PAPUA LNG PROJECT

UPSTREAM ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2: ENVIRONMENTAL AND SOCIAL BASELINE STUDIES

Part 6: Upstream Terrestrial Biodiversity Baseline Report
Annex 2: Upstream Non-volant Mammals Baseline Report

TOTAL E&P PNG LIMITED

December 2019
(Report No. 01215B_1-5_v5)

Upstream Non-volant Mammals Baseline Report
Papua LNG Project

Total E&P PNG Limited

August 2017

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An IUCN Vulnerable Grey Dorcopsis photographed on a camera trap at Site 4.

Report Reference Number: 01215B_25-1-5_v5

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Abbreviations

Term	Definition
ABTC	Australian Biological Tissue Collection, South Australian Museum
AF	Alluvial Forest (general descriptive term)
AMS	Australian Museum, Sydney
ANT-3 OC	Antelope-3 Operations Camp, within PRL-15
asl	above sea level
BC-UPNG	Biology Collection, Biology Department of the University of Papua New Guinea
c.	approximately (abbreviation of *circa*)
CEPA	Conservation and Environmental Protection Authority
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cf.	compare
CR	Critically Endangered (IUCN threat category)
DES	Douglas Environmental Services Pty Ltd
DD	Data Deficient (IUCN category)
DNA	deoxyribonucleic acid
EIS	Environmental Impact Statement
EN	Endangered (IUCN threat category)
ESHIA	Environmental Social and Health Impact Assessment
FIMS	Forest Inventory Mapping System
Fsw	Swamp forest (FIMS category)
GPS	Global Positioning System
Gsw	Grassland swamp (FIMS category)
HF	Hill forest (general descriptive term)
Hm	Hill forest (FIMS category)
Hs	Small-crowned hill forest (FIMS category)
IFC	International Finance Corporation
IUCN	International Union for Conservation of Nature
km	kilometers
LC	Least Concern (IUCN threat category)
LLG	Local Level Government
LNG	Liquid Natural Gas
m	meter
NE	Not Evaluated (by IUCN Red List)
NT	Near Threatened (IUCN threat category)
P	Species protected under the Papua New Guinea *Fauna (Protection and Control) Act 1966*

Term	Definition
Pl	Alluvial forest
PNG	Papua New Guinea
PNG IBR	Papua New Guinea Institute of Biological Research
PNG LNG	Papua New Guinea Liquefied Natural Gas project
PNG-NMAG	Papua New Guinea National Museum and Art Gallery
Po	Open alluvial forest (FIMS category)
PAOI	Project area of influence
PRL-15	Petroleum Retention License 15
RAI	Relative Abundance Index
RNA	Ribonucleic acid
ROW	Right-of-way
SAM	South Australian Museum
SF	Swamp Forest (general descriptive term)
sp.	species (singular)
spp.	species (plural)
subsp.	Subspecies
VU	Vulnerable (IUCN threat category)
WMA	Wildlife Management Area
Wsw	Swamp woodland (FIMS category)
WWF	World Wildlife Fund (now World Wildlife Fund for Nature)

Executive Summary

This report presents the results of the technical study on non-volant mammals (all groups except bats) conducted during field work in two contrasting seasons in the study area for the Papua LNG Project. The study area includes the upstream project area of influence (PAOI) and is divided into five ecological zones: Middle Purari Hills, Southeast Hills, Delta Swamps and Plains, Mangroves, and Southeast Coast.

The study is based on reviews of existing information combined with the results of field work conducted in 2016 in eight main survey sites (and four short-visit sites) and contrasting seasonal conditions (January–February and June–July). Visits to local villages provided opportunities to conduct semi-structured discussions with landowners regarding the distribution, status and intensity of exploitation of various species.

There is a dearth of publicly available prior information on the non-volant mammals of the study area. Previous studies carried out in support of industry activities either provide little or no reliable data or are not publicly available. For surrounding areas, non-volant mammal inventories are most complete for sites at elevations above 600 m above sea level (asl) in the Purari and Kikori River basins, and there is little or no information from lower elevations in any catchments within or adjacent to the study area. Prior to the Project surveys, at a regional scale three of the major ecological zones represented within the study area were effectively unsurveyed—the Delta Swamps and Plains, the Mangroves, and the Southeast Coast.

Analysis of regional records resulted in a list of 47 terrestrial non-volant native mammal species and three aquatic mammal species that are either confirmed present in the study area or that are likely to occur, based on their wider distributions and known habitat associations. The highest native species diversity was predicted for the Middle Purari Hills (45 terrestrial spp.) and Southeast Hills (42 terrestrial spp.) ecological zones, with significantly fewer in the Southeast Coast (30 terrestrial spp. plus 3 aquatic) and Delta Swamps and Plains (21 terrestrial spp.) ecological zones. The Mangroves ecological zone was predicted to host populations of only seven terrestrial non-volant mammal species along with three aquatic species.

The survey employed a variety of methods including small mammal trapping, camera traps, sightings of live animals as well as tracks and traces, the sampling of firepits and an owl roost deposit, examination of trophy specimens, and discussions with experienced hunters. Confirmed records were obtained for 42 non-volant terrestrial mammal species and for three aquatic mammal species. Thirteen species listed as potentially occurring in the study area were not detected, and three species not predicted to occur were definitively recorded (one major range extension and new-to-science species). Most potentially occurring undetected species are probably confined to unsampled higher elevations within the study area, while a few may be present within the study area but genuinely rare. Two of these potentially rare species are conservation listed but neither is likely to be a sensitive issue for the Project.

Non-volant mammal diversity in the study area equals or exceeds that of other well-documented regions of PNG. A total of 12 IUCN listed species was confirmed present in the study area, including three that are Endangered (Giant Bandicoot, Goodfellow's Tree Kangaroo and Western Montane Tree Kangaroo), five that are Vulnerable (Eastern Long-beaked Echidna, Lowland Tree Kangaroo, Grey Dorcopsis, False Water Rat and Dugong), two that are Near Threatened (New Guinea Quoll, Australasian Snubfin Dolphin) and two that are Data Deficient (Woolley's Three-striped Dasyure and Indo-Pacific Bottlenose Dolphin). Five of these species are also nationally Protected. At least eight species are restricted-range, including the Endangered Giant Bandicoot, the Vulnerable and Protected Lowland Tree Kangaroo, and the newly recognized Oriomo Bandicoot. The Lowland Tree Kangaroo is widely distributed within the Middle Purari Hills ecological zone but population densities are probably low everywhere.

The study area records of the Endangered Giant Bandicoot, Vulnerable False Water Rat and the restricted-range Oriomo Bandicoot all represent substantial range extensions and in each case, the first records from the hinterland of the Gulf of Papua. The Giant Bandicoot and False Water Rat are in serious decline elsewhere within their ranges and the newly identified study area populations of these species are of high conservation significance both nationally and globally. Another finding of special conservation significance is occurrence of the Vulnerable Grey Dorcopsis throughout the study area and in particular, its high abundance in alluvial forest habitats.

Two entirely new rodent species are represented in the owl roost sample collected from a cave in the Middle Purari Hills ecological zone near the northeastern boundary of the study area. Judging from the ecology of their closest relatives, both of the unknown species are likely to be uncommon, one with a semi-aquatic lifestyle and the other with insectivorous, 'shrew-like' terrestrial habits. Given their likely habitat association and habits, neither of these species is likely to be a sensitive issue for the Project.

Five invasive alien species were identified in the study area as feral populations. In addition, the domestic cat (*Felis catus*) is kept within the study area and may exist in the feral state (unconfirmed). The introduced rodents are currently restricted to anthropogenic habitats including infrastructure sites as well as local villages where they cause hardship and pose potential risk of disease. The current absence of these species from natural habitats in the study area is interpreted as a consequence of competition with native rodents rather than a reflection of any intrinsic properties of the introduced species—under changed circumstance, these alien species could easily invade natural habitats in the study area.

Analyses of community structure across the various habitat types and along several gradients of disturbance hint at subtle but important differences in the non-volant mammal communities of the different major forest types in study area. There are also strong signals of impacts of natural and anthropogenic disturbance, and some insights into the resilience of the local mammal communities to recover from heavy disturbances associated with past logging activity. Camera trapping is highlighted as an effective means of obtaining quantitative data on relative abundances of various mammal species. However, the rodent community is also identified as a potentially sensitive indicator of habitat condition within the study area.

The study area, as a whole, supports a diverse and largely intact non-volant mammal fauna and it possesses many important conservation values. The more remarkable of these are:

- Populations of the Endangered Western Montane and Goodfellow's Tree Kangaroos, the Vulnerable Eastern Long-beaked Echidna and Vulnerable and restricted-range Lowland Tree Kangaroo, all in the Middle Purari Hills ecological zone.
- Populations of the Endangered and restricted-range Giant Bandicoot in the Southeast Coast ecological zone and at a site on the boundary between the Southeast Hills and Delta Swamps and Plains ecological zones.
- A widespread and locally abundant population of the Vulnerable Grey Dorcopsis, with peak population densities in undisturbed alluvial forest habitats of the Delta Swamps and Plains ecological zone.
- A population of the Vulnerable False Water Rat, confirmed for the Southeast Coast ecological zone and peripherally in the Middle Purari Hills ecological zone, and probably also present in the Mangroves ecological zone.
- A population of the newly recognized and restricted-range Oriomo Bandicoot in the Delta Swamps and Plains, Southeast Hills and Southeast Coast ecological zones.

- Two new-to-science rodent species—the ‘small water rat’ and the ‘undescribed shrew mouse’, both known only from skeletal remains from a cave in the Middle Purari Hills ecological zone. Both are almost certainly restricted-range.

Key attributes of the study area that probably underpin the majority of these conservation values are:

- The low human population density of the entire region apart from the immediate coastal fringe.
- The relatively low levels of disturbance to large tracts of hill, alluvial and swamp forest that are visited infrequently if at all and retain essentially intact mammal communities, affected only by the presence of some alien invasive species, most notably the pig.
- The extreme remoteness of large parts of the northern sector of the study area, particularly the virtually unvisited country to the west of PRL-15 on the flanks of Mount Favenc and in the Kereru Range.
- The historical low socio-economic status and general remoteness of the region, with consequences that include a general absence of firearms from the region and its isolation from commercial markets.

1 Introduction

1.1 Background

The following Project description is focused on the upstream components of the Papua LNG Project and aims at providing minimal but appropriate context for the baseline reports.

Joint venture partners are currently planning the development of the Elk-Antelope gas field, which is located within Petroleum Retention License 15 (PRL-15) in the Gulf Province, Papua New Guinea. TOTAL E&P PNG Limited (TEP PNG), a wholly owned subsidiary of TOTAL has the largest interest in the Elk-Antelope gas field and is the operator of the Papua LNG Project (the Project) on behalf of the other joint venture partners.

The Elk-Antelope gas field is a significant gas discovery in Papua New Guinea consisting of a gas reservoir with several trillion cubic feet of gas reserves located approximately 120 km inland from the township of Kerema, and 340 km northwest of Port Moresby).

The Project will comprise upstream production well development and associated infrastructure at the gas field within PRL-15, construction of an upstream central processing facility (CPF) and delivery of gas and condensate via onshore and offshore export pipelines to a LNG Plant site at Caution Bay, Central Province, 20 km northwest of Port Moresby. The design life for the Project will be 25 years.

The Project area comprises the physical footprint of the various Project components and associated infrastructure as detailed below.

- Production, processing and related facilities (within PRL-15):
  - Wellpads and the associated gathering system (including flowlines and trunkline).
  - CPF.
  - Logistics base and river offloading facilities, accommodation camps, airstrip, roads and bridges.
  - Quarries, communications infrastructure.
  - Initial section of the onshore export pipeline.
- Onshore pipeline (outside PRL-15):
  - Remainder of the onshore export pipeline to landfall on the Gulf coast including valve stations.
  - Temporary laydown areas and camps.
  - Quarries, communications infrastructure.
- Transport (river) corridors:
  - River transport routes — the Purari, Urika-Ivo and Wame-Varoi rivers.
- Offshore pipeline:
  - Offshore section of the export pipeline to a LNG Plant site, Caution Bay.

Initially, the Project will focus on exploiting the Elk-Antelope reservoirs via one to three production wellpads on Antelope and one production wellpad on Elk. Gas and condensate will be transported

from the CPF and delivered to a LNG Plant facility at Caution Bay located on the southern coast of Papua New Guinea.

