites were dictated by the location of the major project elements at the time and the potential export routes which were to the north to Aitape or Wewak and/or eastwards along the Sepik River to the coast.

Prior to these surveys a scoping study (Crome and Woxvold 2009) had investigated what biodiversity information was available for the area and concluded that most prior work had taken place in the eastern and middle Sepik River floodplain, the Bewani, Torricelli and Prince Alexander Mountains to the north or in the ranges to the south and west. It was concluded that the Frieda River catchment was one of the biologically least known areas of PNG with the only significant biological expedition to the area having been the Kaiserin-Augustafluss (Sepik River) Expedition of 1912–13 (hereinafter called Augusta Fluss Expedition). The only other biological exploration within the Frieda River catchment prior to the 2011 surveys appears to have been a collection of bryophytes reported on in Norris and Koponen (1985), Norris et al. (1988) and Piipo (1986 and 1998). The 2011 surveys remain the most up to date and comprehensive ever gathered for the upper Sepik region.

With the evolution of the older project into the present Sepik Development Project a north-westward, rather than an eastward export route was chosen. The habitats in the section from the mine and ISF facilities to Green River are largely intact and continuous but those along the Vanimo to Green River road over the Bewani Mountains to Vanimo are heavily impacted by extensive logging and clearing. On this basis, and the availability of existing information, surveys were carried out in 2017 at three sites in the May River catchment, hereafter termed “the 2017 surveys”. With the exception of butterflies, the groups surveyed were the same as those in the 2011 surveys. The results are presented in EIS Appendix 8B. The 2017 surveys demonstrated that the May River catchment had more-or-less the same biodiversity as the Frieda River catchment, so the Project surveys can be considered a good inventory of both catchments and the Sepik Development Project area down to the Sepik River south of Green River. Together, the 2011 and 2017 surveys will be termed “the Project surveys”.

EIS Appendix 8A Chapter 1 explains the sampling difficulties associated with tropical faunas and it must be accepted that the Project surveys, or any other, do not produce complete inventories for each small sample site but the total data set approaches an inventory for the overall area. For impact analysis it is also necessary to include species that might have been missed by the Project surveys. An inventory of what other species could occur in the Frieda and May River catchments and the Infrastructure corridor was compiled from extra information available in Appendices 8A and 8B and literature sources[3]. This was possible for mammals, birds and frogs but not for the flora, reptiles, odonates and butterflies.

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[2] This older concept still had an ISF, hydroelectric power facility, infrastructure corridor, and river and ocean ports.

[3] Table 3 in Chapter 3 and Appendix 4.7 in Chapter 4 in the EIS Appendix 8A and Tables 1 and 2 in Chapter 3 in EIS Appendix 8B. Literature sources for mammals were Flannery (1994, 1995), Flannery and Seri (1990), Bonaccorso (1998), Wilson and Mittermeier (2015) and Wilson *et al.* (2017); and for birds – Gillard and LeCroy (1966), Diamond (1967, 1969), Pearson (1975), Pratt and Beehler (2015) Hulme (1977), Lister (1977), Stringer (1977), Whitney (1987), Beehler and Prawiradilaga (2010) and Beehler and Pratt (2016). An overview of the Bewani Mountains herpetofauna is given in EIS Appendix 8B and information on frogs and reptiles is available in Allison & Kraus (2003), Kraus & Allison (2006), Dahl *et al.* (2009), Tallowin *et al.* (2017) and Amphibiaweb (https://amphibiaweb.org).

The taxonomy of all groups of fauna and flora has evolved considerably since 2011 and the nomenclature for EIS Appendix 8A was updated in 2015. However there have been further significant changes since then and the 2017 surveys used the most up to date nomenclature. To consolidate the 2011 and 2017 data the nomenclature was completely updated for all species except butterflies[4].

This consolidated inventory is presented in Annex 4. Birds have been divided into two groups for analysis. Landbirds are species of forest, grassland or swamp forest not dependent upon open or grassy wetlands. Waterbirds are species of open swamps, lakes and lakeside vegetation and include ducks, herons, cormorants, rails, waders, terns, reed warblers etc. Forest dwelling rails are included in the landbirds.

2.1 Zoning

The EIS Appendix 8A divides the region into three altitudinal zones and this is followed here.

Montane Zone consists of primary erosional and colluvial (i.e. slope deposit) landforms comprising the northern foothills of the Central Cordillera above 1000 m above sea level (asl). The main vegetation formation is Montane Forest (see Table 1)

Hill Zone consists of primary erosional and colluvial (i.e. slope deposit) landforms comprising the northern foothills of the Central Cordillera between 100 and 1000 m asl. It includes both continuous hills and ranges, and isolated hills surrounded by areas of active alluviation in the Lowland Zone. The main vegetation formations are Hill Forest and Tall Lowland Forest in more gentle terrain at lower elevations.

Lowland Zone consists of depositional landforms resulting from past or present overbank flooding of the Sepik River and its major tributaries. Its upper altitudinal limit is 100 m asl and is here defined as all lands below 100 m asl. This zone is one of flat lands forming river floodplains and excludes isolated hills that jut out of the plains even where these hills do not reach 100 m asl. These hills are rightly part of the Hill Zone as their vegetation is not subject to the effects of overbank river flooding due to the abrupt gradient change at their bases. Tall Lowland Forest and Swamp Forest are the major vegetation formations.

2.2 Vegetation and habitats

Vegetation and habitat typing follows that used in EIS Appendix 8A which is based on the PNG Forest Inventory and Mapping System (FIMS) (Saunders, 1993a, b; Hammermaster & Saunders, 1995).

It should be noted that while the underlying FIMS system is effective for large-scale use, detailed ground truthing frequently uncovers anomalies in the FIMS categories. Takeuchi in EIS Appendix 8A Chapter 2 discusses some of these anomalies in detail, particularly in reference to alignment with FIMS descriptions and altitudinal extents of forest types. He notes, in particular, that montane forest characteristics extend to lower elevations in the Frieda River catchment than would be expected based on FIMS mapping and that the FIMS mapping does not capture the complexity of swampy forest in the lowlands.

The basic vegetation mapping used was FIMS[5], augmented by

- Vegetation studies carried out by W. Takeuchi (EIS Appendices 8A and 8B).
- Examination of Landsat imagery.
- High-resolution (25 cm) aerial photography of areas likely to be developed for the older FRCGP concept captured in 2008 and 2011.
- Lidar data from 2009 and 2011.
- Helicopter reconnaissance in 2009, 2010 and 2017.
- ClearView™ imagery at 15 m resolution from 2009 to 2011.
- A photographic road survey of the Vanimo to Green River road in 2017.

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[4] Since butterflies were not sampled in the 2017 surveys the original nomenclature in EIS Appendix 8A was not updated and the 2011 inventory is not repeated in Annex 4.

[5] The accuracy of FIMS to assess forest cover has been challenged (Shearman *et al.* 2008, 2009, 2010, Shearman and Bryan 2011) and although Filer *et al.* (2009) criticised the methodology used in these studies, Shearman *et al.*'s (2010) rebuttal of this criticism appears cogent.

- The mapping in Lechner et al. (2018).

Table 1 Vegetation and habitat types

FORMATION	FIMS TYPE	DESCRIPTION
Montane Forest	small crowned forest (L)	Dense to almost closed forest 20 to 30 m high where ferns and epiphytes are common. Trees tend to be thin, and oaks (*Castanopis* and *Lithocarpus*) are common or dominant. This includes small crowned lower montane forest with conifers (L±c).
	small crowned forest with *Nothofagus* (LN)	Small crowned forest with *Nothofagus* dominant.
	very small crowned forest (Ls)	This is very small crowned forest ("elfin" forest) and alpine grassland complexes. It is low, 5 to 15 m high, with thin crooked stems and no emergents.
Hill Forest	medium crowned forest (Hm)	Forest with a canopy 25 to 30 m high and emergents up to 40 m. Canopy closure is 6 to 8 and species composition varies with elevation.
Tall Lowland Forest	large to medium crowned forest (Pl)	Tall well-developed lowland rainforest 30 to 35 m high with emergents to 50 m, an irregular canopy and small to large gaps.
	open forest (Po)	Tall forest of small and medium crowned trees to 30 m high with large crowned emergents up to 40 m. Canopy very uneven with many large gaps. Palms and rattans are common. In low-lying areas, sago palm stands develop, and where they have the opportunity, broad-leaved trees can reach great sizes (greater than 100 cm dbh).
	small crowned forest (Ps)	Forest 25 to 30 m high with a dense even canopy of small crowned trees usually on floodplains with poorly drained or gravelly soils.
Peat Forest	peat forest	Stunted forest developed on a peat dome with extremely low floristic diversity with a preponderance of pole-stem trees with poor crown development and small leaves.
Swamp Forests	mixed swamp forest (Fsw)	Generally low forest, 20 to 30 m high, and a patchy generally even height canopy, usually with a dense understory of sago. The water table where this type develops fluctuates greatly, sometimes daily.
	swamp woodland (Wsw)	A dense tall layer of sago or pandanus with scattered trees over a ground layer of sedges, ferns, grass or bare ground. It is permanently inundated.
	mixed swamp forest/swamp woodland (Fsw/Wsw)	These are complexes of the two previous types
	alluvial wooded swamp complexes (Wsw/FsW)	
Successions	riverine mixed successions (Fri/Wri)	This "type" is actually a sere from areas deforested by river movements and varies from grass through an arborescent-stage community which is nearly always accompanied by the proliferation of vines through to secondary forest. Advanced stages grade into open forest (Po).
Off-river waterbodies	herbaceous swamp (Hsw)	These are open water swamps dominated by water plants and sedges. Waterlilies are very common.
	swamp grassland (Gsw)	Flooded grasslands with sedges and reeds
	lakes	

Not all of the imagery was available over all of the area analysed but some combination was available for the entire Project footprint. The most detailed imagery was concentrated on the areas proposed for facilities in the Frieda River catchment. Examination of imagery allowed a reassessment of the boundaries of cleared and/or degraded areas but was not extended to a complete remapping of all vegetation in the area.

The FIMS types have been grouped into larger formations for mapping. Table 1 presents descriptions of vegetation types and formations. The FIMS system includes an assessment of forest condition based on scoring forest areas between 10, completely intact forest, and 0 (forest all cleared and/or degraded) but imagery analysis allowed a more accurate and simpler condition assessment system to be developed based on a five-point scale (Table 2)

Table 2 Vegetation condition classes

CLASS	CONDITION	DESCRIPTION	FIMS CONDITION CLASSES
A	intact	Old growth or primary habitat with natural levels of small gap disturbance (approx. 1%) and infrequent scattered larger gaps up to 0.5 ha each caused by large wind throws, small landslips or possibly human activity at moderate distances from settlements.	9-10
B	lightly disturbed	Forest with small areas of clearance or disturbance caused by isolated garden plots, or larger landslips. Gaps generally greater than 0.2 ha, and areas of canopy damage or thinning. Generally, occurs adjoining settlements, garden areas, or areas of moderately disturbed forest (Type C)	7-8
C	moderately disturbed	Forest with significant areas of clearance or disturbance caused by numerous garden plots, or larger landslips. Gaps often greater than 05 ha, and areas of canopy damage or thinning. Generally, occurs adjoining settlements, garden areas, or areas of heavily disturbed forest (Type D)	6
D	heavily disturbed or early successional	Forest that has been heavily disturbed by man or large-scale natural disturbance such as extensive landslides or flooding. Consisting of complexes of areas of pioneer, early secondary and other regenerating forests with areas of degraded but intact natural or lightly disturbed forest. Most logged forest is in this class	1-5
E	Cleared	Cleared areas, roadside vegetation, low regrowth	0

Beside the vegetation types and formations used for mapping and analysis in Table 1 more general vegetation descriptors are used in the text as shown in Table 3.

Table 3 General vegetation descriptors

VEGETATION	DESCRIPTION
Gallery forest	Strips of forest edging streams through otherwise open habitat such as grasslands, shrublands or savanna.
Riparian forest	Forest immediately adjacent to waterways (greater than 4 m wide at least flow) within continuously forested areas. Variously developed from mature forest with understory of often specialised stream side trees and shrubs to areas dominated by tall grass or vines and scraggly regrowth.
Mossy forest	Small crowned lower montane forest and Small crowned lower montane forest with conifers with strong development of mosses on the trees and the ground.
Heath	Areas of forest where the vegetation is stunted, usually less than 8 metres tall. Few species of trees with fleshy fruits but nearly all with hardened trunks and branches.
Closed forest	All forested areas where the canopy closure exceeds 60%

3. The Study Area

There is no generally accepted way to define a Study Area for impact assessment. Impacts can vary spatially from the micro scale, such as the loss of a single tree, to the international scale, such as the accidental introduction of an exotic disease that may spread throughout PNG. A fundamental guiding principle, however, is available from the watershed emphasis of Program 6 of the PNG National Biodiversity Action Plan (NBSAP), and IFC performance standard 6, which is that a broad landscape view of project impacts is required.

The Study Area defined here (Figure 2) is based on that defined in EIS Appendix 8A. It has been selected to:

- Cover all locations where proposed Project infrastructure is, has been or may be located.
- Be an area within which the majority of impacts are expected to occur.
- Have some ecological rationale and, as far as possible, have natural boundaries.
- Be an area within which the concept of "local" populations of species has some meaning.

The part of the Study Area encompassing the mine and ISF facilities is based upon that in EIS Appendix 8A. For the infrastructure corridor it was not feasible to define natural boundaries, so a 5 km buffer was used. The infrastructure corridor was divided into 11 sections.

Section 0 – Greater Frieda Area (GFA)

This is the area that contains the mine and ISF facilities of the Sepik Development Project and is based upon the Study Area defined in EIS Appendix 8A modified to include the entire catchment of the Frieda River. It is bounded to the north by the Sepik River, to the west by the Saniap River and the northern catchment of the Usake River down to the May and Upper May Rivers, to the east by the Wogamush, Hewe, Miwe and Tau Rivers, and to the south by the catchment boundary. The GFA rises to over 2300 m asl. The lowlands are vegetated in more or less intact Swamp Forest formations with Tall Lowland Forest on the major river floodplains. There are numerous off-river waterbodies (section 6.3) variously mapped in FIMS as herbaceous swamp (Hsw) and grasslands, which they would be when dry, and a large area of Peat Forest (section 6.1). There is little infrastructure located in the Lowland Zone, with the exclusion of part of the FRHEP access road, the Frieda River Port and temporary accommodation camp. The remaining mine and ISF facilities for the Sepik Development Project, including the HITEK open-pit and production infrastructure for the FRCGP and the ISF for the FRHEP (see section 11), are in the Hill Zone, which is clothed in Hill Forest, mostly intact but with large areas of clearing and gardens along the valleys of the Nena and Niar Rivers associated with Wabia and Ok Isai villages. Other degraded areas in the Hill Zone are from past exploration around the HITEK open-pit and garden areas on the western boundary around Fiak and Amaromin villages. There is little to no infrastructure in the Montane Zone, perhaps just the upper edges of the HITEK open-pit and possibly communication towers. The montane forests have more disturbed areas than the hill forest with gardening moving north from the highlands into the southern parts of the Frieda River catchment. There is an outlier of Montane Forest to the north of the HITEK open-pit.

Section 1 – Process Plant to Hotmin (31 km)

This first section of the infrastructure corridor is contained entirely within the GFA. The first 25 km of the transmission line uses the same pylons as the power supply to the process plant so is included as part of the mine and ISF facilities for impact analysis. From the process plant the corridor tracks southwest to the Nena River then follows the river valley to the north east traversing between 400 and 700 m asl before crossing the watershed at approximately 700 m asl. The route then descends to between 100 and 200 m asl and follows the Usake River for approximately 20 km to the junction of the May and Upper May Rivers at the village of Hotmin in the lowlands at about 75 m asl. This section is entirely Hill Forest and mostly intact except for the approaches to Hotmin village. Elevation along the pipeline and transmission line route ranges between 75 and 700 m asl, elsewhere in this section it rises to 1000 m asl.

Section 2 - Hotmin to the West Range (30 km)

The corridor tracks on the southern side of the Right May River at about 80 m asl northwest through Tall Lowland Forest with some areas of clearing by the river, before crossing a low saddle clothed in Hill Forest then descending into the swampy plains of the May River floodplain and eventually crossing the Right May River (South Branch). Continuing across swampy plains of intact Swamp Forest formations, it crosses the Right May River (West Branch) then continues northwest on the swampy floodplains to the West Range crossing a small hill at 188 m asl 5 km before the end. Elevation along the pipeline and transmission line route ranges between 75 and 188 m asl, elsewhere in this section it rises to 400 m asl overall with one odd 975m peak on the southwest edge. Forest in this section is largely intact.

Section 2A – May River Road (21 km)

The proposed road follows the west bank of the May River north from Hotmin traversing the foot slopes of low hills and crossing swampy lowlands to a temporary port to be used for freighting supplies during construction. Within the corridor low hills rise to 400 m asl but the elevation through most of this section is between 40 and 200 m asl. The vegetation is intact Hill Forest on the hills with Tall Lowland Forest and Swamp Forest in lower lying areas. Elevation along the road route ranges between 40 - 180 m asl.

Section 3 - West Range to Idam 1 (14 km)

This section starts by running close to the west bank of the Right May River through Tall Lowland Forest in the river valleys and Hill Forest on the hills then continues along the valley of a tributary stream before crossing the watershed at approximately 400 m asl. It then descends a tributary of the Tawa River into Tall Lowland Forest with small areas of light disturbance before crossing the Tawa River further to the northwest. From the crossing it tracks north across the floodplain of the Idam River 10 km to Idam 1 village at low elevation, 80 m asl or less, again through lightly disturbed Tall Lowland Forest. Elevation along the pipelines and transmission line route ranges between 80 and 400 m asl, elsewhere in the section it rises to 1200 m asl on the southwest edge.

Section 4 - Idam 1 to the Sepik River (34 km)

From Idam 1 village the corridor travels east of the Idam River skirting the western foothills of a spur of the West Range that rises to 600 m asl crossing various swampy areas and foothills. Vegetation formations are lightly disturbed and intact Tall Lowland Forest and Swamp Forest in lower areas and disturbed Hill Forest on the hills. Bisaiabru is bypassed about 10 km from Idam 1 village. From Bisiabru the corridor tracks across the swampy floodplain of the Sepik River and its tributaries, before crossing the Sepik River. The vegetation is intact Swamp Forest with lightly disturbed Hill Forest on the hills shifting into intact and lightly disturbed Tall Lowland Forest. This latter formation shifts from FIMS type small crowned lowland forest (Ps) to open forest (Po) as the Sepik River is approached. Elevation along the pipeline and transmission line route ranges between 30 and 120 m asl, elsewhere in the section elevation remains below about 120 m asl.

Section 5 - Sepik River to Samunai (20 km)

From the Sepik River the corridor remains in the lowlands at below 100 m asl and tracks 12 km to Green River through Tall Lowland Forest showing various levels of disturbance. This area is Tall Lowland Forest, mostly FIMS open forest (Po) but with patches of high quality large crowed forest (Pl) and cleared areas. It then heads north for 8 km across the floodplain to Samunai and the foothills of the Border Mountains through Tall Lowland Forest. From Green River the pipeline runs alongside the Vanimo to Green River road in roadside vegetation. The transmission line does not follow the road exactly but takes a more rectilinear route between pylons. Elevation along the pipeline and transmission line route ranges between 30 and 100 m asl, elsewhere in the section elevation remains below 100 m asl.

Section 6 – Samunai to the Horden River (30 km)

The pipeline runs alongside the Vanimo to Green River road in roadside vegetation along the eastern foothills of the Border Mountains and the edge of the Sepik River floodplain. The entire area is Swamp Forest with Hill Forest on the hills. The vegetation is mostly intact but heavily disturbed or cleared along the road route. Elevation along the pipeline and transmission line route ranges between 80 and 100 m asl, elsewhere in this section it does not rise to more than 100 m asl except in the Border Mountains which rise to about 500 m asl in the corridor 5 km NW of Samunai. The transmission line does not follow the road exactly but takes a more rectilinear route between pylons.

Section 7 - Horden River to the Bewani Foothills *(38 km)*

The pipeline will be buried alongside the Vanimo to Green River road in roadside vegetation across more or less continuous Swamp Forest at between 100 and 200 m asl. Large areas of this section have been heavily disturbed by logging particularly the last 8 to 9 km the route. Elevation along the pipeline and transmission line route ranges between 120 and 200 m asl, elsewhere in the section elevation remains low not rising to more than 250 m asl. The transmission line does not follow the road exactly but takes a more rectilinear route between pylons.

Section 8 - The Bewani Mountains (30 km)

This section follows the Vanimo to Green River road over the Bewani Mountains which is vegetated in heavily logged Hill Forest. The pipeline will be buried alongside the Vanimo to Green River road in roadside vegetation while the transmission line takes a more rectilinear route between pylons. The pipeline and transmission line routes reach a maximum elevation of approximately 700 m asl before descending to Sumumini at approximately 150 m asl. The highest point in this section is 1100 m asl at approximately 6 km east of where the road reaches its highest point. The central and highest part of this section contains areas of steep unlogged country that the transmission line may traverse.

Section 9 - The Bewani Mountains to the Nemayer River (36 km)

The pipeline and transmission line route in this section traverses the lowlands between 150 and 60 m asl through very heavily logged Tall Lowland Forest with patches of Hill Forest. The route follows the Vanimo to Green River road north 16 km to cross the Boap River at Imbrinis village then northeast for 9 km to the Sereri River. After crossing the Sereri River the road tracks north again for 13 km to the Nemayer River. The pipeline will be buried alongside the Vanimo to Green River road in roadside vegetation while the transmission line takes a more rectilinear route between pylons through heavily disturbed forest.

Section 10 - Nemayer River to Vanimo (21 km)

The final 22 km section into the Vanimo Ocean Port traverses west and northwest along the Vanimo to Green River road across the coastal plain generally skirting along the foothills between 40 and 120 m asl. The vegetation is again heavily logged and cleared Tall Lowland Forest with patches of Hill Forest. The highest points in this section are at about 500 m asl on the section's southern edge. The pipeline will be buried alongside the Vanimo to Green River road in roadside vegetation while the transmission line takes a more rectilinear route between pylons through heavily disturbed forest.

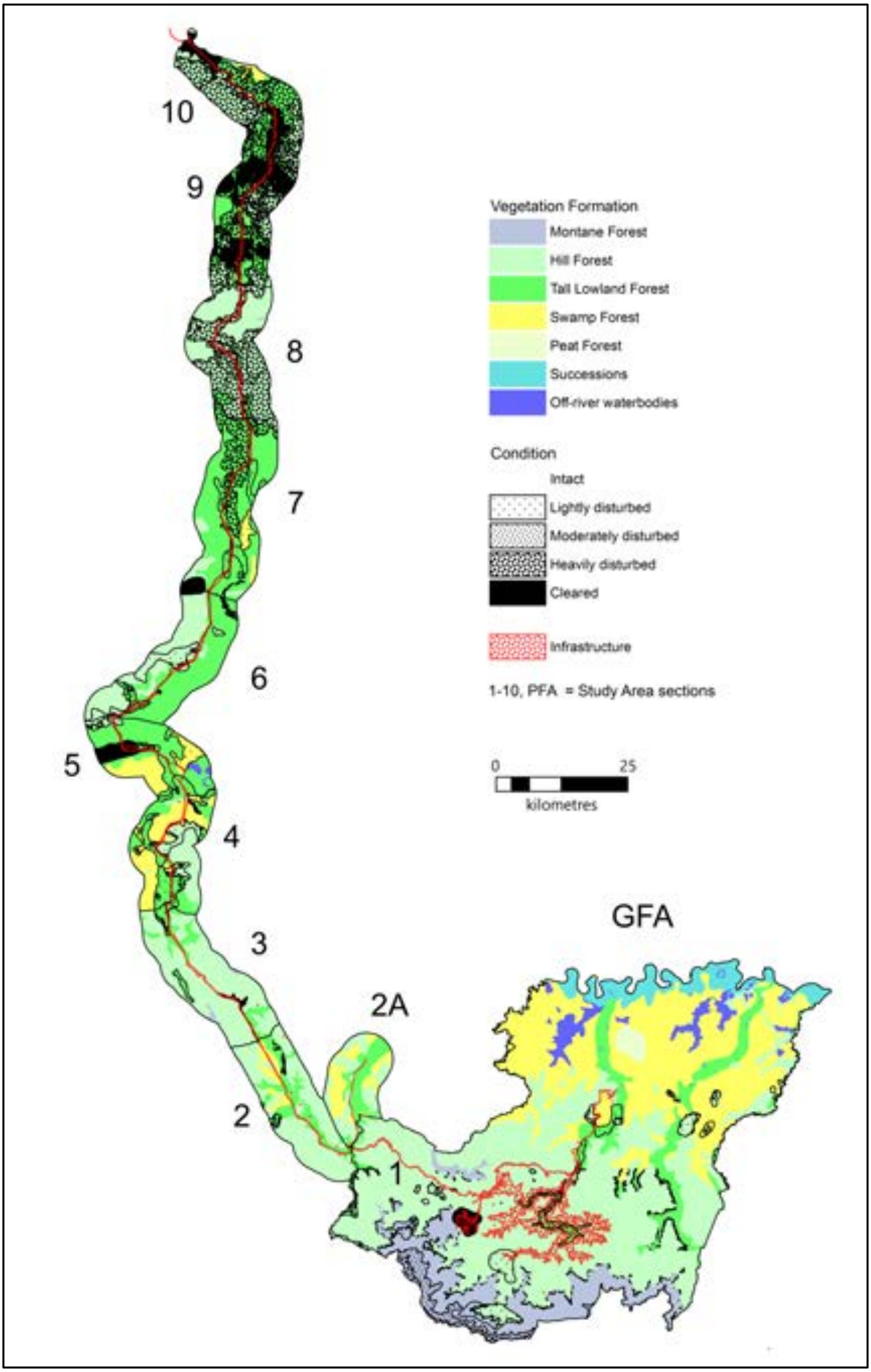

Figure 2 Vegetation in the Study Area

4. Ecosystem dynamics relevant to impact assessment

In order to assess the potential impacts on terrestrial biodiversity of developing the Project, it is necessary to describe natural forest dynamics and the role of various disturbance regimes in habitat functioning. Potential project disturbances may mimic natural processes, interfere with them or provide an entirely novel situation.

4.1 Dynamics in the Hill and Montane Zones

In the Hill and Montane Zones gap phase dynamics is the major driver of forest composition. Gaps from natural tree deaths of one or a few trees form all the time and produce continuous low-level disturbance. Small canopy gaps are a few dozen to a few hundred square metres in area, and seedlings and saplings that have stayed quiescent in the shady understorey are 'released' and grow up to fill the gap. Root suckering is also a common source of regeneration.

The amount of mineral soil is important in determining how a gap is filled. In a gap produced by a tree snapping off the forest substrate remains more-or-less intact and the major change is the product of increased sunshine in the gap. Where a tree has fallen over, and the root ball ripped out of the ground there will be a small area of mineral soil allowing colonisation by pioneer species adapted to sunny mineral soil conditions. As the gap size increases by e.g., wind throws during storms, landslides, logging or mechanical clearing, the area of soil exposed to sunlight or exposed to mineral soil increases allowing colonisation by pioneer and early secondary species.

Large disturbances such as major landslides, fires, intensive logging that removes large portions of forest canopy over large areas, and large-scale clearing produce catastrophic dynamics whereby an entire area regenerates through successional processes from pioneer through secondary stages to intact forest. Where disturbance such as landslides have exposed very large areas of mineral soil, species that can germinate in such conditions and thrive in full sun are favoured over species that need more organic soils and cannot tolerate open conditions. PNG has large areas subject to catastrophic dynamics produced by landslides and the vegetation at Nena D2 survey site is evidence of this (Chapter 3 of EIS Appendix 8A).

Catastrophic disturbances, while a force for maintenance of some forests, can also produce ecosystem collapse and convert closed forest to grasslands or scrublands. The major natural disturbances that would produce catastrophic dynamics in the Hill and Montane Zones are landslides, fires, storms and the scouring of the vegetation from banks of upland and lowland torrential streams by flood surges (Chapter 5 of EIS Appendix 8A).

Fire is a major influence in rainforest dynamics and even the wettest tropical forests can burn during drought years. Past fires, clearing and/or frost can allow grasses and other flammable species to invade forest openings and edges and such species will carry fire indefinitely if there are continuing sources of ignition, further eroding the forest and resulting in permanent grasslands. Fire has had a considerable impact on PNG's forests from the lowlands to the sub-alpine regions and has resulted in major conversions of forest to kunai grasslands, in the highlands and on the ridges leading down to the lowlands of the Sepik River and Ramu River basins. Tropical forest cannot tolerate repeated fires and very wet mossy forest, in particular, is sensitive, usually being destroyed by a single hot fire.

Wildfires need to be distinguished from fire associated with slash and burn agriculture used as a tool for New Guinea gardening. While slash and burn can convert forest to grasslands after prolonged use, the burns that generate gardens are local and small. They may accidentally act as ignition points for larger forest fires but their purpose is to burn debris after felling a small a patch of forest to generate a garden.

4.2 Dynamics in the Lowland Zone

While gap phase dynamics also operate in all the forests of the Lowland Zone, hydrology is a major driver in this Zone. The Lowland Zone is basically a floodplain and floodplains present challenges to ecological understanding (for example see Corenblit *et al.* 2007, Tockner *et al.* 2010, Opperman *et al.* 2010, Tockner and Stanford 2002)[6]. Available qualitative information (Johns *et al.* 2007, Paijmans 1976, 1990) gives a basic picture of vegetation relative to water depth and duration of wet season flooding which can be extrapolated to the Study Area. The transition types in relation to hydrology can be summarised based on the following:

- Lowland open forest (Po) and small crowned forest (Ps) mostly occurs in areas free of flooding but can tolerate flooding for some time.
- Mixed swamp forest (Fsw) and swamp woodland (Wsw)[7] occur in shallow swamps where the water table is at or near the surface for part of the year (Johns *et al*. 2007, Paijmans 1976, 1990). They blend into one another, forest becomes woodland as water depth and flood duration increases.
- Mixed swamp forest (Fsw) can occur in shallow or deep water, moving or stagnant water although it is severely compromised where high energetic river flows last for long periods such as along the Sepik River where riverine mixed successions (Fri/Wri) are a permanent feature (Johns *et al.* 2007, Paijmans 1976, 1990).
- Swamp woodland (Wsw) occurs where flooding is not too deep, and water lies stagnant. As water depth increases it merges into herbaceous swamp (Hsw) and flooded grasslands and eventually into permanent open lakes (Johns *et al.* 2007, Paijmans 1976, 1990).
- Sago occurs throughout these formations and its occurrence can vary from scattered palms in the understory to dense stands. The species grows best in shallow swamps where there is a flow of fresh water. Pure sago stands become permanently stunted in transitions to deep herbaceous swamps and where the water table sinks deep enough to cause water stress (Johns *et al.* 2007, Paijmans 1976, 1990).
- Finally, peat forest occurs on raised peat lenses where the water table is stilted and is maintained by a degree of isolation from normal overbank flows of nutrient rich river water.

FIMS typing does not represent the full complexity of the vegetation here and it is likely that the dynamics may not involve plant communities as such but the ecology of individual species. Hydrology would act to be a primary filter of what species can or cannot thrive and communities detectable on aerial photos may simply represent species associations of varying degrees of permanence. Dominant amongst these species are sago and *Campnosperma* spp.

Vegetation and animal communities are influenced not only by depth and duration of flooding, but also by periodicity and inter-annual variation in flooding and drought, the areal extent of flooding, variation and patterns in connectivity between off-river waterbodies (see section 6.3) and forests, chemical quality of inflowing waters, sediment load in inflowing waters and the amount of exogenous matter[8] that is carried into the ecosystem (partly from Lamberts 2008). Not only are there nutrient inputs from the Hill Zone to the Lowland Zone but also an input of plant and invertebrate propagules. Floodwaters themselves act as dispersers of seeds, fruits and faunas as well as a transport mechanism for floating organic matter facilitating connectivity across the floodplain.

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[6] Lamberts and Koponen's (2008) admission that "Large complex ecosystems are always data deficient when it comes to informing … decision making …" is especially true for the Sepik River from which there is virtually no information on the ecological processes that relate hydrology to vegetation dynamics. Even for the Fly River where the impacts of the Ok Tedi mine has prompted a major hydrological investigation of the river basin, the last compilation of our understanding of the river presents only a superficial analysis of the relationships of vegetation dynamics to hydrology (Bolton 2009).

[7] The difference between forest and woodland is tree density – forest has crowns touching and the ground layer invisible from the air while woodland has separated crowns through which the ground layer is visible (Hammermaster and Saunders 1995).

[8] This varies from whole tree trunks through seeds, fruits and leaves to particulate organic matter.

To add to this complexity, the timing of hydrological events in relation to biological processes affects outcomes. Opperman *et al.* (2010), and Miao *et al.* (2009) have demonstrated that mortality and growth responses to hydrological events depend not only on the nature of the events but also on their sequence. The interaction between hydrology and biodiversity is usually treated as one way but it is actually reciprocal. Biodiversity (vegetation) affects hydrology and can have a strong influence on landform dynamics and Corenblit *et al.* (2007) extended the concept of two-way biotic-abiotic linkages to develop a "fluvial biogeomorphic succession concept".

Multiple sources of water and scale

The Lowland Zone not only receives water from the Sepik River tributaries such as the Frieda and May Rivers but also from channel and overland flows from the Sepik River itself, overland runoff from the Hill Zone, ground water flows and local rainfall. It loses water via the Sepik River, evapotranspiration and ground water movements. It is tempting to consider the Sepik River floodplain as a pulsed system whereby the floodplain is entrained to a cycle of flooding and drought down the main channel (Junk *et. al.* 1989) but there is no *a priori* reason to assume pulses in the Lowland Zone are simple. While there may be a general 'wet season' high water event, at any one time the various inputs might not be coordinated – the Sepik River tributaries need not all flow to the same patterns, it depends upon rainfall events in their respective catchments, and the Sepik River may flow overbank as a result of rain in the Torricelli Mountains to the north in a period of low flows in its southern tributaries. The difficulty of predicting complex flows in tropical floodplains is well demonstrated by Bonnet *et al.* (2008).

There is likely to be strong interannual variation in flood pulses and they need not occur uniformly over the Lowland Zone. Large areas distant from the main streams may be permanently under water and be influenced more by direct rainfall and ground water dynamics than overland flows.

In recognition of variability in pulse events and their potentially varied outcomes, Opperman *et al.* (2010) developed a model of floodplain processes for the Central Valley of California, a probably far simpler system than the Sepik River. They recognise three types of events:

- Activation floods - small events that trigger or influence ecological processes,
- Maintenance floods - larger events that can "perform geomorphic work including bank erosion and deposition", and
- Resetting floods - large events resulting in extensive floodplain changes by scouring and affecting channel location and initiating significant successional changes in vegetation.

Regime shifts, Hysteresis and History

The existence of patterns in vegetation in relation to patterns of water distribution need not imply that the present conditions are responsible for the vegetation patterns. A catena of vegetation along a topographical gradient from lowland open forest (Po) through mixed swamp forest (Fsw), to swamp woodland (Wsw), herbaceous swamp (Hsw) then deep open water implies that such a sequence would occur at a single spot were the water regime to slowly change through time. However, this may not be the case. Instead, there may be threshold responses (Scheffer *et al.* 2001).

A threshold response means that ecosystem (vegetation) changes are abrupt and there is no or little response to steadily changing conditions until a threshold is reached, at which point the system crashes. As a corollary the system can be returned to its original state by re-establishing environmental conditions to the point they were before the crash (Scheffer *et al.* 2001). This does not always work, however, since systems can have multiple stable states and show hysteresis i.e. the reverse trajectory is different to the forward one. In such circumstances restoring the conditions back to just before the threshold will have no effect. Instead the conditions have to be brought back to a period long before the threshold. The diagrams in Scheffer *et al. (*2001) illustrate this well. Large state changes brought about by thresholds or hysteresis are termed Regime Shifts (see for example, Carpenter *et al.* 2008, Tockner *et al.* 2010, Scheffer *et al.* 2001).

It is possible that alternate stable states exist in the Lowland Zone and this would explain the great overlap in water conditions under which the various vegetation formations can be found (Paijmans 1990). An example may be monodominant stands of sago that effectively prevent development of trees by suppressing their seedlings (Johns *et al.* 2007). The alternative stable state of mixed swamp forest (Fsw) cannot be reinstated simply by altering water levels to what they were before sago became dominant, conditions would need to be established that removed the sago itself.

Regime shifts have probably occurred historically in the Lowland Zone and the existing pattern may be relictual in some sense and more the reflection of historical events than present water regimes. While it is undeniable that the vegetation along the Sepik River and its tributaries is highly dynamic responding rapidly to vagaries in overbank flows, the patterns further away in the swamp woodland (Wsw) and wooded swamp complexes (Fsw/Wsw) may be stable and even old. It is very possible the peat forest, for example, is relictual and may be several thousand years old judging by the depth of peat (Chapter 2 of EIS Appendix 8A).

Fire

Fire is a major and catastrophic driver of regime shift during drought in tropical wooded swamps, particularly those on peat and highly organic substrates. When these substrates dry out as a result of drought or draining the forest then not only the forest but also the substrate can be readily burnt eliminating the forest entirely and presenting little chance of it recovering. Burning peaty substrates usually causes subsidence of the ground level often resulting in deep pools or lakes (Wösten *et al.* 2006).

4.3 Conclusion

The role of disturbance in tropical forests tends to make them resilient to human-induced disturbance, but the extent, type and duration of disturbance is critical. Short-term, small-scale disturbances can mimic natural gap phase or small-scale catastrophic dynamics. However, major changes to natural dynamics result in system collapse or forest conversion. This can be brought about by large-scale clearing, an ever-increasing number of small clearings fragmenting the forest, disturbances being too frequent, or as a result of fire, invasion of exotic species, or altered hydrology. However, human activities promoting clearing and fire is the single biggest factor influencing forest loss in PNG (Rogers 2005, Shearman *et al.* 2008, 2009, 2010; Shearman and Bryan 2011).

PART 2 - VALUES

5. Large scale - the Study Area as a whole

The Study Area has biodiversity values as follows: extensive, continuous, largely untouched and previously unexplored forests, very high biodiversity, a range of species new to science, high levels of endemism, migratory and/or congregatory species, and many species of cultural and subsistence importance to local peoples.

5.1 Extensive intact habitats

Some 82% of the Study Area is undisturbed but the largest expanses of intact habitats are in the Frieda and May River catchments and south of the Sepik River (Table 4). The Study Area from the GFA to Idam 1 village is the major contributor to this value with over 90% of the area being undisturbed. The major degraded sites in this region are the valleys of the Nena and Niar Rivers associated with Wabia and Ok Isai villages, the HITK pit area, garden areas around Fiak and Amaromin villages and garden areas in the upper Montane Forests. North of the Sepik River very large areas have been logged or cleared.

Considering all levels of disturbance, the Study Area Lowland Zone north of the Sepik River (sections 7 to 10) has been most impacted (Table 5). The intact Montane Zone north of the Sepik River consists of steep unlogged areas in the Bewani Mountains.

While the Study Area Lowland Zone in the GFA has not been significantly altered by human activity, anecdotal evidence collected during the 2011 surveys suggest that certain exotic fish introduced to the Sepik River may have caused major losses of grassed swamps and wetland vegetation (see Chapter 4 of EIS Appendix 8A). In view of the existing impacts on the lowlands north of Idam 1 village the Lowland Zone in the GFA assumes more importance. It, as part of the Sepik River Basin, is in one of the few relatively unaltered floodplains in the world. Tockner and Stanford (2002) present a global assessment of the state of floodplains and conclude:

> "In Europe and North America, up to 90% of floodplains are already 'cultivated' and therefore functionally extinct....in the developing world, the remaining natural flood plains are disappearing at an accelerating rate, primarily as a result of changing hydrology."

Table 4 Vegetation Condition in Study Area sections

STUDY AREA SECTION	CONDITION*					AREA(HA)
	A	B	C	D	E	
GFA (including 1 Process Plant to Hotmin)	92.4%	4.2%	2.4%	0.5%	0.5%	372,765
2 Hotmin to the West Range	97.9%	1.5%			0.6%	29,321
2A May River Road	100.0					17,750
3 West Range to Idam 1	93.7%	4.9%			1.4%	32,107
4 Idam 1 to the Sepik River	67.3%	32.1%			0.6%	27,414
5 Sepik River to Samunai	68.9%	21.4%			9.7%	23,050
6 Samunai to the Horden River	81.7%	16.5%			1.9%	33,626
7 Horden River to the Bewani foothills	63.5%	11.0		22.8%	2.6%	38,696
8 Bewani Mountains	36.1%	2.5%		61.3%	0.1%	30,677
9 Bewani Mountains to the Nemayer River	10.3%	2.8%		61.	25.9%	37,087
10 Nemayer River to Vanimo	20.6%			67.7%	11.7%	18,077
Grand Total	**79.6%**	**6.5%**	**1.4%**	**9.7%**	**2.8%**	**660,571**

*Entries are percent of that section in that condition.

Table 5 Remaining Intact Vegetation in Study Area sections

	ZONE*		
STUDY AREA SECTION	MONTANE	HILL	LOWLAND
GFA (including 1 Process Plant to Hotmin)	74.2%	93.6%	95.9%
2 Hotmin to the West Range	100. 0%	99. 0%	91.1%
2A May River Road		100. 0%	100. 0%
3 West Range to Idam 1	100. 0%	96.3%	24.5%
4 Idam 1 to the Sepik River		69. 0%	66.5%
5 Sepik River to Samunai		5.4%	71.1%
6 Samunai to the Horden River		79.5%	86.1%
7 Horden River to the Bewani foothills		63.6%	4.9%
8 Bewani Mountains	100. 0%	35.8%	
9 Bewani Mountains to the Nemayer River		6.8%	12.7%
10 Nemayer River to Vanimo		12.4%	26.8%
GFA to Sepik River	**74.5%**	**93.8%**	**93.3%**
North of Sepik River	100. 0%	48. 0%	35.0%
Grand Total	**74.6%**	**78.9%**	**81.5%**

*Entries are percent of section in condition class A.

5.2 High biodiversity

The Project surveys demonstrate conclusively that the Study Area has high biodiversity. Annex 4 shows the species recorded or potentially occurring in each section of the Study Area.

A total of 70 species of mammals were positively identified in the Project surveys and a further 16 remain only partially identified. A further 64 could occur. Table 6 shows that the Hill and Montane Zones of the GFA and the Bewani Mountains have the most diverse mammal faunas.

A total of 234 species of landbirds were positively identified and a further 123 could occur. The Hill and Montane Zones of the GFA and the Bewani Mountains have the most diverse landbird faunas but section 3, West Range to Idam 1, ranks high with its combination of hill and lowland habitats (Table 6).

A total of 23 species of waterbirds were positively identified and a further 50 could occur. They are most diverse in the lowland sections of the Study Area located on or near the Sepik River floodplain (Table 6).

The Study Area is rich in frogs with 60 species recorded and at least another 27 possible. Table 6 indicates that frogs are most diverse in the GFA and the Bewani Mountains.

The Project surveys also found high diversity of reptiles (46 species), odonates (116 species) and plants (1418 species) while the 2011 surveys found 359 species of butterflies in the GFA. It is not possible to predict what other species in these groups may also occur, so Annex 4 shows only the sections of the Study Area in which these species were recorded.

Overall the parts of the Study Area in the Frieda and May River catchments and in the Bewani Mountains tend to have more diverse mammal, landbird and frog faunas but Table 6 shows that every section of the Study Area is of high diversity. In this respect the GFA Hill Zone is more important biogeographically than the Lowland Zone for the flora, which forms a continuous unit with that of the Hunstein Range with biogeographic affinities westward to Indonesian New Guinea (EIS Appendix 8A)

A phenomenon shown by most groups was the expansion of elevational range, with normally montane and submontane species extending to lower elevations in the Study Area.

Table 6 Counts of species in sections of the Study Area

	GFA		INFRASTRUCTURE CORRIDOR									
LIKELIHOOD OF OCCURRENCE	HILL + MONTANE	LOWLAND	1	2/2A	3	4	5	6	7	8	9	10
MAMMALS												
Recorded or strong or medium likelihood	112	74	100	82	86	69	67	67	70	90	63	59
Low likelihood	11	15	10	8	13	19	22	22	22	18	25	25
Total	**123**	**89**	**110**	**90**	**99**	**88**	**89**	**89**	**92**	**108**	**88**	**84**
LANDBIRDS												
Recorded or strong or medium likelihood	327	219	301	218	297	216	216	216	216	280	205	203
Low likelihood	18	21	25	26	19	12	12	12	17	9	24	22
Total	**345**	**240**	**326**	**244**	**316**	**228**	**228**	**228**	**233**	**289**	**229**	**225**
WATERBIRDS												
Recorded or strong or medium likelihood	17	64	7	30	53	63	63	63	63	8	63	69
Low likelihood	47	0	57	34	11	1	1	1	1	18	1	4
Total	**64**	**64**	**64**	**64**	**64**	**64**	**64**	**64**	**64**	**26**	**64**	**73**
FROGS												
Recorded or strong or medium likelihood	70	50	73	53	63	47	46	44	49	71	45	43
Low likelihood	3	12	7	11	14	14	14	16	14	14	17	19
Total	**73**	**62**	**80**	**64**	**77**	**61**	**60**	**60**	**63**	**85**	**62**	**62**
REPTILES												
Recorded	45	45		16	17							
ODONATES												
Recorded	94	75		40	44							
BUTTERFLIES												
Recorded	288	266										
PLANTS												
Recorded	1260	837		339	345							

Table 7 Species new to science recorded at survey sites

FAMILY	TAXON IN EIS APPENDIX 8A	PUBLISHED NAME	REFERENCE	LOWLAND ZONE[1] 2011 SURVEYS							HILL AND MONTANE ZONES 2011 SURVEYS[1]													2017 SURVEY		#SITES
				ES	I	KU	W	WA	FN	KG	OB	OI	M	N1	FB	UO	NU	KO	N2	HI	NB	NL	U	C 1	C 2	
Annonaceae	genus nov. ined.	*Huberantha* gen. nov.	Chaowasku 2015										x		x	x										
Apocynaceae	*Phyllanthera* sp. nov.	*Phyllanthera piforsteriana*	Takeuchi 2014a						X									X		X						3
Ebenaceae	*Diospyros* sp. nov.																			X		X				2
Phyllanthaceae	*Glochidion* sp. nov. aff. *welzenii* Takeuchi																			X	X					2
Fabaceae	*Archidendron* sp. nov., aff. *A. bellum* Harms	*Archidendron calliandrum* de Wit; distr. record for northern PNG	Takeuchi 2012											X							X					2
Gesneriaceae	*Cyrtandra* sp. nov. A												X	X												
Melastomataceae	*Catanthera* sp. nov.																	X	X	X	X					4
Melastomataceae	*Creochiton* sp. nov.																				X	X				2
Melastomataceae	*Medinilla* sp. nov. A, (aff. M. *maluensis* Mansf.)								X									X		X	X	X				5
Melastomataceae	*Medinilla* sp. nov. B, (sect. Heteroblemma)	*Heteroblemma barbatum* (Bakh.f. Cámara Leret, Ridd.Num. & Veldkamp	R. Cámara-Leret *et al.* 2013															X		X						2
Melastomataceae	*Medinilla* sp. nov. C, (sect. Heteroblemma)																	X		X	X					3
Melastomataceae	genus nov.								X	X						X				X						4
Meliaceae	*Chisocheton* sp. nov.,(aff. *pachyrhachis* Harms)								X					X		X	X									4
Monimiaceae	*Kibara* sp. nov.																X	X		X						3
Myrsinaceae	*Ardisia* sp. nov. A, (aff. *A. forbesii* S. Moore)																				X					1
Myrsinaceae	*Ardisia* sp. nov. B, (aff. *A. sogerensis* S. Moore)																X					X				2
Myrsinaceae	*Discocalyx* sp. nov., (aff. *D. orthioneura* K. Schum.)								X				X			X	X									4
Proteaceae	*Helicia* sp. nov., (aff. *H. macrostachya* Lauterb.)	*Helicia woxvoldiana*	Takeuchi 2014b2																	X	X					2
Rubiaceae	*Psychotria* sp. nov. A, (aff. *aquatilis* Merr. & Perry)												X			X			X							3
Rubiaceae	*Psychotria* sp. nov. B	*Psychotria augustaflussiana* Takeuchi & Arifiani	Takeuchi & Arifiani in press										X							X	X					3
Rubiaceae	*Psychotria* sp. nov. C								X							X										2
Rubiaceae	*Psychotria* sp. nov., aff. *P. apdavisiana* Takeuchi.																							X		1
Rubiaceae	*Timonius* sp. nov., aff. *grandifolius* Valeton								X		X		X													3
Winteraceae	*Zygogynum* sp. nov. A							X						X			X		X							4
Aristolochiaceae	*Aristolochia* "jackii" Steud.	*Aristolochia chrismulleriana*	Takeuchi 2013							X																1
Muridae	*Lorentzimys sp.*												X													1
Muridae	*Pogonomys cf. loriae*									X																1
Hylidae	*Litoria sp. nov. 1 cf arfakiana*													X			X	X			X					4
Hylidae	*Litoria sp. nov. 2 cf gasconi*																				X					1
Hylidae	*Litoria sp. nov. 3 cf macki*								X		X		X	X		X										5
Hylidae	*Litoria sp. nov. 4 cf iris*																					X				1

FAMILY	TAXON IN EIS APPENDIX 8A	PUBLISHED NAME	REFERENCE	LOWLAND ZONE[1] 2011 SURVEYS							HILL AND MONTANE ZONES 2011 SURVEYS[1]													2017 SURVEY		#SITES
				ES	I	KU	W	WA	FN	KG	OB	OI	M	N1	FB	UO	NU	KO	N2	HI	NB	NL	U	C 1	C 2	
Hylidae	*Litoria sp. nov. 5 cf nigropunctata*										X	X					X	X			X			X	X	7
Hylidae	*Litoria sp. nov. 6 cf bicolor*											X					X	X			X					4
Hylidae	*Litoria sp. nov. 7 (torrent grunter)*												X			X	X	X			X					5
Hylidae	*Litoria sp. nov. 8 (small, torrent)*											X				X					X	X				4
Hylidae	*Litoria sp. nov. 9 (medium torrent)*																	X			X					2
Microhylidae	*Albericus sp. 1*																	X		X	X	X				4
Microhylidae	*Austrochaperina sp. 1 cf. hooglandi*																			X	X	X				3
Microhylidae	*Austrochaperina sp. 2 (aquilonia)*																	X		X	X	X				4
Microhylidae	*Austrochaperina sp. 3 (aquatic)*															X										1
Microhylidae	*Austrochaperina sp. 4 (Ok Isai))*												X													1
Microhylidae	*Choerophryne sp. nov. 1 cf rostellifer*	*Choerophryne epirrhina*	Iannella *et al.* 2015																		X					1
Microhylidae	*Choerophryne sp. nov. 2*	*Choerophryne grylloides*	Iannella *et al.* 2016																		X	X				2
Microhylidae	*Hylophorbus sp. nov. 1 (tiny)*	*Hylophorbus atrifasciatus*	Kraus 20133					X						X							X					3
Microhylidae	*Hylophorbus sp. nov. 2 (small)*				X		X														X					3
Microhylidae	*Hylophorbus sp. nov. 3 (medium)*	*Hylophorbus proekes*	Kraus and Allison 2009							X		X	X	X		X	X	X		X	X	X				10
Microhylidae	*Hylophorbus sp. nov. 4 (huge)*																				X					1
Microhylidae	*Oreophryne sp. nov. 1 (fast peeper)*												X			X		X		X	X	X				6
Microhylidae	*Oreophryne sp. nov. 2 (short rattler)*											X	X			X		X		X	X	X				7
Microhylidae	*Oreophryne sp. nov. 3 (rasper)*																			X	X	X				3
Microhylidae	*Oreophryne sp. nov. 4 (chirper)*								X		X	X	X	X												5
Ranidae	*Rana sp. nov. cf daemeli*				X																					1
Agamidae	*Hypsilurus sp. 1 (semi-aquatic)*	not counted as novelty																		X						1
Gekkonidae	*Cyrtodactylus novaeguineae*	*Cyrtodactylus rex*	Oliver *et al.* 2016				X			X						X										3
Gekkonidae	*Cyrtodactylus sp. 1 (may be serratus)*	*Cyrtodactylus sp. nov.*																				X				1
Gekkonidae	*Lepidodactylus sp. nov.*										X															1
Scincidae	*Emoia sp. 1*			X			X		X	X																4
Coenagrionidae	*Hylaeargia sp. nov.*	*Hylaeargia simplex*	Theischinger & Richards 2013b																		X		X			2
Coenagrionidae	*Teinobasis sp. 1 cf aurea*	*Teinobasis chrysea*	Theischinger & Richards 2013a									X	X	X												3
Coenagrionidae	*Teinobasis sp. 2*	*Teinobasis lutea*	Theischinger & Richards 2013a										X													1
Megapodagrionidae	*Argiolestes sp. nov. 1(cf kula)*															X										1
Platycnemididae	*Paramecocnemis sp. nov. 1*	*Paramecocnemis spinosus*	Orr *et al.* 2012																		X					1
Platycnemididae	*Paramecocnemis sp. nov. 2*	*Paramecocnemis similis*	Orr *et al.* 2012													X	X									2
Platystictidae	*Drepanosticta sp. nov. 1 (black apps)*								X				X			X		X		X	X					6
Platystictidae	*Drepanosticta sp. nov. 2 (Blue-tail)*	*Drepanosticta elaphos*	Theischinger & Richards 2014								X					X		X								3

FAMILY	TAXON IN EIS APPENDIX 8A	PUBLISHED NAME	REFERENCE	LOWLAND ZONE[1] 2011 SURVEYS							HILL AND MONTANE ZONES 2011 SURVEYS[1]													2017 SURVEY		#SITES
				ES	I	KU	W	WA	FN	KG	OB	OI	M	N1	FB	UO	NU	KO	N2	HI	NB	NL	U	C 1	C 2	
Platystictidae	*Drepanosticta sp. nov. 3 (Ok Isai Blue-tail)*	*Drepanosticta pterophor*	Theischinger & Richards 2014									X														1
Protoneuridae	*Nososticta sp. nov. 1 (orange)*				X			X	X		X										X	X				6
Protoneuridae	*Nososticta sp. nov. 2 (small blue)*								X		X		X					X								4
Protoneuridae	*Nososticta sp. nov. 3 (small blue # 2)*			X		X	X																			3
Aeshnidae	*Gynacantha sp. nov.*	*Gynacantha heros*	Theischinger & Richards 2012a									X														1
Synthemistidae	*Palaeosynthemis sp. nov.*	*Palaeosynthemis elegans*	Theischinger & Richards 2013c										X													1
Libellulidae	*Risiophlebia risi?*	*Akrothemis bimaculata*	Theischinger & Richards 2012							X																1
Argiolestidae	*Metagrion sp. 1*																							X		1
Argiolestidae	*Metagrion sp. 2*																								X	1
Pyrginae	*Chaetocneme* sp. nov.	*Chaetocneme richardsi*	Müller 2016															X								1
Hesperiinae	*Sabera* sp. nov. 1.																				X					1
Hesperiinae	*Sabera* sp. nov. 2.				X																					1
Hesperiinae	*Kobrona* sp. nov.				X	X																				2
Lycaeninae	*Philiris* sp. nov.	*Philiris bubalisatina*	Müller 2014b												X			X			X					3
Lycaeninae	*Candalides* sp. nov.	*Candalides brabyi*	Müller & Tennant 2016a													X					X					2
Morphinae	*Taenaris* sp. nov.										X	X	X		X					X						5
Satyrinae	*Mycalesis* sp. nov. 1.	*Mycalesis woxvoldi*	Müller 2014a	X																						1
Satyrinae	*Mycalesis* sp. nov. 2.																			X	X					2
Totals				3	5	2	4	3	13	7	9	10	21	10	3	19	11	21	3	22	36	16	1			79

1 Site codes: ES - East Sepik I - Iniok KU - Kubkain W - Wogamush WA - Wario FN - Frieda Bend KG - Kaugumi FS - Frieda Strip HL - Hauna (& lakes) WS - Warangai South OB - Ok Binai 1 OI - Ok Isai M - Malia N1 - Nena D1 FB - Frieda Base UO - Upper Ok Binai NU - Nena-Usage KO - Koki N2 - Nena D2 HI - HI NB - Nena Base NL - Nena Limestone U - Ubiame HV - Hotmin Village KV - Kubkain Village PV - Paru Village NV - Nekiei Village W1 – Wameimin 1 Village W2 - Wameimin 2 Village, C1 -Camp 1, C2 – Camp 2.

2 Notwithstanding its late discovery, *H. woxvoldiana* is a common species and is not presently susceptible to any conservation threat(s). Extensive sapling recruitment was evident in all the areas of observed occurrence, particularly in the regrowth resulting from natural agencies (for example, windthrows, landslides) or from anthropogenic activities. The species is almost certainly more widespread than presently recognized. Extensions in geographic range can be expected as future investigators enter other upland environments within the Sepik River basin.

3 Also occurs in Prince Alexander Mountains and Madang Province.

4 Also occurs at Baiyer River, Western Highlands Province.

5.3 Species new to science

The 2011 surveys discovered many species possibly new to science. Since the time of the 2011 surveys the status (new or not) has been resolved for most of these and some have been described taxonomically. The 2011 surveys reported 24 new plants, 2 new mammals, 26 new frogs, possibly 5 new reptiles, 15 new odonates and 9 new butterflies. The 2017 surveys recorded another new species of plant and two new species of damselflies.

29 species have now been named or their status clarified (Table 7). In addition, the vine *Aristolochia "jackii"* Steud has been described as a new species - *A. chrismulleriana*, the dragonfly identified as *Teinobasis scintillans* has been split off as a new species *T. macroglossa* and the dragonfly *Altiapa pandora* has been found to be a new species also – *A. blancae* (Müller and Tennant 2016b). Amongst the geckos *Cyrtodactylus novaeguineae* has been assigned to a new species, *Cyrtodactylus* sp. 1 has been confirmed to be a new species and *Nactus cf pelagicus* has been confirmed not to be that species but its identity remains unknown. The possible new form of Owlet-Nightjar *Aegotheles sp.* reported in Chapter 4 of EIS Appendix 8A has been identified as the widespread Wallace's Owlet-Nightjar *A. wallacii*.

As well as these there were:

- An undescribed species of Feather-tailed Possum at Iniok and East Sepik Sites known only from a few collections elsewhere.
- Five as yet undescribed plants (including 2 new genera) previously known only from the Hunstein Range.
- Two new generic distributional records of plants for New Guinea.
- New distributional records for PNG for eight birds. six plants and four butterflies.
- Four rediscoveries of plants known only from lost types.
- Range extensions for three plants and seven butterfly species previously known only from type localities.
- Range extensions for 15 plants and 34 butterfly species known only from a few specimens.
- Three damselflies and a frog previously known only from single localities in Papua province of Indonesia.
- A frog previously known only from a single locality in Sandaun Province.

This is an indication of the remoteness and biological richness of the Study Area. It is not surprising so many species new to science were recorded, as the Project surveys are the first to have been conducted in this area for vascular plants, vertebrates, odonates and butterflies.

Table 8 Endemism in mammals, birds and butterflies of the Study Area.

	ENDEMICITY	MAMMALS	LANDBIRDS	WATERBIRDS	BUTTERFLIES
1	Occurs more widely in the Indo-Pacific	24%	25%	49%	42%
2	Endemic to New Guinea, its satellite islands, the Bismarcks and Maluku	7%	2%	3%	13%
3	Endemic to New Guinea and its satellite islands Waigeo, Misool, Yapen, Biak, Aru, d'Entrecasteaux and Louisiades	2%	31%		22%
4	Endemic to mainland New Guinea	52%	34%	1%	18%
5	Endemic to northern mainland New Guinea, north of the central cordillera	6%	3%		5%
6	Narrow endemic to the Telefomin region	3%			
7	North Coastal Range endemic	5%	1%		
1M	MIGRANTS		4%	47%	
	4+5+6+7	66%	38%	1%	23%

5.4 Endemic species

Whether any of the species new to science are restricted to the Study Area is unknown but unlikely. The area is nonetheless rich in species endemic to New Guinea and there is sufficient information on mammals, birds and butterflies to be able to estimate levels of endemism (see Chapters 3, 4 and 7 of EIS Appendix 8A). Table 8 shows that mammals, in particular, have high levels of endemism with almost 66% being endemic to mainland New Guinea or smaller areas.

A range of bryophytes were described from the Study Area (Norris and Koponen 1985, Norris *et al.* 1988, Piipo 1986 and 1998) but the distribution of bryophytes is so poorly known in New Guinea that no conclusion can be drawn as to their real levels of endemicity (see Chapter 2 of EIS Appendix 8A for a detailed discussion of plant distribution and collecting data).

5.5 Migratory and/or congregatory species

A range of mammals, birds, odonates and butterflies recorded in EIS Appendices 8A and 8B congregate in groups at times and many undergo local movements. Parrots and pigeons congregate at food sources such as fruiting trees and some birds-of-paradise congregate at communal leks to mate (see Chapter 4 of EIS Appendix 8A). Similarly, some butterflies congregate on hilltops to mate. However, there is no evidence that any of these occur in unusually large congregations in the Study Area.

Similarly, while a range of migratory land birds (Chapter 4 of EIS Appendix 8A) from Australasia and Eurasia occur within the Study Area, those from Australia are not congregatory except on migration and again there is no evidence that any of them occur in unusually large numbers.

Some species of odonates are obligate or facultatively migratory, and mass movements of odonates are well documented elsewhere. Although data for New Guinea species are not available, it is clear that a number of species, such as *Pantala flavescens*, are capable of flying extremely long distances, and several small damselflies breeding in ponds or ephemeral pools in the Study Area may also be migratory.

Thus, while many species migrate or congregate, for most the Study Area is not especially significant. The exceptions are the waterbirds, flying foxes (*Pteropus*), and the cave roosting and breeding bats and swiftlets.

5.5.1 Migratory and/or congregatory water birds

There are about 123 waterbirds recorded from PNG and an additional 12 terns occur off the coast. Twelve species are forest dwelling rails; the remainder are ducks, herons, grebes, terns and waders, 79 of which have been recorded or may occur along the Sepik River. The remaining 32 species are known only from elsewhere in PNG or are very rare vagrants. Most are congregatory, some are breeding residents, many are nomadic within New Guinea and many are migrants from overseas and subject to treaty obligations under the Bonn Convention.

These waterbirds are quite specific in habitat needs, most favouring the edges of shallow swamps and lakes. A minority of species are diving fishers that favour deeper water, and a few are specialists on wet and/or shallowly flooded grasslands. Few species inhabit Swamp Forest formations. Migratory waders favour mudflats and lake edges.

Probably all of the species recorded on the Sepik River are likely to occur in the many swampy and open water habitats of the Study Area. Chapter 4 of EIS Appendix 8A presents a focused assessment of the migratory species. Southern migrants occur in New Guinea in the austral winter and northern migrants (Eurasian-breeding waders – Scolopacidae and Charadriidae) in the austral summer, the latter moving along the East Asian-Australasian Flyway (EAAF). While most migratory waders prefer coastal or sub-coastal habitats, their status on the Sepik River floodplains is unknown.

The Project surveys recorded only small groups of three species of migratory waders in the Study Area but another 26 could occur and the amount of available habitat - mudflats, lake and river edges for foraging and vegetated swamps for roosts, is extensive and suggestive of an area that could accommodate large numbers of migrants and other waterbirds. Until such times as systematic surveys along the entire Sepik River demonstrate otherwise, the Study Area lowlands is best considered of high value for migratory and other congregatory waterbirds, particularly the off-river waterbodies consisting of shallow lakes and their associated floodplains.

The conservation of waders and their habitats is an international problem; many species are in decline globally and continue to be threatened by broad scale wetland loss along the EAAF. Chapter 4 of EIS Appendix 8A presents anecdotal evidence of declines of all waterbirds within the GFA itself.

> " … local waterbird populations have declined significantly in recent years. Local residents indicated that this was associated with marked losses in floating and lakeside vegetation over the previous 10–15 years, thereby reducing habitat required for breeding, foraging and/or sheltering by many waterbirds, including grebes, ducks, rails and jacanas. Significant declines were reported by locals for various ducks and jacanas (for example Cotton Pygmy-Goose and Comb-crested Jacana, formerly common but now rare and unrecorded during the Project surveys). A suite of exotic fish species, one of which is known locally as 'ball-cutter', was introduced into the Sepik River between 1987 and 1997 … and shortly before these changes were noted by local residents. A connection between these events was voiced by our informants." (Chapter 4 of EIS Appendix 8A).

5.5.2 Flying Foxes

Species of flying foxes, *Pteropus,* form large congregations ('camps') during the day, dispersing over the forests to feed at night. Main camps exceed 1,000 individuals and occur when adults congregate for courtship and mating and again when adult females come together in 'maternity camps' to bear and rear the young. Smaller ('satellite') camps comprise non-breeders, usually males or subadults. These patterns have not been documented in any detail for any endemic Melanesian species of flying fox, however, there is a high degree of similarity among all well-documented species of *Pteropus* and it is reasonable to assume that Melanesian species will conform to this pattern (Chapter 3 of EIS Appendix 8A).

Main camps, which are "semi-permanent fixtures in the landscape" (Chapter 3 of EIS Appendix 8A), can be enormous and may involve significant proportions of the entire regional species population. Surveys in New South Wales, Australia, in July 1998 found 99% of the estimated resident state population of *P. poliocephalus* were concentrated in only nine camps (Chapter 3 of EIS Appendix 8A).

The 2011 surveys recorded a maternity colony of up to 100,000 Great Flying Fox *P. neohibernicus* near Wogamush Site and villagers indicated that other camps also occur (Chapter 3 of EIS Appendix 8A). Flyovers in 2011 indicated this camp had gone (Xstrata Frieda River Limited *in litt.* to F. Crome 12 October 2011) but whether the move was permanent, or part of a seasonal movement cannot be said. While this species is widespread in Melanesia there are no known big congregations recorded outside of the Sepik River Basin, where Flannery (1995 quoted in Chapter 3 of EIS Appendix 8A) mentioned "massive camps". Flying fox colonies are largely traditional and not related to the amount of habitat available (Richards 1990). The huge maternity colony that was located at Wogamush Site could represent a significant portion of regionally occurring breeding females and, if the other camps referred to by villagers are also of this species, then the Study Area may represent a breeding stronghold for this species.

5.5.3 Cave bats and birds

The Study Area supports numerous species of bats and at least three species of swiftlet, which congregate and breed in caves. Large colonies of bats and swiftlets would be associated mostly with caves in karst and so be restricted to the Study Area Hill and Montane Zones. They are discussed further under section 7.4.

5.6 Habitats and biodiversity of cultural significance

The Study Area is sparsely populated, and local communities are linked to biodiversity through their largely subsistence lifestyles and a close relationship to their land. The forests and rivers provide the bulk of their needs and they are more-or-less dependent upon the ecosystem services the Study Area provides. Subsistence land use in the Study Area consists of shifting cultivation, largely restricted to the

Study Area Hill and Montane Zones, sago production and fishing in the Study Area Lowland Zone, and hunting and gathering throughout. It is likely that local peoples use several hundred species of plants and animals for food, building, decoration, spiritual purposes, medicine etc. Hunters' prey would include pigs, cassowaries, wallabies, bandicoots, megapodes, rats, flying foxes, possums, tree kangaroos, monitor lizards, frogs, snakes, bats, crocodiles, turtles, lizards, insects and birds. Many plants in the Study Area are used by local people, an example being the resilient bark of *Trichospermum pleiostigma*, which is used for cordage and house flooring throughout New Guinea (Chapter 2 of EIS Appendix 8A). Among the extensive listings of Sepik medicinal plants in Powell (1976), *Cassia alata* can be randomly mentioned as a widely used palliative for skin diseases.

6. Medium Scale - Priority Ecosystems

6.1 Peat Forest Priority Ecosystem

Peat forests are widespread in the Malay Peninsula, Borneo, and Sumatra and occur in Indonesian New Guinea, but had not been recorded in PNG prior to the 2011 surveys (Figure 3). Since then peat forests very similar to those in the GFA but with different species composition have been located on the Fly drainage and there is evidence from the old CSIRO land surveys in the Sepik/Ramu drainage that peat forests occur more widely (Haantjens *et al.* 1968, 1972, Robbins *et al.* 1976). Closer to the Study Area, Ono *et al.* (2015) studied peat at Kraimbit village near the Black Lakes on the Sepik River and found 2 to 3 m deep peat containing sago and grass remnants but did not note the vegetation they were sampling in. There are an estimated 1,100,000 ha of peatlands in PNG itself, supporting a wide range of vegetation from alpine bogs and shrublands to peat swamp forest, mostly in the highlands (Rieley and Page 2016).

Chapter 2 of EIS Appendix 8A describes Peat Forests in detail. Their defining characters are that they are developed on a thick dome-shaped peat lens, the water table is raised above that of the surrounding landscape and close to the surface most of the year, the forest consists of stunted, pole-stem trees with poor crown development, small leaves dominate, there are no emergents, the canopy is flat and uniform, there are no palms, substrates are highly infertile and acidic (pH <4), and biodiversity and endemism are low. Streams always flow out of, never into, Peat Forest. The Peat Forest in the Study Area is developed on peat approximately 28 m thick and contains the West Malesian peat specialist tree *Tetramerista glabra,* recorded for the first time in Papuasia by the 2011 surveys, and has a peculiar vine association of *Timonius caudatus* and *Schradera novoguineensis* (Chapter 2 of EIS Appendix 8A).

The faunal communities of the peat swamp are characterised by their low diversity. Several megachiropteran bat species appear to be absent and microchiropteran bat diversity is low (Chapter 3 of EIS Appendix 8A). Bird species richness and abundance is very low in the Peat Forest and there are no peat specialist birds, but the community has a highly distinctive composition (Chapter 4 of EIS Appendix 8A). The depauperate flora also means that the butterfly fauna is accordingly species poor. The Peat Forest Priority Ecosystem had the lowest butterfly diversity and endemism of any site (Chapter 7 of EIS Appendix 8A). The Peat Forest has a relatively depauperate odonate fauna dominated by common and widespread species.

This Peat Forest may not be the result of fluvial dynamics but instead be a relict developed from organic deposits in brackish estuarine environments when the Sepik River Basin was a shallow inland sea.

The Peat Forest in the Study Area is not declining but may be aggrading and there is evidence that the Kubkain Site, where *Tetramerista glabra* and *Schradera novoguineensis* also occur, may be either degrading Peat Forest or aggrading to a Peat Forest stage (Chapter 2 of EIS Appendix 8A).

6.2 Nena Karst Priority Ecosystem

The karst in the Study Area (Figure 3) is of high biodiversity value. The largest block, the Nena limestone plateau, contains large-scale karst features including at least two large sinkholes (known locally as Inikia and Abo) that are said to contain large colonies of cave roosting megachiropteran bats, most likely the Moluccan Naked-backed Fruit Bat *Dobsonia moluccensis*, but possibly also the IUCN Critically Endangered Bulmer's Fruit Bat *Aproteles bulmerae* (Chapter 3 of EIS Appendix 8A). This karst also supports several montane plants occurring at low elevation (Chapter 2 of EIS Appendix 8A) and is the preferred habitat of the Greater Melampitta, a karst specialist bird (Chapter 4 of EIS Appendix 8A). It has a distinctive frog fauna and a new species of frog *Litoria* sp. nov. 4 cf iris and a gecko *Cyrtodactylus sp. nov.* were located in this habitat (Chapter 5 of EIS Appendix 8A and Table 7). Karst is of major importance in tropical bat conservation (Struebig *et al.* 2008).

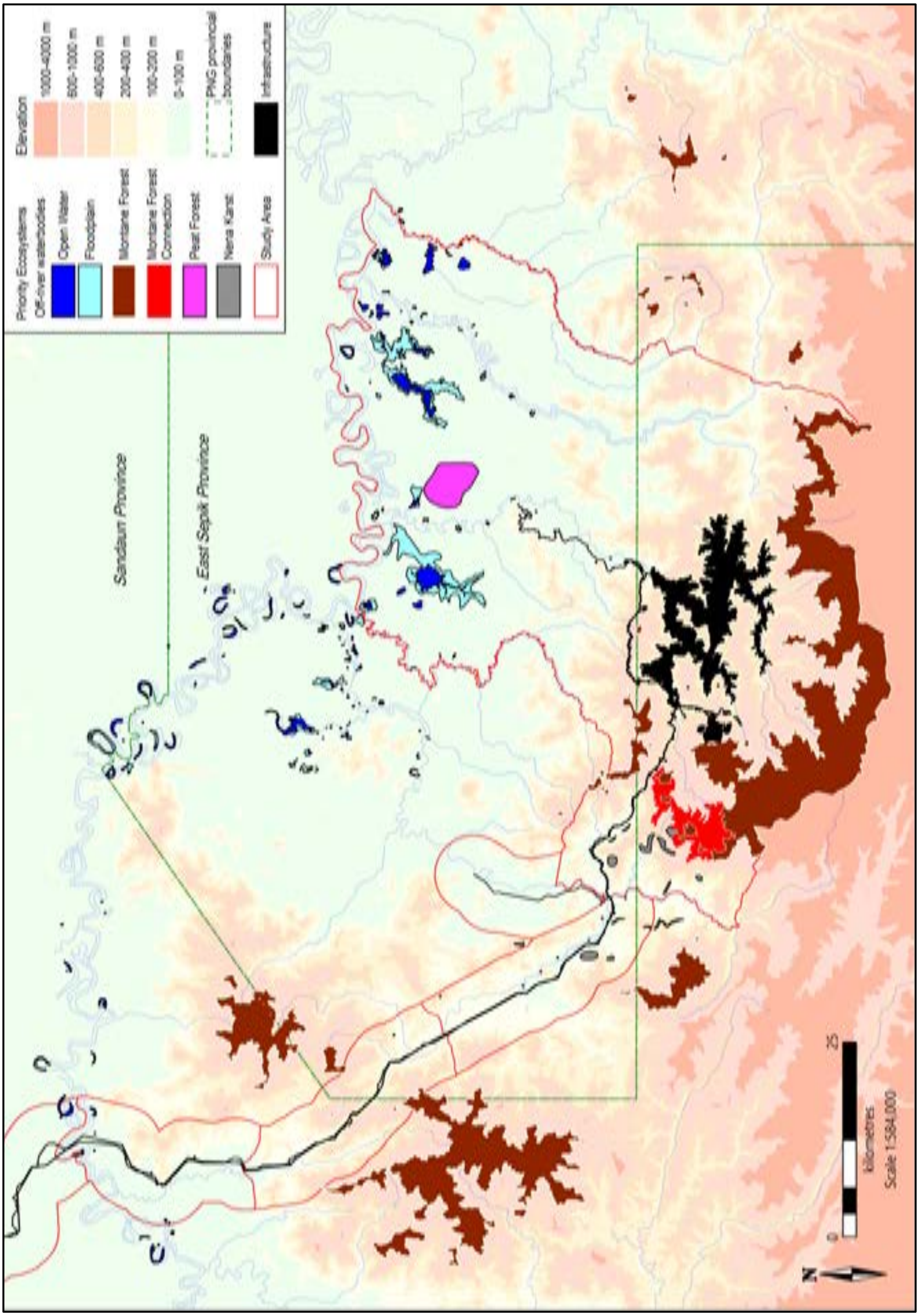

Figure 3 Priority Ecosystems in the south

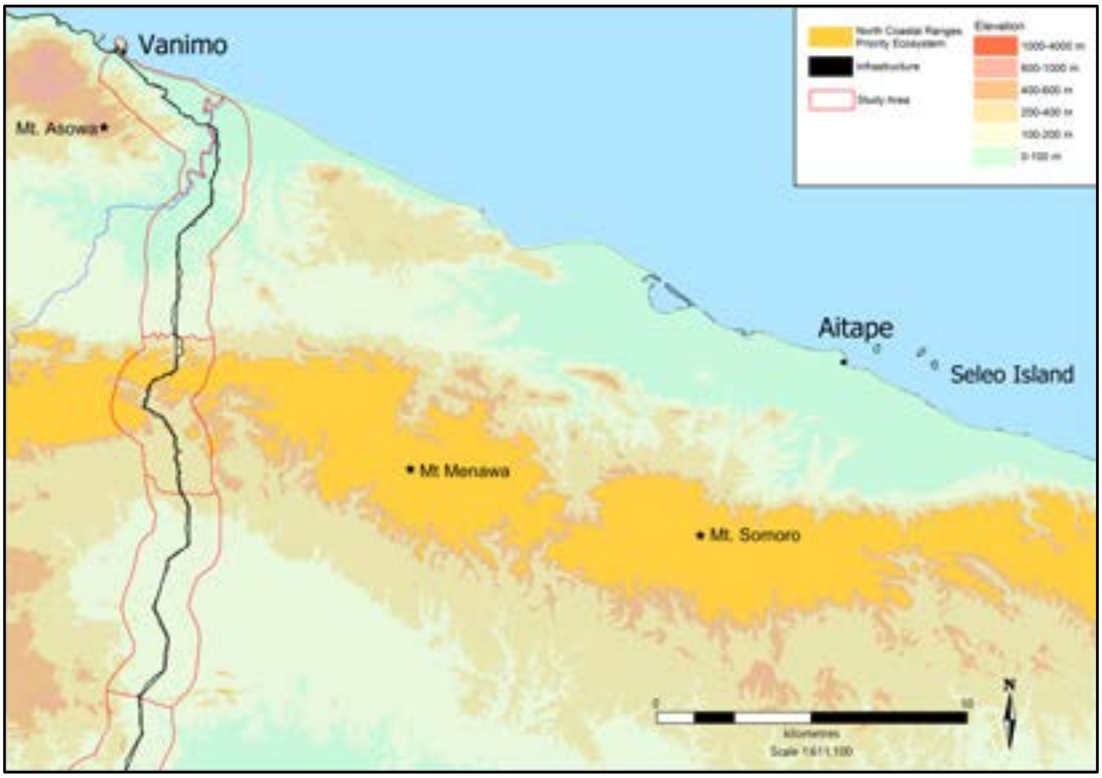

Figure 4 Priority Ecosystems in the north

6.3 Off-river waterbodies Priority Ecosystem

Off-river waterbodies along the Sepik River (Figure 3) provide major habitats for waterbirds and are important nesting and refuge sites for two species of crocodile and two freshwater turtles (Chapter 5 of EIS Appendix 8A). The vegetation in these wetlands, particularly floating mats of vegetation, is necessary for crocodile nesting and the maintenance of open and shallow water habitats is critical for waterbirds. The forested edges to these habitats likely form the major habitat for colonial nesting waterbirds.

6.4 Montane Forest Priority Ecosystem

Chapter 3 of EIS Appendix 8A shows that montane peaks and ridges above 1000 m asl that extend along the southern boundary of the Study Area and occur as outliers in the northern parts of the GFA Hill Zone (Figure 3), support isolates of a montane mammal community with a restricted distribution in New Guinea. It includes two species of tree kangaroos *Dendrolagus* spp., a Long-beaked Echidna *Zaglossus* sp., a Small Dorcopsis *Dorcopsulus* sp. (probably *D. vanheurni*), a striped bandicoot *Microperoryctes* sp., several species of cuscus *Phalanger* spp., and at least one species of giant montane rat. It also supports a range of high elevation birds that extend into the Study Area (Chapter 4 of EIS Appendix 8A).