Further details of the nature and layout of Project components are provided in the Upstream Environmental and Social Baseline Study (ESBS) Report. As part of the Project environmental, social and health impact assessment (ESHIA), a terrestrial biodiversity baseline study has been commissioned to provide a baseline characterization of terrestrial biodiversity and conservation values present in the vicinity of the upstream project area. This report presents the results of the technical study on non-volant mammals (excluding bats) conducted as part of the upstream terrestrial biodiversity baseline study.

1.2 Upstream terrestrial biodiversity study area and ecological zones

The upstream terrestrial biodiversity study area (hereafter 'study area') covers approximately 7,290 km^2 of the Gulf Province lowlands (to c. 600 m above sea level (asl)). The study area is divided into five ecological zones (Middle Purari Hills, Southeast Hills, South East Coast, Delta Swamps and Plains and Mangroves), each of which is expected to support a distinct assemblage of terrestrial biota.

The study area encompasses the upstream project area of influence (upstream PAOI), the area within which the Project may potentially and measurably impact biodiversity. The terrestrial biodiversity field surveys were focused at representative sites within the upstream PAOI, hereafter referred to in this report as survey sites. Further description of the PAOI is provided in the main upstream ESBS report and is no longer referred to in this report.[1]

The study area and its component ecological zones are shown in Figure 1. They are described in more detail in the Upstream Terrestrial Biodiversity Baseline Report.

1.3 Technical study scope and objectives

The taxonomic scope of this report is all groups of mammals except bats, which are reported separately (Armstrong et al, 2017). The study area supports representatives of five major groups of non-volant mammals: monotremes, marsupials and rodents, as well as inshore marine mammals potentially occurring within the study area—cetaceans (dolphins) and a sirenian (the Dugong)[2].

The ecological scope includes the following lifestyles: terrestrial (strictly ground-dwelling), scansorial (mainly ground dwelling but also climbing), arboreal (strictly climbing), semi-aquatic and fully aquatic mammals that use the freshwater to inshore marine habitats. The term 'non-volant terrestrial' is used henceforth for all of these groups except the fully aquatic group which is simply called 'aquatic'.

The objectives of this technical study are:

- To collate and assess existing information relevant to non-volant mammal communities in the vicinity of the study area.
- To survey non-volant mammal communities present in the study area.
- To describe and discuss the composition, condition and conservation significance of non-volant mammal communities present within the study area, including:
  - The presence and status of species of conservation significance recorded or potentially present.
  - Habitats and other landscape features important to non-volant mammal communities.
- To summarize knowledge gaps in relation to non-volant mammal communities present within the study area.

[1] The boundary of the PAOI is shown in figures for context only.
[2] Additional information on marine fauna and reptiles is reported in the Marine Ecology Baseline Report (BMT WBM, 2017).

2 Existing Knowledge

This section summarizes existing knowledge relevant to understanding the distribution and status of non-volant mammals within the study area. The first part of this section summarizes existing knowledge from within the study area. The second part summarizes existing knowledge from areas surrounding the study area.

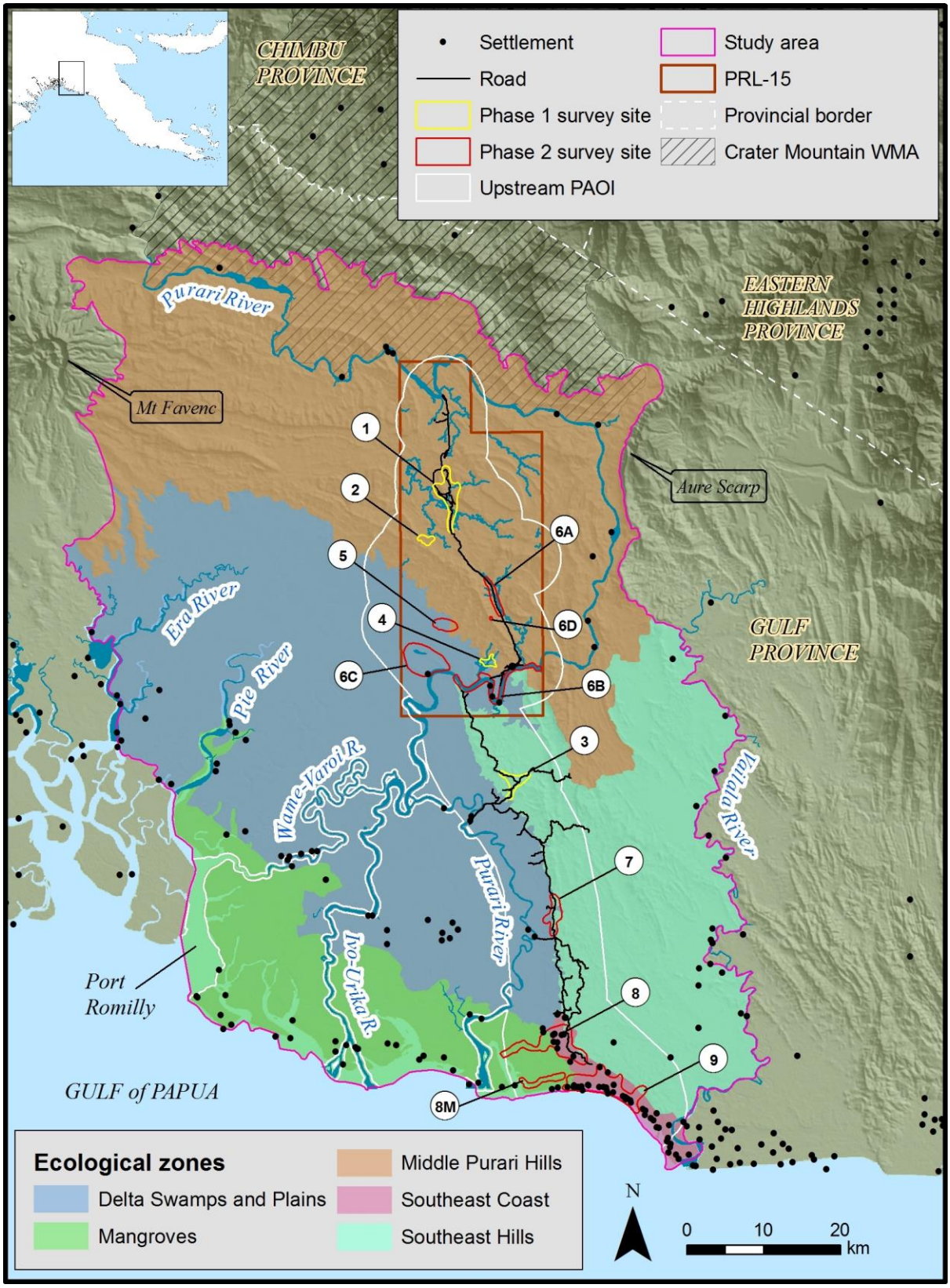

Figure 1. The study area and its component ecological zones.
The upstream PAOI and the location of Phase 1 and 2 upstream terrestrial biodiversity baseline study survey sites. Not all sites were surveyed under the non-volant mammal technical study. Information on the sites surveyed is presented in Section 3.2.

2.1 Existing knowledge for the study area

The lower reaches of the Purari River received virtually no attention during the early period of biological exploration of modern day PNG. For non-volant mammals the earliest confirmed records date from as recently as the mid-1970s and even now there is almost no publicly available data for the study area.

2.1.1 PNG Fisheries and Wildlife Division Surveys 1974–77

The PNG Fisheries and Wildlife Division conducted surveys from 1974-77, the objective of these surveys was to inventory wildlife resources with special reference to those used by local communities, and to assess the potential effects that large-scale development might have on these resources (Liem 1983). Surveys were conducted between Wabo and the coast, with a focus on riverine habitats. In addition to community interviews, the surveys of non-volant mammals employed trapping, spotlighting and selective shooting. Specimens collected during the surveys were originally held at the Wildlife Division facility at Moitaka and some were later transferred to the PNG National Museum and Art Gallery (PNG-NMAG) in Port Moresby. Selected results were reported by Liem (1983). Aplin has previously examined specimens lodged in PNG-NMAG.

2.1.2 Wabo Hydroelectric Scheme Environmental Studies 1977–82

Environmental studies were carried out in 1977–82 to support potential development of a hydroelectric project with a proposed dam-site near Wabo and reported in 21 technical report volumes. No mammal surveys were carried out during these studies. However, Liem and Haines (1977) reported some of the Wildlife Division's survey data (Section 2.1.1) on the occurrence and exploitation of cuscuses, the Dugong and dolphins. Volume 4 (Warrillow 1978), Volume 5 (Egloff and Kaiku 1978) and Volume 12 (Toft 1980) provide additional information on mammal species exploited by local residents, though in many cases the taxa are not identified to species level.

The Wabo hydroelectric studies were later edited into a publicly available monograph (Petr 1983) that included summaries by Pernetta (1983) of wildlife (including mammals) known from the area and by Liem (1983) of wildlife known to be used by local communities.

2.1.3 2011–12 Purari Hydropower surveys

In 2011, new environmental studies were commissioned as part of renewed interest in developing a hydroelectric dam in the Purari River catchment in the vicinity of the northern study area upstream of Wabo (Middle Purari Hills ecological zone). Three multi-disciplinary biodiversity surveys were undertaken in 2011-2012, along with an additional study of natural resource usage. The biodiversity and resource use surveys for non-volant mammals were carried out by Ken Aplin and the resulting dataset ranks among the most detailed for any region of PNG. An environmental impact statement (EIS) was not submitted to government authorities and the data are not available for use in this study.

2.1.4 Studies commissioned for development of the Elk-Antelope gas field

Environmental studies within PRL-15 and along a proposed export pipeline corridor were commissioned by the previous operator (Inter Oil) in support of approvals for petroleum development proposals. These studies cover areas within and southeast of PRL-15, and were variously carried out by Douglas Environmental Services (DES) (2008, 2010) and other unpublished studies. Non-volant mammals were assessed to some extent by all of these studies, which are reviewed briefly below.

2.1.4.1 Douglas Environmental Services

DES and an unpublished study conducted three site-based flora and fauna studies and one preconstruction survey within PRL-15 during the period 2008–2011. Their fauna survey programs comprised:

- Survey at six sites over 11 days in June 2008, with additional incidental observations made at points along the Purari River including Staging, Wabo and various unidentified villages (DES 2008).
- Surveys conducted at 25 sites over 11 days in July 2010 (DES 2010).
- Preconstruction fauna survey conducted along proposed right of way (ROW) over 5 days in March 2011 (unpublished data).

These studies covered a variety of habitats over an extensive area and used a variety of techniques including active searches, live-capture ground trapping and camera trapping. However, sampling efforts were minimal and few useful data resulted. Only three non-volant mammal species were captured across all studies, at least one of which was misidentified (based on a labeled photograph), and identifications of additional 'observed' species were not supported by capture.

2.1.4.2 Unpublished data

A series of rapid assessment vertebrate fauna surveys were coordinated along a proposed pipeline route south of PRL-15, through the lower Purari River and Vailala River catchments. Surveys were conducted at six sites (five within the present study area) over 18 days during November–December 2008. Non-volant mammals were surveyed over three days and nights at each site, with live trapping and spotlighting the principal methods used. Survey effort was higher than that expended by DES and other unpublished studies within PRL-15 and the results were well reported. However, capture rates were low and produced only a few species records. Unfortunately, the only illustrated capture is mislabeled which reduces confidence in the results.

In 2012 another unpublished study submitted an EIS for an entire upstream project proposal, including construction and operations of PRL-15 facilities and an export pipeline route to the coast near Kerema. Earlier reports were reviewed but no additional fauna data were produced.

2.2 Existing knowledge from surrounding areas

Three areas are of direct relevance to the study area: 1) the Purari catchment uplands to the immediate north; 2) the Lakekamu River basin to the east; and 3) the Kikori River basin to the west. Unfortunately, no data are available on non-volant mammals of the Vailala River basin, to the immediate east of the Purari River basin.

2.2.1 Purari catchment uplands

The Purari River drains more than 25,000 km^2 of New Guinea's central cordillera, from west of Mendi and Mount Giluwe in Southern Highlands Province, east-southeast across Western Highlands and Chimbu Provinces, to the Kratke Range in Eastern Highlands Province. To the immediate north of the study area, the landscape of the Purari River catchment is dominated by two extinct volcanoes, Mount Karimui in the west and Crater Mountain in the east. Both rise to elevations above 2,500 m asl. North of the study area the volcanic overlie a limestone plateau with an average elevation of c. 400 m asl; wherever the limestone is exposed it supports a rugged karst landscape with innumerable sinkholes.

Each of Mount Karimui and Crater Mountain has attracted considerable attention from biologists. The first mammal surveys were conducted between 1980 and 1982 by Robin Hide who spent 16 months on the Karimui Plateau with the objective of documenting patterns of land use including wildlife exploitation (Hide et al. 1984). Most samples came from the plateau above 1,100 m asl, but some sampling extended south even to Wabo Station on the Purari River within the study area (Middle

Purari Hills). All specimens collected by Hide are housed in the Biology Collection of the Biology Department, University of Papua New Guinea (BC-UPNG). In 1984 a joint expedition from the South Australian Museum and University of New South Wales (led by Ken Aplin) spent two months surveying vertebrates including mammals in the Mount Karimui area. The voucher collections are housed in the Australian Museum Sydney (AMS) and associated tissue samples in the Australian Biological Tissue Collection (ABTC) of the South Australian Museum (SAM).

The earliest mammal sampling of the Crater Mountain area was carried out by Aplin during a two-week visit to Haia Mission at 600 m asl in 1984, with specimens lodged as per the Karimui collection. More intensive work in this area commenced in 1994 with establishment of the Crater Mountain Wildlife Management Area (WMA) and of the Crater Mountain Biological Research Station, which is located near Haia village, c. 30 km north of Wabo. Only two studies focused on non-volant mammals—a study of movement patterns by the Eastern Long-beaked Echidna *Zaglossus bartoni* (Opiang 2009) and a study of fecundity and survival of forest rodents (Kale et al. 2012). Small numbers of voucher specimens from Crater Mountain have been lodged in the PNG-NMAG and at the University of Kansas Natural History Museum, Lawrence, Kansas.

2.2.2 Lakekamu basin

The Lakekamu basin is a small catchment which straddles the border between Gulf and Central Provinces in the southern foothills of the Owen Stanley Range. The Lakekamu River meets the coast immediately east of Kerema and its middle and upper reaches remain heavily forested (Mack 1998).

The coastal portion of the Lakekamu basin was surveyed in the early to mid-1960s as part of a CSIRO Land Systems Research survey that included the Kerema district of eastern Gulf Province (Mabbutt et al. 1965). In 1966, this survey work extended to the coastal lowlands of eastern Gulf Province, overlapping with the southeast corner of the study area, including the Southeast Coast and parts of the Southeast Hills, Mangroves and Delta Swamps and Plains ecological zones (Ruxton et al. 1969). Non-volant mammals were not surveyed but the general habitat characterizations represent useful historical context for contemporary mammal communities.

Non-volant mammals of the forested inland habitats of the Lakekamu basin were surveyed over two months in 1996 under the Rapid Assessment Program of Conservation International (Mack 1998). Voucher specimens are deposited at the PNG-NMAG in Port Moresby and at the Academy of Natural Sciences in Philadelphia, USA.

2.2.3 The Kikori Basin Conservation Program

The Kikori basin to the west of the study area is biologically speaking the most intensively surveyed region of PNG. Much of this information has accumulated since the late 1980s when commercial reserves of oil and gas were discovered in Southern Highlands Province. In partnership with industry leaders[3], in 1994 the World Wildlife Fund (WWF; now called the Worldwide Fund for Nature) initiated the Kikori Integrated Conservation and Development Project, which continues under the title Kikori Basin Conservation Program[4] (McCall and Flemming 2000). Through this extended period of study, WWF and its partners carried out multiple biodiversity surveys covering a broad range of taxa at elevations from sea level to over 2,500 m asl. From the outset, non-volant mammal surveys were an integral part of this program.

WWF studies most relevant to the present purposes are those conducted between Lake Kutubu (c.800 m asl) in Southern Highlands Province and the Kikori Delta in western Gulf Province (e.g. Hartshorn et al.1995). These surveys span a length of 200+ km within the Kikori valley and on the ranges to the east and west, and cover elevations from sea level to c. 1,440 m asl. Voucher specimens collected during these surveys are lodged in either PNG-NMAG or BC-UPNG.

[3]A joint venture currently led by Esso Highlands Limited as operator of the PNG LNG Project.
[4](http://wwf.panda.org/who_we_are/wwf_offices/papua_new_guinea/index.cfm?uProjectID=PG0013).

Additional surveys of non-volant mammals were commissioned by Enesar Pty Ltd in support of an EIS for the Papua New Guinea Liquefied Natural Gas Project (PNG LNG). Field work and reporting were carried out by WWF staff, with two sites surveyed in 2005 and five sites surveyed in 2008. Only two of the survey sites (Juha North at 213 m asl and Baia River at 328 m asl) are in lowland habitats comparable to those present in the study area. The results of the PNG LNG studies are contained in Annexes 3 and 4 of the publicly available EIS (Crome et al. 2008). A small number of voucher specimens collected during these surveys were lodged in PNG-NMAG and BC-UPNG.

Mammal survey work was carried out on the southern flanks of Mount Sisa by Peter Dwyer in 1979-80 (Dwyer 1984, 1990) and then in 1985 by a SAM team led by Ken Aplin. Although the results of these surveys are often included in reviews of the mammals of the Kikori Basin (e.g. by Leary and Seri 1997; Namo 2004), most of the sampling localities (e.g. Magidobo, Bobole, Namosado) actually lie within the headwaters of the Strickland River. Exceptions are two lowland localities sampled by the SAM team in 1985—Waro and Fogamai'u—these lie within the Hegigio catchment of the Kikori basin. The voucher collections are housed in the AMS and associated tissue samples are in the ABTC of the SAM.

2.3 Summary of existing knowledge for non-volant mammals

The foregoing survey of existing knowledge leads to the following conclusions:

- Non-volant mammals are effectively unsurveyed for the entire study area, with previous studies carried out in support of industry activities either providing little or no reliable data or being unavailable for use in this assessment.
- Non-volant mammal inventories for surrounding areas to the west, north and east are most complete for sites at elevations above 600 m asl in the Purari and Kikori basins, and far less complete for lower elevations in all catchments.
- Three of the major ecological zones represented within the study area are effectively unsurveyed for non-volant mammals on a regional scale (prior to the current Project surveys), namely the Delta Swamps and Plains, the Mangroves, and the Southeast Coast (beach ridges and plains).

A lack of confidence in taxonomic determinations, variably a product of unreliable or unsubstantiated identifications or a genuine lack of taxonomic resolution effectively mars comparisons for the majority of the smaller non-volant mammals. This is most evident and impairing for native rodents of the family Muridae which make up a large proportion of the local mammal fauna.

A broader perspective on the non-volant mammal fauna of the study area can be obtained by consulting the published distribution maps in Flannery's (1995) synthesis of the mammal fauna of New Guinea, tempered with more recent reports and personal knowledge of museum holdings in various institutions around the world, with notions of regional biogeography (Flannery 1995; Aplin 1998), and with an understanding of the region's geomorphic and environmental history through the last ten thousand years or so over which timeframe modern mammal distributions were established in lowland New Guinea (Pasveer and Aplin 1998; Hope and Aplin 2005).

Table 1 is a list of all non-volant mammal species that are either confirmed present in the study area from prior surveys (listed above) or that are likely to occur in each of the ecological zones within the study area based on current knowledge of their wider distributions and patterns of habitat use. The highest species diversity is predicted for the Middle Purari Hills (45 spp.) and Southeast Hills (42 spp.) ecological zones, with significantly fewer in the Southeast Coast (33 spp.) and Delta Swamps and Plains (21 spp.) ecological zones. The Mangroves ecological zone is predicted to host populations of only ten non-volant mammal species.

Table 1. List of the potential non-volant and aquatic mammal fauna of the study area based on existing information, including species that are either confirmed present (C) or that are likely to occur (L) in each ecological zone.

Conservation status is shown for species listed under the IUCN Red List (CR—Critically Endangered; EN—Endangered; VU—Vulnerable; NT—Near Threatened; DD—Data Deficient; LC—Least Concern), species Protected (P) under the PNG Fauna Act 1966 (PNG) and species listed under CITES (Appendix I or II). Also provided are restricted-range (RR) status and an endemism code as defined in Table 4. Restricted-range status for the Long-nosed Echymipera refers to the locally occurring subspecies (see Section 4.4.2). Occurrences in the study area of species marked with an asterisk (*) would represent an extension of known range but are plausible in each case given their biogeographic affinity and known pattern of habitat use. Scientific names with a superscript A are alien invasive species. Ecological zones: MPH—Middle Purari Hills; SH—Southeast Hills; DSP—Delta Swamps and Plains; Mv—Mangroves; SEC—Southeast Coast.

Family	Scientific name	English name	IUCN	PNG	CITES	RR	Endemism	MPH	SH	DSP	Mv	SEC
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna	LC				2	L	L			L
Tachyglossidae	*Zaglossus bartoni*	Eastern Long-beaked Echidna	VU	P	II		4	L				
Dasyuridae	*Dasyurus albopunctatus*	New Guinea Quoll	NT				4	L	L			L
Dasyuridae	*Murexia melanurus*	Black-tailed Murexia	LC				4	L	L			
Dasyuridae	*Murexia longicaudata*	Long-tailed Murexia	LC				4	L	L			
Dasyuridae	*Murexia naso*	Long-nosed Murexia	LC				4	L				
Dasyuridae	*Myoictis leucura*	Woolley's Three Striped Dasyure	DD			RR	5	L	L			
Peramelidae	*Echymipera kalubu*	Common Echymipera	LC				3	L	L	L		L
Peramelidae	*Echymipera rufescens*	Long-nosed Echymipera	LC			RR (subsp.)	4	L	L	L		L
Peramelidae	*Microperoryctes ornata*	Striped Bandicoot	LC				4	L	L			
Peramelidae	*Peroryctes broadbenti**	Giant Bandicoot	EN			RR	5	L	L			L
Peramelidae	*Peroryctes raffrayana*	Raffray's Bandicoot	LC				4	L	L			
Acrobatidae	*Distoechurus pennatus*	Pen-tailed Possum	LC				4	C	L	L		L
Burramyidae	*Cercartetus caudatus*	New Guinea Pygmy Possum	LC				4	L				
Macropodidae	*Dendrolagus goodfellowi*	Goodfellow's Tree Kangaroo	EN	P			4	L				

Family	Scientific name	English name	IUCN	PNG	CITES	RR	Endemism	MPH	SH	DSP	Mv	SEC
Macropodidae	*Dendrolagus notatus*	Western Montane Tree Kangaroo	EN	P			4	L				
Macropodidae	*Dendrolagus spadix*	Lowland Tree Kangaroo	VU	P		RR	5	C	L			
Macropodidae	*Dorcopsis luctuosa* subsp.	Grey Forest Wallaby	VU				5	L	L			L
Macropodidae	*Thylogale brunii*	Dusky Pademelon	VU				3,4	L	L			L
Petauridae	*Dactylopsila trivirgata*	Striped Possum	LC				2	L	L	L		L
Petauridae	*Petaurus breviceps*	Sugar Glider	LC				2	L	L	L		L
Phalangeridae	*Phalanger gymnotis*	Ground Cuscus	LC				4	L	L	L		L
Phalangeridae	*Phalanger intercastellanus/mimicus*	Southeastern/Southern Lowland Cuscus	LC		II		5	C	L	L	L	L
Phalangeridae	*Spilocuscus maculatus*	Spotted Cuscus	LC		II		3	C	L	L	C	C
Pseudocheiridae	*Pseudochirulus canescens*	Lowland Ringtail	LC				4	L	L			L
Muridae	*Chiruromys vates*	Tree Mouse	LC				5	L	L	L		L
Muridae	*Hydromys chrysogaster*	Common Water Rat	LC				2	C	L	L	C	L
Muridae	*Leptomys elegans*	Large Leptomys	LC				5	L	L			
Muridae	*Leptomys signatus**	Fly River Leptomys	LC				5	L	L	L		L
Muridae	*Lorentzimys nouhuysi*	Tree Mouse	LC				4	L	L			L
Muridae	*Melomys lutillus*	Grassland Melomys	LC				4	L	L	L		L
Muridae	*Melomys rufescens*	Black-tailed Melomys	LC				3	L	L	L	L	L
Muridae	*Melomys leucogaster*	White-bellied Melomys	LC				5	L	L	L	L	L
Muridae	*Microhydromys argenteus*	Southern Groove-toothed Shrew Mouse	DD				5	L	L			L
Muridae	*Paramelomys levipes*	Long-footed Paramelomys	LC			RR	5	L	L			L
Muridae	*Paramelomys platyops*	Lowland Paramelomys	LC				3	L	L	L		L
Muridae	*Pogonomelomys brassi*	Brass's Pogonomelomys	LC				5	L	L	L		L
Muridae	*Pogonomys loriae*	Loria's Tree Mouse	LC				4	L	L	L		L
Muridae	*Pogonomys macrourus*	Chestnut Tree Mouse	LC				4	L	L	L		L