The montane mammal community is significant because these species have suffered a decline through the greater part of their distribution along the Central Cordillera of PNG due to hunting and habitat modification. Within the Study Area they have a degree of protection from exploitation by virtue of remoteness and it is possible that they have diverged from the Central Cordilleran populations through local adaptation or genetic drift. This priority ecosystem includes a corridor of forest down to 800 m asl (Figure 3), which provides forest connectivity between the isolated peaks and the main range forests.

6.5 North Coastal Ranges Priority Ecosystem

The term “North Coastal Ranges” can include various combinations of the high isolated northern ranges of New Guinea including the Van Rees, Foya, Cyclops, Denake, Bewani, Torricelli and Prince Alexander Mountains. These ranges support a remarkable diversity of endemic species, particularly mammals and frogs. Their distributions vary from a single mountain range to a combination of ranges (Table 9). These distributions are still poorly understood, and many may prove to extend to lower elevations and to other parts of the Ranges.

Chapters 5 and 6 in EIS Appendix 8B single out the Bewani Mountains as a significant area for frogs and odonates. In relation to frogs:

> "The eastern Bewani Mountains were identified as a major 'Unknown Area' and a major 'Wilderness Area', and Mount Menawa in the Bewani Mountains as a 'Biologically Important Area' for reptiles and amphibians by the Papua New Guinea Conservation Needs Assessment (CNA) (Allison 1993). Since the CNA assessment, surveys in the eastern Bewani Mountains have documented a number of new frog species there (Allison & Kraus 2003; Kraus & Allison 2006b), and Tallowin et al. (2017) reported that the north-western Bewani Mountains are one of the three most species rich areas of New Guinea for frogs, the others being the central highlands and the Torricelli Mountains. Although most species known from the Bewani Mountains occur more widely, and several species previously considered to be endemic have been documented from other north-coast ranges (Kraus & Allison 2006a), the Bewani Mountains are considered to be a significant habitat due to the known high diversity of species occurring there." (EIS Appendix 8B Chapter 5 p. 24).

Invertebrates are not listed in Table 9 but the Bewani Mountains were identified as a biologically important area for conservation of terrestrial invertebrates (Miller et al. 1993). Again, from EIS Appendix 8B.

> ".. the Bewani Mountains are known to have a diverse odonate fauna, based on the collections there by W. Stüber between 1936 and 1939 (Hämäläinen & Orr 2016). This fauna includes numerous species discovered for the first time by Stüber on the lower slopes of the southern Bewani Mountains in what is now Papua Province (Hämäläinen & Orr 2016 and papers quoted within). At least one species, *Papuagrion corruptum*, is to date known only from lowland forest at the base of the Bewani Mountains and several others are known only from the Bewani Mountains plus one or two additional locations in north-central New Guinea (Kalkman & Orr 2013). The lower slopes of the Bewani Mountains are therefore considered a significant habitat for odonates within the infrastructure corridor. "(EIS Appendix 8B Chapter 6 p. 18).

It is this diversity of endemics that qualifies the North Coastal Ranges as a priority ecosystem. For this impact analysis it is more narrowly defined as the Bewani, Torricelli and Prince Alexander Mountains above 500 m asl. While most of the endemics are known as high mountain species generally occurring above 1000 m asl, 500m was designated as a lower limit because ranges are poorly known, and it would encompass the ranges of the bulk of the frogs and odonates.

Table 9 Some endemic species and subspecies in the North Coastal Ranges

SPECIES	RANGE	STATUS*
Northern Glider *Petaurus abidi*	Endemic to the Torricelli Mountains.	CE
Golden-mantled Tree Kangaroo *Dendrolagus pulcherrimus*	Endemic to the Torricelli and Foya Mountains	CE P
Tenkile *Dendrolagus scottae*	Endemic to the Torricelli and Bewani Mountains. Unnamed subspecies (?or species) "Fiwo" in the Bewani Mountains.	CE P
Ziegler's Water Rat Hydromy*s ziegleri*	Endemic to the Torricelli Mountains	DD
Torricelli Mountains Shrew Mouse *Microhydromys musseri*	Endemic to the Torricelli Mountains	DD
Masked Ringtail *Pseudochirulus larvatus*	Isolated population in the Bewani and Torricelli Mountains	LC
D'Albertis' Ringtail *Pseudochirops albertisii*	Population in the Bewani Mountains	NT
Northern Water Rat *Paraleptomys rufilatus*	Subspecies endemic to the Torricelli, Bewani and Cyclops Mountains	EN
Hill's Leaf-nosed Bat *Hipposideros edwardshilli*	Know only from three localities in the Bewani Mountains	VU
Mayr's Forest-Rail *Rallina mayri*	Endemic to the Torricelli, Bewani (*R. m. carmichaeli*) and Cyclops (*R. m. mayri*) Mountains	LC
Mountain Mouse-Warbler *Crateroscelis robusta bastille*	Subspecies restricted to the Bewani and the Torricelli Mountains	LC
Spotted Jewel-Babbler *Ptilorrhoa leucosticta menawa*	Subspecies restricted to Mt Menawa, Bewani Mountains and may extend to the Torricelli Mountains	LC
Black-bellied Cuckooshrike *Coracina montana bicinia*	Subspecies endemic to the Cyclops, Bewani and Torricelli Mountains	LC
Frog *Austrochaperina adamantina*	Previously known only from Mt Nibo, 9 km WSW of Mt Menawa but there is a new record at 340 m asl in the Bewani Mountains (Kraus & Allison 2006)	DD
Frog *Austrochaperina aquilonia*	Known only from the type and paratype localities in the Torricelli Mountains and two localities above 900 m asl in the the Bewani Mountains.	DD
Frog *Austrochaperina basipalmata*	North Coastal Ranges between Tawarin River, Indonesia and the Torricelli Mountains. It occurs around 1,000 m asl.	LC
Frog *Austrochaperina septentrionalis*	Known only from the Bewani and Torricelli Mountains 950 to 1,200 m asl.	DD
Frog *Choerophryne longirostris*	Known only from two sites 1 km apart on Mount Menawa, in the Bewani Mountains, and one site in the Torricelli Mountains	DD
Frog *Cophixalus bewaniensis*	Known only from the type locality in the Bewani Mountains at 950 m asl.	DD
Frog *Litoria mucro*	Known only from the type locality at 550 m asl in the Torricelli Mountains	DD
Frog *Oreophryne cameroni*	The Torricelli and Adelbert Mountains 550-850 m asl	NE
Frog *Oreophryne parkopanorum*	Mt. Sapau summit, Torricelli Mountains 1120 to 1320 m asl	NE
Frog *Xenorhina tumulus*	Known only from two localities: Mambimap, at 1,500 m asl in the Adelbert Mountains; and in the Bewani Mountains (Allison pers. comm. to S. Richards).	DD
Frog *Xenorhina zweifeli*	Known only from the Bewani and Hunstein Mountains 900 to 1900 m asl	DD

*Conservation status IUCN CR – Critically Endangered, EN – Endangered, VU – Vulnerabe, NT – Near Threatened, DD – Data Defficient, LC - Least Concern, NE – Not evaluated. P – Protected under the PNG Fauna (Protection and Control) Act 1966.

7. Fine Scale - Focal Habitats

7.1 Riparian and gallery forests

Forest along riverbanks provides specialised habitat for a range of fauna and plays an important role in fauna ecology. A range of species is particularly abundant in these habitats, including kingfishers, the Shining Flycatcher and butterflies, which tend to congregate to mate in riverine areas. Riverine forest is most important in the lowlands where it supports a variety of large fruiting trees. Consequently, lowland riverine forest is particularly rich in pigeons and parrots, although no species is restricted to this habitat. Many birds will move into these habitats in the drier parts of the year and at hot times of the day, particularly in the lowlands. At such times the riverine forests act as refuges.

7.2 Hilltops

The tops of steep, isolated hills below approximately 900 m asl are a specialised habitat where males of many species of butterflies, particularly species that are rare or sparsely distributed, establish mating territories. Although preferring forested hills, butterflies will use disturbed hilltops so long as there is some forest still left on it where they can establish territories (Chapter 7 of EIS Appendix 8A).

7.3 Upland streams

Stream condition in Upland Torrential Streams and Upland Low-gradient Streams[9] is important for maintaining populations of torrent-dwelling frogs, butterflies, odonates, semi-aquatic rodents and birds such as Salvadori's Teal, Torrent-lark and Torrent Robin. The torrent dwelling frogs and odonates, in particular, require fast flowing clear rocky streams with intact riparian vegetation. The structure and density of riparian vegetation associated with these streams is a major factor determining which species live along them and different assemblages of odonates and frogs occur in different types of streamside vegetation. Some prefer dense overhanging riparian vegetation, some open sections of stream, others smaller shaded streams with complex understorey riparian vegetation, and some frequent streams with open understoreys and canopy gaps that allow large sun patches to penetrate to the creek bed (Chapter 6 of EIS Appendix 8A).

7.4 Caves

Cavernicolous bats and swiftlets depend on caves for roosting or breeding. Bats do not necessarily use the same type of cave for roosting and for breeding and only a small subset of caves in an area may provide optimal roosting habitat. Some species of bats in Australia, congregate in large maternity colonies in just a few caves. The Project surveys did not locate any large microchiropteran cave colonies but did locate what may be large colonies of pteropodids (*Dobsonia* and/or *Aproteles*) in sinkholes and caves. While caves will be most abundant in karst and other limestone areas, rock shelters and cavities in other geologies also provide potential roost and maternity sites. Bat species vary greatly in their choice of roosting sites - some are catholic while others are limited to a subset of available caves.

Bent-winged Bats (*Miniopterus* spp.) have an unusual ecology that can make individual caves significant. These species have large colonial territories of hundreds to thousands of square kilometres that revolve around the long-term use of particular caves as maternity roosts (Dwyer 1966, 1968). In Australia there is evidence that this behaviour results in genetic divergence between populations (Cardinal and Christidis 2000) and so protection of maternity roosts is regarded as essential for the conservation of regional populations (DSEWPC 2011). Maternity roost caves have not been located within the Study Area but may yet be found in one or more of the local blocks of karst.

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[9] See Table 3 of Chapter 1 in EIS Appendix 8A for stream definitions. Upland Torrential Streams are 1-10 m wide clear, cool creeks with oxygenated waters, moderate-high velocity and rocky substrates with riffle-pool morphology and sometimes with waterfalls. Low-gradient Streams are small to medium are similar sized, clear water creeks of low velocity and sandy substrates. Riffle/pool morphology substantially lacking and oxygen levels lower than in UTS.

8. Species scale

The Study Area supports species listed as of conservation concern by IUCN or by national legislation that require individual impact assessments. These are the IUCN Red List threatened categories of Critically Endangered, Endangered, Vulnerable and Near Threatened (part 8 of Annex 4). From here on in these IUCN categories will be capitalised while the use of the terms as simple adjectives will not.

Nine species listed as Critically Endangered by IUCN, 7 as Endangered, 15 as Vulnerable and 28 as Near Threatened occur or may occur in the Study Area. Of these 11 are also protected under the PNG Fauna (Protection and Control) Act 1966. A further 26 species are protected under the Act but listed as Least Concern or Data Deficient by IUCN. The two species of cassowaries, neither listed under the Act and both classified as Least Concern by IUCN, are also included because of their cultural significance. Table 10 shows that 60% were recorded and the rest could possibly occur. The Critically Endangered and Endangered mammals are concentrated in the GFA and the first section of the infrastructure corridor and in the Bewani region (sections 7 and 8) (Table 11). It must be noted that the figures for Critically Endangered may be distorted because echidnas (*Zaglossus* spp.) could not be identified to species. The species present is most likely the IUCN Vulnerable Eastern Long-beaked Echidna *Z. bartoni* but the Critically Endangered Sir David's Long-beaked Echidna *Z. attenboroughi* cannot be ruled out.

Finally, 44 species are listed as Data Deficient by IUCN and not protected under the PNG *Fauna (Protection and Control) Act 1966*. They were not the subject of individual impact assessment but are presented in part 1.9 of Annex 4.

Table 10 Numbers of species of conservation concern

STATUS	RECORDED	POSSIBLE	TOTAL
Critically Endangered	4	5	9
Endangered	4	3	7
Vulnerable	12	3	15
Near Threatened	14	14	28
Protected under the PNG Fauna (Protection and Control) Act 1966 or of cultural significance	17	9	26
TOTAL	51	34	85

Table 11 Potential occurrence of mammals, landbirds and waterbirds of conservation concern in Study Area sections

STATUS	GFA	INFRASTRUCTURE CORRIDOR									
		1	2/2A	3	4	5	6	7	8	9	10
Critically Endangered	4	3	2	2	2	2	2	3	5	1	1
Endangered	2	2	1	1	0	0	0	0	1	0	2
Vulnerable	4	4	5	5	5	5	5	5	6	5	4
Near Threatened	9	15	11	16	12	12	12	13	8	13	15
Protected or of cultural significance	18	19	13	17	13	13	13	14	14	14	13
TOTAL	37	43	32	41	32	32	32	35	34	33	35

9. Protected Areas

There are no protected areas in the Study Area, the nearest is the Hunstein Wildlife Management Area to the east (Figure 5). Its western boundary is the April River and at its closest point, the proposed Uma WMA, it is approximately 38 km from the nearest Project infrastructure.

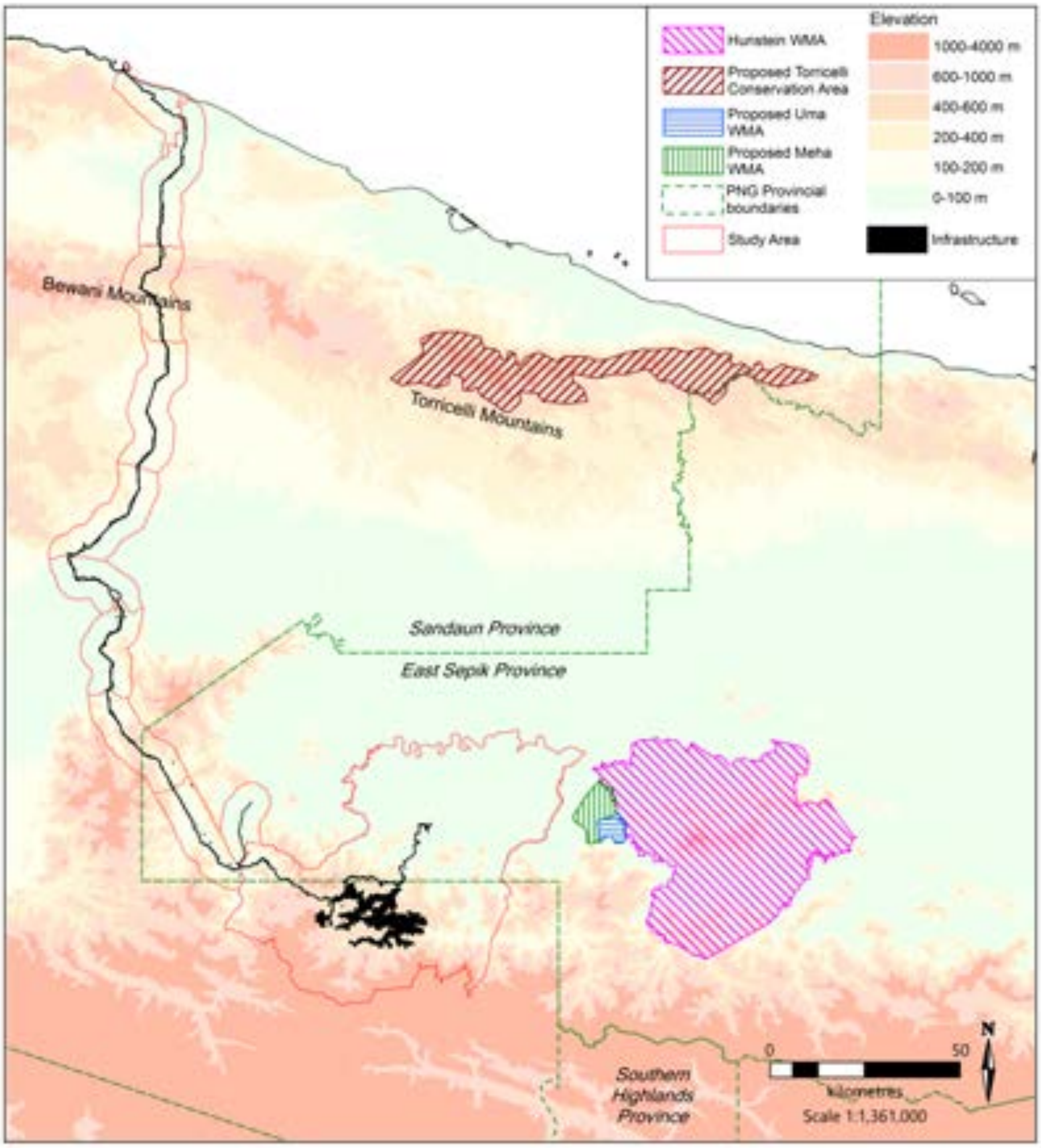

Figure 5 Existing and proposed protected areas

PART 3 - IMPACT ANALYSIS

10. Method of Impact Assessment

This impact assessment is based on the Project description provided by Coffey on 6/6/18 (section 11) and follows the mitigation hierarchy approach.

Avoidance was carried out in the early design stages of the Project whereby the location, geometry and broad scale management of Project elements were designed in such a way as to avoid co-location with high value biodiversity assets as far as possible.

Mitigation consists of "measures taken to reduce the duration, intensity, significance and/or extent of impacts (including direct, indirect and cumulative impacts, as appropriate) that cannot be completely avoided, as far as is practically feasible consisted of developing procedures and techniques to reduce impacts on terrestrial biodiversity as far as possible" (CSBI 2015), which generated a set of suggestions to be included in Environmental Management Plans (EMMPs).

Rehabilitation involves identifying what areas can be rehabilitated and returned to a state where they can support biodiversity.

Residual impacts are those remaining after avoidance, mitigation and rehabilitation and their significance was assessed using a matrix approach.

Finally, **offsetting** is the provision of conservation outcomes that accounts for any residual impacts left after avoidance, mitigation and rehabilitation.

The Project may cause a range of potential direct and indirect effects to occur, which, if they do, may act synergistically impacting terrestrial biodiversity values. Therefore, impacts can have multiple interacting sources. The sources (or causes) of potential impacts assessed here include:

- Direct clearing and habitat loss.
- Edge effects and barrier effects.
- Human disturbance and hunting.
- Impacts of the ISF storage not related to clearing.
- Contamination.
- Indirect impacts from increased access and Introduction of invasives, pests and diseases.
- Fire
- Indirect effects of the mine's programs to mitigate socio-economic impacts.

Direct impacts are those resulting from direct interaction between the Project and the social and/or biophysical environment, and there is an immediate cause-and-effect relationship, whereas indirect impacts are at least one step removed from Project activities in terms of cause-and-effect links.

Analysis of the likelihood of the impact has not been included in this assessment per se, since the impacts described herein are all viewed as being credible outcomes of the Sepik Development Project.

11. Project description

Frieda River Limited (FRL) is assessing the feasibility of the Sepik Development Project (the Project) in northwest Papua New Guinea (PNG). The Project is underpinned by the Frieda River Copper-Gold Project (FRCGP) and supported by three separate but interdependent projects which provide key infrastructure including hydroelectric power. The Project is potentially nation-building and is expected to provide regional benefits to PNG by supporting its Development Strategic Plan 2010-2030.

The four key elements of the Project are located in the Sandaun and East Sepik provinces and comprise:

- Frieda River Copper-Gold Project (FRCGP).
- Frieda River Hydroelectric Project (FRHEP).
- Sepik Infrastructure Project (SIP).
- Sepik Power Grid Project (SPGP).

Frieda River Copper-Gold Project

The FRCGP comprises a large-scale open-pit mine operation feeding ore to a comminution and flotation process plant producing a copper-gold concentrate for export to custom smelters. The copper-gold concentrate will be transported from the process plant to a concentrate storage and export facility located at the Vanimo Ocean Port via a 325-km-long concentrate pipeline located within the infrastructure corridor. The concentrate pipeline and export facility are also part of the FRCGP.

The FRCGP will have a mine life of approximately 33 years preceded by a six-year implementation period.

A spoil dump will be developed in the headwaters of the Ok Binai. This spoil dump will store non-acid forming (NAF) waste rock from Year -1 and organic pre-strip material over the 33-year mine life.

All waste rock (other than that reporting to the Ok Binai waste dump) including PAF waste rock will be placed within the ISF by barge. At the barge loading station the waste rock will be stockpiled, reclaimed and loaded into 5,000 t barges. The barges will transport and deposit the waste rock for subaqueous storage in the ISF.

Thickened tailings will be pumped via a dedicated pipeline from the process plant for subaqueous storage in the ISF.

The FRCGP's power demand will be approximately 180 MW increasing up to 280 MW by Year 8. Offsite power demands for the Vanimo Ocean Port concentrate export facility and Vanimo Infrastructure Area facilities and two concentrate booster pump stations will require approximately 4 MW and 7 MW respectively. This will be supplied via a 22 km, 132 kV transmission line from the hydroelectric powerhouse to the process plant. Power supply to the offsite facilities will be provided by the Northern Transmission Line as part of the SPGP.

Mine infrastructure (workshops, warehouse, muster, training and dining areas and fuel storage) will be located close to the HITEK open-pit. Raw water will be sourced from the ISF and potable water from the Nena River upstream of the ISF.

Overland logistics includes:

- A 39 km mine access road from Hotmin to the mine (unsealed 7.5 m wide dual lane).
- A 33 km unsealed 7.5 m wide dual-lane Link Road from the powerhouse to the mine.
- A buried 325 km-long pipeline providing transport of concentrate to the Vanimo Ocean Port.
- Equipment and goods will be transported via road along the main access route during operations.
- Coaches will be used to transport personnel between points of hire along the public road and from the Green River Airport to the mine.

During construction, freight will be imported via existing ports at Wewak, Lae and Madang and barged upstream along the Sepik River to the Frieda or May River ports until upgrade of the Vanimo to Green River road has been completed. Freight will then be trucked from Vanimo to Green River and barged from the Upper Sepik River Port downstream along the Sepik River. Once the main access road from Green River to the mine is complete all freight will be trucked to site. During operations, freight will be imported via the upgraded Vanimo Ocean Port and trucked to site. Riverine transport will be used during operations on an as required basis.

The main construction camp will be located in the Nena River valley approximately 5 km from the process plant and will accommodate up to 3,550 personnel. A site accommodation village at the mine site will house approximately 2,780 personnel with a further 100 personnel to be accommodated at Vanimo for office, logistics and port operations.

Frieda River Hydroelectric Project

The FRHEP will be capable of producing 600 MW with a firm generating capacity of 410 MW. From approximately Year 2, the excess power available for export will be in the order of 270 MW; this will reduce to 150 MW from Year 8 due to the increase in power demand for the FRCGP.

The ISF will be constructed in the Frieda River catchment approximately 16 km downstream of the mine and 35 to 40 km upstream of its confluence with the Sepik River, and will have an ultimate footprint of approximately 12,700 ha. The ISF final embankment will be approximately 190 m asl (238 m RL) high, utilising 30 million cubic metres of fill and creating a total storage capacity of 9.6 billion cubic metres. The operating water level will be approximately 226 m RL.

Two diversion tunnels will be required to divert river flows from the Frieda River away from the construction area of the embankment while providing protection against 1:100 storm events.

A 40 km unsealed 7.5 m wide dual-lane FRHEP access road from the Frieda River Port to the powerhouse will be constructed.

Sepik Infrastructure Project

The mine will be accessed by a 325 km long infrastructure corridor consisting of the existing road from Vanimo to Green River and a new road from Green River to the mine site. The latter will be at least 7.5 m wide with a gravel pavement surface. The remaining road sections may be sealed during the operations phase. The existing road from Vanimo to Green River will be also upgraded. The road from Vanimo to Hotmin will be a public road but the road from Hotmin to the mine site will be private.

A new 350 m bridge will be built at the Sepik River crossing. The bridge will be dual lane with traffic safety barriers and a pedestrian walkway. The bridge will be approximately 25 m above the river bed to allow for the frequent flooding of the Sepik River that occurs during wet seasons.

A road from Hotmin to Telefomin may also be constructed, but this is not required to support the FRCGP or FRHEP and is not part of the EIS. Similarly, this road has not been considered in this terrestrial biodiversity impact assessment.

The existing airstrip at Green River is located 150 km from the FRCGP site. It will be upgraded to an international airport that will cater for larger aircraft (up to Lockheed C-130) and be open for commercial and domestic use.

The existing Port of Vanimo will be upgraded (and termed the Vanimo Ocean Port) to include up to two new berths to support the FRCGP and other port users.

The Sepik Power Grid Project

The SPGP consists of a new 370 km 275 kV Northern Transmission Line from the FRHEP to the Indonesian border, via Vanimo, which will provide power for the offsite FRCGP facilities. The Northern Transmission Line will be located within the infrastructure corridor. Three substations will be located along the Northern Transmission Line at the FRCGP site accommodation village, near Green River and at Vanimo.

The excess power from the FRHEP also provides an opportunity to supply power to communities along the infrastructure corridor and to industries such as agriculture, fisheries, food and timber processing, mining and manufacturing.

12. Avoidance of potential impacts

Avoidance of impacts can occur at a range of scales from tactical such as preserving a single tree alongside a construction site, to strategic i.e. decisions about project design and layout. This section concerns the strategic design decisions that were made during planning and design phases that avoided impact. Tactical measures are numerous and included in the mitigation options in Table 13.

Extensive work since 2014 has assessed many development options to determine the feasibility of the Project and minimise potential environmental and social impacts. The development options considered prior to 2017 were focussed on the prior stand-alone copper/gold project but remain relevant to the Sepik Development Project. These are described within Chapter 6 of the EIS.

The two most significant design options relevant to avoidance of potential impacts on terrestrial biodiversity were the choice of an export route and disposal of mine waste rock and tailings.

12.1 Product transport and logistics

A range of alternative options to the current proposal have been assessed and include:

1. An infrastructure corridor (road and pipeline) north across the Torricelli Mountains thence to a coastal port near Aitape.
2. An infrastructure corridor (road and pipeline) from the Sepik River port travelling roughly northeast to Wewak.
3. An infrastructure corridor (road and pipeline) north to a port on the Sepik River then riverine transport to an export facility at Wewak (Figure 6).

A comparison of the three main options in relation to terrestrial biodiversity is presented in Table 12. The comparison shows that the existing option avoids potential impacts on the centre of the North Coastal Ranges Priority Ecosystem and the proposed Torricelli Conservation Area. The existing option also largely leaves the Lowland Zone of the GFA intact.

It is difficult to compare vegetation losses under the three scenarios since options 1 and 2 do not have an export power transmission line. Without that, Options 1 and 2 would have entailed greater vegetation clearing and option 3 the same as the existing design.

12.2 Location for mine waste and tailings disposal

Several options for disposal of mine waste rock, most of which is acid generating, and tailings have been considered over many years prior to the present design of disposing of it in the ISF. These have included co-disposal of waste rock and tailings in the Ok-Binai valley south east of the HITEK open pit which would have encompassed more than 750 ha and various combinations of valley dams and tailings storage facilities of up to 2300 ha. All options involved the loss of intact habitat – Hill Forest or Swamp Forest formations. The decision to include all mining waste rock and tailings into the ISF and not construct extra storage areas avoided up to 2400 ha of extra potential forest loss.

12.3 Other strategic avoidance measures

A range of other strategic avoidance measures, which have implications on terrestrial biodiversity have been made. These include:

- Collocating the slurry pipeline and main access road.
- Avoiding virtually all priority ecosystems.
- Keeping the Sepik Development Project disturbance area mostly within the Study Area Hill Zone and on higher elevation areas in the Study Area Lowland Zone thus avoiding disturbance of hydrology dependent habitats.
- Locating some temporary Sepik Development Project construction components (e.g. quarries and spoil dumps) within the ISF boundaries and/or within catchments that drain to the ISF.
- Variations in locations of processing facilities, camps etc. were neutral in terms of avoidance in

that they were all located in undisturbed Hill Forest. The most significant design option in relation to these was to consolidate them.

Table 12 Comparison of concentrate export routes

EXISTING DESIGN	OPTION 1 TORICELLIS	OPTION 2 WEWAK	OPTION 3 SEPIK RIVER
Collocates for approximately 160 km with existing road	No collocation or minimal collocation with small roads in Torricelli Mountains involving significant construction.	Collocation with existing roads and tracks from north of Pagwi to Wewak.	No collocation from process plant to Sepik River.
Construction of 150 km road from process plant in mostly intact Hill Zone vegetation.	Construction of a 230 - 255 km road from the process plant in intact lowland vegetation	Construction of a 212 km road from the process plant in intact lowland vegetation and upgrades or reconstruction of 135 km of existing or derelict roads and tracks through the southern slopes of the Prince Alexander Mountains.	Construction of a 145 km road from process plant to Sepik River port in intact lowland and hill vegetation
Traverses North Coastal Ranges through an existing road corridor	Traverses North Coastal Ranges along some small existing roads but mostly involves new construction.	Traverses southern slopes of Prince Alexander Mountains on existing roads and tracks.	Does not traverse North Coastal Ranges Priority Ecosystem.
Traverses North Coastal Ranges Priority Ecosystem mostly west of the known ranges of many of the North Coastal Range endemics in Table 9.	Traverses North Coastal Ranges Priority Ecosystem mostly within the known ranges of many of the North Coastal Range endemics in Table 9.	Does not traverse North Coastal Ranges Priority Ecosystem	Does not traverse North Coastal Ranges Priority Ecosystem
Avoids the proposed Torricelli Conservation Area	Bisects the proposed Torricelli Conservation Area	Avoids the proposed Torricelli Conservation Area	Avoids the proposed Torricelli Conservation Area
No new airstrip required – only upgrades to Frieda and Green River strips.	Requires new airstrip to be built in Lowland Zone of GFA	Requires new airstrip to be built in Lowland Zone of GFA	Requires new airstrip to be built in Lowland Zone of GFA

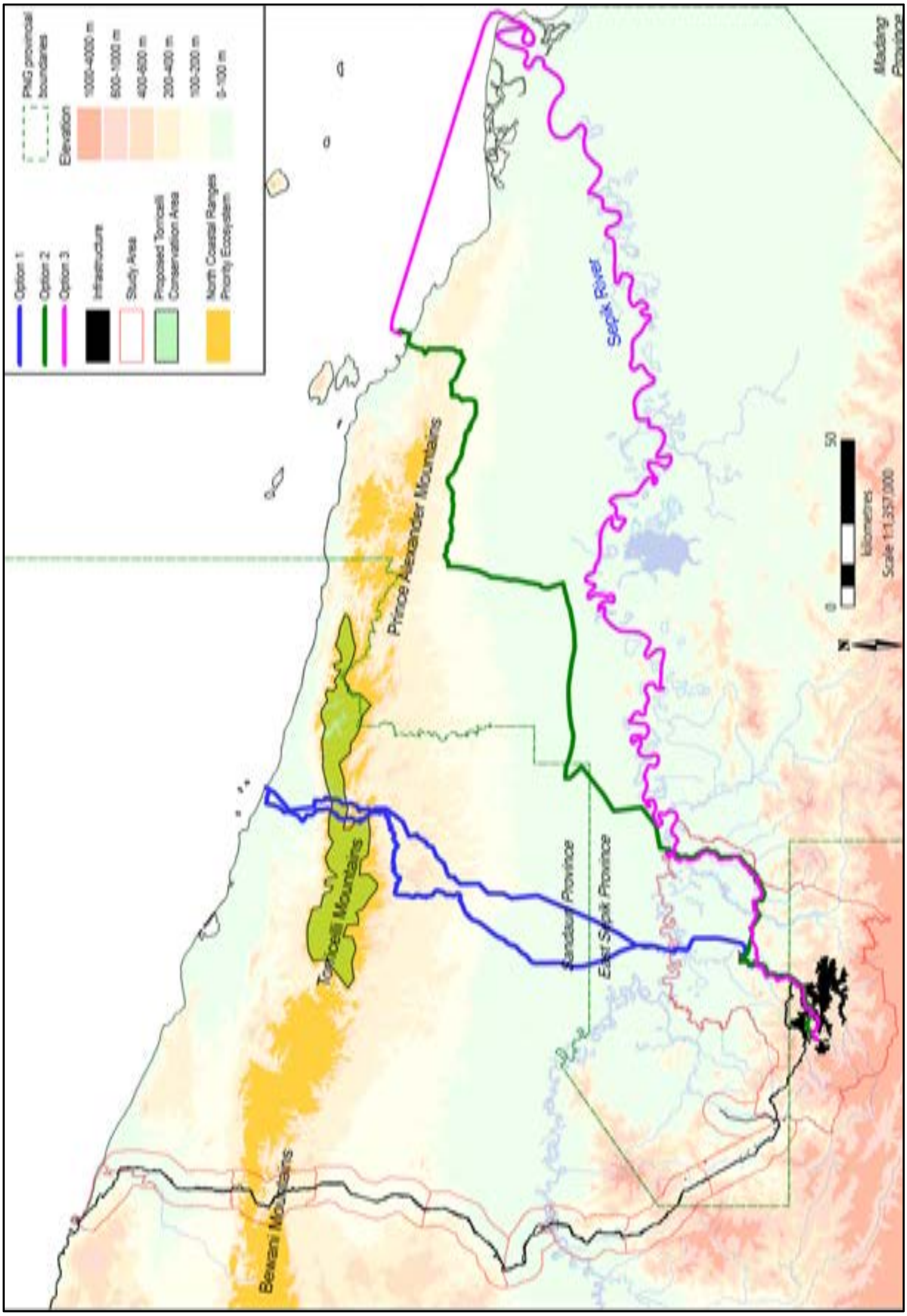

Figure 6 Other options for concentrate export route

13. Mitigation of potential impacts

Proposed mitigation measures have been collected from all the authors of Chapters 2 to 7 of EIS Appendix 8A and assembled in Table 13 for inclusion into one or more Biodiversity Management Sub-plans within the overarching Environmental Management and Monitoring Plans (EMMPs).

13.1 Sources of Direct Impacts

13.1.1 Clearing and Habitat Loss

The immediate consequence of construction is loss of habitat and terrestrial biodiversity from the cleared or inundated areas. There is limited likelihood of very sedentary fauna vacating the area and surviving in the surrounding forest because only the larger and more vagile species, such as wallabies, bats and birds, may relocate and animals that are able to move into surrounding areas are likely to encounter existing territory holders of the same species and be unable to compete and survive (Burns 2005). Large bats may be able to relocate but, for cave roosting species this will be contingent on availability of alternative, unoccupied or under-utilised roost sites.

Linear clearings will occur for roads, tracks, pipelines, conveyors and transmission lines. These will generate less likelihood of entire territories being lost and so fauna impacts may be lower but their major potential impact is through edge and barrier effects. Many species of bats and birds may benefit through creation of linear clearings, which will increase habitat diversity and provide flyways through patches of forest.

In areas allowed to regenerate, biodiversity will recolonise as succession progresses and some recovery will occur, but it will take some time for forest specialists to colonise as evidenced by the depauperate bird community in the disturbed lower sections of the HITEK deposit area (Chapter 4 of EIS Appendix 8A). Should the cleared areas not regenerate and be replaced by grasslands then diversity will be reduced in all faunal groups.

The potential effects of forest clearing may be felt outside the immediate area of impact. Many species such as large fruit bats, cassowaries, parrots and pigeons, forage over large areas and the loss of the forests in the Study Area will reduce the foraging areas for these species and have ecological repercussions elsewhere in the Study Area and possibly beyond. Large fruit bats (Hall and Richards 2000) travel long distances from permanent roosts to forage and habitat loss may impact these roosts even though they may be beyond the Project disturbance area or even the Study Area.

Suggested measures to reduce habitat loss focus on reducing unnecessary clearing and maintaining forest integrity in areas of forest left between Project components. For certain species with very low population densities where single individuals are likely to be significant to population persistence, the suggested measures include a fauna relocation program[10].

River crossings involve a complex set of potential impacts including the removal of riparian vegetation, soil disturbance and potential impacts downstream. This may impact a range of species especially torrent dwelling frogs, odonates and butterflies in and along streams. Specific effects may be unpredictable because of species-specific responses to vegetation removal. For example, the frog, *Litoria* sp. nov 8 (small torrent) requires closed-canopy, high-humidity microhabitats whereas *Litoria* sp. nov 1 cf *arfakiana* prefers more open, less complex riparian habitats (Chapter 5 of EIS Appendix 8A); the latter will be less impacted than the former.

Finally, there are certain valuable forest resources for wildlife for which particular measures are suggested in Table 13. These include:

- **Very large old trees** provide tree hollows for nesting and denning for a wide range of arboreal

[10] Any animals moved would have to be relocated to new areas.

mammals, birds, reptiles and frogs.

- **Large fig trees (*Ficus* spp.)** provide food for numerous frugivorous birds and mammals including Pesquet's Parrot, cassowaries and the manucode birds-of-paradise (O'Brien *et al.* 1998, Shanahan *et al.* 2001, Mack and Dumbacher 2007).
- **Bird-of-paradise display sites**. Birds-of-paradise and bowerbirds are lekking species where males display communally in display areas and compete for females. Some species use individual trees, others specially prepared sites on the ground. Display areas are often traditional and form breeding epicentres for local populations (Frith and Beehler 1998) and their destruction can interrupt breeding activities of many birds simultaneously. While it is not feasible to locate display sites of all species the display trees of Lesser Birds-of-paradise are obvious.
- **Megapode nest-mounds**. Megapodes are large, terrestrial birds that bury their eggs in large mounds of soil and leaf litter, where incubation is achieved by heat generated from decomposing vegetation (Jones *et al.* 1995). In some villages megapode eggs may form an important part of the diet, and the eggs of an individual mound may be harvested regularly for consumption over multiple years.

13.1.2 Edge effects

Edge effects come about by exposure of the forest edge to windier, dryer, hotter and lighter conditions in the forest next to the clearing which can produce continued degradation of forest adjacent to the edge (Fetcher *et al.* 1985, Laurance *et al.* 1997, Harper *et al.* 2005). A particularly severe edge effect is to make the forest edges more susceptible to fire which can start a cyclical process of burning, more edge effect, drying, burning etc. causing the forest to retreat year by year. The documented penetration distance of edge effects into the forest vary from tens of metres to kilometres (Laurance *et al.* 1997, Curran *et al.* 1999) and edge habitats are likely to be a focus for establishment of invasive species of plants and animals. There is insufficient information to determine if certain forest types are more resilient to edge effects than others.

Edge effects may impact most on primary forest specialist fauna such as microhylid frogs, interior birds and invertebrates adapted to dark humid interior microclimates and particular stream-side habitats. Such species retreat from the forest edge as it dries out and becomes lighter. Mammal communities in degraded edge habitats typically include fewer species than the original forest and have different community structures (Asquith and Mejia-Chang 2005).

Vegetated streams, particularity clear mountains streams, within or proximal to cleared areas will experience edge effects via increased exposure. This would affect frogs and odonates in particular (Clausnitzer 2003). Water temperature is also likely to increase in these situations, which will impact on long term breeding success of frog species requiring cool waters (Welsh and Ollivier 1998).

Generalist forest species and grassland fauna species adapted to drier, more open habitats, such as many species of birds and butterflies, and bats will be advantaged, and some may colonise the forest edge.

Under natural conditions, regrowth and sealing of the forest edge in the tropics is rapid so edge effects will be short lived. Most of the measures suggested in Table 13 to reduce habitat loss are effective for reducing edge effect, particularly those related to maintaining as narrow a clearing width as possible.

Taken as a whole, the Project disturbance areas will create a very long edge making this potential impact pervasive. The effects are likely to be more significant in the following circumstances and are where the suggested measures in Table 13 could be most effectively focussed:

- Where clearings are large and maintained for long periods. Under such circumstances edge effects operate continuously and even novel vegetation communities may develop (Laurance and Bierregaard 1997, Oliviera *et al.* 2004).
- On high elevation steep slopes exposed to the wind above cuttings.
- Where roads and other linear clearings surround small blocks of forest, which allows edge effects to penetrate from all sides.

13.1.3 Barrier effects

Barrier effects occur where a strip of open habitat provides a barrier of hostile habitat that prevents fauna from moving across the gap, thus splitting or fragmenting populations. Rivers provide barriers to many forest animals and long linear clearings in forest provide another, particularly to specialist forest species. A wide range of species can be affected (Oxley *et al.* 1974, Swihart and Slade 1984, Goosem (1997), Dyer *et al.* 2002).

Narrower linear infrastructure provides less of a barrier and most birds and reptiles and many mammals, frogs and butterflies would not find them a significant problem. However, a range of specialist arboreal mammals and butterflies, odonates and frogs specialising in cool dark areas of the forest are likely to find roads significant barriers and this will reduce options for larger scale dispersal. However, it is unclear whether or not this would impinge on the persistence of any of these more sedentary forest animals (Goosem 2001).

Considerable work has been undertaken in Australia on active measures to manage barrier effects (Goosem 2001, 2004), including building 'underpasses' and 'overpasses' that allow fauna to pass below and above a roadway, respectively. These approaches work well in rainforest in northeast Queensland (Goosem *et al.* 2006) and typical frequencies of usage have been shown to be adequate to maintain metapopulation viability in the case of old habitat fragments separated by otherwise impassable barriers (Taylor and Goldingay 2003, Taylor *et al.* 2011, Weston *et al.* 2011).

Barrier effects can be reduced by maintaining as narrow a cleared corridor as possible, allowing the pipeline corridor and access roads to regenerate as far as possible, and, ideally, allowing the canopy to close wherever possible. The measures suggested in Table 13 to reduce habitat loss and edge effects are likely to be effective in reducing barrier effects but, considering the extent of the potential barrier, active measures to build overpasses and underpasses are also suggested.

13.1.4 Human Disturbance of Fauna

Hunting

Hunting is a major contributor to the decline of larger mammals and birds in New Guinea (Kocher Schmid 1993) and an indirect impact the Project may have is to increase hunting rates in the Study Area. This could come about by improving access, hunting by the workforce, increased wealth of landowners allowing purchase of better weapons and hunting by in-migrants.

Virtually all fauna in the Study Area are potential prey but the larger or more spectacular species, which have been locally extirpated in many settled areas in PNG (Kocher Schmid 1993), are particularly targeted. The presence and relative abundance of these favoured prey species serves as an indicator of hunting (Diamond and Bishop 2003).

Hunting is a traditional local pursuit and interviews conducted in villages within and around the Study Area (EIS Appendix 8A) revealed that all households consume bush-meat at least occasionally, with some eating bush-meat once or twice a week (Centre for Environmental Health 2011). Chapter 4 of EIS Appendix 8A indicates that residents of Ok Isai, Hauna, Aoum 3, Nekiei, Usok and Wameimin 2 in the GFA hunt birds such as cassowaries, pigeons, parrots, hornbills and brush-turkeys.

In general, the GFA Hill Zone appears to experience only low levels of hunting except within a few kilometres of villages and along walking tracks that link villages and mining exploration infrastructure. The current level of hunting in the GFA Montane Zone is unknown but hunters from the GFA villages do hunt there. A significant increase in hunting in the Montane Zone could possibly locally exterminate fauna such as echidnas, tree kangaroos, wallabies and cuscus. The Study Area Lowland Zone is difficult to traverse and is likely to have been impacted little by hunting except around settlements and along waterways. There is limited information on hunting along the infrastructure corridor although it would be expected to be high north of the Sepik River and through the Bewani Mountains along the Vanimo to Green River road

Non-locals already come into the GFA to hunt birds (I. Woxvold *pers. obs.*), and such incursions may increase with Project development and is likely to result in some increase in hunting, the magnitude of which will depend largely upon management of Project staff and accessibility to the Study Area. In the areas along the Vanimo to Green River road and the logged areas much of the large fauna has likely been extirpated already.

Suggested measures to mitigate this are centred on controlling the work force and controlling access.

Other disturbances and causes of death

Death, disturbance and harassment of fauna can be brought about by direct human interference, including Project traffic, collisions with transmission lines, noise, lights, dust and fumes.

Any disturbance to fauna causing them to retreat from construction sites is likely to be temporary and fauna is likely to return if not hunted or harassed. Direct human harassment of fauna can be a problem if not prohibited and measures are included in Table 13 to achieve that.

Traffic deaths can be managed by controlling speed limits and driver behaviour under the Traffic and Transport Sub-plans to EMMPs.

Birds and bats colliding with transmission lines may lead to deaths over the life of the Project. In the Study Area Lowland Zone flocks of waterbirds, flying foxes and fruit pigeons are likely to be particularly Vulnerable. Design criteria to reduce this probability may need to be developed (Jenkins *et al.* 2010)[11].

Noise is a particular issue for birds and bats, which communicate acoustically and there is growing evidence that many bird species are less abundant in noisy areas (Parris and Schneider 2008, Slabbekoorn and Ripmeester 2008). This probably cannot be mitigated beyond the noise standards for human health imposed by the Project.

Dust from traffic is a minor nuisance to most fauna. The most sensitive group are butterflies where the effects of dust are manifested through the leaf-eating larvae, which would be highly sensitive to dust build-up on leaves. Watering roads can reduce potential impacts.

Lights from facilities can affect the behaviour of nocturnal birds but the issues are very local, and a measure is suggested in Table 13 to adjust the directions of lights so as not to shine into the forest.

13.1.5 Impacts of the Integrated Storage Facility

Impacts on floodplain vegetation dynamics

The Integrated Storage Facility is the largest component of the Project and the biggest contributor to terrestrial habitat loss. Construction of this impoundment may also impact floodplain vegetation dynamics by altering flow regimes in the Nena and Frieda Rivers.

The ISF has been designed as a ‘flow-through’ system. Inflow water will be managed by discharging it to the Frieda River downstream of the ISF embankment. This will take place via a set of hydroelectric power intakes, and through the spillway during storm events. The average river flow for the Frieda River is estimated to be 223 m^3/s.

Prior to commissioning of the hydroelectric power facility, the environmental flow intake will allow for water discharge at 50 m^3/s. There will be a period of two days when there will be no flow during the transition to the environmental flow intake and the full residual flow of 50 m^3/s will be restored after a total of five days assuming typical river flows.

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[11] From first principles Jenkins et al. (2010) suggest a range of design features to reduce collisions: lines should be kept as low as possible and span lengths as short as possible, cabling used should be as thick as possible, vertically separated arrays of lines should be avoided as much as possible, lines of similar height and structure with common sources and destinations should run in close parallel in effectively a common servitude, and lines with very different heights and configurations should be kept well apart by making the lines more visible by, for example, aviation balls or pendants hung from the wires.

The hydroelectric power facility will maintain a minimum 50 m^3/s discharge during the operating life of the facility, however, there are expected to be occasions when the natural flow of the Frieda River will fall below 50 m^3/s and under these circumstances the flow from the ISF will match the river flow. The ISF will have freeboard to allow probable maximum flood events to be discharged safely through the spillway without impinging on the embankment crest.

The short period of cessation of flows and a resumption of more-or-less normal flows suggests that.

- Changes to the bed of the Frieda River will be minimal, with the exception of periods of drought when flows may be lower.
- Suspended sediment in inflows is largely captured within the ISF.
- There is expected to be negligible sedimentation impacts on the off-river waterbodies.
- The ISF may reduce allochthonous input into the Frieda River as silt and larger organic fragments and debris will be sequestered in the reservoir sediments. It is not possible to predict the long-term potential impacts of this in view of the numerous water sources on the floodplain. In periods of low flow the reduced sediment loads in the water being released would counteract a tendency for the river bed to aggrade.

Catastrophic dam failure

A catastrophic flood resulting from dam failure is likely to be a "resetting flood" (Opperman *et al.* 2010). Whether the flood heights produced would be within the normal variation for flood levels in this area is unknown to this author. Considering that the Sepik River dominates the floodplain dynamics of the Study Area Lowland Zone a flood itself is unlikely to have lasting effects in the Lowland Zone. However, the effects of solid waste outflows through bed aggradation in the Nena and Frieda Rivers and subsequent increased overbank flows, as has occurred elsewhere, could be more severe and long lasting. If such an event occurs, it is likely to affect vegetation dynamics in the long term. It cannot be said how extensive such changes to overbank flows would be within the Lowland Zone.

Risks of extreme natural hazards in relation to Project elements (such as failure of the ISF embankment) their potential consequences and proposed management measures are assessed within Chapter 10 of the EIS.

13.1.6 Contamination of waterways and forest

The Project will use and/or generate a wide range of potential gaseous, liquid and solid contaminants including but not limited to hydrocarbons, process chemicals, fine sediments from erosion and spoil, sewage and biocides. If not properly stored or managed, these may impact biodiversity through direct mortality, reductions in reproductive output and reduced survivability. Amphibians are particularly sensitive to organic and inorganic contaminants (summaries in Sparling *et al.* 2010) and are highly susceptible to metal contaminates, and acidification of freshwater habitats (Ultsch *et al.* 1999).

There are numerous species of fauna and flora and many potential contaminants and a virtual lack of information on exotoxicology of the New Guinea fauna so only the most general, rather than species specific predictions, can be made as to potential impacts:

All fauna is at risk from directly consuming contaminants if they have access to wastes, chemicals, fuels and hydrocarbons. These substances would be managed in accordance with the Project EMMPs. While there may be instances of fauna being exposed to these substances this is likely to be limited and likely without consequences on the population as a whole.

Emissions include those from the process plant and exhaust emissions from machinery and traffic. The air quality and noise modelling indicate any exceedances of human health guideline values would be limited to the mine and ISF embankment and immediate surrounds. Air quality and noise would be mitigated under Air and noise Management Sub-plans of Project EMMPs.

Changes to the water quality of waterways is likely the major route whereby contaminants can impact biodiversity in the Study Area. The fauna most directly threatened are frogs, odonates, waterbirds, kingfishers, and a small number of species of forest birds and mammals that specialise in eating aquatic fauna. The major sources of contaminants would be managed by various sub-plans of Project EMMPs and are designed to minimise contamination of streams downstream of the Project.

The potential impact of silt and suspended solids in streams surrounding the project construction areas and flowing in to the ISF caused by runoff and erosion would manifest through physical impacts and synergy with chemical contaminants. Silt can smother stream microhabitats such as interstitial spaces among rocks, fill deep holes, and alter streamside vegetation by silt deposition and changes to flooding regimes. For example, there is a link between fine sediments and declines in amphibian communities (Corn *et al.* 2003, Ashton *et al.* 2006). However, New Guinea streams and rivers are extremely dynamic and undergo periodic spates and floods with high levels of suspended solids, which normally clear rapidly (S. Richards *pers. obs.*), and the amphibious fauna has adapted to this. Erosion and run off would be mitigated through an Erosion and Sediment Control Sub-plans of EMMPs.

Contamination will be managed under a range of sub-plans to the Project EMMPs. These include:

- Acid and Metalliferous Drainage, Waste Rock and Tailings Management Sub-plan
- Erosion and Sediment Control Sub-plan
- Hazardous Materials, Fuel Handling and Spill Response Management Sub-plan
- Rehabilitation Management Sub-plan
- Waste Management Sub-plan
- Water Management Sub-plan

Table 13 Proposed mitigation measures

PROPOSED MEASURE	RELEVANCE*			
	A	B	C	D
Measures to be included in an ecology management plan				
General measures aimed at reducing forest loss and degradation				
Mark the extent of vegetation to be cleared on all technical drawings and mark in the field. Do not clear beyond design limits.	X	X		
Where practicable, use land clearing techniques that preserve the rootstock of removed vegetation in the ground.		X	X	
Where there are choices for quarry locations locate them in cleared areas, secondary and/or degraded forest as far as practicable.	X	X	X	
Delineate vegetation to be retained between Project components following construction		X	X	
Measures for linear infrastructure aimed at reducing forest loss, edge and barrier effects.				
As far as possible, ensure any linear infrastructure in swampy lowland habitats is designed and constructed so as to maintain the original drainage patterns of the habitat.	X	X	X	X
Keep the width of linear clearings as narrow as possible.	X	X	X	
Allow trees that verge the access roads and routes of pipelines and conveyors to grow so that the canopy closes over the gap wherever practicable and safe to do so.		X	X	
Install fauna ‘underpasses’ and /or ‘overpasses’ at strategic locations along the infrastructure corridor to reduce vehicular fauna strike.		X	X	
Measures for temporary facilities				
Locate temporary facilities such as vehicle parks, lay down areas, storage sites, bulk fuel storage, dumps and temporary camps within cleared areas, secondary and/or degraded forest as far as practicable.		X	X	
In finalizing design of a temporary facility or infrastructure element ensure that it, or as much of it as is practicable, is located in cleared areas, secondary and/or degraded forest.	X	X		
Where there is a display tree of birds of paradise at a site proposed for a temporary facility such as vehicle parks, lay down areas, storage sites, fuel dumps, dumps, and temporary camps retain the tree as far as practicable.		X	X	
Where there is a megapode mound at a site proposed for a temporary facility such as vehicle parks, lay down areas, storage sites, fuel dumps, dumps, and temporary camps retain the mound as far as practicable.		X	X	
Retain large trees (including fig trees) likely to have hollows and other roosting sites for fauna at sites for temporary facilities such as vehicle parks, lay down areas, storage sites, bulk fuel storage, dumps and temporary camp where practicable and safe to do so				
Measures to be included in a rehabilitation plan				
General				

PROPOSED MEASURE	RELEVANCE*			
	A	B	C	D
Where practicable spread excavated soil, mulch and discarded vegetation debris (including natural seed stock) on reclaimed or rehabilitated disturbed land surfaces to facilitate natural revegetation.				
Include threatened plant species, the food plants of listed butterfly species and fruiting plants that attract frugivores in revegetation plans as far as possible.		X	X	X
Use of new species in rehabilitation				
Attempt to cultivate the new species of plants and use them in regeneration.				
Establish a project to identify the food plants of the new butterfly species so as to cultivate these plants and use them in regeneration.				
Measures to reduce impacts on Priority Ecosystems				
Peat Forest Priority Ecosystem				
Do not place any temporary infrastructure in the Peat Forest Priority Ecosystem and do not locate any infrastructure that may affect its drainage.	X	X	X	X
Nena Karst				
Do not construct infrastructure in the Nena Karst Priority Ecosystem as far as practicable.	X	X	X	X
Off-river waterbodies				
Do not place any infrastructure, permanent or temporary in lakes, billabongs or ponds.	X	X	X	X
Do not use lakes, billabongs or ponds as waste disposal areas for Project activities including fly camps and exploration camps.	X	X	X	X
Ensure linear infrastructure does not affect the hydrology of lakes, billabongs or ponds.	X	X	X	X
Montane Forest Priority Ecosystem				
Limit disturbance in montane forest as far as practicable and do not place any temporary infrastructure in this habitat	X	X	X	X
North Coastal Ranges				
As far as practicable place transmission line pylons in already cleared or degraded areas	X	X		
Measures to reduce impacts on focal habitats				
Riparian and gallery forests				
Conduct fine-scale routing of access ways to place crossings in disturbed riparian vegetation as far as practicable and keep road alignment approaches to watercourses as close to right angles as practicable to limit disturbances to the banks of watercourses.		X	X	X
Limit the extent of riparian vegetation cleared, and trim, rather than remove riparian trees where practicable.		X	X	X
Stabilise cleared banks to provide a suitable habitat for regeneration		X	X	X
Where watercourse crossings are to be revegetated use local species wherever practicable.		X	X	X
Prohibit the washing, servicing or refuelling of equipment, vehicles or machinery near or within watercourses.		X	X	X
Hilltops				
Where facilities are placed on hilltops endeavour to retain some forest on or close to the summit.	X	X	X	X
Revegetate hilltops with plant species native to the Project area.			X	X
Upland streams				
Place suitable erosion control devices between tracks and upland torrential streams.		X	X	X
Reduce sediment loading by reducing side casting above watercourses and maintaining vegetated buffers arounds stream as far as practicable.		X	X	X
Where practicable, valley-bottom access way alignments will be located so as to provide a buffer strip of natural vegetation between the access ways and watercourses.		X	X	X
Prohibit disposal of domestic and industrial waste into forest streams or sinkholes.	X	X	X	X
Implement good industry-practice management of in-stream activities to limit the downstream extent of turbid water created by fords, trenching or bridge building as far as practicable.		X	X	X
Prohibit the washing, servicing or refuelling of equipment, vehicles or machinery near or within watercourses.		X	X	X
Measures for inclusion in a quarantine plan and a weeds, pests and diseases management plan				
Develop pest and weed quarantine procedures (including for inbound foreign freight), a weeds management plan to limit the introduction of invasive weed species, periodic habitat monitoring to detect new alien incursions, and protocols for reporting sightings of serious infestations, and establish inspection and treatment standards and procedures for all freight types, including imported bulk materials. It will cover both Company and Contractors		X	X	X
Prohibit transportation of live plants or seeds to FRCGP and FRHEP Project sites unless part of an approved rehabilitation plan.	X	X	X	X
Ensure soil and weed seeds are cleaned from plant and machinery brought into the Project area from overseas, logging areas or agricultural areas elsewhere in PNG prior to reaching the Project site (applies to Company and Contractors).	X	X	X	X

PROPOSED MEASURE	RELEVANCE*			
	A	B	C	D
Establish procedures to prohibit Project workers/contractors from establishing any gardens, or introducing or transporting any plants, seeds or animals, including fish species, within the Project area.	X	X	X	X
Carry out pre-construction survey of work sites for weeds, exotic fauna and dieback using a risk-based approach to identify areas susceptible to invasion of exotic species.	X	X	X	X
Eradicate infestations of high priority weeds will be eradicated prior to commencement of construction.		X	X	X
Where appropriate, establish permanent chemical wash down point(s) to prevent weeds and pathogens being transported to work sites.		X	X	X
Measures for avoiding wildfire				
If fire hazard exists, pushed vegetation should be left to rot at the forest edge rather than burnt.		X	X	X
Develop and implement measures to reduce risks of wildfires in Emergency Response and Fire Management Sub-plans of EMMPs for the construction and operations phases of the Project aimed at reducing the likelihood of wildfires starting in the Project disturbance area to very low. The sub-plans will include banning the burning of cleared vegetation and other fires, particularly in the hill environment in drought years.		X	X	X
Measures for reducing indirect impacts brought about by in-migration and improving access to the Project area				
Maintain the mine access road (south of Hotmin), link road and FRHEP access road as private roads.		X	X	X
Control access along all Project roads.		X	X	X
Make Project roads and other linear infrastructure impassable to vehicles at closure where these are not required for ongoing environmental management and monitoring, with the exception of road access to the village of Paupe				X
Mitigations for inclusion in a biodiversity management plan				
Reduction of hunting and disturbance to fauna				
Prohibit hunting, collecting, or harassing of wildlife, keeping wildlife as pets and/or the possession and/or transport of wildlife products by Project employees and contractors at Project sites.	X	X	X	X
Implement appropriate inductions and education to ensure staff comply with hunting and collecting regulations.	X	X	X	X
Include training in the recognition of endangered fauna in inductions of all staff and contractors. Encourage a precautionary approach "If in doubt - report it".				
Do not allow megapode mounds next to infrastructure to be disturbed and prohibit the collection of eggs from megapode mounds on mine leases.	X	X	X	X
Control speed limits on Project unsealed roads, tracks, pipeline rights of way (ROWs) and transmission line corridors.	X	X	X	X
Fauna may not be disturbed or harassed by Project employees or contractors.	X	X	X	X
Prohibit the procurement or consumption of bush meat in Project sites including fly camps and exploration camps.	X	X	X	X
Prohibit non-security related Project employees and contractors from possessing firearms and/or bows and arrows while engaged in Project activities.	X	X	X	X
Prohibit keeping or temporary housing of pets or wild fauna at Project facilities other than trained guard dogs under the control of a handler.	X	X	X	X
Maintain a 500 m buffer at any large Flying Fox camp (>1000 animals) and a 200 m buffer at camps having 500 to 1000 animals	X	X	X	X
Install markers visible to birds on the transmission line to reduce the likelihood of bird and bat strikes at high risk locations including near waterbodies.		X	X	X
Unsealed roads, tracks, pipeline rights of way (ROWs) and transmission line corridors will be maintained in a damp and compacted condition (when required) to minimize dust.		X	X	X
Where practicable, direct lights at facilities and camps to minimise shine into surrounding forest.		X	X	X
Cave management				
Ensure that any limestone karst areas situated above 500 m asl and located within 2 km of any Project component is surveyed for the presence of roosting populations of If Bulmer's Fruit Bat Aproteles bulmerae prior to the construction of these Project components.	X	X	X	X
If Bulmer's Fruit Bat *Aproteles bulmerae* is located, develop a management plan that includes 1) avoidance of direct disturbance and encroachment by Project activities on the roosting site, 2) avoiding construction that would increase access to the roosting site, 3) monitor the population, 4) a local cultural awareness programme, with the objective of a local moratorium on hunting of cave roosting flying foxes. A plan for Bulmer's Fruit Bat *A. bulmerae* may best be rolled up into a fauna at risk management program.		X	X	
Conduct a pre-clearance survey of infrastructure, including quarries, to determine presence of caves with bat colonies and where colonies are located within 100 m of infrastructure, establish procedures to reduce disturbance, where practicable.		X	X	X
Establish cave management protocols for worker and contractor inductions, to prohibit unnecessary disturbance of bat colonies by Project workers.	X	X	X	X
Limit or control where practical, blasting within 150 m of known colonies of cave bats.	X	X	X	X
Potential quarry sites should not be located within 150 m of caves with protected bat species.	X	X	X	X
Conservation program				

PROPOSED MEASURE	RELEVANCE*			
	A	B	C	D
Establish a conservation program for fauna at risk of being overhunted at the start of construction as part of a program to manage direct impacts and indirect impacts of in-migration.	X	X	X	X
Develop a fauna relocation program for species of conservation concern to be implemented during clearing of relevant habitat.		X	X	X
Project workers or contractors to report any sightings of the following species to the Project environment team: Long-beaked Echidna *Zaglossus* spp, Telefomin Cuscus *Phalanger matanim*, Black-spotted Cuscus *Spilocuscus rufoniger* and any tree kangaroo.	X	X	X	X
Mitigations related to reducing the possibility of contamination				
Storage and handling of hazardous substances will be in accordance with Australian Standards AS 2243.10 (AS/NZS, 1993) and AS 2508 (AS, 2000 and 2001).	X	X	X	X
Manage sewage in an appropriate manner to limit environmental contamination.	X	X	X	X
Store fuel in correctly bunded facilities (i.e., contained) with sumps and establish sump cleaning procedures. Also temporary fuel stores along the ROW and access roads to be correctly bunded during construction.	X	X	X	X
Appropriate spill response equipment to be provided at construction sites, and fuel storage/handling facilities.	X	X	X	X
Operations sites will be designed to intercept potentially contaminated water.	X	X	X	
Fuel, lubricating oils and chemicals will be stored in appropriately sized designated areas that have impervious liners and bunds.	X	X	X	X
Diesel storage system will be purpose built, above ground and within containment bunds. Oil spill prevention and response plans will be in place.		X		
Measures to reduce resource use demands on forests				
Use timber salvaged from work areas as construction material in lieu of imported timber wherever practicable.		X		
Establish chain of custody guidelines for timber sourced for the Project to minimise the risk of using illegally logged timber for the Project.	X	X	X	X
Implement measures to mitigate the possibility of widespread small-scale illegal logging to supply the project with timber by refusing to purchase timber from such sources.	X	X	X	X

* A = exploration and detailed design, B = construction, C = operations, D = closure.

13.2 Sources of Indirect impacts

13.2.1 Introduction of weeds, pests and diseases

The Project itself has no plans to introduce exotic species. However, the Project will create conditions that increase the risk of introducing an invasive species (e.g., through the movement of heavy machinery) and create conditions (e.g., cleared areas) favourable for the growth of weeds and pests. This in turn has the potential to impact biodiversity values.

Biological invasions have played a major role in the irreversible loss of biodiversity worldwide (Long 2003; ISSG 2018), and while many forms of environmental damage may be mitigated or reversed through reinstatement programs, once established, the removal of invasive species is often impossible. The Global Invasive Species Database (ISSG 2010) listed 80 species that had invaded terrestrial habitats in PNG and this has increased to 87 in 2018 (ISSG 2018). Others have also become established in Papua Province, Indonesia (Flannery 1995; Long 2003; Kemp and Burnett 2007; Tjaturadi *et al.* 2007) while others from PNG have thus far been overlooked such as the Eurasian Tree-Sparrow (Chapter 4 of Appendix 7A).

Weeds and pests can also be vectors for a range of diseases. Such transmission is commonplace and sometimes can occur between mammals and other vertebrates, with sometimes severe consequences. The native Christmas Island rats were likely exterminated by an alien trypanosome (Wyatt et al. 2008), and the decline of the native rodent fauna of Madagascar is due to the spread of plague (Ganzhorn 2003). Both cases are linked to the introduction of the Black Rat. The decline and extinction of many Hawaiian native birds is also due to introduced diseases (Van Riper et al. 1986 and references in Wikelski et al. 2004)[12]. The capacity of weeds, pests and diseases to permanently alter ecosystems as a whole makes

[12] To date, there is no evidence from New Guinea to suggest that disease has contributed to the decline of any native species. However, wildlife diseases often go undetected due to the secretive nature of fauna and the specialized skills required for diagnosis.

this perhaps the most important potential indirect impact that needs to be mitigated for long-term health of the biodiversity of the Study Area. Annex 2 presents a more detailed introduction to pests and exotics of concern in PNG.

The GFA terrestrial habitats are remarkably free of invasive species, weeds and pests, which tend to be confined to disturbed areas such as Iniok Site, drill pads and near villages (EIS Appendices 8A Chapter 3 and 8B Chapter 2). Takeuchi in EIS Appendix 8B Chapter 2 notes that the numerous invasive plants found around garden areas at the 2017 survey sites were “visual nuisances but do not present significant conservation threats” and that areas away from villages had no invasives. He also notes that there were no aquatic weeds such as *Eichhornia crassipes* and *Salvinia adnata*.

All invasive plants observed during the Project surveys were weeds of low invasive capacities and are not regarded as conservation threats. Apart from house sparrow, feral pigs and black rats, the Project surveys detected no invasive or pest vertebrates. With the exception of areas around villages this lack of invasives is likely to be the rule along the Infrastructure corridor until Green River. From then on it would be expected that the number of invasive species increases along the Vanimo to Green River road and the heavily logged areas it traverses.

Weed, Pest and Quarantine Management Sub-plans will be incorporated into the Project EMMPs but managing invasion and spread of exotics within the Study Area is likely to be challenging. During construction there is likely to be large volumes of transport and long supply lines to other parts of PNG and internationally and this is the critical phase of the Project for weeds, pests and disease management. Traffic will be much reduced after construction.

The Project will use existing as well as new public roads so quarantine management for all movements of traffic and people is not feasible. It must also be noted that local people already within the GFA and along the Infrastructure corridor can come and go and carry what they want at will along existing footpaths and boat routes. Considering this, the core aims of Weed, Pest and Quarantine Management Sub-plans to EMMPs should be:

1. Not bringing into PNG exotic species from overseas.
2. Not bringing into the GFA exotics from elsewhere in PNG

While the road is likely to be a key risk, one of the most effective points for quarantine is probably going to be at the Vanimo port as well as the freight handling centre termed the "Vanimo Industrial Area". Table 13 includes a range of proposed measures which could be included in such plans.

The impact reduction effects of any Weed, Pest and Quarantine Management Sub-plans to EMMPs would be in the GFA and the southern sections of the Infrastructure corridor south of Green River. The situation north of Green River with the exiting public road and heavy logging traffic is such that the Project’s presence, so long as it did not introduce a new exotic species, would make no difference.

13.2.2 Fire

Fire is a significant factor in closed forest dynamics; during droughts even wet forests can burn. While fire in wet tropical areas is considered uncommon, it has had a marked impact on environments throughout New Guinea where repeated burning has converted much forested land to grasslands such as in the Lae-Wau-Bulolo Valley, the Markham Valley and the Western Highlands Province. Closer to the Study Area, the north coast of New Guinea has large areas of kunai grassland, the presumed result of fires in the early twentieth century.

There is little or no evidence of wildfires being an ecological force within the Study Area, but the development of the Project has the potential to change this and it has the potential to be a significant indirect impact. The most sensitive forests to fire are Montane Forest on high ridges particularly with *Nothofagus*, Heath, and Swampy Forest in the Study Area Lowland Zone developed on peat substrates. Once forest has burnt, kunai is usually the first pioneer and, being a fire-dependent grass is maintained - successive fires slowly eroding the edge of the adjoining forest. Control of grass and its avoidance in reinstatement is an important mitigation for fire.

Peat forests are particularly sensitive; fire runs through the peat underground and can smoulder for years (Page *et al.* 2004). Ignition of Peat Forest is usually the result of changes to drainage drying the peat, which can then take fire. In Kalimantan and Sumatra large tracts of forest were burnt in periods of heavy drought, e.g., during the 1997 El Nino. This same event caused widespread burning of forests in the highlands of PNG (Haberle *et al.* 2001). Once burnt, Peat Forest cannot regenerate on the mineral substrate.

Wildfires may be brought about by small domestic fires getting away, accidental industrial fires, or in-migrants or workers deliberately setting fires. Fire management is within the Emergency Response and Fire Management Sub-plans of EMMPs.

13.2.3 In-migration and facilitating industrial and agricultural development

The problems of in-migration for resource projects are well known in PNG. For example, at Tabubil a large area surrounding the mining town is denuded as a result of several thousand squatters trying to maintain a living (S. Richards *pers. obs.*). The topic is treated at length in the Project Induced In-Migration Management Strategy (Jackson 2018), which concludes that in-migration it is likely to occur and can only be managed by joint efforts with government and local stakeholders.

It must be recognised that the Frieda and May River catchments are remote but have never been inaccessible - access has always been available via the Sepik River. The integrity of the ecosystems in these catchments is a product of low populations. The available activities other than settling are small scale artisanal gold mining, eaglewood collecting and occasional hunting, activities which obviously have never attracted enough people to degrade the catchments. Either that or the locals are very good at defending their resources, particularly alluvial gold. This may change with a mine as an attractor and the provision by the Sepik Development Project of road access from Vanimo via the infrastructure corridor.

In-migrants failing to find work may establish small enterprises serving the mine workforce, settle and pursue a subsistence lifestyle, move in with relatives (won-toks), establish semi-commercial hunting and forest product extraction businesses, or leave. If uncontrolled this would lead to overhunting and forest degradation, potentially extending beyond the Project disturbance area itself into the Study Area.

This increased human movement would exacerbate issues of quarantine and spread of invasive species, greatly increase the potential for impacts from fire, and could overwhelm the Project's environmental management of these issues.

The in-migration study (Jackson 2018) notes that the Frieda and May River catchments have a history of outward migration and that skilled Sepik peoples are now residing in other parts of PNG. Most significantly the local social systems encourage outsiders to migrate to the area. Jackson (2018) states "In short, the region surrounding the Project has always had limited economic development and its people have every incentive to move towards the Project in the hope of sharing in some of its cash benefits." The following set of incentives Jackson (2018) demonstrates the inevitability of in-migration and the difficulty for a single entity to manage it.

- The small size of the near mine population
- Their very limited capacity to supply the Project or to absorb migrants
- Their traditional (mainly) cognatic descent system
- Their traditional welcome for outsiders to boost their population numbers
- Their traditional alliances with groups well outside the proposed mining area
- The existence of polygamy in all three groups
- The accessibility (despite remoteness) of almost all villages
- The known presence of extensive alluvial gold deposits in the FRL neighbourhood (and the probable presence of more than is presently known of), and
- The presence in the Middle Sepik and other parts of the East Sepik Province of experienced artisanal miners……."

Measures to limit in-migration can be found in the Social Impact Assessment (Appendix 12 of the EIS).

Related to in-migration the Sepik Development Project could facilitate the development of other projects, small or large scale, within the Study Area, particularly by the provision of roads. Indeed, one of the aims of the Sepik Development Project is to stimulate development in Sandaun and East Sepik Provinces. The issue for impact assessment is whether:

- Any putative projects that would engender further forest or biodiversity loss would occur whether or not the Sepik Development Project existed, in which case the Sepik Development Project is irrelevant.
- Use of the Sepik Development Project infrastructure could make previously unfeasible projects feasible in which case their impacts would be attributable to the Sepik Development Project to some extent unless the SDFP could control use of its infrastructure.
- A feasible project could be made more profitable or occur sooner with the Sepik Development Project's presence.

At the small scale Booyong Forest Science (2011) concluded that there was (1) a high risk of expanding small scale logging operations to supply the Project, most likely "on the alluvial plains adjacent to the larger rivers where the best quality stands of commercial tree species occur", and (2) an increased interest in harvesting Eaglewood resin[13] because of improved access to the resource and improved and cheaper transport to regional centres to meet with Eaglewood traders.

Booyong Forest Science (2011) recommended a range of mitigations including:

- Establish chain of custody guidelines for all timber sourced to minimise the risk of importing illegally logged timber from within and outside the Project area.
- Implement measures to mitigate the possibility of widespread small-scale illegal logging.

A synergy not specifically addressed in Booyong Forest Science (2011) is the possibility that if a sawmill is set up to process salvaged logs for the Project there is likely to be an incentive to maintain supply to the mill from beyond the Project disturbance area, once the Project is constructed. Table 13 includes a range of biodiversity mitigation measures specifically directed towards salvage logging including a requirement to close any mill on completion of Project construction.

It is at the larger scale where mitigations are unlikely to be effective. The main project the Sepik Development Project is likely to interact with is the proposed Idam-Siawi Agro-Forestry Project which plans to develop 141,000 ha of palm, rice, sago and agroforestry plantations in the Vanimo, Green and Telefomin districts within a project area of 750,000 ha. The EIS for this project indicates that clearing will occur at the rate of approximately 14,000 ha per year and approximately "60,000 m^3 of logs and 50,000 m^3 of boards" will be exported annually. This massive logging and agriculture project requires the construction of 155 km of main road 10 m wide, 275 km of 8 m wide branch roads and 280 km of 5m wide skidding roads. The sections 3 and 4 of the Sepik Development Project infrastructure corridor are entirely within the proposed Idam Siawi logging areas.

While the Idam Siawi project will likely build its own roads the Hotmin Road could be used to expand operations further east and south. The present Idam-Siawi project maps show logging terminating to the west of the GFA but the logging concession itself may extend over most of the GFA in Sandaun province.

The retention of management of access to the mine access road from Hotmin is the only mitigation available.

13.2.4 Indirect effects of the mine's programs to mitigate socio-economic impacts.

Many resource projects develop socio-economic programs as part of the community affairs operations and/or as mitigations for potential social impacts. These programs have the potential to indirectly or unconsciously impact biodiversity and the environment in the same way as any other part of the Project,

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13 Species of *Gyrinops*, A*etoxylon*, *Gongystylis* and more commonly, *Aquilaria.*

particularly as such programs sometimes do not receive the intense environmental scrutiny that construction attracts.

Socio-economic programs can inadvertently generate novel potential impacts not producible by the Project itself. Prominent amongst these is introduction of exotic species for agricultural or food purposes such as *Vetiver*, fish etc. that could not get to the Study Area unless specifically transported. Others include the establishment of non-timber forest product extractive industries, and establishment of medium-scale agriculture programs that clear forest. There are numerous examples world wide of humanitarian programs causing biodiversity loss, a good example being the decline of vultures due to the spread of veterinary drugs in Asia (Lemus *et al.* 2008).

It is strongly suggested that all social programs be required to have a risk assessment conducted and mitigations implemented to manage the potential impacts of these programs on the environment.

13.2.5 Impacts of resettlement programs

The construction of the mine and ISF facilities will entail the resettlement of approximately 1300 people from four villages in the GFA. Ultimately the villagers will decide where they wish to have new settlements constructed on their land and at this stage these sites are the subject of negotiation. Resettlement will entail further clearing for villages, the conversion of new forest to gardens and the construction of roads to those sites. Depending upon the new village locations this could make areas of forest previously distant from the present villages more accessible and thus increase hunting pressure. It must be conservatively assumed that some of the chosen resettlement sites may be at higher elevations (above 800 m asl) and thus closer to or within the Montane Forest Priority Ecosystem and closer to the montane fauna that has suffered so much from hunting. It is suggested that relocation areas not be at the higher altitudes or in Priority Ecosystems.

14. Rehabilitation

Assuming the ISF and HITEK open-pit remain as water filled voids, that the Green River Hotmin public road and the FRHEP access road remain open and the transmission line is continued to be managed the rest of the infrastructure is theoretically available for rehabilitation. This amounts to about 1,240 ha or about 9% of the Project disturbance area, excluding river surfaces. Ten to thirty percent of this is likely to be available immediately after construction and the rest after mine closure in 30 years. The bulk of this such as road edges in more gentle terrain will likely regenerate naturally and quickly. Difficult areas such as steep batters on roads, compacted areas from vehicle parks and laydowns, and steep sidecast may require revegetation.

Options for revegetation need to be considered carefully. Incorrect use of species could produce more potential impacts on biodiversity than the revegetation is meant to compensate for. The following guidelines would form a basis for developing a rehabilitation system:

- Revegetate with local species.
- Avoid the use of exotics species (i.e. alien to New Guinea) for revegetation.
- Grasses should not be used as they carry fire which can erode the forest edge.
- Propagate the plant species new to science and the plant species of conservation concern (part 8 of Annex 4) for use in reinstatement.
- As far as practicable, propagate butterfly food plants and use them in reinstatement[14].
- Use species of plants in revegetation that provide nectar and fruit for fauna. They attract dispersers, which generate a seed rain that speeds up regeneration and reduces costs.

Further rehabilitation measures are included within the Rehabilitation sub-plan in the Project EMMPs.

Overall the areas available for rehabilitation until mine closure would not significantly reduce impacts because of their very small size in trelation to the overall permanent habitat loss.

[14] Most species feed on saplings, vines and/or herbaceous plants in shaded areas so the introduction of such plants would need to be later in the reinstatement process. For example, the Aristolochia food plants of all the species in the Study Area of conservation concern are fleshy vines that tend to be slow growing and may be difficult to establish and maintain.

15. Residual impact assessment

The assessment of the significance of residual impacts, assuming the effective implementation of avoidance, mitigation and rehabilitation, was done by examining both the magnitude of the impact and the sensitivity of the receptor being impacted. This interaction between magnitude and sensitivity was expressed in a matrix, the entries being measures of significance of the impact.

The **magnitude** of an impact is defined as the amount and type of change, including the severity or intensity of the change, its potential geographic extent and the likely duration of the impact (Table 14). **Sensitivity** combines the inherent susceptibility of the receptor to change, including its capacity to adapt to, or accommodate, the kinds of changes that the project may bring about; the societal or ecological value of the receptor such as its conservation status, or its iconic or symbolic importance to culture, society or the community. Assigning sensitivity to receptors is more problematic because of the inclusion of susceptibility with value. Sensitivity is classified as low, medium or high (Table 15). There are six classes of **significance** of impact – Extreme, Major, Moderate, Minor, Negligible and Positive (Table 16) for the various combinations of magnitude and sensitivity.

In making assessments direct and indirect impacts are separated on the basis that management of the latter are not entirely within the Project's control. An assessment of the significance of direct impacts is first made then that is modified to a final assessment after consideration of indirect impacts and impacts from resettlement. All assessments assume that there is no catastrophic failure of the ISF, that the mitigations discussed above are in place, that the PIIMMP is operational, that quarantine, Weed, Pest and Quarantine Management Sub-plans to EMMPs are in place and that wildfires are not caused by the Project.

Table 17 summarises the results.

Table 14 Criteria for magnitude of impact

DETECTIBILITY WITH RESPECT TO NATURAL VARIABILITY	EXTENT OF EFFECT		
	Widespread and long term (> 10 years); changes not able to be practically or significantly rehabilitated or alleviated.	**Extend beyond the disturbance are to the surrounding area but are contained within the general area.**	**Confined in the Project disturbance area or a small, isolated locale outside.**
Effect barely detectable	Negligible	Negligible	Negligible
Effect will be readily detectable but not severe.	Medium	Low	Low
Effect likely to be very large	High	High	Medium

Table 15 Criteria for sensitivity of receptor

	SENSITIVITY		
	High	**Medium**	**Low**
Formal status/value; importance to society and community.	A critical national or international recognised site or value. An IUCN Critically Endangered or Endangered Species Iconic or symbolic importance to cultural value systems.	A regional or provincial recognised site or value. An IUCN Vulnerable species and/or classified as Protected under the PNG Fauna Act	Zero or only local value or recognition.
Vulnerability	Restricted distribution.	Abundance and distribution are limited.	Abundant, widespread, numerous representative examples occur.
Resilience	Limited or no capacity to adapt to change.	Some resilience to change.	Easily adaptable to change (or no change required).

Table 16 Matrix of significance

MAGNITUDE OF IMPACT	SENSITIVITY OF RECEPTOR		
	HIGH	MEDIUM	LOW
HIGH	Extreme	Major	Moderate
MEDIUM	Major	Moderate	Minor
LOW	Moderate	Minor	Negligible
NEGLIGIBLE	Negligible	Negligible	Negligible
POSITIVE	Positive	Positive	Positive

15.1 Large scale - the Study Area as a whole

At the scale of the Study Area as whole, the values introduced in Section 5 above are all higher-level values and the sensitivity rates as "High". These are the values that would normally be included in a set of criteria for deciding on whether or not to designate an area as a protected area or as a World Heritage site. Impacts on these higher-level values have to be considered in context. At the level of the Project disturbance area alone impacts are severe or indeed catastrophic. At the national level, on the other hand, the impacts are small.

Table 17 Impact analysis for large, medium and fine scale values

VALUE	SENSITIVITY	RESIDUAL DIRECT IMPACTS		+ INDIRECT IMPACTS	
		M*	S	M	S
Large scale –the Study Area as a whole					
Extensive intact habitats	High	Medium	Major	Medium	Major
High biodiversity	High	Negligible	Negligible	Low	Moderate
Species new to science	High	Negligible	Negligible	Low	Moderate
Endemic species	High	Negligible	Negligible	Negligible	Negligible
Migratory species of water birds	High	Negligible	Negligible	Negligible	Negligible
Flying Foxes	High	Negligible	Negligible	Low	Moderate
Habitats and biodiversity of cultural significance	High	Low	Moderate	Low	Moderate
Medium Scale – Priority Ecosystems					
Peat Forest	High	Negligible	Negligible	Negligible	Negligible
Nena Karst	High	Negligible	Negligible	Negligible	Negligible
Off-river waterbodies	High	Negligible	Negligible	Negligible	Negligible
Montane Forest	High	Negligible	Negligible	Medium	Major
North Coastal Ranges	High	Negligible	Negligible	Negligible	Negligible
Fine Scale – Focal Habitats					
Riparian and gallery forests	High	Low	Moderate	Low	Moderate
Hilltops	High	Negligible	Negligible	Negligible	Negligible
Upland streams	High	Low	Moderate	Low	Moderate
Caves	High	Negligible	Negligible	Low	Moderate

* M – magnitude, S - significance

15.1.1 Extensive Intact Habitats

It is estimated that the total footprint of approximately 16,067 ha will result in the clearing or inundation (forest loss) of about 15,400 ha of forest, the remainder being cleared areas, roadside vegetation and river surface (Table 18). Approximately 68% of the forest loss will be Hill Forest and 20% Tall Lowland Forest. 91% will be permanently lost. A total of 43% of forest loss is in intact forest (Class A) and a further 37% in lightly disturbed forest (Class B). Sections 7 to 10 of the infrastructure corridor are dominated by heavily disturbed and cleared areas, including roadside vegetation.

A total of 86% of forest loss is in the GFA (Table 18) and the largest contributor to the losses is the ISF and its embankment accounting for 80% of the total footprint and 76% of Class A forest losses (Table 20). Approximately 85% of the total footprint of approximately 16,000 will be in the Hill Zone and 96% in Sandaun Province.

Table 18 Estimated vegetation losses by section and formation

FORMATION & CONDITION*	STUDY AREA SECTION[1]												TOTAL (HA)
	GFA	1	2	2A	3	4	5	6	7	8	9	10	
Montane Forest													
A													**3**
Hill Forest													**10,915**
A	35%	92%	31%	50%	32%	2%		6%		11%			**5,260**
B	38%					19%	7%	13%		9%			**5,354**
D	1%	2%								56%	8%	5%	**301**
Tall Lowland Forest													**3,284**
A	5%	6%	48%	45%	24%	23%	48%	48%	44%		3%		**1,242**
B	1%				13%	23%	14%	10%	9%		5%		**339**
C													**10**
D	11%								28%	1%	22%	1%	**1,693**
Swamp Forest													
A			21%	5%		28%	4%						**123**
B						4%							**33**
River & Cleared*	9%				31%		27%	23%	20%	23%	63%	94%	**1,718**
Total (ha)	**13,991**	**224**	**231**	**26**	**243**	**219**	**138**	**201**	**232**	**196**	**232**	**143**	**16,076**

1 Entries are % of total footprint in that section.

*A to E reflect condition of vegetation. A corresponds to intact and mature forest and E to heavily disturbed. Categories B to D are intermediate categories of condition.

This is a large area of forest and the loss is concentrated in the Frieda River catchment. It is likely to have an impact locally around the Project disturbance area. In the regional context of the Study Area, the loss is not great in terms of the entire Study Area but the majority of the losses will be in the GFA Hill Zone, which will lose approximately 8% of its estimated 170,000 ha of forest. Losses in the Study Area Lowland Zone and Montane Zone will be negligible. There will be barrier effects produced by the Project. The most important contributor to reducing impacts is avoidance by design and mitigations are unlikely to reduce impacts drastically, except by ameliorating barrier and edge effects. The residual direct impact is estimated as major.

More important are indirect effects from in-migration, wildfires and potential invasion of exotic species. This could reduce the integrity of not only the GFA but extend impacts further into the May River catchment and the southwest region of the Sepik River drainage and, if not mitigated to some extent, could produce continuing forest degradation and risk an extreme residual impact. Measures to ameliorate potential effects of in-migration are likely to have some effect, particularly Fly-in Fly-Out and no construction of major township style facilities. This and effective Weed, Pest and Quarantine Management Sub-plans to

EMMPs could act to retain the residual as major. Further losses from clearing for resettlement villages and roads would not alter this assessment.

However, it must be remembered that the Sepik Development Project is designed to stimulate development in Sandaun and East Sepik provinces and so, while wildfires and exotic species invasions are still undesirable under any scenario, in-migration itself may be a desirable outcome and some indirect impacts related to in-migration will be a reality without a coordinated regional approach involving all stakeholders.

Table 19 Estimated forest losses excluding river and cleared areas – section x condition

CONDITION*	STUDY AREA SECTION[1]												TOTAL (HA)
	GFA	1	2	2A	3	4	5	6	7	8	9	10	
A	40%	98%	100%	100%	56%	54%	53%	54%	44%	11%	3%		**6,629**
B	39%				13%	46%	21%	23%	9%	9%	5%		**5,726**
C													**10**
D	12%	2%							28%	57%	29%	6%	**1,993**
E†	4%				31%		27%	23%	20%	23%	63%	94%	**1,068**
R	5%												**650**
Total (ha)	***13,991***	***224***	***231***	***26***	***243***	***219***	***138***	***201***	***232***	***196***	***232***	***143***	***16,076***
Total %	***86%***	***1%***	***1%***	***0%***	***2%***	***1%***	***1%***	***1%***	***2%***	***1%***	***2%***	***1%***	

1 Entries are % of total footprint in that section.

*A to E reflect condition of vegetation. A corresponds to intact and mature forest and E to heavily disturbed. Categories B to D are intermediate categories of condition.

† includes roadside vegetation.

Table 20 Estimated losses (ha) for individual Project components

COMPONENT	CONDITION*						TOTAL	% TOTAL FOOTPRINT
	A	B	C	D	E†	R		
ISF	4,735	5,412		1,662		622	12,431	77%
ISF embankment area	327					26	353	2%
Total ISF	***5,062***	***5,412***		***1,662***		***647***	***12,784***	***80%***
Transmission line	822	218		257	284		1,582	10%
HITEK open pit	3				518		522	3%
Pipelines along Vanimo to Green River road					226		226	1%
Green River to Hotmin Road	170	34			20		224	1%
Spoil dump	47	23		63			132	1%
Quarry	107	4				3	114	1%
Other	417	35	10	12	20		493	3%
Total (ha)	**6,629**	**5,726**	**10**	**1,993**	**1,718**	**650**	**16,076**	

*A to E reflect condition of vegetation. A corresponds to intact and mature forest and E to heavily disturbed. Categories B to D are intermediate categories of condition.

† includes roadside vegetation.

15.1.2 High Biodiversity

A major impact on the extent of intact forest does not necessarily imply a major reduction in the number of species. Species numbers is not related to extent of habitat in a linear fashion but rather exponentially – it declines at a slower rate than habitat loss. This does not mean individual species may be severely reduced or eliminated from the Study Area. Some may, and these are dealt with in section 15.4. Overall it is predicted that high biodiversity will be maintained because species losses are likely to be low. Any reductions to species numbers, if any at all, will be in the GFA not the infrastructure corridor because losses of intact vegetation are concentrated in the GFA.

Virtually all the terrestrial fauna will be lost from areas cleared (or inundated for the ISF) for Project development and the extent to which it can recolonise depends upon how much area is allowed to regenerate. Areas that regenerate only to grass or shrublands will develop only a low diversity of widespread secondary and grassland species, while areas that regenerate back to forest will build up species rapidly. This will depend on terrestrial biodiversity maintaining its richness in the Study Area overall in order for it to remain a source for species to recolonise. In the case of the Project, however, the majority of forest losses will be permanent in that they will end up as lakes, which, while available for aquatic species, will only provide habitat for waterbirds and a few species of generalist frogs and reptiles, not forest species as a whole.

It is unlikely that the loss of 8% of the GFA will cause any extinctions in the Study Area or the provinces and therefore reductions in diversity unless there are species entirely restricted to the Project disturbance area.[15] None seem to be. The residual direct impacts are likely to be negligible.

As for all values, indirect impacts present the greater threat and so residual impacts will be higher. Potential indirect impacts of in-migration would act through increasing habitat loss and possible reduction in populations of hunted species (see individual species accounts in section 15.4). Measures to ameliorate potential effects of in-migration are likely to have some effect, particularly not constructing a major township for the workforce. This and effective implementation of Weed, Pest and Quarantine Management Sub-plans to Project EMMPs could act to produce a final residual direct + indirect impact of moderate. Further losses from clearing for resettlement villages and roads would act to make it very difficult to reduce residual impacts to less than moderate.

15.1.3 Species New to Science

The residual potential impact on species new to science depends upon the extent to which they are restricted to the Study Area or a small part of it. The fact that many were only found at a single site is uninformative in this respect. For example, many of the birds recorded at a single site are common and widespread PNG species. All biological samples show a reverse J curve in terms of species frequencies i.e. most species are rare, and few species are abundant in samples. This is a fundamental pattern in ecology and partly a product of sampling (see for example Preston 1962, Andrewarther and Birch 1954, Tokeshi 1990, Hubbell and Lake 2003).

Any biodiversity survey in such a remote and inaccessible part of the tropics that has not been biologically explored before is likely to find species new to science, and our knowledge of the distribution of perhaps the majority of species in PNG is more informative of collector's activity rather than underlying distributional patterns. Nonetheless, with so many new species it is possible that some are restricted or have a significant part of their population within the Study Area There are many examples of species with restricted distributions for example the tree *Stockwellia quadrifida* that is restricted to a small area on the Atherton Tablelands (Carr *et al.* 2002), and the conifer, *Wollemia nobilis,* which appears to have a population of less than 100 mature trees in a canyon near Sydney (Farjon 2010)[16].

Where species new to science are found on isolated mountaintops, mountain ranges, islands or restricted habitats they may be expected to be restricted in distribution. The only species likely to be so restricted in the Study Area is the butterfly *Mycalesis* sp. nov. 1 found only in the Peat Forest Priority Ecosystem, all the others are in habitat that is continuous along the north slope of the Central Cordillera or on the continuous Sepik River lowlands and thus are unlikely to have very narrow distributions.

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[15] Attempts to predict species loss with declining habitat area have been tried using the methods of island biogeography, for example Koh and Ghazoul's (2010) matrix calibrated model. However, the controversy surrounding backward application of species area metrics are such as to make attempts at predicting species loss with declining area unhelpful (He and Hubbell, 2011, 2013).

[16] These are examples of relictual populations in possibly old and geologically stable areas, a different situation than the Study Area, but they illustrate the point.

Of the species potentially new to science listed in Table 7, five - a plant, a mammal, a reptile, and two odonates, were found only at survey sites within the Project disturbance area (Malia, HI, Frieda Base, Ubiame, Frieda Strip, Frieda Bend and Wario); the rest occurred outside, or both inside and outside the Project disturbance area. However, experience suggests that continued exploration continues to increase the ranges of species previously thought to be narrowly restricted; the large number of range extensions resulting from the Project surveys demonstrates this. Even in the 2017 surveys Takeuchi recorded *Diospyros fusicarpa* Bakh. Which was previously known only from the Cyclops Mountains.

It is extremely unlikely that any of the new species, including those only found so far in the Project footprint, are entirely restricted to the Study Area, as all but *Mycalesis sp. nov.* 1 were in widespread habitats. It is predicted that all are likely to be found outside the Project disturbance area and that most, if not all, occur widely within the Study Area and also outside. This can be tested by corroborative surveys in the May River and its headlands and in the higher mountains south of the Study Area, but the 2017 surveys, while limited in scope, generally supported this pattern.

For the plants there is the option of using them in revegetation and for the butterflies the option of planting their food plants. The negligible potential impact predicted for the Peat Forest Priority Ecosystem (Section15.2.1) would serve specifically for *Mycalesis sp. nov.* 1. The residual direct impacts on species new to science are expected to be negligible.

In assessing indirect impacts, it is noted that none of the species new to science would be of any interest to hunters or subsistence gatherers and so would not be targeted by any in-migrants. However, like any other species they would still be impacted by extra habitat loss brought about by the activities of in-migrants and through clearings for villages and roads for the resettlement program. This and the accidental introduction of exotics is likely the more important potential indirect impact and the Weed, Pest and Quarantine Management Sub-plans to EMMPs are key mitigations. The final residual direct + indirect impacts are predicted to be moderate. Further losses from clearing for resettlement villages and roads would act to make it very difficult to reduce residual impacts to less than moderate.

15.1.4 Endemic Species

The endemic species are neither concentrated in particular ecological niches nor particular locations within the Study Area, and nothing singles them out as being any more or less sensitive than any other species. Irrespective of what happens to the biodiversity as a whole it is highly unlikely to alter the levels of endemism in the biota. The residual impact is predicted to be negligible both for direct and indirect impacts.

15.1.5 Migratory and/or Congregatory Species

There are three aspects to an assessment of residuals for the migratory or congregatory species.

- To what extent would the capacity of the Study Area to provide habitat for congregatory waterbirds be reduced?
- To what extent would waterbird populations be reduced?
- To what extent would large flying fox colonies be impacted?

The prime waterbird habitat in the Study Area is the off-river waterbodies in the Study Area Lowland Zone. Other habitats such as riversides may support waterbirds but not in the numbers required to be classed as congregations. Since potential impacts on off-river waterbodies are predicted to be negligible (section 15.2.3), the residual direct impacts on waterbird habitat and populations is predicted to be negligible.

There is extensive habitat that could serve as sites for flying fox camps, but camps are likely to be few, and measures proposed to avoid impacts on camps should result in a negligible residual direct impact. The amount of forest lost is unlikely to measurably reduce resources for the wide ranging flying foxes.

Indirect impacts could be more significant in that waterbirds and flying foxes could be hunted, the flying foxes much more so as they are easier to catch. The introduction of exotics or disease remains an issue but the Weed, Pest and Quarantine Management Sub-plans to EMMPs should reduce risks to a reasonable extent. Overall the residual direct + indirect impacts are predicted to be negligible for waterbirds. Flying foxes are more attractive to hunters but large camps would likely be encountered more in the Lowland Zone than in the Hill and Montane Zones and the known camp at Wogamush is far from the areas that in-migrants may choose to migrate too. Some hunting would be expected but the magnitude should be low and the residual direct + indirect impacts are predicted to be moderate. The resettlement program is unlikely to affect this as villagers that hunt in the lowlands where camps are concentrated will not increase their hunting efforts there.

Overall, the capacity of the Study Area to support migratory and/or congregatory species, would not be reduced but if in-migration is higher than predicted flying fox colonies could be reduced.

15.1.6 Habitats and biodiversity of cultural significance

As discussed in section 5.6 communities are linked to biodiversity through their largely subsistence lifestyles and a close relationship to their land. The forests and rivers provide the bulk of their needs and they are more-or-less dependent upon the ecosystem services the Study Area provides. It is likely that people use several hundred species of plants and animals for food, building, decoration, spiritual purposes, medicine etc. Hunters' prey would include pigs, cassowaries, wallabies, bandicoots, megapodes, rats, flying foxes, possums, tree kangaroos, monitor lizards, frogs, snakes, bats, crocodiles, turtles, lizards, insects and birds.

Since such a wide array of habitats and biodiversity are culturally significant, potential impacts on this value would mostly work via potential impacts on the other values, so, overall, the cultural importance of the Study Area is unlikely to decline greatly in value considering the amount of habitat remaining and the prediction that few if any species will be lost. However, the predicted residual direct + indirect impacts impact on the most culturally significant large animals tends to be moderate or higher (Annex 1). Overall therefore the residual direct + indirect impacts are predicted to be moderate.

15.2 Medium Scale - Priority Ecosystems

15.2.1 Peat Forest Priority Ecosystem

No infrastructure would be located, nor any Project activities take place on or near the Peat Forest Priority Ecosystem. The influence of the ISF on hydrology of the Frieda River is unlikely to have any effect on the Peat Forest Priority Ecosystem which is located in an area dominated by the hydrology of the Sepik River. Project infrastructure is unlikely to improve access for others to the Peat Forest Priority Ecosystem as it is most easily accessed from the Sepik or Frieda Rivers. The only potential impacts that could act on the Peat Forest Priority Ecosystem are wildfire, a catastrophic weed invasion, or draining and logging brought about by forestry companies using Project infrastructure to access the GFA. These are either extremely unlikely or would be effectively mitigated. Overall the residual direct + indirect impacts on the Peat Forest Priority Ecosystem is expected to be negligible and the resettlement program is unlikely to affect this.

15.2.2 Nena Karst Priority Ecosystem

No infrastructure is planned to be located nor any Project activities carried out at or near the main concentration of karst. The only limestone quarry planned for the Project is likely to exploit 17 ha of an eastern outlier without karstic features, located some 17 km to the southeast of the main karst. The residual direct impacts are expected to be negligible.

The difficulty of traversing steep karst is such that indirect impacts from in-migration or the resettlement program is unlikely to impact on the habitats in this priority ecosystem although cave fauna, which are assessed separately (sections 15.3.4 and 18.1.7) may be hunted. Other potential impacts that could erode the value of this priority ecosystem is the introduction of exotic invasive species. Indirect impacts are predicted to not increase the residual impact on the karst as a whole above negligible.

15.2.3 Off-river waterbodies Priority Ecosystem

No infrastructure would be placed on or near any off-river waterbody. The only infrastructure that approaches any is the infrastructure corridor at the Sepik River (section 7) which is 1.5 km from the nearest waterbody. This, and the measures to control contamination under Sub-plans to EMMPs, should make the residual direct impact on this priority ecosystem negligible. It is unlikely that the hydrology of any of the off-river waterbodies will be affected by the Project because of their distance from the ISF and their apparent lack of hydrological dependence on flows in the Nena River.

These sites are highly unlikely to be a focus for in-migration and no resettlement will occur anywhere near them so indirect impacts from those sources are unlikely to increase residual impacts above negligible. The major potential impacts that could erode these wetlands are the introduction of exotic invasive species which should be reduced under Weed, Pest and Quarantine Management Sub-plans to EMMPs and so overall residual direct + indirect impacts are likely to be negligible.

15.2.4 Montane Forest Priority Ecosystem

No infrastructure is planned be built in this ecosystem except for possibly communications towers. Approximately 4 to 6 ha of the upper rim of the HITEK open-pit may extend above 1,000 m asl. The residual direct impact is predicted to be negligible.

The potential impacts that could erode the value of this priority ecosystem are hunting, wildfires, the introduction of exotic invasive species, and in-migration resulting in further forest degradation. Paradoxically, it may be these higher forests that may be most impacted by in-migration if the populations at Telefomin continue increasing which would not only put pressure on forests in this zone but also increase hunting pressure on montane mammals and increase risks of introduction of exotics and disease. The Project In-Migration Management Strategy is critical in this respect as are a Weed, Pest and Quarantine Management Sub-plans to EMMPs to reduce likelihood of exotics and plant diseases establishing in these forests which are very susceptible to die back. Indirect impacts are predicted to increase the overall residual impacts to major because of the difficulty of controlling behaviour of settlers to Telefomin and environs. Resettlement could exacerbate the potential impacts if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas.

15.2.5 North Coastal Ranges Priority Ecosystem

Habitat loss and impacts on the North Coastal Ranges endemic fauna (Table 9) through the Bewani Mountains is likely to be minimal because

1. The pipeline will be in degraded roadside vegetation and well below the known lower elevation limits of most of the North Coast Range species discussed in section 15.4 below.
2. The infrastructure corridor is to the west of the known ranges of most of the species in Table 8. If one of these species is found to occur near the corridor then impact may be likely, but this would also represent a significant increase in range.
3. Construction of pads for the transmission line pylons on higher hills along the route may impact some potential habitat but the pads are unlikely to be built above 700 m asl, well below the known lower elevation limit of the most important habitats in the range, and a mitigation is suggested to locate pylons on degraded areas where feasible.
4. Vegetation losses to construct fly roads used for transmission line construction and maintenance of clearings under transmission lines during operations will all be in the lower elevation areas that are not favoured by most endemic North Coastal Range species.
5. The Project is unlikely to increase any putative barrier effects provided by the existing Vanimo to Green River road.

Direct residual impacts are predicted to be negligible. Indirect residual impacts are unlikely to increase this because the area is unlikely to be attractive to in-migrants heading to the GFA and resettlement will not occur here. The area already has a major road through it so the only potential impact from weeds, pests and diseases would be if a species invades that does not already occur. The Weed, Pest and Quarantine Management Sub-plans to EMMPs should reduce the likelihood of that.

15.3 Fine Scale - Focal Habitats

15.3.1 Riparian and Gallery Forests

Most, if not all, such habitats within the Project disturbance area will be cleared or inundated. Outside the Project disturbance area, however, measures to reduce clearing should act to ensure no other riparian or gallery forests are removed. Silt is likely to impact all streams downstream of construction areas and this may impact on riparian and gallery forest by altering flooding regimes immediately downstream of the silt sources. Measures to manage this are included in Sub-plans to EMMPs and the residual direct impacts should be able to be reduced to moderate.

Since these habitats are mostly in the lowlands and mostly encountered when crossing rivers along the infrastructure corridor they are unlikely destinations for in-migrants nor part of the resettlement program. With effective Weed, Pest and Quarantine Management Sub-plans to EMMPs the residual impacts are likely to remain moderate.

Overall the Study Area is unlikely to lose its overall capacity to maintain diversity in riparian and gallery forests.

15.3.2 Hilltops

Some hilltops suitable for butterfly congregations within the Project disturbance area will likely be cleared or inundated. However, unlike streams, hilltops outside the Project disturbance area are unlikely to be affected by chemical and silt contamination from construction. The most likely source of impacts to hilltops outside the Project disturbance area are wildfires, the introduction of exotic invasive species, and possible clearing by in-migration and resettled villagers. There are likely a very large number of suitable hilltops in the Study Area, so residual direct + indirect impacts are predicted to be negligible.

15.3.3 Upland Streams

There are likely to be no direct impacts on any streams above 1,000 m asl but all upland streams in the Study Area Hill Zone within the Project disturbance area will be eliminated or disturbed. Outside the Project disturbance area measures to reduce contamination would be mitigated through sub-plans to EMMPs. However, silt is likely to impact streams downstream of construction areas and reduce their capacity to maintain diversity of specialist amphibious species. Overall this is likely to affect only a small proportion of upland streams, so the Study Area is unlikely to lose its overall capacity to maintain diversity in these focal habitats. Residual direct impacts are predicted to be moderate (Table 9).

Other potential impacts are the introduction of exotic invasive species, and in-migration resulting in further stream degradation. A particular potential issue is the accidental introduction of frog diseases, which globally have manifested particular in mountain streams. With the Project In-Migration Management Strategy and Weed, Pest and Quarantine Management Sub-plans to EMMPs indirect impacts are unlikely to increase the residual impact beyond moderate.

15.3.4 Caves

It is likely some caves, if there are any, in the area of the proposed limestone quarry or in non-limestone geology will be damaged or lost during construction. The area of the ISF is not prospective for caves so losses here are unlikely. The suggested mitigations for caves and cave fauna would act to keep damage to a minimum within the Project disturbance area and there should be no direct impacts outside the Project disturbance area where the majority of caves are likely to be located i.e. in the Nena Karst Priority Ecosystem. Residual direct impacts are predicted to be negligible. It is hard to see how indirect impacts would physically damage caves so the indirect impacts on cave fauna would be through hunting and introduction of wildlife diseases. The Project In-Migration Management Strategy and Weed, Pest and Quarantine Management Sub-plans to EMMPs should reduce the residual direct + indirect impacts to moderate.

15.4 Species scale – species of conservation concern and/or cultural significance

Species individually assessed include:

- IUCN Critically Endangered species
- IUCN Endangered species
- IUCN Near Threatened species
- Species protected under the PNG Fauna (Protection and Control) Act 1966
- Species of particular cultural importance to local peoples.

The impact analyses assess first the residual direct impact, then how that would be changed by adding indirect residual impacts, including in-migration impacts, then how that would be altered again, if at all, by resettlement if that occurs in the higher more sensitive areas of the GFA.

Annex 1 presents individual impact assessments and the results are summarised in Table 21.

Considering residual direct impacts 74 species are predicted to have a negligible, 6 minor and 5 moderate residual direct impacts. Adding potential residual indirect impacts increases the significance of residual impacts because of the difficulty of controlling in-migration effects off Project leases – 45 species retain their negligible status, but 24 are elevated to minor, 8 to moderate and 8 to major (Indirect 1 – Table 21). These may be elevated further by patterns of resettlement with 8 species potentially having extreme residual impacts, 8 having major residual impacts, 16 having moderate residual impacts and7 minor residual impacts should resettlement occur at high elevations (Indirect 2 – Table 21). The species with the greatest residual impacts are all rare, high value hunted species. It must be noted, however, that many of these species are only potentially present. As such this assessment is conservative.

Table 21 Results of impact analysis for individual species

SPECIES	Occ[1]	STATUS	DIRECT*	INDIRECT 1	INDIRECT 2
Tenkile *Dendrolagus scottae*	M	CR P	Negligible	Negligible	Negligible
Weimang *Dendrolagus pulcherrimus*	L	CR P	Negligible	Negligible	Negligible
Northern Glider *Petaurus abidi*	L	CR	Negligible	Negligible	Negligible
Sir David's Long-beaked Echidna *Zaglossus attenboroughi*	L	CR P	Moderate	Major	Extreme
Eastern Long-beaked Echidna *Zaglossus bartoni*	X	VU P	Minor	Moderate	Major
Telefomin Cuscus *Phalanger matanim*	X	CR P	Negligible	Major	Extreme
Black-spotted Cuscus *Spilocuscus rufoniger*	X	CR	Moderate	Major	Extreme
Bulmer's Fruit Bat *Aproteles bulmerae*	L	CR	Negligible	Major	Extreme
Halfordia papuana Lauterb.	X	CR	Negligible	Negligible	Negligible
Liverwort *Schistochila undulatifolia Piipo*	X	CR	Negligible	Negligible	Negligible
Goodfellow's Tree Kangaroo *Dendrolagus goodfellowi*	X	EN P	Moderate	Major	Extreme
Western Montane Tree Kangaroo *Dendrolagus notatus*	X	EN P	Negligible	Major	Extreme
Northern Water Rat *Paraleptomys rufilatus*	S	EN	Negligible	Negligible	Negligible
Far Eastern Curlew *Numenius madagascariensis*	M	EN	Negligible	Negligible	Negligible
Calidris tenuirostris Great Knot	M	EN	Negligible	Negligible	Negligible
Ornithoptère Méridional *Ornithoptera meridionalis*	X	EN	Negligible	Negligible	Negligible
Maple Silkwood *Flindersia pimenteliana F. Muell.*	X	EN	Negligible	Negligible	Negligible
Grizzled Tree Kangaroo *Dendrolagus inustus*	S	VU P	Negligible	Minor	Minor
New Guinea Pademelon *Thylogale browni*	X	VU	Negligible	Minor	Moderate
Hill's Leaf-nosed Bat *Hipposideros edwardshilli*	S	VU	Negligible	Negligible	Negligible
Salvadori's Teal *Salvadorina waigiuensis*	S	VU P	Negligible	Moderate	Major

SPECIES	Occ[1]	STATUS	DIRECT*	INDIRECT 1	INDIRECT 2
Pesquet's Parrot *Psittrichas fulgidus*	X	VU	Minor	Moderate	Major
Papuan Eagle *Harpyopsis novaeguineae*	X	VU P	Minor	Moderate	Major
Coachwood *Ceratopetalum succirubrum C.T. White*	X	VU	Negligible	Negligible	Negligible
Burmese Rosewood *Pterocarpus indicus Willd.*	X	VU	Negligible	Negligible	Negligible
Kwila *Intsia bijuga (Colebr.) Kuntze*	X	VU	Negligible	Negligible	Negligible
Palosapis *Anisoptera thurifera (Blanco) Blume subsp. polyandra (Blume) Ashton*	X	VU	Negligible	Negligible	Negligible
Papuan Nutmeg *Myristica buchneriana Warb.*	X	VU	Negligible	Negligible	Negligible
Guma *Horsfieldia ampliformis de Wilde*	X	VU	Negligible	Negligible	Negligible
Bangara *Horsfieldia sepikensis Markgr.*	X	VU	Negligible	Negligible	Negligible
Dragonfly *Bironides teuchestes*	X	VU	Minor	Minor	Minor
Plush-coated Ringtail Possum *Pseudochirops corinnae*	S	NT	Negligible	Minor	Moderate
D'Albertis's Ringtail Possum *Pseudochirops albertisii*	S	NT	Negligible	Minor	Minor
Small Mountain Dorcopsis *Dorcopsulus ?vanheurni*	X	NT	Negligible	Minor	Moderate
New Guinean Quoll *Dasyurus albopunctatus*	X	NT	Negligible	Minor	Minor
Victoria Crowned Pigeon *Goura victoria*	X	NT P	Negligible	Moderate	Major
Pale-billed Sicklebill *Drepanornis bruijnii*	S	NT P	Negligible	Minor	Minor
Yellow-breasted Satinbird *Loboparadisea sericea*	X	NT P	Negligible	Minor	Moderate
Doria's Goshawk *Megatriorchis doriae*	X	NT	Negligible	Minor	Moderate
Gurney's Eagle *Aquila gurneyi*	S	NT	Negligible	Minor	Moderate
Forest Bittern *Zonerodius heliosylus*	X	NT	Negligible	Minor	Minor
Blue-black Kingfisher *Todiramphus nigrocyaneus*	X	NT	Negligible	Minor	Minor
Banded Yellow Robin *Poecilodryas placens*	S	NT	Negligible	Minor	Minor
Beach Stone-curlew *Esacus magnirostris*	S	NT	Negligible	Negligible	Negligible
Bar-tailed Godwit *Limosa lapponica*	S	NT	Negligible	Negligible	Negligible
Black-tailed Godwit *Limosa limosa*	S	NT	Negligible	Negligible	Negligible
Red Knot *Calidris canutus*	M	NT	Negligible	Negligible	Negligible
Curlew Sandpiper *Calidris ferruginea*	S	NT	Negligible	Negligible	Negligible
Red-necked Stint *Calidris ruficollis*	S	NT	Negligible	Negligible	Negligible
Asian Dowitcher *Limnodromus semipalmatus*	M	NT	Negligible	Negligible	Negligible
Grey-tailed Tattler *Tringa brevipes*	S	NT	Negligible	Negligible	Negligible
Chimaera Birdwing *Ornithoptera chimaera*	S	NT P	Negligible	Negligible	Negligible
New Guinea Kauri *Agathis labillardieri Warb.*	X	NT	Negligible	Negligible	Negligible
Cycad *Cycas rumphii Miq.*	X	NT	Negligible	Negligible	Negligible
Aglaia agglomerata Merr. & Perry	X	NT	Negligible	Negligible	Negligible
Aglaia euryanthera Harms	X	NT	Negligible	Negligible	Negligible
Aglaia rimosa (Blanco) Merr.	X	NT	Negligible	Negligible	Negligible
Aglaia subcuprea Merr. & Perry	X	NT	Negligible	Negligible	Negligible
Guma *Myristica globosa Warb.*	X	NT	Negligible	Negligible	Negligible
Northern Cassowary *Casuarius unappendiculatus*	X	LC	Minor	Major	Extreme
Dwarf Cassowary *Casuarius bennetti*	X	LC	Minor	Major	Extreme
Black-billed Sicklebill *Drepanornis albertisi*	S	LC P	Negligible	Minor	Moderate
Black Sicklebill *Epimachus fastosus*	M	LC P	Negligible	Minor	Moderate
Loria's Satinbird *Cnemophilus loriae*	M	LC P	Negligible	Negligible	Negligible
Short-tailed Paradigalla *Paradigalla brevicauda*	L	LC P	Negligible	Negligible	Negligible

SPECIES	Occ[1]	STATUS	DIRECT*	INDIRECT 1	INDIRECT 2
Superb Bird-of-paradise *Lophorina superba*	X	LC P	Negligible	Minor	Moderate
Queen Carola's Parotia *Parotia carolae*	X	LC P	Negligible	Minor	Moderate
King of Saxony Bird-of-paradise *Pteridophora alberti*	L	LC P	Negligible	Minor	Moderate
Lesser Bird-of-paradise *Paradisaea minor*	X	LC P	Negligible	Moderate	Major
Twelve-wired Bird-of-paradise *Seleucidis melanoleucus*	X	LC P	Negligible	Minor	Moderate
Magnificent Bird-of-paradise *Diphyllodes magnificus*	X	LC P	Negligible	Minor	Moderate
King Bird-of-paradise *Cicinnurus regius*	X	LC P	Negligible	Minor	Moderate
Magnificent Riflebird *Ptiloris magnificus*	X	LC P	Negligible	Minor	Moderate
Jobi Manucode *Manucodia jobiensis*	X	LC P	Negligible	Negligible	Negligible
Glossy-mantled Manucode *Manucodia ater*	X	LC P	Negligible	Negligible	Negligible
Crinkle-collared Manucode *Manucodia chalybatus*	X	LC P	Negligible	Negligible	Negligible
Trumpet Manucode *Phonygammus keraudrenii*	S	LC P	Negligible	Negligible	Negligible
Palm Cockatoo *Probosciger aterrimus*	X	LC P	Minor	Moderate	Major
Blyth's Hornbill *Rhyticeros plicatus*	X	LC P	Minor	Moderate	Major
Little Egret *Egretta garzetta*	X	LC P	Negligible	Negligible	Negligible
Eastern Great Egret *Ardea alba*	X	LC P	Negligible	Negligible	Negligible
Intermediate Egret *Ardea intermedia*	X	LC P	Negligible	Negligible	Negligible
Boelen's python *Morelia boeleni*	S	NE P	Negligible	Minor	Moderate
Goliath Birdwing *Ornithoptera goliath*	S	LC P	Negligible	Negligible	Negligible
Butterfly of Paradise *Ornithoptera paradisea*	S	LC P	Negligible	Negligible	Negligible

* entries are estimated significance of residual impacts INDIRECT 1 = direct + indirect impacts INDIRECT 2 = direct + indirect impacts assuming the Montane Zone of the GFA is much impacted by resettlement patterns.

1 OCCURENCE. X – recorded, S– strong likelihood of occurring, M – moderate likelihood of occurring, L – low likelihood of occurring.

16. Monitoring

It is suggested that a biodiversity monitoring program be implemented aimed at demonstrating that the values of the Study Area have been maintained through construction, operation and closure of the Project. Five monitoring activities are suggested that could be undertaken as part of such a program.

- Imagery analysis of relevant areas of the Study Area to monitor habitat cover and condition in order to determine:
  - The extent, if any, of indirect effects from increased access.
  - The extent, if any, of fires.
  - Broad-scale vegetation community changes to the Study Area Lowland Zone resulting from inundation of the ISF.
- Monitoring of amphibious fauna in streams and adjoining forests in order to provide[17]:
  - An integrated measure of ecological health of streams and riparian vegetation.
  - A demonstration of the persistence of many of the species new to science.
- Annual sampling of forest condition and biodiversity at Project road and facility edges.
- Annual aerial surveys of waterbirds and Flying Fox colonies in the Study Area Lowland Zone in order to determine the abundance of Migratory and/or Congregatory Species.

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[17] Persistence of sensitive amphibious fauna requires maintenance of stream habitat conditions, water quality, riparian habitat structure and forest microclimates. They thus are excellent integrators of ecological condition. Shifts in species assemblages of amphibious fauna in tropical areas undergoing forest degradation is a powerful indicator of habitat degradation (Clark and Samways 1996, Brown 1997, Clausnitzer 2003) and in New Guinea may represent a useful indicator of ecosystem health in closed forests (Oppel 2006). Frogs have been used to monitor the health of a wide range of freshwater ecosystems (Oertli 2008, Dodd 2010), so a monitoring program can be designed within an existing framework of tested field and analytical protocols. The characteristics that make them useful indicators are that they have variable but low resilience so that populations respond rapidly to small changes in ecosystem parameters (Brown 1997), assemblages of odonates and frogs can be identified and defined on the basis of their habitat associations, from a broad to a very fine scale, and specific indicator species for each assemblage can be identified. Most important, adult odonates and frogs are easy to sample and identify and their presence and abundance reflects responses of both larvae and adults. Frogs can be even automatically sampled using acoustic sampling.

17. Conclusions and offsets

The final part of the mitigation hierarchy is where plans are put forward as to how to offset the residual impacts of a project and Annex 3 briefly introduces the "standard" way of approaching this. This standard approach might be appropriate if the Sepik Development Project was a stand-alone mining project in isolation, but it has evolved to become a regional and national development project. It is at this level that the preceding impact analysis needs to be contextualised and in which "offsets" need to be considered.

The direct physical impacts of the Project are high, but it is predicted that they alone will not result in irreparable loss of habitats or biodiversity to the core areas – the Frieda and May River catchments and the Sepik lowlands. The main issues are indirect – in-migration, interactions with and stimulation of other developments and the expansion of exotics, weeds and diseases. The latter is a general problem but the two former, while bug-bears for stand-alone resource projects, are exactly what regional and national development projects want to achieve.

In the end the major impacts of the Sepik Development Project are likely to be not from the FRCGP and FRHEP but from the development opportunities provided by electrification of north western PNG and the growth of its population. Large scale logging industries have been operating for many years in Sandaun and East Sepik and are destined to expand southwards, the western Sepik River floodplain may become a major agricultural area for PNG, north coast industries may develop, and oil palm could expand with a more extensive road system and the option to electrify processing plants. Such a basket of stand-alone projects inevitably will result in economic advancement for PNG, expansion of population and the loss of large parts of Sandaun's forests and biodiversity.

The Sepik Development Project is designed to stimulate this development expansion and so would bear some responsibility for the long-term erosion of the natural assets of the Study Area in the absence of any strategic approach to the problem. Alone, as the FRCGP and FRHEP, it does not have the power or legitimacy to manage these inevitable regional impacts that come with development. As a flagship development project, it does. Biodiversity loss as a result of regional development requires a coordinated regional approach and the production of conservation outcomes involving all stakeholders - villagers, local, regional and national government and private enterprise[18].

Frieda River Limited has a long pedigree of stakeholder engagement and knows how critical this is in PNG and it has the connections and fora to stimulate a regional approach to incorporating conservation planning in regional development. An effective response to the potential biodiversity impacts the broader development project is likely to engender would be for Frieda River Limited to expand activities of the existing consultative systems to include regional conservation planning, including the inclusion of other private enterprise projects[19].

This is fully relatable to and probably the most effective way to develop an offset system. Rather than follow the procedures in Annex 3 - calculate offset needs then try to find them - a high level, integrated regional approach establishes active negotiated conservation developments to which everyone can contribute. Offsets for any project would then be a formal contribution to a planned conservation system by the particular project.

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[18] It is salutary to note that major local concern of landholders in respect to the project were environmental issues (Jackson 2018).

[19] This could be a system of conservation areas run like Tenkile, revegetation enterprises, species conservation programs but all part of a focussed effort to retain the region's biodiversity in the face of its development. It should be noted that the consultative procedures FRL uses are the same systems used by conservation practitioners to develop protected areas and conservation activities. It should also be noted here that conservation activities are legitimate economic activities and part of development - there is no reason that conservation work should not be a legitimate income source for local people.

PART 4 REFERENCES

Allison, A. and Kraus, F. 2003. A new species of *Austrochaperina* (Anura: Microhylidae) from northern Papua New Guinea. *Journal of Herpetology* 37: 637–644.

Andrewartha, H. G. and Birch L. C. 1954. *The Distribution and Abundance of Animals.* University of Chicago Press, Chicago, Illinois.

Aplin, K. P. 1998 Vertebrate zoogeography of the Bird's Head of Irian Jaya, Indonesia. In: Miedema, J, Odé, C. and Dam, M. A. C. (eds), *Perspectives on the Bird's Head Peninsula of Irian Jaya, Indonesia. Proceedings of an interdisciplinary conference*: 803-890. Rodopi Publishers, Leiden, The Netherlands.

Aplin, K. P. and Kale, E. 2011. Non-volant mammals of the Muller Range, Papua New Guinean. In: Richards, S. J. and Gamui, B. G. (eds.) *Rapid Biological Assessments of the Nakanai Mountains and the upper Strickland Basin: surveying the biodiversity of Papua New Guinea's sublime karst environments.* RAP Bulletin of Biological Assessment 60. Arlington, Conservation International, VA, USA.

Aplin, K., Armstrong, K. and Wright, D. 2016. *Aproteles bulmerae.* The IUCN Red List of Threatened Species 2016: e.T1933A22136238. http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T1933A22136238.en. Downloaded on 25 March 2018.

Armstrong, K. & Aplin, K. 2017a. *Hipposideros edwardshilli.* The IUCN Red List of Threatened Species 2017: e.T10133A22090348. http://dx.doi.org/10.2305/IUCN.UK.2017-2.RLTS.T10133A22090348.en. Downloaded on 25 March 2018.

Ashton, D. T., Marks, S. B. and Welsh, H. H. 2006. Evidence of continued effects from timber harvesting on lotic amphibians in redwood forests of northwestern California. *Forest Ecology and Management* 221: 183-193.

Asquith, N. M. and Mejia-Chang, M. 2005. Mammals, edge effects, and the loss of tropical forest diversity. *Ecology* 86: 379–390.

Australian Tropical Rainforest Plants 2015. *Aglaia euryanthera*. http://keys.trin.org.au/key-server/data/0e0f0504-0103-430d-8004-060d07080d04/media/Html/taxon/Aglaia_euryanthera.htm

Baillie, J. E. M., Turvey, S. T. and Waterman C. 2010 Survival of Attenborough's long-beaked echidna *Zaglossus attenboroughi* in New Guinea. *Oryx* 43: 146-148.

Baptista, L. F., Trail, P. W. and Horblit, H. M. 1997. Family Columbidae Pigeons and Doves. Pp. 60–245 in Del Hoyo, J., Elliott, A. and Sargatal, J. (eds.) *Handbook of the Birds of the World. Vol. 4. Sandgrouse to Cuckoos.* Lynx Ediciones, Barcelona.

Barstow, M. & Jimbo, T. 2017. *Anisoptera thurifera*. The IUCN Red List of Threatened Species 2017: e.T63011A68069745. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T63011A68069745.en. Downloaded on 29 April 2018.

Beehler, B. M. & Beehler, C. H. 1986. Observations on the ecology and behaviour of the Pale–billed Sicklebill. *Wilson Bulletin* 98: 505–515.

Beehler, B. M. and Pratt, T. K. 2016. *Birds of New Guinea. Distribution Taxonomy and Systematics.* Princeton, Princeton University Press, N J.

Beehler, B. M. and Prawiradilaga, D. 2010. New taxa and new records of birds from the North Coastal Ranges of New Guinea. *Bulletin of the British Ornithologists' Club* 130:277-285.

BirdLife International. 2016a. *Calidris tenuirostris.* The IUCN Red List of Threatened Species 2016: e.T22693359A93398599. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22693359A93398599.en. Downloaded on 25 March 2018.

BirdLife International. 2016b. *Salvadorina waigiuensis*. The IUCN Red List of Threatened Species 2016: e.T22680127A92845212. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22680127A92845212.en. Downloaded on 25 March 2018.

BirdLife International. 2016c. *Harpyopsis novaeguineae*. The IUCN Red List of Threatened Species 2016: e.T22696007A93538251. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22696007A93538251.en. Downloaded on 25 March 2018.

BirdLife International. 2016d. *Goura victoria.* The IUCN Red List of Threatened Species 2016: e.T22691874A93326799. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22691874A93326799.en. Downloaded on 25 March 2018.

BirdLife International. 2016e. Drepanornis bruijnii. The IUCN Red List of Threatened Species 2016: e.T22706160A94053738. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22706160A94053738.en. Downloaded on 07 May 2018.

BirdLife International. 2016f. *Megatriorchis doriae.* The IUCN Red List of Threatened Species 2016: e.T22695706A93524334. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22695706A93524334.en. Downloaded on 25 March 2018.

BirdLife International. 2016g. *Aquila gurneyi*. The IUCN Red List of Threatened Species 2016: e.T22696056A93541423. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22696056A93541423.en. Downloaded on 25 March 2018.

BirdLife International. 2016h. *Esacus magnirostris*. The IUCN Red List of Threatened Species 2016: e.T22728621A94992570. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22728621A94992570.en. Downloaded on 07 May 2018.

BirdLife International. 2016i. Casuarius bennetti. The IUCN Red List of Threatened Species 2016: e.T22678111A92755192. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T22678111A92755192.en. Downloaded on 25 March 2018.

BirdLife International. 2017a. *Numenius madagascariensis (amended version of assessment). The IUCN Red List of Threatened Species 2017: e.T22693199A118601473. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22693199A118601473.en.* Downloaded on 25 March 2018.

BirdLife International. 2017b. *Psittrichas fulgidus*. The IUCN Red List of Threatened Species 2017: e.T22685025A118772050. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22685025A118772050.en. Downloaded on 25 March 2018.

BirdLife International. 2017c. *Loboparadisea sericea* (amended version of 2016 assessment). The IUCN Red List of Threatened Species 2017: e.T22706091A111048632. http://dx.doi.org/10.2305/IUCN.UK.2017-1.RLTS.T22706091A111048632.en. Downloaded on 25 March 2018.

BirdLife International. 2017d. *Zonerodius heliosylus*. The IUCN Red List of Threatened Species 2017: e.T22697274A117210228. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22697274A117210228.en. Downloaded on 25 March 2018.

BirdLife International. 2017e. *Todiramphus nigrocyaneus.* The IUCN Red List of Threatened Species 2017: e.T22683282A118148059. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22683282A118148059.en. Downloaded on 26 March 2018.

BirdLife International. 2017f. *Gennaeodryas placens* (amended version of assessment). The IUCN Red List of Threatened Species 2017: e.T22704880A118832293. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22704880A118832293.en. Downloaded on 26 March 2018.

BirdLife International. 2017g. *Casuarius unappendiculatus.* The IUCN Red List of Threatened Species 2017: e.T22678114A118134784. http://dx.doi.org/10.2305/IUCN.UK.2017-3.RLTS.T22678114A118134784.en. Downloaded on 25 March 2018.

BirdLife International. 2018. Species factsheet: *Goura victoria*. Downloaded from http://www.birdlife.org on 26/05/2018

Bolton, B. (ed.). 2009. *The Fly River, Papua New Guinea: Environmental Studies in an Impacted Tropical River System.* Elsevier, Burlington, MA.

Bonaccorso, F. J. 1998. *Bats of Papua New Guinea.* Conservation International Tropical Field Guide Series. Conservation International, Washington, D. C.

Bonnet, M. P., Barroux, G., Martinez, J. M., Seyler, F., Moreira-Turcq, P., Cochonneau, G., Melack, J. M., Boaventura, G., Maurice-Bourgoin, L., Leo´n, J. G., Roux, E., Calmant, S., Kosut, P., Guyot, J. L. and Seyler P. 2008. Floodplain hydrology in an Amazon floodplain lake (Lago Grande de Curuaı´). *Journal of Hydrology* 349: 18– 30.

Booyong Forest Science 2011. *Implications of the Frieda River Project for Forestry and Oil Palm Development.* Report to Coffey Environments.

Brown, K. S. Jnr. 1997. Diversity, disturbance, and sustainable use of Neotropical forests: insects as indicators for conservation monitoring. *Journal of Insect Conservation* 1: 25-42.

Bryophyte Specialist Group 2000. *Schistochila undulatifolia*. The IUCN Red List of Threatened Species 2000: e.T39214A10176238. http://dx.doi.org/10.2305/IUCN.UK.2000.RLTS.T39214A10176238.en. Downloaded on 26 March 2018.

Burns, C. E. 2005. Behavioral ecology of disturbed landscapes: the response of territorial animals to relocation. *Behavioral Ecology* 16: 898–905.

Cámara-Leret, R., Ridder-Numan, J. W. A. and Veldkamp, J. F. 2013. Revision of Heteroblemma gen. nov. (Dissochaeteae – Melastomataceae) from Malesia and Vietnam. *Blumea* 58: 229-240.

Carpenter, S. R., Brock, W. A., Cole, J. J., Kitchell, J. F. and Pace, M. L. 2008. Leading indicators of trophic cascades. *Ecology Letters* 11: 128-138.

Carr D. J., Carr S. G. M., Hyland B. P. M., Wilson P. G. and Ladiges P. Y. 2002 Stockwellia quadrifida (Myrtaceae), a new Australian genus and species in the eucalypt group. *Botanical Journal of the Linnaean Society,* 139: 415-421.

Centre for Environmental Health. 2011. *Baseline Health, Diet and Nutrition Survey Frieda River Project*. Unpublished report to Coffey Environments.

Chaowasku, T. 2015. *Huberantha*, a replacement name for *Hubera* (Annonaceae: Malmeoideae: Miliuseae). *Kew Bulletin* 70: 23.

Churchill, S.K. 2008. *Australian bats*. 2nd ed. Allen and Unwin, Crows Nest, NSW.

Clark, T. E. and Samways, M. J. 1996. Dragonflies (Odonata) as indicators of biotope quality in the Krüger. National Park, South Africa. *Journal of Applied Ecology* 33: 1001-1012.

Clausnitzer, V. 2003. Dragonfly communities in coastal habitats of Kenya: indication of biotope quality and the need for conservation measures. *Biodiversity and Conservation* 12: 333-356.

Coates, B. J. 1985. *The Birds of PNG, Including the Bismarck Archipelago and Bougainville*. Volume I, Non–Passerines. Dove Publications, Alderley, Queensland.

Coates, B. J. 1990. *The Birds of PNG, Including the Bismarck Archipelago and Bougainville. Volume II, Passerines.* Alderley, Queensland: Dove Publications.

Coates, B. J. and Peckover, W. S. 2001. *Birds of New Guinea and the Bismarck Archipelago, a Photographic Guide*. Dove Publications, Alderley, Queensland.

Corenblit, D., Tabacchi, E., Steiger, J. and Gurnell, A. M. 2007. Reciprocal interactions and adjustments between fluvial landforms and vegetation dynamics in river corridors: A review of complementary approaches. *Earth-Science Reviews* 84:56–86

Corn, P. S., Bury, R. B., Hyde, E. J. 2003. Conservation of North American stream amphibians. Pp. 24-36 in: Semlitsch, R. D. (ed.), *Amphibian Conservation.* Smithsonian Institute Press, Washington, D.C.

Crome, F. H. J. and Moore, L. A. 1990. Cassowaries in north–eastern Queensland: report of a survey and a review and assessment of their status and conservation and management needs. *Australian Wildlife Research* 17: 369–385.

Crome, F. H. J. and Woxvold, I. 2009. *Scoping (Phase 1) report for terrestrial biodiversity studies for the Frieda River Project.* Report to Coffey Natural Systems.

CSBI 2015. *A cross-sector guide for implementing the mitigation hierarchy.* Prepared by the Biodiversity Consultancy on behalf of IPIECA, ICMM and the Equator Principles Association: Cambridge UK.

Curran, L. M., Caniago, I., Paoli, G. D., Astianti, D., Kusneti, M., Leighton, M., Nirarita, C. E. and Haeruman, H. 1999. Impact of El Niño and logging on canopy tree recruitment in Borneo. *Science*, 286: 2184–2188.

Dahl C., Novotny V., Moravec J. and Richards S. J. 2009. Beta diversity of frogs in the forests of New Guinea, Amazonia and Europe: contrasting tropical and temperate communities. *Journal of Biogeography* 36: 896–904.

de Wilde, W. J. J. O. de. 1985a. A new account of the genus *Horsfieldia* (Myristicaceae), Part 1. *Gardeners Bulletin of Singapore.* 37: 115–179.

de Wilde, W. J. J. O. de. 1985b. A new account of the genus *Horsfieldia* (Myristicaceae), Part 2. *Gardeners Bulletin of Singapore.* 38: 55–144.

de Wilde, W. J. J. O. de. 1995. Census of *Myristica* (Myristicaceae) in New Guinea anno 1994. *Blumea* 40: 237–344.

de Wilde, W. J. J. O. de. 1998. The myrmecophilous species of *Myristica* (Myristicaceae) from New Guinea. *Blumea* 43: 165–182

de Wilde, W. J. J. O. de. 2000. Myristicaceae. *Flora Malesiana* ser. I, 14: 1–632.

Diamond J. M. 1967. Birds of the Torricelli Mountains, New Guinea. *American Philosophical Society Yearbook* 1967: 260–263.

Diamond J. M. 1969. Preliminary results of an ornithological exploration of the north coastal range, New Guinea. American Museum *Novitates* 2362: 1–57.

Diamond J. M. and Bishop K. D. 2003. *Seasonality in Birds in the Kikori River Catchment: Year-2003 Studies*. WWF KICDP Report.

Dickman, C., Helgen, K. & Wright, D. 2016. *Paraleptomys rufilatus*. The IUCN Red List of Threatened Species 2016: e.T16121A22419478. http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T16121A22419478.en. Downloaded on **1**1 May 2018.

Ding Hou, Larsen, K. and Larsen., S. S. 1996. Caesalpiniaceae (Leguminosae-Caesalpinioideae). *Flora Malesiana.* ser. I, 12: 409–730.

Dingle, H. 2004. The Australo–Papuan bird migration system: another consequence of Wallace's Line. *Emu* 104: 95–108.

Dodd, C. K. 2010. *Amphibian ecology and conservation: A handbook of techniques*. Oxford University Press, Oxford.

DSEWPC 2011. *Miniopterus schreibersii bassanii* – Southern Bent-wing Bat. In: Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. URL: http://www. environment. gov. au/cgi-bin/sprat/public/publicspecies. pl?taxon_id=76606.

Dudgeon, D. and Smith, R. E. W. 2006. Exotic species, fisheries and conservation of freshwater biodiversity in tropical Asia: the case of the Sepik River, Papua New Guinea. *Aquatic Conservation: Marine and Freshwater Ecosystems* 16: 203–215.

Dwyer, P. D. 1966. The population pattern of *Miniopterus schriebersii* (Chiroptera: Vespertilionidae) in Australia. *Journal of Mammalogy* 47: 716-718.

Dwyer, P. D. 1968. The biology, origin and adaptation of *Miniopterus australis* (Chiroptera) in New South Wales. *Australian Journal of Zoology* 14: 1073-1137.

Dyer, S. J., O'Neill, J. P., Wasel, S. M. and Boutin, S. 2002. Quantifying barrier effects of roads and seismic lines on movements of female woodland caribou in northeastern Alberta. *Canadian Journal of Zoology* 80: 839 - 845

Eddowes, P. J. 1977. *Commercial timbers of Papua New Guinea*, Hebamo Press, Papua New Guinea.

Eddowes, P. J. 1998a. *Flindersia pimenteliana.* he IUCN Red List of Threatened Species 1998: e.T38149A10102702. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T38149A10102702.en. Downloaded on 26 March 2018.

Eddowes, P. J. 1998b. *Ceratopetalum succirubrum*. The IUCN Red List of Threatened Species 1998: e.T38161A10097209. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T38161A10097209.en. Downloaded on 26 March 2018.

Eddowes, P. J. 1998c. *Halfordia papuana*. The IUCN Red List of Threatened Species. 1998: e.T38151A10103085. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T38151A10103085.en. Downloaded on 26 March 2018.

Farjon, A. 2010. *A Handbook of the World's Conifers*. Brill, Leiden and Boston

Farjon, A. 2013. *Agathis labillardieri*. The IUCN Red List of Threatened Species 2013: e.T42193A2960026. http://dx.doi.org/10.2305/IUCN.UK.2013-1.RLTS.T42193A2960026.en. Downloaded on 26 March 2018.

Fetcher, N., Oberdauer, S. F. and Strain, B. R. 1985. Vegetation effects on microclimate in lowland tropical forest in Costa Rica. *International Journal of Biometeorology* 29: 145–155.

Filer C., Keenan R. J., Allen B.J. and McAlpine J. R. 2009. Deforestation and forest degradation in Papua New Guinea. *Annals of forest Science* 66: 813. (Published Online: 25 November 2009.)

Flannery, T. F. 1994. *Possums of the World. A monograph of the Phalangeroidea*. Geo Publications and the Australian Museum, NSW.

Flannery, T. F. 1995. *Mammals of New Guinea*. Revised and updated edition. Reed Books, Chatswood, New South Wales.

Flannery, T. F. and Colgan, D. J. 1993. A new species and two new subspecies of *Hipposideros* (Chiroptera) from western Papua New Guinea. *Records of the Australian Museum* 45: 43-58.

Flannery, T. F. and Groves, C. P. 1998. A revision of the genus *Zaglossus* (Monotremata, Tachyglossidae), with description of new species and subspecies. *Mammalia* 62: 367–396.

Flannery, T. F. and Seri, L. 1990. The mammals of southern West Sepik Province, PNG: their distribution, abundance, human use and zoogeography. *Records of the Australian Museum* 42: 173–208.

Flannery, T. F., Martin, R. M. and Szalay, A. 1996. *Tree Kangaroos a Curious Natural History*. Reed, Port Melbourne, Victoria.

Foreman, D. B. 1978. *Myristicaceae*. Pp. 175–215 in: Womersley, J. S. (ed.) *Handbooks of the Flora of PNG* Vol. 1. Melbourne University Press, Carlton, Victoria.

Fortune Hopkins, H.C. and Hoogland, R. D. 2002. Cunoniaceae. *Flora Malesiana* ser. I, 16: 53–165.

Frazier, S. 2007. Threats to biodiversity. Pp. 1199–1229 in Marshall, A. J. and Beehler, B. M. (eds.) *The Ecology of Papua (Part Two).* Periplus Editions, Hong Kong.

Frith, C. B. and Beehler, B. M. 1998. *The Birds of Paradise: Paradisaeidae*. Oxford University Press, Oxford.

Ganzhorn, J. U. 2003. Effects of introduced *Rattus rattus* on endemic small mammals in dry deciduous forest fragments in western Madagascar. *Animal Conservation* 6: 147–157.

Gilliard, E. T. and LeCroy, M. 1966. Birds of the middle Sepik region, New Guinea. Results of the American Museum of Natural History expedition to New Guinea in 1953-1954. *Bulletin of the American Museum of Natural History* 132: 247–275.

Gimenez Dixon, M. 1996. *Ornithoptera meridionalis*. The IUCN Red List of Threatened Species 1996: e.T15519A4740678. http://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T15519A4740678.en. Downloaded on 26 March 2018.

Goosem, M. 1997. Internal fragmentation: The effects of roads, highways and powerline clearings on movements and mortality of rainforest vertebrates. Pp. 241 – 255 in Laurence, W. F. and Bierregaard, R. O. Jr. (eds.). *Tropical Forest Remnants. Ecology, Management, and Conservation of Fragmented Communities.* University of Chicago Press, Chicago.

Goosem, M. 2001. Effects of tropical rainforest roads on small mammals: inhibition of crossing movements. *Wildlife Research* 28: 351-364.

Goosem, M. 2004. Linear infrastructure in tropical rainforests: mitigating potential impacts on fauna of roads and powerline clearings. Pp 418-434 in: Lunney, D. (ed.) *Conservation of Australia's forest fauna.* Royal Zoological Society of NSW, Mosman, NSW.

Goosem, M, Weston, N. and Bushnell, S. 2006. Effectiveness of rope bridge arboreal overpasses and faunal underpasses in providing connectivity for rainforest fauna. Pp. 304-316 in: Irwin, C. L., Garrett P. and McDermott K. P. (eds.) Proceedings of the 2005 International Conference on Ecology and Transportation, Centre for Transportation and the Environment, North Carolina State University, Raleigh, NC.

Gregory, P. 2008. Significant sightings from Papua Province, Indonesian tour reports. *Muruk* 9: 1–33.

Gymnosperm Database (2015). *Agathis labillardieri*. http://www.conifers.org/ar/Agathis_labillardieri.php Accessed 21/01/2014.

Haantjens, H. A., Arnold, J, M., McAlpine, J. R., Saunders, J. C., Reiner, E., Robbins, R. G. and Mabbutt, J. A. 1968. *Lands of the Wewak–Lower Sepik Area, Territory of Papua and New Guinea.* Land Research Series No. 22. CSIRO.

Haantjens, H. A., Heyligers, P. C., Fagan, R. H., Saunders, J. C. and McAlpine, J. R. 1972. *Lands of the Aitape–Ambunti Area, Papua New Guinea.* Land Research Series No. 30. CSIRO.

Haberle, S. G, Hope, G. S., van der Kaars, S. 2001. Biomass burning in Indonesia and Papua New Guinea: natural and human induced fire events in the fossil record. *Palaeogeography, Palaeoclimatology, Palaeoecology* 171: 259-268.

Hall, L. and Richards, G. 2000. *Flying foxes, fruit and blossom bats of Australia.* Krieger Publishing Co., Malabar, Florida.

Hämäläinen, M. & Orr, A. G. 2016. Wilhelm Stüber (1877–1942), collector extraordinaire of New Guinean dragonflies, discoverer of the fabulous Sepik blue orchid, tragic victim of war. *Agrion* 20: 68–88.

Hammermaster, E. T. and Saunders, J. C. 1995. *Forest Resources and Vegetation Mapping of Papua New Guinea.* PNGRIS Publ. 4. CSIRO and AIDAB, Canberra.

Harper, K. A., Macdonald, S. E., Burton, P. J., Chen, J., Brosofske, K. D., Saunders, S. C., Euskirchen, E. S., Robers, D., Jaiteh, M. S. and Esseen, P. -A. 2005. Edge influence on forest structure and composition in fragmented landscapes. *Conservation Biology* 19: 768–782.

Hartley, T. G. 1969. A revision of the genus *Flindersia* (Rutaceae). *Journal of the Arnold Arboretum*. 50: 481–526.

Hartley, T. G. 1986. Floristic relationships of the rainforest flora of New Guinea. *Telopea* 2: 619–630.

He, F. and Hubbell, S. 2013 Estimating extinction from species–area relationships: why the numbers do not add up. *Ecology* 94: 1905–1912.

He, F. and Hubbell, S. P. 2011. Species–area relationships always overestimate extinction rates from habitat loss. *Nature* 473:368–371

Healey, C. J. 1986. The impact of man on birds of paradise in the Jimi valley. *Muruk* 1: 34–69.

Helgen, K. M. 2007. A Taxonomic and Geographic Overview of the Mammals of Papua. Pp. 689-749 in Marshall, A. J. and Beehler, B. M. (eds), *The Ecology of Papua*. Periplus Editions, Singapore.

Helgen, K. M., Dickman, C. & Salas, L. 2008. *Pseudochirops albertisii.* The IUCN Red List of Threatened Species 2008:e.T18503A8354282. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T18503A8354282.en. Downloaded on 25 April 2018.

Helgen, K. M., Miguez, R. P., Kohen, J. K. and Helgen, L. E. 2012. Twentieth century occurrence of the Long-Beaked Echidna *Zaglossus bruijnii* in the Kimberley region of Australia. *Zookeys* 255: 103-132.

Hill, K. D. 2010. *Cycas rumphii.* The IUCN Red List of Threatened Species 2010: e.T42081A10623127. http://dx.doi.org/10.2305/IUCN.UK.2010-3.RLTS.T42081A10623127.en. Downloaded on 26 March 2016.

Hubbell, S. P. and Lake J. 2003. The neutral theory of biogeography and biodiversity: and beyond. In Blackburn, T. and Gaston, K. (eds.) *Macroecology: concepts and consequences*. Blackwell Scientific, Oxford.

Hulme D. 1977. The birds of Lumi, in the West Sepik Province. *New Guinea Bird Society Newsletter* 129: 5–6.

Hyvönen, J. 1989. On the bryogeography of Western Malesia. *Journal of the Hattori Botanical Laboratory*. 66: 231–354.

Iannella, A., Oliver, P. and Richards, S. 2015. Two new species of Choerophryne (Anura, Microhylidae) from the northern versant of Papua New Guinea's central cordillera. *Zootaxa* 4058: 332-340.

Igag, P. 2002. *The conservation of large rainforest parrots. A study of the breeding biology of Palm Cockatoos, Eclectus Parrots and Vulturine Parrots.* M. Sc. Thesis, Australian National University, Canberra.

ISSG 2010. ISSG Global Invasive Species Database. www.issg.org/database/: accessed 28 April 2010, Invasive Species Specialist Group.

ISSG 2018. ISSG Global Invasive Species Database. http://www.iucngisd.org/gisd.

Jackson. 2018. *Project Induced In-Migration Management Strategy (PIIMMS).* Prepared for Frieda River Limited, Brisbane, Queensland.

Jenkins, A. R., Smallie, J. J. and Diamond, M. 2010. Avian collisions with power lines: a global review of causes and mitigation with a South African perspective. *Bird Conservation International* 20: 263-278.

Johns, R. J., Shea, G. A. and Puradyatmika, P., 2007. Lowland Swamp and Peat Vegetation of Papua. *Pp.* 910-944 *in* Marshall, A. J. and Beehler, B. M. (eds.) *The Ecology of Papua Part Two*. Periplus Editions, Hong Kong.

Johnson, A., Bino, R. and Igag, P. 2004. A preliminary evaluation of the sustainability of cassowary Aves: Casuariidae capture and trade in PNG. *Animal Conservation* 7: 129–137.

Jones, D. N., Dekker, R. W. R. J. and Roselaar, C. S. 1995. *The Megapodes: Megapodiidae*. Oxford University Press, Oxford.

Junk, W. J., Bayley, P. B. and Sparks, R. E. 1989. The flood pulse concept in river floodplain systems, in: Dodge, D. P. (ed.), *Proceedings of the international large river symposium (LARS). Canadian Special Publication of Fisheries and Aquatic Sciences.* 106: 110-127.

Kalkman, V. 2009a. *Bironides teuchestes.* The IUCN Red List of Threatened Species 2009: e.T163877A5662936. http://dx.doi.org/10.2305/IUCN.UK.2009-2.RLTS.T163877A5662936.en. Downloaded on 25 March 2018.

Kemp, A. 1995. *The Hornbills*. Oxford: Oxford University Press.

Kemp, A. 2001. Family Bucerotidae (Hornbills). Pp. 436–526 in Del Hoyo, J., Elliott, A. and Sargatal, J., (eds.). *Handbook of the Birds of the World. Vol. 6. Mousebirds to Hornbills.* Lynx Edicions, Barcelona.

Kemp, N. J. and Burnett, J. B. 2007. A non–native primate (*Macaca fascicularis*) in Papua: implications for biodiversity. Pp. 1348–1364 in Marshall, A. J. and Beehler, B. M. (eds.) *The Ecology of Papua (Part Two).* Periplus Editions, Hong Kong.

Kinbag, F. 1995. Cuscus thought to be extinct found in Madang. *The New Guinea Tropical Ecology and Biodiversity Digest* Issue 6: 5.

King, C. E. and Nijboer, J. 1994. Conservation considerations for crowned pigeons, genus *Goura*. *Oryx* 28: 22–30.

Kinnaird, M. F. and O’Brien, T. G. 2007. *The Ecology and Conservation of Asian Hornbills, Farmers of the Forest.* University of Chicago Press, Chicago.

Kocher Schmid, C. 1993. Birds of Nokopo. *Muruk* 6: 1–61.

Koh, L. P. and Ghazoul, J. 2010. A Matrix-Calibrated Species-Area Model for Predicting Biodiversity Losses Due to Land-Use Change. *Conservation Biology* 11: 994-1001.

Koponen, T. and Norris, D. H. 1983. Bryophyte flora of the Huon Peninsula, PNG. I. Study Area and its bryological exploration. *Annales Botanici Fennici* 20: 15–29.

Kraus, F. 2013. A new species of *Hylophorbus* from Papua New Guinea. *Current Herpetology* 32: 102-110

Kraus, F. and Allison, A. 2006. Range extensions for reptiles and amphibians along the northern versant of Papua New Guinea. *Herpetological Review* 37: 364–368.

Kraus, F. and Allison, A. 2009. New species of frogs from Papua New Guinea. *Bishop Museum Occasional Papers* 14: 1–36.

Lamberts, D. 2008. Little impact, much damage: The consequences of Mekong River flow alterations for the Tonle Sap ecosystem. *Pp.* 3–18 *in* Kummu, M., Varis, O. and Keskinen. M. (eds.) *Modern Myths of the Mekong—A Critical Review of Water and Development Concepts, Principles and Policies.* Water and Development Publications, Helsinki University of Technology, Finland.

Lamberts, D. and Koponen, J. 2008. Flood-pulse alterations and productivity of the Tonle sap ecosystem: A model for impact assessment. *Ambio* 37: 178-184.

Laubenfels, D. J. de, and Adema, F. A. 1998. Taxonomic revision of the genera *Cycas* and *Epicycas* gen. nov. (Cycadaceae). *Blumea* 43: 351–400.

Laurance, W. F. and Bierregaard, R. O. Jr. 1997. *Tropical forest remnants: Ecology, management, and conservation of fragmented communities*. University of Chicago Press, Chicago.

Laurance, W. F., Bierregaard, R. O., Gascon, C., Didham, R. K., Smith, A. P., Lynam, A. J., Viana, V. M., Lovejoy, T. E., Sieving, K. E., Sites, J. W. Andersen, M., Tocher, M. D., Kramer, E. A., Restrepo, C. and Moritz, C. 1997. Tropical forest fragmentation: synthesis of a diverse and dynamic discipline. Pp. 502–525 in: Laurance, W. F. and Bierregaard, R. O. Jr. (eds.) *Tropical forest remnants. Ecology, management and conservation of fragmented communities*. University of Chicago Press, Chicago.

Lauterbach, C. 1918. Die Rutaceen Papuasiens. *Bot. Jahrb.* 55: 221–265.

Leary, T., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Aplin, K., Dickman, C., Salas, L., Flannery, T., Martin, R. & Seri, L. 2008a. *Dendrolagus scottae.* The IUCN Red List of Threatened Species 2008: e.T6435A12773127. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T6435A12773127.en. Downloaded on 20 May 2018.

Leary, T., Singadan, R., Menzies, J., Wright, D., Helgen, K., Dickman, C. and Salas, L. 2008b. *Pseudochirops corinnae*. The IUCN Red List of Threatened Species 2008a: e.T18504A8356425. http://dx.doi.org/10.2305/IUCN.UK.2008.RLTS.T18504A8356425.en. Downloaded on 25 March 2018.

Leary, T., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Aplin, K., Dickman, C., Salas, L., Flannery, T., Martin, R. & Seri, L. 2016a. *Dendrolagus pulcherrimus*. The IUCN Red List of Threatened Species 2016: e.T136696A21957219. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T136696A21957219.en. Downloaded on 09 April 2018.

Leary, T., Wright, D., Hamilton, S., Singadan, R., Menzies, J., Bonaccorso, F., Salas, L., Dickman, C. & Helgen, K. 2016b. *Petaurus abidi.* The IUCN Red List of Threatened Species 2016: e.T16726A21959298. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T16726A21959298.en. Downloaded on 21 April 2018.

Leary, T., Seri, L., Flannery, T., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Menzies, J., Allison, A., James, R., Salas, L. and Dickman, C. 2016c. *Phalanger matanim.* The IUCN Red List of Threatened Species 2016: e.T16851A21950802. http://dx.doi.org/10.2305.

Leary, T., Singadan, R., Menzies, J., Helgen, K., Allison, A., James, R., Flannery, T., Aplin, K., Dickman, C. and Salas, L. 2016d. *Spilocuscus rufoniger*. The IUCN Red List of Threatened Species 2016: e.T20639A21949788. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T20639A21949788.en. Downloaded on 25 March 2018.

Leary, T., Seri, L., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Menzies, J., Allison, A., James, R., Dickman, C., Aplin, K., Flannery, T., Martin, R. and Salas, L. 2016e. *Dendrolagus goodfellowi.* The IUCN Red List of Threatened Species 2016: e.T6429A21957524. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6429A21957524.en. Downloaded on 25 March 2018.

Leary, T., Seri, L., Flannery, T., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Menzies, J., Allison, A. and James, R. 2016f. *Dendrolagus notatus*. The IUCN Red List of Threatened Species 2016: e.T6427A21957392. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6427A21957392.en. Downloaded on 25 March 2018.

Leary, T., Seri, L., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Menzies, J., Allison, A., James, R., Dickman, C., Aplin, K., Flannery, T., Martin, R. & Salas, L. 2016g. *Dendrolagus inustus*. The IUCN Red List of Threatened Species 2016: e.T6431A21957669. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6431A21957669.en. Downloaded on 25 March 2018.

Leary, T., Seri, L., Flannery, T., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Menzies, J., Allison, A. and James, R. 2016h. *Thylogale browni*. The IUCN Red List of Threatened Species 2016: e.T21874A21958526. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T21874A21958526.en. Downloaded on 25 March 2018.

Leary, T., Singadan, R., Menzies, J., Helgen, K., Allison, A., James, R., Flannery, T., Aplin, K., Dickman, C. and Salas, L. 2016i. *Dorcopsulus vanheurni*. The IUCN Red List of Threatened Species 2016: e.T6802A21952770. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6802A21952770.en. Downloaded on 25 March 2018.

Lechner, A. M., Hunter, J. and Duc, K. N. 2018. *Desktop assessment of commercial forestry and agroforestry within the infrastructure corridor of the Sepik Development Project*. Report prepared by the University of Nottingham, Malaysia Campus for Frieda River Limited, Brisbane, Queensland

Lemus, J. A., Blanco, G., Grande, J., Arroyo, B., García-Montijano, M. and Martínez, F. 2008. Antibiotics threaten wildlife: circulating quinolone residues and disease in Avian scavengers*. PLOS One.* 2008 Jan 16;3(1):e1444.

Lister C. A. 1977. Birds seen along the Sepik River. New Guinea Bird Society Newsletter 129: 14.

Long, J. L. 2003. *Introduced Mammals of the World: Their History, Distribution and Influence*. CSIRO Publishing, Melbourne.

Mack, A. L. 1995. Distance and non–randomness of seed dispersal by the dwarf cassowary *Casuarius bennetti. Ecography* 18: 286–295.

Mack, A. L. and Dumbacher, J. 2007. Birds of Papua. Pp. 654–688 in Marshall, A. J. and Beehler, B. M. (eds.) *The Ecology of Papua (Part One).* Periplus Editions, Hong Kong.

Mack, A. L. and Wright, D. D. 1998. The Vulturine Parrot, *Psittrichas fulgidus,* a threatened New Guinea endemic: notes on its biology and conservation. *Bird Conservation International* 8: 185–194.

Mack, A. L. and Wright, D. D. 2005. The Frugivore Community and the Fruiting Plant Flora in a New Guinea Rainforest: Identifying Keystone Frugivores. Pp. 184–203 in Dew, L. J. and Boubli, J. P. eds. *Tropical Fruits and Frugivores: The Search for Strong Interactors.* Springer, The Netherlands.

Mack, A. L., Widodo, W. and Boeadi 2000. Birds of the Wapoga area, Papua Province, Indonesia, Indonesia. In Mack, A. L. and Alonso, L. E., (eds.) *A biological assessment of the Wapoga River area of northwestern Papua Province, Indonesia*. RAP Bulletin of Biological Assessment 14. Conservation International, Washington, D. C.

Marchant, S. and P. J. Higgins (eds). 1990. *Handbook of Australian, New Zealand and Antarctic Birds. Volume One – Ratites to Ducks.* Oxford University Press, Melbourne, Victoria.

Martin, R. 2005. *Tree-kangaroos of Australia and New Guinea.* University of New South Wales Press, Kensington, New South Wales.

Maxwell, S., Burbidge, A. and Morris, K. 1996 Eds. T*he 1996 Action Plan for Australian Marsupials and Monotremes.* Wildlife Australia: Canberra.

Miao, S., Zou, C. B. and Breshears, D. B. 2009. Vegetation Responses to Extreme Hydrological Events: Sequence Matters. *The American Naturalist* 173: 113-118.

Miller, S.E., Cowie, R., Polhemus, D. A. and Eldredge, L. 1993. Biodiversity and conservation of the nonmarine invertebrate fauna of Papua New Guinea. Pp 227–325 in: Beehler, B. (ed) *Papua New Guinea conservation needs assessment,* Volume 2. USAID and Government of PNG, Washington and Boroko.

Morren, G. E. B., Jr. 1989. Mammals of the East Miyanmin area, Telefomin District, PNG, with notes on folk knowledge and taxonomy. *Science in New Guinea* 15: 119–135.

Müller, C. J. 2014a. A new species of *Mycalesis* Hübner, 1818 from the Sepik Basin, Papua New Guinea (Lepidoptera: Nymphalidae, Satyrinae). *Nachrichten des Entomologischen Vereins Apollo* 35: 209-213.

Müller, C. J. 2014b. Six new species of *Philiris* Rober, 1891 (Lepidoptera, Lycaenidae) from Papua New Guinea. *Zookeys*, 395, 33-55.

Müller, C. J. 2016. A new species of *Chaetocneme* Felder, 1860 from Papua New Guinea (Lepidoptera: Hesperiidae). *Tropical Lepidoptera Research* 26: 56-59.

Müller, C. J. and Tennent, W. J. 2016a. Two new species of *Candalides* Hübner, 1819 (Lepidoptera: Lycaenidae) from Papua New Guinea and Indonesia. *Tropical Lepidoptera Research* 26: 25-31

Müller, C. J. and Tennent, W. J. 2016b. A new species of *Altiapa* Parsons, 1986 from Papua New Guinea (Lepidoptera: Nymphalidae: Satyrinae) *Tropical Lepidoptera Research* 26: 19-24.

Murphy, S., Legge, S. and Heinsohn, R. 2003. The breeding biology of palm cockatoos (*Probosciger aterrimus*): a case of a slow life history. *Journal of Zoology* 261: 327–339.