Family	Scientific name	English name	IUCN	PNG	CITES	RR	Endemism	MPH	SH	DSP	Mv	SEC
Muridae	*Rattus exulans*[A]	Polynesian Rat	LC				1	L	L			L
Muridae	*Rattus leucopus*	Southern Lowland Rat	LC				1	L	L	L		L
Muridae	*Rattus rattus*[A]	Black Rat	LC				1	L	L			L
Muridae	*Rattus steini*[A]	Small Spiny Rat	LC				4	L	L			
Muridae	*Rattus verecundus*	Slender Rat	LC				4	L	L			
Muridae	*Rattus* sp. 1, Fly + Kikori uplands	An unnamed Rattus	NE				5	L	L			
Muridae	*Rattus* sp. 2, Kikori uplands + Mount Karimui	An unnamed Rattus	NE				5	L	L			
Muridae	*Uromys caudimaculatus*	A White-tailed Giant Rat	LC				2	L	L	L	L	L
Muridae	*Xenuromys barbatus*	Rock-dwelling Giant Rat	LC				4	L	L			
Muridae	*Xeromys myoides**	False Water Rat	VU		I		1		L	L	L	L
Canidae	*Canis familaris*[A]	Dog	LC				1	C	C	C		C
Felidae	*Felis catus*[A]	Cat	LC				1	L	L	L		L
Suidae	*Sus scrofa*[A]	Pig	LC				1	C	C	C		C
Delphinidae	*Orcaella heinsohni*	Australian Snubfin Dolphin	NT		I		1				C	C
Delphinidae	*Tursiops aduncus*	Indo-Pacific Bottlenose Dolphin	DD		II		1				C	C
Dugongidae	*Dugong dugon*	Dugong	VU	P	I		1				C	C
Total non-volant mammals (excluding invasive alien species)								**45**	**42**	**21**	**10**	**33**

3. Methods

3.1 Survey sites and timing

The survey was conducted at eight main localities in the study area (see Figure 1 and Figures 2–9), with short visits made to three other survey localities (Sites 6A, 6D, 8M) and to one cave on Wi'i Creek following a recommendation by landowners. Visits were made to nine local communities to gather local knowledge of wildlife (Table 2).

Field work took place over two periods in 2016: Phase 1 from 19 January to 16 February 2016; and Phase 2 from 21 June to 20 July.

Table 2. Geographic location and timing of visits for each of the survey sites within the study area. Co-ordinates for the Wi'i Creek cave are not shown (**) due to the conservation sensitivity of the locality.

Location	UTM PNG94		Site alt (m asl)	Arrival	Departure	Trail elevations (m asl)	
	Easting	Northing				Min	Max
Phase 1							
Site 1	294689	9209644	110	19-Jan 14:30	27-Jan 11:00	70	200
Site 2	291894	9202769	95	27-Jan 11:15	2-Feb 10:30	75	200
Site 3	303459	9171560	130	2-Feb 10:45	8-Feb 16:00	100	190
Site 4	300251	9186944	30	9 Feb 14:20	16-Feb 09:30	45	55
Evara Village	297561	9166273	17	6-Feb	7-Feb	n/a	
Poroi 1 Village	300457	9182433	25	12-Feb	12-Feb	n/a	
Phase 2							
Site 5	294432	9191260	20	21-Jun 17:00	2-Jul 10:45	20	45
Site 6A	300655	9195465	n/a	27-Jun 09:20	28-Jun 16:10	30	75
Site 6D	300280	9192765	n/a	26-Jun 10:15	26-Jun 16:00	185	310
Site 7	308305	9153930	15	2-Jul 11:00	9-Jul 12:25	5	30
Site 8	308835	9138610	5	9-Jul 12:40	15-Jul 09:20	0	30
Site 8M	M1 309575 M2 309180 M3 308595	9133025 9132980 9132770	2	various 11-13 Jul	various 11-13 Jul	0	5
Site 9	315970	9131180	2	15-Jul 09:30	20-Jul 13:45	0	30
Wi'i Creek owl roost cave	**	**	320	30-Jun 13:30	30-Jun 13:55	n/a	
Mapaio Fish Camp	292023	9185351	20	6-Jul	6-Jul	n/a	
Poroi 1 Village	300457	9182433	25	6-Jul	6-Jul	n/a	
Aivai Village	305966	9151237	23	9-Jul	9-Jul	n/a	
Wabo Village	286605	9227855	43	29-Jun	29-Jun	n/a	
Subu 2 Village	308833	9219173	42	29-Jun	29-Jun	n/a	
Oru/Hururu Villages	317727	9130344	2	19-Jul	19-Jul	n/a	
Kavava/Mareke Villages	315281	9131264	2	19-Jul	19-Jul	n/a	
Harevavo/ Marea Villages	310995	9131679	2	20-Jul	20-Jul	n/a	

3.1.1 Site 1

Site 1 is located in PRL-15 in the upper Era River catchment, Middle Purari Hills ecological zone. All natural habitat in this area is mapped as Hill forest (Hm) but there are patches of alluvial forest along Boa Creek. Accommodation was at the Antelope-3 Operations Camp (ANT-3 OC). Non-volant mammal survey at this site focused on six areas that represented contrasting habitats (Figure 2):

1) The environs of the ANT-3 OC which was sampled by small mammal trapping and short term deployment of camera traps in areas showing clear signs of mammal activity in the form of footprints and diggings. The trapping in the camp was undertaken specifically to detect the presence of introduced rodents and to assess the opportunity for interaction with native mammals.

2) Road verge habitats in close proximity to the ANT-3 OC, also sampled by small mammal trapping. This trapping was undertaken specifically to document the extent to which introduced rodents living in the camp environment are dispersing via the road network.

3) Creek habitats in the vicinity of the ANT-3 OC and along the road between the ANT-2 and ANT-5 drilling pads. These habitats were surveyed by active day and night searches for tracks and other signs, and sightings of active animals. Alluvial forest on the river terrace was sampled by deployment of camera traps.

4) Hill forest on the ridge to the west of the ANT-3 OC, which was sampled by small mammal trapping, and deployment of camera traps.

5) The abandoned ANT-2 drilling pad and camp clearings, which were sampled by trapping. These areas support weedy grass and shrub communities and were sampled by small mammal trapping to investigate the small mammal succession on heavily disturbed sites and to find out whether they were occupied by introduced rodents.

A ‘stopover’ camp used by local residents adjacent to the abandoned ANT-1 drilling pad featured several firepit that were sampled for skeletal analysis (Figure 2); discarded bones were collected from around the camp.

3.1.2 Site 2

Site 2 is located in the Middle Purari Hills ecological zone in the Mena basin headwaters, upper Era River catchment near the divide between the Era River and Pie River catchments (Figure 3). Natural habitat in this area is mapped as Hill forest (Hm) but there are patches of alluvial forest on terraces of an unnamed creek running past the camp.

The substrate at this site is weakly consolidated mudstone, and the hill forest community displays an exceptionally high level of natural disturbance due to a combination of tree fall and small-scale landslides and slumps. The result is a mosaic of vegetation types at various successional stages, including many dense stands of climbing palm that inhibited movement around the camp.

Non-volant mammal survey at this site focused on three areas that represented contrasting habitats:

1) A mosaic of early to late regrowth scrub and hill forest communities on dissected ridges to southwest of the camp, sampled by small mammal trapping and deployment of camera traps.

2) Streamside vegetation and alluvial forest on terraces along an unnamed watercourse to the east of the camp. The creek varied from 3–10 m wide and comprised a series of riffles and pools, all with gravel bed-load. Flanking terraces stood 1–2 m above the streambed and water depths ranged from 20–50 cm. Most of the creek was shaded by tree cover or choked with tree fall. Sampling methods used at this site were small mammal trapping, deployment of camera traps, and active day and night searches for tracks and other signs.

3.1.3 Site 3

Site 3 is located in the northern section of the proposed export pipeline corridor (Figure 4). The fly camp was located c. 5 km northeast of a logging camp and c. 8 km northeast of Evara village, both on the Purari River. The fly camp is situated in the Southeast Hills ecological zone but is c. 2.5 km from a boundary with the Delta Swamps and Plains ecological zone. All natural habitat within the Southeast Hills ecological zone around Site 3 is mapped as Hill forest (Hm).

Survey effort at this site was focused exclusively on the Southeast Hills ecological zone. Much of the forest habitat in this zone is heavily disturbed by logging activity.

Non-volant mammal survey at this site focused on three areas:

1) Areas of hill forest that had been subject to logging at varying levels of intensity. One area was sampled by small mammal trapping and deployment of camera traps. A second area was used for active day and night searches for tracks and other signs, and sightings of active animals.

2) An active forestry road located southeast of the fly camp. This was sampled by small mammal trapping and by active day searches for tracks and other signs.

3) An abandoned forestry road running past and continuing west of the fly camp, overgrown with weeds, grasses and shrubs. This habitat was sampled by small mammal trapping, deployment of camera traps, and by active day and night searches for tracks and other signs, and sightings of active animals.

A ‘seismic’ camp (from previous exploration activities) was located adjacent to the abandoned forestry road c. 2.4 km northwest of the fly camp (Figure 4). The seismic camp featured several firepit that were sampled for skeletal analysis; discarded bones were collected from around the camp.

3.1.4 Site 4

Site 4 is located in the south of PRL-15 and southeast of the proposed ‘CPF, logistics base and airstrip area’ (Figure 5). The fly camp was located in the Delta Swamps and Plains ecological zone, near a border with the Middle Purari Hills ecological zone. Apart from the localized disturbance associated with various drilling pads and access tracks running between them, this area supports a mosaic of primary Open alluvial forest (Po), Swamp forest (Fsw) and Hill forest (Hm). Within the area surveyed for non-volant mammals the habitat is a mosaic of mature alluvial and swamp forests.

Streams within the terrace complex were deeply incised, with overhanging forest cover.

Non-volant mammal survey at this site focused on three areas that represented contrasting habitats:

1) The clearings within alluvial forest around the fly camp and helipad, and the nearby drilling pads, which were overgrown with dense scrub. These areas supported weedy grass and shrub communities and were sampled by small mammal trapping to investigate the small mammal succession on heavily disturbed sites and to find out whether they were occupied by introduced rodents.

2) Alluvial forest on a broad flat surface to the east of the fly camp, sampled by small mammal trapping and deployment of camera traps. Other areas of alluvial forest to the southeast and west of the camp were subject to active day searches for tracks and other signs and/or sampled by deployment of camera traps.

3) Streamside vegetation and forest on alluvial terraces along an unnamed watercourse (tributary of Oyomo Creek) to the west of the fly camp. This habitat was sampled by small mammal trapping, deployment of camera traps and by active day and night searches for tracks and other signs, and sightings of active animals.

A temporary hunting camp with a ‘single-use’ firepit was located alongside the stream to the west of the fly camp (Figure 5). This was removed in entirety for skeletal analysis.

3.1.5 Site 5

Site 5 is located in the central west of PRL-15 (Figure 6). The fly camp was located in the north of the proposed ‘CPF, logistics base and airstrip area’ near the boundary between the Middle Purari Hills and Delta Swamps and Plains ecological zones.

Elevated country to the east of the camp supports mature and essentially undisturbed Hill forest (Hm), while the low-lying areas to the south and west support a mosaic of Open alluvial forest (Po) and Swamp forest (Fsw). Stands of alluvial forest close to the camp had suffered dieback and contained numerous dead tree boles, the majority still standing but clothed in climbing vines. Potential dieback and its causes are discussed in more detail in the Upstream Vegetation Mapping and Forest Condition Baseline Report (Rogers, 2017). In the absence of an effective canopy, the understorey in these areas consists of a dense, and in many areas, virtually impenetrable tangle of vines, chiefly *Calamus* spp. Patches of similarly impacted alluvial forest were observed during helicopter travel around the site, interspersed with patches of unaffected alluvial forest and swamp communities dominated by sago-palms.

Non-volant mammal survey at this site focused on areas that represented contrasting habitats:

1) A mosaic of alluvial forest and swamp forest habitats to the east of the fly camp, much of it impacted by tree dieback. This area was sampled by small mammal trapping.

2) Hill forest habitats further to the east of the camp, sampled with trapping and the deployment of camera traps.

3) Alluvial forest on low terraces with interspersed patches of sago palm in depressions, accessed by tracks running north and west of the camp and sampled by deployment of camera traps.

3.1.6 Sites 6A and 6D

Site 6A is located in PRL-15 and is within the catchment of Kuku Creek in the Middle Purari Hills ecological zone (Figure 7). The survey was carried out along and beside a segment of the road between Herd Base and Hou Creek Base.