Norris, D. H. 1990. Bryophytes in perennially moist forests of PNG: ecological orientation and prediction of disturbance effects. *Botanical Journal of the Linnaean Society* 104: 281–291.

Norris, D. H. and Koponen, T. 1985. Bryophytes from Frieda River, East and West Sepik Provinces, PNG. I. *Acta Botanici Fennici* 22: 367–396.

Norris, D. H., Reese, W. D. and Koponen, T. 1988. Bryophytes from Frieda River, East and West Sepik Provinces, Papua New Guinea III. *Syrrhopodon curticancellinatus*, specis nova (Caluymperaceae). *Annales Botanici Fennici* 25:149-151.

O'Brien, T. G., Kinnaird, M. F., Dierenfeld, E. S., Conklin-Brittain, N. L., Wrangham, R. W. and Silver, S. C. 1998. What's so special about figs? *Nature* 392: 668.

Oakwood, M. and Pritchard, D. 1999. Little evidence of toxoplasmosis in a declining species, the northern quoll, Dasyurus hallucatus. *Wildlife Research* 26: 329-333.

Oertli, B. 2008. The use of dragonflies in the assessment and monitoring of aquatic habitats. Pp 79-95 in Cordoba-Aguilar, A. (ed.) *Dragonflies and damselflies: Model organisms for ecological and evolutionary research.* Oxford University Press, Oxford.

Ogden, J., Wardle, G. M. and Ahmed, M. 1987. Population dynamics of the emergent conifer *Agathis australis* (D. Don) Lindl. (Kauri) in New Zealand II. Seedling population sizes and gap-phase regeneration. *New Zealand Journal of Botany* 25: 231- 242.

Oliver, P. Richards, S, Mumpuni M. and Rösler, H. 2016. The Knight and the King: Two New Species of Giant Bent-toed Gecko (*Cyrtodactylus*, Gekkonidae, Squamata) from northern New Guinea, with Comments on Endemism in the North Papuan Mountains. *ZooKeys* 562: 105-130. DOI: 10.3897/zookeys.562.6052

Ono, E., Umemura, M., Ishida, T. and Takenaka, C. 2015. Preliminary investigation of the formation age and chemical characterization of the tropical peat in the middle Sepik Plain, northern Papua New Guinea. *Geoscience Letters* 2: **DOI:** 10.1186/s40562-015-0021-4.

Opiang, M. D. 2009 Home ranges, movement, and den use in long-beaked echidnas, Zaglossus bartoni, from PNG. *Journal of Mammalogy* 90: 340-346.

Oppel, S. 2006. Comparison of two Odonata communities from a natural and a modified rainforest in Papua New Guinea. *International Journal of Odonatology* 9: 89-102.

Opperman, J. J., Luster, R. McKenney, B. A., Roberts, M. and Meadows, A. W. 2010. Ecologically Functional Floodplains: Connectivity, Flow Regime, and Scale. *Journal of the American Water Resources Association* 46: 211-226.

Orr, A., Kalkman, V. and Richards, S. J. 2012. A review of the New Guinean genus *Paramecocnemis*, Lieftinck (Odonata: Platycnemididae),with the description of three new species. *Australian Entomologist* 39: 161-177.

Oxley, D. J., Fenton, J. M. B. and Carmody, G. R. 1974. The effects of roads on populations of small mammals. *Journal of Applied Ecology* 11:51 – 59.

Page, S. E., Wüst, R. A. J., Weiss, D., Rieley, J. O., Shotyk, W. and Limin, S. H. 2004. A record of Late Pleistocene and Holocene carbon accumulation and climate change from an equatorial peat bog (Kalimantan, Indonesia): implications for past, present and future carbon dynamics. *Journal of Quaternary Science* 19: 625-635.

Paijmans, K. 1976. (ed.) *New Guinea Vegetation.* CSIRO, Canberra.

Paijmans, K. 1990. Wooded Swamps in New Guinea. Pp. 335 – 356 in Lugo, A., Brinson, M. and Brown, S. (eds.) *Ecosystems of the World 15: Forested Wetlands.* Elsevier: Amsterdam.

Palliser, T. 1989. Lowland birds of the Vanimo region, West Sepik Province. *Muruk* 4: 11–17.

Pannell, C. M. 1992. A Taxonomic Monograph of the Genus *Aglaia* Lour. (Meliaceae). *Kew Bulletin, Addit. Ser. XVI.* HMSO, London, England.

Pannell, C. M. 1998a. *Aglaia agglomerata.* The IUCN Red List of Threatened Species 1998: e.T34905A9895985. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T34905A9895985.en. Downloaded on 26 March 2016.

Pannell, C. M. 1998b. *Aglaia rimosa.* The IUCN Red List of Threatened Species 1998: e.T34917A9897290. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T34917A9897290.en. Downloaded on 26 March 2016.

Pannell, C. M. 1998c. *Aglaia subcuprea.* The IUCN Red List of Threatened Species 1998: e.T34922A9897812. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T34922A9897812.en. Downloaded on 26 March 2016.

Pannell, C. M. 1998d. *Aglaia euryanthera.* The IUCN Red List of Threatened Species 1998: e.T36631A10009150. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T36631A10009150.en. Downloaded on 26 March 2016.

Parris, K. M. and Schneider, A. 2008. Impacts of traffic noise and traffic volume on birds of roadside habitats. *Ecology and Society* 14: 29.

Parsons, M. J. 1998. *The butterflies of PNG: Their systematics and biology*. Academic Press, London.

Pearson, D. L. 1975. Survey of the birds of a lowland forest plot in the East Sepik District, PNG. *Emu* 75: 175–177.

Piipo, S. 1986. Bryophytes from Frieda River, East and West Sepik Provinces, PNG. II. *Annales Botanici Fennici* 23: 1–10.

Piipo. S. 1998. Bryophytes from Frieda River, east and West Sepik Provinces, Papua New Guinea IV. *Chiloscyphus koponenii sp. nov.* (Geocalycaceae) *Annales Botanici Fennici* 35:55-57.

Powell, J. M. 1976. Ethnobotany. Pages 106–183 in Paijmans, K. ed. *Papua New Guinea Vegetation.* CSIRO and Australian National University Press, Canberra.

Pratt, T. K. 2000. Evidence for a previously unrecognized species of owlet-nightjar. *The Auk* 117: 1–11.

Pratt, T. K. and Beehler, B. M. 2015. Birds of New Guinea. 2nd edition. Princeton, Princeton University Press, N. J.

Preston, F. W. 1962. The Canonical Distribution of Commonness and Rarity: Part I. *Ecology* 43: 185–215.

Raymond,J. T., Tell L., Bush, M., Nichols, D. K., Schulman, F. Y. and Montali R. J. 2000. Subcutaneous atypical mycobacteriosis in captive Tiger Quolls *Dasyurus maculatus*. *Veterinary Patholology* 37: 137–142

Richards G. and Hall. L. 2000. Flying Foxes. UNSW Press, Sydney.

Richards, G. 1990. The Spectacled flying-fox, *Pteropus conspicillatus*, (Chiroptera: Pteropodidae) in North Queensland. 1. Roost sites and distribution patterns. *Australian Mammalogy* 13: 17-24.

Robbins, R. G., Haantjens, H. A., Mabbutt, J. a., Short, K., Reiner, E. Saunders, J. C. and Pullen, R. 1976. *Lands of the Ramu–Madang Area, Papua New Guinea.* Land Research Series No. 37. CSIRO.

Rodrigues, L., Ramos Pereira, M., Rainho, A. and Palmeirim, J. 2010. Behavioural determinants of gene flow in the bat Miniopterus schreibersii. *Behavioral Ecology and Sociobiology* 64: 835-843.

Rogers, H. 2005. *Fire and dieback in Papua New Guinea's forests: Brief review for the* PNG *Gas Project EIA.* Report to ENESAR Consultants Pty. Ltd.

Rumbucher, K., 1973. Eine neue Unterart von *Schoenbergia goliath* sowie zwei markante Individualformen in der Gattung *Ornithoptera* (Lep., Papilionidae)., *Entomologische Zeitschrift, Frankfurt am Main* 83: 1-10.

Saunders, J. C. 1993a. *Forest Resources of Papua New Guinea.* Colour maps (4) at 1: 1,000,000 scale. PNGRIS Publication 2. CSIRO and AIDAB, Canberra.

Saunders, J. C. 1993b. *Forest Resources of Papua New Guinea. Explanatory Notes to Map.* PNGRIS Publication 2. CSIRO and AIDAB, Canberra.

Scheffer, M., Carpenter, S. R., Foley, J., Folke, C. and Walker, B. 2001. Catastrophic shifts in ecosystems. *Nature* 413: 591–596.

Shanahan, M., So, S., Compton, S. G. and Corlett, R. 2001. Fig-eating by vertebrate frugivores: A global review. *Biological Reviews* 76: 529–572.

Shearman, P. L. and Bryan, J. 2011. A Bioregional analysis of the distribution of rainforest cover, deforestation and degradation in Papua New Guinea. *Austral Ecology* 36: 9–24.

Shearman, P. L., Bryan J. E., Ash, J., Hunnam P., Mackey B. and Lokes, B. 2008. *The State of the Forests of Papua New Guinea. Mapping the extent and condition of forest cover and measuring the drivers of forest change in the period 1972–2002.* University of Papua New Guinea.

Shearman, P. L., Ash, J., Mackey, B., Bryan, J. E. and Lokes, B. 2009. Forest conversion and degradation in Papua New Guinea 1972–2002. *Biotropica* 41: 379–390.

Shearman, P. L., Bryan J. E., Ash, J., Mackey B. and Lokes, B. 2010. Deforestation and degradation in Papua New Guinea: a response to Filer and colleagues, 2009. *Annals of Forest Science* 67: 300-304.

Slabbekoorn, H. and Ripmeester, E. A. 2008. Birdsong and anthropogenic noise: implications and applications for conservation. *Molecular Ecology* 17: 72–83.

Sparling, D. W., Linder, G., Bishop, C. A. and Krest, S. K. 2010. *Ecotoxicology of Amphibians and Reptiles* (second edition). CRC Press, Boca Raton.

Stresemann, E. 1923. Dr. Bürger's ornithologische ausbeute im stromgebiet des Sepik. Ein beitrag zur kenntnis der vogelwelt Neuguineas. *Archiv Für Naturgeschicthe* 89A (7): 1–96.

Stringer M. 1977. The middle Sepik – a birder's paradise. *New Guinea Bird Society Newsletter* 129: 11–13.

Struebig, M. J., Kingston, T. and Zubaid, A. 2008. Conservation value of forest fragments to palaeotropical bats*.* *Biological Conservation* 141: 2112–2126.

Swihart, R. K. and Slade, N. 1984. Road crossing in *Sigmodon hispidus* and *Microtus ochrogaster. Journal of Mammalogy* 65: 357 – 360.

Symes, C. T., Hughes, J. C., Mack, A. L. and Marsden, S. J. 2006. Geophagy in birds of Crater Mountain Wildlife Management Area, PNG. *Journal of Zoology* 268: 87–96.

Takeuchi, W. 2005a. *Compilation of herbarium and literature records for IUCN-listed plants, with recommendations for delisting and additions to the IUCN database.* Report prepared for Conservation International, Washington, DC. Unpublished.

Takeuchi, W. 2005b. *Botanical results from a floristic survey of montane environments within the PNG Gas Project concession.* Report to ENESAR Consulting Pty. Ltd. Annex 1 to Appendix 1 Terrestrial biodiversity analysis of the upstream project area. In: Coffey Natural Systems. 2009. PNG LNG Project Environmental Impact Statement. January 2009. Report prepared by Coffey Natural Systems Pty. Ltd for ExxonMobil, Brisbane, Queensland.

Takeuchi, W. 2008. *Flora of the upstream portion of the PNG LNG Project, Southern highlands and Western Provinces, PNG.* Report to ENESAR Consulting Pty. Ltd. Annex 1 to Appendix 1 Terrestrial biodiversity analysis of the upstream project area. In: Coffey Natural Systems. 2009. PNG LNG Project Environmental Impact Statement. January 2009. Report prepared by Coffey Natural Systems Pty. Ltd for ExxonMobil, Brisbane, Queensland.

Takeuchi, W. 2012. Modern sequels to the Kaiserin-Augusta-Fluss itinerary of Carl Ledermann: floristic discoveries from the upper Sepik of Papua New Guinea. *Phytotaxa* 60: 17–31.

Takeuchi, W. 2013. Floristic records from the upper Sepik of Papua New Guinea: *Aristolochia chrismülleriana* sp. nov. (Aristolochiaceae), *Monanthocitrus paludosa* (Rutaceae), and *Secamone timorensis* (Apocynaceae). *Phytotaxa* 114: 51–57.

Takeuchi, W. 2014a. Notes on *Phyllanthera* (Apocynaceae) from the upper Sepik of Papua New Guinea: *P. lancifolia* and *P. piforsteriana* sp. nov. *Phytotaxa* 163: 173–179.

Takeuchi, W. 2014b. A distinctive addition to the tree flora of Papua New Guinea: Helicia woxvoldiana sp. nov. (Proteaceae), a large-flowered myrmecophyte from the upper Sepik. *Phytotaxa* 172: 94–100.

Tallowin, O., Allison, A., Algar, A. C., Kraus, F. and Meiri, S. 2017. Papua New Guinea terrestrial-vertebrate richness: elevation matters most for all except reptiles. *Journal of Biogeography* 2017: 1–11. doi:10.1111/jbi.12949

Tan, B. C., Piipo, S. and Norris. D. H. 2007. *Bryophytes of PNG: their diversity, ecology, and conservation*. Ppp 269–302 in: Marshall, A. J. and Beehler, B. M. (eds.) The Ecology of Papua. The Ecology of Indonesia Series, Vol. 6. Periplus Editions (HK) Ltd, Hong Kong.

Taylor, B. D. and Goldingay. R. L. 2003. Cutting the carnage: wildlife use of road culverts in northeast New South Wales. *Ecology and Society* 30: 529–537.

Taylor, B. D. and Goldingay. R. L. 2009. Can road-crossing structures improve population viability of an urban gliding mammal? Ecology and Society 14(2): 13. [online] URL: http://www.ecologyandsociety.org/vol14/iss2/art13/

Taylor, B., Goldingay. R. and Ball, T. 2011. Wooden poles can provide habitat connectivity for a gliding mammal. *Australian Mammalogy* 33: 36-43

Theischinger, G. and Richards, S. J. 2012a. *Gynacantha heros* spec. nov., a large crepuscular species from Papua New Guinea (Anisoptera: Aeshnidae). *Odonatologica* 41: 355-359.

Theischinger, G. and Richards, S. J. 2012b. *Akrothemis*, A new libellulid genus from Papua New Guinea (Anisoptera: Libellulidae). *Odonatologica* 41: 337-345.

Theischinger, G. and Richards, S. J. 2013a. Three new species of *Teinobasis* Kirby from Papua New Guinea (Zygoptera: Coenagrionidae). *Odonatologica* 42: 359-366

Theischinger, G. and Richards, S. J. 2013b. *Hylaeargia simplex* spec. nov., a third species of *Hylaeargia* Lieftinck, from New Guinea (Zygoptera: Platycnemididae). *Odonatologica* 42: 157-161.

Theischinger, G. and Richards, S. J. 2013c. *Palaeosynthemis elegans* spec. nov., a new dragonfly from Papua New Guinea (Anisoptera: Synthemistidae). Odonatologica 42: 63-66.

Theischinger, G. and Richards, S. J. 2014. *Drepanosticta elaphos* sp. nov. and *Drepanosticta pterophora* sp. nov. from Papua New Guinea (Odonata: Platystictidae. *Odonatologica* 43: 91-103.

Tjaturadi, B., Richards, S. and Krey, K. 2007. Exotic herpetofauna: a new threat to New Guinea's biodiversity? Pp. 1365–1368 in Marshall, A. J. and Beehler, B. M. (eds.) *The ecology of Papua (Part Two).* Periplus Editions, Hong Kong.

Tockner, K. and Stanford, J. A. 2002. Riverine flood plains: present state and future trends. *Environmental Conservation* 29: 308–330.

Tockner, K., Pusch, M., Borchardt, D. and Lorang, M. S. 2010. Multiple stressors in coupled river–floodplain ecosystems. *Freshwater Biology 55* (Suppl. 1): 135–151.

Tokeshi, M. 1990. Niche apportionment or random assortment: species abundance patterns revisited. *Journal of Animal Ecology* 59: 1129–1146

Ultsch, G. R., Bradford, D. F. and Freda, J. 1999. Physiology: Coping with the environment. Pp 189-214 in McDiarmid, R. and Altig, R. (eds) *Tadpoles: The biology of anuran larvae.* University of Chicago Press, Chicago.

Van Riper, C., S. G. van Riper, M. L. Goff, and Laird, M. 1986. The epizootiology and ecological significance of malaria on the birds of Hawaii. *Ecological Monographs* 56: 327-344.

Verdcourt, B. 1979. *A Manual of New Guinea Legumes. Botany Bulletin* 11. Office of Forests, Division of Botany. Kristen Press, Madang.

Waruruai, J., Sipana,B., Koch,M., Barrows, L. R., Matainaho, T. K. and Raia, P. P. 2011. An ethnobotanical survey of medicinal plants used in the Siwai and Buin districts of the Autonomous Region of Bougainville. *Journal of Ethnopharmacology* 138: 564–577.

Watson, M. and Asoyama, S. 2001. Dispersion, habitat use, hunting behaviour, vocalizations, and conservation status of the New Guinea Harpy Eagle *Harpyopsis novaeguineae. Journal of Raptor Research* 35: 235–239.

Welsh, H. H. and Ollivier, L. M. 1998. Stream amphibians as indicators of ecosystem stress: a case study from California's redwoods. *Ecological Applications* 8: 1118-1132.

Westcott, D. A., Setter, M., Bradford, M. G., McKeown, A. and Setter, S. 2008. Cassowary dispersal of the invasive pond apple in a tropical rainforest: the contribution of subordinate dispersal modes in invasion. *Diversity and Dispersal* 14: 432–439.

Weston, N., Goosem, M., Marsh, H., Cohen, M. and Wilson, R. 2011. Using canopy bridges to link habitat for arboreal mammals: successful trials in the Wet Tropics of Queensland. *Australian Mammalogy* 33: 93-105

Whitmore, T. C. 1977. A first look at *Agathis*. *Tropical Forestry Papers* No. 11.

Whitney B. M. 1987. The Pale-billed Sicklebill *Epimachus bruijnii* in Papua New Guinea. Emu 87: 244–246.

Wikelski, M., J. Foufopoulos, H. Vargas, and Snell, H. 2004. Galápagos Birds and Diseases: Invasive Pathogens as Threats for Island Species. *Ecology and Society* 9: 5. [online] URL: http://www.ecologyandsociety.org/vol9/iss1/art5/

Wilson, D. E. and Mittermeier, R. A. (eds). 2015. *Handbook of the Mammals of the World*. Vol. 5. Monotremes and Marsupials. Lynx Ediciones. Barcelona.

Wilson, D. E., Lacher, T. E. and Mittermeier, R. A. (eds). 2017. *Handbook of the Mammals of the World.* Vol. 7. Rodents II. Barcelona. Lynx Ediciones. Barcelona.

Woinarski, J. C. Z., Oakwood, M., Winter, J., Burnett, S., Milne, D., Foster, P., Myles H. and Holmes, B. 2008. *Surviving the toads: patterns of persistence of the northern quoll Dasyurus hallucatus in Queensland.* Report submitted to the Natural Heritage Trust Strategic Reserve Program, as a component of project 2005/162: Monitoring and Management of Cane Toad Impact in the Northern Territory.

Woolley, P., Leary, T., Seri, L., Flannery, T., Wright, D., Hamilton, S., Helgen, K., Singadan, R., Menzies, J., Allison, A. & James, R. 2016. *Dasyurus albopunctatus*. The IUCN Red List of Threatened Species 2016: e.T6299A21946965. http://dx.doi.org/10.2305/IUCN.UK.2016-2.RLTS.T6299A21946965.en. Downloaded on 25 March 2018.

World Conservation Monitoring Centre 1998a. *Intsia bijuga.* The IUCN Red List of Threatened Species 1998: e.T32310A9694485. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T32310A9694485.en. Downloaded on 26 March 2018.

World Conservation Monitoring Centre 1998b. *Pterocarpus indicus.* The IUCN Red List of Threatened Species 1998: e.T33241A9770599. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T33241A9770599.en Downloaded on 26 March 2018.

World Conservation Monitoring Centre 1998c. *Myristica buchneriana*. The IUCN Red List of Threatened Species 1998: e.T37857A10082239. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T37857A10082239.en Downloaded on 26 March 2018.

World Conservation Monitoring Centre 1998d. *Myristica globosa.* The IUCN Red List of Threatened Species 1998: e.T37876A10077890. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T37876A10077890.en. Downloaded on 26 March 2018.

World Conservation Monitoring Centre 1998e. *Horsfieldia sepikensis.* he IUCN Red List of Threatened Species 1998: e.T37170A10037546. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T37170A10037546.en. Downloaded on 26 March 201826 March 2018.

World Conservation Monitoring Centre. 1998f. Horsfieldia ampliformis. The IUCN Red List of Threatened Species 1998: e.T37175A10037738. http://dx.doi.org/10.2305/IUCN.UK.1998.RLTS.T37175A10037738.en. Downloaded on 26 March 2018.

Wösten, J. H. M., Berg, J. Van Den, Van Eijk, P., Geversd, G. J. M., Giesene, W. B. J. T., Hooijer, A., Idris, Aswandi, Leenman, P. H., Rais, Dipa Satriadi, Siderius, C., Silviush, M. J., Suryadiputra, N. and Wibisono, Iwan Tricahyo. 2006. Interrelationships between Hydrology and Ecology in Fire Degraded Tropical Peat Swamp Forests. *International Journal of Water Resources Development* 22: 157-174.

Woxvold, I. A. 2008. *Avifauna of the Upstream Portion of the PNG LNG Project, Southern Highlands and Western Provinces,* PNG. Unpublished report to Coffey Natural Systems.

Wyatt, K. B., Campos, P. F., Gilbert, M. T. P., Kolokotronis, S-O., Hynes, W. H., DeSalle, R., Daszak, P., MacPhee, R. D. E. and Greenwood, A. D. 2008. Historical mammal extinction of Christmas Island (Indian Ocean) correlates with introduced infectious disease. *PLOS One* 3 (11): e3602.

Zweifel, R. G. 1958. Results of the Archbold Expeditions. No. 78. Frogs of the Papuan hylid genus *Nyctimystes*. *American Museum Novitates 1896:* 1-51.

PART 5 ANNEXES

18. Annex 1 Individual species discussions

The basic biological and ecological data in the following species accounts are from original accounts written by the authors of EIS Appendix 8A. The impact analyses themselves are the responsibility of the present author.

In the following it is assumed that there is no catastrophic failure of the ISF and the sub-plans to EMMPs are effective. Sub-plans will include:

- Project In-Migration Management Strategy
- Weed, Pest and Quarantine Management Sub-plans
- Emergency Response and Fire Management Sub-plan
- Acid and Metalliferous Drainage, Waste Rock and Tailings Management Sub-plan
- Erosion and Sediment Control Sub-plan
- Hazardous Materials, Fuel Handling and Spill Response Management Sub-plan
- Rehabilitation Management Sub-plan
- Waste Management Sub-plant
- Water Management Sub-plan
- Traffic and Transport Sub-plan

Measures relating to socio-economic aspects including in-migration are contained within the Social Impact Assessment (Appendix 12 of the EIS) for the Project.

The impact analyses assess first the residual direct impact, then how that would be changed by adding indirect residual impacts, including in-migration impacts, then how that would be altered again, if at all, by resettlement if that occurs in the higher more sensitive areas of the GFA.

18.1 Critically Endangered Species

All IUCN Critically Endangered species are of High sensitivity.

18.1.1 Tenkile or Fiwo *Dendrolagus scottae*

Tenkile is a black tree kangaroo weighing up to 11.5 kg restricted to the Torricelli and eastern Bewani Mountains. It is a flagship species for conservation in PNG and the Tenkile Conservation Alliance (TCA) has been working with villages in the Torricelli Mountains since 2001 to help protect it, the Weimang and other biodiversity in the Torricelli Mountains. There are two, apparently isolated, populations which may be two distinct subspecies - Tenkile, restricted to the Torricelli Mountains, and Fiwo in the eastern Bewani Mountains.

Like all tree kangaroos these are arboreal animals that frequently come to the ground. They feed on leaves and fruits in the canopy.

Tenkile were thought to number less than 100 individuals but thanks to the efforts of TCA the population may now be 200 or so. The population occupies less than 200 km^2 in the heavily populated central and eastern parts of the Torricelli Mountains.

Fiwo are at present thought to be restricted to the eastern Bewani Mountains above 1500 m asl on Mt Menawa, 30-40 km east of the Vanimo to Green River road. Fiwo is thought to occupy a larger range in an area where there is much less settlement, so the Fiwo population may be more secure than the Tenkile. TCA aims to conduct surveys for Fiwo to confirm this or otherwise (Flannery *et al.* 1996, Leary *et al.* 2008a, http://www.tenkile.com).

Despite its known distribution being to the east of the infrastructure corridor there is a possibility that some Fiwo may occur closer to the infrastructure corridor possibly even within the upper elevations of the Bewani Mountains section where there are still areas of intact forest that have not been logged, although hunting will have extirpated any tree kangaroos in the vicinity of the Vanimo to Green River road. Such a discovery would be a significant extension of range. There are likely to be negligible residual direct impacts because:

- The infrastructure corridor is distant from its known range.
- The export pipeline itself is alongside the Vanimo to Green River road in degraded roadside vegetation and well below the species' known lower elevation limits.
- Construction of pads for the transmission line pylons on higher hills along the route may impact some potential habitat but the pads are unlikely to be built above 700 m asl thus well below the known lower elevation limit.
- Vegetation losses to fly roads used for transmission line construction and maintenance of clearings under transmission lines during operations will all be in the lower elevation areas not favoured by these species.
- The Project is unlikely to increase any putative barrier effects provided by the existing Vanimo to Green River road.

The biggest threat to this species has been hunting and control of the work force is the major mitigation. However, hunting by in-migrants is less easily controlled and cannot be controlled at all off the Project's leases and roads. The infrastructure corridor through the Bewani Mountains is unlikely to bring more settlers or in-migrants to the Bewani Mountains themselves as the road has existed for some time and logging in this section of the infrastructure corridor is intense. In-migrants will be attracted to the mine area and it is not envisioned that the Bewani Mountains will be a settlement target for them.

Fly-roads for transmission line construction could extend potential hunting access to areas further east from the road but the longest fly road is likely to be less than a kilometre long and fly-roads are unlikely to add to the access already provided by the numerous logging tracks in the Bewani Mountains. Logging roads extending off the main road already exist along much of the corridor but none of them facilitate penetration of hunters towards the known population of this species further east. No resettlement is planned to occur in the Bewani Mountains. It could be suggested that travellers could stop and opportunistically hunt this species, but it is unlikely as the species is sparse, and would require a dedicated hunting trip distant from the road.

Indirect effects are not predicted to increase residual impacts beyond negligible.

18.1.2 Weimang *Dendrolagus pulcherrimus*

The Weimang, formerly a subspecies of Goodfellow's Tree Kangaroo, is one of the most beautiful of the tree kangaroos – its English name being Golden-mantled Tree Kangaroo. Fossil evidence and local information indicates this species was once widespread but has been exterminated from most of its original range. It is now definitely known only from mid-montane forests between the villages of Weight and Kuliek in the Torricelli Mountains and also in the Foja Mountains at elevations between 680 and 1,700 m asl. There is an unconfirmed record from the Prince Alexander Mountains (Flannery *et al.* 1996, Leary *et al.* 2016a). Tenkile (http://www.tenkile.com) do not record that Weimang occurs in the Bewani Mountains and its known distribution in the eastern Torricelli Mountains is distant from the infrastructure corridor.

Despite its known distribution being to the east of the infrastructure corridor the species' former wider range makes it possible that some Weimang may occur closer to the infrastructure corridor possibly even within the upper elevations of the Bewani Mountains section where there are still areas of intact forest at higher elevations that have not been logged, although hunting will have extirpated any tree kangaroos in the vicinity of the Vanimo to Green River road.

There are likely to be negligible residual direct impacts because:

- The infrastructure corridor is distant from its known range.
- The export pipeline itself is alongside the Vanimo to Green River road in degraded roadside vegetation and well below its known lower elevation limits.
- Construction of pads for the transmission line pylons on higher hills along the route may impact some potential habitat but the pads are unlikely to be built above 700 m asl thus well below the

known lower elevation limit.

- Vegetation losses to fly roads used for transmission line construction and maintenance of clearings under transmission lines during operations will all be in the lower elevation areas not favoured by these species.
- The Project is unlikely to increase any putative barrier effects provided by the existing Vanimo to Green River road.

The biggest threat has been hunting and control of the work force is the mitigation for all species. However, hunting by in-migrants is less easily controlled and cannot be controlled at all off the Project's leases and roads. The infrastructure corridor through the Bewani Mountains is unlikely to bring more settlers or in-migrants to the Bewani Mountains themselves as the road has existed for some time and logging in this section of the infrastructure corridor is intense. In-migrants will be attracted to the mine area and it is not envisioned that the Bewani Mountains will be a settlement target for in-migrants.

Fly-roads for transmission line construction could extend potential hunting access to areas further east from the road but the longest fly road is likely to be less than a kilometre long and fly-roads are unlikely to add to the access already provided by the numerous logging tracks in the Bewani Mountains. Logging roads extending off the main road already exist along much of the corridor but none of them facilitate penetration of hunters towards the known population of this species further east. No resettlement is planned to occur in the Bewani Mountains. It could be suggested that travellers could stop and opportunistically hunt this species, but it is unlikely as the species is sparse, and would require a dedicated hunting trip distant from the road.

Indirect effects are not predicted to increase residual impacts beyond negligible.

18.1.3 Northern Glider *Petaurus abidi*

The Northern Glider is an arboreal species similar in appearance to the widespread Sugar Glider (*Petaurus breviceps*) but twice the size. It is known only from seven specimens from a small area centred on Mt Somoro. It occurs mostly above 800 m asl but is known to range down to 300 m asl and has been recorded from gardens (Flannery 1995) so is not restricted to primary forest. Leary *et al.* (2016b) say that fossil records indicate that the species never occurred in the Bewani Mountains but provide no reference. Wilson *et al.* (2015) suggest it could occur in the "poorly surveyed North Coastal Ranges" between Mt Menawa and Mt Sapua, 37 and 125 km respectively east of the Vanimo to Green River road. It is threatened by heavy deforestation due to human encroachment (i.e., conversion to gardens), and by hunting (Leary et al. 2016b).

Despite its known distributions being to the east of the infrastructure corridor there is a low probability that some individuals may occur closer to the infrastructure corridor possibly even within the upper elevations of the Bewani Mountains section where there are still areas of intact forest that have not been logged. There are likely to be negligible residual direct impacts should this species occur because:

- The infrastructure corridor is distant from its known range.
- The export pipeline itself is alongside the Vanimo to Green River road in degraded roadside vegetation and well below its known lower elevation limits.
- Construction of pads for the transmission line pylons on higher hills along the route may impact some potential habitat but the pads are unlikely to be built above 700 m asl thus below the favoured elevational range for this species, but above its lower limit.
- Vegetation losses to fly roads used for transmission line construction and maintenance of clearings under transmission lines during operations will all be in the lower elevation areas not favoured by these species.
- The Project is unlikely to increase any putative barrier effects provided by the existing Vanimo to Green River road.

The Northern Glider is hunted but being smaller it is less attractive prey compared to tree kangaroos. Hunting is none the less a concern and control of the work force is the major mitigation for all species. However, hunting by in-migrants is less easily controlled and cannot be controlled at all off the Project's leases and roads. The infrastructure corridor through the Bewani Mountains is unlikely to bring more settlers or in-migrants to the Bewani Mountains themselves as the road has existed for some time and logging in this section of the infrastructure corridor is intense. In-migrants will be attracted to the mine area and it is not envisioned that the Bewani Mountains will be a settlement targets for in-migrants.

Fly-roads for transmission line construction could extend potential hunting access to areas further east from the road but the longest fly road is likely to be less than a kilometre long and fly-roads are unlikely to add to the access already provided by the numerous logging tracks in the Bewani Mountains. Logging roads extending off the main road already exist along much of the corridor but none of them facilitate penetration of hunters towards the known populations of these species further east. No resettlement is planned to occur in the Bewani Mountains. It could be suggested that travellers could stop and opportunistically hunt this species, but it is unlikely as the species is sparse, and would require a dedicated hunting trip distant from the road.

Indirect effects are not predicted to increase residual impacts beyond negligible.

18.1.4 The Echidnas *Zaglossus* spp.

Both the Eastern Long-beaked Echidna *Z. bartoni* and Sir David's Long-beaked Echidna *Z. attenboroughi* are considered together, even though one is IUCN Vulnerable, because of uncertainty about echidna identity in all parts of the Study Area.

There are three species of long-beaked echidnas *Zaglossus* spp. (Flannery and Groves 1998) all of which are protected under the PNG Fauna (Protection and Control) Act 1966. The Eastern Long-beaked Echidna *Z. bartoni* (IUCN Vulnerable) is the species most likely present in the Study Area with the nearest confirmed records from the vicinity of Telefomin and Tifalmin (Flannery and Seri 1990). Flannery and Seri (1990) and Flannery (1995) considered long-beaked echidnas to only occur above 1,200 m asl and interviews with hunters at Wameimin 1 and 2 indicated that echidnas occur on the higher peaks and ridges of the GFA. However, the Eastern Long-beaked Echidna occurs from 600 m asl on the southern side of the Central Cordillera (Aplin, pers. ob. 1984, reported in Flannery 1995) and the Western Long-beaked Echidna *Z. bruijn*i has been recorded near sea level (Aplin 1998) so they could range down to the lower hill areas in the GFA and, less likely, along the infrastructure corridor.

The Critically Endangered Sir David's Long-beaked Echidna *Z. attenboroughi* cannot be ruled out of occurring in the Study Area. At present it is known only from the Cyclops Mountains, where it ranges down to 166 m asl (Baillie *et al.* 2010) but recent fossil finds (Aplin pers. obs.) indicate that it once ranged into northwest PNG. Moreover, the Baiyer River Sanctuary donated a modern skeleton of the species labelled 'Sepik foothills' to the Australian Museum in the 1960s (Helgen *in prep*.). It could occur in the Study Area, particularly the Bewani Mountains. Any undiscovered population of Sir David's Long-beaked Echidna would be of high conservation value.

Echidnas are mostly nocturnal animals weighing up to 10 kg, with spines hidden to varying degrees by dark hair. The long snout is used to probe the forest floor for earthworms and grubs. They shelter in burrows or below rocks during the day and juveniles may den in thick vegetation or hollow logs. The home range of Eastern Long-beaked Echidna is 10 to 200 ha (Opiang 2009). They occur in a range of habitats from forest to grasslands and scrub and can be moderately abundant in montane habitats e. g. in the Foya Mountains (K. Helgen, *pers. comm.* to K. Aplin 2011) and the Muller Range (Aplin and Kale 2011). Helgen *et al.* (2012) shows Western Long-beaked Echidna *Z. bruijni* occurred historically in northwestern Australia and may still do. He provides insights into habitat selection stressing the use of rocky ground. In referring to its habitat in New Guinea he states, "inaccessible and sparsely inhabited rocky areas provide some of the most important remaining areas … for *Zaglossus* in New Guinea".

Long-beaked echidnas are culturally significant being favoured prey, frequently fed to older people, and believed in some parts of PNG to be the senescent forms of other animals such as tree kangaroos, cuscus and bandicoots.

Echidnas are obviously impacted generally by habitat loss but can survive in disturbed habitats. They are unlikely to be impacted by barrier effects. No infrastructure is planned for the higher elevations of the

Study Area, so they will suffer only a tiny amount of habitat loss from the upper edges of the pit and possibly a communications tower in the GFA. In the infrastructure corridor between the process plant and Idam 1 village there is a strong to moderate likelihood of their occurrence and some habitat loss is expected. They only have a low probability of occurring in the generally low elevation route the infrastructure corridor will take elsewhere and are most likely extirpated alongside the Vanimo to Green River road. However, further habitat loss could be expected where the transmission line deviates from the road to take advantage of locating towers on high ground, particularly in the Bewani Mountains. The residual direct impact is predicted to be minor and moderate for the Eastern and Sir David's Long-beaked Echidna respectively.

While the activities of the workforce can be controlled, increased hunting by potential in-migrants is less easily controlled. FRL is unlikely to be able to significantly reduce the potential for in-migrants to hunt outside the Mining Leases. Because of the uncertainties associated with in-migration, Indirect effects are predicted to increase residual impacts to moderate and major for the Eastern and Sir David's Long-beaked Echidna respectively.

Resettlement could exacerbate these impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further. The residual impacts could be major for the Eastern Long-beaked Echidna but extreme for Sir David's Long-beaked Echidna should it occur.

18.1.5 Telefomin Cuscus *Phalanger matanim*

The small (1 to 2 kg) Telefomin Cuscus is known only from Telefomin and Urapmin, about 20 km south southwest of the GFA (Flannery 1995, Leary *et al.* 2016c). It occurs in Montane Forest between 1,400 and 2,600 m asl, sympatrically with other species of cuscuses but little is known about its ecology. It was not recorded during the Project surveys but Leary *et al.* (2016c) suggested that it might occur north of the known collection localities and interviews at the survey villages suggested it can be caught within 10 km of the GFA (EIS Appendix 8A Chapter 3). If it occurs, it would be in the highest parts of the GFA and likely nowhere along the infrastructure corridor.

The tiny known range of the Telefomin Cuscus is entirely within the heavily populated highland agricultural zone and "the only place where it is known with certainty was largely destroyed by fire in 1998" (Leary *et al.* 2016c). Suitable habitat occurs within the highest parts of the GFA but no infrastructure is planned for the higher elevation parts of the GFA and no habitat will be lost with the possible exception of the upper edges of the pit and possibly a communications tower.

Telefomin Cuscus appear to be more-or-less completely arboreal so would be susceptible to barrier effects from linear infrastructure but there is no linear infrastructure planned at these elevations.

Hunting is probably still a threat to this species (Flannery 1994, 1995, Leary *et al.* 2016c). Banning hunting by the work force is the major mitigation, however, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced, especially if the human population around Telefomin, where the Telefomin Cuscus is centred, increases greatly.

Residual direct impacts are predicted to be negligible but indirect effects are predicted to increase residual impacts to major because of the uncertainties surrounding in-migration, particularly its effects around Telefomin.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be extreme.

18.1.6 Black-spotted Cuscus *Spilocuscus rufoniger*

The very rare Black-spotted Cuscus *Spilocuscus rufoniger* is the largest of the cuscuses weighing up to 6. 5 kg. It is known from scattered localities within the Mamberamo, Sepik and Ramu drainages from sea level to at least 1,200 m asl (Flannery 1995) but there are few recent records[20]. Villagers at Nekei, Paru and Kubkain villages (EIS Appendix 8A Chapter 3) confirmed it occurs in the Study Area, and hunters interviewed in the 2017 survey also reported the presence of the species possibly more in the Hill Zone than the often-inundated areas of the Lowland Zone. According to Paru villagers it is less abundant or less readily captured than the Common Spotted Cuscus *S. maculatus*. Nothing is known of its ecology or behaviour, but it is a folivore and supposedly restricted to primary closed forest and, although forest cover is largely intact across most of its range and despite low human populations, the species is nowhere abundant.

Habitat for this species will be lost but suitable habitat for it is abundant and widespread in the Study Area. This cuscus is arboreal so would be susceptible to barrier effects from linear infrastructure. Considerable work has been undertaken in Australia (e. g. Goosem 2001, 2004) to overcome these effects and reduce mortality caused by traffic and two methods that have proven effective in rainforest are the installation of 'underpasses' and 'bridges' (e. g. Goosem et al. 2006, Taylor and Goldingay 2003, 2009). The former could be particularly useful for the Black-spotted Cuscus.

Hunting is probably the primary threat (Flannery 1994, 1995, Leary *et al.* 2016d). The Black-spotted Cuscus has been exterminated from the eastern parts of its range (Flannery 1994) and is losing much habitat in Indonesian Papua (Leary *et al.* 2016d). Both this and the Common Spotted Cuscus are hunted in the Study Area; the 2011 surveys indicated that as many as 100, mostly Common Spotted Cuscus, were being taken yearly by all villages combined in the GFA. Hunting is thus the major concern and control of the work force is the major mitigation. However, hunting by in-migrants is less easily controlled.

Residual direct impacts are predicted to be moderate for Black-spotted Cuscus, but Indirect effects are predicted to increase residual impacts to major on the basis that It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced.

Resettlement into areas where the resettled people have not had access to for hunting in the past could exacerbate the potential impacts further and the residual impacts could be extreme.

18.1.7 Bulmer's Fruit Bat *Aproteles bulmerae*

Bulmer's Fruit Bat is one of the rarest and most endangered mammals on earth. There are few specimens of this large, bare backed bat in museums and it was originally thought to occur in only one cave (Luplupwintem cave at 2,400 m asl near Tabubil, Western Province) but Aplin *et al.* (2016) present evidence of a wider distribution which is still being painstakingly elucidated. The species is known only from PNG and appears to be restricted to roosting in deep sinkholes in montane and hill karst. It is definitely known from only two caves, is extremely rare and virtually nothing is known of its ecology. Generally, large fruit bats move around in big foraging ranges, daily movements of several tens of kilometres are recorded for some species, and many are known to use multiple roosting sites (Richards and Hall 2000). Hunting and disturbance of cave roosts appears to be the primary threat to this species as evidenced by the history of Luplupwuntim cave. It is not known whether any diseases or exotic species are a threat to it. The conservation and management of all these species is not only dependent upon forest conservation but specifically on cave protection, particularly for Bulmer's Fruit Bat and bent wing bats (e. g. Rodrigues *et al.* 2010; DSEWPC 2011).

Bulmer's Fruit Bat was not recorded in the Study Area, but the presence of this significant and elusive species cannot be discounted. The modern records indicate an extensive but fragmented range along the Central Cordillera and a recent record from Telefomin indicates a roost exists in karst proximal to the Project location. The Nena Karst is close enough to be a candidate area for it and has the type of large limestone dolines like the known roost and fossil sites.

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[20] Kyemana Village and Mount Bubiari (Flannery and Seri 1990), the Bismarck-Ramu area (Kinbag 1995) and a captive animal in Jayapura (http://www. flickr. com/photos/thirnbeck/5355396751/)

There is no Project infrastructure planned for the karst areas so even if Bulmer's Fruit Bat occurs there will be no direct impacts on roosting or breeding caves. Loss of habitat will reduce foraging areas, but the areas of remaining habitat are huge and there should be negligible direct impacts.

Hunting is the primary threat and control of the work force is the major mitigation. However, hunting by in-migrants is less easily controlled. Increases in population around Telefomin and Hotmin could increase the numbers of hunters willing to take the risk of the dangerous descent into the deep dolines this species roosts in. Indirect effects are therefore predicted to increase residual impacts to as high as major.

Resettlement into areas where the resettled people have not had access to for hunting in the past could exacerbate the potential impacts further and the residual impacts could be extreme.

18.1.8 Saffronheart *Halfordia papuana* Lauterb.

The only Critically Endangered tree species in the Study Area is the small tree Saffronheart that was collected at Frieda Bend Site. Four of the six German syntypes for *H. papuana*, were obtained at Hunsteinspitze, ca. 79 km east of the Study Area (Lauterbach 1918) and the Frieda record in the 2011 surveys provides modern verification of the populations first seen by Ledermann in 1913. Eddowes (1977, 1998c) reported the species as being mostly confined to the Bulolo/Wau region in Morobe Province, where less than 250 individuals were said to remain in submontane and montane rainforest between 1,200 and 2,700 m asl.

However, the species is much more widespread and common than its IUCN ranking would suggest. At the PNG National Herbarium there are at least 55 documented collections, an anomalously high count for a Critically Endangered taxon (Takeuchi 2005a) and substantial montane populations have been recorded recently from the Eastern Highlands near Nogoli (Takeuchi 2005a and b, 2008). The rediscovery of historical populations from the GFA has now occurred in Hill Forest and at elevations below 100 m asl.

H. papuana is dubiously distinct from the earlier names "*H. drupifera*" and "*H. kendack*" (Takeuchi 2005b) and future revision is likely to combine these species. Rutaceae authority T.G. Hartley (1986: 627) has expressed the view that there is just one species of *Halfordia* in Papuasia, and this is corroborated by the character overlap between taxa. Should this prove to be the case the species would have a wide distribution including northeast Queensland. The species is of limited commercial value and the Bulolo/Wau populations referred to by Eddowes (1998c) have been mostly impacted by large-scale clear-cutting and forest conversion to *Araucaria* plantations. Based on recent field observations and contemporary taxonomic opinion, the IUCN Red List entry for this species is in need of reappraisal.

Permanent loss of habitat will reduce populations of this tree, but its wider distribution will act in natural offset of local impacts and they are potential recruits in regeneration. The anticipated losses can be mitigated through nursery propagation and planting in areas designated for managed revegetation. Illegal logging using Project infrastructure, wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for indirect impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Residual direct impacts are predicted to be negligible and indirect effects are not predicted to increase residual impacts beyond this.

It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.1.9 A Liverwort *Schistochila undulatifolia* Piipo

New Guinea is a Malesian centre of speciation and endemism for *Schistochila*. Fourteen of the 19 species are endemic to New Guinea; an unusually high percentage compared to the background level of 18% for New Guinea bryophytes as a whole (Hyvönen 1989 Tan *et. al.* 2007). One species, *S. undulatifolia*, is known only from the type locality at Nena Base specified in the original collection as: "Frieda River prospecting area of Frieda Copper Co., 9 km NW of Frieda Base Camp, helipad M200 of Nena area, 800 m asl, 4°40'S, 141°43'E" (Piipo 1986). Three other specimens were also obtained from "nearby forests". Judging from a map of the collection localities in Norris and Koponen (1985 p. 371, Fig. 2), these were all obtained at Nena Base or at points immediately to the north and east. The species was growing on fallen tree trunks and branches and this liverwort is probably a substage or canopy epiphyte in mature communities. Nothing more is known of the plant's ecology or population biology. It is classified as Critically Endangered by IUCN because "the area of occupancy is less than 10 km² with only one locality and the habitat is declining" (Bryophyte Specialist Group 2000). However, the habitat available is large and continuous and is not declining and this species IUCN status may need updating.

Any attempt to ascertain the susceptibility of *S. undulatifolia* to potential Project impacts is severely constrained by practical difficulties. There are few bryologists worldwide capable of reliable determinations on Papuasian bryophytes (B. Tan and T. Koponen, *pers. comm*. to W. Takeuchi 2011) and bryophytes are probably the most difficult plants to in an EIS.

Although the habitats immediately around Nena Base have been disturbed by facilities construction and subsistence gardening, the adjoining forest and much of the GFA is old growth so the potential habitat for *S. undulatifolia* is considerable. However, since bryophyte communities can change rapidly over short distances (Norris and Koponen 1985), *S. undulatifolia* cannot be assumed to be present in locations contiguous with Nena Base or in ecologically similar localities. Until such time as other populations are found, it must be assumed to be restricted to near Nena base.

Epiphytic bryophytes are sensitive to microclimate and habitat change (Koponen and Norris 1983, Norris 1990) and although Project clearing would threaten any undiscovered populations, wildfires and the introduction of exotic diseases and pests are probably the major concern. Forest degradation by in-migration is less easily controlled but in-migrants are unlikely to target bryophytes for harvest. Short of placing a buffer around the type locality or doing more bryological surveys, design and implementation of mitigations specific to *S. undulatifolia* would be inappropriate and ill-advised at this time due to lack of information. Considering that the Nena resource is not being developed in this Project and Nena Base is outside the Project disturbance area, the residual direct impacts are predicted to be negligible. Indirect effects are not predicted to increase residual impacts beyond this.

18.2 Endangered Species

All IUCN Endangered species are of High sensitivity.

18.2.1 Goodfellow's Tree Kangaroo *Dendrolagus goodfellowi*

Goodfellow's Tree Kangaroo is a widespread New Guinea endemic occurring as different subspecies in what appears to be a naturally fragmented range. The form most likely to occur in the Frieda and May River catchments is *D. g. buergersi,* a large, blue-eyed animal weighing up to 9 kg with bright chestnut fur and a double golden stripe down the back (Flannery *et al.* 1996). It is distributed along the Central Cordillera west to the Strickland River and north to the Sepik foothills. The species appears to have shrunk in range - early records are from between sea level and 2,860 m asl, but now it appears to occur mostly above 1,000 m asl (Flannery 1995, Leary *et al.* 2016e). In the southern part of Sandaun Province Flannery and Seri (1990) found it was restricted to above 1,000 m asl and to be common only in the Thurnwald Range, and patchily distributed near Telefomin. A hunting trophy said to come from the Nena Karst was found in Wameimin 2 Village and hunters from Wameimin 1 and 2 stated that this species, 'Yema', could be hunted on the peaks and ridges within the GFA. This species, like all the tree kangaroos, has been extirpated from many areas (Flannery *et al.* 1996, Leary *et al.* 2016e) and hunting remains a primary threat.

Habitat for Goodfellow's Tree Kangaroos will be lost, but the Sub-plans to EMMPs should reduce construction impacts to low levels and residual direct impacts are predicted to be moderate.

Hunting is the major concern and banning hunting by the work force is the major mitigation. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced, especially if the human population around Telefomin increases greatly. Indirect effects are therefore predicted to increase residual impacts to major because of the uncertainties surrounding in-migration.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be extreme.

18.2.2 Western Montane Tree Kangaroo *Dendrolagus notatus*

A second tree kangaroo occurs in the GFA and is clearly distinguished from 'Yema' by informants (EIS Appendix 8A Chapter 3)[21] who described it as large with dark fur and tail which is consistent with Western Montane Tree Kangaroo *D. notatus*, which occurs from west of the Strickland River to near Lae between 900 and 3,100 m asl (Helgen 2007, Leary *et al.* 2016f). It occurs at nearby Mt Stolle (Martin 2005). Its tolerance to forest disturbance is not well known but it can be found in secondary forest (Flannery *et al.* 1996, Leary *et al.* 2016f).

Suitable habitat for this strictly montane species occurs only within the highest parts of the GFA. No infrastructure is planned for these higher elevations and no habitat will be lost with the possible exception of the upper edges of the pit and possibly a communications tower. Residual direct impacts are predicted to be negligible.

As for all tree kangaroos hunting is the major concern and banning hunting by the work force is the major mitigation. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced, especially if the human population around Telefomin increases greatly. Indirect effects are predicted to increase residual impacts to major because of the uncertainties surrounding in-migration.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be extreme.

18.2.3 Northern Water Rat *Paraleptomys rufilatus*

This species is a small (60 gm) rodent known from montane forests in the Cyclops, Bewani and Prince Alexander Mountains between 1,200 and 1,700 m asl. It is considered to be Endangered because it's distribution is less than 200 km^2 and it is known from less than five localities. Dickman *et al.* (2016) record that it is hunted.

It is likely to occur in the upper parts of the Bewani Mountains section of the infrastructure corridor, but the route of the pipeline and transmission line are well below 1,200 m asl. If the species is sensitive to forest degradation, then it will have already been extirpated from the road edges where the pipe will be laid. If it survives in such degraded, heavily trafficked habitat then it is likely much more widespread. Construction of pads for the transmission line pylons on higher hills along the route may impact some habitat but they are unlikely to be built above 700 m asl. There are likely to be negligible residual direct impacts.

The infrastructure corridor through the Bewani Mountains will not bring more settlers or in-migrants to the Bewani Mountains as the road has existed for some time. In-migrants will be attracted to the mine area. No resettlement is planned to occur in the Bewani Mountains so Indirect effects are not predicted to increase residual impacts beyond negligible.

18.2.4 Far Eastern Curlew *Numenius madagascariensis*

The Far Eastern Curlew is a mostly coastal migratory wader and might occur at the northern end of the infrastructure corridor. Impacts on migratory waders in general are covered in section 18.4.14. Conservation issues concerning Palaearctic waders and their habitats are discussed in EIS Appendix 8A Chapter 4 and the situation has worsened since that was written (BirdLife International 2017a).

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[21] Morren (1989: 128) stated of 'Debalmin' that it was "known from the undisturbed montane forests of the upper slopes of Mt Stolle" but Miyan hunters interviewed at Wameimin 1 and 2 villages during the survey indicated that it could be caught locally within the Area and in the same forests as 'Yema'.

There will be no direct or indirect impacts to the coastal habitats of this species and residual impacts are predicted to be negligible.

18.2.5 Great Knot *Calidris tenuirostris*

Like the Far Eastern Curlew, the Great Knot is a mostly coastal migratory wader and might occur at the northern end of the infrastructure corridor. Impacts on migratory waders in general are covered in section 18.4.14. Conservation issues concerning Palaearctic waders and their habitats are discussed in EIS Appendix 8A Chapter 4 and the situation has worsened since that was written (BirdLife International 2016a).

There will be no direct or indirect impacts to the coastal habitats of this species and residual impacts are predicted to be negligible.

18.2.6 Ornithoptère Méridional *Ornithoptera meridionalis*

The large birdwing butterflies (genus *Ornithoptera*) are highly prized by collectors, all are protected under the PNG Fauna (Protection and Control) Act 1966 and three are recorded in the Study Area.

Ornithoptère Méridional *O. meridionalis* is the smallest in the genus yet the male's wingspan reaches up to 99 mm and females 124 mm. Males are green and black with a thin spatulate tail to the narrow hindwing, while females are predominantly brown and cream. The larvae feed exclusively on the vine *Pararistolochia meridionaliana*. It is endemic to New Guinea, essentially south of the Central Cordillera, where it is primarily a lowland species, although there are records as high as 700 m asl in the Lake Kutubu district. It is an inhabitant of the margins of primary and advanced secondary forest. It was recorded in the 2011 surveys at Kaugumi Site and could occur anywhere in the Study Area.

The IUCN Red List provides no information for the Endangered Ornithoptère Méridional (Gimenez Dixon 1996) but probably the greatest threats to this and the other three species is large-scale forest loss from expanding shifting cultivation and agriculture, fire, and invasive species replacing the *Aristolochia* food plant, which would lead to local extinctions. Certain introduced pests such as rats and cane toads will feed on the larvae and pupae of Birdwings.

Although birdwings generally are restricted to primary and advanced secondary forest they favour forest margins and may respond positively to linear clearings in forest, but degradation of the forest edge by weed invasion and/or use of herbicides that reduces abundance of their vining food plants, would degrade this. The Ornithoptère Méridional can cross barriers like roads but unlikely large cleared areas. They tend not to use waterways as a flight path, unlike many butterfly species; therefore, disruption to streamline vegetation would not adversely affect the species. Dust along roads would be moderately detrimental as the larval food plant would likely suffer dieback in such areas and dust on leaves of food plant would inhibit larvae feeding on them.

Permanent loss of habitat may reduce populations, but they may benefit from the creation of more edges, especially if their food plants are abundant. The anticipated losses can be mitigated through nursery propagation and planting of their food plants in areas designated for managed revegetation. Forest degradation by in-migration is less easily controlled. Residual direct impacts are predicted to be negligible and should their food plants expand in population the residual impacts may even be positive. Indirect effects are not predicted to increase residual impacts beyond negligible. Resettlement patterns are unlikely to alter this assessment.

18.2.7 Maple Silkwood *Flindersia pimenteliana* F. Muell.

Maple Silkwood is a valuable timber tree reaching 40 m in height and the species (sensu Hartley 1969) is very variable. It occurs from 100–2,700 m asl at widely scattered localities from the Vogelkop to central and northern provinces at low frequencies in most hill environments (W. Takeuchi, *pers. obs*.). It is common in the rainforests of northeast Queensland where it was a significant timber species until the cessation of logging there. Eddowes (1998a) reported population reductions in the Bulolo/Wau districts of PNG as a result of overharvesting. However, the species is light demanding with light to medium wood density and regenerates very well in logged Queensland forests (F. Crome *pers. obs*.). The status of the

Australian populations was not considered during the determination of Red List status for this species (Eddowes 1998a). Not only does it regenerate well but also there are many large populations documented by herbarium collections such as in the Papuan Ultrabasic Belt and on karst of the Southern Ranges where logging is prevented by topography (Takeuchi 2005a).

Permanent loss of habitat will reduce populations of this tree, but its wider distribution will act in natural offset of local impacts and they are potential recruits in regeneration. The anticipated losses can be mitigated through nursery propagation and planting in areas designated for managed revegetation. Illegal logging using Project infrastructure, wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for indirect impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Residual direct impacts are predicted to be negligible and indirect effects are not predicted to increase residual impacts beyond negligible. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.3 Vulnerable Species

All IUCN Vulnerable species are of Moderate sensitivity.

18.3.1 Grizzled Tree Kangaroo *Dendrolagus inustus*

A third tree kangaroo, the Grizzled Tree Kangaroo is a widely distributed species from the Vogelkop to Wewak in the North Coastal Ranges and surrounding lowlands between 100 and 1400 m asl (Flannery 1995, Wilson *et al.* 2015, Leary *et al.* 2016g). It could occur anywhere in the infrastructure corridor from at least the Sepik River northwards.

It occurs in primary and secondary forest and, like most Tree kangaroos, is partly terrestrial and heavily hunted. It's habitat and its populations have likely been severely reduced by logging and hunting in and around the Bewani Mountains.

It is unlikely the Project will result in much habitat loss for this species. The construction alongside the Vanimo to Green River road is in roadside vegetation. The only habitat that may be lost would be for construction of pads for the transmission line pylons and fly roads should any go through unlogged areas. The Project is unlikely to increase the barrier effects of the existing road for this species. Residual direct impacts are predicted to be negligible.

Hunting is the major concern and banning hunting by the work force is the major mitigation. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. However, the infrastructure corridor is unlikely to bring more settlers or in-migrants to the Bewani Mountains as the road has existed for some time and logging in this section of the infrastructure corridor is intense. In-migrants will be attracted to the mine area and no resettlement is planned to occur in the Bewani Mountains. However, fly-roads for transmission line construction could extend potential hunting access to areas further away from the road but the longest fly road is likely to be less than a kilometre long and fly-roads are unlikely to add to the access already provided by the numerous logging tracks in the Bewani Mountains. Logging roads extending off the main road already exist along much of the corridor. Because it occurs in the lowlands it could be accessible to travellers to stop and opportunistically hunt this species so indirect effects are predicted to increase impacts to minor and resettlement patterns are unlikely to alter this.

18.3.2 New Guinea Pademelon *Thylogale browni*

The New Guinea Pademelon weighs up to 9 kg and is endemic in north central New Guinea from the Cyclops Mountains to east of Wau, from sea level to 3,000 m asl (Flannery 1995). It's habitat requirements are not fully understood but the genus *Thylogale* as a whole are grazers and it seems likely that it favours areas of natural disturbance with grasses such as riparian habitats where grasses are often present in early successional vegetation. One animal was seen in the GFA at Malia Site and hunters interviewed from many villages gave good descriptions of the species, which they know as 'sumul'. In some cases, hunters expressed the view that the unstriped Brown's Pademelon were immature individuals of the larger

White-striped Forest Wallaby *Dorcopsis hageni.* Accordingly, statements regarding the abundance of either of the two locally occurring wallaby species in the GFA should be taken with caution. Morren (1989) confirms the presence of Brown's Pademelon in the general area and it could occur anywhere in the Study Area.

As one of the larger game animals in PNG, this species is actively hunted and it has probably declined in some areas. However, away from human populations the species is under no other threat and probably remains at least locally abundant.

The current IUCN rating for Brown's Pademelon reflects its vulnerability to hunting in areas close to human settlements (Leary *et al.* 2016h). However, its natural range includes large tracts of relatively unexploited forest in the lowlands and hills, especially in the Sepik foothills and in the Mamberamo basin of Papua Province, Indonesia. Forest clearing that produces a mosaic of open and closed habitats is likely to favour this species. However, this could be negated if forest clearing is accompanied by increased hunting.

Permanent loss of habitat will reduce populations of the species within the Study Area but since the species is likely to also benefit from the mosaics produced by clearing the Project may actually increase its habitat and eventually populations will recover. It is unlikely to be impacted by barrier effects. Residual direct impacts are predicted to be negligible or even positive.

Hunting remains the primary threatening process. Banning hunting by the work force is the major mitigation, however, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Because of the uncertainties associated with the effects of in-migration, indirect effects are predicted to increase residual impacts to minor.

Resettlement could exacerbate the potential impacts if villagers are moved into parts of the Study Area where they would not normally, or only occasionally, hunt in which case, while grassy habitats would increase hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be moderate.

18.3.3 Hill's Leaf-nosed Bat *Hipposideros edwardshilli*

Hill's Leaf-nosed Bat *Hipposideros edwardshilli* is a medium-sized bat described from the Bewani Mountains by Flannery and Colgan (1993) where it is known from only three localities in the vicinity of Imonda Station and Pou Village at 200 to 300 m asl and there have been no subsequent records anywhere else (Armstrong and Aplin 2017). Though a few individuals were found roosting in a cave, the species is poorly known and it may use other types of roost sites. It may have a broader distribution and could occur elsewhere in the Study Area, especially in areas of limestone. It feeds on the wing and by using a sit-and-wait hunting strategy from perches (Flannery and Colgan 1993) and forages in villages and gardens as well as forest.

Imonda station is 25 km west of the Vanimo to Green River road but considering the paucity of information on bats (see EIS Appendices 8A and 8B) this species could occur anywhere in the northern part of the infrastructure corridor. The Project will result in habitat loss for this species – while the export pipeline itself is alongside the Vanimo to Green River road in degraded roadside vegetation, losses of more intact vegetation will occur for construction of pads for transmission line pylons, fly roads used for transmission line construction and clearings under transmission lines – all in lower elevation areas favoured by this species. This species would not be impacted by barrier effects.

Minimising the Project disturbance area, preventing wildfires from starting at the Project disturbance area, and cave protection procedures should reduce construction impacts to low levels and residual direct impacts are predicted to be negligible.

While all small bats are hunted this species is unlikely to be specifically targeted. Banning hunting by the work force is the major mitigation, however, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. However, the infrastructure corridor is unlikely to bring more settlers or in-migrants to the Bewani

Mountains themselves as the road has existed for some time and logging in this section of the infrastructure corridor is intense. In-migrants will be attracted to the mine area and it is not envisioned that the Bewani Mountains will be a settlement targets for in-migrants. Fly-roads for transmission line construction could extend potential hunting access to areas further west from the road but the longest fly road is likely to be less than a kilometre long and fly-roads are unlikely to add to the access already provided by the numerous logging tracks in the Bewani Mountains. Logging roads extending off the main road already exist along much of the corridor but none of them facilitate penetration of hunters towards the known populations of this species around Imonda. No resettlement is planned to occur in the Bewani Mountains. Indirect effects are not predicted to increase residual impacts beyond negligible and resettlement patterns will not affect this assessment.

18.3.4 Salvadori's Teal *Salvadorina waigiuensis*

Salvadori's Teal is a small duck, barred black and white above with a dark head, orange-yellow bill and a stiff tail often held erect. It is generally scarce but can be locally common. It feeds by dabbling and diving for invertebrates and aquatic vegetation in streams and rivers and on the edges of lakes. It is reportedly largely nocturnal but is often encountered during the day (Coates 1985, F. Crome *pers. obs*.) in a range of aquatic habitats particularly cool streams with pebbly bottoms and exposed pebble banks in Hill Forest and Montane Forest. It is endemic to New Guinea where it occurs throughout the Central Cordillera, the Vogelkop, and the Huon Peninsula between 70 m asl and 4,300 m asl (Coates 1985, BirdLife International 2016b). It is rare at lower elevations. If not hunted, it can persist even in small streams through garden areas (F. Crome *pers. obs.*). It has not been recorded in the Study Area but has a strong chance of occurring in rivers and streams above ca. 500 m asl. BirdLife International (2016g) indicates the species has been extirpated in some places and "declines have been attributed to hunting, predation by dogs, and habitat degradation, largely through increasing human pressure and siltation, especially from hydroelectric projects, mining and logging but these have only impacted small areas". They also suggest that stocking of rivers with exotic trout species is a potential risk to food sources for this species.

Salvadori's Teal is able to survive in streams in cleared areas, so forest loss should not impact it greatly; hydrological changes, contamination of waterways and hunting may be the more significant potential impacts should this species occur in the Study Area.

Suitable habitat occurs within the highest parts of the Study Area but most infrastructure is planned for the lower elevations and minimal habitat will be lost. Residual direct impacts are predicted to be negligible.

Hunting is probably still a threat and while banning hunting by the work force is the major mitigation, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects, therefore, are predicted to increase residual impacts to moderate.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be major.

18.3.5 Pesquet's Parrot *Psittrichas fulgidus*

Pesquet's Parrot is a large, black and red parrot with a bare vulture-like head. It is a nomadic, specialist frugivore patchily distributed throughout New Guinea in Hill Forest and Montane Forest, feeding on a select variety of figs (Mack and Wright 1998). This species is heavily hunted for its feathers (BirdLife International 2017b) and has been extirpated from large areas (Coates 1985, Kocher Schmid 1993, Mack and Wright 1998, Igag 2002). In the absence of hunting, this species appears tolerant of moderate habitat disturbance (I. Woxvold *pers. obs*.). It was among the most widely encountered species in the Study Area Hill Zone.

There will be loss of habitat f and tree nesting hollows or this species and some population losses would be expected, particularly in the GFA. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. There will be loss of nesting hollows for the frugivores and a mitigation to retain large nesting trees and fig trees around temporary facilities is suggested. This species is unlikely to be impacted by barrier effects. Residual direct impacts are predicted to be minor.

Hunting is still a threat and while banning hunting by the work force is the major mitigation, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects are predicted to increase impacts to moderate.

Resettlement could exacerbate the potential impacts further if villagers are moved into parts of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further. The residual impacts in such a case could be major.

18.3.6 Papuan Eagle *Harpyopsis novaeguineae*

The endemic New Guinea Eagle occurs at low densities throughout the island in mostly undisturbed forests from sea-level to over 3,000 m asl. This eagle does not soar, but hunts mammals and birds, including wallabies, juvenile cassowaries, megapodes and arboreal marsupials, on the ground, in trees or from tree hollows by flying through or low over the canopy. Its calls carry up to 2 km (Watson and Asoyama 2001). Breeding pairs require extensive territories (13.0 ± 3.9 km^2 Watson and Asoyama 2001) and its density on the mainland is estimated to be 0.01 to 0.04 individuals/ km^2 (BirdLife International 2016c). A pair was recorded between Ok Isai Site and Ok Isai village in the 2011 surveys and birds provisionally identified as this species were heard calling from a distance at Nena D1 and Camp 1. It occurs in a variety of forests, but it is unknown to what degree this species may use Swamp Forest. These eagles are sensitive to habitat disturbance and hunted for feathers, so they are very rare or extirpated from areas near human settlement where hunting persists (Coates 1985, Watson and Asoyama 2001, BirdLife International 2016c).

There will be habitat loss for this species and some population losses would be expected, particularly in the GFA. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. This species is unlikely to be impacted by barrier effects. Residual direct impacts are predicted to be minor.

Hunting is still a threat and while banning hunting by the work force is the major mitigation, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects are predicted to increase residual impacts to moderate.

Resettlement could exacerbate the potential impacts further if villagers are moved into parts of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further. The residual impacts in such a case could be major.

18.3.7 Coachwood *Ceratopetalum succirubrum C.T. White*

Coachwood is a canopy tree of which there are at least 46 specimen collections in the PNG National Herbarium from scattered localities in New Guinea and its satellite islands. The species is also present in the rainforests of northeast Queensland where it was once a common commercial timber. The geographic range of Coachwood is much wider than given by Eddowes (1998b), suggesting that the IUCN dossier may need reappraisal. The species is listed by IUCN primarily in recognition of its commercial value and the overharvesting of historical populations, but Coachwood is usually common whenever populations are found (Fortune Hopkins and Hoogland 2002). This pattern of spotty abundance is exhibited within the GFA and, judging from observed frequencies and the presence of sapling crops, coachwood is not at risk there.

Permanent loss of habitat will reduce populations of this tree, but its wider distribution will act in natural offset of local impacts and they are potential recruits in regeneration. The anticipated losses can be mitigated through nursery propagation and planting in areas designated for managed revegetation. Illegal logging using Project infrastructure, wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Direct residual impacts are predicted to be negligible and indirect effects are not predicted to increase this further. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.3.8 Burmese Rosewood *Pterocarpus indicus Willd.*

Burmese Rosewood or Red Sandalwood is probably the most important leguminous tree in New Guinea (Verdcourt 1979) and is a characteristic emergent in the lowlands, growing to 50 m high. It is distributed from continental Asia to the Santa Cruz Islands (Verdcourt 1979) in a variety of forest types. The species is heavily logged throughout its range. According to World Conservation Monitoring Centre (1998b) "The Viet Nam subpopulation has been extinct for some 300 years. An extensive forest survey in Sri Lanka failed to find the species, and information on subpopulations in India, Indonesia and the Philippines indicate the species is seriously threatened. Exploitation of the few known stands in Peninsular Malaysia may have caused its extinction there. What are believed to be the largest remaining subpopulations, in New Guinea, are being heavily exploited". However, this species regenerates well, cuttings can be readily struck and are often done so by villagers, and it is a medicinal plant in PNG (Waruruai *et al.* 2011).

There will be little habitat loss for this species in the Lowland Zone, as the Project impact is mostly in the Hill Zone. Individual trees will be lost along the infrastructure corridor and the lower parts of the GFA. The anticipated losses can be mitigated through nursery propagation and planting in areas designated for managed revegetation. Illegal logging using Project infrastructure, wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Direct residual impacts are predicted to be negligible and indirect effects are not predicted to increase this further. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.3.9 Kwila *Intsia bijuga* (Colebr.) Kuntze

Kwila can exceed 40 m high and is distinguished from its New Guinea congeners by leaves with 1–2 pairs of leaflets (Ding Hou *et al.* 1996). The dense, attractive wood (Merbau in international trade, Kwila in PNG commerce) is valued for flooring, furniture, and construction (Verdcourt 1979, World Conservation Monitoring Centre 1998a). It is often a dominant in lowland forests in New Guinea and has been collected from virtually every part of Papuasia. Its range includes East Africa, Indochina, all of Malesia, Australia, Melanesia, and Micronesia (Verdcourt 1979, Ding Hou *et al.* 1996). Although present in a variety of forest types, Kwila is conspicuous in seasonally flooded forests and is probably the most common emergent on the Sepik River floodplain. Commercial overharvesting is the most significant threat, and, in some areas, it has been eliminated as a commercial resource but not as a species.

There will be some habitat loss for this species in the Lowland Zone, but the Project impact is mostly in the Hill Zone. Individual trees will be lost along the infrastructure corridor and the lower parts of the GFA. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations, the species' wider distribution will act in natural offset of local impacts and it is a potential recruit in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of this species in areas designated for managed revegetation.

Illegal logging using Project infrastructure, wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Direct residual impacts are predicted to be negligible and indirect effects are not predicted to increase this further. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.3.10 Palosapis *Anisoptera thurifera* (Blanco) Blume subsp. *polyandra* (Blume) Ashton

This is a tall lowland tree growing up to 50 m and widely distributed from the Philippines through Indonesia and New Guinea. It is a fast-growing timber species and a significant logging target that thrives in pioneer situations. It is one of the 10 major timbers exported by PNG and over the next 100 years the population is predicted to decline by up 45% (Barstow and Jimbo 2017). Palosapis grows well in poor soils but does not mast flower like other dipterocarps. (Barstow and Jimbo 2017).

There will be some habitat loss for this species in the Lowland Zone, but the Project impact is mostly in the Hill Zones. Individual trees will be lost along the infrastructure corridor and the lower parts of the GFA. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations, the species' wider distribution will act in natural offset of local impacts and it is a potential recruit in regeneration. Because this performs well as a pioneer species there would be little need for nursery propagation and planting of this species in areas designated for managed revegetation. Residual direct impacts are predicted to be negligible.

Illegal logging using Project infrastructure, wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Indirect effects are not predicted to increase residual impacts any higher. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.3.11 Papuan Nutmeg *Myristica buchneriana* Warb.

Myristica is a large genus in New Guinea and over 70 of the 90 known species have only been discovered and/or described within the last 30 years (de Wilde 1995, 1998). Because of the restricted-range endemism characteristic of this genus, it is very likely that more species remain to be found. *Myristica buchneriana* Warb., so called because of the presence of an aromatic aril around the seeds like commercial nutmeg, is a 10 to 30 m high tree with large ellipsoid fruits distributed from Jayapura to Milne Bay and the Papuan Islands (Foreman 1978) and has often been collected along ridge crests from 300–1,300 m asl (Foreman 1978, World Conservation Monitoring Centre 1998c). At least in Mamose region (Madang, Morobe, and the Sepik Provinces), it is a common lowland tree in primary and secondary forests and is not under immediate conservation threat (W. Takeuchi *pers. obs*.). The World Conservation Monitoring Centre (1998c) does not list any threatening processes for this species.

Unlike the commercial timber trees this species occurs scattered in the forest and rarely forms dense stands. Thus, while there will be habitat loss, particularly within the GFA, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations and the species is a potential recruit in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of this species in areas designated for managed revegetation. Residual direct impacts are predicted to be negligible.

Wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Indirect effects are not predicted to increase residual impacts beyond negligible. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.3.12 Guma *Horsfieldia ampliformis* de Wilde

Horsfieldia ampliformis de Wilde (another Guma) is a shrub or small tree to 8 m high and is difficult to distinguish from the widespread and variable *H. laevigata* (ibid.). The uncertainties regarding *H. ampliformis* are such that its status as a distinct species is arguable. Only two collections of *H. ampliformis* were known to de Wilde, a male specimen from East Sepik Province, and a female from Morobe Province.

Both were obtained from Lower Montane Forest (L ± c) at 1200–1300 m asl (de Wilde 1985a, b). A survey collection from the HI Site was identified as this species based on de Wilde's (1985a, b) key and description. Because of its subarborescent stature, *H. ampliformis* is not logged. The World Conservation Monitoring Centre (1998f) does not list any threatening processes for this species.

Unlike the commercial timber trees this species occurs scattered in the forest and rarely forms dense stands. Thus, while there will be habitat loss particularly within the GFA, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations and the species is a potential recruit in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of this species in areas designated for managed revegetation. Residual direct impacts are predicted to be negligible.

Wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Indirect effects are not predicted to increase this further. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.3.13 Bangara *H. sepikensis* Markgr.

Horsfieldia sepikensis Markgr. (Bangera in Sepik vernacular) is a 10–25 m high tree. The predominantly 3-merous flowers are its most noteworthy feature. The only other New Guinea congener with 3-merous flowers is *H. olens*, a species primarily of Irian Jaya and differing by the quadrangular-sided branchlets and longer flowers (de Wilde 1985b). It is thus far known only from East Sepik Province, at scattered sites including the April River and the Hunstein Range (de Wilde 1985a, b). The species is found in primary and secondary forests, and in ridge habitats, from 0–50 m asl (ibid.). The World Conservation Monitoring Centre (1998e) does not list any threatening processes for this species.

Unlike the commercial timber trees this species occurs scattered in the forest and rarely forms dense stands. Thus, while there will be habitat loss particularly within the GFA, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations and the species is a potential recruit in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of this species in areas designated for managed revegetation. Residual direct impacts are predicted to be negligible.

Wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale targeted felling of individual trees is unlikely. Residual indirect impacts are predicted to be negligible. It is unlikely this assessment would be changed by resettlement patterns.

18.3.14 Dragonfly *Bironides teuchestes*

Bironides teuchestes is a small black and yellow species previously known only from the vicinity of Jayapura and the slopes of the Cyclops Mountains. Its IUCN Vulnerable listing was due to this restricted distribution, and the known habitat destruction in that area (Kalkman 2009a). It was found perched in sun in forest near torrential streams at Malia and Frieda Bend Sites in the 2011 surveys. Nothing is known about its ecology, but it appears to be genuinely rare.

This species may be affected by damage to upland torrential streams. Clearing will eliminate local populations, but the species is likely to persist if stream bank disturbance is minimized and clearing does not extend beyond Project disturbance area limits. Mitigations to minimise the Project disturbance area, control clearing at watercourses and control of AMD, tailings and contaminants should result in the residual direct impacts being minor.

In-migration, if it resulted in further deforestation, would exacerbate this to some extent so the residual indirect impact would be greater, this could be reduced to some extent by the Project In-Migration

Management Strategy, so indirect effects are not predicted to increase residual impacts beyond minor. Resettlement would be unlikely to exacerbate the potential impacts further.

18.4 Near Threatened Species

All IUCN Near Threatened species are of Low sensitivity except for those also listed under the PNG Fauna (Protection and Control) Act 1966 which are of Moderate sensitivity.

18.4.1 Plush-coated Ringtail Possum *Pseudochirops corinnae*

The Plush-coated Ringtail Possum is likely to occur on the higher peaks and ridges in the Study Area. It is a small (1.3 kg), docile, folivorous silvery green possum with three parallel stripes on the back. It is nocturnal, sleeps on branches during the day and is very easily captured. It is endemic to New Guinea and widely distributed throughout the Central Cordillera and the Huon Peninsula between 900 and 2,900 m asl (Flannery 1995). It can be moderately abundant in areas with relatively undisturbed forest and low hunting pressure and can occur in secondary forest (Flannery 1994, 1995, Leary *et al.* 2008b).

No infrastructure is planned for the higher elevation parts of the Study Area and no habitat of the Plush-coated Ringtail will be lost with the possible exception of the upper edges of the pit and possibly a communications tower. The species is more-or-less completely arboreal so would be susceptible to barrier effects from linear infrastructure but there is little of this at the elevations it favours. Residual direct impacts are predicted to be negligible.

Leary *et al.* (2008b) say “it has possibly been extirpated from some areas due to over-exploitation” so hunting is a concern and control of the work force is the major mitigation. Banning hunting by the work force is the major mitigation, however, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects therefore are predicted to increase residual impacts to minor.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be moderate.

18.4.2 D'Albertis's Ringtail Possum *Pseudochirops albertisii*

D'Albertis's Ringtail Possum is the smallest in its genus and weighs less than a kilo. It is a small dark arboreal species found in montane forest above 1000 m asl on isolated mountains in northern New Guinea including the Arfak, Weyland, Cyclops and Torricelli Mountains, possibly the Bewani Mountains, and Yapen Island (Helgen *et al.* 2008).

The infrastructure corridor is distant from its known range, but the species may extend to the upper parts of the Bewani Mountains section of the infrastructure corridor. The pipeline is alongside the Vanimo to Green River road in degraded roadside vegetation and well below the lower elevation limits of this species, Construction of pads for the transmission line pylons on higher hills along the route may impact some potential habitat but the pads are unlikely to be built above 700 m asl thus well below the known lower elevation limits. Vegetation losses to fly roads used for transmission line construction and maintenance of clearings under transmission lines will all be in the lower elevation areas not favoured by this species and the Project is unlikely to increase any putative barrier effects provided by the existing Vanimo to Green River road.

Considering the above there are likely to be negligible residual direct impacts should this species occur.

Hunting could be a threat and control of the work force is the major mitigation. However, hunting by in-migrants is less easily controlled and cannot be controlled at all off the Project’s leases and roads. The infrastructure corridor through the Bewani Mountains is unlikely to bring more settlers or in-migrants to the Bewani Mountains themselves as the road has existed for some time and logging in this section of the infrastructure corridor is intense. In-migrants will be attracted to the mine area and it is not envisioned that the Bewani Mountains will be a settlement targets for in-migrants. Fly-roads for transmission line construction could extend potential hunting access to areas further east from the road but the longest fly road is likely to be less than a kilometre long and fly-roads are unlikely to add to the access already provided by the numerous logging tracks in the Bewani Mountains. Logging roads extending off the main road already exist along much of the corridor but none of them facilitate penetration of hunters towards the known populations of these species further east. No resettlement is planned to occur in the Bewani Mountains. However, it is possible that travellers could stop and opportunistically hunt this species. Indirect effects therefore are predicted to increase residual impacts to minor.

18.4.3 Small Mountain Dorcopsis *Dorcopsulus ?vanheurni*

Small Mountain Dorcopsis are small wallabies widespread in New Guinea between 800 and 3,100 m asl (Flannery 1995) on both the Central Cordillera and many isolated ranges but have been "extirpated from the Hunstein, Schrader, and the Torricelli ranges, and probably the Adelberts" (Leary *et al*. 2016i). Although they occur mainly in primary forests, Small Mountain Dorcopsis will use secondary forest and gardens.

K. Aplin (EIS Appendix 8A) writes "Morren (1989: 129) recorded a species of *Dorcopsulus* in Miyanmin hunting territory (as 'Sumul', a name shared with other wallabies) and stated that it was "common in undisturbed mid-montane forest above 1600 m". Miyanmin hunters interviewed at Wameimin 1 and 2 villages during the Project survey described a small montane forest wallaby under the name 'Soyabu'. They stated that it was present at high elevations in the Study Area as well as on the more distant, larger mountains. It was said to be moderately common in the Study Area, and easily hunted with dogs. No trophy jaws of this species were presented. Flannery and Seri (1990: 186) recorded a Small Forest Wallaby (as *Dorcopsulus vanheurni*) in Miyanmin territory down to 1,000 m asl, and as "common in montane forests between 1,300 and 2,300 m".

The GFA is heavily forested and open areas of the kind usually favoured by pademelons are uncommon except along rivers with grassy banks. Clearing that produces a mosaic of open and closed habitats could favour this species. It is unlikely to be found along the infrastructure corridor.

Suitable habitat for this more montane species occurs only within the higher parts of the GFA. No infrastructure is planned for these higher elevations and little habitat will be lost with the possible exception of the upper parts of the pit and possibly a communications tower. Since the species is likely to benefit from the mosaics produced by clearing the Project may actually increase its habitat and eventually populations will recover. It is unlikely to be impacted by barrier effects. Residual direct impacts are predicted to be negligible or even positive.

Hunting remains the primary threatening process. Banning hunting by the work force is the major mitigation, however, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced so indirect effects are predicted to increase residual impacts to minor.

Resettlement could exacerbate the potential impacts if villagers are moved into parts of the Study Area where they would not normally, or only occasionally, hunt in which case, while grassy habitats would increase, hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be moderate.

18.4.4 New Guinean Quoll *Dasyurus albopunctatus*

The New Guinean Quoll is a nocturnal, medium sized (to 0.5 kg) spotted marsupial carnivore endemic to New Guinea and found across the entire island from sea level to subalpine habitats (Flannery 1995). Prime habitat is large areas of mature forest, but it can persist in secondary forest in proximity to villages. Interviews with hunters at Wameimin 1 and 2 villages in the 2011 surveys indicated it occurs at all elevations but is commoner higher up. Habitat is abundant in the Study Area, but New Guinea Quoll population densities are probably low.

The major threat is habitat loss but considering the wide distribution of the New Guinean Quoll, and its general adaptability residual direct impacts are predicted to be negligible.

Hunting may not be as significant an issue for the New Guinean Quoll as other mammals and appears to be an issue only if taken to extreme levels. Experience in Australia suggests diseases and pests may be major threats (e. g. Maxwell *et al.* 1996, Oakwood and Pritchard 1999, Raymond *et al*. 2000, Woinarski *et al*. 2008, Woolley *et al.* 2016). There have been severe declines in native species of *Dasyurus* in Australia. Besides the problem of habitat loss, two issues have been considered to be involved in these declines - disease and exotic species such as cane toads and foxes.

Diseases such as toxoplasmosis have been held responsible for declines in *D. hallucatus* (Maxwell *et al.* 1996 but see Oakwood and Pritchard 1999 for a contrary view) and atypical mycobacteriosis is known to infect captive *Dasyurus maculatus* (Raymond *et al.* 2000). Within the last 20 years the eruption and spread of Devil Facial Tumour Disease has decimated populations of the Tasmanian Devil *Sarcophilus harrissii*, a related species of marsupial carnivore (http://dpipwe.tas.gov.au/wildlife-management/save-the-tasmanian-devil-program).

The cane toad *Bufo marinus*, a toxic species, has been held directly responsible for rapid declines of *D. hallucatus* in northern Australia, as shown by local extinctions following dispersal of the toad (Woinarski *et al.* 2008). Toads are considered a threat in New Guinea also (Woolley *et al.* 2008). The Weed, Pest and Quarantine Management Sub-plans to EMMPs is particularly important for this species.

Indirect effects are predicted to increase residual impacts to minor. In view of the importance of disease rather than hunting as an indirect impact resettlement patterns will not change this assessment as in-migrants are more likely to be vectors for carrying wildlife diseases, via animals carried into the GFA, than locals.

18.4.5 Victoria Crowned Pigeon *Goura victoria*

Weighing up to 3.5 kg, the Victoria Crowned Pigeon is, with its three congeners, the world's largest living pigeon and member of a unique subfamily endemic to New Guinea (Baptista *et al.* 1997). It is endemic to the northern lowlands from eastern Geelvink Bay to Astrolabe Bay and some offshore islands where it inhabits all forest types up to ca. 600 m asl including Swamp Forest, disturbed forest (Mack et al. 2000) and even highly degraded secondary forests near settlements (F. Crome, *pers. obs*.)[22]. It forages on the ground for fruits and seeds and is very easily hunted. This species appears still to be common in the GFA, particularly the Lowland Zone. This species is protected under the PNG Fauna (Protection and Control) Act 1966 so its sensitivity is medium.

Habitat loss is a major problem, but the species is adaptable and can survive in a range of disturbed habitats. It is unlikely to be impacted by barrier effects. There will be habitat loss throughout the Study Area but, considering its wide distribution, residual direct impacts are predicted to be negligible.

Hunting presents a major threat to all *Goura* species because they are easy to hunt and prized for their meat and plumes and have been extirpated from the vicinity of many settled areas (Coates 1985; King and Nijboer 1994). Hunting of large pigeons for food is common in the Study Area.

Logging is regularly cited as a major threat to crowned pigeons (King and Nijboer 1994; BirdLife International 2016d, 2018) but further study is required to understand their tolerance of logged forest. Other threats include habitat fragmentation, dogs and, in areas with roads, collisions with traffic.

While the activities of the workforce can be controlled, increased hunting by potential in-migrants is less easily controlled and it is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Because of the uncertainties associated with in-migration, indirect effects are predicted to increase residual impacts to moderate.

Resettlement could exacerbate the potential impacts if villagers are moved into parts of the Study Area where they would not normally, or only occasionally hunt. The residual impacts in such a case could be major.

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[22] Its tolerance has resulted in a change from IUCN Vulnerable to Near Threatened (BirdLife International 2016d).

18.4.6 Pale-billed Sicklebill *Drepanornis bruijnii*

This large bird-of-paradise, while not brilliantly coloured, has a remarkable long downcurved bill. It is a common but poorly known species ranging along the northern lowlands of New Guinea and "…occupying lowland forest (to 175 m AMSL) from eastern Geelvink Bay east to a very small known area of occurrence within PNG—at four sites on the north coastal plains near Vanimo and in the footslopes of the northern and southern flanks of the Bewani Mountains (Beehler and Beehler 1986; Whitney 1987; Beehler and Pratt 2016). … Reports of its occurrence further south along the upper Sepik River … appear to be unconfirmed, though potentially suitable habitat extends there unbroken from known locations to the north. It is tolerant of some habitat disturbance (Beehler and Beehler 1986; Whitney 1987), though recent intensive logging and conversion to oil palm has no doubt reduced its range within PNG. The infrastructure corridor traverses areas of lowland forest potentially occupied by this species; most likely in areas of intact alluvial and foothill forest north of Green River." (Chapter 4 in EIS Appendix 8B)

According to Birdlife International (2016e) it is relatively common in selectively logged forest. Males have large territories and display on branches in midstory trees (Pratt & Beehler 2015). The species eats fruit and insects in the forest canopy.

Habitat loss is the major issue with large areas of its range having been or in the process of being logged.

The Project will result in losses of intact vegetation for construction of pads for transmission line pylons, fly roads used for transmission line construction and clearings under transmission lines – all in lower elevation areas favoured by this species. The pipeline is alongside the Vanimo to Green River road in degraded roadside vegetation, this species would not be impacted by barrier effects. Residual direct impacts are predicted to be negligible.

This is not a spectacular species so would be unlikely to be a favoured hunting target. Control of the work force is the major mitigation for hunting but hunting by in-migrants is less easily controlled and cannot be controlled at all off the Project's leases and roads. The infrastructure corridor is unlikely to bring more settlers or in-migrants to north of Green River as the road has existed for some time and logging in this section of the infrastructure corridor is intense. In-migrants will be attracted to the mine area and it is not envisioned that the Bewani Mountains will be a settlement targets for in-migrants. Fly-roads for transmission line construction could extend potential hunting access to areas further west from the road but the longest fly road is likely to be less than a kilometre long and fly-roads are unlikely to add to the access already provided by the numerous logging tracks in the Bewani Mountains. No resettlement is planned to occur in the Bewani Mountains. Nonetheless travellers could stop and opportunistically hunt this species which is easy to find. Indirect effects are predicted to increase residual impacts to minor. This is unlikely to be affected by resettlement patterns.

18.4.7 Yellow-breasted Satinbird *Loboparadisea sericea*

The rarely seen Yellow-breasted Satinbird is a small, secretive and poorly known species. It has silky yellow underparts and warm brown upperparts with conspicuous, swollen, turquoise green wattles either side of the bill. The mating system remains unknown (Frith and Beehler 1998). It is patchily distributed on the Central Cordillera from the Weyland Mountains to the Herzog Range in Morobe Province in Montane Forest between 1,200 and 2,000 m asl, although it has been recorded as low as 600 m asl. This species is protected under the PNG Fauna (Protection and Control) Act 1966 so its sensitivity is medium.

The Yellow-breasted Bird-of-paradise appears to be restricted to primary forest (Woxvold 2008, BirdLife International 2017c). Since no infrastructure is planned for the higher elevations and only a tiny amount of habitat may be lost from the upper edges of the pit and possibly a communications tower. Residual direct impacts are predicted to be negligible.

Hunting remains a concern, but the species is not specifically targeted. Control of the work force is the major mitigation to reduce hunting. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced and indirect effects are predicted to increase residual impacts to minor.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be moderate.

18.4.8 Doria's Goshawk *Megatriorchis doriae*

Doria’s Goshawk is a small raptor, to 70 cm long. It usually flies below the canopy mainly preying on birds. It is a poorly known New Guinea endemic sparsely distributed from sea level up to at least 1,100 m asl. The paucity of records appears to be at least partly due to its unobtrusive habits. It’s tolerance to habitat loss or degradation is poorly known, though it has been seen repeatedly in logged forest near Port Moresby (BirdLife International 2016f). A single Doria’s Goshawk was observed at close range at Nena D1 Site during the 2011 surveys.

Doria’s Goshawk requires large areas of forest. Habitat of this species will be lost, particularly in the GFA but the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. This species is unlikely to be impacted by barrier effects. Residual direct impacts are predicted to be negligible.

The species is hunted (BirdLife International 2016f) and control of the work force is the major mitigation to reduce this. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced and indirect effects are predicted to increase residual impacts to minor.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be moderate.

18.4.9 Gurney's Eagle *Aquila gurneyi*

The rarely seen Gurney’s Eagle is a typical eagle that soars high over the forest (Coates 1985, Pratt and Beehler 2015). It occurs in the Moluccas and throughout New Guinea, where it is widespread though sparsely distributed in all forest habitats from sea level to ca. 1,300 m asl (Coates 1985, BirdLife International 2016g). Although it appears to prefer primary forest it has been seen foraging over cleared and cultivated areas (Coates 1985). It has not been recorded in the Study Area but is likely to occur and suitable habitat is widespread. BirdLife International (2016g) considers that “It clearly occurs at low population densities and is likely to be declining slowly through habitat loss and degradation” but offer no specific analysis of threats. Hunting may also present a threat to this species, but the situation is less clear than for the more conspicuous Papuan Eagle.

Gurney's Eagle requires large areas of forest and habitat of this species will be lost, particularly in the GFA but the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. This species is unlikely to be impacted by barrier effects. Residual direct impacts are predicted to be negligible.

The species does not appear to be specifically targeted by hunters and control of the work force is the major mitigation to reduce hunting. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced and indirect effects are predicted to increase residual impacts to minor.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase. The residual impacts in such a case could be moderate.

18.4.10 Forest Bittern *Zonerodius heliosylus*

This New Guinea endemic is a reclusive, solitary, rarely seen and cryptically marked, black and buff striped heron to 70 cm long, so poorly known that its voice is yet to be described (Coates 1985, Coates and Peckover 2001, provisionally described in Woxvold 2008). It is a widely distributed inhabitant of forest swamps, streams and pools from the lowlands to 1,430 m asl. It was recorded at Malia Site during the 2011 surveys and elsewhere in the region it has been reported from near Maprik (Pearson 1975) and Vanimo (Palliser 1989), Astrolabe Bay and the Bismarck Range (Stresemann 1923). It is not known to what degree this species is tolerant of disturbed habitats, though it has been recorded previously in selectively logged forest (Palliser 1989).

BirdLife International (2017d) lists no specific threats to the Forest Bittern but habitat loss, degradation and fragmentation present the major threats to it in the Study Area. Habitat of this species will be lost, particularly in the GFA, but the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. This species is unlikely to be impacted by barrier effects. Residual direct impacts after mitigations to minimise the Project disturbance area and prevent wildfires from starting at the Project disturbance area are predicted to be negligible.

The species does not appear to be specifically targeted by hunters and the major indirect impacts would be further forest loss from in-migration and wildfires and the accidental introduction of exotic diseases and pests. Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Indirect effects are predicted to increase residual impacts to minor. Resettlement patterns would be unlikely to alter this.

18.4.11 Blue-black Kingfisher *Todiramphus nigrocyaneus*

The Blue-Black Kingfisher is a medium-sized kingfisher with deep blue and black upper parts, known from only a few widely scattered sites. According to Woxvold (Chapter 4 in EIS Appendix 8B) it is a "rare and poorly known New Guinea endemic occupying lowland forest to ca. 600 m AMSL (Beehler and Pratt 2016). The distinctive subspecies occupying northern mainland PNG, T*odirhamphus nigrocyaneus quadricolor*, is known from a handful of sites from Yapen Island and the lowlands of north Papua Province (Indonesia) east to Astrolabe Bay and an isolated population recently discovered in the lower Markham River (I. Woxvold, unpublished data; Beehler and Pratt 2016). Not recorded in 2017, but provisionally recorded … at the Kaugumi site during the 2009-2011 surveys. Suitable habitat within the Study Area occurs as alluvial forest and tall swamp vegetation, including swamp forest and sago swamp woodland. Potentially absent from logged forest areas in the northern sector of the Study Area."

Reports from Papua Province, Indonesia, include numbers of birds in "swamp forest" around Nimbokrang near Jayapura (Gregory 2008). The main threats are likely to be habitat loss, degradation and fragmentation, through clearing or large-scale changes in hydrology and stream contamination. It may be threatened by logging, particularly of Swamp Forest, and the consequential decline in water quality (BirdLife International 2017e).

Areas of lowland forest suitable for this species will be lost throughout the infrastructure corridor and lower sections of the GFA. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations and is very unlikely to cause local extinctions. It is unlikely to be impacted by barrier effects but may be impacted by changes to water quality and stream side vegetation but mitigations to control clearing at watercourses, control AMD, tailings and contaminants should result in residual direct impacts to be negligible.

Hunting is unlikely to be an issue for this species but further deforestation resulting from in-migration would be a threat. This can only be controlled to a limited extent by the Project In-Migration Management Strategy. Because of the uncertainties associated with the effects of in-migration, indirect effects are predicted to increase residual impacts to minor. Resettlement is unlikely to affect this assessment.

18.4.12 Banded Yellow Robin *Poecilodryas placens*

The Banded Yellow Robin is an inconspicuous, small olive-green and yellow bird that forages for insects in the lower stages of the forest (Coates 1990). It is patchily distributed in Hill Forest and Montane Forest from 100 to 1,450 m asl throughout New Guinea but not recorded so far from the Sepik region (BirdLife International 2017f, Coates 1990). It appears to prefer primary forest. BirdLife International (2017f) state: "Although the small total population may be isolated into subpopulations, some of which may be threatened by logging, its extensive and often inaccessible range suggests that there are more, safe subpopulations yet to be discovered." As a species of primary forest interior, it would be threatened by clearing and fragmentation.

There will be habitat loss for this species, should it occur, however, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. Residual direct impacts after mitigations, should this species occur, are likely to be negligible.

Hunting is unlikely to be an issue for this species but further deforestation resulting from in-migration would be a threat. Because of the uncertainties associated with the effects of in-migration, indirect effects are predicted to increase residual impacts to minor. Resettlement is unlikely to affect this assessment.

18.4.13 Beach Stone-curlew *Esacus magnirostris*

The Beach Stone-curlew is a large, resident shorebird of beaches, tidal flats, reefs and mangroves and is widespread in the Asia Pacific region. It lays a single egg in a scrape in the sand at the landward edge of the beach, often using the same area repeatedly. It forages mainly in the intertidal zone on crustaceans and other invertebrates (BirdLife International 2016h). It is threatened by human disturbance of beach habitats and may be impacted by predation by introduced mammals.

It may occur on shores and subcoastal habitats at the northern end of the infrastructure corridor, but likely to be scarce as much of the Vanimo coast is frequently visited by humans. The Project does not impinge on any of its coastal habitats except at the port at Vanimo where the species is highly unlikely to be still extant. Residual direct impacts are predicted to be negligible and indirect effects are not predicted to increase residual impacts further.

18.4.14 Listed waders

A range of threatened migratory waders could potentially occur within the Project area including the two Endangered species Far Eastern Curlew *Numenius madagascariensis* and Great Knot *Calidris tenuirostris* (considered above in sections 18.2.4 and 18.2.5), and the Near Threatened Black-tailed Godwit *Limosa limosa*, Bar-tailed Godwit *L. lapponica,* Red-necked Stint *Calidris ruficollis,* Red Knot *Calidris canutus)*, Curlew Sandpiper *C. ferruginea*, Asian Dowitcher *Limnodromus semipalmatus* and Grey-tailed Tattler *Tringa brevipes*. None are protected under the PNG Fauna (Protection and Control) Act 1966.

These species generally have large breeding ranges in the Russian Far East and beyond, and migrate south to winter in Europe, Africa, the Middle East and Australasia. The vast majority that visit New Guinea are *en route* to Australia via the East Asian-Australasian flyway. Numbers are highest from October to November and again from April to May when they are on passage between Australia and the breeding grounds, but some birds remain throughout the summer months They frequent shallow freshwater and muddy marine habitats and, though predominantly coastal, can also occur in interior wetlands.

Few waders were recorded in the Study Area, but any can occur on soft muds and sands adjacent to any of the major waterways, open swamps and lakes in the Lowland Zone. Waders have undergone large and well-documented declines and the major threats are loss and fragmentation of nesting habitat, loss of key stopover sites, particularly in the Yellow Sea region, hunting, water pollution and drought and loss of high quality wintering sites (BirdLife International 2016a, 2017a). Conservation issues concerning Palaearctic waders and their habitats are discussed in EIS Appendix 8A Chapter 4 and the situation has worsened since that was written (BirdLife International 2017a).

There will be no direct impacts to the coastal habitats of these species nor the off-river waterbodies which would be their primary inland habitat. The major potential impacts are contamination of waterways reaching these habitats (Frazier 2007). Mitigations aimed at preventing contamination should result in negligible residual direct impacts on these species and indirect effects are not predicted to increase this further.

18.4.15 Chimaera Birdwing *Ornithoptera chimaera*

The Chimaera birdwing *O. chimaera* is confined to the Central Cordillera of New Guinea where it is locally common in primary forest and forest margins in upland areas between 1,200 and 2,800 m asl wherever its food plant, *Pararistolochia pithecurus* grows. Males have wingspans up to 153 mm and females up to 178 mm It is relatively common at Telefomin (Parsons, *pers. comm.* to C. Muller, 2010). This species is quite elusive and relatively inconspicuous, despite its size. It was not recorded in the Study Area but could easily occur. This species is protected under the PNG Fauna (Protection and Control) Act 1966 so its sensitivity is medium.

Birdwings favour forest margins and may respond positively to linear clearings in forest, but degradation of the forest edges that reduces the abundance of their food plants, would degrade this. This is a large, powerful, high-flying species that can cross gaps readily - even large barriers (up to 2 km wide). They tend not to use waterways as a flight path, unlike many butterfly species; therefore, disruption to streamline vegetation would not adversely affect the species. Dust along roads would be moderately detrimental as the larval food plant would likely suffer dieback in such areas and dust on leaves of food plant would inhibit larvae feeding on them.

Permanent loss of habitat may reduce populations, but they may benefit from the creation of more edges, especially if their food plants are abundant. The anticipated losses can be mitigated through nursery propagation and planting of their food plants in areas designated for managed revegetation. Forest degradation by in-migration is less easily controlled. Residual direct impacts are predicted to be negligible and should their food plants expand in population the residual impacts may even be positive. Indirect effects are not predicted to increase residual impacts beyond this. Resettlement patterns are unlikely to alter this assessment.

18.4.16 New Guinea Kauri *Agathis labillardieri* Warb.

New Guinea Kauri is a widespread endemic occurring from 50 to 2,000 m asl, mainly distributed in Papua (Indonesia) and islands off the Vogelkop Peninsula but extending into PNG. According to Farjon (2013) it extends to the Sepik River but maps in Whitmore (1977) and the Gymnosperm Database (2015) indicate it occurs patchily to north of Mt Hagen. The species, like all *Agathis*, is long-lived and grows to huge sizes (60 m high) over several hundred years. It is a common emergent in the GFA. Farjon (2013) indicates logging is a threat to the population of "mature" trees and it "can only maintain itself if the forest is left undisturbed for at least 100 years". This dependence on a lack of disturbance does not conform with literature on the dynamics of this genus where regeneration of many, perhaps all species, is disturbance related. Logging experiences with congeners in North Queensland suggests bare mineral soil may be needed for seed germination (F. Crome *pers. obs*.) and the New Zealand *A. australis* regenerates densely after large-scale disturbance then self-thins until continued mortality produces gaps that allows a second non-synchronised wave of recruitment (Ogden *et al.* 1987). Whitmore (1977) also records several plantations of New Guinea Kauri indicating a capacity to regenerate in full light. Kauris probably need disturbance to establish large populations but for trees to reach large stature they need to be left alone. Besides logging, clearance for palm oil plantations in lowland areas has reduced this species' area of occupancy to some extent.

There will be habitat loss for this species, some population reduction would be expected within the GFA and individual trees will be lost along the infrastructure corridor. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations, the species' wider distribution will act in natural offset of local impacts and it is a potential recruit in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of this species in areas designated for managed revegetation. Residual direct impacts are predicted to be negligible.

Illegal logging using Project infrastructure, wildfires, and the accidental introduction of exotic diseases and pests are the major concern. The former is highly unlikely and the Weed, Pest and Quarantine Management Sub-plans and Emergency Response and Fire Management Sub-plans to EMMPs are the major mitigations for impacts. Forest degradation by in-migration is less easily controlled but large-scale felling of individual kauris is unlikely. Indirect effects are not predicted to increase residual impacts beyond negligible. It is unlikely this assessment would be changed by resettlement patterns as the species is so widespread.

18.4.17 Cycad *Cycas rumphii* Miq

Cycads are valued for horticulture and over-collecting has depleted some populations leading to CITES listing as an Appendix II family and some species such as *Cycas rumphii* Miq as IUCN Near Threatened. This species is widespread in Indonesia, New Guinea, the Bismarck Archipelago, the Solomons, and the Marshall and Caroline Islands, and was recorded at Iniok, Wario, and Wogamush in the surveys. It is one of the commonest species in the genus and has sizable populations in the Ambunti District (W. Takeuchi *pers. obs*.). It is a primitive, palm-like gymnosperm exceeding 10 m in height bearing pinnate leaves up to 3 m long clustered in a terminal spray. Large bright orange seeds are produced among the leaves at the apices of long stems. The seeds have an inner spongy layer and can float in seawater and most of the known populations are probably the result of ocean dispersal (Laubenfels and Adema 1998). It grows mainly in strand or coastal forest, often on limestone, but also in woodland. Hill (2010) describes it as locally abundant but, at least in the upper Sepik region, it is not under conservation threat (W. Takeuchi *pers. obs*.). *C. rumphii* is less desired for horticulture because of its size, and so is not subject to commercial collecting pressure.

There will be habitat loss for this species, some population reduction would be expected within the GFA and individual trees will be lost along the infrastructure corridor. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations, the species' wider distribution will act in natural offset of local impacts and it is a potential recruit in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of this species in areas designated for managed revegetation. Residual direct impacts are predicted to be negligible.

Forest degradation by in-migration is less easily controlled but large-scale targeted collecting of individual cycads is unlikely, and indirect effects are not predicted to increase residual impacts beyond negligible. Resettlement would be unlikely to exacerbate the potential impacts further.

18.4.18 The Aglaias

IUCN lists four species of *Aglaia* that occur in the Study Area as Near Threatened (Pannel 1998a, b, c and d), although it is not clear why. The genus *Aglaia*, with more than 105 species, is the largest genus and taxonomically the most difficult in its family. Morphological characters are almost never individually diagnostic (Pannell 1992). It is, however, one of the characteristic components of the Malesian flora and is frequently a local dominant in the lowland forests of New Guinea. With only 38 currently recognized species in Papuasia the genus is disproportionately represented in the IUCN rankings. The present IUCN overweighting for *Aglaia* taxa, in relation to other groups with much fewer collections, suggests that future adjustments to the listings may be required.

Aglaia agglomerata Merr. is a tree from 3–32 m high and occurs as two variants—one where the infructescence produces only 1 or 2 large fruits, and a second variant which bears numerous (up to 36) smaller fruits (Pannel 1992). The cause for this dichotomy is unknown, as both forms can occur together, virtually side by side, in the same population (W. Takeuchi *pers. obs.*). It is found only on the New Guinea mainland, from the Vogelkop Peninsula to Milne Bay Province (Pannell 1992, 1998a). At least 23 determined collections are present in the PNG National Herbarium. This ecologically versatile species occurs from 10–1800 m asl in primary and secondary forests, riverine forest, and even on limestone (Pannell 1992).

Aglaia rimosa (Blanco) Merr. can occur as an understory shrub or a canopy tree to 30 m high (Pannell 1992) and can be recognized by the shiny, peltate scales visible to the naked eye on vegetative surfaces. It has a wide geographic distribution including Taiwan, the Philippines, Sulawesi, Moluccas, New Guinea, and the Bismarck Archipelago. The species has been documented by collections from sea level to 1,350 m asl in secondary habitats, riverine forests, and coastal limestone (Pannell 1992, 1998b). Unlike many congeners, it appears to have a tolerance for disturbance and is capable of establishing in regrowth as a mid-stage entrant (W. Takeuchi *pers. obs*.). Forest clearing, if done on a controlled basis, may actually result in increasing the amount of potential habitat.

Aglaia subcuprea Merr. and Perry is a tree 4 to 30 m in height and with bole diameters up to 1.6 m. Like other Aglaias, this species is difficult to characterize and even Pannell (1992) was unable to determine if collections from the Solomon Islands are part of the *subcuprea* facies or outside of it. Endemic to Papuasia, *Aglaia subcuprea* has been documented from at least 24 localities in New Guinea and New Ireland (Takeuchi 2005a). The species is found over a wide range of lowland and montane environments to 2,570 m asl, including seasonally inundated primary forest, secondary forest, and riverine habitats (Pannell 1992).

Aglaia euryanthera Harms is a small tree found in New Guinea up to 2,100 m asl and northeast Queensland in rainforests, riverine forests and gallery forests (Australian Tropical Rainforest Plants 2015).

Pannel (1998a, b, c and d) lists habitat loss as a potential threat for all these species but considering their widespread distributions, regeneration capacity, preference in some cases for secondary habitats, and that they are generally not logging target, they would appear to be secure.

There will be habitat loss for all four species and some population reduction would be expected within the GFA and individual trees will be lost along the infrastructure corridor. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations, the species' wider distribution will act in natural offset of local impacts and they are potential recruits in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of these species in areas designated for managed revegetation. Residual direct impacts are predicted to be negligible.

Forest degradation by in-migration is less easily controlled but large-scale targeted collecting of these species is unlikely and indirect effects are not predicted to increase residual impacts beyond negligible. Resettlement would be unlikely to exacerbate the potential impacts further.

18.4.19 Guma *Myristica globosa* Warb

M. globosa Warb. (Guma in Sepik vernacular) is a tree to 35 m in height distributed throughout New Guinea, where at least 196 collection sites are represented in the PNG National Herbarium, mainly in the lowlands (excepting monsoon forest) at elevations from sea level to 1,500 m asl (de Wilde 1995). It is one of the more widespread species in the genus, occurring from the Moluccas to the Solomon Islands (Foreman 1978). At least in Mamose region, *M. globosa* is often common where it occurs (W. Takeuchi *pers. obs*.). Although it achieves timber size, *M. globosa*'s unusually wide distribution would tend to mitigate logging impacts on the species as a whole. The World Conservation Monitoring Centre (1998d) does not list any threatening processes for this species.

This species occurs scattered in the forest and rarely forms dense stands. Thus, while there will be habitat loss particularly within the GFA, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations and the species is a potential recruit in regeneration. The anticipated losses can be mitigated through nursery propagation and planting of this species in areas designated for managed revegetation. Residual direct impacts should negligible.

Forest degradation by in-migration is less easily controlled but large-scale targeted felling of this species is unlikely and indirect effects are not predicted to increase residual impacts beyond negligible. Resettlement would be unlikely to exacerbate the potential impacts further.

18.5 Protected and/or locally important species

Species protected under the PNG Fauna (Protection and Control) Act 1966 are of Moderate sensitivity except those of high cultural significance which are of High sensitivity.

18.5.1 Cassowaries

Two of the three species of cassowary occur in the Study Area – the Northern Cassowary *Casuarius unappendiculatus* and the Dwarf Cassowary *C. bennetti*. Neither are protected under the PNG Fauna (Protection and Control) Act 1966, both are classed as Least Concern by IUCN but both all extremely culturally significant so are considered of high sensitivity for this EIS. Restricted to the Australo-Papuan region, cassowaries are of major cultural and economic importance to local communities throughout New Guinea. Cassowaries are the world's largest avian frugivores, solitary and territorial, with individual birds occupying a large home range that provides fruit all year round. Cassowaries are believed to play an important role in forest ecosystem dynamics by dispersing the seeds of many rainforest plants (Mack 1995, Mack and Wright 2005, Westcott *et al.* 2008).

The 1.5 m high Northern Cassowary is endemic to northern New Guinea and inhabits rainforest and swampy forest to at least 500 m asl preferring forest on gentle terrain (Coates 1985, Pratt and Beehler 2015). The global population is estimated at ten to twenty thousand (BirdLife International 2017g) and the species is widespread and common in the Study Area Lowland Zone. The Dwarf Cassowary reaches 1. 1 m high and occurs throughout upland forests of New Guinea and New Britain, but also locally in the lowlands (Coates 1985, Coates and Peckover 2001). The Dwarf Cassowary probably occurs throughout the Study Area Hill and Montane Zones. All cassowaries tolerate habitat disturbance, especially where this increases the abundance of fruiting plants, and have been recorded in secondary growth and habitat mosaics (e. g. Coates 1985, Crome and Moore 1990, Marchant and Higgins 1990, Mack *et al.* 2000, Birdlife International 2016i). Suitable habitat for both cassowaries is widespread throughout the Study Area.

There will be habitat loss for both species particularly in the GFA but considering the wide distribution of most, and their general adaptability the residual direct impacts are predicted to be minor.

Hunting remains a primary threatening process. Cassowaries have been locally extirpated near many settled areas (e. g. Gilliard and LeCroy 1966, Coates 1985, Healey 1986, Johnson *et al.* 2004, BirdLife International 2016i and 2017g, Pratt and Beehler 2015). Banning hunting by the work force is the major mitigation. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced and these birds are primary targets Indirect effects are predicted to increase the residual impact to major.

Resettlement could exacerbate the potential impacts if villagers are moved into parts of the Study Area where they would not normally, or only occasionally hunt. The residual impacts in such a case could be higher.

18.5.2 Birds of paradise

All the species of Bird-of-paradise and Satinbirds are protected under the PNG Fauna (Protection and Control) Act 1966 so their sensitivity is medium. Nine species of Birds-of-paradise and Satinbirds were recorded, nine others could occur. Two of these the Pale-billed Sicklebill and the Yellow-breasted Satinbird are discussed above (sections 18.4.6 and 18.4.7.) All but two are endemic to New Guinea and all are protected under the PNG Fauna (Protection and Control) Act 1966. All are arboreal foragers for fruit and insects, usually in the middle and upper stages of the forest, and most have communal display grounds (leks) where males compete for females. The males are characterised by spectacular plumage while the females are duller plain brown.

Eight species are fundamentally montane or mid montane in distribution and would only occur in the Montane Zone or upper reaches of the Hill Zone of the Study Area. The Black Sicklebill *Epimachus fastosus* is a large species where the blue-black males carry huge sabre-shaped tails over a meter long. While polygynous the males display solitarily rather than in leks (Frith and Beehler 1998). It occurs on the Vogelkop and Bomberai Peninsula in Papua Province, Indonesia, along the Central Cordillera of New Guinea from the Weyland Mountains to the Kratke Range, and on the Bewani and Torricelli mountains in the North Coastal Ranges, between 1,280 and 2,550 m asl, mainly from 1,800 to 2,150 m asl, in Montane Forest. While not recorded in the Study Area it is one of the few montane long-tailed birds of paradise that range low enough in elevation to potentially occur.

Males of the Black-billed Sicklebill *Drepanornis albertisi* are, in contrast, short tailed, brown with flank plumes tipped iridescent purple, but have very long, down-curved bills. The species is more insectivorous than other birds-of-paradise and uses its long beak to probe bark, foliage etc. for insects. The males display solitarily while in audible contact with one another in an “exploded lek” (Frith and Beehler 1998). The species occurs in the west of Papua Province, Indonesia, and the central and eastern, but not the middle, parts of the Central Cordillera, between 600 and 2,500 m asl (mostly 1,100 to 1,900 m asl) elevation in Hill Forest and Montane Forest. It also occurs on the Huon Peninsula. It was not recorded in the Study Area but has been collected 70 km east of the Frieda Strip Site at Lordberg (4.92 S 143.0 E) (Stresemann 1923).

The King-of-Saxony Bird-of-paradise *Pteridophora alberti* is a species of high mountains (1,400 to 2,850 m asl, but mostly 1,800 to 2,500, in Lower Montane Forest (L ± c) and, if it occurs at all, it could only be in the very highest parts of the Study Area. It is a small (22 cm long) species where the males, which are black with yellow underparts, boast two long plumes from the rear of the head that can reach 50 cm long and consist of a bare feather shaft with 40–50 sky blue "flags" decorating the outer edge. It is polygynous with males displaying an "exploded lek" (Frith and Beehler 1998). It only occurs on the Central Cordillera from the Weyland Mountains to the Kratke Range.

Loria's Bird-of-paradise *Cnemophilus loriae* is a small montane species distributed from the Weyland Mountains to the Owen Stanleys between 1,200 to 3,000 m asl, mostly above 2,000 m asl in Montane Forest and Lower Montane Forest (L ± c). It was not recorded in the Study Area but is difficult to detect.

The Short-tailed Paradigalla *Paradigalla brevicauda* and Superb Bird-of-paradise *Lophorina superba* are much more obvious if present. The Paradigalla is an all-black bird, 23 cm long, with yellow wattles on the front of the face and an iridescent blue-green crown. It is a canopy feeder and while the species is probably polygynous the males display solitarily rather than in leks (Frith and Beehler 1998). It occurs in Montane Forest between 1,400 and 2,580 m asl, but mostly above 1,580 m asl from the Weyland Mountains to the Bismarck Range. It occurs in secondary forest, forest edges and garden areas as well as primary forest. The Superb Bird-of-Paradise is similarly sized, and males have an iridescent blue-green breast and a cape of long nape plumes. Males display in an "exploded lek" (Frith and Beehler 1998). It occurs throughout the Central Cordillera, the Vogelkop and the Huon Peninsula between 1,000 to 2,300 m asl (mostly 1,650 to 1,900 m asl) in Hill Forest and Montane Forest.

The only montane bird-of-paradise recorded in the Study Area was Queen Carola's Parotia *Parotia carolae*, a medium-sized species (26 cm long), in which the males are velvety black with an iridescent breast and complex head decorations including three long wiry plumes emerging from behind each eye. While an arboreal forager it forms terrestrial leks where males gather loosely within earshot but out of sight of each other to display (Frith and Beehler 1998). It occurs in the central and western part of the Central Cordillera from about Mt Hagen west to the Weyland Range in forests between 1,100 and 2,000 m asl but generally above 1,450 m asl.

The remaining nine species are hill or lowland birds. The most conspicuous is the Lesser Bird-of-paradise *Paradisea minor*, adult males of which are brown and yellow with an iridescent green throat and have long, dense yellow plumes that emerge from under the wings. It is a lekking species in which up to 10 or more males perform at leks, which may be temporary or used continuously for many years. Leks may be formed in any habitat type, but usually in the upper portion or top branches of a canopy tree, often in a prominent position such as a ridge crest (Frith and Beehler 1998). The Lesser Bird-of-paradise is endemic to northern New Guinea from the Huon Peninsula west to the Vogelkop Peninsula and nearby Misool and Yapen islands, where it inhabits primary and disturbed Lowland Open Forest (Po) and Hill Forest (HM) up to ca. 1,550 m asl (Frith and Beehler 1998). This was one of the most conspicuous and widespread birds of the Study Area Hill Zone.

Another spectacular lowland species is the large (33 to 36 cm) Twelve-wired Bird-of-paradise *Seleucides malanoleucos*. Males are velvety black with a long, decurved bill, yellow belly and huge yellow side plumes from which long, thin black recurved wires extend back across the body. The species is polygynous, and males display from emergent, bare, near-vertical branches (Frith and Beehler 1998). It occurs throughout the lowlands of New Guinea inhabiting Swamp Forest formations, especially with sago, mostly below 100 m asl (Frith and Beehler 1998). It is omnivorous and is strongly associated with pandanus and sago and it stays mostly in the canopy. It was recorded only in the Study Area Lowland Zone.

Two common small species of the middle storey, understory and ground layers are the Magnificent Bird-of-paradise *Cicinnurus magnificus* and the King Bird-of-paradise *C. regius*. Males of the former are brilliantly coloured with complex plumage, including a thick, iridescent, silky, yellow cape and two curled tail streamers. It is a common and predominantly frugivorous species (Frith and Beehler 1998). The leks are on the ground in "courts", which are spaced together out of sight and earshot of each other. The species is widespread in throughout New Guinea including Yapen and Salawati islands from near sea-level to over 1,750 m asl, but mostly between 400 and 1,400 m asl (Frith and Beehler 1998). It frequents the middle and lower strata of primary forest (Frith and Beehler 1998) and also occurs in disturbed habitats (Coates 1990). Male King Birds-of-paradise are brilliant orange-red with a white belly and two long, bare tail-feather shafts tipped with iridescent green plumes. The lek is a terrestrial "exploded lek" where males gather loosely within earshot but out of sight of each other to display on perches 100 m or more apart. It also is a widespread common resident of forests, including Swamp Forest formations and gallery forest up to ca. 300 m asl, less commonly higher (Frith and Beehler 1998). Both species were common in the Study Area, the Magnificent Bird-of-paradise commoner in the Hill Zone.

The final five species are medium sized (32-43 cm) black, relatively unadorned birds of the upper and middle parts of the canopy. All are solitary, do not form leks, and are highly frugivorous. The Magnificent Riflebird *Ptiloris magnificus* is a long-billed species, where the males are velvety black with an iridescent breast and cap and filamentous flank plumes. It is a solitary, non-lekking species and territorial males are polygynous, calling and displaying from tree trunks, branches and dead stumps to attract females. It feeds on fruit and invertebrates (Frith and Beehler 1998). A shy species, its presence is usually revealed by the male's distinctive call (Frith and Beehler 1998). It inhabits forests in the lowlands and hills up to 1,450 m asl (normally lower than 700 m asl) as well as swampy and gallery forest throughout New Guinea and eastern Cape York Peninsula, Australia. It was patchily distributed in the Study Area Hill Zone.

The Manucodes are similarly solitary and non-lekking species. Three of them - Glossy–mantled Manucode *Manucodia atra*, Crinkle-collared Manucode *M. chalybata* and Jobi Manucode *M. jobiensis* are extremely difficult to identify in the field. Unlike other birds-of-paradise, the sexes are similar. The Glossy-mantled Manucode is iridescent black, sheened green and purple with dense, velvety feathers above the eye. The Crinkle-collared Manucode and Jobi Manucode are very similar except they have elongate erectile feathers above the eye forming a small tuft.

The Glossy-mantled Manucode is the most common manucode in open and disturbed habitats, occurring throughout New Guinea in forest edge, secondary growth, Swamp Forest formations, woodlands and scrub in the lowlands and foothills, locally up to ca. 900 m asl. It is not found in the interior of primary rainforest (Coates 1990). The Crinkle-collared Manucode also occurs throughout New Guinea but predominantly between 600 and 1,500 m asl, though it has also been recorded near sea-level (Frith and Beehler 1998) and appears to enter intact forest more. Both species apparently specialise on figs (Frith and Beehler 1998). The Jobi Manucode is more restricted in distribution being found only in the northern lowlands and a restricted part of the southwestern lowlands of New Guinea where it inhabits various types of forest and forest edges normally up to 500 m asl but occasionally as high as 750 m asl (Frith and Beehler 1998).

The several sightings of manucodes during the surveys suggest strongly that all three are present.

Finally, although not recorded, the Trumpet Manucode *Manucodia keraudrenii* is likely to occur. It is a medium sized (28 to 31 cm long), all black, iridescent green and blue bird with a shaggy mane of loose feathers on the nape of the neck. It is very noisy but not often seen and forages for fruit and insects in the canopy. This species is monogamous and does not engage in group displays (Frith and Beehler 1998). It is widespread throughout New Guinea and occurs on northeast Cape York, Australia. It occurs in forest at elevations from 200 to 2,000 m asl, but mainly above 900 m asl (Frith and Beehler 1998). There are only two lowland records from the northern slopes of the Central Range. It is predominantly a bird of primary forest in New Guinea although not in Australia, where it has been recorded often at forest edges and in secondary forest.

While none of these birds-of-paradise would survive if subject to large scale clearing of their habitats, all the lowland and hill birds of paradise are tolerant of forest disturbance to some extent and occupy edge and secondary habitats commonly. For the more frugivorous species a mosaic of habitats provides a more plentiful and reliable source of fruit. The higher elevation species are more dependent on primary forest but do use edge and secondary habitats, particularly the Short-tailed Paradigalla, the Superb Bird-of-paradise and Queen Carola's Parotia which can use very disturbed forest and even garden areas (Frith and Beehler 1998). Though generally reliant on undisturbed forest, the Black Sicklebill is moderately tolerant of disturbed habitats, being found in forest edge and occasionally in adjacent secondary growth as well as primary formations (Frith and Beehler 1998, I. Woxvold pers. obs.).

Hunting is likely the most significant threatening process for all except the duller species such as the manucodes and Loria's Bird-of-paradise. For those with dense leks the loss of an entire lekking area through clearing could impact a local population e. g. display grounds of the Magnificent Bird-of-paradise may be separated by only 150-300 m asl (Frith and Beehler 1998).

Since no infrastructure is planned for the higher elevations and only a tiny amount of habitat may be lost from the upper edges of the pit and possibly a communications tower, any upland species that may occur are highly unlikely to be impacted at all. For the lowland species all can occupy or even favour disturbed habitat mosaics so even though some habitat will be lost it is unlikely to impact significantly on local populations. None of the birds-of-paradise are likely to be impacted by barrier effects. The issue of loss of lekking sites remains but it will not be practical to locate the leks of all species, as many are very hard to locate. The exception is the display trees of the Lesser Bird-of-paradise, which usually are obvious where they occur in more open areas. Residual direct impacts are predicted to be negligible for all species.

Hunting of the more valued species is a potential impact. Banning hunting by the work force is the major mitigation. However, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects are not predicted to increase residual impacts beyond negligible for the less valued species and to increase residual impacts to minor for all but the Lesser Bird-of-paradise. The residual impact for the latter is predicted to be moderate because of the demand for its plumes.

Resettlement could exacerbate the potential impacts if villagers are moved into parts of the Study Area where they would not normally, or only occasionally hunt. The residual impacts in such a case could be moderate and possibly major for the Lesser Bird-of-paradise.

18.5.3 Palm Cockatoo *Probosciger aterrimus*

The Palm Cockatoo is a conspicuous black cockatoo with a red face and large crest, which occurs throughout the New Guinea lowlands and hills up to 1,300 m asl in rainforest, secondary forest and tropical savanna. It also occurs in northern Australia and islands in the New Guinea region. It eats a variety of fruit and the kernels of hard nuts and seeds (Igag (2002) and is known to eat earth, which may help detoxify some of the seeds it eats (Symes *et al.* 2006). Palm Cockatoos are hunted for their meat and plumes (e. g. Kocher Schmid 1993) and have declined or become locally extinct in many places (Coates 1985, Igag 2002). Their population biology in New Guinea has not been investigated; though in Australia they breed infrequently and typically lay only one egg at a time (Murphy *et al*. 2003). While these sensitivities have led to downward declines in settled areas in New Guinea there are still large areas of remote and intact forest where Palm Cockatoo populations remain secure. Palm Cockatoos occur throughout the Study Area, though in smaller numbers than most other large parrots and cockatoos.

As well as requiring large areas of forest Palm Cockatoos require nesting hollows in mature trees.

There will be habitat loss for this species and some population losses would be expected. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. There will be loss of nesting hollows and a mitigation to retain large nesting trees around temporary facilities is suggested. This species in unlikely to be impacted by barrier effects. Residual direct impacts are predicted to be minor.

Hunting is a threat and while banning hunting by the work force is the major mitigation, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects are predicted to increase residual impacts to moderate.

Resettlement could exacerbate the potential impacts further if villagers are moved into parts of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further. The residual impacts in such a case could be major.

18.5.4 Blyth's Hornbill *Rhyticeros plicatus*

The only Hornbill in New Guinea, Blyth's Hornbill *Aceros plicatus*, is one of the region's largest and most mobile frugivores and plays an important role in forest ecosystem dynamics (Mack and Wright 2005, Kinnaird and O'Brien 2007). It ranges from the northern Moluccas to the Solomons and is widespread throughout New Guinea up to 1,800 m asl. Blyth's Hornbill occurs and is hunted throughout the Study Area where it was one of the most widely recorded bird species. During the survey at Frieda Bend Site a hunting dog killed a male hornbill, which had alighted on the ground. Outsiders also come to these remote forests to hunt. At Frieda Strip Site in October 2009 I. Woxvold met a resident of Ambunti who had travelled in by boat specifically to hunt 'Kokomo' (hornbills), which he said are still common there relative to areas near his home. Hornbills are sensitive to a wide range of threats. They occur in low densities, reproduce slowly and require large areas of habitat with ample supply of fruiting trees and tree nesting holes (Kemp 1995, 2001, Kinnaird and O'Brien 2007). Blyth's Hornbills are also hunted for food, ornamental use, or to be kept as pets, and have thus become scarce near many settled areas (Coates 1985). Despite these pressures, its status in New Guinea is fairly secure, particularly given that the island boasts the largest contiguous area of forest in the Asian hornbill realm (Kinnaird and O'Brien 2007).

There will be loss of habitat for this species and some population losses would be expected. However, the large areas of remaining habitat suggest that the impact will not threaten Study Area populations. There will be loss of nesting hollows and a mitigation to retain large nesting trees around temporary facilities is suggested. This species in unlikely to be impacted by barrier effects. Residual direct impacts after mitigations to minimise the Project disturbance area and prevent wildfires from starting at the Project disturbance area are predicted to be minor.

Hunting is a threat and while banning hunting by the work force is the major mitigation, hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects are predicted to increase residual impacts to moderate.

Resettlement could exacerbate the potential impacts further if villagers are moved into parts of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase further. The residual impacts in such a case could be major.

18.5.5 Egrets

Three species of cosmopolitan egrets are protected under the PNG Fauna (Protection and Control) Act 1966 - Little Egret *Egretta garzetta,* Eastern Great Egret *Ardea alba* and Intermediate Egret *Ardea intermedia*. Though some egrets are present in PNG all year round, the breeding status of all species is poorly understood and is complicated by the annual migration of waterbirds between Australia and New Guinea (Dingle 2004). All three egrets are known from wetlands in the Sepik drainage, with Intermediate and the Eastern Great Egret being the commonest and all three occur in the Study Area Lowland Zone with single birds and small parties regularly seen in the larger lakes (Warui, Warangai, etc.), oxbow lakes, back-water flood zones and inundated grasslands near the Sepik River. However, it is unknown whether the Study Area supports breeding colonies. Suitable wetland habitat is widespread in the Study Area Lowland Zone and present in limited areas along waterways in the Study Area Hill Zone.

Egrets favour open wetlands and their primary habitats in the Study Area are the off-river waterbodies, which are unlikely to be impacted at all by the Project, and, to a lesser extent, open riverbanks and flooded grassland. The major potential impacts are contamination in waterways reaching these habitats (Frazier 2007). Mitigations aimed at preventing contamination should result in negligible residual direct impacts on these species. Indirect effects are not predicted to increase residual impacts beyond negligible. Resettlement patterns are unlikely to alter this assessment.

18.5.6 Boelen's python *Morelia boeleni*

Boelen's Python is a large, heavy-bodied snake up to 3 m long and New Guinea's only truly montane python occurring above 1,000 m asl along the entire length of the Central Cordillera. It is protected under the PNG Fauna (Protection and Control) Act 1966. The species was not recorded from the Study Area but could easily occur in the higher parts.

No infrastructure is planned for the higher elevations of the Study Area, so Boelen's Python will suffer only a tiny amount of habitat loss from the upper edges of the pit and possibly a communications tower. Minimising the Project disturbance area and preventing wildfires from starting at the Project disturbance area should all reduce construction impacts to low levels at these high elevations and residual direct impacts are predicted to be negligible.

The species does not appear to be specifically targeted by hunters and control of the work force is the major mitigation to reduce hunting. Hunting by in-migrants is less easily controlled. It is unlikely that the potential for in-migrants to hunt outside the Mining Leases is able to be significantly reduced. Indirect effects are predicted to increase residual impacts to minor.

Resettlement could exacerbate the potential impacts further if villagers are moved into the higher elevations of the Study Area where they would not normally, or only occasionally, hunt in which case both habitat loss and hunting would be expected to increase especially if access roads to resettlement areas traverse high elevation areas. The residual impacts in such a case could be moderate.

18.5.7 Other Birdwing Butterflies

The large birdwing butterflies (genus *Ornithoptera*) are highly prized by collectors, all are protected under the PNG Fauna (Protection and Control) Act 1966 and three were recorded and one could occur in the Study Area. Ornithoptère Méridional and the Chimaera Birdwing are evaluated above (sections 18.2.6 and 18.4.15).

The Butterfly of Paradise *Ornithoptera paradisea* is distributed widely occurring in a number of scattered localities throughout New Guinea, Salawati and possibly Yapen Island. Most records are from low elevations north of the Central Cordillera. The species is essentially confined to primary forest, including swampy areas. It a huge birdwing; the males have wingspans up to 125 mm and the females 170 mm. The males are black, green and gold with smaller tailed hindwings (EIS Appendix 8A Chapter 7 Plates 31 and 32). The larvae feed on *Pararistolochia* species, and, apparently, only *P. paradiseana* in East Sepik Province (Parsons 1998).

The Butterfly of Paradise is reported to emit a vanilla-like scent from a fringe of white hairs on the inner margin of the hindwing (Parsons 1998). Males, in particular, are relatively inconspicuous, tending to remain inactive for long periods whilst settled on elevated perches. They often establish territories on the tops of tall ridges especially in steep ravines or narrow clearings. In such situations, single males will perch usually in excess of 20 m above the ground and defend their territories vigorously, even chasing large birds that enter the territory. Females are more often encountered feeding at flowers some metres above the ground or flying in search of oviposition sites.

The Goliath Birdwing *O. goliath* is the second largest butterfly in the world. Males have wingspans up to 160 mm and females 210 mm. The male is green, black and gold and the female black with the rear halves of the hindwings yellow. The larvae feed exclusively on *Aristolochia goliathiana* and *A. crassinervia* and a single larva generally occupies each vine. Despite its size, this butterfly is often inconspicuous, usually flying very high in the canopy. Females may congregate at flowers growing at the tops of large trees. Males are less commonly observed and spend some time settled on foliage high above the ground. The species occurs from Seram to PNG and is widely distributed on the mainland from near sea level to about 2,200 m asl, but mostly 1,200 to 1,800 m asl, and on many satellite islands including Goodenough Island (Rumbucher, 1973) but its continued occurrence there requires confirmation. The species is most common in primary and secondary Hill Forest and Montane Forest in mountainous areas where it is often encountered along creeks or in deep ravines, flying several metres above the ground.

Although these birdwings are restricted to primary and advanced secondary forest they favour forest margins and may respond positively to linear clearings in forest, but degradation of the forest edge by weed invasion and/or use of herbicides that reduces abundance of their food plants, would degrade this. Both are large, powerful, high-flying species that can cross gaps readily - even large barriers (up to 2 km wide) would not likely significantly impact them. They tend not to use waterways as a flight path, therefore, disruption to streamline vegetation would not adversely affect the species. Dust along roads would be moderately detrimental as the larval food plant would likely suffer dieback in such areas and dust on leaves of food plant would inhibit larvae feeding on them.

Permanent loss of habitat may reduce populations, but they may benefit from the creation of more edges, especially if their food plants are abundant. The anticipated losses can be mitigated through nursery propagation and planting of their food plants in areas designated for managed revegetation. Forest degradation by in-migration is less easily controlled. Residual direct impacts are predicted to be negligible and should their food plants expand in population the residual impacts may even be positive. Indirect effects are not predicted to increase residual impacts beyond negligible. Resettlement patterns are unlikely to alter this assessment.

19. Annex 2 Invasive species

19.1 Plants

A number of invasive aquatic plants have become established in PNG. Many of these are fast-growing and form thick mats on the surface of rivers and wetlands that clog waterways and impede a variety of natural processes, such as water flow, light penetration and oxygenation of sub-surface waters. Troublesome species already established in PNG include Water Hyacinth *Eichhornia crassipes*, Alligator Weed *Alternanthera philoxeroides,* Cat-tails *Typha latifolia*, *Pistia stratiotes*, *Salvinia molesta* (ISSG 2018) and *Limnocharis flava*. The Water Hyacinth has been listed among the world's 100 worst invasive species (Lowe *et al.* 2000). Infestations of these and other species may alter the floristics, structure and distribution of wetland vegetation relied upon by fauna for food, shelter and reproduction, and the distribution and abundance of invertebrates, fish and amphibians taken as prey.

In dry-land habitats in PNG, various introduced plant species are now established as environmental weeds. These include a number of fast-growing vines and climbers, *Antigonon leptopus, Mikania micrantha, Mimosa diplotricha and Passiflora tarminiana,* many of which are capable of smothering and killing the native shrubs and trees on which they grow.

Invasive plants may be expected to affect local fauna once established. For example, invasive plants along watercourses were considered the most serious threat to South Africa's endemic odonates (Samways and Taylor 2004). Because odonates are extremely sensitive to light and shade conditions, changes to riparian vegetation structure through the introduction of invasive alien plant species can cause major shifts in the structure of odonate assemblages. This process was illustrated by Samways and Sharratt (2010) who found that restoration of riparian corridors in Africa through large-scale removal of alien trees that encouraged growth of indigenous plants, gradually restored 'endemic' odonate species that had been replaced in the modified alien environment by common, widespread species.

19.2 Fishes

Introduced fish can have a major impact on freshwater ecosystems. Some have been introduced to New Guinea that have elsewhere been shown to reduce, localise or extirpate native fish and invertebrate populations, increase turbidity and the levels of silt suspended in the water column, and alter wetland vegetation. The Sepik-Ramu basin is now badly contaminated with exotic fish species (Dudgeon and Smith 2006; Polhemus and Allen 2007), which may have irreversibly altered riparian and wetland vegetation. Fish can be major impactors on terrestrial and amphibious biodiversity via direct predation, alteration of habitat and competition. Within the Study Area they are likely to impact waterbirds, crocodiles, turtles, odonates and frogs, particularly in the Hill Zone where amphibious species breed in waters that are fish-free or that contain small native gobies, gudgeons, and rainbow fish. Introduction of exotic fish to previously fish-free or fish-poor environments is likely to dramatically alter the community structure and abundance of fauna using those habitats (McPeek 2008). During the 2011 surveys local residents frequently spoke of recent (10–15 years) large-scale losses of floating and lakeside vegetation and a marked decline in numbers of various waterbirds that coincided with a series of fish introductions (Dudgeon and Smith 2006).

19.3 Mammals

Domestic cats *Felis catus* and feral cat populations originating from escaped pets are capable of consuming large numbers of native animals, but their impacts on populations of prey species remains poorly documented. Dickman (1996) reported that the food of feral cats in Australia is small mammals but geckos, legless lizards, skinks, dragons, goannas and snakes are also eaten. The impacts of cat predation on native fauna in New Guinea are unknown, but it is likely that the introduction of cats to the Study Area will reduce populations of some native frogs and reptiles, as well as small mammals and birds. Cats are poorly adapted to long-term survival in rainforest (Flannery 1995), nevertheless, they may persist in the vicinity of human settlements and have been implicated in the local decline of fauna in such areas (Flannery 1995). They are almost certainly capable of maintaining feral populations in the vicinity of

Project infrastructure. From these established bases, they will hunt around the margins of disturbed habitats and come into contact with a broad range of native fauna. Direct predation on native animals by cats will be relatively confined and of only local significance. Cats (*Felis silvestris*) also host numerous zoonotic diseases including the *Toxoplasma* helminths implicated in the decline of the Christmas Island native rats (Wyatt *et al*. 2008).

The Long-tailed Macaque *Macaca fascicularis* is one of the world's most numerous and widespread monkeys, and over the last two decades it has become established in the Cyclops Mountains (Kemp and Burnett 2003). It is listed as one of the world's 100 worst invasive species (Lowe *et al.* 2000) and is regarded as having a high potential to invade PNG as it is an ecological generalist, tolerant of disturbed habitats, not under pressure from local predators, except perhaps dogs and large pythons, and uses previously unoccupied ecological niches in new areas (Kemp and Burnett 2007). Because of its ability to inhabit a wide range of habitats it is predicted to have the potential to occupy almost all of lowland and parts of upland New Guinea. Human hunting may have played a major role in limiting population expansion to date.

In the Study Area, this species would impact fauna by predation and competition. They are proven nest predators, and in some areas have been implicated in contributing to considerable declines of native bird species, including the extinction of a range of forest bird species on Mauritius (Kemp and Burnett 2007). Kemp and Burnett (2007) showed that bird species diversity and abundance around Jayapura was lower in areas where there were Long-tailed Macaques.

Exotic Rodents, including *Rattus exulans*, *R. rattus* (including *R. tanezumi*) are already established regionally in the Sepik River Basin and *R. norvegicus* and House Mice *Mus musculus* may also be present (Flannery 1995; Long 2003). However, these species are generally restricted to human-altered habitats such as agricultural fields and settlements. *R. exulans* and *R. rattus* are probably present in at least some local villages in the Study Area and possibly around some of the existing Project infrastructure. Many rodents, especially of the genus *Rattus*, have the potential to impact upon bird populations via predation of eggs, nestlings and adults. For example, *R. rattus* is responsible for catastrophic declines of birds on islands that formerly lacked such predators (Burger and Gochfeld 1994). *R. rattus* and *R. norvegicus* are reservoirs or vectors for at least 60 zoonotic diseases (Weber 1982), many pathogenic to humans and other mammals, especially other rodents.

Although none of the exotic rats seem to be particularly invasive of natural habitats in New Guinea, *R. rattus* in particular seems capable of establishing populations in a variety of contexts. Typically, this occurs where grasses or berry-producing weedy shrubs dominate the vegetation for some years, thereby providing abundant food, or around human habitations where they survive on scraps and cockroaches etc. While these populations may not lead on to larger scale invasion of natural habitats, there will be a certain amount of foraging activity and dispersal of young into the edges of natural habitats. In turn, this may lead to contact between the exotic rats and native mammals of various kinds (native rats, marsupial carnivores etc), thereby providing opportunities for transfer of novel pathogens to native mammals.

Feral pigs *Sus scrofa* probably occur throughout the Study Area especially at lower elevations, especially on alluvial terraces, alongside watercourses, or in swampy forests except perhaps in the Peat Forest Priority Ecosystem where there was little evidence of pig activity which likely reflects the low productivity of this habitat. Feral pigs dig up the forest floor potentially impacting understory plant populations and ground dwelling fauna including many species of mammals, frogs and birds. Feral pig populations could increase as a consequence of two main factors: increased local human populations resulting in larger areas of active and abandoned gardens which provide prime foraging habitat for feral pigs, and increased access to formerly remote areas along tracts of disturbance associated with infrastructure. In areas close to settlements, any increase in feral pig populations is likely to be countered by increased traditional hunting activity. However, this will be less effective in more remote locations.

Other mammals Indian House Shrew (*Suncus murinus*), Malay Civet (*Viverra tangalunga*), Palm Civet (*Paradoxurus hermaphroditus*), and Javan Mongoose (*Herpestes javanicus*) are all established as feral pests in various parts of eastern Indonesia. The latter three carnivores would be a serious impact on the Study Area should they become established.

19.4 Birds

No introduced bird species are likely to impact upon local populations of native forest or wetland fauna or likely to be able to survive in closed forests of the Study Area.

19.5 Herpetofauna

Two species of toad (genus *Bufo*) have been introduced into New Guinea and pose a threat to a broad range of native fauna. They are predators on a range of invertebrates and small vertebrates. Toads of the genus *Bufo* produce a powerful toxin that is present in eggs, larvae and adults, and, at least in Australia, have been responsible for the deaths of large numbers of native animals. The behaviour of fauna such as dasyures, herons, egrets and raptors that feed on eggs, tadpoles and/or adult toads make them particularly Vulnerable to poisoning. However, a recent study suggests that birds may be less susceptible to toad toxins than some other taxa such as reptiles and marsupials. (Beckmann and Shine 2009). Some odonates, for example, consume their toad with little ill effect (Crossland and Alford 1998).

The Cane Toad *Rhinella marina* was introduced to eastern New Guinea from South America to control sweet potato moths and now occurs across northern and southern mainland New Guinea (Tjaturadi *et al.* 2007). Though not yet reported from Papua Province, Indonesia, Cane Toads are present near the border in Vanimo. Although the Cane Toad has a patchy distribution in PNG it is known to occur in the lower reaches of the Sepik River Basin, particularly in coastal areas (Lever 2001), and it is likely that this exotic toad will eventually colonise the Study Area. Fortunately cane toads are restricted predominantly to open savanna habitats, urban areas, and to disturbed forest environments that have been substantially modified by human activities. They are less common in, and appear to disperse slowly through, dense closed forests so they are unlikely to overlap extensively with forest fauna in the Study Area. Cane Toads disperse well with human transport (boats, vehicles, crates and other containers) and move along roads to colonise new areas. Clearings in forest opened up by Project development would provide suitable habitat. Once established, cane toads are almost impossible to eradicate and attempts to control this rapidly spreading and highly toxic amphibian in Australia have failed. In the absence of a road network linking coastal areas to the Study Area, the most likely scenario for the arrival of Cane Toads in the Study Area is the accidental movement of individuals to site in cargo or on vehicles transporting cargo.

The Asiatic Toad (*B. melanostictus*) was reported from the Vogelkop Peninsula (around Manokwari and Sorong) in Papua (Tjaturadi *et al.* 2007). It has not been found in mainland PNG.

19.6 Invertebrates

Among invertebrates, alien ant species present perhaps the most serious threat to biodiversity in the Study Area. Invasive ant species now established in PNG include the Yellow Crazy Ant *Anoplolepis gracilipes*, the Little Fire Ant *Wasmannia auropunctata* which is established around Wewak, *Paratrechina longicornis* and the Fire Ant *Solenopsis geminate*. The first two species are potentially the most destructive. Both are easily dispersed via human commerce and the transport of infested equipment, food, logs and other vegetation (ISSG 2018).

The Yellow Crazy Ant has invaded and degraded native ecosystems in islands across the Pacific and Indian Oceans and is listed among the world’s 100 worst invasive species. On Christmas Island the species has formed super-colonies that have decimated Red Land Crab *Gecarcoidea natalis* populations (Lowe *et al.* 2000). Crazy Ants are found in a wide variety of habitats from disturbed areas to natural forest, where they outcompete most native species. Crazy Ants prey on, or interfere in the reproduction of, a variety of arthropods, reptiles, birds and mammals on the forest floor and canopy.

On Bird Island in the Seychelles they have displaced about 60,000 pairs of sooty terns (*Sterna fuscata*) (ISSG 2018). There impacts can be subtle; a large proportion of lycaenid butterflies are myrmecophagous (associated with ants) (e.g., Chapter 6 of EIS Appendix 8A, Plate 28) and usually the larvae of each species are attended by only a single ant species. The butterflies cannot survive without the ants and therefore the potential impacts are doubled if pest ants displace the native ants.

The Little Fire Ant is regarded as perhaps the most threatening ant species in the Pacific region, where it is held responsible for biodiversity loss by reducing the abundance of flying and tree-dwelling insects, eliminating arachnid populations and attacking and eating some vertebrates. In Vanuatu this species is steadily eliminating bird species that produce altricial young (dependent, poorly developed nestlings, as in most passerines) (Mack and Dumbacher 2007). A true generalist in its habitat preferences, it is found in undisturbed forest as well as urban and agricultural areas (ISSG 2018).

Other pest invertebrates significant for biodiversity are molluscs, flies (Diptera) and wasps (Hymenoptera) and some butterflies.

The Giant African Snail *Achatina fulica* is one of the worst snail pests of the tropics. Introduced as potential food it has been a significant agricultural pest, transmits plant and human disease and invades native ecosystems (IISSG 2018).

The Rosy Wolf Snail *Euglandina rosea* is a predatory land snail responsible for the extinction of numerous land snails on Tahiti and the reduction of native snail populations on Hawaii and Mauritius. Introduced to control the Giant African snail it is considered the most serious threat to native snails in the Pacific (IISSG 2018).

Banana Skipper *Erionota thrax* (Linnaeus, 1767) is a butterfly and pest of banana plantations in its native south-east Asia, this species has recently been recorded in PNG, as far east as New Ireland (C. Müller *pers. obs*). Records for Papua are scanty and its impact on banana productivity has yet to be assessed. One specimen was observed at Frieda Base Site, where banana plants abound. This taxon could potentially become an economic pest to bananas grown in villages and may already be so to some degree.

Migratory Awl *Badmamia exclamationis* (Fabricius, 1775) This migratory butterfly is a potential pest of Terminalia catappa, which is commonly used in reinstatement at mine sites and was recorded at four survey sites within the Study Area. Major fluctuations in numbers are characteristic of this species and when in peak the larvae may entirely strip the foliage of the food plants (C. Müller *pers. obs*).

Lime Butterfly *Papilio demoleus* Linnaeus, 1758 Until recently this widespread south-east Asian butterfly was only known from the dry area around Port Moresby but it has now been recorded in West Papua by Moonen (1999) and since about the year 2000 has become widespread throughout much of New Guinea, including the Bismarcks (Tennent *et al.* 2011). Although several native food plants are recorded, it also thrives on Citrus and could become a pest of orange and pomelo plantations.

19.7 References

Beckmann, C. and Shine. R. 2009. Impact of Invasive Cane Toads on Australian birds. Conservation Biology 23: 1544–1549.

Burger, J. and Gochfeld, M. 1994. Predator and effects of humans on island nesting seabirds. pp 39-67 in Nettleship, D. N., Burger, J. and Gochfeld, M. (eds.) Seabirds on islands. Threats, case studies and action plans. Birdlife Conservation Series No 1. Cambridge Birdlife International.

Crossland, M.R. and Alford, R.A. 1998. Evaluation of the toxicity of eggs, hatchlings and tadpoles of the introduced toad Bufo marinus (Anura: Bufonidae) to native Australian aquatic predators. Australian Journal of Ecology 23: 129-137.

Dickman, C. R. 1996. Overview of the impacts of feral cats on Australian native fauna. Australian Nature Conservation Agency, Canberra.

Dudgeon, D. and Smith, R. E. W. 2006. Exotic species, fisheries and conservation of freshwater biodiversity in tropical Asia: the case of the Sepik River, Papua New Guinea. Aquatic Conservation: Marine and Freshwater Ecosystems 16: 203–215.

Flannery, T. F. 1995. Mammals of New Guinea. Chatswood, NSW: Reed Books.

IISSG 2018. ISSG Global Invasive Species Database. www.issg.org/database/: accessed 28 April 2010.

Lever C. 2001. The Cane Toad: the History and Ecology of a Successful Colonist. West Westbury Publishing, Yorkshire.

Long, J. L. 2003. Introduced Mammals of the World: Their History, Distribution and Influence. CSIRO Publishing, Melbourne.

Lowe, S., Browne, M. and De Poorter, M. 2000. 100 of the World's Worst Invasive Alien Species: A Selection from the Global Invasive Species Database. Invasive Species Specialist Group (ISSG). Electronic version available at: www.issg.org/booklet.pdf

Mack, A. L. and Dumbacher, J. 2007. Birds of Papua. Pp. 654–688 in Marshall, A. J. and Beehler, B. M. (eds.) The Ecology of Papua (Part One). Hong Kong, Periplus Editions.

McPeek, M. A. 2008. Ecological factors limiting the distributions and abundances of Odonata. Pp. 51-62 In Cordoba-Aguilar, A. (editor) Dragonflies and damselflies: Model organisms for ecological and evolutionary research. Oxford University Press, Oxford.

Moonen, J. J. M., 1999. Papilio demoleus L. (Lepidoptera, Papilionidae) in West Irian. Transactions of the Lepidopterological Society of Japan 50: 82-84.

Polhemus, D. A. and Allen, G. R. 2007. Inland water ecosystems in Papua: classification, biota and threats. Pp. 858–900 in Marshall, A. J. and Beehler, B. M. (eds.) The Ecology of Papua (Part Two). Hong Kong, Periplus Editions.

Samways, M. J. and Taylor, S. 2004. Impacts of invasive alien plants on Red-listed South African dragonflies (Odonata). South African Journal of Science. 100: 78-80.

Samways, M. J. and Sharratt, N. J. 2010. Recovery of endemic dragonflies after removal of invasive alien trees. Conservation Biology 24: 267-277.

Tennent, W. J., Dewhurst, C. F., Muller, C. J. 2011. On the recent spread of Papilio demoleus Linnaeus, 1758, in Papua New Guinea (Lepidoptera, Papilionidae). Butterflies (Teinopalpus) 58:30-33.

Tjaturadi, B., Richards, S. and Krey, K. 2007. Exotic herpetofauna: a new threat to New Guinea's biodiversity? Pp. 1365–1368 in Marshall, A. J. and Beehler, B. M. (eds.) The ecology of Papua (Part Two). Hong Kong, Periplus Editions.

Weber, W.J. 1982. Diseases transmitted by rats and mice. Fresco, California, Thompson Publication.

Wyatt, K. B., Campos, P. F., Gilbert, M. T. P., Kolokotronis, S-O., Hynes, W. H., DeSalle, R., Daszak, P., MacPhee, R. D. E. and Greenwood, A. D. 2008) Historical mammal extinction of Christmas Island (Indian Ocean) correlates with introduced infectious disease. PLOS One 3 (11): e360.

20. Annex 3 Offsetting Residual Impacts

The mitigation hierarchy calls for residual impacts to be offset. PNG has not had an offset policy but CEPA is in the process of preparing a draft policy and it is likely, but not guaranteed, that such a policy would reflect in some form the guidance for offsets provided in IFC PS6. Under PS6 biodiversity offsets are "measurable conservation outcomes resulting from actions designed to compensate for significant residual adverse biodiversity impacts arising from project development and persisting after appropriate avoidance, minimization and restoration measures have been taken". The literature on offsets has expanded considerably since the 2012 edition of the IFC Performance standards and while there is much guidance, indeed exhortation, on how to do it there are few case studies that get to grips with the reality of achieving offsets in jurisdictions like PNG.

In developing offsets, the steps are first to determine what needs offsetting, work out a metric to measure offset debt, identify where the offset can be achieved then do it. Monitoring is required the whole way, ideally as part of a biodiversity action plan.

What needs offsetting?

Offsets are required for residual impacts on biodiversity and the approach depends upon, in the IFC context, whether critical habitat is involved or not. Offsets under PS6 for critical habitat require net gain of biodiversity value while for non-critical habitat it is no net loss. Critical habitat is defined as

> "… areas with high biodiversity value, including (i) habitat of significant importance to Critically Endangered and/or Endangered11 species; (ii) habitat of significant importance to endemic and/or restricted-range species; (iii) habitat supporting globally significant concentrations of migratory species and/or congregatory species; (iv) highly threatened and/or unique ecosystems; and/or (v) areas associated with key evolutionary processes."

The Guidance notes to PS6 elaborate further and notes 55, 56 and 57 provide an inventory of 17 criteria for classification as critical habitat (Table 22).

Table 22 Criteria for critical habitat under IFC PS6 Guidance Notes

GUIDANCE NOTE	#	CRITERION
55	1	Critically Endangered (CR) and/or Endangered (EN) species
	2	Endemic and/or restricted-range species
	3	Migratory and/or congregatory species
	4	Highly threatened and/or unique ecosystems
	5	Key evolutionary processes
56	6	Areas required for the reintroduction of CR and EN species and refuge sites for these species (habitat used during periods of stress (e.g., flood, drought or fire)).
	7	Ecosystems of known special significance to EN or CR species for climate adaptation purposes.
	8	Concentrations of Vulnerable (VU) species in cases where there is uncertainty regarding the listing, and the actual status of the species may be EN or CR.
	9	Areas of primary/old-growth/pristine forests and/or other areas with especially high levels of species diversity.
	10	Landscape and ecological processes (e.g., water catchments, areas critical to erosion control, disturbance regimes (e.g., fire, flood)) required for maintaining critical habitat.
	11	Habitat necessary for the survival of keystone species.
	12	Areas of high scientific value such as those containing concentrations of species new and/or little known to science.
57	13	Areas that meet the criteria of the IUCN's Protected Area Management Categories Ia, Ib and II, although areas that meet criteria for Management Categories III-VI may also qualify depending on the biodiversity values inherent to those sites.
	14	UNESCO Natural World Heritage Sites that are recognized for their Global Outstanding Value.

	15	The majority of Key Biodiversity Areas (KBAs), which encompass inter alia Ramsar Sites, Important Bird Areas (IBA), Important Plant Areas (IPA) and Alliance for Zero Extinction Sites (AZE).
	16	Areas determined to be irreplaceable or of high priority/significance based on systematic conservation planning techniques carried out at the landscape and/or regional scale by governmental bodies, recognized academic institutions and/or other relevant qualified organizations (including internationally-recognized NGOs).
	17	Areas identified by the client as High Conservation Value (HCV) using internationally recognized standards, where criteria used to designate such areas is consistent with the high biodiversity values listed in paragraph 16 of Performance Standard 6.

There are five major strategic decisions that are needed to guide offset development:

- Whether offsets are designed for no net loss or for net gain.
- Whether offsets are designed to meet an accounting goal (x ha of offset for y ha of impact) or designed to maximally contribute to conservation in the region.
- Whether to have a single offset or a basket of several.
- To what extent the Project will involve itself in ongoing management of offsets.
- What are the possible funding mechanisms.

Any offset proposal must be developed in consultation with stakeholders. The following potential offset opportunities are suggested as a guide only:

- Manage all or part of the GFA as a conservation area under the PNG *Conservation Areas Act 1978*.
- Provide management support for the existing Hunstein WMA
- Provide support or help expand the Tenkile Conservation Alliance in the Torricelli Mountains This could be a “trade-up” considering the concentration of critically endangered fauna in the North Coastal Ranges.
- Establish a reserve for endemic mammals in the remaining forests around Telefomin.
- Revegetate the road edges of the infrastructure corridor.
- Make the mining lease areas a fauna reserve.

21. Annex 4 Consolidated biodiversity records (2011/2017)

The following tables consist of species recorded during the Project surveys and those that may possibly occur in the Study Area. The data is consolidated from EIS Appendices 8A and 8B with updated taxonomy. The names are consistent with those in the 2017 surveys (Appendix 8B) and where the name differs from that in the 2011 surveys the name used in the 2011 surveys is also given.

For impact analysis it was also necessary to include species that might have been missed by the Project surveys. An inventory of what other species could occur in the Study Area was compiled from extra information available in Table 3 in Chapter 3 and Appendix 4.7 in Chapter 4 in the EIS Appendix 8A, Tables 1 and 2 in Chapter 3 in EIS Appendix 8B and literature sources. This was possible for mammals, birds and frogs but not the other groups.

Literature sources for mammals were Flannery (1994, 1995), Flannery and Seri (1990), Bonaccorso (1998), Wilson and Mittermeier (2015) and Wilson et al. (2017); and for birds – Gillard and LeCroy (1966), Diamond (1967, 1969), Pearson (1975), Pratt and Beehler (2015) Hulme (1977), Lister (1977), Stringer (1977), Whitney (1987), Beehler and Prawiradilaga (2010) and Beehler and Pratt (2016). An overview of the Bewani Mountains herpetofauna is given in EIS Appendix 8B and information on frogs and reptiles is available in Allison & Kraus (2003), Kraus & Allison (2006), Dahl et al. (2009), Tallowin et al. (2017) and Amphibiaweb (https://amphibiaweb.org).

Since butterflies were not sampled in the 2017 surveys the original nomenclature in EIS Appendix 8A was not updated and the 2011 inventory is not repeated in Annex 2.

The STATUS column is the conservation status according to IUCN and the PNG Fauna (Protection and Control) Act 1966. IUCN Status: CR = Critically Endangered, E = Endangered, VU = Vulnerable, NT = Near Threatened, DD = Data Deficient, LC = Least Concern; NE = Not assessed. P = protected under the PNG Fauna (Protection and Control) Act 1966.

For species that may occur but were not recorded likelihood of occurrence was judged on a four-level scale.