Apart from the localized disturbance associated with the road and some small roadside gardens, this area supports a mature hill forest community growing on the valley slopes and patches of alluvial forest growing on low-lying alluvial terraces. Side-streams are deeply incised within the terrace complex and have overhanging forest cover.

Non-volant mammal survey at this site was restricted to small mammal trapping, the observation of tracks and traces, and sampling of a firepit.

Small mammal trapping was used to sample two habitats:

1) The roadside habitat, which is overgrown with dense scrub.

2) Stream-side habitats along a tributary (Wara Djo’oua) of Kuku Creek.

Tracks were recorded along the roadsides which were flanked by many areas of shallow water and mud, and presented numerous good surfaces for detecting animal movements.

A firepit was sampled at a garden hut belonging to one of the field assistants.

Site 6D is located in the PRL-15 in an area of rugged terrain to the west of Kuku Creek (Figure 7). It falls within the Middle Purari Hills ecological zone and supports mature hill forest with many areas of natural disturbance due to frequent landslides. The area was traversed during a single day visit, with survey effort limited to searching made for tracks and traces.

3.1.7 Site 7

Site 7 is located to the south of PRL-15 in the proposed export pipeline corridor (Figure 8). The camp was located on a former logging road that runs along the boundary between the Delta Swamps and Plains ecological zone (to the west) and the Southeast Hills ecological zone (to the east). Logging activity in both ecological zones ceased more than 10 years ago and the area now supports advanced secondary forests. The road has been kept clear of regrowth and varies in width from 10–20 m; it supports a carpet of vines and is fringed by a zone of dense shrubs and palms.

Small crowned hill forest (Hs) on the low hills to the east of the road had been heavily logged about a decade or more ago and still presented a broken canopy and dense understorey. The Open alluvial forest (Po) to the west of the road is more variable in condition, with some patches heavily disturbed and others seemingly intact. Small muddy-bottomed streams emerge from the low hills but the drainage rapidly becomes disorganized with no major channels encountered on the alluvial plain. Low-lying areas support patches of swamp woodland (Wsw) and swamp grassland (Gsw) habitat.

Non-volant mammal survey at this site focused on the following habitats:

1) Road-side habitats along the logging track heading north and south from camp, sampled by trapping and the observation of tracks and traces on muddy surfaces.

2) Alluvial forest to the west of the logging road, sampled by trapping and the deployment of camera traps.

3.1.8 Site 8

Site 8 is in the south of the proposed export pipeline corridor (Figure 9). The fly camp was established c. 0.5 km east of Avavu village on a broad alluvial plain that supports a mosaic of active gardens, palm plantations and regrowth forest. The site provided access to two ecological zones—Southeast Hills to the east and Southeast Coast to the south and around the fly camp.

A 2 km wide belt of Alluvial forest (Pl) to the east of the camp was intensively logged in 2012. This area now supports a remnant scatter of original trees interspersed with dense sapling regrowth. In many areas, the ground is strewn with decaying timber off-cuts and the surface is visibly disturbed by heavy machinery. The logging road has been kept clear of regrowth and numerous gardens have been planted along its margins.

Two discrete ranges of hills are present in the southeast sector of the site – Heve Hill which has rounded topography and rises to c. 55 m asl, and the Paevera Hills with more angular topography and local peaks at 80 m asl. Both are mapped as non-calcareous sedimentary substrates but this is erroneous for Heve Hill (see below). The habitat on Heve Hill is mapped as Hill forest (Hm) while that on the Paevera Hills is mapped as Small crowned hill forest (Hs).

Non-volant mammal survey at this site focused on areas that represented contrasting habitats:

1) Gardens and palm plantations around the fly camp and helipad, sampled with small mammal trapping.

2) Patches of regrowth forest interspersed between gardens and plantations, sampled by small mammal trapping.

3) The 20–30 m wide logging road that runs southeast toward Paevera Village, sampled by observations of track and traces.

4) Secondary forest and other regrowth habitats in the logged alluvial forest, sampled by small mammal trapping and the deployment of camera traps.

5) Patches of primary forest in the logged alluvial forest, sampled by small mammal trapping and the deployment of camera traps.

Heve Hill was visited on 14 July 2016 with landowners from Huruta village. The landscape features localized outcrops of calcareous siltstone and shows a variety of typical karst landforms such as dry valleys below stream sinks and small sinkholes on ridges. This area was protected from logging activities but is used for hunting and extraction of forest products including timber for local use.

3.1.9 Site 8M

Site 8M is situated within the Mangroves ecological zone in the southwest of the export pipeline corridor (Figure 9). The site comprises three sampling localities along Oeha Creek, a major tidal tributary of the Purari River.

Access to each locality was by boat and movement within the sites was limited by the terrain, which comprised patches of deep mud along tidal drainages, interspersed with slightly elevated areas supporting mangrove forest. The area is visited for fishing, gathering of shellfish and collecting of forest products but shows minimal disturbance away from the few semi-permanent camps.

Visits were made over several days to service bat detectors and harp traps. During these visits, muddy surfaces were examined for wildlife tracks and traces. No small mammal trapping for non-volant mammals was undertaken at this site.

3.1.10 Site 9

Site 9 is located near the coast, midway along Orokolo Bay, and in proximity to several potential routes for the terminal segment of the onshore export pipeline corridor (Figure 9). The topography in this area features a broad coastal plain (1–2 km wide), part of the Southeast Coast ecological zone, and a low coastal range, the Paevera Hills, part of the Southeast Hills ecological zone. The Paevara Hills rise to local peaks of 80 m asl and slightly higher elevations further to the east.

The coastal plain comprises a series of sub-parallel dune ridges with intervening shallow swales, each running approximately parallel to the coast. The fore dunes support a series of villages, gardens and palm plantations, with patches of coastal scrub and small freshwater wetlands present at the eastern end of the bay. Inland of the villages are further plantations including coconut and betel nut palms on ridges and sago palms in low-lying areas. Further inland, this gives way to a 1 km wide belt of Alluvial forest (Pl) with localized areas of disturbance and then to Small crowned hill forest (Hs) as the land begins to rise towards the Paevera Hills. Numerous small gardens are present along the ecotone between the coastal plain and the foothills.

Non-volant mammal survey at this site focused on areas that represented contrasting habitats:

1) The clearings around the fly camp, and nearby patches of coastal scrub, sampled by small mammal trapping.

2) The plantation zone, including both coconut and sago palm stands, and low-lying areas inundated after rain. These habitats were sampled with small mammal trapping.

3) Alluvial forest sampled by small mammal trapping and the deployment of camera traps.

4) Gardens along the coastal plain/foothill ecotone, sampled by small mammal trapping.

3.1.11 Wi'i Creek owl and bat roost cave

The existence of large caves in an area of rugged terrain in the northeast corner of the study area was mentioned by residents of Wabo village and confirmed by residents of Subu 2 Village who gave approval for Aplin to visit the area. The area was accessed via Wi'i Creek (a tributary of the Purari River) on 30 June 2016 and a large cave system was located part way up a limestone bluff on a steep heavily forested slope.

The cave entrance is at an elevation of c. 320m asl and the limestone hills behind the cave rise to local peaks (within 1 km) of 75–550m asl. The slopes and ridges support undisturbed hill forest. Similar limestone hills to the east along the Aure Scarp support emergent trees of *Trisyngyne* (formerly *Nothofagus*) sp. No evidence was seen of recent human visitation to the cave and there had been no recent gardening anywhere along Wi'i Creek. However, an overgrown walking track running part way along Wi'i Creek attests to occasional visits to this area.

A bone accumulation was found at the entrance to the cave. The physical condition and taxonomic composition of this material identifies it as the regurgitated prey remains of owls. A bulk sample of bone was collected from an area of the cave where the remains were sitting on top of recently slumped sediment. This unstable context ensures that the prey remains are also recently deposited and thus representative of the contemporary fauna of the surrounding habitats.

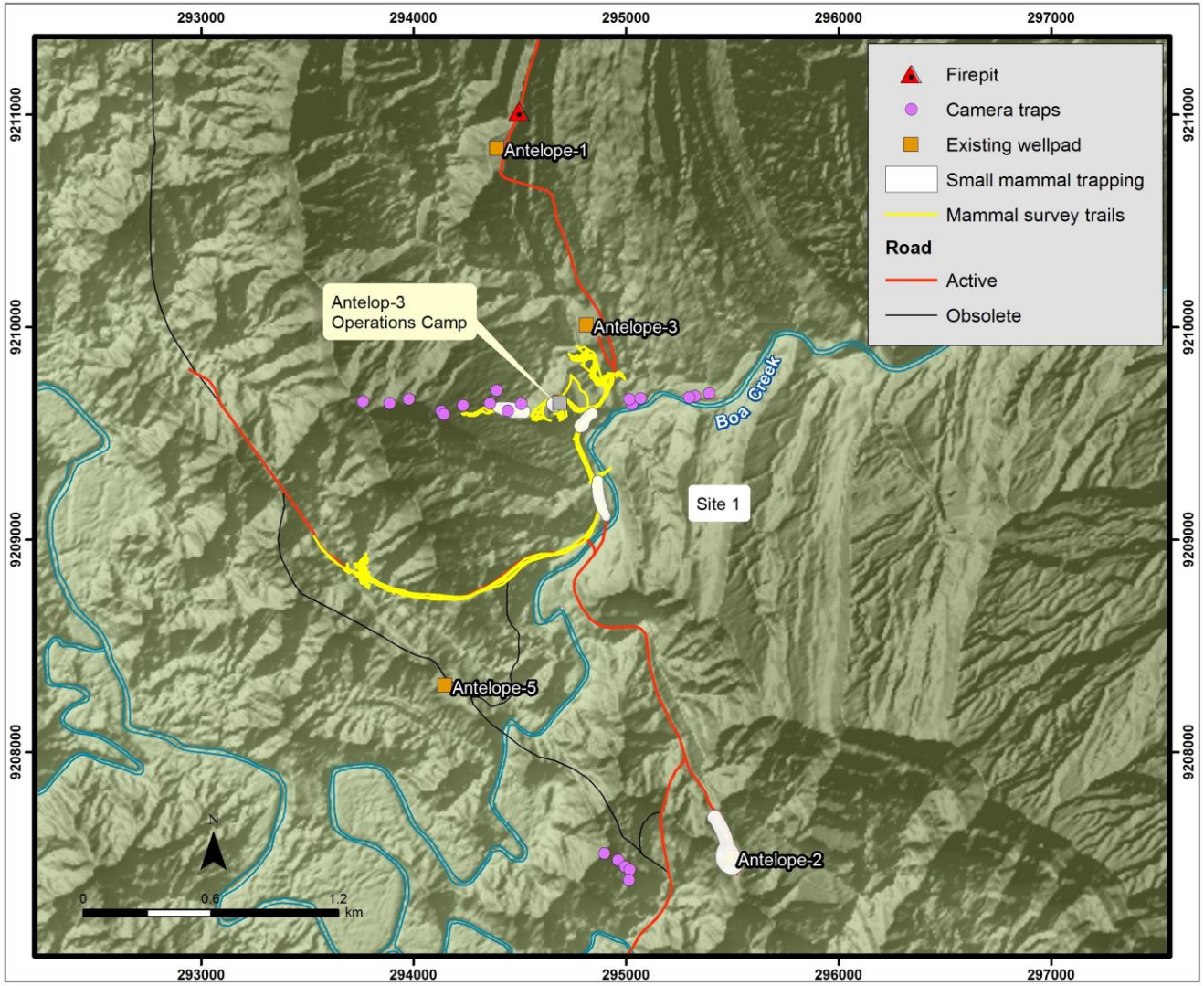

Figure 2. Map of the survey effort for non-volant mammals at Site 1.