- S Known ranges and habitat preferences indicate a strong likelihood of occurring
- M Known ranges and habitat preferences indicate a moderate likelihood of occurring
- L Known ranges and habitat preferences indicate a low likelihood of occurring
- N Does not or extremely unlikely to occur

For mammals, birds and frogs the tables columns are segments of the Study Area as follows:

GFA HM	Greater Frieda Area hill and montane zones
GFA L	Greater Frieda Area lowland zones
1	Infrastructure corridor section 1 Process Plant to Hotmin
2	Infrastructure corridor section 2 Hotmin to the West Range (includes section 2A – May River Road)
3	Infrastructure corridor section 3 West Range to Idam 1
4	Infrastructure corridor section 4 Idam 1 to the Sepik River
5	Infrastructure corridor section 5 Sepik River to Samunai
6	Infrastructure corridor section 6 Samunai to the Horden River
7	Infrastructure corridor section 7 Horden River to the Bewani Foothills
8	Infrastructure corridor section 8 The Bewani Mountains
9	Infrastructure corridor section 9 The Bewani Mountains to the Nemayer Rive
10	Infrastructure corridor section 10 Nemayer River to Vanimo

21.1 Mammal occurrence or potential occurrence in the the Study Area.

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Tachyglossidae	Sir David's Long-beaked Echidna	*Zaglossus attenboroughi*		CR P	L	L	L	L	L	L	L	L	L	L	N	N
Tachyglossidae	Eastern Long-beaked Echidna	*Zaglossus bartoni*		VU P	V	L	S	M	M	L	L	L	L	S	L	N
Dasyuridae	New Guinean Quoll	*Dasyurus albopunctatus*		NT	V	L	S	L	M	L	L	L	L	S	L	L
Dasyuridae	Three-striped Dasyure	*Myoictis melas*		LC	1	S	S	1	S	M	M	M	M	S	L	L
Dasyuridae	Speckled Dasyure	*Neophascogale lorentzi*		LC	S	N	L	N	N	N	N	N	N	L	N	N
Dasyuridae	Narrow-striped Marsupial Shrew	*Phascolosorex dorsalis*		LC	L	N	L	N	N	N	N	N	N	L	N	N
Dasyuridae	Short-furred Dasyure	*Murexia longicaudata*		LC	2	M	S	S	S	M	M	M	M	M	L	L
Dasyuridae	Black-tailed Dasyure	*Murexechinus melanurus*		LC	S	M	S	S	S	M	M	M	M	S	L	L
Peramelidae	Raffray's Bandicoot	*Peroryctes raffrayana*		LC	2	S	S	S	S	M	M	M	M	S	L	L
Peramelidae	Clara's Echymipera	*Echymipera clara*	Clara's Spiny Bandicoot	LC	1	1	S	1	2	S	S	S	S	S	M	M
Peramelidae	Common Echymipera	*Echymipera kalubu*	Common Spiny Bandicoot	LC	6	1	S	1	1	S	S	S	S	S	M	M
Peramelidae	Long-nosed Echymipera	*Echymipera rufescens*	Long-nosed Spiny Bandicoot	LC	1	2	S	1	1	S	S	S	S	S	M	M
Peramelidae	Striped Bandicoot	*Microperoryctes longicauda*		LC	V	N	M	N	N	N	N	N	N	L	N	N
Buramyidae	Long-tailed Pygmy Possum	*Cercartetus caudatus*		LC	L	N	N	N	N	N	N	N	N	L	N	N
Phalangeridae	Mountain Cuscus	*Phalanger carmelitae*		LC	1	N	L	1	N	N	N	N	N	L	N	N
Phalangeridae	Ground Cuscus	*Phalanger gymnotis*		LC	3	3	S	1	1	M	M	M	M	S	M	L
Phalangeridae	Telefomin Cuscus	*Phalanger matanim*		CR P	V	N	L	N	N	N	N	N	N	N	N	N
Phalangeridae	Northern Common Cuscus	*Phalanger orientalis*		LC	2	2	S	1	1	S	S	S	S	S	S	M
Phalangeridae	Common Spotted Cuscus	*Spilocuscus maculatus*		LC	1	1	S	1	1	S	S	S	S	S	S	S
Phalangeridae	Black-spotted Cuscus	*Spilocuscus rufoniger*		CR	V	S	S	S	V	S	S	S	S	S	S	L
Pseudocheiridae	Lowland Ringtail	*Pseudochirulus canescens*	Lowland Ringtail Possum	LC	2	S	S	S	S	S	S	S	S	S	S	M
Pseudocheiridae	Masked Ringtail Possum	*Pseudochirulus larvatus*		LC	S	L	S	L	L	L	L	L	L	S	N	N
Pseudocheiridae	D'Albertis's Ringtail Possum	*Pseudochirops albertisii*		NT	N	N	N	N	N	N	N	N	M	S	M	N
Pseudocheiridae	Plush-coated Ringtail Possum	*Pseudochirops corinnae*		NT	S	L	S	N	L	N	N	N	N	N	N	N
Pseudocheiridae	Coppery Ringtail Possum	*Pseudochirops cupreus*		LC	M	N	N	N	N	N	N	N	N	N	N	N
Petauridae	Great-tailed Triok	*Dactylopsila megalura*		LC	S	N	M	N	N	N	N	N	N	N	N	N
Petauridae	Long-fingered Triok	*Dactylopsila palpator*		LC	S	N	S	N	L	N	N	N	N	N	N	N
Petauridae	Striped Possum	*Dactylopsila trivirgata*		LC	V	S	S	S	S	S	S	S	S	S	L	L
Petauridae	Northern Glider	*Petaurus abidi*		CR	N	N	N	N	N	N	N	N	N	L	N	N
Petauridae	Sugar Glider	*Petaurus breviceps*		LC	V	S	S	S	S	S	S	S	S	S	M	M
Acrobatidae	a Feather-tailed Possum	*Distoechurus sp. nov.*		NE	S	2	S	S	S	S	S	S	S	S	M	M
Macropodidae	Western Montane Tree Kangaroo	*Dendrolagus notatus*		EN P	V	N	M	N	N	N	N	N	N	N	N	N
Macropodidae	Goodfellow's Tree Kangaroo	*Dendrolagus goodfellowi*		EN P	V	L	L	L	L	N	N	N	N	N	N	N
Macropodidae	Grizzled tree kangaroo	*Dendrolagus inustus*		VU P	N	N	N	N	N	N	L	L	S	S	S	L
Macropodidae	Tenkile	*Dendrolagus scottae*		CR P	N	N	N	N	N	N	N	N	M	M	N	N
Macropodidae	Waimang	*Dendrolagus pulcherrimus*		CR P	N	N	N	N	N	N	N	N	N	L	N	N
Macropodidae	White-striped Dorcopsis	*Dorcopsis hageni*		LC	2	2	S	1	1	S	S	S	S	S	M	M
Macropodidae	Small Mountain Dorcopsis	*Dorcopsulus ?vanheurni*		NT	V	N	S	N	L	N	N	N	N	N	N	N

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Macropodidae	New Guinea Pademelon	*Thylogale browni*	Brown's Pademelon	VU	3	V	S	S	1	S	L	L	L	S	L	L
Muridae	Highland Brush Mouse	*Abeomelomys sevia*		LC	L	N	N	N	N	N	N	N	N	N	N	N
Muridae	Squirrel-toothed Rat	*Anisomys imitator*		LC	S	N	N	N	N	N	N	N	N	N	N	N
Muridae	Shawmayer's Brush Mouse	*Coccymys shawmayeri*		LC	L	N	N	N	N	N	N	N	N	N	N	N
Muridae	Earless Water Rat	*Crossomys moncktoni*		LC	S	N	N	N	N	N	N	N	N	N	N	N
Muridae	Common Water-rat	*Hydromys chrysogaster*	Water Rat	LC	2	S	S	S	S	S	S	S	S	S	S	S
Muridae	Ziegler's Water Rat	*Hydromys ziegleri*		DD	N	N	N	N	N	N	N	N	L	L	N	N
Muridae	Western White-eared Giant Rat	*Hyomys dammermani*		DD	L	N	N	N	N	N	N	N	N	N	N	N
Muridae	Long-footed Tree Mouse	*Lorentzimys nouhuysi*		LC	S	L	S	M	S	L	L	L	L	S	L	L
Muridae	Greater Smal-toothed Rat	*Macruromys major*		LC	S	N	S	N	L	N	N	N	N	N	N	N
Muridae	De Vis's Woolly Rat	*Mallomys aroaensis*		LC	S	N	L	N	N	N	N	N	N	N	N	N
Muridae	Rothschild's Woolly Rat	*Mallomys rothschildi*		LC	S	N	L	N	N	N	N	N	N	N	N	N
Muridae	Montane Mammelomys	*Mammelomys lanosus*		LC	S	N	S	N	N	N	N	N	N	S	N	N
Muridae	Lowland Mammelomys	*Mammelomys rattoides*		LC	6	1	S	M	S	M	M	M	M	S	L	N
Muridae	Black-tailed Melomys	*Melomys rufescens*		LC	2	M	M	M	M	M	M	M	M	L	M	M
Muridae	Papua Grassland Mosaic-tailed Rat	*Melomys lutillus*		LC	L	S	S	S	S	S	S	S	S	S	S	S
Muridae	Northern Groove-toothed Shrew Mouse	*Microhydromys richardsoni*		DD	2	L	S	L	1	L	L	L	L	S	L	L
Muridae	Mountain Mosaic-tailed Rat	*Paramelomys rubex*		LC	S	N	S	N	L	N	N	N	N	S	N	N
Muridae	Thomas's Mosaic-tailed Rat	*Paramelomys mollis*		LC	S	N	L	N	N	N	N	N	N	N	N	N
Muridae	Lowland Paramelomys	*Paramelomys platyops*	Lowland Mosaic-tailed Rat	LC	7	4	S	S	S	S	S	S	S	S	S	S
Muridae	Northern Water Rat	*Paraleptomys rufilatus*		EN	N	N	N	N	N	N	N	N	N	S	N	N
Muridae	Short-haired Water Rat	*Paraleptomys wilhelmina*		DD	S	N	N	N	N	N	N	N	N	N	N	N
Muridae	New Guinea Waterside Rat	*Parahydromys asper*		LC	S	N	S	N	S	N	N	N	N	S	N	N
Muridae	Brass's Brush Mouse	*Pogonomelomys brassii*		LC	M	M	M	M	M	M	M	M	M	M	M	M
Muridae	Shaw Mayer's Brush Mouse	*Pogonomelomys mayeri*		LC	S	L	S	L	S	N	N	N	N	S	N	N
Muridae	Chestnut Tree-Mouse	*Pogonomys macrourus**	Pogonomys cf. mollipilosus*	LC	1	S	S	S	S	M	M	M	M	S	L	L
Muridae	Large Tree Mouse	*Pogonomys loriae**	Pogonomys cf. loriae*	LC	S	1	S	S	S	S	S	S	S	S	S	S
Muridae	Champion's Tree Mouse	*Pogonomys championi*		DD	M	N	N	N	N	N	N	N	N	N	N	N
Muridae	Torricelli Mountains Shrew Mouse	*Pseudohydromys musseri*		DD	N	N	N	N	N	N	N	N	N	M	N	N
Muridae	Western Shrew Mouse	*Pseudohydromys occidentalis*		DD	L	N	N	N	N	N	N	N	N	N	N	N
Muridae	Polynesian Rat	*Rattus exulans*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Muridae	Moss-forest Rat	*Rattus niobe*		LC	S	N	S	N	L	N	N	N	N	S	N	N
Muridae	Large Spiny Rat	*Rattus praetor*	Spiny rat	LC	3	S	S	1	s	S	S	S	S	S	S	S
Muridae	Black Rat	*Rattus rattus*		LC	1	2	S	S	1	S	S	S	S	S	S	S
Muridae	Small Spiny Rat	*Rattus steini*	Stein's Rat	LC	2	L	S	S	1	M	L	L	L	S	L	N
Muridae	New Guinea Slender Rat	*Rattus verecundus*		LC	S	L	S	S	S	L	L	L	L	S	N	N
Muridae	Giant naked-tailed Rat	*Uromys anak*		LC	S	N	S	N	L	N	N	N	N	L	N	N
Muridae	Giant White-tailed Rat	*Uromys affin caudimaculatus*		LC	2	2	S	1	S	S	S	S	S	S	S	S
Muridae	Rock-dwelling Giant-rat	*Xenuromys barbatus*	Rock-dwelling Rat	LC	S	S	S	1	S	S	S	S	S	S	S	S
Suidae	Feral Pig	*Sus scrofa*		LC	2	4	S	S	S	S	S	S	S	S	S	S
Pteropodidae	Dagger-toothed Long-nosed Fruit	*Macroglossus minimus*	Long-nosed Blossom Bat	LC	1	3	S	1	1	S	S	S	S	S	S	S

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Pteropodidae	Common Blossom Bat	*Syconycteris australis*		LC	12	7	S	1	1	S	S	S	S	S	S	S
Pteropodidae	Bismarck Blossom Bat	*Syconycteris cf. finschi*		NE	4	4	S	S	S	S	S	S	S	S	S	S
Pteropodidae	Moss-forest Blossom Bat	*Syconycteris hobbit*		LC	L	N	N	N	N	N	N	N	N	N	N	N
Pteropodidae	Greater Tube-nosed Fruit Bat	*Nyctimene aello*	Broad-striped Tube-nosed Fruit Bat	LC	1	3	S	S	S	S	S	S	S	S	S	S
Pteropodidae	Dragon Tube-nosed Fruit Bat	*Nyctimene draconilla*	Lesser Tube-nosed Fruit Bat	DD	5	6	S	S	S	M	M	M	M	M	M	M
Pteropodidae	Mountain Tube-nosed Fruit Bat	*Nyctimene certans*			S	N	S	N	L	L	L	L	L	S	L	L
Pteropodidae	Common Tube-nosed Fruit Bat	*Nyctimene albiventer papuanus*	Tube-nosed Fruit Bat	LC	7	1	S	1	1	S	S	S	S	S	S	S
Pteropodidae	Green Tube-nosed Fruit Bat	*Paranyctimene raptor*		LC	2	1	S	S	1	S	S	S	S	S	S	S
Pteropodidae	Steadfast Tube-nosed Fruit Bat	*Paranyctimene tenax*		LC	4	3	S	S	S	S	S	S	S	S	S	S
Pteropodidae	Bulmer's Fruit Bat	*Aproteles bulmerae*		CR	L	N	N	N	N	N	N	N	N	N	N	N
Pteropodidae	Lesser Bare-backed Fruit Bat	*Dobsonia minor*	Lesser Naked-backed Fruit Bat	LC	2	4	S	S	1	S	S	S	S	S	S	S
Pteropodidae	Moluccan Naked-backed Fruit Bat	*Dobsonia moluccensis*		LC	2	S	S	S	1	S	S	S	S	S	S	S
Pteropodidae	Large-eared Flying Fox	*Pteropus macrotis*		LC	S	1	S	S	S	S	S	S	S	S	S	S
Pteropodidae	Great Flying Fox	*Pteropus neohibernicus*		LC	V	V	S	S	S	S	S	S	S	S	S	S
Pteropodidae	Spectacled Flying Fox	*Pteropus conspicillatus*		LC	N	N	N	N	N	L	L	L	L	M	S	S
Pteropodidae	Small Flying Fox	*Pteropus hypomelanus*		LC	N	N	N	N	N	N	N	N	N	N	L	L
Pteropodidae	Common Rousette Bat	*Rousettus amplexicaudatus*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Rhinolophidae	Large-eared Horseshoe Bat	*Rhinolophus philippinensis*[1]		LC	3	1	S	1	M	M	M	M	M	M	M	M
Rhinolophidae	Arcuate Horseshoe Bat	*Rhinolophus arcuatus*		LC	S	L	S	L	S	L	L	L	L	S	L	L
Rhinolophidae	New Guinea Horseshoe Bat	*Rhinolophus euryotis*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Rhinolophidae	Eastern Horseshoe Bat	*Rhinolophus megaphyllus*		LC	S	L	S	M	S	L	L	L	L	L	L	L
Hipposideridae	Temminck's Leaf-nosed Bat	*Aselliscus tricuspidatus*	Aselliscus tricuspidatus 112 sCF) Trident Leaf-nosed Bat	LC	8	5	S	1	2	S	S	S	S	S	S	S
Hipposideridae	Dusky Leaf-nosed Bat	*Hipposideros ater*		LC	1	S	S	S	S	S	S	S	S	S	S	S
Hipposideridae	Fawn-colored Leaf-nosed Bat	*Hipposideros cervinus*	Fawn Leaf-nosed Bat	LC	2	1	S	1	S	S	S	S	S	S	S	S
Hipposideridae	Diadem Leaf-nosed Bat	*Hipposideros diadema*		LC	7	7	S	1	2	S	S	S	S	S	S	S
Hipposideridae	Maggie Taylor's Leaf-nosed Bat	*Hipposideros maggietaylorae*		LC	3	1	S	S	1	S	S	S	S	S	S	S
Hipposideridae	Wollaston's Leaf-nosed Bat	*Hipposideros wollastoni*		LC	5	1	S	1	S	L	L	L	L	S	L	L
Hipposideridae	Telefomin Leaf-nosed Bat	*Hipposideros corynophyllus*[2]	75 mCF (Hipposideros semoni or H. muscinus)	LC	2	4	S	1	S	N	N	N	N	N	N	N
Hipposideridae	Fly River Leaf-nosed Bat	*Hipposideros muscinus*	90 mCF (Hipposideros semoni or H. muscinus)	LC	5	5	S	1	2	N	N	N	N	N	N	N
Hipposideridae	Spurred Leaf-nosed Bat	*Hipposideros calcaratus*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Hipposideridae	Hill's Leaf-nosed Bat	*Hipposideros edwardshilli*		VU	N	N	N	N	N	N	N	N	N	S	N	N
Hipposideridae	Semon's Leaf-nosed Bat	*Hipposideros semoni*		LC	S	N	S	M	S	S	S	S	S	S	S	S
Emballonuridae	Lesser Sheath-tailed Bat	*Mosia nigrescens*	Mosia nigrescens 64 sCF / i.cvFM)	LC	11	7	S	1	2	S	S	S	S	S	S	S

FAMILY	COMMON NAME	*SCIENTIFIC NAME*	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Emballonuridae	Bare-rumped Sheath-tailed Bat	*Saccolaimus saccolaimus*	27 sh.cFM.d (Emballonura sp.) + 24 cFM (Saccolaimus sp.)	LC	7	5	S	1	1	S	S	S	S	S	S	S
Emballonuridae	Beccari's Free-tailed Bat	*Emballonura beccarii*		LC	S	L	L	L	L	L	L	L	L	L	L	L
Emballonuridae	Greater Sheath-tailed Bat	*Emballonura dianae*	34 i.fFM.d / sCF (Emballonura sp.)	LC	2	2	S	1	1	L	L	L	L	L	L	L
Emballonuridae	New Guinea Sheath-tailed Bat	*Emballonura furax*		LC	S	S	S	1	2	L	L	L	L	L	L	L
Emballonuridae	Raffray's Sheath-tailed Bat	*Emballonura raffrayana*		LC	S	S	S	S	S	L	L	L	L	L	L	L
Vespertillionidae	Maluku Myotis	*Myotis moluccarum*	Myotis moluccarum (4 st.bFM /st.sFM.d) Moluccan Myotis	LC	3	3	S	1	S	S	S	S	S	S	S	S
Vespertillionidae	Papuan Long-eared Bat	*Nyctophilus microtis*		LC	S	1	S	1	2	S	S	S	S	S	S	S
Vespertillionidae	Small-toothed Long-eared Bat	*Nyctophilus microdon*[3]	55 st.bFM *N. microdon, 53 st.fFM Nyctophilus aff. microdon*	DD	S	1	S	S	S	L	L	L	L	L	L	L
Vespertillionidae	Small Melanesian Bent-winged Bat	*Miniopterus macrocneme*[4]	Pipistrellus angulatus (47 st.cFM.h) New Guinean Pipistrelle	DD	9	7	S	1	2	S	S	S	S	S	S	S
Vespertillionidae	Large Bent-winged Bat	*Miniopterus magnater*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Vespertillionidae	Medium Bent-winged Bat	*Miniopterus medius*		LC	S	N	S	M	S	S	S	S	S	S	S	S
Vespertillionidae	Little Long-fingered Bat	*Miniopterus australis*[5]	55 st.cFM.d / cFM (a vespertilionid)	LC	5	1	S	1	2	S	S	S	S	S	S	S
Vespertillionidae	Great Long-fingered Bat	*Miniopterus tristis*[6]	Miniopterus magnater 37 st.cFM) Large Bent-winged Bat	LC	10	7	S	1	2	S	S	S	S	S	S	S
Vespertillionidae	Flute-nosed Bat	*Murina florium*		LC	S	S	S	1	1	S	S	S	S	S	S	S
Vespertillionidae	Fly River Woolly Bat	*Kerivoula muscina*		LC	S	S	S	S	S	M	M	M	M	M	M	M
Vespertillionidae	Papuan Pipistrelle	*Pipistrellus papuanus*	Lesser Papuan Pipistrelle	LC	1	S	S	S	S	S	S	S	S	S	S	S
Vespertillionidae	New Guinean Pipistrelle	*Pipistrellus angulatus*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Vespertillionidae	Mountain Pipistrelle	*Pipistrellus collinus*		LC	S	L	S	N	L	L	L	L	L	L	L	L
Vespertillionidae	Short-winged Pipistrelle	*Philetor brachypterus*		LC	S	S	S	S	S	L	L	L	L	S	L	L
Mollosidae	Papuan Free-tailed Bat	*Otomops papuensis*		DD	S	S	S	S	S	S	S	S	S	S	S	S
Mollosidae	Mantled Free-tailed Bat	*Otomops secundus*		DD	S	S	S	S	S	S	S	S	S	S	S	S
Mollosidae	New Guinea Free-tailed Bat	*Tadarida kuboriensis*		LC	L	N	N	N	N	N	N	N	N	N	N	N

*Conservation status IUCN CR-Critically Endangered, EN – Endangered, VU – Vulnerabe, NT – Near Threatened, DD – Data Defficient, LC - Least Concern, NE – Not evaluated. P – protected under PNG *Fauna (Protection and Control) Act 1966.*

1-12	# of combined survey sites at which recorded
V	Village informant record from Sepik Development Project survey
S	Species not recorded whose known ranges and habitat preferences indicate a strong likelihood of occurring
M	Species not recorded whose known ranges and habitat preferences indicate a moderate likelihood of occurring
L	Species not recorded whose known ranges and habitat preferences indicate a low likelihood of occurring
N	Does not or extremely unlikely to occur

* taxonomy complex and needs revision. Identification not definitive.

1 Recorded in EIS Appendix 8B as "*Rhinolophus* cf. *philippinensis*". If this proves to be another species *R. philippinensis* remains a strong possibility to occur.

2 Recorded in EIS Appendix 8B as "*Hipposideros* cf. *corynophyllus* 75 mCF". If this proves to be another species *H. corynophyllus* remains a strong possibility to occur.

3 Referred to in EIS APPENDIX 8A Chapter 3 Table 21 and CH. 3 Appendix 3.5 but omitted from list of recorded mammals (Table 6)

4 Recorded in EIS Appendix 8B as "*Miniopterus* cf. *macrocneme* 48 st.cFM". If this proves to be another species *M. macrocneme* remains a strong possibility to occur.

5 Recorded in EIS Appendix 8B as "*Miniopterus* cf. *australis* 55 st.cFM". If this proves to be another species *H. australis* remains a strong possibility to occur.

6 Recorded in EIS Appendix 8B as "*Miniopterus* cf. *tristis* 38 st.cFM". If this proves to be another species *H. tristis* remains a strong possibility to occur.

21.2 Landbird occurrence or potential occurrence in the Study Area.

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Casuariidae	Dwarf Cassowary	*Casuarius bennetti*		LC	3	L	S	L	1	N	N	N	L	S	N	N
Casuariidae	Northern Cassowary	*Casuarius unappendiculatus1*		LC	3	8	S	1	1	S	S	S	S	S	L	L
Anatidae	Salvadori's Teal	*Salvadorina waigiuensis*		VU	S	L	L	L	S	N	N	N	N	N	N	N
Megapodiidae	Wattled Brushturkey	*Aepypodius arfakianus*		LC	1	L	S	L	1	L	L	L	L	S	N	N
Megapodiidae	Collared Brushturkey	*Talegalla jobiensis*		LC	6	6	S	1	2	S	S	S	S	S	S	S
Megapodiidae	New Guinea Scrubfowl	*Megapodius decollatus*		LC	1	3	S	1	1	S	S	S	S	S	S	S
Phasianidae	Brown Quail	*Coturnix ypsilophora*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Phasianidae	King Quail	*Excalfactoria chinensis*	Coturnix chinensis	LC	S	S	S	S	S	S	S	S	S	S	S	S
Ardeidae	Forest Bittern	*Zonerodius heliosylus*		NT	1	S	S	S	S	S	S	S	S	S	S	S
Accipitridae	Black-winged Kite	*Elanus caeruleus*		LC	L	S	L	L	M	S	S	S	S	L	S	S
Accipitridae	Pacific Baza	*Aviceda subcristata*		LC	2	1	S	1	S	S	S	S	S	S	S	S
Accipitridae	Long-tailed Honey Buzzard	*Henicopernis longicauda*		LC	4	2	S	S	S	S	S	S	S	S	S	S
Accipitridae	Bat Hawk	Macheiramphus alcinus		LC	S	S	S	S	S	S	S	S	S	S	S	S
Accipitridae	Papuan Eagle	*Harpyopsis novaeguineae*	New Guinea Eagle	VU	3	1	S	1	S	S	S	S	S	S	L	L
Accipitridae	Pygmy Eagle	*Hieraaetus weiskei*		LC	2	1	S	1	S	S	S	S	S	S	S	S
Accipitridae	Gurney's Eagle	*Aquila gurneyi*		NT	S	S	S	S	S	S	S	S	S	S	L	L
Accipitridae	Chestnut-shouldered Goshawk	*Erythrotriorchis buergersi*		DD	S	S	S	S	S	S	S	S	S	S	L	L
Accipitridae	Doria's Goshawk	*Megatriorchis doriae*		NT	1	S	S	S	S	S	S	S	S	S	S	S
Accipitridae	Variable Goshawk	*Accipiter hiogaster*		LC	S	5	S	1	S	S	S	S	S	S	S	S
Accipitridae	Brown Goshawk	*Accipiter fasciatus*		LC	S	S	S	S	M	N	N	N	N	N	N	N
Accipitridae	Black-mantled Goshawk	*Accipiter melanochlamys*		LC	S	L	S	N	M	N	N	N	N	N	N	N
Accipitridae	Grey-headed Goshawk	*Accipiter poliocephalus*		LC	S	1	S	S	1	S	S	S	S	S	S	S
Accipitridae	Meyer's Goshawk	*Accipiter meyerianus*		LC	S	L	S	L	M	N	N	N	N	N	N	N
Accipitridae	Papuan Harrier	*Circus spilothorax*	Eastern Marsh-Harrier	LC	L	1	M	L	M	S	S	S	S	N	S	S
Accipitridae	Black Kite	*Milvus migrans*		LC	S	2	S	S	S	S	S	S	S	S	S	S
Accipitridae	Whistling Kite	*Haliastur sphenurus*		LC	1	6	S	1	1	S	S	S	S	S	S	S
Accipitridae	Brahminy Kite	*Haliastur indus*		LC	2	6	S	1	1	S	S	S	S	S	S	S
Accipitridae	White-bellied Sea Eagle	*Haliaeetus leucogaster*	White-bellied Fish-Eagle	LC	L	7	S	1	L	S	S	S	S	L	S	S
Rallidae	Chestnut Forest Rail	*Rallicula rubra*		LC	L	N	N	N	N	N	N	N	N	N	N	N
Rallidae	Forbes's Forest Rail	*Rallicula forbesi*	Rallina forbesi	LC	S	N	M	N	L	N	N	N	N	N	N	N
Rallidae	Mayr's Forest Rail	*Rallicula mayri*		LC	N	N	N	N	N	N	N	N	N	S	N	N
Rallidae	Red-necked Crake	*Rallina tricolor*		LC	1	2	S	1	1	S	S	S	S	S	S	S
Columbidae	Metallic Pigeon	*Columba vitiensis*		LC	S	S	S	S	1	S	S	S	S	S	S	S
Columbidae	Amboyna Cuckoo-Dove	*Macropygia amboinensis*	Slender-billed Cuckoo-Dove	LC	10	2	S	1	1	S	S	S	S	S	S	S
Columbidae	Bar-tailed Cuckoo-Dove	*Macropygia nigrirostris*	Black-billed Cuckoo-Dove	LC	2	2	S	1	1	S	S	S	S	S	S	S
Columbidae	Great Cuckoo-Dove	*Reinwardtoena reinwardti*	Reinwardtoena reinwardtsi	LC	7	3	S	1	S	S	S	S	S	S	S	S
Columbidae	Pacific Emerald Dove	*Chalcophaps longirostris*	Chalcophaps indica Emerald Dove	LC (as C. indica)	S	1	S	S	1	S	S	S	S	S	S	S
Columbidae	Stephan's Emerald Dove	*Chalcophaps stephani*		LC	3	4	S	S	S	S	S	S	S	S	S	S
Columbidae	New Guinea Bronzewing	*Henicophaps albifrons*		LC	S	S	S	S	1	S	S	S	S	S	S	S
Columbidae	Thick-billed Ground Pigeon	*Trugon terrestris*		LC	1	1	S	1	1	S	S	S	S	S	S	S
Columbidae	Cinnamon Ground Dove	*Gallicolumba rufigula*		LC	3	3	S	1	S	S	S	S	S	S	S	S

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Columbidae	White-breasted Ground Dove	*Alopecoenas jobiensis*	Gallicolumba jobiensis	LC	S	S	S	S	S	S	S	S	S	S	S	S
Columbidae	Bronze Ground Dove	*Alopecoenas beccarii*	Gallicolumba beccarii	LC	S	N	S	N	S	N	N	N	N	S	N	N
Columbidae	Pheasant Pigeon	*Otidiphaps nobilis*		LC	2	S	S	S	1	S	S	S	S	S	S	S
Columbidae	Victoria Crowned Pigeon	*Goura victoria*	Victoria Crowned Pigeon	NT	3	9	S	1	2	S	S	S	S	S	L	L
Columbidae	Wompoo Fruit Dove	*Ptilinopus magnificus*		LC	7	6	S	1	2	S	S	S	S	S	S	S
Columbidae	Pink-spotted Fruit Dove	*Ptilinopus perlatus*		LC	4	3	S	1	S	S	S	S	S	S	S	S
Columbidae	Ornate Fruit Dove	*Ptilinopus ornatus*		LC (as P. gestroi)	1	S	S	S	S	S	S	S	S	S	S	S
Columbidae	Orange-fronted Fruit Dove	*Ptilinopus aurantiifrons*		LC	S	2	S	S	1	S	S	S	S	M	S	S
Columbidae	Superb Fruit Dove	*Ptilinopus superbus*		LC	9	6	S	1	2	S	S	S	S	S	S	S
Columbidae	Coroneted Fruit Dove	*Ptilinopus coronulatus*		LC	9	8	S	1	1	S	S	S	S	S	S	S
Columbidae	Beautiful Fruit Dove	*Ptilinopus pulchellus*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Columbidae	White-bibbed Fruit Dove	*Ptilinopus rivoli2*		LC	1	L	S	L	S	L	L	L	L	S	L	L
Columbidae	Claret-breasted Fruit Dove	*Ptilinopus viridis*		LC	N	N	N	N	1	N	N	N	N	S	N	N
Columbidae	Orange-bellied Fruit Dove	*Ptilinopus iozonus*		LC	3	9	S	1	2	S	S	S	S	S	S	S
Columbidae	Dwarf Fruit Dove	*Ptilinopus nainus*	Ptilinopus naina	LC	3	1	S	1	1	S	S	S	S	S	S	S
Columbidae	Purple-tailed Imperial Pigeon	*Ducula rufigaster*		LC	7	5	S	1	S	S	S	S	S	S	S	S
Columbidae	Rufescent Imperial Pigeon	*Ducula chalconota*		LC	S	N	S	N	1	N	N	N	N	N	N	N
Columbidae	Pinon's Imperial Pigeon	*Ducula pinon*	Pinon Imperial-Pigeon	LC	1	7	S	1	1	S	S	S	S	S	S	S
Columbidae	Collared Imperial Pigeon	*Ducula mullerii*		LC	M	1	S	S	1	S	S	S	S	M	S	S
Columbidae	Zoe's Imperial Pigeon	*Ducula zoeae*	Banded Imperial-Pigeon	LC	11	9	S	1	1	S	S	S	S	S	S	S
Columbidae	Torresian Imperial Pigeon	*Ducula spilorrhoa*		LC	N	N	N	N	1	N	N	N	N	L	S	S
Columbidae	Papuan Mountain Pigeon	*Gymnophaps albertisii*		LC	5	4	S	S	1	L	L	L	S	S	L	N
Cuculidae	Ivory-billed Coucal	*Centropus menbeki*		LC	8	8	S	1	1	S	S	S	S	S	S	S
Cuculidae	Black-billed Coucal	*Centropus bernsteini*		LC	S	3	S	1	1	S	S	S	S	S	S	S
Cuculidae	Pheasant Coucal	*Centropus phasianinus*		LC	S	1	S	S	1	S	S	S	S	S	S	S
Cuculidae	Dwarf Koel	*Microdynamis parva*		LC	6	3	S	1	S	S	S	S	S	S	S	S
Cuculidae	Pacific Koel	*Eudynamys orientalis*		LC	2	4	S	S	2	S	S	S	S	S	S	S
Cuculidae	Channel-billed Cuckoo	*Scythrops novaehollandiae*		LC	1	2	S	1	2	S	S	S	S	S	S	S
Cuculidae	Long-billed Cuckoo	*Chrysococcyx megarhynchus*	Rhamphomantis megarhynchus	LC	1	3	S	1	S	S	S	S	S	S	S	S
Cuculidae	Rufous-throated Bronze Cuckoo	*Chrysococcyx ruficollis*		LC	S	S	S	S	S	N	N	N	N	N	N	N
Cuculidae	Shining Bronze Cuckoo	*Chrysococcyx lucidus*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Cuculidae	White-eared Bronze Cuckoo	*Chrysococcyx meyerii*	Chrysococcyx meyeri	LC	1	S	S	S	S	S	S	S	S	S	S	S
Cuculidae	Little Bronze Cuckoo	*Chrysococcyx minutillus*	Little (Malay) Bronze-Cuckoo	LC	1	4	S	S	1	S	S	S	S	S	S	S
Cuculidae	White-crowned Cuckoo	*Cacomantis leucolophus*	White-crowned Koel Caliechthrus leucolophus	LC	4	S	S	S	S	S	S	S	S	S	S	S
Cuculidae	Chestnut-breasted Cuckoo	*Cacomantis castaneiventris*		LC	8	S	S	S	S	S	S	S	S	S	S	S
Cuculidae	Fan-tailed Cuckoo	*Cacomantis flabelliformis*		LC	M	M	M	M	1	N	N	N	N	N	N	N
Cuculidae	Brush Cuckoo	*Cacomantis variolosus*		LC	6	8	S	1	1	S	S	S	S	S	S	S
Cuculidae	Oriental (/Himalayan) Cuckoo	*Cuculus optatus(/saturatus)*		LC	2	M	M	M	M	M	M	M	M	M	M	M
Tytonidae	Greater Sooty Owl	*Tyto tenebricosa*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Tytonidae	Western Barn Owl	*Tyto alba*		LC	N	S	L	L	L	S	S	S	L	L	L	L
Strigidae	Rufous Owl	*Ninox rufa*		LC	S	1	S	S	S	S	S	S	S	S	S	S

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Strigidae	Barking Owl	*Ninox connivens*		LC	N	S	L	L	1	S	S	S	L	L	L	L
Strigidae	Papuan Boobook	*Ninox theomacha*	Jungle Hawk-Owl	LC	3	1	S	1	2	S	S	S	S	S	S	S
Strigidae	Papuan Hawk-Owl	*Uroglaux dimorpha*		LC	1	2	S	1	2	S	S	S	S	S	S	S
Podargidae	Marbled Frogmouth	*Podargus ocellatus*		LC	3	2	S	1	1	S	S	S	S	S	S	S
Podargidae	Papuan Frogmouth	*Podargus papuensis*		LC	3	3	S	1	1	S	S	S	S	S	S	S
Caprimulgidae	White-throated Nightjar	*Eurostopodus mystacalis*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Caprimulgidae	Papuan Nightjar	*Eurostopodus papuensis*	Papuan Eared-Nightjar	LC	S	1	S	S	S	S	S	S	S	S	S	S
Caprimulgidae	Large-tailed Nightjar	*Caprimulgus macrurus*		LC	S	1	S	S	S	S	S	S	S	S	S	S
Aegothelidae	Feline Owlet-nightjar	*Aegotheles insignis*		LC	S	N	M	L	L	N	N	N	N	S	N	N
Aegothelidae	Wallace's Owlet-nightjar	*Aegotheles wallacii*		LC	1	N	S	M	M	N	N	N	N	S	N	N
Aegothelidae	Mountain Owlet-nightjar	*Aegotheles albertisi*		LC	S	N	S	L	M	N	N	N	N	M	N	N
Aegothelidae	Barred Owlet-nightjar	*Aegotheles bennettii*		LC	S	1	S	1	1	S	S	S	S	S	S	S
Hemiprocnidae	Moustached Treeswift	*Hemiprocne mystacea*		LC	3	S	S	S	S	S	S	S	S	S	S	S
Apodidae	Glossy Swiftlet	*Collocalia esculenta*		LC	9	1	S	1	S	S	S	S	S	S	S	S
Apodidae	Mountain Swiftlet	*Aerodramus hirundinaceus*		LC	1	L	S	L	S	N	N	N	N	S	N	N
Apodidae	Bare-legged Swiftlet	*Aerodramus nuditarsus*		LC	S	N	N	N	1	N	N	N	N	S	N	N
Apodidae	Uniform Swiftlet	*Aerodramus vanikorensis*		LC	1	2	S	1	1	S	S	S	S	S	S	S
Apodidae	Three-toed Swiftlet	*Aerodramus papuensis*		DD	S	N	S	N	1	N	N	N	N	S	N	N
Apodidae	Papuan Spine-tailed Swift	*Mearnsia novaeguineae*	Papuan Needletail	LC	1	7	S	1	1	S	S	S	S	S	S	S
Apodidae	White-throated Needletail	*Hirundapus caudacutus*		LC	1	S	S	S	S	S	S	S	S	S	S	S
Coraciidae	Oriental Dollarbird	*Eurystomus orientalis*	Dollarbird	LC	1	5	S	S	1	S	S	S	S	S	S	S
Alcedinidae	Hook-billed Kingfisher	*Melidora macrorrhina*		LC	7	6	S	1	1	S	S	S	S	S	S	S
Alcedinidae	Common Paradise Kingfisher	*Tanysiptera galatea*		LC	1	2	S	S	S	S	S	S	S	S	L	N
Alcedinidae	Buff-breasted Paradise Kingfisher	*Tanysiptera sylvia*		LC	S	1	S	S	S	S	S	S	S	S	S	S
Alcedinidae	Shovel-billed Kookaburra	*Clytoceyx rex*		LC	S	S	S	S	1	S	S	S	S	S	S	S
Alcedinidae	Rufous-bellied Kookaburra	*Dacelo gaudichaud*		LC	10	8	S	1	1	S	S	S	S	S	S	S
Alcedinidae	Blue-black Kingfisher	*Todiramphus nigrocyaneus*	Todirhamphus nigrocyaneus	NT	S	1	S	S	S	S	S	S	S	S	S	S
Alcedinidae	Beach Kingfisher	*Todiramphus saurophagus*		LC	N	N	N	N	N	N	N	N	N	N	N	S
Alcedinidae	Sacred Kingfisher	*Todiramphus sanctus*	Todirhamphus sanctus	LC	S	2	S	S	1	S	S	S	S	S	S	S
Alcedinidae	Yellow-billed Kingfisher	*Syma torotoro3*		LC	6	8	S	1	S	S	S	S	S	S	S	S
Alcedinidae	Mountain Kingfisher	*Syma megarhyncha*		LC	S	N	S	N	1	N	N	N	N	N	N	N
Alcedinidae	Papuan Dwarf Kingfisher	*Ceyx solitarius*	Variable Kingfisher Ceyx lepidus	LC	10	5	S	1	S	S	S	S	S	S	S	S
Alcedinidae	Azure Kingfisher	*Ceyx azureus*	Alcedo azurea	LC	4	3	S	S	S	S	S	S	S	S	S	S
Alcedinidae	Little Kingfisher	*Ceyx pusillus*	Alcedo pusilla	LC	S	S	S	S	S	S	S	S	S	S	S	S
Meropidae	Blue-tailed Bee-eater	*Merops philippinus*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Meropidae	Rainbow Bee-eater	*Merops ornatus*		LC	1	4	S	S	1	S	S	S	S	S	S	S
Bucerotidae	Blyth's Hornbill	*Rhyticeros plicatus*	Aceros plicatus	LC P	10	10	S	1	1	S	S	S	S	S	S	S
Falconidae	Nankeen Kestrel	Falco cenchroides		LC	L	S	L	L	L	S	S	S	S	L	S	S
Falconidae	Oriental Hobby	*Falco severus*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Falconidae	Brown Falcon	*Falco berigora*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Falconidae	Peregrine Falcon	*Falco peregrinus*		LC	S	S	S	S	1	S	S	S	S	S	S	S
Cacatuidae	Palm Cockatoo	*Probosciger aterrimus*		LC P	7	8	S	1	2	S	S	S	S	S	S	S

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Cacatuidae	Sulphur-crested Cockatoo	*Cacatua galerita*		LC	11	8	S	1	2	S	S	S	S	S	S	S
Psittaculidae	Pesquet's Parrot	*Psittrichas fulgidus*		VU	11	3	S	S	S	S	S	S	S	S	S	S
Psittaculidae	Buff-faced Pygmy Parrot	*Micropsitta pusio4*		LC	1	3	S	S	S	S	S	S	S	S	S	S
Psittaculidae	Red-breasted Pygmy-Parrot	*Micropsitta bruijnii*		LC	S	L	S	M	S	L	L	L	L	S	L	L
Psittaculidae	Papuan King Parrot	*Alisterus chloropterus*		LC	1	L	S	M	1	L	L	L	L	S	N	N
Psittaculidae	Eclectus Parrot	*Eclectus roratus*		LC	9	8	S	1	2	S	S	S	S	S	S	S
Psittaculidae	Red-cheeked Parrot	*Geoffroyus geoffroyi*		LC	5	9	S	1	2	S	S	S	S	S	S	S
Psittaculidae	Blue-collared Parrot	*Geoffroyus simplex*		LC	6	1	S	1	S	S	S	S	S	S	S	S
Psittaculidae	Brehm's Tiger Parrot	*Psittacella brehmii*		LC	L	N	M	N	N	N	N	N	N	N	N	N
Psittaculidae	Modest Tiger Parrot	Psittacella modesta		LC	L	N	N	N	N	N	N	N	N	N	N	N
Psittaculidae	Madarasz's Tiger Parrot	*Psittacella madaraszi*		LC	M	N	M	N	L	N	N	N	N	N	N	N
Psittaculidae	Plum-faced Lorikeet	Oreopsittacus arfaki		LC	L	N	N	N	N	N	N	N	N	N	N	N
Psittaculidae	Pygmy Lorikeet	*Charmosyna wilhelminae*		LC	S	N	S	N	M	N	N	N	N	N	N	N
Psittaculidae	Red-fronted Lorikeet	*Charmosyna rubronotata*		LC	3	1	S	S	S	S	S	S	S	S	S	S
Psittaculidae	Red-flanked Lorikeet	*Charmosyna placentis*		LC	2	1	S	1	S	S	S	S	S	S	S	S
Psittaculidae	Fairy Lorikeet	*Charmosyna pulchella*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Psittaculidae	Josephine's Lorikeet	*Charmosyna josefinae*		LC	S	N	S	N	N	N	N	N	N	S	N	N
Psittaculidae	Papuan Lorikeet	*Charmosyna papou5*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Psittaculidae	Yellow-billed Lorikeet	*Neopsittacus musschenbroekii*		LC	S	N	M	N	1	N	N	N	N	N	N	N
Psittaculidae	Black-capped Lory	*Lorius lory*		LC	12	9	S	1	1	S	S	S	S	S	S	S
Psittaculidae	Brown Lory	*Chalcopsitta duivenbodei6*		LC	S	2	S	S	S	S	S	S	S	S	S	S
Psittaculidae	Dusky Lory	*Pseudeos fuscata*		LC	2	3	S	S	S	S	S	S	S	S	S	S
Psittaculidae	Goldie's Lorikeet	*Psitteuteles goldiei*		LC	S	N	S	N	1	N	N	N	N	N	N	N
Psittaculidae	Coconut Lorikeet	*Trichoglossus haematodus*		LC	12	9	S	1	2	S	S	S	S	S	S	S
Psittaculidae	Edwards's Fig Parrot	*Psittaculirostris edwardsii*		LC	1	3	S	1	S	S	S	S	S	S	S	S
Psittaculidae	Orange-breasted Fig Parrot	*Cyclopsitta gulielmitertii*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Psittaculidae	Double-eyed Fig Parrot	*Cyclopsitta diophthalma*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Psittaculidae	Orange-fronted Hanging Parrot	*Loriculus aurantiifrons*		LC	2	1	S	S	S	S	S	S	S	S	S	S
Pittidae	Papuan Pitta	*Erythropitta macklotii*	Red-bellied Pitta Pitta erythrogaster	LC	S	1	S	S	2	S	S	S	S	S	S	S
Pittidae	Hooded Pitta	*Pitta sordida*		LC (as P. novaeguineae)	1	1	S	1	1	S	S	S	S	S	S	S
Ptilonorhynchidae	Tan-capped Catbird	*Ailuroedus geislerorum*	White-eared Catbird Ailuroedus buccoides	LC (as A. melanotis)	6	6	S	1	S	S	S	S	S	S	S	S
Ptilonorhynchidae	Northern Catbird	*Ailuroedus jobiensis*	Spotted Catbird Ailuroedus melanotis	LC (as A. buccoides)	2	N	S	N	M	N	N	N	N	S	N	N
Ptilonorhynchidae	MacGregor's Bowerbird	*Amblyornis macgregoriae*		LC	S	N	M	N	L	N	N	N	N	N	N	N
Ptilonorhynchidae	Masked Bowerbird	*Sericulus aureus*		LC	S	N	M	N	M	N	N	N	N	S	N	N
Ptilonorhynchidae	Yellow-breasted Bowerbird	*Chlamydera lauterbachi*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Ptilonorhynchidae	Fawn-breasted Bowerbird	Chlamydera cerviniventris		LC	S	S	S	S	S	S	S	S	S	S	S	S
Climacteridae	Papuan Treecreeper	*Cormobates placens*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Maluridae	Wallace's Fairywren	*Sipodotus wallacii*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Maluridae	Broad-billed Fairywren	*Chenorhamphus grayi*	Malurus grayi	LC	2	S	S	S	1	S	S	S	S	S	S	S
Maluridae	Emperor Fairywren	*Malurus cyanocephalus*		LC	1	2	S	S	S	S	S	S	S	S	S	S
Maluridae	White-shouldered Fairywren	*Malurus alboscapulatus*		LC	2	2	S	S	S	S	S	S	S	S	S	S

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Maluridae	Orange-crowned Fairywren	*Clytomyias insignis*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Meliphagidae	Ruby-throated Myzomela	*Myzomela eques*	Red-throated Myzomela	LC	2	S	S	S	S	S	S	S	S	S	S	S
Meliphagidae	Red Myzomela	*Myzomela cruentata*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Meliphagidae	Black Myzomela	*Myzomela nigrita7*		LC	2	N	S	N	M	N	N	N	N	S	N	N
Meliphagidae	Mountain Myzomela	*Myzomela adolphinae*		LC	S	N	S	N	S	N	N	N	N	S	N	N
Meliphagidae	Red-collared Myzomela	*Myzomela rosenbergii*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Meliphagidae	Green-backed Honeyeater	*Glycichaera fallax*		LC	S	1	S	S	S	S	S	S	S	S	S	S
Meliphagidae	Leaden Honeyeater	*Ptiloprora plumbea*		LC	S	N	S	N	M	N	N	N	N	N	N	N
Meliphagidae	Yellowish-streaked Honeyeater	*Ptiloprora meekiana*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Meliphagidae	Rufous-backed Honeyeater	*Ptiloprora guisei*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Meliphagidae	Mayr's Honeyeater	*Ptiloprora mayri*		LC	N	N	N	N	N	N	N	N	N	S	N	N
Meliphagidae	Plain Honeyeater	*Pycnopygius ixoides*		LC	1	S	S	S	S	S	S	S	S	S	S	S
Meliphagidae	Marbled Honeyeater	*Pycnopygius cinereus*		LC	S	N	S	L	1	N	N	N	N	N	N	N
Meliphagidae	Streak-headed Honeyeater	*Pycnopygius stictocephalus*		LC	5	6	S	1	1	S	S	S	S	S	S	S
Meliphagidae	Silver-eared Honeyeater	*Lichmera alboauricularis*		LC	L	2	L	L	S	S	S	S	S	L	S	S
Meliphagidae	Spotted Honeyeater	*Xanthotis polygrammus*		LC	S	L	S	S	1	L	L	L	L	S	M	L
Meliphagidae	Tawny-breasted Honeyeater	*Xanthotis flaviventer*		LC	11	8	S	1	2	S	S	S	S	S	S	S
Meliphagidae	Meyer's Friarbird	*Philemon meyeri*		LC	6	1	S	S	1	S	S	S	S	S	S	S
Meliphagidae	New Guinea Friarbird	*Philemon novaeguineae*		LC (as P. buceroides)	10	9	S	1	1	S	S	S	S	S	S	S
Meliphagidae	Long-billed Honeyeater	*Melilestes megarhynchus*		LC	8	6	S	1	1	S	S	S	S	S	S	S
Meliphagidae	Common Smoky Honeyeater	*Melipotes fumigatus*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Meliphagidae	Olive Straightbill	*Timeliopsis fulvigula*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Meliphagidae	Tawny Straightbill	*Timeliopsis griseigula*		LC	N	N	N	N	N	N	N	N	N	L	L	L
Meliphagidae	Rufous-banded Honeyeater	*Conopophila albogularis*		LC	L	1	L	L	L	S	S	S	S	L	L	L
Meliphagidae	Black-throated Honeyeater	*Caligavis subfrenata*		LC	S	N	M	N	1	N	N	N	N	N	N	N
Meliphagidae	Obscure Honeyeater	*Caligavis obscura*	Caligavis obscurus	LC	9	1	S	1	S	S	S	S	S	S	S	S
Meliphagidae	Yellow-browed Melidectes	*Melidectes rufocrissalis*		LC	S	N	M	N	L	N	N	N	N	N	N	N
Meliphagidae	Belford's Melidectes	*Melidectes belfordi*		LC	L	N	N	N	N	N	N	N	N	N	N	N
Meliphagidae	Ornate Melidectes	*Melidectes torquatus*		LC	S	N	S	N	M	N	N	N	N	N	N	N
Meliphagidae	Varied Honeyeater	*Gavicalis versicolor*		LC	N	N	N	N	N	N	N	N	N	N	L	S
Meliphagidae	Forest Honeyeater	*Meliphaga montana*		LC	3	N	S	N	M	N	N	N	N	S	N	N
Meliphagidae	Mountain Honeyeater	*Meliphaga orientalis*		LC	S	N	S	L	S	N	N	N	N	S	N	N
Meliphagidae	Mimic Honeyeater	*Meliphaga analoga*		LC	6	2	S	S	S	S	S	S	S	S	S	S
Meliphagidae	Yellow-gaped Honeyeater	*Meliphaga flavirictus*		LC	S	S	S	S	1	S	S	S	S	S	S	S
Meliphagidae	Puff-backed Honeyeater	*Meliphaga aruensis*		LC	7	4	S	S	S	S	S	S	S	S	S	S
Acanthizidae	Goldenface	*Pachycare flavogriseum*	Pachycare flavogrisea	LC	3	N	S	L	1	N	N	N	N	S	N	N
Acanthizidae	Rusty Mouse-warbler	*Crateroscelis murina*		LC	11	5	S	1	1	S	S	S	S	S	S	L
Acanthizidae	Bicolored Mouse-warbler	*Crateroscelis nigrorufa*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Acanthizidae	Mountain Mouse-warbler	*Crateroscelis robusta*		LC	M	N	L	N	N	N	N	N	N	S	N	N
Acanthizidae	Pale-billed Scrubwren	*Sericornis spilodera*		LC	6	1	S	1	S	S	S	S	S	S	S	S
Acanthizidae	Tropical Scrubwren	*Sericornis beccarii*	Tropical/ Beccari's Scrubwren	LC	1	S	S	S	S	S	S	S	S	S	S	S
Acanthizidae	Large Scrubwren	*Sericornis nouhuysi*		LC	M	N	L	N	N	N	N	N	N	S	N	N

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Acanthizidae	Buff-faced Scrubwren	*Sericornis perspicillatus*		LC	S	N	M	N	M	N	N	N	N	S	N	N
Acanthizidae	Grey-green Scrubwren	*Sericornis arfakianus*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Acanthizidae	Brown-breasted Gerygone	*Gerygone ruficollis*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Acanthizidae	Large-billed Gerygone	*Gerygone magnirostris*		LC	S	3	S	S	2	S	S	S	S	S	S	S
Acanthizidae	Yellow-bellied Gerygone	*Gerygone chrysogaster*		LC	8	6	S	1	S	S	S	S	S	S	S	S
Acanthizidae	Green-backed Gerygone	*Gerygone chloronota*	Gerygone chloronotus	LC	3	1	S	S	S	S	S	S	S	S	S	S
Acanthizidae	Fairy Gerygone	*Gerygone palpebrosa*		LC	4	L	S	L	S	L	L	L	L	S	L	L
Acanthizidae	Grey Thornbill	*Acanthiza cinerea*		LC	M	N	N	N	1	N	N	N	N	S	N	N
Pomatostomidae	Papuan Babbler	*Garritornis isidorei*	New Guinea Babbler Pomatostomus isidorei	LC	1	3	S	1	S	S	S	S	S	S	S	S
Orthonychidae	Papuan Logrunner	*Orthonyx novaeguineae*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Cnemophilidae	Loria's Satinbird	*Cnemophilus loriae*		LC P	M	N	L	N	N	N	N	N	N	N	N	N
Cnemophilidae	Yellow-breasted Satinbird	*Loboparadisea sericea*		NT P	S	N	S	N	1	N	N	N	N	N	N	N
Melanocharitidae	Black Berrypecker	*Melanocharis nigra*		LC	7	2	S	1	S	S	S	S	S	S	S	S
Melanocharitidae	Mid-mountain Berrypecker	*Melanocharis longicauda*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Melanocharitidae	Fan-tailed Berrypecker	*Melanocharis versteri*		LC	S	N	M	N	N	N	N	N	N	S	N	N
Melanocharitidae	Streaked Berrypecker	*Melanocharis striativentris*		LC	S	N	S	N	M	N	N	N	N	N	N	N
Melanocharitidae	Spotted Berrypecker	*Rhamphocharis crassirostris*		LC	S	N	M	N	L	N	N	N	N	N	N	N
Melanocharitidae	Dwarf Longbill	*Oedistoma iliolophus*	Plumed Longbill Toxorhamphus iliolophus	LC	7	S	S	S	S	S	S	S	S	S	S	S
Melanocharitidae	Pygmy Longbill	*Oedistoma pygmaeum*		LC	S	S	S	S	1	S	S	S	S	S	S	S
Melanocharitidae	Yellow-bellied Longbill	*Toxorhamphus novaeguineae*	Green-crowned Longbill	LC	9	5	S	1	1	S	S	S	S	S	S	S
Melanocharitidae	Slaty-headed Longbill	*Toxorhamphus poliopterus*		LC	S	L	S	N	M	N	N	N	N	N	N	N
Paramythiidae	Tit Berrypecker	*Oreocharis arfaki*		LC	S	L	S	N	S	N	N	N	N	S	N	N
Psophodidae	Papuan Whipbird	*Androphobus viridis*		DD	M	N	N	N	N	N	N	N	N	N	N	N
Psophodidae	Spotted Jewel-babbler	*Ptilorrhoa leucosticta*		LC	M	N	L	N	1	N	N	N	N	S	N	N
Psophodidae	Blue Jewel-babbler	*Ptilorrhoa caerulescens*		LC	7	5	S	1	S	S	S	S	S	S	S	S
Psophodidae	Chestnut-backed Jewel-babbler	*Ptilorrhoa castanonota*		LC	2	N	S	N	1	N	N	N	N	S	N	N
Machaerirhynchidae	Yellow-breasted Boatbill	*Machaerirhynchus flaviventer*		LC	4	S	S	S	S	S	S	S	S	S	S	S
Machaerirhynchidae	Black-breasted Boatbill	*Machaerirhynchus nigripectus*		LC	M	N	L	N	N	N	N	N	N	N	N	N
Artamidae	White-breasted Woodswallow	*Artamus leucorynchus*		LC	S	1	S	S	1	S	S	S	S	S	S	S
Artamidae	Great Woodswallow	*Artamus maximus*		LC	S	N	S	N	1	N	N	N	N	S	N	N
Artamidae	Lowland Peltops	*Peltops blainvillii*		LC	6	3	S	S	S	S	S	S	S	S	S	S
Artamidae	Mountain Peltops	*Peltops montanus*		LC	1	N	S	N	1	N	N	N	N	S	N	N
Artamidae	Black Butcherbird	*Melloria quoyi*	Cracticus quoyi	LC	6	4	S	1	2	S	S	S	S	S	S	S
Artamidae	Hooded Butcherbird	*Cracticus cassicus*		LC	6	8	S	1	1	S	S	S	S	S	S	S
Rhagologidae	Mottled Berryhunter	*Rhagologus leucostigma*		LC	S	N	S	N	L	N	N	N	N	N	N	N
Campephagidae	Stout-billed Cuckooshrike	*Coracina caeruleogrisea*		LC	2	L	M	L	L	L	L	L	L	S	L	L
Campephagidae	Barred Cuckooshrike	*Coracina lineata*		LC	S	N	S	N	1	N	N	N	N	S	N	N
Campephagidae	Boyer's Cuckooshrike	*Coracina boyeri*		LC	3	6	S	1	1	S	S	S	S	S	S	S
Campephagidae	White-bellied Cuckooshrike	*Coracina papuensis*		LC	S	2	S	S	S	S	S	S	S	S	S	S
Campephagidae	Hooded Cuckooshrike	*Coracina longicauda*		LC	L	N	N	N	N	N	N	N	N	N	N	N
Campephagidae	Black-shouldered Cicadabird	*Coracina incerta*		LC	S	N	S	L	1	N	N	N	L	S	L	N
Campephagidae	Grey-headed Cuckooshrike	*Coracina schisticeps*		LC	12	6	S	1	1	S	S	S	S	S	S	L

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Campephagidae	Black Cicadabird	*Coracina melas*	New Guinea Cuckooshrike	LC	3	S	S	S	S	S	S	S	S	S	S	S
Campephagidae	Black-bellied Cuckooshrike	*Coracina montana*		LC	1	N	S	N	1	N	N	N	N	S	N	N
Campephagidae	Golden Cuckooshrike	*Campochaera sloetii*		LC	1	3	S	1	2	S	S	S	S	S	S	S
Campephagidae	Black-browed Triller	*Lalage atrovirens*		LC	7	9	S	1	1	S	S	S	S	S	S	S
Neosittidae	Papuan Sittella	Daphoenositta papuensis		LC	M	N	L	N	N	N	N	N	N	N	N	N
Eulacestomatidae	Wattled Ploughbill	Eulacestoma nigropectus		LC	M	N	N	N	N	N	N	N	N	N	N	N
Oreoicidae	Rufous-naped Bellbird	Aleadryas rufinucha		LC	M	N	N	N	N	N	N	N	N	S	N	N
Oreoicidae	Piping Bellbird	*Ornorectes cristatus*	Crested Pitohui Pitohui cristatus	LC	2	N	S	N	S	N	N	N	N	S	N	N
Pachycephalidae	Black Pitohui	*Melanorectes nigrescens*		LC	S	N	M	N	L	N	N	N	N	N	N	N
Pachycephalidae	Rusty Whistler	*Pachycephala hyperythra*		LC	1	S	S	S	S	S	S	S	S	S	S	S
Pachycephalidae	Brown-backed Whistler	*Pachycephala modesta*		LC	M	N	N	N	N	N	N	N	N	N	N	N
Pachycephalidae	Grey Whistler	*Pachycephala simplex*	Brown Whistler	LC (as P. griseiceps)	1	S	S	S	S	S	S	S	S	S	S	S
Pachycephalidae	Sclater's Whistler	*Pachycephala soror*		LC	2	L	S	S	S	N	N	N	N	N	N	N
Pachycephalidae	Regent Whistler	*Pachycephala schlegelii*		LC	L	N	N	N	N	N	N	N	N	S	N	N
Pachycephalidae	Golden-backed Whistler	*Pachycephala aurea*		LC	S	S	S	S	S	S	S	S	S	N	N	N
Pachycephalidae	Black-headed Whistler	*Pachycephala monacha*		LC	S	L	S	M	S	N	N	N	L	S	N	N
Pachycephalidae	White-bellied Whistler	*Pachycephala leucogastra*		LC	S	S	S	S	1	S	S	S	S	S	M	N
Pachycephalidae	Rusty Pitohui	*Pseudorectes ferrugineus*	Pitohui ferrugineus	LC	1	2	S	1	S	S	S	S	S	S	S	S
Pachycephalidae	Sooty Shrikethrush	*Colluricincla tenebrosa*	Colluricincla umbrina	LC	M	N	L	N	1	N	N	N	N	N	N	N
Pachycephalidae	Little Shrikethrush	*Colluricincla megarhyncha*	Little Shrike-thrush	LC	8	3	S	1	S	S	S	S	S	S	S	S
Pachycephalidae	Grey Shrikethrush	*Colluricincla harmonica*	Grey Shrike-thrush	LC	L	2	L	M	1	M	M	M	M	M	S	S
Oriolidae	Northern Variable Pitohui	*Pitohui kirhocephalus*	Variable Pitohui	LC	12	6	S	1	1	S	S	S	S	S	S	S
Oriolidae	Hooded Pitohui	*Pitohui dichrous*		LC	S	M	S	M	S	M	M	M	S	S	L	L
Oriolidae	Brown Oriole	*Oriolus szalayi*		LC	S	2	S	S	2	S	S	S	S	S	S	S
Dicruridae	Spangled Drongo	*Dicrurus bracteatus*		LC	10	8	S	1	1	S	S	S	S	S	S	S
Rhipiduridae	Willie Wagtail	*Rhipidura leucophrys*	Willie-wagtail	LC	S	4	S	1	1	S	S	S	S	S	S	S
Rhipiduridae	Northern Fantail	*Rhipidura rufiventris*		Lc (as R. isura)	2	S	S	S	S	S	S	S	S	S	S	S
Rhipiduridae	Sooty Thicket Fantail	*Rhipidura threnothorax*		LC	6	1	S	1	1	S	S	S	S	S	S	S
Rhipiduridae	White-bellied Thicket Fantail	*Rhipidura leucothorax*		LC	2	9	S	1	1	S	S	S	S	S	S	S
Rhipiduridae	Black Fantail	*Rhipidura atra*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Rhipiduridae	Chestnut-bellied Fantail	*Rhipidura hyperythra*		LC	4	L	S	M	S	L	L	L	L	S	N	N
Rhipiduridae	Friendly Fantail	*Rhipidura albolimbata*		LC	M	N	N	N	N	N	N	N	N	S	N	N
Rhipiduridae	Dimorphic Fantail	*Rhipidura brachyrhyncha*		LC	M	N	N	N	1	N	N	N	N	N	N	N
Rhipiduridae	Rufous-backed Fantail	*Rhipidura rufidorsa*		LC	10	1	S	1	S	S	S	S	S	S	S	S
Rhipiduridae	Drongo Fantail	*Chaetorhynchus papuensis*		LC	S	L	S	L	S	N	N	N	M	S	N	N
Monarchidae	Black Monarch	*Symposiachrus axillaris*	Monarcha axillaris	LC	S	N	S	N	1	N	N	N	N	S	N	N
Monarchidae	Spot-winged Monarch	*Symposiachrus guttula*	Monarcha guttulus	LC	5	2	S	1	1	S	S	S	S	S	S	S
Monarchidae	Hooded Monarch	*Symposiachrus manadensis*	Monarcha manadensis	LC	4	3	S	S	S	S	S	S	S	S	S	S
Monarchidae	Rufous Monarch	*Monarcha rubiensis*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Monarchidae	Black-winged Monarch	*Monarcha frater*		LC	S	N	S	N	1	N	N	N	N	S	N	N
Monarchidae	Golden Monarch	*Carterornis chrysomela*	Monarcha chrysomela	LC	6	1	S	S	1	S	S	S	S	S	S	S
Monarchidae	Ochre-collared Monarch	*Arses insularis*	Rufous-collared Monarch	LC	4	3	S	1	S	S	S	S	S	S	S	S

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Monarchidae	Torrent-lark	*Grallina bruijnii*	Grallina bruijni	LC	1	N	S	L	S	N	N	N	N	S	N	N
Monarchidae	Satin Flycatcher	*Myiagra cyanoleuca*		LC	S	1	S	S	1	S	S	S	S	S	S	S
Monarchidae	Shining Flycatcher	*Myiagra alecto*		LC	2	6	S	1	2	S	S	S	S	S	S	S
Corvidae	Grey Crow	*Corvus tristis*		LC	10	6	S	1	S	S	S	S	S	S	S	S
Melampittidae	Lesser Melampitta	*Melampitta lugubris*		LC	M	N	N	N	N	N	N	N	N	N	N	N
Melampittidae	Greater Melampitta	*Megalampitta gigantea*	Melampitta gigantea	LC	S	N	S	N	M	N	N	N	N	S	N	N
Ifritidae	Blue-capped Ifrit	Ifrita kowaldi		LC	L	N	N	N	N	N	N	N	N	N	N	N
Paradisaeidae	Glossy-mantled Manucode	*Manucodia ater5*	*Manucodia atra*	LC P	S	3	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Jobi Manucode	*Manucodia jobiensis*		LC P	S	1	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Crinkle-collared /Jobi Manucode	*Manucodia chalybatus8*		LC P	3	1	S	L	S	L	L	L	L	S	L	L
Paradisaeidae	Trumpet Manucode	*Phonygammus keraudrenii*	Manucodia keraudrenii	LC P	S	M	S	M	S	M	M	M	M	S	L	L
Paradisaeidae	Short-tailed Paradigalla	*Paradigalla brevicauda*		LC P	L	N	N	N	N	N	N	N	N	N	N	N
Paradisaeidae	Queen Carola's Parotia	*Parotia carolae*	Carola's Parotia	LC P	1	N	S	N	M	N	N	N	N	N	N	N
Paradisaeidae	King of Saxony Bird-of-paradise	*Pteridophora alberti*		LC P	L	N	N	N	N	N	N	N	N	N	N	N
Paradisaeidae	Superb Bird-of-paradise	*Lophorina superba*		LC P	S	N	S	N	1	N	N	N	N	N	N	N
Paradisaeidae	Magnificent Riflebird	*Ptiloris magnificus*		LC P	4	1	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Black Sicklebill	*Epimachus fastosus*	Epimachus fastuosus	LC P	M	N	L	N	N	N	N	N	N	N	N	N
Paradisaeidae	Black-billed Sicklebill	Drepanornis albertisi		LC P	S	N	M	N	L	N	N	N	N	N	N	N
Paradisaeidae	Pale-billed Sicklebill	Drepanornis bruijnii		NT P	N	N	N	N	L	M	S	S	S	S	S	S
Paradisaeidae	Magnificent Bird-of-paradise	*Diphyllodes magnificus*	Cicinnurus magnificus	LC P	9	L	S	N	1	N	N	N	L	S	L	N
Paradisaeidae	King Bird-of-paradise	*Cicinnurus regius*		LC P	5	6	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Twelve-wired Bird-of-paradise	*Seleucidis melanoleucus*	Seleucidis melanoleuca	LC P	M	3	S	1	1	S	S	S	S	M	S	S
Paradisaeidae	Lesser Bird-of-paradise	*Paradisaea minor*		LC P	11	3	S	1	1	S	S	S	S	S	S	S
Petroicidae	Ashy Robin	*Heteromyias albispecularis*		LC	M	N	M	N	M	N	N	N	N	N	N	N
Petroicidae	Black-chinned Robin	*Poecilodryas brachyura*		LC	2	S	S	S	1	S	S	S	S	S	S	S
Petroicidae	Black-sided Robin	*Poecilodryas hypoleuca*		LC	8	7	S	1	S	S	S	S	S	S	S	S
Petroicidae	Banded Yellow Robin	*Poecilodryas placens*		NT	S	N	S	N	M	N	N	N	N	N	N	N
Petroicidae	Black-throated Robin	*Poecilodryas albonotata*		LC	M	N	N	N	N	N	N	N	N	N	N	N
Petroicidae	Slaty Robin	*Peneothello cyanus*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Petroicidae	Mangrove Robin	*Peneoenanthe pulverulenta*	Eopsaltria pulverulenta	LC	N	N	N	N	N	N	N	N	N	N	S	S
Petroicidae	White-faced Robin	*Tregellasia leucops*		LC	2	L	S	L	M	L	L	L	L	S	L	L
Petroicidae	Green-backed Robin	*Pachycephalopsis hattamensis*		LC	S	N	M	N	L	N	N	N	N	N	N	N
Petroicidae	White-eyed Robin	*Pachycephalopsis poliosoma*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Petroicidae	Torrent Flyrobin	*Monachella muelleriana*	Torrent Robin	LC	6	N	S	N	S	N	N	N	N	S	N	N
Petroicidae	Canary Flyrobin	*Microeca papuana*		LC	M	N	N	N	N	N	N	N	N	S	N	N
Petroicidae	Yellow-legged Flyrobin	*Microeca griseoceps*		LC	S	N	S	N	1	N	N	N	N	S	N	N
Petroicidae	Olive Flyrobin	*Microeca flavovirescens*		LC	1	S	S	S	S	S	S	S	S	S	S	S
Petroicidae	Lemon-bellied Flyrobin	*Microeca flavigaster*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Petroicidae	Garnet Robin	*Eugerygone rubra*		LC	L	N	N	N	N	N	N	N	N	N	N	N
Petroicidae	Papuan Scrub Robin	*Drymodes beccarii*	Drymodes superciliaris Northern Scrub Robin	LC	1	L	L	L	L	L	L	L	L	S	L	L
Petroicidae	Lesser Ground Robin	*Amalocichla incerta*		LC	S	N	S	N	L	N	N	N	N	S	N	N
Hirundinidae	Barn Swallow	*Hirundo rustica*		LC	S	S	S	S	S	S	S	S	S	S	S	S

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Hirundinidae	Pacific Swallow	*Hirundo tahitica*		LC (as H. javanica)	1	3	S	1	1	S	S	S	S	S	S	S
Hirundinidae	Red-rumped Swallow	Cecropis daurica		LC	S	S	S	S	S	S	S	S	S	S	S	S
Hirundinidae	Tree Martin	*Petrochelidon nigricans*	Hirundo nigricans	LC	S	S	S	S	S	S	S	S	S	S	S	S
Phylloscopidae	Island Leaf Warbler	*Phylloscopus maforensis*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Cisticolidae	Golden-headed Cisticola	*Cisticola exilis*		LC	S	2	S	S	S	S	S	S	S	S	S	S
Zosteropidae	Black-fronted White-eye	*Zosterops minor*		LC	8	N	S	N	M	N	N	N	N	S	N	N
Zosteropidae	Capped White-eye	*Zosterops fuscicapilla*	Zosterops fuscicapillus	LC	S	N	M	N	L	N	N	N	N	S	N	N
Sturnidae	Metallic Starling	*Aplonis metallica*		LC	S	2	S	S	S	S	S	S	S	S	S	S
Sturnidae	Singing Starling	*Aplonis cantoroides*		LC	S	2	S	S	1	S	S	S	S	S	S	S
Sturnidae	Yellow-faced Myna	*Mino dumontii*		LC	9	9	S	1	2	S	S	S	S	S	S	S
Sturnidae	Golden Myna	*Mino anais*		LC	1	2	S	S	S	S	S	S	S	S	S	S
Turdidae	Russet-tailed Thrush	*Zoothera heinei*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Muscicapidae	Pied Bush Chat	*Saxicola caprata*		LC	N	N	N	N	1	M	M	M	M	N	N	N
Dicaeidae	Red-capped Flowerpecker	*Dicaeum geelvinkianum*		LC	9	4	S	1	1	S	S	S	S	S	S	S
Nectariniidae	Black Sunbird	*Leptocoma aspasia*	Nectarinia aspasia	LC	10	6	S	1	1	S	S	S	S	S	S	S
Nectariniidae	Olive-backed Sunbird	*Cinnyris jugularis*	Nectarinia jugularis	LC	S	1	S	S	S	S	S	S	S	S	S	S
Passeridae	Eurasian Tree Sparrow	*Passer montanus*		LC	1	M	M	M	M	M	M	M	M	M	M	M
Estrildidae	Blue-faced Parrotfinch	*Erythrura trichroa*		LC	S	N	S	N	M	N	N	N	N	S	N	N
Estrildidae	Papuan Parrotfinch	*Erythrura papuana*		LC	M	N	S	N	M	N	N	N	N	N	N	N
Estrildidae	Streak-headed Mannikin	*Lonchura tristissima*		LC	S	1	S	S	S	S	S	S	S	S	S	S
Estrildidae	Great-billed Mannikin	*Lonchura grandis*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Estrildidae	Hooded Mannikin	*Lonchura spectabilis9*		LC	S	1	S	S	S	S	S	S	S	S	S	S
Estrildidae	Chestnut-breasted Mannikin	*Lonchura castaneothorax*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Motacillidae	Grey Wagtail	*Motacilla cinerea*		LC	3	M	M	M	M	M	M	M	M	M	M	M

*Conservation status IUCN CR-Critically Endangered, EN – Endangered, VU – Vulnerabe, NT – Near Threatened, DD – Data Defficient, LC - Least Concern, NE – Not evaluated. P – protected under PNG *Fauna (Protection and Control) Act 1966.*

1-12	# of combined survey sites at which recorded
V	Village informant record from Sepik Development Project survey
S	Species not recorded whose known ranges and habitat preferences indicate a strong likelihood of occurring
M	Species not recorded whose known ranges and habitat preferences indicate a moderate likelihood of occurring
L	Species not recorded whose known ranges and habitat preferences indicate a low likelihood of occurring
N	Does not or extremely unlikely to occur

21.3 Waterbird occurrence or potential occurrence in the Study Area.

FAMILY	COMMON NAME	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Anatidae	Spotted Whistling Duck	*Dendrocygna guttata*		LC	1	1	L	M	L	S	S	S	S	N	S	S
Anatidae	Wandering Whistling Duck	*Dendrocygna arcuata*		LC	L	S	L	M	L	S	S	S	S	N	S	S
Anatidae	Raja Shelduck	*Radjah radjah*	Tadorna radjah	LC	L	S	L	M	L	S	S	S	S	N	S	S
Anatidae	Cotton Pygmy Goose	*Nettapus coromandelianus*		LC	L	S	L	S	M	S	S	S	S	N	S	S
Anatidae	Pacific Black Duck	*Anas superciliosa*		LC	S	3	S	S	1	S	S	S	S	S	S	S
Anatidae	Grey Teal	*Anas gracilis*		LC	M	S	S	S	S	S	S	S	S	L	S	S
Anatidae	Hardhead	*Aythya australis*		LC	M	S	S	S	S	S	S	S	S	L	S	S
Podicipedidae	Little Grebe	*Tachybaptus ruficollis*		LC	L	S	L	S	L	S	S	S	S	L	S	S
Podicipedidae	Australasian Grebe	*Tachybaptus novaehollandiae*		LC	L	S	L	S	L	S	S	S	S	L	S	S
Threskiornithidae	Australian White Ibis	*Threskiornis molucca*		LC	L	S	L	S	L	S	S	S	S	L	S	S
Ardeidae	Yellow(/Little) Bittern	*Ixobrychus sinensis /dubius*		LC	L	1	L	M	S	S	S	S	S	L	S	S
Ardeidae	Black Bittern	*Dupetor flavicollis*		LC	M	1	L	S	M	S	S	S	S	M	S	S
Ardeidae	Nankeen Night Heron	*Nycticorax caledonicus*	Rufous Night-Heron	LC	M	2	L	S	M	S	S	S	S	M	S	S
Ardeidae	Striated Heron	*Butorides striata*	Butorides striatus	LC	M	S	L	S	M	S	S	S	S	M	S	S
Ardeidae	Eastern Cattle Egret	*Bubulcus coromandus*		LC	M	S	L	S	M	S	S	S	S	M	S	S
Ardeidae	Great-billed Heron	*Ardea sumatrana*		LC	L	2	L	1	M	S	S	S	S	L	S	S
Ardeidae	Great Egret	*Ardea alba*	Eastern Great Egret Ardea modesta	LC P	L	4	L	1	1	S	S	S	S	L	S	S
Ardeidae	Intermediate Egret	*Ardea intermedia*	Mesophoyx intermedia	LC P	L	3	L	S	M	S	S	S	S	L	S	S
Ardeidae	Pied Heron	*Egretta picata*	Ardea picata	LC	L	2	L	S	M	S	S	S	S	L	S	S
Ardeidae	Little Egret	*Egretta garzetta*		LC P	L	1	L	1	M	S	S	S	S	L	S	S
Pelecanidae	Australian Pelican	*Pelecanus conspicillatus*		LC	L	S	L	M	L	S	S	S	S	L	S	S
Phalacrocoracidae	Little Pied Cormorant	*Microcarbo melanoleucos*	Phalacrocorax melanoleucos	LC	M	3	L	1	1	S	S	S	S	L	S	S
Phalacrocoracidae	Little Black Cormorant	*Phalacrocorax sulcirostris*		LC	1	2	L	M	1	S	S	S	S	L	S	S
Phalacrocoracidae	Great Cormorant	*Phalacrocorax carbo*		LC	M	1	L	1	1	S	S	S	S	L	S	S
Anhingidae	Australasian Darter	*Anhinga novaehollandiae*	Australian Darter	LC	M	2	L	1	L	S	S	S	S	L	S	S
Pandionidae	Eastern Osprey	*Pandion cristatus*		LC	L	S	L	L	L	S	S	S	S	L	S	S
Rallidae	Buff-banded Rail	*Gallirallus philippensis*		LC	S	S	S	S	S	S	S	S	S	S	S	S
Rallidae	Bare-eyed Rail	*Gymnocrex plumbeiventris*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Rallidae	Pale-vented Bush-hen	*Amaurornis moluccana*	Rufous-tailed Waterhen	LC	S	2	S	1	1	S	S	S	S	N	S	S
Rallidae	Baillon's Crake	*Porzana pusilla*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Rallidae	Spotless Crake	*Porzana tabuensis*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Rallidae	White-browed Crake	*Porzana cinerea*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Rallidae	New Guinea Flightless Rail	*Megacrex inepta*		LC	L	1	L	L	S	S	S	S	S	N	S	S
Rallidae	Australasian Swamphen	*Porphyrio melanotus*	Purple Swamphen P. porphyrio	LC	L	1	L	L	S	S	S	S	S	N	S	S
Rallidae	Dusky Moorhen	*Gallinula tenebrosa*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Rallidae	Eurasian Coot	*Fulica atra*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Burhinidae	Beach Stone-curlew	*Esacus magnirostris*		NT	N	N	N	N	N	N	N	N	N	N	N	S
Charadriidae	Masked Lapwing	*Vanellus miles*		LC	L	3	L	L	S	S	S	S	S	N	S	S
Charadriidae	Pacific Golden Plover	*Pluvialis fulva*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Charadriidae	Grey Plover	*Pluvialis squatarola*		LC	L	S	L	L	L	L	L	L	L	N	L	S
Charadriidae	Little Ringed Plover	*Charadrius dubius*		LC	L	1	L	L	S	S	S	S	S	N	S	S

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Charadriidae	Lesser Sand Plover	*Charadrius mongolus*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Charadriidae	Greater Sand Plover	*Charadrius leschenaultii*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Charadriidae	Oriental Plover	*Charadrius veredus*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Jacanidae	Comb-crested Jacana	*Irediparra gallinacea*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Whimbrel	*Numenius phaeopus*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Little Curlew	*Numenius minutus*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Far Eastern Curlew	*Numenius madagascariensis*		EN	N	N	N	N	N	N	N	N	N	N	N	M
Scolopacidae	Bar-tailed Godwit	*Limosa lapponica*		NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Black-tailed Godwit	*Limosa limosa*		NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*		LC	N	N	N	N	N	N	N	N	N	N	N	L
Scolopacidae	Great Knot	*Calidris tenuirostris*		EN	N	N	N	N	N	N	N	N	N	N	N	M
Scolopacidae	Red Knot	*Calidris canutus*		NT	N	N	N	N	N	N	N	N	N	N	N	M
Scolopacidae	Broad-billed Sandpiper	*Calidris falcinellus*	Limicola falcinellus	LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Curlew Sandpiper	*Calidris ferruginea*		NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Long-toed Stint	*Calidris subminuta*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Red-necked Stint	*Calidris ruficollis*		NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Little Stint	*Calidris minuta*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Asian Dowitcher	*Limnodromus semipalmatus*		NT	N	N	N	N	N	N	N	N	N	N	N	M
Scolopacidae	Latham's Snipe	*Gallinago hardwickii*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Swinhoe's Snipe	*Gallinago megala*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Common Sandpiper	*Actitis hypoleucos*		LC	1	1	L	L	1	S	S	S	S	N	S	S
Scolopacidae	Grey-tailed Tattler	*Tringa brevipes*		NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Marsh Sandpiper	*Tringa stagnatilis*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Wood Sandpiper	*Tringa glareola*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Common Greenshank	*Tringa nebularia*		LC	L	S	L	L	S	S	S	S	S	N	S	S
Laridae	Gull-billed Tern	*Gelochelidon nilotica*		LC	N	N	N	N	N	N	N	N	N	N	N	L
Laridae	Little Tern	*Sternula albifrons*	Sternella albifrons	LC	N	N	N	N	N	N	N	N	N	N	N	L
Laridae	Common Tern	*Sterna hirundo*		LC	N	N	N	N	N	N	N	N	N	N	N	L
Laridae	Whiskered Tern	*Chlidonias hybrida*	Chlidonias hybridus	LC	L	2	L	L	S	S	S	S	S	N	S	S
Acrocephalidae	Clamorous Reed Warbler	*Acrocephalus stentoreus*		LC	L	S	L	S	L	S	S	S	S	L	S	S
Locustellidae	Papuan Grassbird	Megalurus macrurus		LC	1	S	S	S	S	S	S	S	S	S	S	S
Cisticolidae	Golden-headed Cisticola	*Cisticola exilis*		LC	S	2	S	S	S	S	S	S	S	S	S	S

*Conservation status IUCN CR-Critically Endangered, EN – Endangered, VU – Vulnerabe, NT – Near Threatened, DD – Data Defficient, LC - Least Concern, NE – Not evaluated. P – protected under PNG *Fauna (Protection and Control) Act 1966.*

1-12	# of combined survey sites at which recorded
V	Village informant record from Sepik Development Project survey
S	Species not recorded whose known ranges and habitat preferences indicate a strong likelihood of occurring
M	Species not recorded whose known ranges and habitat preferences indicate a moderate likelihood of occurring
L	Species not recorded whose known ranges and habitat preferences indicate a low likelihood of occurring
N	Does not or extremely unlikely to occur

21.4 Frog occurrence or potential occurrence in the Study Area.

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS *	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Microhylidae	Asterophrys turpicola		LC	S	S	S	S	S	S	S	S	S	S	S	S
Microhylidae	Austrochaperina sp 1 cf hooglandi		NE	3	N	L	N	N	N	N	N	N	N	N	N
Microhylidae	Austrochaperina adamantina		DD	N	N	N	N	N	N	N	N	L	S	L	N
Microhylidae	Austrochaperina aquilonia		DD	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Austrochaperina basipalmata		LC	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Austrochaperina rivularis		LC	S	S	S	S	S	S	S	S	S	S	S	S
Microhylidae	Austrochaperina septentrionalis		DD	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Austrochaperina sp. 2 (aquilonia?)		NE	4	N	S	N	L	N	N	N	N	L	N	N
Microhylidae	Austrochaperina sp. 3 (aquatic)		NE	2	N	S	N	L	N	N	N	N	L	N	N
Microhylidae	Austrochaperina sp. 4 (Ok Isai)		NE	1	S	S	S	S	M	M	M	M	M	M	M
Microhylidae	Callulops personatus	Callulops sp. 2	LC	S	2	S	S	S	S	S	S	S	S	S	S
Microhylidae	Callulops sp. 1		NE	3	N	S	N	M	N	N	N	N	L	N	N
Microhylidae	Choerophryne brunhildae		NE	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	*Choerophryne epirrhina*	Choerophryne sp. nov. 1 cf rostellifer	NE	1	N	L	N	N	N	N	N	N	L	L	L
Microhylidae	*Choerophryne grylloides*	Choerophryne sp. nov. 2	NE	2	N	L	N	L	N	N	N	N	L	N	N
Microhylidae	Choerophryne longirostris		DD	N	N	N	N	N	N	N	N	N	M	N	N
Microhylidae	Choerophryne proboscidea		LC	1	3	S	1	2	S	S	S	S	S	S	L
Microhylidae	Choerophryne rostellifer		LC	S	L	S	S	S	L	L	L	S	S	M	L
Microhylidae	Choerophryne sp. 1	Albericus sp. 1	NE	4	N	S	N	L	N	N	N	N	L	N	N
Microhylidae	Cophixalus balbus		DD	8	3	S	M	S	M	M	M	M	S	M	M
Microhylidae	Cophixalus bewaniensis		DD	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Cophixalus biroi		LC	S	N	S	N	L	N	N	N	N	M	N	N
Microhylidae	Cophixalus sp. cf bewaniensis		NE	1	N	S	L	S	N	N	N	N	L	N	N
Microhylidae	Copiula pipiens		DD	L	N	L	N	L	N	N	N	N	M	L	L
Microhylidae	Copiula sp. 1	Copiula pipiens	NE	9	6	S	1	1	S	L	L	L	L	L	L
Microhylidae	Copiula tyleri		LC	M	N	M	N	L	N	N	N	N	M	N	N
Ceratobatrachidae	Cornufer papuensis	Platymantis papuensis	LC	10	7	S	1	2	S	S	S	S	S	S	S
Microhylidae	*Hylophorbus atrifasciatus*	Hylophorbus sp. nov. 1 (tiny)	NE	2	1	M	M	1	M	M	M	M	M	M	M
Microhylidae	Hylophorbus proekes	Hylophorbus sp. nov. 3 (medium)	NE	S	1	S	1	2	M	M	M	M	S	M	M
Microhylidae	*Hylophorbus* sp. 1		NE	S	M	S	1	2	M	M	M	M	M	M	M
Microhylidae	Hylophorbus sp. nov. 2 (small)		NE	1	2	M	M	M	M	M	M	M	M	M	M
Microhylidae	Hylophorbus sp. nov. 4 (huge)		NE	1	N	M	N	L	N	N	N	N	L	N	N
Myobatrachidae	Lechriodus melanopyga		LC	S	S	S	S	S	S	S	S	S	S	S	S
Dicroglossidae	Limnonectes grunniens		LC	3	4	S	1	2	S	S	S	S	S	S	S
Microhylidae	Liophryne schlaginhaufeni		LC	1	L	S	L	M	L	L	L	L	S	L	L
Pelodryadidae	Litoria albolabris		DD	N	L	L	L	L	L	L	L	L	S	S	S
Pelodryadidae	Litoria angiana		LC	1	N	M	N	N	N	N	N	N	N	N	N
Pelodryadidae	Litoria chrisdahli		DD	N	M	M	M	M	L	L	L	M	M	M	L
Pelodryadidae	Litoria eucnemis		LC	4	S	S	S	S	S	S	S	S	S	S	S
Pelodryadidae	Litoria eurynastes		NE	M	M	M	M	M	M	M	M	M	M	M	M
Pelodryadidae	Litoria humboldtorum		LC	1	L	S	L	1	N	N	N	L	M	L	L

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS *	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Pelodryadidae	Litoria hunti		DD	2	S	S	1	S	S	S	S	S	S	S	S
Pelodryadidae	Litoria infrafrenata		LC	S	3	S	1	1	S	S	S	S	S	S	S
Pelodryadidae	Litoria leucova		DD	3	N	S	N	M	N	N	N	N	M	N	N
Pelodryadidae	Litoria modica		LC	2	N	M	N	L	N	N	N	N	M	N	N
Pelodryadidae	Litoria mucro		DD	S	L	S	M	S	M	M	M	M	M	M	M
Pelodryadidae	Litoria nigropunctata		LC	S	S	S	S	S	S	S	S	S	S	S	S
Pelodryadidae	Litoria purpureolata		DD	S	3	S	1	1	M	M	M	M	M	M	M
Pelodryadidae	Litoria pygmaea		LC	4	1	S	S	S	S	S	S	S	S	S	S
Pelodryadidae	*Litoria richardsi*		DD	S	S	L	L	1	L	L	L	L	L	L	L
Pelodryadidae	Litoria sp. 1	Litoria sp. nov. 5 cf nigropunctata	NE	5	L	S	1	S	L	L	L	M	M	L	L
Pelodryadidae	Litoria sp. nov. 1 cf arfakiana		NE	4	N	S	N	M	N	N	N	N	L	N	N
Pelodryadidae	Litoria sp. nov. 2 cf gasconi		NE	1	N	M	N	L	N	N	N	N	L	N	N
Pelodryadidae	Litoria sp. nov. 3 cf macki		NE	4	1	S	M	M	L	L	L	L	M	L	L
Pelodryadidae	Litoria sp. nov. 4 cf iris		NE	1	N	M	N	N	N	N	N	N	N	N	N
Pelodryadidae	Litoria sp. nov. 6 cf bicolor		NE	4	L	S	M	M	L	L	L	L	M	L	L
Pelodryadidae	Litoria sp. nov. 7 (torrent grunter)		NE	5	N	S	L	M	L	L	L	L	M	N	N
Pelodryadidae	Litoria sp. nov. 8 (small, torrent)		NE	4	L	S	L	M	L	L	L	L	M	N	N
Pelodryadidae	Litoria sp. nov. 9 (medium torrent)		NE	2	N	S	N	M	N	N	N	N	M	N	N
Pelodryadidae	Litoria thesaurensis		LC	1	S	S	1	S	S	S	S	S	S	S	S
Microhylidae	Mantophryne lateralis		LC	S	3	S	S	S	S	S	S	S	S	S	S
Pelodryadidae	Nyctimystes fluviatilis		DD	2	L	S	S	L	L	L	L	L	L	L	L
Pelodryadidae	Nyctimystes pulcher		LC	2	N	S	N	L	N	N	N	N	S	N	N
Microhylidae	Oreophryne biroi		LC	4	7	S	1	2	S	S	S	S	S	S	S
Microhylidae	Oreophryne *cameroni*		NE	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Oreophryne hypsiops		LC	7	7	S	1	2	S	S	S	S	S	S	S
Microhylidae	Oreophryne parkeri		DD	M	M	M	M	M	M	M	M	M	S	M	M
Microhylidae	Oreophryne *parkopanorum*		NE	N	N	N	N	N	N	N	N	N	L	N	N
Microhylidae	Oreophryne sp. cf hypsiops		NE	L	1	L	L	L	M	M	L	L	L	L	M
Microhylidae	Oreophryne sp. nov. 1 (fast peeper)		NE	6	L	S	L	S	L	N	N	L	M	L	L
Microhylidae	Oreophryne sp. nov. 2 (short rattler)		NE	7	L	S	S	S	L	L	L	S	S	M	L
Microhylidae	Oreophryne sp. nov. 3 (rasper)		NE	3	N	M	N	L	N	N	N	N	L	N	N
Microhylidae	Oreophryne sp. nov. 4 (chirper)		NE	4	1	S	S	S	L	L	L	M	M	L	L
Ranidae	Papurana arfaki/jimiensis	Rana arfaki/jimiensis	LC	8	1	S	1	1	S	S	S	S	S	S	S
Ranidae	Papurana garritor		LC	S	S	S	S	S	S	S	S	S	S	S	S
Ranidae	Papurana papua	Rana papua	LC	S	6	S	1	1	S	S	S	S	S	S	S
Ranidae	Papurana sp. nov. cf daemeli	Rana sp. nov. cf daemeli	NE	L	1	L	L	L	M	M	L	L	L	L	M
Ranidae	Papurana volkerjane	Rana sp. 1cf grisea	DD	10	1	S	S	1	M	M	M	M	S	L	L
Microhylidae	*Sphenophryne cornuta*		LC	1	1	S	1	1	S	S	S	S	S	S	S
Microhylidae	Xenorhina arboricola		DD	4	L	S	L	M	N	N	N	L	S	N	N
Microhylidae	Xenorhina obesa		LC	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Xenorhina oxycephala		LC	S	6	S	1	1	S	S	S	S	S	S	S
Microhylidae	Xenorhina rostrata		LC	S	S	S	S	S	S	S	S	S	S	S	S
Microhylidae	Xenorhina sp. 1	Xenorhina sp. 1 (slow call)	NE	3	1	S	1	S	M	M	M	M	M	L	L
Microhylidae	Xenorhina sp. 2 (soft fast call)		NE	1	1	S	S	S	M	M	M	M	M	L	L

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS *	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Microhylidae	Xenorhina tumulus		DD	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Xenorhina zweifeli		DD	N	N	N	N	N	N	N	N	N	S	N	N

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1-12	# of combined survey sites at which recorded
V	Village informant record from Sepik Development Project survey
S	Species not recorded whose known ranges and habitat preferences indicate a strong likelihood of occurring
M	Species not recorded whose known ranges and habitat preferences indicate a moderate likelihood of occurring
L	Species not recorded whose known ranges and habitat preferences indicate a low likelihood of occurring
N	Does not or extremely unlikely to occur

21.5 Reptiles from the Project surveys

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS *	GFA HM	GFA L	1	2	3
Agamidae	*Hypsilurus modestus*		LC	8	4		1	1
Agamidae	*Hypsilurus magnus*	Hypsilurus sp. 1 (semi-aquatic)	LC	2	1		1	1
Agamidae	*Hypsilurus sp. 2 (cf dilophus)*		NE	2	3			
Gekkonidae	*Cyrtodactylus rex*	Cyrtodactylus novaeguineae	NE	2	3			
Gekkonidae	*Cyrtodactylus sermowaiensis*		LC	7	6		1	1
Gekkonidae	*Cyrtodactylus sp. nov.*	Cyrtodactylus sp. 1 (may be serratus)	NE	2	1			
Gekkonidae	*Gehyra cf. brevipalmata*		NE	0	0		1	
Gekkonidae	*Gehyra sp.*		NE	1	2			
Gekkonidae	*Gekko vittatus*		NE	1	2			1
Gekkonidae	*Hemidactylus frenatus*		LC	2	3			
Gekkonidae	*Lepidodactylus sp. nov.*		NE	1	1			
Gekkonidae	*Nactus cf. multicarinatus*		NE	0	0		1	1
Gekkonidae	*Nactus sp.*	Nactus cf. pelagicus	NE	3	4			
Scincidae	*Emoia caeruleocauda*		LC	4	7		1	1
Scincidae	*Emoia jakati*		LC	0	0		1	1
Scincidae	*Emoia kordoana*		NE	5	4		1	1
Scincidae	*Emoia longicauda*		NE	2	5		1	1
Scincidae	*Emoia obscura*		LC	9	7			
Scincidae	*Emoia pallidiceps*		LC	7	3		1	1
Scincidae	*Emoia sp.*		NE	0	0		1	1
Scincidae	*Emoia sp. 1*		NE	2	3			
Scincidae	*Eugongylus rufescens*		NE	3	1			
Scincidae	*Lamprolepis smaragdina*		NE	2	1			
Scincidae	*Lipinia noctua*		NE	1	1			
Scincidae	*Sphenomorphus minutus*		LC	0	0		1	1
Scincidae	*Sphenomorphus simus*		LC	10	6			1
Scincidae	*Sphenomorphus solomonis*		NE	2	1		1	
Scincidae	*Sphenomorphus sp. (tiny)*		NE	3	2			
Scincidae	*Sphenomorphus jobiensis-group*		NE	1	3			
Scincidae	*Tribolonotus gracilis*		LC	4	1			
Varanidae	*Varanus jobiensis*	Varanus probably indicus	LC	2	1			1
Boidae	*Candoia aspera*		NE	3	1			1
Boidae	*Candoia carinata*		NE	1	2			
Elapidae	*Aspidomorphus muelleri*		LC	0	0		1	
Elapidae	*Aspidomorphus lineaticollis*		LC	2	2			
Colubridae	*Boiga irregularis*		NE	9	4		1	1
Colubridae	*Dendrelaphis sp.*		NE	3	4			
Colubridae	*Stegonotus cucullatus*		NE	3	2		1	
Colubridae	*Stegonotus diehli*		NE	0	0			1
Colubridae	*Stegonotus cf diehli*		NE	3	3			
Colubridae	*Tropidonophis doriae*		LC	4	1			
Colubridae	*Tropidonophis sp. (prob multiscutellatus)*		NE	1	2			
Pythonidae	*Leiopython albertisii*		NE	1	2			
Pythonidae	*Morelia amethistina*		LC	3	2			
Pythonidae	*Morelia viridis*		LC	2	2			
Pythonidae	*Morelia spilotes*		NE P	S	N			

21.6 Odonates from the Project surveys

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3
Calopterygidae	*Neurobasis ianthinipennis*		NE	11	2			
Calopterygidae	*Neurobasis australis*		LC	0	0		1	1
Chlorocyphidae	*Rhinocypha tincta*		LC	11	3		1	1
Coenagrionidae	*Agriocnemis ?aderces*		NE	0	2			
Coenagrionidae	*Agriocnemis femina*		LC	3	2			
Coenagrionidae	*Archibasis crucigera*		LC	1	3			
Coenagrionidae	*Archibasis mimetes*		LC	1	3			
Coenagrionidae	*Argiocnemis ensifera*		NE	1	5			1
Coenagrionidae	*Austroagrion? sp*		NE	0	1			
Coenagrionidae	*Hylaeargia simplex*	*Hylaeargia sp. nov.*	NE	2	0			
Coenagrionidae	*Palaiargia ceyx*		NE	3	0			
Coenagrionidae	*Palaiargia charmosyna*		NE	2	0		1	1
Coenagrionidae	*Palaiargia halcyon*		DD	1	0			
Coenagrionidae	*Papuargia stueberi*		DD	4	0		1	
Coenagrionidae	*Papuagrion occipitale*		NE	8	6		1	1
Coenagrionidae	*Papuagrion sp.*		NE	0	0		1	1
Coenagrionidae	*Pseudagrion civicum*		NE	3	1		1	1
Coenagrionidae	*Teinobasis dominula*		NE	1	6			
Coenagrionidae	*Teinobasis olthofi*		NE	2	3		1	1
Coenagrionidae	*Teinobasis macroglossa*	*Teinobasis scintillans*	NE	12	5			
Coenagrionidae	*Teinobasis chrysea*	*Teinobasis sp. 1 cf aurea*	NE	3	0			
Coenagrionidae	*Teinobasis lutea*	*Teinobasis sp. 2*	NE	1	0			
Coenagrionidae	*Teinobasis macroglossus*		NE	0	0		1	1
Coenagrionidae	*Teinobasis sp 3. (tiny)*		NE	1	0			
Coenagrionidae	*Teinobasis sp.*		NE	0	0			1
Coenagrionidae	*Thaumatagrion funereum*		DD	0	1			
Coenagrionidae	*Xiphiagrion truncatum*		NE	2	1			
Isostictidae	*Selysioneura capreola*		NE	5	0		1	1
Isostictidae	*Selysioneura drymobia*		NE	3	1			
Isostictidae	*Selysioneura umbratilis*		NE	2	1			
Isostictidae	*Tanymecosticta sp.*		NE	1	0			
Lestidae	*Indolestes luxatus*		NE	0	3			
Lestidae	*Indolestes lygisticercus*	*Indolestes lygistocercus*	NE	0	1		1	
Argiolestidae	*Metagrion sp. 1*	*Argiolestes sp 1. (ornatus group)*	NE	6	1		1	
Argiolestidae	*Metagrion sp. 2*	*Argiolestes sp. 2 (ornatus group - B&W)*	NE	10	2			1
Argiolestidae	*Argiolestes sp. 3 (australis group)*		NE	5	0			
Argiolestidae	*Argiolestes sp. nov. 1(cf kula)*		NE	1	0			
Argiolestidae	*Podopteryx selysi*		LC	2	0			
Platycnemididae	*Arrhenocnemis sp.*		NE	1	0		1	
Platycnemididae	*Cyanocnemis aureofrons*		DD	6	0			
Platycnemididae	*Idiocnemis chloropleura*		NE	11	1			1
Platycnemididae	*Idiocnemis inaequidens*		LC	4	0			
Platycnemididae	*Idiocnemis obliterata*		NE	10	3		1	1
Platycnemididae	*Lochmaeocnemis malacodora*		NE	1	0			
Platycnemididae	*Paramecocnemis spinosus*	*Paramecocnemis sp. nov. 1*	NE	1	0			
Platycnemididae	*Paramecocnemis similis*	*Paramecocnemis sp. nov. 2*	NE	2	0			
Platystictidae	*Drepanosticta clavata*		NE	8	1		1	1
Platystictidae	*Drepanosticta dendrolagina*		NE	1	1			
Platystictidae	*Drepanosticta sp. nov. 1 (black apps)*		NE	6	1			
Platystictidae	*Drepanosticta elaphos*	*Drepanosticta sp. nov. 2 (Blue-tail)*	NE	3	0			
Platystictidae	*Drepanosticta pterophora*	*Drepanosticta sp. nov. 3 (Ok Isai Blue-tail)*	NE	1	0			
Platycnemididae	*Nososticta beatrix*		NE	2	1			
Platycnemididae	*Nososticta callisphaena*		NE	2	1		1	1
Platycnemididae	*Nososticta chalybeostoma*	*Nososticta chalybeostoma?*	NE	6	3			
Platycnemididae	*Nososticta cyanura*		NE	1	0		1	1
Platycnemididae	*Nososticta erythrura*		LC	6	1			
Platycnemididae	*Nososticta parafonticola*	*Nososticta fonticola?*	NE	11	1			
Platycnemididae	*Nososticta nigrifrons*	*Nososticta lorentzi*	DD	2	2		1	
Platycnemididae	*Nososticta melanoxantha*		NE	1	1		1	1
Platycnemididae	*Nososticta nigrofasciata*		NE	1	2		1	1
Platycnemididae	*Nososticta tricolorata*		NE	1	0			
Platycnemididae	*Nososticta rosea cruentata*	*Nososticta sp. nov. 1 (orange)*	NE	4	3		1	1

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	1	2	3
Platycnemididae	*Nososticta azurosignata*	*Nososticta sp. nov. 2 (small blue)*	NE	4	1			
Platycnemididae	*Nososticta caerulea*	*Nososticta sp. nov. 3 (small blue # 2)*	NE	0	3			
Aeshnidae	*Agyrtacantha dirupta*		LC	3	7		1	
Aeshnidae	*Agyrtacantha microstigma*		NE	5	4			
Aeshnidae	*Agyrtacantha tumidula*		NE	0	3			
Aeshnidae	*Gynacantha kirbyi*		LC	1	2			
Aeshnidae	*Gynacantha heros*	*Gynacantha sp. nov.*	NE	1	0			
Aeshnidae	*Plattycantha venatrix*		NE	3	1			
Corduliidae	*Hemicordulia silvarum*		NE	12	5		1	1
Corduliidae	*Metaphya tillyardi*		LC	2	0			1
Corduliidae	*Procordulia leopoldi*		NE	1	0			
Gomphidae	*Ictinogomphus australis*		LC	4	3			
Gomphidae	*Ictinogomphus lieftincki*		NE	0	0		1	1
Libellulidae	*Agrionoptera longitudinalis*		LC	10	4		1	1
Libellulidae	*Agrionoptera insignis*		LC	1	5		1	
Libellulidae	*Bironides teuchestes*		VU	1	0			
Libellulidae	*Brachydiplax duivenbodei*		LC	0	1			
Libellulidae	*Diplacina anthaxia*	*Diplacina phoebe anthaxia*	NE	1	1			1
Libellulidae	*Diplacina smaragdina*		NE	10	0		1	1
Libellulidae	*Diplacina sp. 1 (white spot)*		NE	6	2			
Libellulidae	*Diplacodes bipunctata*		LC	2	0			
Libellulidae	*Huonia arborophila*		LC	0	0		1	1
Libellulidae	*Huonia epinephele*		NE	8	1		1	1
Libellulidae	*Huonia thalassophila or arborophila*		NE	8	0			
Libellulidae	*Lyriothemis meyeri*		LC	5	6		1	1
Libellulidae	*Microtrigonia marsupialis*		NE	1	0			
Libellulidae	*Nannophlebia adonira*		NE	0	1			
Libellulidae	*Nannophlebia amphicyllis*		NE	5	1		1	1
Libellulidae	*Nannophlebia axiagasta*		NE	0	1			
Libellulidae	*Nannophya pygmaea*		LC	1	2		1	1
Libellulidae	*Nesoxenia mysis*		NE	6	7		1	1
Libellulidae	*Neurothemis decora*		NE	1	6			
Libellulidae	*Neurothemis ramburii*		LC	0	0			1
Libellulidae	*Neurothemis stigmatizans*		LC	3	7		1	1
Libellulidae	*Orthetrum glaucum*		LC	8	2			
Libellulidae	*Orthetrum serapia*		LC	2	6			1
Libellulidae	*Orthetrum villosovittatum*		LC	11	8		1	1
Libellulidae	*Pantala flavescens*		LC	5	7			
Libellulidae	*Protorthemis coronata*		NE	8	5		1	1
Libellulidae	*Rhyothemis phyllis*		LC	1	1			1
Libellulidae	*Rhyothemis princeps irene*		LC	2	7			
Libellulidae	*Rhyothemis resplendens*		LC	0	3		1	1
Libellulidae	*Akrothemis bimaculata*	*Risiophlebia risi?*	NE	0	1			
Libellulidae	*Tetrathemis irregularis*		LC	0	2		1	1
Libellulidae	*Tholymis tillarga*		LC	0	1			
Libellulidae	*Tramea aquila*		NE	0	4			1
Libellulidae	*Zyxomma petiolatum*		LC	3	6			
Libellulidae	*Zyxomma elgneri*		LC	0	2			
Macromiidae	*Macromia melpomene*		NE	8	1			
Macromiidae	*Macromia terpsichore*	*Macromia terpsichore*	NE	2	2		1	1
Synthemistidae	*Palaeosynthemis cyrene*		NE	3	0			
Synthemistidae	*Palaeosynthemis feronia*		NE	1	0			1
Synthemistidae	*Palaeosynthemis primigenia*		NE	3	0			
Synthemistidae	*Palaeosynthemis elegans*	*Palaeosynthemis sp. nov.*	NE	1	0			

*Conservation status IUCN CR-Critically Endangered, EN – Endangered, VU – Vulnerabe, NT – Near Threatened, DD – Data Defficient, LC - Least Concern, NE – Not evaluated. P – protected under PNG *Fauna (Protection and Control) Act 1966.*

21.7 Plants from the Project surveys

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
S	Pteridophytes						
Aspleniaceae	Asplenium acrobryum H. Christ			9	5	1	
Aspleniaceae	Asplenium affine Sw.			4			
Aspleniaceae	Asplenium bantamense (Blume) Baker	Diplazium bantamense Blume		1			
Aspleniaceae	Asplenium bipinnatifidum Baker			5	2		1
Aspleniaceae	Asplenium contiguum Kaulf.			1			
Aspleniaceae	Asplenium cromwellianum Rosenst.			2			
Aspleniaceae	Asplenium cuneatum Lam.			3	2		
Aspleniaceae	Asplenium decorum Kunze			1			
Aspleniaceae	Asplenium foersteri Rosenst.			3			
Aspleniaceae	Asplenium macrophyllum Sw.			1			
Aspleniaceae	Asplenium musifolium Mett.			1			
Aspleniaceae	Asplenium nidus L.			4	7	1	1
Aspleniaceae	Asplenium pellucidum Lam			1			
Aspleniaceae	Asplenium phyllitidus D. Don subsp. malesicum Holttum	Asplenium phyllitidus D. Don		10	6	1	1
Aspleniaceae	Asplenium scandens J. Sm.			5			
Aspleniaceae	Asplenium subemarginatum Rosenst.			2			
Aspleniaceae	Asplenium tenerum Forst. f.			6	6	1	
Athyriaceae	Athyrium accedens (Blume) Milde	Diplazium accedens Blume		2			1
Athyriaceae	Diplazium cordifolium Blume			8	4	1	1
Athyriaceae	Diplazium esculentum (Retz.) Sw.		LC	1	1		
Athyriaceae	Diplazium sp.				1	1	
Athyriaceae	Diplazium stipitipinnula Holttum			2	2		
Athyriaceae	Diplazium weinlandii H. Christ			1			
Blechnaceae	Blechnum keysseri Rosenst.			2	3		
Blechnaceae	Blechnum orientale L.			5	3	1	1
Blechnaceae	Stenochlaena areolaris (Harr.) Copel.			1	4	1	1
Blechnaceae	Stenochlaena milnei Underwood			1	4		
Blechnaceae	Stenochlaena palustris (Burm. f.) Bedd.			3	7	1	
Cyatheaceae	Alsophila hornei Baker	Cyathea hornei (Baker) Copel.		2			
Cyatheaceae	Cyathea archboldii C. Chr.			1			
Cyatheaceae	Cyathea contaminans (Wall.) Copel.			1			
Cyatheaceae	Cyathea hunsteiniana Brause	Cyathea hunsteinii Brause		2			
Cyatheaceae	Cyathea lepidoclada (C. Chr.) Domin			2			
Cyatheaceae	Cyathea perpelvigera Alderw.			1			
Cyatheaceae	Cyathea pulcherrima Copel.			1			
Cyatheaceae	Cyathea spp.			12	7	1	1
Davalliaceae	Davallia pectinata Sm.			4			
Davalliaceae	Davallia repens (L. f.) Kuhn			1			1
Davalliaceae	Davallia solida (G. Forst.) Sw.			1	3		
Davalliaceae	Davallodes novoguineense (Rosenst.) Copel.			1			
Davalliaceae	Davallia repens (L. f.) Kuhn			2			
Davalliaceae	Davallia pentaphylla Blume			2			
Davalliaceae	Davallia heterophylla Sm.			1			
Dennstaedtiaceae	Dennstaedtia scandens (Blume) T. Moore			2			
Dennstaedtiaceae	Histiopteris integrifolia Copel.			1			
Dennstaedtiaceae	Microlepia speluncae (L.) T. Moore			1			
Dennstaedtiaceae	Pteridium aquilinum (L.) Kuhn			2			
Dipteridaceae	Dipteris conjugata Reinw.			3	1		
Dipteridaceae	Dipteris lobbiana (Hook.) T. Moore			8			
Dipteridaceae	Dipteris novoguineensis Posth.	Dipteris novo-guineensis Posthumus		1			
Dryopteridaceae	Bolbitis heteroclita (Presl) Ching			6	3	1	1
Dryopteridaceae	Bolbitis quoyana (Gaudich.) Ching			7	6	1	1
Dryopteridaceae	Bolbitis rivularis (Brack.) Ching			6	4	1	1
Dryopteridaceae	Dryopolystichum phaeostigma (Ces.) Copel.			1	1		
Dryopteridaceae	Dryopteris sp			3			
Dryopteridaceae	Elaphoglossum novoguineense Rosenst.			4			
Dryopteridaceae	Elaphoglossum sp.			1			1
Dryopteridaceae	Lastreopsis novoguineensis Holttum			2			
Dryopteridaceae	Lomagramma sinuata C. Chr.			4	2		
Dryopteridaceae	Polystichum bamlerianum Rosenst.			1			
Dryopteridaceae	Teratophyllum articulatum (Fée) Kuhn			7	2	1	1
Gleicheniaceae	Dicranopteris linearis (Burm. f.) Underwood			9	4		1
Gleicheniaceae	Diplopterygium sp.	Gleichenia sp., subg. Diplopterygium		2			
Gleicheniaceae	Gleichenia hirta Blume			1			
Gleicheniaceae	Sticherus milnei (Baker) Ching	Gleichenia milnei Baker		2			
Hymenophyllaceae	Abrodictyum meifolium (Bory ex Willd.) Ebihara & K. Iwats.			3	1		

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Hymenophyllaceae	Abrodictyum obscurum (Blume) Ebihara & K. Iwats.			1			
Hymenophyllaceae	Abrodictyum schlechteri (Brause) Ebihara & K. Iwats.			2			
Hymenophyllaceae	Cephalomanes apiifolium (C. Presl) K. Iwats.	Callistopteris apiifolia (Presl) Copel.		2			
Hymenophyllaceae	Cephalomanes atrovirens Presl			5	1		
Hymenophyllaceae	Cephalomanes oblongifolium Presl			1			
Hymenophyllaceae	Cephalomanes singaporeanum Bosch			2			
Hymenophyllaceae	Cephalomanes sp.			1			1
Hymenophyllaceae	Crepidomanes aphlebioides (H. Christ) I.M. Turner			3	1		1
Hymenophyllaceae	Crepidomanes humilis (G. Forst.) Bosch	Trichomanes humile G. Forst.		2			
Hymenophyllaceae	Crepidomanes intermedium (Bosch) Ebihara & K. Iwats.			4			
Hymenophyllaceae	Hymenophyllum brassii C. Chr.			2			
Hymenophyllaceae	Hymenophyllum denticulatum Sw.			2			
Hymenophyllaceae	Hymenophyllum ellipticosorum Alderw.			2			
Hymenophyllaceae	Hymenophyllum gorgoneum Copel.			2			
Hymenophyllaceae	Hymenophyllum pallidum (Blume) Ebihara & K. Iwats.			3			
Hymenophyllaceae	Hymenophyllum pilosissimum (C. Chr.) Copel.			1			
Hymenophyllaceae	Hymenophyllum sp.			1			
Hypodematiaceae	Didymochlaena truncatula (Sw.) J. Sm.		LC	1			
Hypodematiaceae	Leucostegia pallida (Mett.) Copel.			5			
Lindsaeaceae	Lindsaea bakeri (C. Chr.) C. Chr.			2			
Lindsaeaceae	Lindsaea kingii Copel.			1			
Lindsaeaceae	Lindsaea lucida Blume			5	1		
Lindsaeaceae	Lindsaea microstegia Copel.			5	2		
Lindsaeaceae	Lindsaea obtusa J. Sm.			8	6	1	1
Lindsaeaceae	Lindsaea repens (Bory) Thwaites			5			
Lindsaeaceae	Lindsaea rosenstockii Brause			3			
Lindsaeaceae	Lindsaea tenuifolia Blume			7	2	1	1
Lindsaeaceae	Sphenomeris chinensis (L.) Maxon			4	2	1	1
Lindsaeaceae	Sphenomeris retusa (Cav.) Maxon			5	2	1	1
Lindsaeaceae	Tapeinidium longipinnulum (Ces.) C. Chr.			3	2		
Lindsaeaceae	Tapeinidium novoguineense Kramer			2			
Lomariopsidaceae	Lomariopsis kingii (Copel.) Holttum			2	1		
Lycopodiaceae	Huperzia nummularifolia (Blume) Jermy			1			
Lycopodiaceae	Huperzia phlegmaria (L.) Rothm.			9	2		1
Lycopodiaceae	Huperzia squarrosa (Forst. f.) Trevis.			1			
Lycopodiaceae	Lycopodiella cernua (L). Pic. Serm.			6	3	1	
Lycopodiaceae	Lycopodium volubile Forst. f.			1			
Lygodiaceae	Lygodium circinnatum (Burm. f.) Swartz				1		
Lygodiaceae	Lygodium dimorphum Copel.			3			
Lygodiaceae	Lygodium salicifolium Presl			1	2	1	
Lygodiaceae	Lygodium scandens (L.) Sw.			2	1		
Lygodiaceae	Lygodium versteegii H. Christ			2			
Marattiaceae	Angiopteris evecta (Forst.) Hoffm.			3	2		1
Marattiaceae	Christensenia aesculifolia (Blume) Maxon subsp. korthalsii (deVriese) Rolleri	Christensenia aesculifolia (Blume) Maxon		6	1		1
Marattiaceae	Ptisana sp. A	Marattia sp. A, pinnae glaucous		1			
Marattiaceae	Ptisana sp. B	Marattia sp. B, not glaucous		5	2		
Nephrolepidaceae	Nephrolepis cordifolia (L.) Presl			4			
Nephrolepidaceae	Nephrolepis davallioides (Sw.) Kunze			1			
Nephrolepidaceae	Nephrolepis obliterata (R. Br.) J. Sm.				1		
Nephrolepidaceae	Nephrolepis spp.			2	4	1	1
Oleandraceae	Oleandra pilosa Hook.	Oleandra neriiformis Cav.		1			
Oleandraceae	Oleandra werneri Rosenst.			3			
Ophioglossaceae	Helminthostachys zeylanica (L.) Hook.			2	1		1
Ophioglossaceae	Ophioglossum pendulum L.			2	1		
Polypodiaceae	Aglaomorpha drynarioides (Hook.) Roos			5			
Polypodiaceae	Aglaomorpha heraclea (Kunze) Copel.			2	2		
Polypodiaceae	Aglaomorpha novoguineensis (Brause) C. Chr.			1			
Polypodiaceae	Aglaomorpha rigidula (Sw.) Hovenkamp & S.Linds.	Drynaria rigidula Bedd.		1	2	1	
Polypodiaceae	Aglaomorpha sparsisora (Desv.) Hovenkamp & S.Linds.	Drynaria sparsisora (Desv.) T. Moore		4	4	1	
Polypodiaceae	Belvisia mucronata (Fee) Copel.			4			
Polypodiaceae	Belvisia spicata (L. f.) Mirbel ex Copel.			4			
Polypodiaceae	Calymmodon clavifer (Hook.) T. Moore			1			
Polypodiaceae	Ctenopteris eximia Copel.			1			

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Polypodiaceae	Ctenopteris subsecundodissecta (Zoll.) Copel.			2			
Polypodiaceae	Ctenopteris taxodioides (Baker) Copel.			3			
Polypodiaceae	Goniophlebium demersum (Brause) Rodl-Linder			4			
Polypodiaceae	Goniophlebium percussum (Cav.) Wagner & Grether			2			1
Polypodiaceae	Goniophlebium persicifolium (Desv.) Bedd.			1	1		
Polypodiaceae	Goniophlebium pseudoconnatum (Copel.) Copel.			2			
Polypodiaceae	Grammitis adspersa (Blume) Blume			2			
Polypodiaceae	Grammitis pleurogrammoides (Rosenst.) Copel.			2			
Polypodiaceae	Lecanopteris deparioides (Ces.) Baker			2			
Polypodiaceae	Lecanopteris sinuosa Copel.			3			
Polypodiaceae	Lemmaphyllum accedens (Blume) Donk			9	3		1
Polypodiaceae	Leptochilus sp.				1		
Polypodiaceae	Loxogramme sp.			1			
Polypodiaceae	Microsorum linguiforme (Mett.) Copel.			8	3		1
Polypodiaceae	Microsorum papuanum (Baker) Parris			3	1		
Polypodiaceae	Microsorum powellii (Hook. & Baker) Copel.			1			
Polypodiaceae	Microsorum pteropus (Blume) Copel.		LC	2	1		1
Polypodiaceae	Microsorum punctatum (L.) Copel.			4			
Polypodiaceae	Microsorum rampans (Baker) Parris			4	1		
Polypodiaceae	Oreogrammitis fasciata (Blume) Parris			2			
Polypodiaceae	Phymatosorus membranifolium (R. Br.) S.G. Lu	Microsorum membranifolium (R. Br.) Ching		6	3		
Polypodiaceae	Prosaptia contigua (Forst. f.) Presl			3			
Polypodiaceae	Pyrrosia foveolata (Alston) Morton			2			
Polypodiaceae	Pyrrosia lanceolata (L.) Farwell			5	2		
Polypodiaceae	Pyrrosia longifolia (Burm.) Morton				1		
Polypodiaceae	Pyrrosia novo-guineae (Christ) M.G. Price	Pyrrosia novoguineae (H. Christ) Price		1			
Polypodiaceae	Pyrrosia piloselloides (L.) Price			1	2		
Polypodiaceae	Pyrrosia princeps (Mett.) Morton			1	1		
Polypodiaceae	Pyrrosia sp.				1	1	
Polypodiaceae	Scleroglossum minus (Fee) C. Chr.			2			
Polypodiaceae	Selliguea albidosquamata (Blume) Parris			3			
Polypodiaceae	Selliguea enervis (Cav.) Ching			5			
Polypodiaceae	Selliguea hellwigii (Diels) Hovenkamp			5			
Polypodiaceae	Selliguea plantaginea Brack.			2			
Polypodiaceae	Selliguea sp.				1	1	
Psilotaceae	Psilotum complanatum Sw.			1	1		
Psilotaceae	Psilotum nudum (L.) P. Beauv.			1			
Pteridaceae	Adiantum hollandiae Alderw.			2			
Pteridaceae	Anthrophyum sp., “reticulatum-callifolium group”			2	1		
Pteridaceae	Antrophyum plantagineum (Cav.) Kaulfuss			1			
Pteridaceae	Ceratopteris thalictroides (L.) Brongn.		LC		2		
Pteridaceae	Pityrogramma calomelanos (L.) Link			4	4	1	1
Pteridaceae	Pleurofossa dareaecarpa (Hook.) Nakai ex H. Itô	Monogramma dareicarpa Hook.		2			
Pteridaceae	Pteris ligulata Gaudich.			2	2		
Pteridaceae	Pteris moluccana Bl.				2	1	
Pteridaceae	Pteris papuana Ces.			1	1		
Pteridaceae	Pteris tripartita Sw.			3	3	1	
Pteridaceae	Pteris wallichiana Agardh				1		
Pteridaceae	Pteris warburgii H. Christ			3			
Pteridaceae	Rheopteris cheesmaniae Alston			6	1		
Pteridaceae	Syngramma schlechteri Brause			7	4	1	1
Pteridaceae	Taenitis blechnoides (Willd.) Sw.			5	2		
Pteridaceae	Taenitis sp.			2			
Pteridaceae	Trichiogramme borneensis (Hook.) Kuhn	Syngramma borneensis (Hook.) J. Sm.		2	2	1	
Pteridaceae	Vittaria elongata Sw.	Haplopteris elongata (Sw.) Crane		4	3		
Pteridaceae	Vittaria scolopendrina (Bory) Mett.	Haplopteris scolopendrina (Bory) Presl		2	2		
Saccolomataceae	Orthiopteris campylura (Kunze) Copel.			1	1		
Saccolomataceae	Saccoloma sorbifolium (Sm.) Christ	Cystodium sorbifolium (Sm.) J. Sm.		3	6	1	1
Salviniaceae	Azolla pinnata R. Br.		LC		2		
Salviniaceae	Salvinia adnata Desv.	Salvinia molesta Mitchell			1		
Schizaeaceae	Schizaea dichotoma (L.) J. Sm.			8	2		
Schizaeaceae	Schizaea digitata (L.) Sw.			1			
Schizaeaceae	Schizaea malaccana Baker			1			

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Schizaeaceae	Schizaea wagneri Sell.			1			
Selaginellaceae	Selaginella angustiramea Muell.			2			
Selaginellaceae	Selaginella cf. durvillei (Bory) Brown			1			
Selaginellaceae	Selaginella spp.			12	6	1	1
Selaginellaceae	Selaginella velutina Ces.			7	4	1	1
Tectariaceae	Arthropteris articulata (Brack.) C. Chr.			7	1		
Tectariaceae	Pleocnemia irregularis (Presl) Holttum			2			
Tectariaceae	Pteridrys sp.			2	1		
Tectariaceae	Tectaria bamleriana (Rosenst.) C. Chr.			1			
Tectariaceae	Tectaria decurrens (Presl) Copel.			4	1		1
Tectariaceae	Tectaria menyanthides (Presl) Copel.			6	3		1
Tectariaceae	Tectaria pleiosora (Alderw.) C. Chr.			2			
Thelypteridaceae	Ampelopteris prolifera (Retz.) Copel.				2		
Thelypteridaceae	Amphineuron immersum (Blume) Holttum			2	1		
Thelypteridaceae	Cyclosorus sp.	Plesioneuron sp.		3			
Thelypteridaceae	Cyclosorus sp.	Pneumatopteris sp.		2	5		
Thelypteridaceae	Cyclosorus sp.	Pronephrium cf. micropinnatum Holttum		1			
Thelypteridaceae	Pneumatopteris sogerensis (Gepp) Holttum				1	1	
Thelypteridaceae	Sphaerostephanos invisus (Forst. f.) Holttum			2	4	1	1
Thelypteridaceae	Sphaerostephanos multiauriculatus (Copel.) Holttum			5	2	1	1
Thelypteridaceae	Sphaerostephanos spp.			10	4		
Thelypteridaceae	Sphaerostephanos unitus (L.) Holttum			2	5	1	1
Thelypteridaceae	Sphaerostephanos warburgii (Kuhn & H. Christ) Holttum			6			
Thelypteridaceae	Thelypteris sp.	Coryphopteris sp.		3			
Gymnosperms	0						
Araucariaceae	Agathis labillardieri Warb.		NT	6	4	1	1
Cupressaceae	Papuacedrus papuana (F.Muell.) H.L.Li.	Libocedrus papuana F. Muell.		2			
Cycadaceae	Cycas rumphii Miq.		NT	1	3		
Gnetaceae	Gnetum gnemon (L.) Lauterb. & K. Schum.		LC	7	7	1	1
Gnetaceae	Gnetum gnemonoides Brongn.		LC		2		
Gnetaceae	Gnetum latifolium Blume		LC	1	2		
Podocarpaceae	Dacrycarpus sp.			1			
Podocarpaceae	Dacrydium imbricatus (Blume) de Laub.			1			
Podocarpaceae	Nageia wallichiana (C. Presl) Kuntze	Decussocarpus wallichianus (Presl) de Laub.		3			1
Podocarpaceae	Phyllocladus hypophyllus Hook. f.		LC	2			
Podocarpaceae	Podocarpus neriifolius D. Don		LC		5		
Podocarpaceae	Podocarpus pilgeri Foxw.		LC	1			
Podocarpaceae	Podocarpus rubens de Laub.		LC	2			
Podocarpaceae	Sundacarpus amarus (Blume) C.N.Page	Prumnopitys amara (Blume) de Laub.		1			
Monocotyledons	0						
Amaryllidaceae	Crinum asiaticum L.			2	1		1
Araceae	Aglaonema marantifolium Blume			1	2	1	
Araceae	Alocasia brancifolia (Schott) A. Hay			1	6	1	1
Araceae	Alocasia hollrungii Engl.			4	4	1	1
Araceae	Alocasia lauterbachiana (Engl.) A. Hay				4	1	
Araceae	Alocasia macrorrhizos (L.) G. Don			2	3	1	
Araceae	Alocasia nicolsonii A. Hay			1			
Araceae	Amydrium zippelianum (Schott) Nicolson				3		
Araceae	Caladium bicolor Vent.				1		
Araceae	Colocasia esculenta (L.) Schott			3	5	1	1
Araceae	Cyrtosperma macrotum Becc. ex Engl.			6	4	1	1
Araceae	Cyrtosperma sp.			1			
Araceae	Epipremnum amplissimum (Schott) Engl.			3	2		1
Araceae	Epipremnum pinnatum (L.) Engl.			3	5	1	
Araceae	Holochlamys beccarii (Engl.) Engl.			3	1		1
Araceae	Homalomena lauterbachii Engl.		LC	3	1		
Araceae	Homalomena sp.			2	2	1	1
Araceae	Homalomena stollei Engl. & K. Krause			2			
Araceae	Pothos falcifolius Engl. & K. Krause			1			
Araceae	Pothos spp.			1	1	1	1
Araceae	Pothos tener Wall.			2	2		
Araceae	Pothos versteegii Engl.			2	1		
Araceae	Rhaphidophora spp.			8	4	1	1
Araceae	Schismatoglottis calyptrata (Roxb.) Zoll. & Moritzi	Schismatoglottis cf. acutangula Engl.		3	1	1	
Araceae	Scindapsus schlechteri K. Krause			1			
Araceae	Scindapsus spp.			1	1	1	1
Araceae	Spathiphyllum schlechteri (Engl. & K. Krause) Nicolson			2	1		
Arecaceae	Actinorhytis calapparia H. Wendl & Drude				1		

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Arecaceae	Areca catechu L.			2	7	1	1
Arecaceae	Areca macrocalyx Zipp. ex Blume		LC	1	1		
Arecaceae	Arenga microcarpa Becc.			2			
Arecaceae	Calamus aruensis Becc.	Calamus hollrungii Becc.		3	2	1	
Arecaceae	Calamus spp.			12	7	1	1
Arecaceae	Calyptrocalyx spp.			1	3		
Arecaceae	Caryota rumphiana Martelli var. papuana Becc.	Caryota rumphiana Martelli		6	6	1	1
Arecaceae	Cocos nucifera L.			2	5	1	1
Arecaceae	Cyrtostachys sp.			1	2		1
Arecaceae	Heterospathe elegans subsp. humilis (Becc.) M.S.Trudgen & W.J.Baker	Heterospathe humilis Becc.		1			
Arecaceae	Heterospathe macgregorii (Becc.) H.E. Moore			1	2	1	
Arecaceae	Hydriastele costata F.M. Bailey			4	5	1	1
Arecaceae	Hydriastele ledermanniana (Becc.) W.J. Baker & Loo			1			
Arecaceae	Hydriastele microspadix (Becc.) Burret			6	5	1	1
Arecaceae	Korthalsia zippelii Blume			7	7	1	1
Arecaceae	Licuala sp.			3	4	1	1
Arecaceae	Linospadix albertisianus (Becc.) Burret	Linospadix albertisiana (Becc.) Burrett		2			
Arecaceae	Livistona sp.			2	1	1	1
Arecaceae	Metroxylon sagu Rottb.			3	6	1	1
Arecaceae	Orania glauca Essig			3	1		
Asparagaceae	Cordyline fruticosa (L.) A. Chev.			5	7	1	1
Bromeliaceae	Ananas comosus (L.) Merr.			3	5	1	1
Burmanniaceae	Burmannia longifolia Becc.			1			
Cannaceae	Canna indica L.			2	3	1	
Commelinaceae	Amischotolype mollissima Hassk.			1			
Commelinaceae	Aneilema acuminatum R. Br.			2	1		
Commelinaceae	Commelina diffusa Burm. f.			2	6	1	
Commelinaceae	Floscopa scandens Lour.			1	4		
Commelinaceae	Pollia thyrsiflora (Blume) Steud.			3			1
Corsiaceae	Corsia sp.			1			
Costaceae	Cheilocostus speciosus (J.Koenig) C.D.Specht	Costus speciosus (Koen.) J. Sm.		3	5	1	1
Costaceae	Tapeinochilos hollrungii Warb.			3	4		
Cyperaceae	Capitularina involucrata (J.V. Suringar) Kern			2	1		1
Cyperaceae	Cyperus cephalotes Vahl				1		
Cyperaceae	Cyperus cyperinus (Retz.) J.V. Suringar			2			
Cyperaceae	Cyperus diffusus Vahl			2	2	1	
Cyperaceae	Cyperus platystylis R. Br.				1		
Cyperaceae	Cyperus sp.			1			
Cyperaceae	Eleocharis sp.				2		
Cyperaceae	Fimbristylis dichotoma (L.) Vahl subsp. dichotoma	Fimbristylis dichotoma (L.) Vahl	LC	1	3	1	
Cyperaceae	Fimbristylis littoralis Gaudich.		LC		2		
Cyperaceae	Hypolytrum compactum Nees & Meyen ex Kunth	Hypolytrum compactum Nees & Mey		2	1		
Cyperaceae	Hypolytrum nemorum (Vahl) Spreng.	Hypoletrum nemorum (Vahl) Spreng.		2	1		
Cyperaceae	Kyllinga brevifolia Rottb.	Cyperus brevifolius (Rottb.) Hassk.		1	1		
Cyperaceae	Machaerina glomerata (Gaudich.) Koyama			2			
Cyperaceae	Mapania macrocephala (Gaudich.) K. Schum.			4	4		
Cyperaceae	Mapania sumatrana (Miq.) Benth.	Thoracostachyum sumatranum (Miq.) Kurz		1	1		
Cyperaceae	Paramapania parvibractea (C.B.Clarke) Uittien			5	2		1
Cyperaceae	Paramapania sp.			1			
Cyperaceae	Scirpodendron ghaeri (Gaertn.) Merr.				1		
Cyperaceae	Scirpus sp.			2			
Cyperaceae	Scleria ciliaris Nees			1			
Cyperaceae	Scleria polycarpa Boeck.			4	4	1	1
Cyperaceae	Scleria scrobiculata Nees & Mey			1	3	1	1
Dioscoreaceae	Dioscorea bulbifera L.				2		
Dioscoreaceae	Dioscorea esculenta (Lour.) Burk.			1	5		
Dioscoreaceae	Dioscorea nummularia Lam.			2	3		
Dioscoreaceae	Dioscorea spp.			1	1	1	1
Flagellariaceae	Flagellaria indica L.			11	7	1	1
Hanguanaceae	Hanguana malayana (Jack) Merr.		LC	4	4		1
Heliconiaceae	Heliconia papuana W.J. Kress			2			
Hypoxidaceae	Curculigo orchoides Gaertn., or aff.			3	3	1	

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Hypoxidaceae	Molineria capitulata (Lour.) Herb.	Curculigo capitulata (Lour.) Kuntze		1	1		1
Juncaceae	Juncus effusus L.			1			
Marantaceae	Donax canniformis (G.Forst.) K.Schum.	Donax cannaeformis (Forst. f.) K. Schum.		4	6	1	1
Marantaceae	Phrynium minor (Valeton) Suksathan & Borchs.			1	1	1	1
Marantaceae	Phrynium sp.			3	5		
Marantaceae	?Phrynium giganteum Scheff.	Cominsia gigantea (Scheff.) K. Schum.			1		
Musaceae	Musa × paradisiaca L.	Musa paradisiaca L.		2	4	1	1
Musaceae	Musa sp.			1	2		
Nymphaeaceae	Barclaya motleyi Hook.f.	Hydrostemma motleyi (Hook. f.) Mabberley	DD	4	4	1	1
Orchidaceae	Acriopsis liliifolia (J.Koenig) Seidenf.	Acriopsis javanica Reinw.		2	1		
Orchidaceae	Agrostophyllum sp.			2	1		
Orchidaceae	Apostasia wallichii R. Br.			2	1		
Orchidaceae	Appendicula dendrobioides (Schltr.) Schltr.			1			
Orchidaceae	Appendicula reflexa Blume			1			
Orchidaceae	Bromheadia pulchra Schltr.			2	2		
Orchidaceae	Bulbophyllum chloranthum Schltr.			1			
Orchidaceae	Bulbophyllum digoelense J.J. Sm.			1			
Orchidaceae	Bulbophyllum longipedicellatum J.J. Sm.			1			
Orchidaceae	Bulbophyllum montense Ridl.			2			
Orchidaceae	Bulbophyllum spp.			10	2	1	1
Orchidaceae	Bulbophyllum werneri Schltr.			3			
Orchidaceae	Calanthe ventilabrum Rchb.f.	Calanthe cf. ventilabium Rchb. f.		1			
Orchidaceae	Ceratostylis sp.			1			
Orchidaceae	Chilopogon oxysepalum (Schltr.) Schltr.	Chilopogon cf. bracteatum Schltr.		1			
Orchidaceae	Cleisostoma sp.			1			
Orchidaceae	Coelogyne asperata Lindl.			5	3		1
Orchidaceae	Corymborkis veratrifolia (Reinw.) Blume			4	3		
Orchidaceae	Dendrobium globiflorum Schltr.			1			
Orchidaceae	Dendrobium insigne (Blume) Rchb. f.				1		
Orchidaceae	Dendrobium lineale Lindl.			1			
Orchidaceae	Dendrobium pachystele Schltr.				1		
Orchidaceae	Dendrobium spectabile (Blume) Miq.			1			
Orchidaceae	Dendrobium violaceum subsp. cyperifolium (Schltr.) T.M.Reeve & P.Woods	Dendrobium cyperifolium Schltr.		1			
Orchidaceae	Dendrobium spp.			3	1	1	1
Orchidaceae	Diplocaulobium sp.			2			
Orchidaceae	Dipodium scandens (Blume) J.J.Sm.	Dipodium pandanum F.M. Bailey		3			1
Orchidaceae	Eria sp.			1			
Orchidaceae	Glomera sp.			3			
Orchidaceae	Goodyera sp.				1		
Orchidaceae	Grammatophyllum speciosum Blume	Grammatophyllum papuanum J.J. Sm.		2	3	1	1
Orchidaceae	Habenaria dracaenifolia Schltr.				1		
Orchidaceae	Hippeophyllum sp.			1			
Orchidaceae	Hylophila sp.			1			
Orchidaceae	Liparis condylobulbon Rchb. f.			1			
Orchidaceae	Liparis pedicellaris Schltr.			1			
Orchidaceae	Malaxis sp.			4			1
Orchidaceae	Mediocalcar sp.			2			
Orchidaceae	Nervillea sp.			2			
Orchidaceae	Oberonia sp.			1			
Orchidaceae	Phreatia spp.			4			
Orchidaceae	Plocoglottis cf. tarana J.J. Sm.			2	1		
Orchidaceae	Plocoglottis kaniensis Schltr.	Plocoglottis papuana Schltr.		2	1	1	
Orchidaceae	Podochilus imitans Schltr.			1			
Orchidaceae	Podochilus scapelliformis Blume			1			
Orchidaceae	Pseuderia cf. diversifolia J.J. Sm.			1			
Orchidaceae	Pseudovanilla gracilis (Schltr.) Garay	Galeola cf. gracilis Schltr.			1		
Orchidaceae	Spathoglottis plicata Blume			6	3	1	1
Orchidaceae	Tropidia disticha Schltr.			1			1
Orchidaceae	Tropidia similis Schltr.			1	1		
Orchidaceae	Vanilla planifolia Andrew				3		
Pandanaceae	Freycineta klossii Ridl.			1			
Pandanaceae	Freycinetia angustissima Ridl.			3	2		
Pandanaceae	Freycinetia beccarii Solms	Freycinetia elliptica Merr. & Perry		1			
Pandanaceae	Freycinetia elegantula B.C. Stone			1			
Pandanaceae	Freycinetia marantifolia Hemsl.			2			

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Pandanaceae	Freycinetia percostata Merr. & Perry			1			
Pandanaceae	Freycinetia spp.			12	8	1	1
Pandanaceae	Pandanus adinobotrys Merr. & Perry				1		
Pandanaceae	Pandanus danckelmannianus K. Schum.			1	2		
Pandanaceae	Pandanus sp., sect. Maysops			2	1		
Pandanaceae	Pandanus spp.			12	6	1	1
Philydraceae	Helmholtzia novoguineensis (K. Krause) Skottsb.			1			
Poaceae	Axonopus compressus (Sw.) P. Beauv.			4	6	1	1
Poaceae	Bambusa vulgaris Schrad.				6	1	
Poaceae	Centotheca lappacea (L.) Desv.	Centotheca latifolia (Osb.) Trin.		5	6	1	1
Poaceae	Chrysopogon aciculatus (Retz.) Trin.			1	3		
Poaceae	Coix lacryma-jobi L.			2	1		1
Poaceae	Cymbopogon citratus Stapf				1	1	
Poaceae	Cynodon dactylon (L.) Pers.				1	1	
Poaceae	Cyrtococcum accrescens Stapf			1	1	1	1
Poaceae	Cyrtococcum patens var. latifolium (Honda) Ohwi	Cyrtococcum accrescens (Trin.) Stapf.			1		
Poaceae	Echinochloa stagnina (Retz.) Beauv.				1		
Poaceae	Eragrostis nutans (Retz.) Nees ex Steud.	Eragrostis chariis (Schult.) Hitchc.		2			
Poaceae	Ichnanthus pallens var. major (Nees) Stieber	Ichnanthus vicinus (F.M. Bailey) Merr.			1		
Poaceae	Imperata cylindrica (L.) P. Beauv.			1	2		
Poaceae	Isachne albens Trin.		LC	1			
Poaceae	Isachne sp.			1	2		
Poaceae	Leersia hexandra Sw.				1		
Poaceae	Leptaspis urceolata (Roxb.) R. Br.			2	4	1	
Poaceae	Lophatherum gracile Brongn.			7	5	1	1
Poaceae	Melinis minutiflora P.Beauv.				1	1	
Poaceae	Nastus productus (Pilg.) Holttum			3	1	1	
Poaceae	Neololeba atra (Lindl.) Widjaja	Bambusa forbesii (Ridl.) Holttum		4	4	1	
Poaceae	Oplismenus sp.			1			
Poaceae	Paspalum conjugatum Berg.			4	3		
Poaceae	Paspalum longifolium Roxb.			1	1		
Poaceae	Paspalum scrobiculatum L.			1			
Poaceae	Pennisetum macrostachyum (Brogn.) Trin.				3	1	
Poaceae	Phragmites karka (Retz.) Trin. ex Steud.		LC		3		
Poaceae	Saccharum officinarum L.			3	4	1	1
Poaceae	Saccharum robustum Brandes & Jeswiet ex Grassl			1	6	1	
Poaceae	Saccharum spontaneum L. var. edulis (Hassk.) K.Schum.			1	1	1	1
Poaceae	Sorghum sp.			2	3	1	
Poaceae	Thysanolaena latifolia (Roxb. ex Hornem.) Honda	Thysanolaena maxima (Roxb.) Kuntze		1	1		
Poaceae	Urochloa mutica (Forssk.) T.-Q.Nguyen			1	3		
Poaceae	Zea mays L.			2	4	1	1
Pontederiaceae	Eichhornia crassipes (Mart.) Solms				1		
Ruscaceae	Dracaena angustifolia (Medik.) Roxb.	Pleomele angustifolia (Roxb.) N.E. Br.		2	5	1	1
Smilacaceae	Smilax cf. zeylanica L.			1	1		
Smilacaceae	Smilax sp.			2	4	1	1
Triuridaceae	Sciaphila sp.			2	1		
Xanthorrhoeaceae	Dianella ensifolia (L.) DC.			11	7	1	1
Zingiberaceae	Alpinia calycodes K. Schum.			4	2		
Zingiberaceae	Alpinia cf. pulchra (Warb.) K. Schum.			1			
Zingiberaceae	Alpinia sp. A			1			
Zingiberaceae	Alpinia sp. B			1	2		
Zingiberaceae	Alpinia spp.			1	1	1	1
Zingiberaceae	Curcuma australasica Hook. f.		LC	2	1		1
Zingiberaceae	Etlingera sp.				1		
Zingiberaceae	Eugenia sp.				1	1	
Zingiberaceae	Hornstedtia cyathifera Valeton			1			
Zingiberaceae	Hornstedtia scottiana (F. Muell.) K. Schum.			3	5	1	1
Zingiberaceae	Pleuranthodium sp.			4	1	1	1
Zingiberaceae	Riedelia corallina Valeton			3	4		
Zingiberaceae	Riedelia longifolia Valeton			2			
Zingiberaceae	Riedelia macrantha K. Schum.			2			
Zingiberaceae	Riedelia spp.			4	2	1	1
Zingiberaceae	Zingiber officinale Roxb.				1		
Zingiberaceae	Zingiber zerumbet (L.) J.E. Sm.				1		
Dicotyledons	0						

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Acanthaceae	Hemigraphis reptans (Forst.) T. And. ex Hemsl.			5	2	1	1
Acanthaceae	Hulemacanthus densiflorus Bremek.			1			
Acanthaceae	Hypoestes floribunda R. Br.				1		
Acanthaceae	Justicia gendarussa Burm. f.	Gendarussa vulgaris Nees		2	1		1
Acanthaceae	Lepidagathis sp.			1	3	1	1
Acanthaceae	Ptyssiglottis pubisepala (Lindau) B. Hansen			2			
Acanthaceae	Ruellia sp.			3			1
Acanthaceae	Sanchezia sp.			1	1	1	
Acanthaceae	Staurogyne novoguineensis (Kaneh. & Hatus.) B.L. Burtt			1			
Achariaceae	Erythrospermum candidum (Becc.) Becc.			1	3	1	
Achariaceae	Pangium edule Reinw.			6	7	1	1
Achariaceae	Ryparosa calotricha Mildbr.			1	2	1	1
Achariaceae	Trichadenia philippinensis Merr.			2	2	1	1
Actinidiaceae	Saurauia conferta Warb.			2			1
Actinidiaceae	Saurauia schumanniana Diels			5	1		1
Actinidiaceae	Saurauia sp.			2	3		
Actinidiaceae	Saurauia stichophlebia Diels, or aff.			2			
Amaranthaceae	Achyranthes aspera L.			1	1		1
Amaranthaceae	Alternanthera sessilis (L.) DC.		LC	1	1		1
Amaranthaceae	Amaranthus spinosus L.				3		
Amaranthaceae	Celosia argentea L.				1		
Amaranthaceae	Cyathula prostrata (L.) Blume			1	1		
Anacardiaceae	Buchanania amboinensis Miq.			3	7	1	1
Anacardiaceae	Buchanania arborescens (Blume) Blume			3	6	1	1
Anacardiaceae	Campnosperma brevipetiolata Volkens			7	7	1	1
Anacardiaceae	Campnosperma montanum Lauterb.			2	1		
Anacardiaceae	Dracontomelon dao (Blanco) Merr. & Rolfe			2	2		
Anacardiaceae	Euroschinus papuanus Merr. & Perry			3	3		
Anacardiaceae	Mangifera minor Blume		LC	2	2		
Anacardiaceae	Rhus caudata Lauterb.			1	1		
Anacardiaceae	Rhus taitensis Guill.			3	2		1
Anacardiaceae	Semecarpus albicans Lauterb.			1			
Anacardiaceae	Semecarpus aruensis Engl.			1			
Anacardiaceae	Semecarpus bracteata Lauterb.	Semecarpus bracteatus Lauterb.			1		
Anacardiaceae	Semecarpus magnifica K. Schum.	Semecarpus magnificus K. Schum.		2	6	1	
Anacardiaceae	Semecarpus nidificans (Lauterb.) Ding Hou			2			
Anacardiaceae	Semecarpus spp.			1	1	1	1
Anacardiaceae	Spondias cyatherea Sonnerat			2	2		
Annonaceae	Annona muricata L.				2		
Annonaceae	Artabotrys sp., “suaveolens-inodorus group”			1			
Annonaceae	Cananga odorata Hook. f. & Thoms.			3	5	1	1
Annonaceae	Cyathocalyx sp.			1	1		
Annonaceae	Goniothalamus aruensis Scheff.			2	2	1	
Annonaceae	Goniothalamus imbricatus Scheff.			1			
Annonaceae	Haplostichanthus longirostris (Scheff.) van Heusden			3	2		
Annonaceae	Haplostichanthus longirostris (Scheffer) Heusden	Papualthia longirostris (Scheff.) Diels		1	1		
Annonaceae	Huberantha gen. nov.	genus nov. ined.		2	1		
Annonaceae	Mitrella kentii (Blume) Miq.			1			
Annonaceae	Polyalthia sp.			2			
Annonaceae	Popowia cf. pisocarpa Endl.			4	1		
Annonaceae	Popowia pisocarpa (Blume) Endl. ex Walp.			1			1
Annonaceae	Pseuduvaria sp.				1		
Annonaceae	Schefferomitra subaequalis (Scheff.) Diels			1	1		
Annonaceae	Uvaria sp.				1	1	
Annonaceae	Xylopia sp.				1		
Apiaceae	Centella asiatica (L.) Urb.			2			
Apiaceae	Mackinlaya celebica (Harms) Philipson			6	1		
Apiaceae	Mackinlaya radiata Philipson			1			
Apocynaceae	Alstonia macrophylla Wall. ex G. Don			5	1	1	1
Apocynaceae	Alstonia scholaris (L.) R. Br.		LC	1	5	1	
Apocynaceae	Alyxia acuminata K. Schum.			4	1		
Apocynaceae	Anodendron oblongifolium Hemsl.				2		
Apocynaceae	Cerbera floribunda K. Schum.			7	6	1	1
Apocynaceae	Dischidia hirsuta Decne.			1			
Apocynaceae	Dischidia sp.			1	2		
Apocynaceae	Dischidia torricellensis (Schltr.) P.I. Forst.			6	2	1	1
Apocynaceae	Gymnema sp.			1			
Apocynaceae	Hoya lauterbachii K. Schum.			1			
Apocynaceae	Hoya piestolepis Schltr.			1			
Apocynaceae	Hoya spp.			2	4	1	1

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Apocynaceae	Hoya sussuela (Roxb.) Merr.			1			
Apocynaceae	Hoya torricellensis Schltr.			1			
Apocynaceae	Ichnocarpus frutescens (L.) R. Br.			2	1		
Apocynaceae	Lepiniopsis ternatensis Valeton			2			
Apocynaceae	Marsdenia sp.			1			
Apocynaceae	Melodinus forbesii Fawc.			1	2		
Apocynaceae	Micrechites rhombifolius Markgr.			2			
Apocynaceae	Ochrosia citrodora Lauterb. & K. Schum.			3	2		
Apocynaceae	Papuechites aambe (Warb.) Markgr.			3	2		
Apocynaceae	Parsonsia curvisepala K. Schum.			2			
Apocynaceae	Parsonsia lata Merr. & Perry			1	1		
Apocynaceae	Phyllanthera lancifolia (P.I. Forst.) Venter			3	1	1	
Apocynaceae	Phyllanthera piforsteriana Takeuchi	Phyllanthera sp. nov.		2	1		
Apocynaceae	Tabernaemontana aurantiaca Gaudich.			2	4		1
Apocynaceae	Tabernaemontana pandacaqui Poir.			2	2	1	1
Apocynaceae	Tylophora cissoides Blume			1	4		
Apocynaceae	Tylophora sp.				1	1	
Apocynaceae	Voacanga grandifolia (Miq.) Rolfe				3	1	
Aquifoliaceae	Ilex scabridula Merr. & Perry			1			
Araliaceae	Osmoxylon boerlagei (Warb.) Philipson			2	1		
Araliaceae	Osmoxylon geelvinkianum Becc.			8	2	1	1
Araliaceae	Osmoxylon novoguineense (Scheff.) Becc.			3	7	1	1
Araliaceae	Polyscias sp.	Arthrophyllum sp.		1			
Araliaceae	Polyscias spectabilis (Harms) Lowry & G.M.Plunkett	Gastonia spectabilis (Harms) Philipson		4	1		
Araliaceae	Polyscias zippeliana (Miq.) Valeton			2			
Araliaceae	Schefflera spp.			11	6	1	1
Aristolochiaceae	Aristolochia chrismuelleriana Takeuchi	Aristolochia “jackii” Steud.			1		
Aristolochiaceae	Aristolochia lauterbachiana O.C. Schmidt or A. novoguineensis O.C. Schmidt			3	1	1	1
Aristolochiaceae	Aristolochia tagala Cham.			1	1		
Asteraceae	Adenostemma lavenia (L.) Kuntze			2	2		
Asteraceae	Ageratum conyzoides L.			4	3	1	1
Asteraceae	Bidens pilosa L.			2	2		
Asteraceae	Blumea arfakiana Martelli			3	1		
Asteraceae	Blumea riparia (Blume) DC.			5	2		
Asteraceae	Cosmos caudatus H.B.K.				1		
Asteraceae	Crassocephalum crepidioides (Benth.) S. Moore			6	3	1	
Asteraceae	Decaneuropsis obovata (Gaudich.) H.Rob. & Skvarla	Vernonia cuneata Less.		4			
Asteraceae	Erechtites valerianifolius (Wolf) DC.	Erechtites valerianifolia (Wolf) DC.		3	1		1
Asteraceae	Erigeron sumatrensis Retz.			1	1		
Asteraceae	Olearia sp.			2			
Asteraceae	Tagetes erecta L.	Tagetes cf. patula L.			1		
Asteraceae	Tagetes sp.				1	1	
Atherospermataceae	Dryadodaphne novoguineensis (Perkins) A.C. Sm.			2			
Balanophoraceae	Balanophora papuana Schltr.			1			
Balsaminaceae	Impatiens hawkeri Bull			3			
Begoniaceae	Begonia brachybotrys Merr. & Perry			2	1		
Begoniaceae	Begonia kaniensis Irmscher			1	1	1	
Begoniaceae	Begonia papuana Warb.			1			
Begoniaceae	Begonia spp.			11	3	1	1
Bignoniaceae	Neosepicaea viticoides Diels			1			
Bignoniaceae	Pandorea pandorana (Andrews) Steenis subsp. pandorana	Pandorea pandorana (Andrews) Steenis		2			1
Bignoniaceae	Tecomanthe dendrophila (Blume) K. Schum.			4	2		
Bixaceae	Bixa orellana L.				2		
Boraginaceae	Tournefortia sarmentosa Lam.			3	1		1
Brassicaceae	Nasturtium officinale R.Br.	Rorippa nasturtium-aquaticum (L.) Hayek		1			
Burseraceae	Canarium acutifolium (DC.) Merr.			4	3	1	1
Burseraceae	Canarium indicum L.				2		
Burseraceae	Canarium maluense Lauterb. subsp. maluense	Canarium maluense Lauterb.		7	3	1	1
Burseraceae	Canarium oleosum Engl.			1			
Burseraceae	Canarium vitiense A. Gray			2	4	1	
Burseraceae	Haplolobus floribundus (K. Schum.) H.J. Lam			2			
Burseraceae	Santiria rubiginosa Blume			1	1		
Campanulaceae	Peracarpa carnosa (Wall.) Hook. & Thompson			1			
Cannabaceae	Celtis latifolia (Blume) Planch.			3			
Cannabaceae	Celtis philippensis Blanco			2	1		

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Cannabaceae	Celtis rigescens (Miq.) Planch.			2	1	1	
Cannabaceae	Celtis spp.			1	1	1	1
Cannabaceae	Gironniera celtidifolia Gaudich.			1			
Cannabaceae	Gironniera hirta Ridl.			2			
Cannabaceae	Gironniera rhamnifolia Blume			2			
Cannabaceae	Gironniera subaequalis Planch.			5			1
Cannabaceae	Parasponia sp.			1			
Cannabaceae	Trema cannabina Lour.			2	3	1	
Cannabaceae	Trema orientalis (L.) Blume			1			
Cannabaceae	Ziziphus angustifolia (Miq.) Hatus. ex Steenis	Zizyphus angustifolius (Miq.) Hatus.		2	3		1
Cannabaceae	Ziziphus papuana Lauterb.	Zizyphus papuanus Lauterb.		5	2		1
Capparaceae	Crateva religiosa G.Forst. f.	Crataeva religiosa Forst. f.		1	1		
Cardiopteridaceae	Citronella suaveolens (Blume) Howard			2			
Cardiopteridaceae	Gonocaryum litorale (Blume) Sleumer			6			1
Caricaceae	Carica papaya L.			2	4	1	1
Caryophyllaceae	Drymaria cordata (L.) Willd. ex Roemer & Schult			2	2		
Casuarinaceae	Gymnostoma papuanum (S. Moore) L.A.S. Johnson	Gymnostoma papuana (S. Moore) L.A.S. Johnson		5	3	1	1
Celastraceae	Brassiantha pentamera A.C. Sm.			1	1		
Celastraceae	Perrottetia alpestris (Blume) Loes.				1		
Celastraceae	Salacia erythrocarpa K. Schum.			1			
Chloranthaceae	Ascarina philippinensis C.B. Rob.			1	1		
Chloranthaceae	Ascarina sp.			1			
Chloranthaceae	Chloranthus elatior Link	Chloranthus erectus (Buch.-Ham.) Verdc.		6	3	1	1
Chloranthaceae	Sarcandra glabra (Thunb.) Nakai			1			
Chrysobalanaceae	Maranthes corymbosa Blume			3			1
Chrysobalanaceae	Parastemon versteeghii Merr. & L.M.Perry			3	1		1
Chrysobalanaceae	Parinari papuana C.T. White			4			1
Clethraceae	Clethra canescens Reinw. ex Blume			1			
Clusiaceae	Calophyllum papuanum Lauterb.		LC		3		
Clusiaceae	Calophyllum soulattri Burm.			4	2		1
Clusiaceae	Calophyllum spp.			1	3	1	1
Clusiaceae	Garcinia cf. hunsteinii Lauterb.			1	1	1	1
Clusiaceae	Garcinia cymosa (K. Schum.) I.M. Turner & P.F. Stevens				1		
Clusiaceae	Garcinia dulcis (Roxb.) Kurz			2			
Clusiaceae	Garcinia hollrungii Lauterb.			3	1		
Clusiaceae	Garcinia hunsteinii Lauterb.			1			
Clusiaceae	Garcinia sp., sect. Cambogia			3	3	1	1
Clusiaceae	Garcinia spp.			2	5	1	1
Clusiaceae	genus is under revision; all names may be subject to change	Garcinia celebica L.		1			
Combretaceae	Combretum indicum (L.) DeFilipps	Quisqualis indica L.		1	4		
Combretaceae	Combretum tetralophum C.B. Clarke				2		
Combretaceae	Combretum trifoliatum Vent.				2		
Combretaceae	Terminalia canaliculata Exell			1	4	1	1
Combretaceae	Terminalia complanata K. Schum.			4	4	1	1
Combretaceae	Terminalia impediens Coode			1	1		
Combretaceae	Terminalia oreadum Diels			1			
Combretaceae	Terminalia rubiginosa K. Schum.			2			
Combretaceae	Terminalia spp.			1	1	1	1
Connaraceae	Connarus sp., "semidecandrus group"			1	1		
Connaraceae	Rourea minor (Gaertn.) Leenh.				1		
Connaraceae	Santaloides radlkoferanum (Schum.) G. Schellenb.	Rourea radlkoferiana K. Schum.		1			
Convolvulaceae	Ipomoea aquatica Forssk.				4		
Convolvulaceae	Ipomoea batatas (L.) Lam.			3	3	1	1
Convolvulaceae	Ipomoea sp.				3		
Convolvulaceae	Lepistemon owariense (P. Beauv.) Hallier f.	Lepistemon urceolatum (R. Br.) F. Muell.			1		
Convolvulaceae	Merremia gemella (Burm. f.) Hallier f.				3		
Convolvulaceae	Merremia peltata (L.) Merr.			4	7	1	1
Convolvulaceae	Operculina sp.			2	1		
Cornaceae	Mastixia kaniensis Melch. subsp. ledermannii (Melch.) Matthew	Mastixia kaniensis Melch.		4	2	1	
Cucurbitaceae	Benincasa hispida (Thunb.) Cogn.				1		
Cucurbitaceae	Citrullus lanatus (Thunb.) Matsum. & Nakai	Citrullus vulgaris Schrad.		1	2	1	1
Cucurbitaceae	Cucumis sativus L.			1	3	1	1
Cucurbitaceae	?Neoalsomitra clavigera (M.Roem.) Hutch.	Neoalsomitra trifoliolata (F. Muell.) Hutch.			4		
Cucurbitaceae	Trichosanthes sp.			4	1		1
Cucurbitaceae	Zanonia indica L.				1		
Cucurbitaceae	Zehneria sp.			2	3		