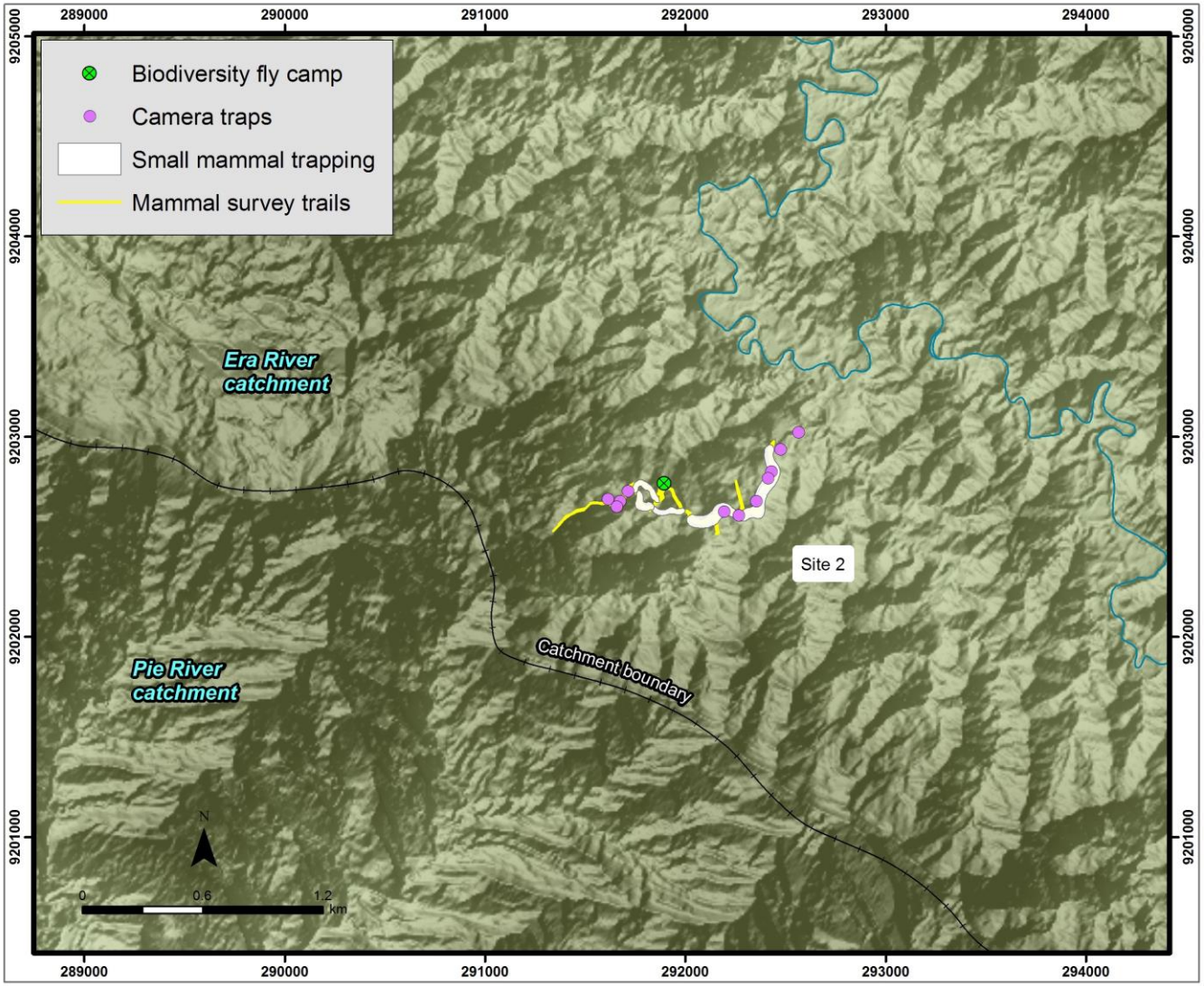

Figure 3. Map of the survey effort for non-volant mammals at Site 2.

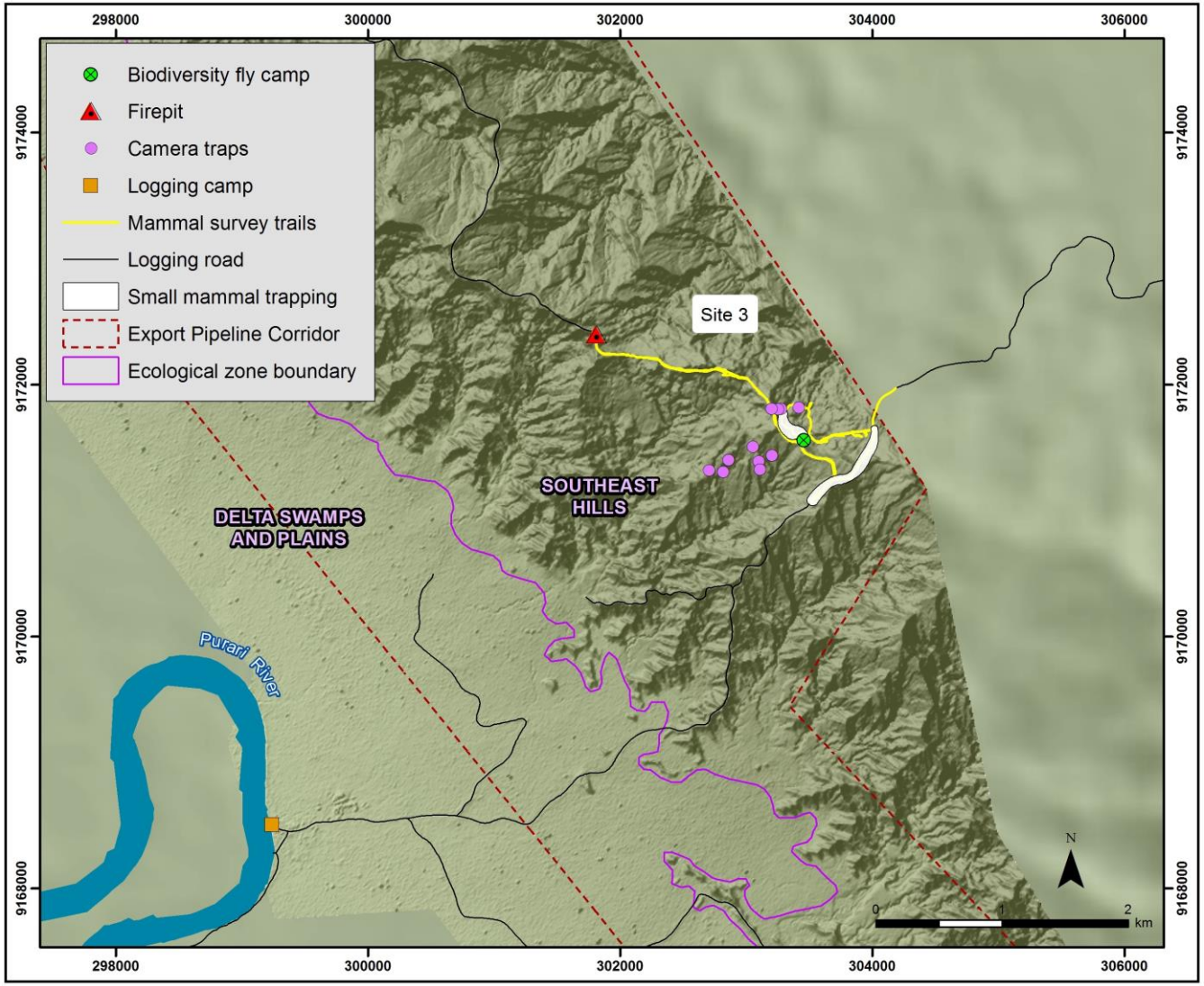

Figure 4. Map of the survey effort for non-volant mammals at Site 3.

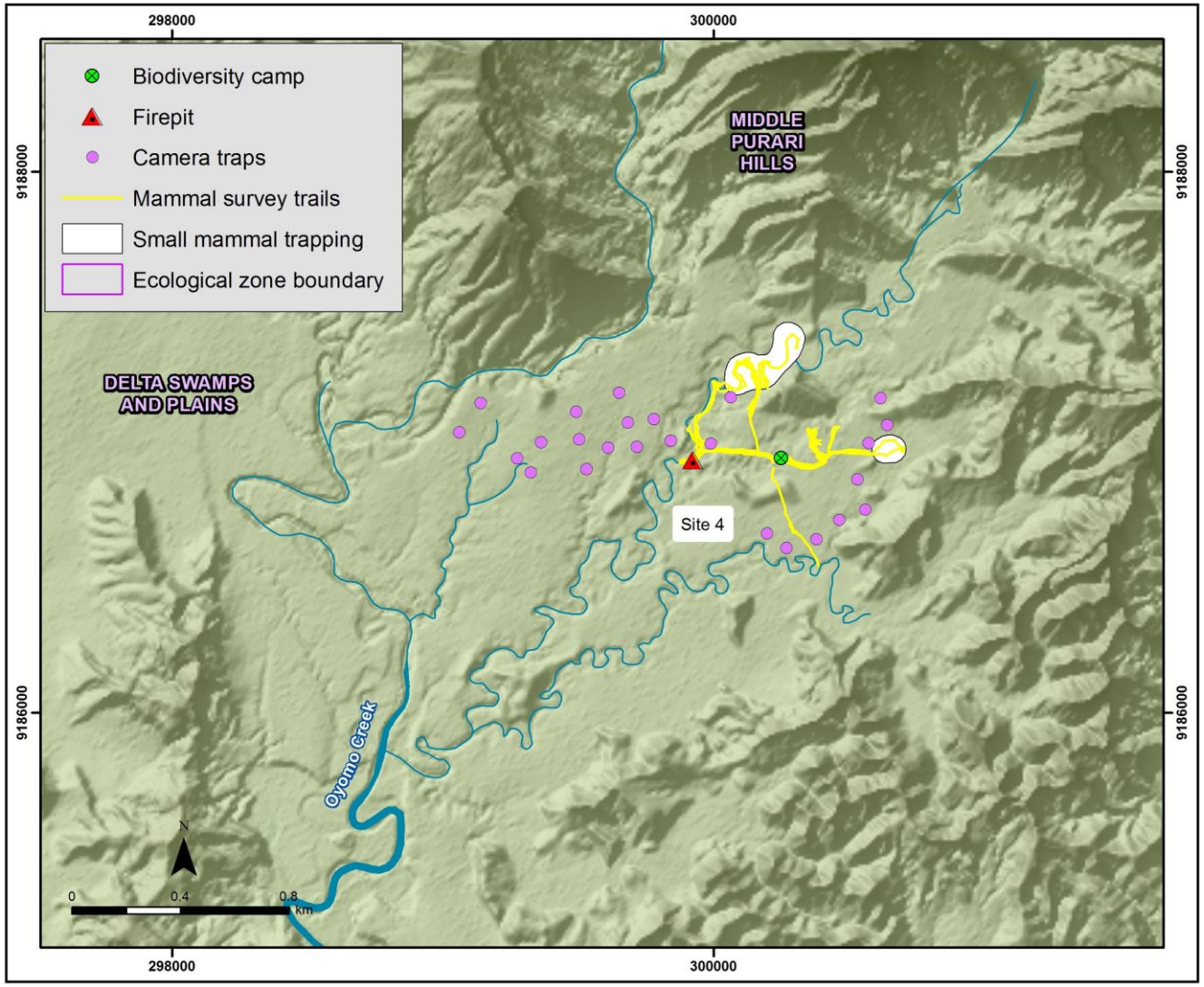

Figure 5. Map of the survey effort for non-volant mammals at Site 4.

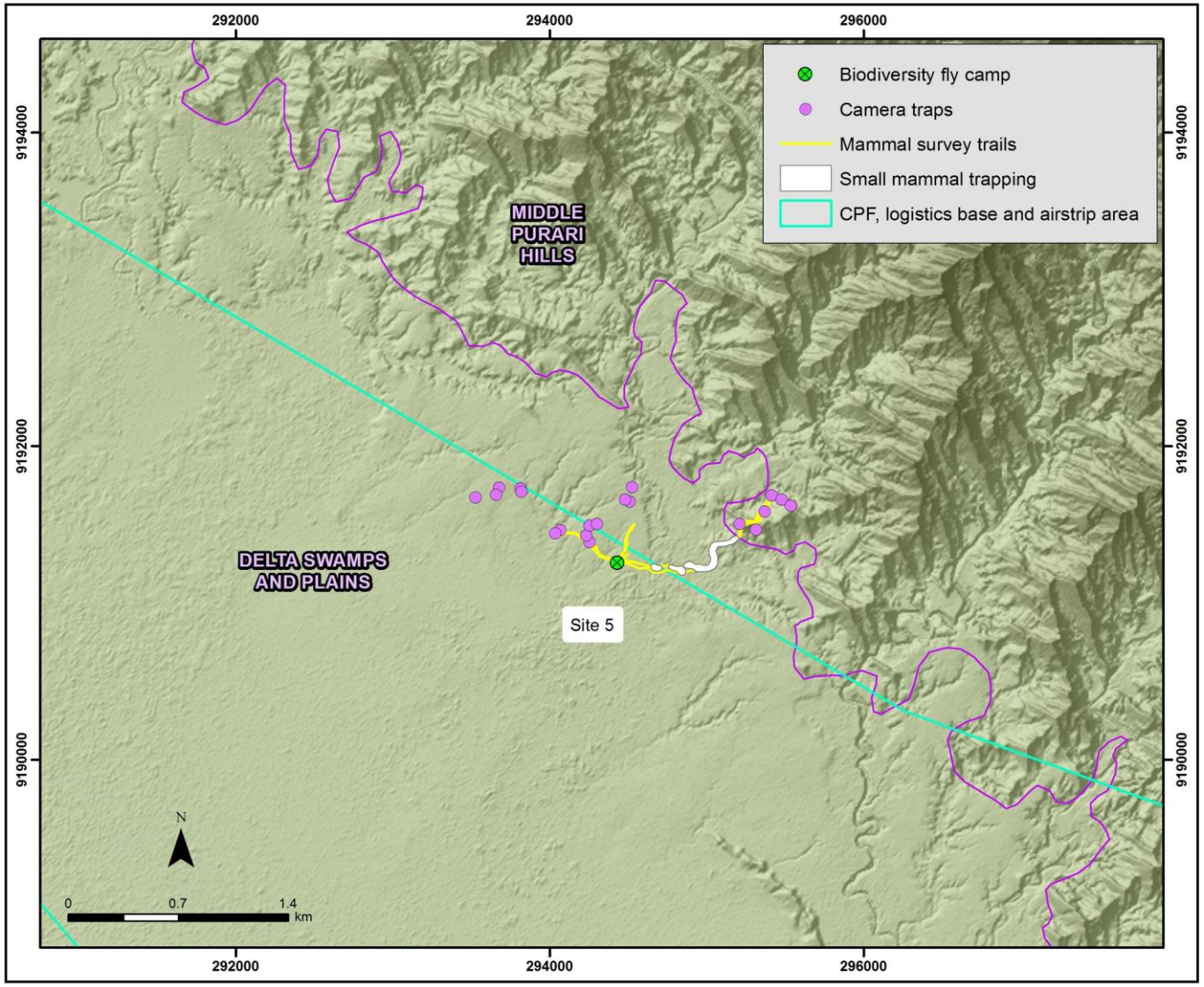

Figure 6. Map of the survey effort for non-volant mammals at Site 5.

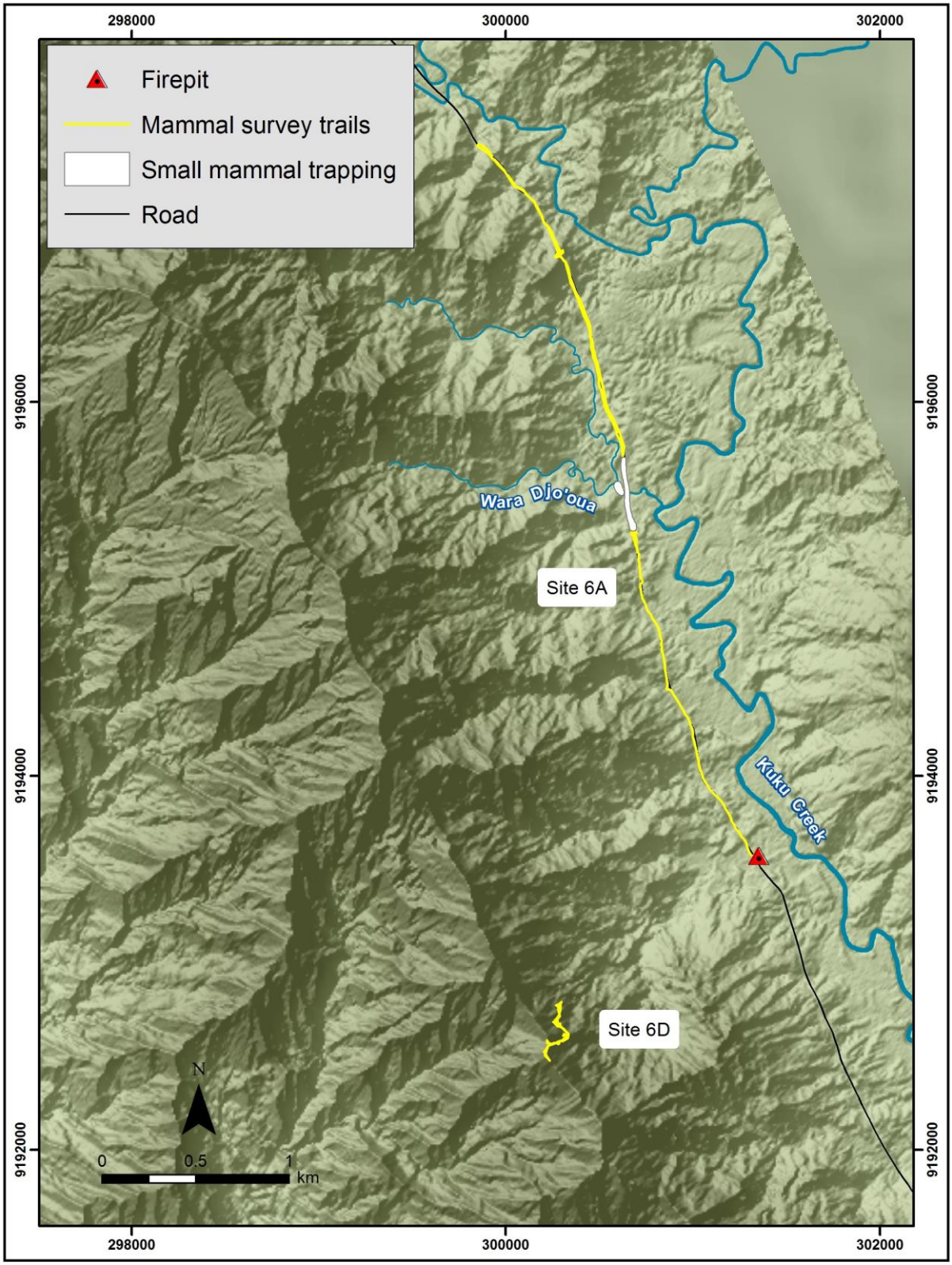

Figure 7. Map of the survey effort for non-volant mammals at Site 6A and 6D. No small mammal trapping was carried out at Site 6D.

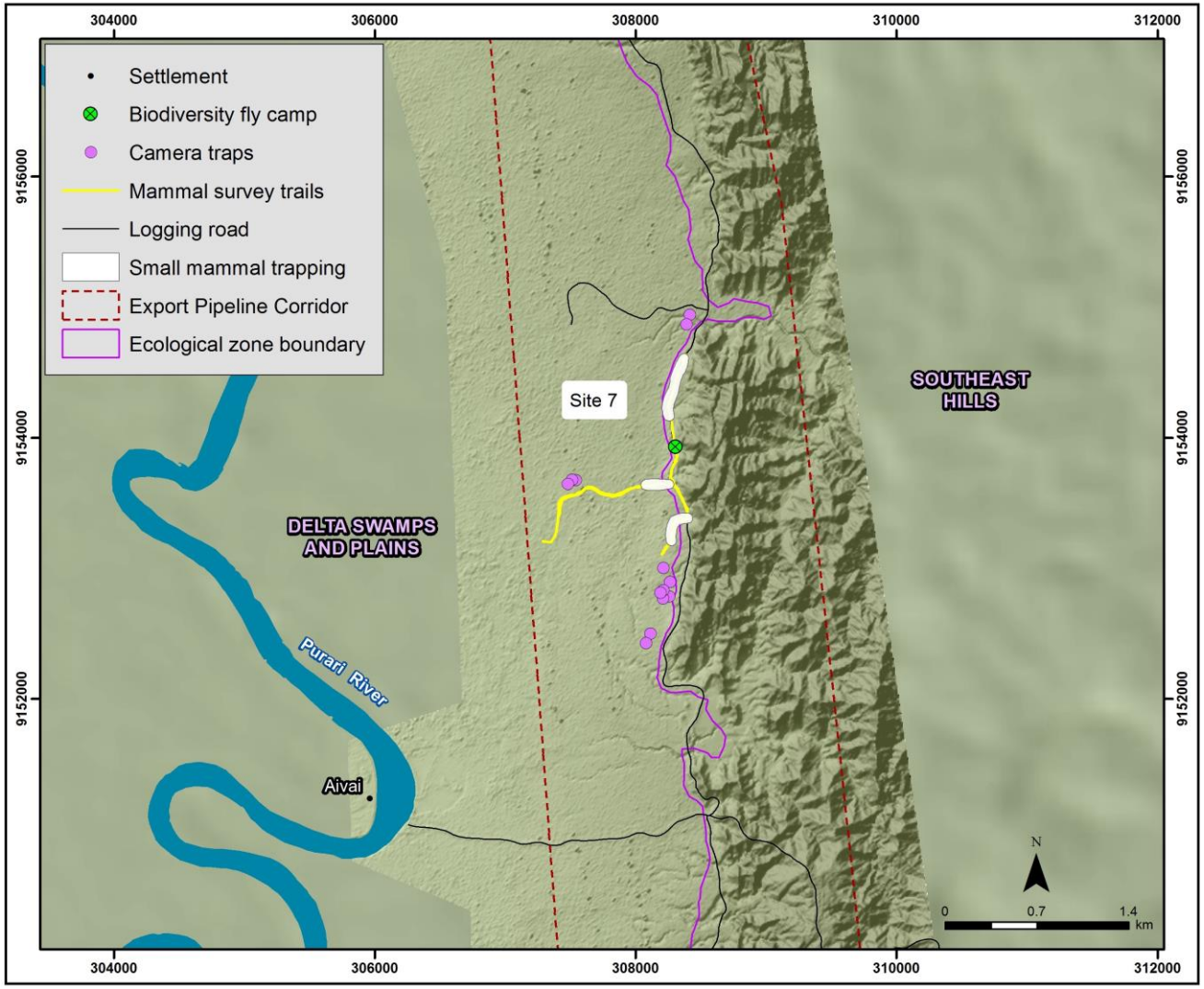

Figure 8. Map of the survey effort for non-volant mammals at Site 7.

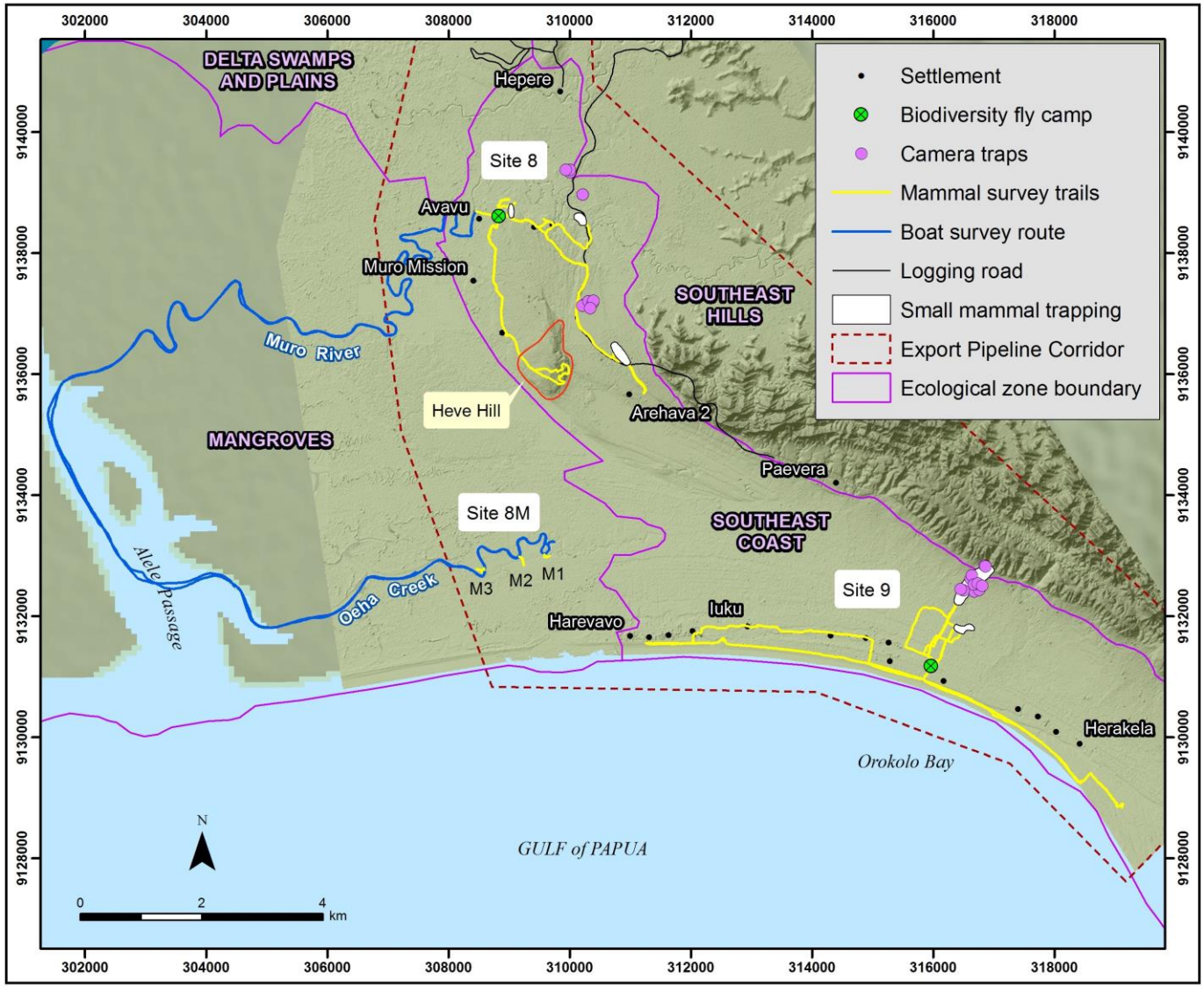

Figure 9. Map of the survey effort for non-volant mammals at Sites 8, 8M and 9. No small mammal trapping was carried out at Site 8M.