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Cunoniaceae	Acsmithia reticulata (Schltr.) Hoogland			2			
Cunoniaceae	Aistopetalum multiflorum Schltr.			1			
Cunoniaceae	Aistopetalum viticoides Schltr.			2			
Cunoniaceae	Ceratopetalum succirubrum C.T. White		VU	3			
Cunoniaceae	Gillbeea papuana Schltr.			1			
Cunoniaceae	Pullea glabra Schltr.			3			
Cunoniaceae	Schizomeria sp.			3			
Cunoniaceae	?Caldcluvia nymanii (K.Schum.) Hoogland	Opocunonia nymanii (K. Schum.) Schltr.		3			
Cunoniaceae	Weinmannia fraxinea (D. Don) Miq.			7	2		1
Cunoniaceae	Weinmannia urdanetensis Elmer			2			
Daphniphyllaceae	Daphniphyllum gracile Gage			2			
Dichapetalaceae	Dichapetalum papuanum (Becc.) Boerl.			2			
Dichapetalaceae	Dichapetalum sp.			2			
Dilleniaceae	Dillenia castaneifolia (Miq.) Martelli ex Dur. & Jacks.				2	1	
Dilleniaceae	Dillenia montana Diels			1			
Dilleniaceae	Dillenia sp.			7	5	1	1
Dilleniaceae	Tetracera lanuginosa Diels			2	1		
Dilleniaceae	Tetracera nordtiana F.Muell. var. moluccana Hoogland	Tetracera nordtiana F.Muell.		4	2		1
Dipterocarpaceae	Anisoptera thurifera (Blanco) Blume subsp. polyandra (Blume) Ashton	Anisoptera thurifera (Blanco) Blume	VU	3			1
Dipterocarpaceae	Hopea iriana Slooten			1			
Dipterocarpaceae	Hopea sp.			6	1		1
Dipterocarpaceae	Vatica rassak (Korth.) Blume		LC	6	8	1	1
Ebenaceae	Diospyros buxifolia (Blume) Hiern.			2	2		1
Ebenaceae	Diospyros fusicarpa Bakh.			3	1	1	1
Ebenaceae	Diospyros papuana Valeton ex Bakh.			4	2		1
Ebenaceae	Diospyros sp. nov.			2			
Elaeocarpaceae	Aceratium brassii A.C. Sm.			2			
Elaeocarpaceae	Aceratium cf. ledermannii Schltr.			1			
Elaeocarpaceae	Aceratium oppositifolium DC.			5	2		
Elaeocarpaceae	Aceratium pittosporoides Schltr.			5	1		1
Elaeocarpaceae	Aceratium sp.			1			1
Elaeocarpaceae	Elaeocarpus angustifolius Blume			7	4	1	1
Elaeocarpaceae	Elaeocarpus bilobatus Schltr.			2			
Elaeocarpaceae	Elaeocarpus branderhorstii Pulle				1		
Elaeocarpaceae	Elaeocarpus culminicola Warb.			3			
Elaeocarpaceae	Elaeocarpus dolichodactylis Schltr. subsp. dolichostylis	Elaeocarpus dolichodactylis Schltr.		4	1	1	
Elaeocarpaceae	Elaeocarpus dolichostylis Schltr.				3	1	
Elaeocarpaceae	Elaeocarpus ledermannii Schltr.			3	1	1	
Elaeocarpaceae	Elaeocarpus miegei Weibel			2			
Elaeocarpaceae	Elaeocarpus peistocarpus Schltr.				1		
Elaeocarpaceae	Elaeocarpus polydactylis Schltr.			1			
Elaeocarpaceae	Elaeocarpus prafiensis Weibel				1		
Elaeocarpaceae	Elaeocarpus schlechteranus A.C. Sm.			2			
Elaeocarpaceae	Elaeocarpus sepikanus Schltr.			4	3	1	1
Elaeocarpaceae	Elaeocarpus spp.			1	1	1	1
Elaeocarpaceae	Sericolea micans Schltr.			3			
Elaeocarpaceae	Sloanea cf. aberrans (Brandis) A.C. Sm.			3			
Elaeocarpaceae	Sloanea paradisearum F. Muell.			1			
Elaeocarpaceae	Sloanea pulchra (Schltr.) A.C. Sm.			3	1		
Elaeocarpaceae	Sloanea sogerensis Baker f.			3	5	1	
Elaeocarpaceae	Sloanea spp.			4	2	1	1
Ericaceae	Dimorphanthera brevipes Schltr.			3			
Ericaceae	Dimorphanthera denticulifera Sleumer			2			
Ericaceae	Dimorphanthera kempteriana Schltr.			2			1
Ericaceae	Diplycosia edulis Schltr.			2			
Ericaceae	Diplycosia morobeensis Sleumer			1	1	1	
Ericaceae	Diplycosia rufescens Schltr.			3			
Ericaceae	Rhododendron macgregoriae F. Muell.			5			
Ericaceae	Rhododendron zoelleri Warb.			1			
Ericaceae	Vaccinium acrobracteatum K.Schum.			1			1
Ericaceae	Vaccinium finisterrae Schltr.			1			
Ericaceae	Vaccinium sp. A, sect. Oarianthe			2			
Ericaceae	Vaccinium sp. B, sect. Bracteata			2			
Erythroxylaceae	Erythroxylum ecarinatum Hochr.			2			1
Escalloniaceae	Polyosma cf. cestroides Schltr.			3			
Escalloniaceae	Polyosma cf. dentata Schltr.			2			
Escalloniaceae	Polyosma integrifolia Blume			4			
Escalloniaceae	Polyosma sp.			2			1
Euphorbiaceae	Acalypha hellwigii Warb.			2			
Euphorbiaceae	Acalypha longispica Warb.			1			

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Euphorbiaceae	Actephila discoidea Heijkoop & Welzen	Actephila lindleyi (Steud.) Airy Shaw		1			
Euphorbiaceae	Alchornea scandens (Lour.) Müll.Arg.	Trophis scandens (Lour.) Hook. & Arn.			1		
Euphorbiaceae	Annesijoa novoguineensis Pax & Hoffm.			1			
Euphorbiaceae	Antidesma excavatum Miq. var. excavatum	Antidesma excavatum Miq.		4	2		1
Euphorbiaceae	Claoxylon sp.			2	3	1	1
Euphorbiaceae	Codiaeum finisterrae Pax, or aff.				1		
Euphorbiaceae	Codiaeum variegatum (L.) Rumph. ex A.Juss.	Codiaeum variegatum (L.) Blume		4	3	1	
Euphorbiaceae	Croton muriculatus Airy Shaw			1	1		
Euphorbiaceae	Endospermum moluccanum (Teijsm. & Binn.) Kurz	Endospermum labios Schodde		7	6	1	1
Euphorbiaceae	Euphorbia hirta L.			2	3	1	1
Euphorbiaceae	Hancea penangensis (Müll.Arg.) S.E.C.Sierra, Kulju & Welzen	Mallotus penangensis Müll. Arg.		1			
Euphorbiaceae	Macaranga aleuritoides F. Muell.			3	7	1	1
Euphorbiaceae	Macaranga bifoveata J.J. Sm.			2	1		
Euphorbiaceae	Macaranga caudata Pax & Hoffm.			2	1		
Euphorbiaceae	Macaranga clavata Warb.			2			
Euphorbiaceae	Macaranga fallacina Pax & Hoffm.			2	5		
Euphorbiaceae	Macaranga gracilis Pax & Hoffm.			2			
Euphorbiaceae	Macaranga inermis Pax & Hoffm.			3	3		
Euphorbiaceae	Macaranga lanceolata Pax & Hoffm.			1			
Euphorbiaceae	Macaranga papuana (J.J. Sm.) Pax & Hoffm.			2	2		
Euphorbiaceae	Macaranga polyadenia Pax & Hoffm.			2			
Euphorbiaceae	Macaranga quadriglandulosa Warb. var. quadriglandulosa	Macaranga quadriglandulosa Warb.		3	1	1	
Euphorbiaceae	Macaranga reiteriana Pax & Hoffm.			1			
Euphorbiaceae	Macaranga sp., “Longistipulata group”			2			
Euphorbiaceae	Macaranga spp.			1	1	1	1
Euphorbiaceae	Macaranga strigosa Pax & Hoffm., or aff.			3	1		
Euphorbiaceae	Macaranga tessellata Gage			5	2		1
Euphorbiaceae	Mallotus floribundus (Blume) Müll. Arg.			2	1		
Euphorbiaceae	Mallotus paniculatus (Lam.) Müll. Arg.				1		
Euphorbiaceae	Mallotus peltatus (Geiseler) Müll. Arg.			2	1		
Euphorbiaceae	Mallotus pleiogynus Pax & K.Hoffm.	Octospermum pleiogynum (Pax & Hoffm.) Airy Shaw		1			
Euphorbiaceae	Mallotus repandus (Rottler) Müll. Arg.			1	1		
Euphorbiaceae	Mallotus spp.			1	2	1	1
Euphorbiaceae	Manihot esculenta Crantz			3	5	1	1
Euphorbiaceae	Melanolepis multiglandulosa (Reinw. ex Blume) Rchb. & Zoll.			1	3	1	1
Euphorbiaceae	Omalanthus novoguineensis (Warb.) K. Schum.			6	5	1	
Euphorbiaceae	Pimelodendron amboinicum Hassk.			9	6	1	1
Euphorbiaceae	Spathiostemon javensis Bl.				1		
Euphorbiaceae	Syndrella? sp.				1		
Euphorbiaceae	Wetria insignis (Steud.) Airy Shaw			1			
Fabaceae	Abrus precatorius L.				2		
Fabaceae	Adenanthera novoguineensis Baker f.			2	1		
Fabaceae	Arachis hypogaea L.			1	3	1	1
Fabaceae	Archidendron aruense (Warb.) de Wit			3	2	1	1
Fabaceae	Archidendron calliandrum de Wit; distr. record for northern PNG	Archidendron sp. nov., aff. A. bellum Harms		2			
Fabaceae	Archidendron clypearia (Jack) Nielsen			7	5	1	1
Fabaceae	Archidendron lucyi F. Muell.			3	5	1	1
Fabaceae	Clitorea ternatea L.				1		
Fabaceae	Crotalaria pallida Ait.				2		
Fabaceae	Dahlbergia spp.			2	3		
Fabaceae	Derris elegans Grah. ex Benth.			1	1		
Fabaceae	Derris sp.				2		
Fabaceae	Desmodium ormocarpoides DC.			1	2		
Fabaceae	Desmodium sp.				3		
Fabaceae	Entada rheedii Spreng.	Entada pursaetha DC.		4	5	1	
Fabaceae	Erythrina variegata L.		LC		2		
Fabaceae	Falcataria moluccana (Miq.) Barneby & J.W.Grimes	Paraserianthes falcataria (L.) Nielsen		5	5	1	1
Fabaceae	Inocarpus fagifer (Parkinson ex Z) Fosberg				1		
Fabaceae	Intsia bijuga (Colebr.) Kuntze		VU	6	7	1	1
Fabaceae	Kingiodendron alternifolium (Elmer) Merr. & Rolfe			1	1	1	
Fabaceae	Leucaena leucocephala (Lam.) de Wit			1	1		
Fabaceae	Maniltoa megacephala Harms			1	2		
Fabaceae	Maniltoa plurijuga Merr. & Perry			3	2		

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Fabaceae	Maniltoa psilogyne Harms			2	4		
Fabaceae	Maniltoa schefferi K. Schum. & Hollrung			3	2		1
Fabaceae	Maniltoa spp.			1	1	1	1
Fabaceae	Milletia pinnata (L.) Panigrahi			3	5		
Fabaceae	Mimosa pudica L.			2	1		
Fabaceae	Mucuna mollissima Kurz	Mucuna cyanosperma K. Schum.			1		
Fabaceae	Mucuna novo-guineensis Scheff.			7	6	1	1
Fabaceae	Phaseolus vulgaris L.				3		
Fabaceae	Pterocarpus indicus Willd.		VU	4	6	1	1
Fabaceae	Pueraria montana var. lobata (Willd.) Sanjappa & Pradeep	Pueraria triloba sensu Makino		1	3		
Fabaceae	Pueraria pulcherrima (Koord.) Koord.-Schumacher			1	2	1	
Fabaceae	Rhynchosia acuminatissima Miq.				3		
Fabaceae	Senna alata (L.) Roxb.	Cassia alata L.		2	5	1	1
Fabaceae	Strongylodon lucidus (G.Forst.) Seem.	Strongylodon siderospermus Cordemoy		1	3		
Fabaceae	Tephrosia sp.			1	2		
Fabaceae	Tephrosia vogelii Hook. f.				3	1	
Fagaceae	Castanopsis acuminatissima (Blume) A. DC.			7			1
Fagaceae	Lithocarpus celebicus (Miq.) Rehder			7	1		1
Fagaceae	Lithocarpus rufovillosus (Markgr.) Rehder			3			
Gesneriaceae	Aeschynanthus spp.			11	2		
Gesneriaceae	Agalmyla sp.			6	1		
Gesneriaceae	Cyrtandra bracteata Warb.			1	1	1	1
Gesneriaceae	Cyrtandra cf. decurrens de Vriese			1			
Gesneriaceae	Cyrtandra fusco-vellea K. Schum.			3			
Gesneriaceae	Cyrtandra hispidissima Schltr.			4			
Gesneriaceae	Cyrtandra janowskyi Schltr., or aff.			1			
Gesneriaceae	Cyrtandra schumanniana Schltr.				1		
Gesneriaceae	Cyrtandra sp. B, sect. Geodesme			4			
Gesneriaceae	Cyrtandra sp. nov. A			2			
Gesneriaceae	Cyrtandra spp.			11	4	1	1
Gesneriaceae	genus under revision; all names may be subject to change	Cyrtandra bracteata Warb.		5	2		
Goodeniaceae	Scaevola oppositifolia R. Br.	Scaevola oppositifolia R. Br.		7	1		1
Gunneraceae	Gunnera macrophylla Blume			2			
Haloragaceae	Gonocarpus halconensis (Merr.) Orchard			2			
Hernandiaceae	Hernandia guianensis Aubl.	Hernandia ovigera L.		5	3	1	1
Himantandraceae	Galbulimima belgraveana (F. Muell.) Sprague			3			
Icacinaceae	Platea excelsa Blume var. borneensis (Heine) Sleumer	Platea excelsa Blume		5	2		1
Icacinaceae	Polyporandra scandens Becc.			1			
Icacinaceae	Rhyticaryum longifolium Lauterb. & K. Schum.			4	4	1	1
Icacinaceae	Rhyticaryum novoguineense (Warb.) Sleumer			1			
Ixonanthaceae	Ixonanthes reticulata Jack			3			
Juglandaceae	Engelhardia rigida Blume			1			
Lamiaceae	Callicarpa longifolia Lam.			2	4	1	
Lamiaceae	Callicarpa pentandra Roxb.	Geunsia pentandra (Roxb.) Merr.		2	5	1	
Lamiaceae	Clerodendrum porphyrocalyx Lauterb. & K. Schum.			2			
Lamiaceae	Clerodendrum tracyanum (F. Muell.) Benth.			2	2		
Lamiaceae	Clerodendrum tracyanum (F.Muell.) Benth.	Clerodendrum buruanum Miq.		3	1		1
Lamiaceae	Coleus sp.			1	1		
Lamiaceae	Faradaya splendida F. Muell.			3	5	1	1
Lamiaceae	Gmelina cf. ledermanni H.J. Lam			2	7		
Lamiaceae	Gmelina cf. moluccana Backer ex K. Heyne			3			
Lamiaceae	Gmelina sp.			1	1	1	1
Lamiaceae	Hyptis capitata Jacq.			1	5	1	
Lamiaceae	Ocimum gratissimum L.			1			
Lamiaceae	Petraeovitex multiflora Merr.			1			
Lamiaceae	Plectranthus sp.			1			
Lamiaceae	Premna serratifolia L.			1	5	1	
Lamiaceae	Teijsmanniodendron ahernianum (Merr.) Bakh.			5	5	1	1
Lamiaceae	Vitex cofassus Reinw. ex Blume			1	2		
Lauraceae	Actinodaphne cf. nitida Teschner			1	1	1	1
Lauraceae	Actinodaphne nitida Teschner			9	1		
Lauraceae	Actinodaphne tomentosa Teschner			3			
Lauraceae	Alseodaphne sp.			4			

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Lauraceae	Beilschmiedia acutifolia Teschner			2			
Lauraceae	Beilschmiedia cf. acutifolia Teschner			1			1
Lauraceae	Cinnamomum eugenoliferum Kosterm.			3			1
Lauraceae	Cinnamomum spp.			10	2	1	1
Lauraceae	Cryptocarya cf. pusilla Teschner			3			
Lauraceae	Cryptocarya magnifolia Teschner			1			1
Lauraceae	Cryptocarya multipaniculata Teschner, or aff.			3	2		
Lauraceae	Cryptocarya spp.			12	4	1	1
Lauraceae	Endiandra sp.			4			1
Lauraceae	Litsea guppyi (F. Muell.) F. Muell. ex Forman			3	1		
Lauraceae	Litsea ledermannii Teschner			1			
Lauraceae	Litsea spp.			11	4	1	1
Lauraceae	Persea americana L.			1	1		
Lauraceae	Phoebe forbesii Gamble			2			
Lecythidaceae	Barringtonia acutangula (L.) Gaertn.				3		
Lecythidaceae	Barringtonia apiculata Lauterb.	Barringtonia sepikensis Lauterb.		1	3		
Lecythidaceae	Barringtonia calyptrata (Miers.) R. Br. ex. Benth.				1		
Lecythidaceae	Barringtonia calyptrocalyx K. Schum.			2			
Lecythidaceae	Barringtonia cf. calyptrocalyx K. Schum.				1	1	
Lecythidaceae	Barringtonia josephstaalensis Takeuchi			1	1		
Lecythidaceae	Barringtonia papuana Lauterb.			2	2	1	1
Lecythidaceae	Planchonia papuana R.Knuth	Planchonia papuana Merr. & Perry		5	6	1	1
Lentibulariaceae	Utricularia striatula Sm.		LC	1			
Linaceae	Hugonia jenkinsii F.Muell.			1			1
Linaceae	?Durandea jenkinsii (F.Muell.) Stapf	Hugonia jenkinsii F.Muell.		1	3		
Loganiaceae	Fagraea berteroana A. Gray ex Benth.			1			
Loganiaceae	Fagraea bodenii Wernham			1			
Loganiaceae	Fagraea ceilanica Thunb.			6	3	1	
Loganiaceae	Fagraea gracilipes A.Gray	Fagraea amabilis S. Moore		2			
Loganiaceae	Geniostoma rupestre Forst.			1			
Loganiaceae	Geniostoma weinlandii K. Schum.			3			
Loganiaceae	Neuburgia corynocarpa (A. Gray) Leenh.			5	6	1	1
Loganiaceae	Neuburgia rumphiana Leenh.				1		
Loganiaceae	Picrophloeus javanensis Blume	Fagraea elliptica Roxb.		2			
Loganiaceae	Strychnos axillaris Colebr.			1			
Loganiaceae	Strychnos minor Dennst.			1	2		
Loganiaceae	Utania racemosa (Jack) Sugumaran	Fagraea racemosa Jack		4	8	1	1
Loranthaceae	Amyema friesiana (K. Schum.) Danser			2	2		
Loranthaceae	Amyema seemeniana (K. Schum.) Danser			1	2		
Loranthaceae	Amyema squarrosa Danser			1			
Loranthaceae	Cecarria obtusifolia (Merr.) Barlow			1			
Loranthaceae	Decaisnina hollrungii (K. Schum.) Barlow			5	2		
Loranthaceae	Decaisnina sp.			1			
Loranthaceae	Dendrophthoe curvata (Blume) Miq.				2		
Loranthaceae	Macrosolen cochinchinensis (Lour.) Tiegh.			2			
Lythraceae	Duabanga moluccana Blume				3		
Lythraceae	Lagerstroemia piriformis Koehne				2		
Magnoliaceae	Magnolia tsiampacca (L.) Figlar & Noot.	Elmerrillia tsiampacca (L.) Dandy		1			
Malpighiaceae	Stigmaphyllon mariae C.E.Anderson	Ryssopterys timoriensis (DC.) Jussieu			2		
Malvaceae	Abelmoschus manihot (L.) Medik.			1	1	1	1
Malvaceae	Abroma augusta L.			2	4	1	1
Malvaceae	Commersonia bartramia (L.) Merr.			3	2		1
Malvaceae	Hibiscus rosa-sinensis L.				2		
Malvaceae	Kleinhovia hospita L.			2	5	1	1
Malvaceae	Melochia umbellata (Houtt.) Stapf.				1		
Malvaceae	Microcos chrysothyrsa Burret			1			
Malvaceae	Microcos grandiflora Burret			2			1
Malvaceae	Microcos spp.			1	1	1	1
Malvaceae	Pterocymbium beccarii K. Schum.			1			
Malvaceae	Sida rhombifolia L.			1	2		
Malvaceae	Sterculia ampla Baker f.			2	3		
Malvaceae	Sterculia macrophylla Vent.			9	6	1	1
Malvaceae	Sterculia schumanniana (Lauterb.) Mildbr.			4	3		
Malvaceae	Sterculia shillinglawii F.Muell.			3	1		
Malvaceae	Sterculia sp.			1			1
Malvaceae	Talipariti archboldianum (Borss. Waalk.) Fryxell	Hibiscus archboldianus Borss. Waalk.		1	6	1	
Malvaceae	Talipariti dalbertisii (F. Muell.) Fryxell	Hibiscus cf. d'albertisii F. Muell.		1			

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Malvaceae	Talipariti ellipticifolium (Borss. Waalk.) Fryxell	Hibiscus ellipticifolius Borss. Waalk.		2	1		
Malvaceae	Talipariti spp.			1	1	1	1
Malvaceae	Talipariti tiliaceum (L.) Fryxell	Hibiscus tiliaceus L.		2	3		
Malvaceae	Theobroma cacao L.			2	4	1	1
Malvaceae	Thespesia populnea (L.) Solander ex Correa		LC		3	1	
Malvaceae	Trichospermum pleiostigma (F. Muell.) Kosterm.			3	6	1	1
Malvaceae	Triumfetta pilosa Roth			1	2		
Melastomataceae	Astronia atro-viridis Mansf.			2			
Melastomataceae	Astronia crassiloba J.F. Maxwell			1			
Melastomataceae	Astronia grandiflora J.F. Maxwell			1			
Melastomataceae	Astronia hollrungii Cogn.			2			
Melastomataceae	Astronia rugata J.F. Maxwell				1		
Melastomataceae	Astronia sp.			3	1	1	1
Melastomataceae	Astronidium sp.			1	1	1	1
Melastomataceae	Beccarianthus sp.			1	1	1	1
Melastomataceae	Beccarianthus sp. A			1			
Melastomataceae	Beccarianthus sp. B			2	2		
Melastomataceae	Catanthera longistylis (Mansf.) Nayar			2			
Melastomataceae	Catanthera paniculata (Nayar) Nayar			2			
Melastomataceae	Catanthera sp. nov.			4			
Melastomataceae	Creochiton novoguineensis (Baker f.) Veldkamp & Nayar			1			
Melastomataceae	Creochiton sp. nov.			2			
Melastomataceae	Diplectria divaricata (Willd.) Kuntze			1			
Melastomataceae	Dissochaeta angiensis Kaneh. & Hatus. ex Ohwi	Dissochaeta angiensis Ohwi		2			1
Melastomataceae	Dissochaeta schumannii Cogn.			2			
Melastomataceae	genus nov.			2	2		
Melastomataceae	Heteroblemma barbatum (Bakh.f.) Cámara-Leret, Ridd.-Num. & Veldkamp	Medinilla sp. nov. B, sect. Heteroblemma		2			
Melastomataceae	Heteroblemma cf.barbatum (Bakh.f.) Cámar a-Leret, Ridd.-Num. & Veldkamp	Medinilla sp. nov. C, sect. Heteroblemma		3			
Melastomataceae	Medinilla aff. compacta Bakh. f.			1			
Melastomataceae	Medinilla auriculata Lauterb., or aff.			3			
Melastomataceae	Medinilla dentata Veldkamp			4			
Melastomataceae	Medinilla rubrifructus Ohwi			2			
Melastomataceae	Medinilla sp. A, aff. M. maluensis Mansf.			4	1		
Melastomataceae	Medinilla sp. D, “quadrifolia group”			5	3		
Melastomataceae	Medinilla spp.			1	1	1	1
Melastomataceae	Medinilla teysmannii Miq.			2			
Melastomataceae	Medinilla triplinervia Cogn.			1			
Melastomataceae	Medinilla versteegii Mansf.			2			
Melastomataceae	Melastoma malabathricum L.			5	3	1	
Melastomataceae	Memecylon cf. schraderbergense Mansf.			2	2		
Melastomataceae	Poikilogyne cordifolia (Cogn.) Mansf.			2			
Melastomataceae	Poikilogyne multiflora J.F. Maxwell			1			
Melastomataceae	Pternandra cf. galeata (Korth.) Ridl.			5	3		
Melastomataceae	Sonerila papuana Cogn.			3	1		1
Meliaceae	Aglaia agglomerata Merr. & Perry		NT	1			
Meliaceae	Aglaia argentea Bl.		LC	1	1		
Meliaceae	Aglaia cf. lepiorrhachis Harms			1			
Meliaceae	Aglaia euryanthera Harms		NT	1			
Meliaceae	Aglaia lawii (Wight) Saldanha ex Ramamoorthy		LC	2			
Meliaceae	Aglaia rimosa (Blanco) Merr.		NT	3	2		
Meliaceae	Aglaia sapindina (F. Muell.) Harms		LC	2			
Meliaceae	Aglaia spp.			1	1	1	1
Meliaceae	Aglaia subcuprea Merr. & Perry		NT	2			
Meliaceae	Aglaia subminutiflora C. DC.			2			
Meliaceae	Aglaia tomentosa Teijsm. & Binn.		LC	1	2		
Meliaceae	Anthocarapa nitidula (Benth.) T.D. Penn. ex Mabb.			2	2		
Meliaceae	Aphanamixis polystachya (Wall.) R.N. Parker			4	1		1
Meliaceae	Chisocheton ceramicus (Miq.) C. DC.			3	1		
Meliaceae	Chisocheton lasiocarpus (Miq.) Valeton			1	1	1	1
Meliaceae	Chisocheton lasiocarpus (Miq.) Valeton, entity “weinlandi”			2	2		
Meliaceae	Chisocheton pohlianus Harms			1			
Meliaceae	Chisocheton sp. nov., aff. pachyrhachis Harms			3	1		
Meliaceae	Dysoxylum acutangulum Miq.			1			
Meliaceae	Dysoxylum alliaceum (Blume) Blume			3			
Meliaceae	Dysoxylum arborescens (Blume) Miq.			2			

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Meliaceae	Dysoxylum brevipaniculum C. DC.			1	1		
Meliaceae	Dysoxylum excelsum Blume			2	1		
Meliaceae	Dysoxylum gaudichaudianum (A. Juss.) Miq.			3	1		
Meliaceae	Dysoxylum latifolium Benth.			3			
Meliaceae	Dysoxylum papuanum (Merr. & Perry) Mabb.			1			
Meliaceae	Dysoxylum parasiticum (Osb.) Kosterm.			1			
Meliaceae	Dysoxylum sparsiflorum Mabb.			1	1		
Meliaceae	Dysoxylum spp.			1	1	1	1
Meliaceae	Dysoxylum variabile Harms			5	1		1
Meliaceae	Vavaea amicorum Benth.			2			
Menispermaceae	Chlaenandra ovata Miq.			1	3	1	
Menispermaceae	Hypserpa polyandra Becc.			3	2		
Menispermaceae	Macrococculus pomiferus Becc.			2			
Menispermaceae	Parabaena tuberculata Becc.			1			
Menispermaceae	Pycnarrhena tumefacta Miers			1	1		
Menispermaceae	Tinospora minutiflora K.Schum.	Legnephora minutiflora (K. Schum.) Diels		1			
Menispermaceae	Stephania japonica (Thunb. ex Murr.) Miers			2	2		
Menispermaceae	Stephania zippeliana Miq.			1			
Menispermaceae	Tinospora dissitiflora (Lauterb. & K. Schum.) Diels				1		
Monimiaceae	Kairoa villosa (Kaneh. & Hatus.) Renner & Takeuchi			4	1		
Monimiaceae	Kibara sp. A			1			
Monimiaceae	Kibara sp. nov.			3			
Monimiaceae	Levieria montana Becc.			1			
Monimiaceae	Palmeria arfakiana Becc.			4			1
Monimiaceae	Palmeria hypargyrea Perkins			1			
Monimiaceae	Steganthera dentata (Valeton) Kaneh. & Hatus.				1		
Monimiaceae	Steganthera hirsuta (Warb.) Perkins			1	1		
Monimiaceae	Steganthera hospitans (Becc.) Kaneh. & Hatus.			8	2		1
Moraceae	Antiaropsis decipiens K. Schum.			2	3		
Moraceae	Artocarpus altilis (Parkins.) Fosb.			3	5	1	1
Moraceae	Artocarpus vriesianus Miq.			3			1
Moraceae	Broussonetia papyrifera (L.) Vent.				2		
Moraceae	Ficus adelpha Lauterb. & K. Schum.			1			
Moraceae	Ficus aff. aurita Reinw. ex Blume			5	1		
Moraceae	Ficus arbuscula Lauterb. & K. Schum.			6	3	1	1
Moraceae	Ficus arfakensis King			1	3	1	
Moraceae	Ficus botryocarpa Miq.			1	2		
Moraceae	Ficus casearioides King			1			
Moraceae	Ficus cf. adenosperma Miq.			3	1		
Moraceae	Ficus cf. megalophylla Diels			1			
Moraceae	Ficus chrysolepis Miq.			1			
Moraceae	Ficus copiosa Steud.			2			
Moraceae	Ficus disticha Blume			1			
Moraceae	Ficus glandulifera Wall. ex Miq.			2	3		
Moraceae	Ficus gul Lauterb. & K. Schum.			2	2		
Moraceae	Ficus gymnorygma Summerh.			2			
Moraceae	Ficus microcarpa L. f.				1		
Moraceae	Ficus mollior F. Muell. ex Benth.			2	1		
Moraceae	Ficus nasuta Summerh.				2		
Moraceae	Ficus nodosa Teijsm. & Binn.			1	1		
Moraceae	Ficus odoardi King			2			
Moraceae	Ficus phatnophylla Diels			1			
Moraceae	Ficus pungens Reinw. ex Blume			3	2		
Moraceae	Ficus septica Burm. f.			2	2		
Moraceae	Ficus sp. A			1			
Moraceae	Ficus sp. B			1			
Moraceae	Ficus sp., "augusta facies"			1			
Moraceae	Ficus spp.			1	1	1	1
Moraceae	Ficus subcuneata Miq.			2			
Moraceae	Ficus subtrinervia Lauterb. & K. Schum.			5	3	1	1
Moraceae	Ficus subulata Blume			4	3		
Moraceae	Ficus trachypison K. Schum.			1			
Moraceae	Ficus virgata Reinw. ex Blume			2	2		
Moraceae	Ficus wassa Roxb.			4	2		
Moraceae	Parartocarpus venenosa Becc.	Parartocarpus venenosus (Zoll. & Moritzi) Becc.		1			
Moraceae	Prainea scandens King ex Hook. f.			1			
Moraceae	Streblus glaber (Merr.) Corner			2	1		
Myristicaceae	Endocomia macrocoma (Miq.) de Wilde subsp. prainii (King) de Wilde	Endocomia macrocoma (Miq.) de Wilde		1	3	1	1

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Myristicaceae	Gymnacranthera farquhariana Warb. var. zippeliana (Miq.) R.T.A. Schouten	Gymnacranthera farquhariana Warb.		3	6	1	1
Myristicaceae	Horsfieldia ampliformis de Wilde		VU	1			
Myristicaceae	Horsfieldia basifissa de Wilde			1	1		
Myristicaceae	Horsfieldia laevigata (Blume) Warb.			2	5	1	1
Myristicaceae	Horsfieldia pilifera Markgr.			1			
Myristicaceae	Horsfieldia schlechteri Warb.			1			
Myristicaceae	Horsfieldia sepikensis Markgr.		VU		1		
Myristicaceae	Horsfieldia spp.			1	1	1	1
Myristicaceae	Horsfieldia subtilis (Miq.) Warb. var. subtilis	Horsfieldia subtilis (Miq.) Warb.		3	4	1	1
Myristicaceae	Horsfieldia sylvestris (Houtt.) Warb.		LC	2	3		
Myristicaceae	Myristica buchneriana Warb.		VU	1	2		
Myristicaceae	Myristica cornutiflora J. Sinclair			1			
Myristicaceae	Myristica dasyneura de Wilde			1			
Myristicaceae	Myristica fusca Markgr.			1			
Myristicaceae	Myristica globosa Warb.		NT	3			
Myristicaceae	Myristica lancifolia Poir.			2	1		
Myristicaceae	Myristica spp.			2	3	1	1
Myristicaceae	Myristica subalulata Miq.			3	3	1	1
Myrtaceae	Decaspermum bracteatum (Roxb.) A.J. Scott			1	3		1
Myrtaceae	Decaspermum sp.			1			
Myrtaceae	Kania eugenioides Schltr.			3			
Myrtaceae	Kania eugenioides Schltr.	Metrosideros eugenioides (Schltr.) Steenis		1			
Myrtaceae	Metrosideros ramiflora Lauterb.			2	1		
Myrtaceae	Octamyrtus behrmannii Diels			2			
Myrtaceae	Octamyrtus pleiopetala (F. Muell.) Diels			1			
Myrtaceae	Psidium guajava L.				2	1	
Myrtaceae	Rhodomyrtus trineura (F. Muell.) F. Muell. ex Benth.			2			
Myrtaceae	Syzygium aff. hemilamprum (F. Muell. ex F.M. Bailey) Craven & Biffin				1		
Myrtaceae	Syzygium buettnerianum (K. Schum.) Niedenzu			3			
Myrtaceae	Syzygium cf. hylophilum (Lauterb. & K. Schum.) Merr. & Perry			1			
Myrtaceae	Syzygium cladopterum (Diels) Merr. & Perry			1			
Myrtaceae	Syzygium effusum (A. Gray) C. Muell.			4	3		
Myrtaceae	Syzygium fastigiatum (Blume) Merr. & Perry			3			
Myrtaceae	Syzygium furfuraceum Merr. & Perry			1	1		
Myrtaceae	Syzygium kipidamasii Takeuchi			1	1		
Myrtaceae	Syzygium lagerstroemioides Merr. & Perry			3			
Myrtaceae	Syzygium longipes Merr. & Perry			3	4	1	1
Myrtaceae	Syzygium malaccense (L.) Merr. & Perry			3	4	1	1
Myrtaceae	Syzygium pachycladum (Lauterb. & K. Schum.) Merr. & Perry			1	2		
Myrtaceae	Syzygium plumeum (Ridl.) Merr. & Perry			4			
Myrtaceae	Syzygium sayeri (F.Muell.) B.Hyland	Syzygium dictyophlebium Merr. & Perry		4			
Myrtaceae	Syzygium spp.			12	7	1	1
Myrtaceae	Syzygium tympananthum (Diels) Merr. & Perry			2			
Myrtaceae	Syzygium versteegii (Lauterb.) Merr. & Perry				2		
Myrtaceae	Syzygium xylopiaceum (Diels) Merr. & Perry			7	1		
Myrtaceae	Xanthomyrtus cf. polyclada Diels			2			
Myrtaceae	Xanthomyrtus schlechteri Diels			1			
Myrtaceae	Xanthomyrtus scolopacina (Ridl.) Diels			3			
Nepenthaceae	Nepenthes ampullaria Jack		LC	4	5	1	1
Nepenthaceae	Nepenthes mirabilis (Lour.) Druce		LC	2	1	1	1
Nepenthaceae	Nepenthes neo-guineensis Macfarlane			2			
Nothofagaceae	Nothofagus flaviramea Steenis			1			
Nyctaginaceae	Pisonia longirostris Teijsm. & Binn.			8	6	1	1
Ochnaceae	Schuurmansia henningsii K. Schum.			12	5	1	1
Oleaceae	Chionanthus polygamus (Roxb.) Kiew	Chionanthus oxycarpus (Lingelsh.) Kiew		1			
Oleaceae	Chionanthus ramiflorus Roxb.			3			
Oleaceae	Chionanthus salicifolius (Lingelsh.) Kiew			1			
Oleaceae	Chionanthus sessiliflorum (Hemsl.) Kiew			2	2		
Oleaceae	Chionanthus spp.			1	1	1	1
Oleaceae	Jasminum gilgianum K.Schum.	Jasminum schumannii Lingelsh.		2	1		
Oleaceae	Jasminum longipetalum King & Gamble	Jasminum turneri C.T. White			1		
Onagraceae	Ludwigia adscendens (L.) Hara			1			
Onagraceae	Ludwigia hyssopifolia (D. Don) Exell		LC	1	5	1	

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Onagraceae	Ludwigia octovalvis (Jacq.) Raven		LC	4	3		
Opiliaceae	Cansjera leptostachya Benth.			2	1	1	
Opiliaceae	Opilia amentacea Roxb.			1	1	1	
Oxalidaceae	Averrhoa bilimbi L.				5		
Oxalidaceae	Averrhoa carambola L.				1		
Oxalidaceae	Oxalis corniculata L.				1		
Pandaceae	Galearia celebica Koord.			4	4		
Paracryphiaceae	Quintinia ledermannii Schltr.			3			
Paracryphiaceae	Sphenostemon papuanum (Lauterb.) Steenis & Erdtman				1	1	
Paracryphiaceae	Nouhuysia papuana Lauterb.	Sphenostemon papuanum (Lauterb.) Steenis		4			
Passifloraceae	Adenia heterophylla (Blume) Koord.			1	4		
Passifloraceae	Passiflora aurantioides (K.Schum.) Krosnick	Hollrungia aurantioides K. Schum.		1	1		
Passifloraceae	Passiflora foetida L.			2	4	1	1
Penaeaceae	Crypteronia cumingii (Planch.) Planch. ex Endl.			5			
Pentaphragmataceae	Pentaphragma grandiflorum Kurz			4	1		1
Pentaphylacaceae	Eurya sp.			3			
Pentaphylacaceae	Ternstroemia britteniana F. Muell.			1			
Pentaphylacaceae	Ternstroemia cherryi (F.M. Bailey) Merr. ex J.F.Bailey & C.T White	Ternstroemia cherryi (F.M. Bailey) Merr.		1			
Pentaphylacaceae	Ternstroemia merrilliana Kobuski			2	1	1	
Phyllanthaceae	Agrostistachys borneensis Becc.			2	2		
Phyllanthaceae	Antidesma rhynchophyllum K. Schum.				2	1	
Phyllanthaceae	Aporosa lamellata Airy Shaw			1			
Phyllanthaceae	Aporosa laxiflora Pax & Hoffm.			1	1		
Phyllanthaceae	Aporosa papuana Pax & Hoffm.			3	1		
Phyllanthaceae	Baccaurea papuana F.M. Bailey			1	3	1	
Phyllanthaceae	Breynia cernua (Poir.) Müll. Arg.			2	5	1	
Phyllanthaceae	Breynia vestita Warb.			3	1		
Phyllanthaceae	Bridelia insulana Hance	Bridelia penangiana Hook. f.		1	1		
Phyllanthaceae	Cleistanthus sp.			1			
Phyllanthaceae	Glochidion aff. chodrocarpum Airy Shaw				2		
Phyllanthaceae	Glochidion cf. fulvirameum Miq.			2			
Phyllanthaceae	Glochidion nesophilum Airy Shaw			1			
Phyllanthaceae	Glochidion novoguineense K. Schum.			2	3		1
Phyllanthaceae	Glochidion sp. nov. aff. welzenii Takeuchi			2			
Phyllanthaceae	Glochidion zeylanicum (Gaertn.) A.Juss. var. supra-axillare (Benth.) Airy Shaw	Glochidion perakense Hook. f.		4	2		1
Phyllanthaceae	Phyllanthus ciccoides Müll. Arg.			1			
Phyllanthaceae	Phyllanthus clamboides (F. Muell.) Diels				1		
Phyllanthaceae	Phyllanthus rheophilus Airy Shaw			6	1		
Piperaceae	Peperomia pellucida (L.) Kunth			3	4	1	1
Piperaceae	Piper amboinense (Miq.) C. DC.			1	1		
Piperaceae	Piper betle L.			3	4	1	1
Piperaceae	Piper caninum Blume			7	3		
Piperaceae	Piper celtidiforme Opiz, or aff.			2	2		
Piperaceae	Piper decumanum (Rumph.) L.			2			
Piperaceae	Piper interruptum Opiz			1			
Piperaceae	Piper macropiper Pennant			6	5	1	
Piperaceae	Piper majusculum Blume			3			
Piperaceae	Piper mestonii F.M. Bailey			3	5		
Piperaceae	Piper novo-guineense Warb.			1			
Piperaceae	Piper pseudoamboinense C. DC.			2	2		1
Piperaceae	Piper rodatzii K. Schum. & Lauterb.			1			
Piperaceae	Piper versteegii C. DC.			1			
Pittosporaceae	Pittosporum pullifolium Burkill			2	1		
Pittosporaceae	Pittosporum ramiflorum Zoll.			2			
Pittosporaceae	Pittosporum sinuatum Blume			9	6	1	1
Plantaginaceae	Limnophila sp.				1		
Polygalaceae	Epirixanthes cf. papuana J.J. Sm.			1			
Polygalaceae	Eriandra fragrans P. Royen & Steenis			2	2	1	1
Polygalaceae	Polygala paniculata L.			2	2	1	1
Polygalaceae	Securidaca cacumina Wurdack	Securidaca ecristata Kassau		6			
Polygalaceae	Xanthophyllum papuanum Whitm. ex Meijden			3			
Polygonaceae	Persicaria chinensis (L.) H. Gross	Polygonum chinense L.			1		
Portulacaceae	Portulaca oleracea L.				2		
Primulaceae	Ardisia forbesii S. Moore			1	1	1	
Primulaceae	Ardisia imperialis var. novoguineensis(Mez) C.M.Hu	Ardisia imperialis K. Schum.		1	3		
Primulaceae	Ardisia laciniata Mez			2			
Primulaceae	Ardisia sp. C				1		

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Primulaceae	Ardisia sp. nov. A, aff. A. forbesii S. Moore			1			
Primulaceae	Ardisia sp. nov. B, aff. A. sogerensis S. Moore			2			
Primulaceae	Ardisia ternatensis Scheff.			2			
Primulaceae	Conandrium polyanthum (Lauterb. & K. Schum.) Mez			1	4		
Primulaceae	Discocalyx latepetiolata (Mez) Sleumer			2			
Primulaceae	Embelia cotinoides (S. Moore) Merr.			2	1		
Primulaceae	Fittingia tubiflora Mez			1			
Primulaceae	Maesa haplobotrys F. Muell.			4	1		
Primulaceae	Maesa montis-wilhelmi P. Royen			1			
Primulaceae	Myrsine acrosticta (Mez) Pipoly			2			
Primulaceae	Myrsine coriifolia (Sleumer) Pipoly			1			
Primulaceae	Myrsine leucantha (K. Schum.) Pipoly			4			
Primulaceae	rediscovery of Discocalyx pygmaea Kaneh. & Hatus., previously known only from the Cycloop Mts. type coll.	Discocalyx sp. nov., aff. D. orthioneura K. Schum.		3	1		
Proteaceae	Helicia odorata Diels			4			
Proteaceae	Helicia oreadum Diels			3			
Proteaceae	Helicia spp.			1	1	1	1
Proteaceae	Helicia woxvoldiana	Helicia sp. nov., aff. H. macrostachya Lauterb.		2			
Rhamnaceae	Alphitonia excelsa (Fenzl) Reiss. ex Endl.			2	2		
Rhamnaceae	Alphitonia macrocarpa Mansf.			2			1
Rhamnaceae	Berchemia sp.			1			
Rhamnaceae	Emmenosperma alphitonioides F. Muell.				1		
Rhamnaceae	Gouania microcarpa DC.			2	1		
Rhamnaceae	Rhamnus napalensis (Wall.) M.A.Lawson	Rhamnus nipalensis (Wall.) Lawson ex Hook.		4			
Rhizophoraceae	Carallia brachiata (Lour.) Merr.				3		
Rhizophoraceae	Gynotroches axillaris Blume			7	2		
Rosaceae	Prunus arborea (Blume) Kalkman var. arborea	Prunus arborea (Blume) Kalkman		6	2	1	1
Rosaceae	Prunus cf. pullei (Koehne) Kalkman			2			
Rosaceae	Prunus dolichobotrys (Lauterb. & K. Schum.) Kalkman			6			
Rosaceae	Prunus gazelle-peninsulae (Kaneh. & Hatus.) Kalkman			1			
Rosaceae	Prunus osiana Takeuchi			1			
Rosaceae	Prunus schlechteri (Koehne) Kalkman	Rubus schlechteri (Koehne) Kalkman		3			
Rosaceae	Rubus moluccanus L.			8	3	1	1
Rousseaceae	Carpodetus arboreus (Lauterb. & K. Schum.) Schltr.			1			
Rubiaceae	Airosperma grandifolia (Valeton) Takeuchi & Arifiani	Airosperma grandifolia Valeton		4	3		
Rubiaceae	Amaracarpus brassii Merr. & Perry			1			
Rubiaceae	Amaracarpus sp.			1	1	1	1
Rubiaceae	Antirhea sp.				1		
Rubiaceae	Argostemma bryophilum K. Schum.			2			
Rubiaceae	Argostemma cf. callitrichum Valeton			2			
Rubiaceae	Atractocarpus decorus (Valeton) C.F. Puttock			5			
Rubiaceae	Atractocarpus macarthurii (F. Muell.) C.F. Puttock			4			1
Rubiaceae	Atractocarpus sessilis (F. Muell.) C.F. Puttock			1	1		
Rubiaceae	Atractocarpus spp.			1	1	1	1
Rubiaceae	Coelospermum salomoniense (Engl.) J.T.Johanss.	Caelospermum salomoniense (Engl.) J.T. Johansson		2			
Rubiaceae	Coffea arabica L.			1	2		
Rubiaceae	Coptosapelta cf. maluensis Valeton			1			
Rubiaceae	Coptosapelta fuscescens Valeton				1		
Rubiaceae	Coptosapelta hameliaeblasta (Wernham) Valeton			1			
Rubiaceae	Cyclophyllum cf. caudatum (Valeton) A.P. Davis & Ruhsam			2			
Rubiaceae	Cyclophyllum cf. longiflorum (Valeton) A.P. Davis & Ruhsam			1			
Rubiaceae	Dolicholobium gertrudis K. Schum.			2	2	1	1
Rubiaceae	Dolicholobium linearilobum M.E. Jansen			2			
Rubiaceae	Dolicholobium oxylobum K. Schum.			3	1	1	1
Rubiaceae	Gardenia gjellerupii Valeton			2			
Rubiaceae	Gardenia lamingtonii F.M. Bailey			2			
Rubiaceae	Gardenia sp.			1	1	1	1

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Rubiaceae	Geophila repens (L.) I.M. Johnston			2			
Rubiaceae	Hedyotis schlechteri (Valeton) Merr. & Perry			1			
Rubiaceae	Hydnophytum ?moseleyanum Becc.			4	2		
Rubiaceae	Hydnophytum sp.			2	3	1	1
Rubiaceae	Ixora cf. leptopus Valeton			2	1	1	
Rubiaceae	Ixora minor (Valeton) Mouly & B.Bremer	Versteegia ?minor Valeton		1			
Rubiaceae	Ixora novoguineensis Mouly & B.Bremer	Versteegia cauliflora (Lauterb. & K. Schum.) Valeton		2	1	1	
Rubiaceae	Ixora sp.			4	4	1	1
Rubiaceae	Lasianthus cf. cyanocarpus Jack			1	1	1	1
Rubiaceae	Lasianthus cyanocarpus Jack			2			
Rubiaceae	Mastixiodendron sp.			2	2		1
Rubiaceae	Mitragyna speciosa Korth.			2			
Rubiaceae	Morinda cf. glomerata (Blume) Miq.			1			
Rubiaceae	Morinda citrifolia L.	Morinda bracteata Roxb.			1		
Rubiaceae	Morinda citrifolia L.				1		
Rubiaceae	Morinda umbellata L.			5	1		
Rubiaceae	Mussaenda chrysotricha Valeton			2	1		
Rubiaceae	Mussaenda cylindrocarpa Burck			2			
Rubiaceae	Mussaenda ferruginea K. Schum.			3	4	1	1
Rubiaceae	Mussaenda oreadum Wernham			1			
Rubiaceae	Mussaenda scratchleyi Wernham			1	1		
Rubiaceae	Mycetia javanica (Blume) Reinw. ex Korth.			5	1		
Rubiaceae	Myrmecodia cf. schlechteri Valeton			1			
Rubiaceae	Myrmecodia longissima Valeton			1			
Rubiaceae	Myrmecodia sp.				1	1	
Rubiaceae	Nauclea orientalis (L.) L.			2	6	1	1
Rubiaceae	Nauclea spp.			2	2	1	1
Rubiaceae	Neonauclea obversifolia (Valeton) Merr. & Perry			1	1		
Rubiaceae	Neonauclea spp.			5	2	1	1
Rubiaceae	nomen nudum; invalid name	Andira pseudoixoraeflora Ridsdale		4	3		
Rubiaceae	Oldenlandia lapeyrousii (DC.) Terrell & H.Rob.	Hedyotis lapeyrousii DC.		7	4	1	1
Rubiaceae	Oldenlandia pubescens Valeton	Hedyotis pubescens (Valeton) Merr. & Perry		1	1		
Rubiaceae	Ophiorrhiza spp.			8	3	1	1
Rubiaceae	Pachystylus zippelianus (Miq.) Bremek.	Pachystylus guelcherianus K. Schum.		4	1		
Rubiaceae	Pavetta platyclada Lauterb. & K. Schum.			2			
Rubiaceae	Psychotria amplithyrsa Valeton			1	4		
Rubiaceae	Psychotria augustaflussiana Takeuchi & Arifiani	Psychotria sp. nov. B		3			
Rubiaceae	Psychotria dieniensis Merr. & Perry			1			
Rubiaceae	Psychotria ectasiphylla Lauterb. & K. Schum.				1		
Rubiaceae	Psychotria leptothyrsa Miq.			5	2		
Rubiaceae	Psychotria micrococca (Lauterb. & K. Schum.) Valeton			3	1		
Rubiaceae	Psychotria olivacea Valeton				1		
Rubiaceae	Psychotria petiolosa Valeton				1		
Rubiaceae	Psychotria ramulosa Merr. & Perry			3			
Rubiaceae	Psychotria sp. nov. C			1	1		
Rubiaceae	Psychotria sp. nov., aff. apdavisiana Takeuchi			1	1	1	1
Rubiaceae	Psychotria spp., climbers			7	4	1	1
Rubiaceae	Psychotria aurea Lauterb.	Psychotria sp. nov. A, aff. aquatilis Merr. & Perry		3			
Rubiaceae	redundant entry	Psychotria leptothyrsa Miq.		2			
Rubiaceae	Rothmannia macromera (Lauterb. & K. Schum.) Ridsdale			2			
Rubiaceae	Saprosma subrepandum (K. Schum. & Lauterb.) Valeton			1	2		
Rubiaceae	Schradera novoguineensis (Valeton) Puff, Buchner & Greimler				3		
Rubiaceae	Schradera ramiflora (Valeton) Puff, Buchner & Greimler			3			
Rubiaceae	Tarenna sambucina var. buruensis (Miq.) Fosberg & Sachet	Tarenna buruensis (Miq.) Valeton			1		
Rubiaceae	Tarenna sp.			1	2		
Rubiaceae	Timonius avenis Valeton			1			
Rubiaceae	Timonius caudatus Valeton, or aff.			3	1		
Rubiaceae	Timonius flavescens (Jack) Baker			2			
Rubiaceae	Timonius grandifolius Valeton			6	5	1	1

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Rubiaceae	Timonius kaniensis Valeton			2	3		
Rubiaceae	Timonius oblongus Valeton			1			
Rubiaceae	Timonius pubistipulis S. Darwin			1			
Rubiaceae	Timonius secundiflorus S. Darwin			3			
Rubiaceae	Timonius sp. nov., aff. grandifolius Valeton			2	1		
Rubiaceae	Timonius subavenis (Valeton) S. Darwin				1		
Rubiaceae	Timonius timon (Spreng.) Merr.			1	3	1	1
Rubiaceae	Uncaria calophylla Blume ex Korth.			3	2		
Rubiaceae	Uncaria cordata (Lour.) Merr.			2	3	1	
Rubiaceae	Uncaria lanosa Wall. var. appendiculata (Benth.) Ridsdale	Uncaria lanosa Wall.		6	6	1	
Rubiaceae	Urophyllum britannicum Wernham			4	1		1
Rubiaceae	Urophyllum cf. glaucescens Valeton			1	2		
Rubiaceae	Wendlandia paniculata (Roxb.) DC.			1	2		
Rutaceae	Acronychia sp.			3			
Rutaceae	Acronychia trifoliolata Zoll. & Mor.			2			
Rutaceae	Citrus limon (L.) Osbeck				1	1	
Rutaceae	Euodia cuspidata K. Schum.			2			
Rutaceae	Flindersia pimenteliana F. Muell.		EN	3	1		
Rutaceae	Flindersia sp.			1			1
Rutaceae	Halfordia papuana Lauterb.		CR		1		
Rutaceae	Lunasia amara Blanco var. amara	Lunasia amara Blanco		2	1	1	
Rutaceae	Melicope elleryana (F. Muell.) T.G. Hartley			7	2		
Rutaceae	Melicope novoguineensis Valeton			4	2	1	1
Rutaceae	Melicope spp.			2	1	1	1
Rutaceae	Melicope xanthoxyloides (F. Muell.) T.G. Hartley			1			
Rutaceae	Micromelum minutum (Forst. f.) Wight & Arn.			1	1		
Rutaceae	Monanthocitrus paludosa (Lauterb.) B.C.Stone	Triphasia aff. brassii (C.T. White) Swingle			1		
Rutaceae	?Melicope tetrandra Roxb.	Tetractomia tetrandrum (Roxb.) Merr.		1			
Rutaceae	Wenzelia dolichophylla (Lauterb. & K. Schum.) Tanaka				1		
Sabiaceae	Meliosma pinnata (Roxb.) Maxim.			2	1		
Sabiaceae	Sabia pauciflora Blume			1	1		
Salicaceae	Casearia clutiifolia Blume	Casearia clutiaefolia Blume		4	1	1	1
Salicaceae	Casearia macrantha Gilg			2	1	1	1
Salicaceae	Flacourtia zippelii Slooten			1	1		
Salicaceae	Homalium foetidum (Roxb.) Benth.		LC	2			
Salicaceae	?Stachycrater philippinus Turcz.	Osmelia philippina (Turcz.) Benth.		1	1		
Salicaceae	Xylosma papuana Gilg			1			
Santalaceae	Cladomyza kaniensis (Pilg.) Stauffer			1			
Santalaceae	Dendromyza sp.			2			
Santalaceae	?Scleromelum aurantiacum K.Schum. & Lauterb.	Scleropyrum aurantiacum (Lauterb. & K. Schum.) Pilg.		3	1		
Sapindaceae	Alectryon sp.			2			
Sapindaceae	Allophylus cobbe (L.) Raeusch.	Pometia pinnata Forst.		9	7	1	1
Sapindaceae	Cupaniopsis bilocularis Adema			2			
Sapindaceae	Cupaniopsis macropetala Radlk.				1		
Sapindaceae	Cupaniopsis stenopetala Radlk.			2			
Sapindaceae	Dictyoneura obtusa Blume			2	1		
Sapindaceae	Guioa spp.			1	3	1	1
Sapindaceae	Harpullia arborea (Blanco) Radlk.			1	1		
Sapindaceae	Harpullia cf. cauliflora K. Schum. & Lauterb.			2	1	1	
Sapindaceae	Harpullia ramiflora Radlk.			4	1		
Sapindaceae	Harpullia spp.			1	1	1	1
Sapindaceae	Jagera javanica (Blume) Kalkman subsp. javanica	Jagera javanica (Blume) Kalkman		2	5	1	1
Sapindaceae	Lepisanthes senegalensis (Poir.) Leenh.			2	1		1
Sapindaceae	Mischocarpus sp.			3			
Sapindaceae	Rhysotoechia sp.			2			
Sapindaceae	Sarcopteryx squamosa (Roxb.) Radlk.			1			
Sapindaceae	Toechima erythrocarpum (F. Muell.) Radlk.			1			
Sapindaceae	Tristiropsis acutangula Radlk.			1			
Sapotaceae	Beccariella sp. nov.			1			
Sapotaceae	Palaquium sp.				1		
Sapotaceae	Planchonella anteridifera (C.T. White & W.D. Francis) H.J. Lam			2	1	1	
Sapotaceae	Planchonella firma (Miq.) Dubard			1			
Sapotaceae	Planchonella myrsinodendron (F.Muell.) Swenson, Bartish & Munzinger	Planchonella cf. obovoidea H.J. Lam		4			
Sapotaceae	Planchonella spp.			1	1	1	1
Sapotaceae	Planchonella xylocarpa (C.T.White) Swenson, Bartish & Munzinger	Planchonella xylocarpa (C.T. White) Swenson		2			

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Scrophulariaceae	Buddleja asiatica Lour.			1			
Solanaceae	Capsicum anuum L.			1	4	1	1
Solanaceae	Lycianthes memecylonoides (Bitter & Schltr.) Bitter	Solanum memecylonoides Bitter & Schltr.		2			
Solanaceae	Lycianthes oliveriana (K. Schum. & Lauterb.) Bitter	Solanum oliverianum Lauterb. & K. Schum.		4	3		1
Solanaceae	Lycianthes sp.	Solanum sp., subgenus Lycianthes		1			
Solanaceae	Nicotiana tabacum L.			2	4	1	1
Solanaceae	Physalis minima L.			1	1		
Solanaceae	Solanum lycopersicum L.				2		
Solanaceae	Solanum sp.	Solanum sp., subgenus Solanum			1		
Staphyleaceae	Turpinia pentandra (Schltr.) B.L. Linden			1			
Stemonuraceae	Gomphandra australiana F. Muell.			3	2	1	1
Stemonuraceae	Gomphandra montana (G. Schellenb.) Sleumer			1	1	1	
Stemonuraceae	Medusanthera laxiflora (Miers) R. A. Howard			3	4	1	1
Stemonuraceae	Stemonurus monticola (G. Schellenb.) Sleumer	Stemonurus monticolus (Schellenb.) Sleumer		1	3		1
Styracaceae	Bruinsmia styracoides Boerl. & Koords.			2			
Symplocaceae	Symplocos cochinchinensis (Lour.) S. Moore			2			1
Tetramelaceae	Octomeles sumatrana Miq.		LC	4	6	1	1
Tetrameristaceae	Tetramerista glabra Miq.				3		
Theaceae	Eurya tigang K. Schum. & Lauterb.			3			
Theaceae	Gordonia amboinensis (Miq.) Merr.	Gordonia papuana Kobuski		5	1	1	1
Thymelaeaceae	Gyrinops ledermannii Domke			3	2	1	1
Thymelaeaceae	Phaleria coccinea (Gaudich.) F. Muell.			3	2	1	1
Thymelaeaceae	Phaleria macrocarpa (Scheff.) Boerl.			1	2	1	1
Trimeniaceae	Trimenia papuana Ridl.			5			
Urticaceae	Cypholophus sp.			1			
Urticaceae	Dendrocnide sp.			1	3		1
Urticaceae	Elatostema angulare H.J.P. Winkl.			3			
Urticaceae	Elatostema beccarii H. Schroet.			1			
Urticaceae	Elatostema integrifolium (D.Don) Wedd.	Elatostema sesquifolium (Reinw.) Hassk.		3	2		
Urticaceae	Elatostema macrophyllum Brogn.	Elatostema macrophylla Brogn.		2			
Urticaceae	Elatostema novoguineense Warb.	Elatostema novo-guineense Warb.		5	2		1
Urticaceae	Elatostema spp.			10	2	1	1
Urticaceae	Elatostema weinlandii K. Schum.			2			
Urticaceae	Leucosyke capitellata Wedd.	Leucosyke capitellata (Poir.) Chew		3	4		1
Urticaceae	Nothocnide melastomatifolia (K. Schum.) Chew			1	2	1	
Urticaceae	Nothocnide repanda (Bl.) Bl.				1		
Urticaceae	Oreocnide rubescens (Blume) Miq.	Villebrunea rubescens (Blume) Blume		1	1		
Urticaceae	Pilea sp.			2			
Urticaceae	Pipturus argenteus (G. Forst.) Wedd.	Pipturus argenteus (Forst. f.) Wedd.		3			1
Urticaceae	Poikilospermum amboinense Zipp. ex Miq.			6	5	1	1
Urticaceae	Poikilospermum inaequale Chew			2			
Urticaceae	Poikilospermum paxianum (H.J.P. Winkl.) Merr.			1			
Urticaceae	Procris frutescens Blume			3			
Urticaceae	Procris grueningii (H.J.P.Winkl.) R.J.Johns	Procris gruningii H.J.P. Winkl.		1			
Urticaceae	Urticastrum decumanum (Roxb.) Kuntze	Laportea decumana (Roxb.) Wedd.		3	4		1
Verbenaceae	Stachytarpheta jamaicensis (L.) Vahl			1	3		
Violaceae	Rinorea horneri Kuntze	Rinorea horneri (Korth.) Kuntze		1			
Vitaceae	Ampelocissus muelleriana Planch.			3	1		
Vitaceae	Cayratia geniculata (Blume) Gagnep.			1	1		
Vitaceae	Cayratia japonica (Thunb.) Gagnep.			2	3	1	
Vitaceae	Cayratia trifolia (L.) Domin			1	2		
Vitaceae	Cissus aristata Blume			1	2	1	
Vitaceae	Cissus javana DC.			1	1		
Vitaceae	Leea coryphantha Lauterb.			4	5		
Vitaceae	Leea indica (Burm. f.) Merr.			8	6	1	1
Vitaceae	Leea zippeliana Miq.			5	2	1	1
Vitaceae	Nothocissus penninervis (F. Muell.) Latiff			4	4		
Vitaceae	Tetrastigma lauterbachianum Gilg			9	5	1	1

FAMILY	SCIENTIFIC NAME	NAME IN 2011	STATUS*	GFA HM	GFA L	2	3
Winteraceae	?Tasmannia piperita (Hook. f.) Miers	Drimys piperita Hook. entity myrtoides Vink		1			
Winteraceae	Zygogynum sp. B			3			
Winteraceae	Zygogynum sp. C				1		
Winteraceae	Zygogynum sp. nov. A			3	1		

*Conservation status IUCN CR-Critically Endangered, EN – Endangered, VU – Vulnerabe, NT – Near Threatened, DD – Data Defficient, LC - Least Concern, NE – Not evaluated. P – protected under PNG *Fauna (Protection and Control) Act 1966*

21.8 Species of conservation concern

FAMILY	COMMON NAME	SCIENTIFIC NAME	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Macropodidae	Tenkile	*Dendrolagus scottae*	CR P	N	N	N	N	N	N	N	N	M	M	N	N
Macropodidae	Waimang	*Dendrolagus pulcherrimus*	CR P	N	N	N	N	N	N	N	N	N	L	N	N
Petauridae	Northern Glider	*Petaurus abidi*	CR	N	N	N	N	N	N	N	N	N	L	N	N
Tachyglossidae	Sir David's Long-beaked Echidna	*Zaglossus attenboroughi*	CR P	L	L	L	L	L	L	L	L	L	L	N	N
Tachyglossidae	Eastern Long-beaked Echidna	*Zaglossus bartoni*	VU P	0.5	L	S	M	M	L	L	L	L	S	L	N
Phalangeridae	Telefomin Cuscus	*Phalanger matanim*	CR P	0.5	N	L	N	N	N	N	N	N	N	N	N
Phalangeridae	Black-spotted Cuscus	*Spilocuscus rufoniger*	CR	0.5	S	S	S	0.5	S	S	S	S	S	S	L
Pteropodidae	Bulmer's Fruit Bat	*Aproteles bulmerae*	CR	L	N	N	N	N	N	N	N	N	N	N	N
Rutaceae	Saffronheart	*Halfordia papuana Lauterb.*	CR	1											
Bryophytes	Liverwort	*Schistochila undulatifolia Pipo*	CR												
Macropodidae	Goodfellow's Tree Kangaroo	*Dendrolagus goodfellowi*	EN P	0.5	L	L	L	L	N	N	N	N	N	N	N
Macropodidae	Western Montane Tree Kangaroo	*Dendrolagus notatus*	EN P	0.5	N	M	N	N	N	N	N	N	N	N	N
Muridae	Northern Water Rat	*Paraleptomys rufilatus*	EN	N	N	N	N	N	N	N	N	N	S	N	N
Scolopacidae	Far Eastern Curlew	*Numenius madagascariensis*	EN	N	N	N	N	N	N	N	N	N	N	N	M
Scolopacidae	Great Knot	*Calidris tenuirostris*	EN	N	N	N	N	N	N	N	N	N	N	N	M
Papilionidae	Ornithoptère Méridional	*Ornithoptera meridionalis Rothschild, 1897*	EN P	0	1										
Rutaceae	Maple Silkwood	*Flindersia pimenteliana F. Muell.*	EN	**3**	**1**										
Macropodidae	Grizzled tree kangaroo	*Dendrolagus inustus*	VU P	N	N	N	N	N	N	L	L	S	S	S	L
Macropodidae	New Guinea Pademelon	*Thylogale browni*	VU	3	0.5	S	S	1	S	L	L	L	S	L	L
Hipposideridae	Hill's Leaf-nosed Bat	*Hipposideros edwardshilli*	VU	N	N	N	N	N	N	N	N	N	S	N	N
Anatidae	Salvadori's Teal	*Salvadorina waigiuensis*	VU	S	L	L	L	S	N	N	N	N	N	N	N
Psittaculidae	Pesquet's Parrot	*Psittrichas fulgidus*	VU	11	3	S	S	S	S	S	S	S	S	S	S
Accipitridae	Papuan Eagle	*Harpyopsis novaeguineae*	VU	3	1	S	1	S	S	S	S	S	S	L	L
Cunoniaceae	Coachwood	*Ceratopetalum succirubrum C.T. White*	VU	**3**											
Fabaceae	Burmese Rosewood	*Pterocarpus indicus Willd.*	VU	**4**	**6**										
Dipterocarpaceae	Palosapis	*Anisoptera thurifera (Blanco) Blume subsp. polyandra (Blume) Ashton*	VU	**3**											
Fabaceae	Kwila	*Intsia bijuga (Colebr.) Kuntze*	VU	**6**	**7**										
Myristicaceae	Pauan Nutmeg	*Myristica buchneriana Warb.*	VU	**1**	**2**										
Myristicaceae	Guma	*Horsfieldia ampliformis de Wilde*	VU	**1**											
Myristicaceae	Bangara	*Horsfieldia sepikensis Markgr.*	VU		**1**										
Libellulidae	Dragonfly	*Bironides teuchestes*	VU	1	0										
Pseudocheiridae	Plush-coated Ringtail Possum	*Pseudochirops corinnae*	NT	S	L	S	N	L	N	N	N	N	N	N	N
Pseudocheiridae	D'Albertis's Ringtail Possum	*Pseudochirops albertisii*	NT	N	N	N	N	N	N	N	N	M	S	M	N
Macropodidae	Small Mountain Dorcopsis	*Dorcopsulus ?vanheurni*	NT	0.5	N	S	N	L	N	N	N	N	N	N	N
Dasyuridae	New Guinean Quoll	*Dasyurus albopunctatus*	NT	0.5	L	S	L	M	L	L	L	L	S	L	L
Columbidae	Victoria Crowned Pigeon	*Goura victoria*	NT	3	9	S	1	2	S	S	S	S	S	L	L
Paradisaeidae	Pale-billed Sicklebill	*Drepanornis bruijnii*	NT P	N	N	N	N	L	M	S	S	S	S	S	S
Cnemophilidae	Yellow-breasted Satinbird	*Loboparadisea sericea*	NT P	S	N	S	N	1	N	N	N	N	N	N	N
Accipitridae	Doria's Goshawk	*Megatriorchis doriae*	NT	1	S	S	S	S	S	S	S	S	S	S	S

FAMILY	COMMON NAME	SCIENTIFIC NAME	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Accipitridae	Gurney's Eagle	*Aquila gurneyi*	NT	S	S	S	S	S	S	S	S	S	S	L	L
Ardeidae	Forest Bittern	*Zonerodius heliosylus*	NT	1	S	S	S	S	S	S	S	S	S	S	S
Alcedinidae	Blue-black Kingfisher	*Todiramphus nigrocyaneus*	NT	S	1	S	S	S	S	S	S	S	S	S	S
Petroicidae	Banded Yellow Robin	*Poecilodryas placens*	NT	S	N	S	N	M	N	N	N	N	N	N	N
Burhinidae	Beach Stone-curlew	*Esacus magnirostris*	NT	N	N	N	N	N	N	N	N	N	N	N	S
Scolopacidae	Bar-tailed Godwit	*Limosa lapponica*	NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Black-tailed Godwit	*Limosa limosa*	NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Red Knot	*Calidris canutus*	NT	N	N	N	N	N	N	N	N	N	N	N	M
Scolopacidae	Curlew Sandpiper	*Calidris ferruginea*	NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Red-necked Stint	*Calidris ruficollis*	NT	L	S	L	L	S	S	S	S	S	N	S	S
Scolopacidae	Asian Dowitcher	*Limnodromus semipalmatus*	NT	N	N	N	N	N	N	N	N	N	N	N	M
Scolopacidae	Grey-tailed Tattler	*Tringa brevipes*	NT	L	S	L	L	S	S	S	S	S	N	S	S
Papilionidae	Chimaera Birdwing	*Ornithoptera chimaera*	NT	S	S	S	S	S	S	S	S	S	S	S	S
Araucariaceae	New Guinea Kauri	*Agathis labillardieri Warb.*	NT	**6**	**4**										
Cycadaceae	Cycad	*Cycas rumphii Miq.*	NT	**1**	**3**										
Meliaceae		*Aglaia agglomerata Merr. & Perry*	NT	**1**											
Meliaceae		*Aglaia euryanthera Harms*	NT	**1**											
Meliaceae		*Aglaia rimosa (Blanco) Merr.*	NT	**3**	**2**										
Meliaceae		*Aglaia subcuprea Merr. & Perry*	NT	**2**											
Myristicaceae	Guma	*Myristica globosa Warb.*	NT	**3**											
Casuariidae	Northern Cassowary	*Casuarius unappendiculatus1*	LC	3	8	S	1	1	S	S	S	S	S	L	L
Casuariidae	Dwarf Cassowary	*Casuarius bennetti*	LC	3	L	S	L	1	N	N	N	L	S	N	N
Cnemophilidae	Loria's Satinbird	*Cnemophilus loriae*	LC P	M	N	L	N	N	N	N	N	N	N	N	N
Paradisaeidae	Glossy-mantled Manucode	*Manucodia ater5*	LC P	S	3	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Jobi Manucode	*Manucodia jobiensis*	LC P	S	1	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Crinkle-collared /Jobi Manucode	*Manucodia chalybatus8*	LC P	3	1	S	L	S	L	L	L	L	S	L	L
Paradisaeidae	Trumpet Manucode	*Phonygammus keraudrenii*	LC P	S	M	S	M	S	M	M	M	M	S	L	L
Paradisaeidae	Short-tailed Paradigalla	*Paradigalla brevicauda*	LC P	L	N	N	N	N	N	N	N	N	N	N	N
Paradisaeidae	Queen Carola's Parotia	*Parotia carolae*	LC P	1	N	S	N	M	N	N	N	N	N	N	N
Paradisaeidae	King of Saxony Bird-of-paradise	*Pteridophora alberti*	LC P	L	N	N	N	N	N	N	N	N	N	N	N
Paradisaeidae	Superb Bird-of-paradise	*Lophorina superba*	LC P	S	N	S	N	1	N	N	N	N	N	N	N
Paradisaeidae	Magnificent Riflebird	*Ptiloris magnificus*	LC P	4	1	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Black Sicklebill	*Epimachus fastosus*	LC P	M	N	L	N	N	N	N	N	N	N	N	N
Paradisaeidae	Black-billed Sicklebill	*Drepanornis albertisi*	LC P	S	N	M	N	L	N	N	N	N	N	N	N
Paradisaeidae	Magnificent Bird-of-paradise	*Diphyllodes magnificus*	LC P	9	L	S	N	1	N	N	N	L	S	L	N
Paradisaeidae	King Bird-of-paradise	*Cicinnurus regius*	LC P	5	6	S	1	S	S	S	S	S	S	S	S
Paradisaeidae	Twelve-wired Bird-of-paradise	*Seleucidis melanoleucus*	LC P	M	3	S	1	1	S	S	S	S	M	S	S
Paradisaeidae	Lesser Bird-of-paradise	*Paradisaea minor*	LC P	11	3	S	1	1	S	S	S	S	S	S	S
Cacatuidae	Palm Cockatoo	*Probosciger aterrimus*	LC P	7	8	S	1	2	S	S	S	S	S	S	S
Bucerotidae	Blyth's Hornbill	*Rhyticeros plicatus*	LC P	10	10	S	1	1	S	S	S	S	S	S	S
Ardeidae	Great Egret	*Ardea alba*	LC P	L	4	L	1	1	S	S	S	S	L	S	S
Ardeidae	Intermediate Egret	*Ardea intermedia*	LC P	L	3	L	S	M	S	S	S	S	L	S	S
Ardeidae	Little Egret	*Egretta garzetta*	LC P	L	1	L	1	M	S	S	S	S	L	S	S
Pythonidae	Boelen's python	*Morelia boeleni*	NE P	S	N	M	M	M							

FAMILY	COMMON NAME	SCIENTIFIC NAME	STATUS*	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Papilionidae	Goliath Birdwing	*Ornithoptera goliath*	LC P												
Papilionidae	Butterfly of Paradise	*Ornithoptera paradisea*	LC P												

*Conservation status IUCN CR-Critically Endangered, EN – Endangered, VU – Vulnerabe, NT – Near Threatened, DD – Data Defficient, LC - Least Concern, NE – Not evaluated. P – protected under PNG *Fauna (Protection and Control) Act 1966.*

1-12	# of combined survey sites at which recorded
V	Village informant record from Sepik Development Project survey
S	Species not recorded whose known ranges and habitat preferences indicate a strong likelihood of occurring
M	Species not recorded whose known ranges and habitat preferences indicate a moderate likelihood of occurring
L	Species not recorded whose known ranges and habitat preferences indicate a low likelihood of occurring
N	Does not or extremely unlikely to occur
	Cannot predict

Blank cells refer to lack of knowledge of distribution

21.9 IUCN Data Deficient Species

FAMILY	COMMON NAME	SCIENTIFIC NAME	GFA HM	GFA L	1	2	3	4	5	6	7	8	9	10
Muridae	Ziegler's Water Rat	*Hydromys ziegleri*	N	N	N	N	N	N	N	N	L	L	N	N
Muridae	Western White-eared Giant Rat	*Hyomys dammermani*	L	N	N	N	N	N	N	N	N	N	N	N
Muridae	Northern Groove-toothed Shrew Mouse	*Microhydromys richardsoni*	2	L	S	L	1	L	L	L	L	S	L	L
Muridae	Short-haired Water Rat	*Paraleptomys wilhelmina*	S	N	N	N	N	N	N	N	N	N	N	N
Muridae	Champion's Tree Mouse	*Pogonomys championi*	M	N	N	N	N	N	N	N	N	N	N	N
Muridae	Torricelli Mountains Shrew Mouse	*Pseudohydromys musseri*	N	N	N	N	N	N	N	N	N	M	N	N
Muridae	Western Shrew Mouse	*Pseudohydromys occidentalis*	L	N	N	N	N	N	N	N	N	N	N	N
Pteropodidae	Nyctimene draconilla	*Dragon Tube-nosed Fruit Bat*	5	6	S	S	S	M	M	M	M	M	M	M
Vespertillionidae	Nyctophilus microdon3	*Small-toothed Long-eared Bat*	S	1	S	S	S	L	L	L	L	L	L	L
Vespertillionidae	Small Melanesian Bent-winged Bat	*Miniopterus macrocneme4*	9	7	S	1	2	S	S	S	S	S	S	S
Mollosidae	Papuan Free-tailed Bat	*Otomops papuensis*	S	S	S	S	S	S	S	S	S	S	S	S
Mollosidae	Mantled Free-tailed Bat	*Otomops secundus*	S	S	S	S	S	S	S	S	S	S	S	S
Accipitridae	Chestnut-shouldered Goshawk	*Erythrotriorchis buergersi*	S	S	S	S	S	S	S	S	S	S	L	L
Apodidae	Three-toed Swiftlet	*Aerodramus papuensis*	S	N	S	N	1	N	N	N	N	S	N	N
Psophodidae	Papuan Whipbird	*Androphobus viridis*	M	N	N	N	N	N	N	N	N	N	N	N
Accipitridae	Chestnut-shouldered Goshawk	*Erythrotriorchis buergersi*	S	S	S	S	S	S	S	S	S	S	L	L
Apodidae	Three-toed Swiftlet	*Aerodramus papuensis*	S	N	S	N	1	N	N	N	N	S	N	N
Psophodidae	Papuan Whipbird	*Androphobus viridis*	M	N	N	N	N	N	N	N	N	N	N	N
Microhylidae	Frog	*Austrochaperina adamantina*	N	N	N	N	N	N	N	N	L	S	L	N
Microhylidae	Frog	*Austrochaperina aquilonia*	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Frog	*Austrochaperina septentrionalis*	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Frog	*Choerophryne longirostris*	N	N	N	N	N	N	N	N	N	M	N	N
Microhylidae	Frog	*Cophixalus balbus*	8	3	S	M	S	M	M	M	M	S	M	M
Microhylidae	Frog	*Cophixalus bewaniensis*	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Frog	*Copiula pipiens*	L	N	L	N	L	N	N	N	N	M	L	L
Pelodryadidae	Frog	*Litoria albolabris*	N	L	L	L	L	L	L	L	L	S	S	S
Pelodryadidae	Frog	*Litoria chrisdahli*	N	M	M	M	M	L	L	L	M	M	M	L
Pelodryadidae	Frog	*Litoria hunti*	2	S	S	1	S	S	S	S	S	S	S	S
Pelodryadidae	Frog	*Litoria leucova*	3	N	S	N	M	N	N	N	N	M	N	N
Pelodryadidae	Frog	*Litoria mucro*	S	L	S	M	S	M	M	M	M	M	M	M
Pelodryadidae	Frog	*Litoria purpureolata*	S	3	S	1	1	M	M	M	M	M	M	M
Pelodryadidae	Frog	*Litoria richardsi*	S	S	L	L	1	L	L	L	L	L	L	L
Pelodryadidae	Frog	*Nyctimystes fluviatilis*	2	L	S	S	L	L	L	L	L	L	L	L
Microhylidae	Frog	*Oreophryne parkeri*	M	M	M	M	M	M	M	M	M	S	M	M
Ranidae	Frog	*Papurana volkerjane*	10	1	S	S	1	M	M	M	M	S	L	L
Microhylidae	Frog	*Xenorhina arboricola*	4	L	S	L	M	N	N	N	L	S	N	N
Microhylidae	Frog	*Xenorhina tumulus*	N	N	N	N	N	N	N	N	N	S	N	N
Microhylidae	Frog	*Xenorhina zweifeli*	N	N	N	N	N	N	N	N	N	S	N	N

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