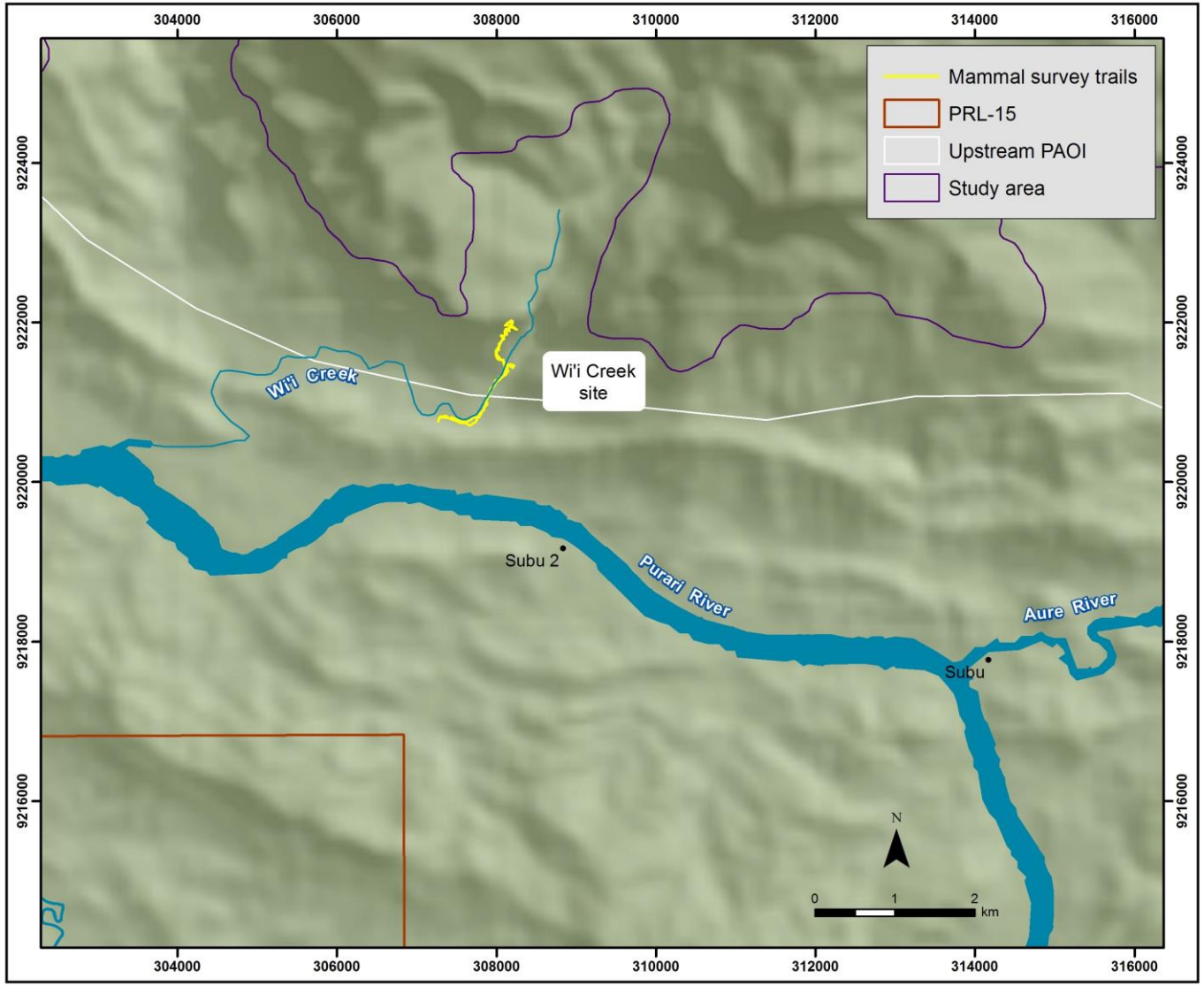

Figure 10. Map of survey coverage at the Wi'i Creek Cave site.

3.2 Survey methods and effort

A variety of methods were used to maximize the chance of obtaining Project-critical information on sensitive species and habitats as well as detecting a variety of species at each locality.

- Small mammal trapping with both live capture (Elliott traps) and kill traps (Snap-E Trap model).
- Deployment of camera traps.
- Active daytime searches for tracks and other traces such as feces, burrows, nests etc.
- Night-time walks with torches (usually combined with checking of mist nets for bats).
- Examination of temporary campsites to find discarded bones and to sample firepit contents that frequently contain bone and tooth fragments of locally obtained prey items.
- Collection of remains accumulated by owls at a cave roost.
- Discussions with local residents concerning locally occurring mammals, including their distribution, habitat use, abundance, and mode and intensity of exploitation.

The effort devoted to each of these methods at each site is shown in Table 3.

The allocation of small mammal trapping effort differed in scale and emphasis between sites in order to target particular issues. At Site 1 considerable effort was directed at trapping in disturbed habitats including the camp area and the various access roads and nearby abandoned drilling pads and former camps, all done with the objective of determining the distribution of introduced rodents in these habitats. At Sites 1, 3, 6A and 7 roadside habitats were targeted to examine the dispersal of introduced rodent species and their potential interactions with native species. At Site 2 considerable effort was directed at trapping in the large areas of natural disturbance, as these were potentially informative on the capacity for local native species to persist in the face of moderate levels of disturbance. At Sites 8 and 9 garden and plantation habitats were targeted, and at Sites 7 and 8 attention was also given to areas disturbed by logging. At all sites, some effort was directed at sampling undisturbed habitats in order to characterize the mammal fauna of different forest types.

Table 3. The effort devoted to each of the main survey methods at each survey site.

Site	Small mammal traps set	Camera traps		Daytime searches Hrs	Night-time searches Hrs	Firepits sampled
		No. units	Hrs			
Site 1	805	21	6,832.75	48	16	5
Site 2	518	11	1,064.75	36	14	0
Site 3	444	11	1,344.00	41	14	2
Site 4	360	25	40,615.00	45	16	1
Site 5	217	20	11,383.25	52	16	0
Site 6A	174	0	-	8	-	1
Site 6D	0	0	-	4	-	0
Site 7	374	13	1,419.75	38	14	1
Site 8	212	11	926.25	32	14	2
Site 8M	0	0	-	4	-	0
Site 9	242	11	1,118.5	25	12	2
Totals	**3,346**	**123**	**64,704.25**	**333**	**116**	**14**

3.2.1 Small mammal trapping

Small mammal trapping sites were selected to sample the major habits represented at each site. These are shown on Figures 1–8. Additional detail on trapping site locations, habitats and effort is provided in Appendix 1.

Small mammal trapping used a combination of live-capture Elliott Traps and Snap-E kill traps (see Plates 2.1 and 2.2). Traps were set on the ground or tied to low branches or fallen timber in a linear 'trapline' array. Traplines comprised a variable number of traps (range: 10–145) to accommodate variation in habitat and terrain features, such as the area of habitat being sampled and the area of accessible terrain at a particular trapping site. Blocks of uncooked sweet potato were used as the primary bait at all sites, as this does not attract ants. Tinned meat was used in some circumstances to target carnivorous mammals such as water rats. Traps were usually left in the same position for 2–3 nights before being moved to a new trapping location.

Some small mammal trapping was carried out in each of Evara, Poroi 1, Wabo, Avavu and Mareke villages. This was achieved by leaving Snap-E kill traps with residents who set traps in and around the village over several nights. Through this means, information was obtained on the occurrence of introduced pest rodents in local villages. One night of trapping was conducted in the camp environs at Herd Base.

3.2.2 Camera traps

All camera traps (Plate 2.4) were set up at ground level by Iain Woxvold, usually on obvious animal trails or beside fruiting trees. Whenever possible, to reduce the impact of human disturbance camera traps were deployed in areas that were not being visited regularly by other survey team members. The positioning of camera traps around each of the sites is shown on Figures 1–8. Details of the camera traps used and their settings are provided in Woxvold (2017).

The majority of camera trap deployments were short-term, i.e., for the duration of the fly camp. These were 'baited' with either a pile of cooked rice or raw sweet potato. Provision of bait encourages animals to stay longer which results in a larger number of images and more chance of obtaining a diagnostic image.

At Sites 4 and 5 a smaller number of camera traps were set up without baits and left to operate for a period of nearly three months. This long-term deployment was done for two reasons: firstly, to check whether any species were being missed due to the disturbance associated with camp construction and/or survey activities; and secondly, in order to obtain an unbiased (no baits) dataset potentially useful for input to a monitoring baseline.

Identification of mammal images was performed by Ken Aplin. The recorded images were scored as separate 'encounters' if they were at least 30 minutes apart in time. If more than one individual of a species appeared in an image this was counted as multiple encounters. For marsupials, young carried in the pouch were not scored as a separate encounter but a young at heel was.

Most images could be identified to species. However, the three locally occurring rats of the genus *Paramelomys* are too similar in size and appearance to consistently distinguish them; these were recorded as *Paramelomys* spp. Similarly, some images of bandicoots could not be allocated to species and these were scored as *Echymipera* sp.

3.2.3 Daytime searches

Searching for tracks and traces of non-volant mammals occurred as a precursor to selecting trapping sites and as an adjunct to almost every other activity.

3.2.4 Night-time searches

Nighttime was dedicated to the servicing of mist nets (for bat surveys) but this activity provided an opportunity to also encounter nocturnally active arboreal mammals such as cuscuses and tree mice. These were located by eye-shine with the aid of head-torches and by listening for characteristic vocalizations. On occasion, it was possible to capture mammals by hand following sightings. The hours spent by the mammal survey team in this activity are shown in Table 3 but on most occasions, several team members took part and so the total person hours would be somewhat higher. Members of the herpetofauna survey team also reported sightings of mammals and made some important captures by hand. All such finds are incorporated in the reported results.

3.2.5 Firepit sampling

Animal remains were identified from bone fragments found in firepits. Firepits were located at former temporary campsites (established by non-Project personnel such as local landowners, loggers, etc.) in the vicinity of Sites 1, 3, 4 and 6A (see Figures 1, 3, 4 and 6). The contents were excavated with a trowel and taken back to camp where they were washed through fly screen, rough-sorted to remove charcoal and clay, fixed in 70% ethanol and then rinsed in water to permit transport, detailed sorting and analysis. The area around these temporary camps was searched for additional discarded bones.

3.2.6 Village group interviews

Group interviews were conducted in *tok pisin* by Junior Novera at two villages during the Phase 1 survey and by Junior Novera and Ken Aplin at eight villages during Phase 2. Discussion focused on the range of wildlife exploited by local residents, the methods used for their capture, the relative importance of various categories of wildlife for subsistence and commercial activities, and the nature of any problems associated with wildlife, including introduced pest rodents. Participants were encouraged to present hunters' trophies and items of decoration that included wildlife products for examination and this often prompted further discussion. Local language (*tok ples*) names were recorded whenever possible.

Subsequent to the Phase 2 survey a household survey was carried out in 27 villages by the ERIAS Group social team. This gathered additional useful data on wildlife occurrences and exploitation of a selection of mammals of special interest.

The majority of the interview-based data collected by the terrestrial biodiversity study team will be reported in the Upstream Land and Natural Resources Baseline Report (ERIAS Group, 2017); this report presents findings that are critical to understanding the distribution, abundance and current pattern of exploitation of non-volant mammals with particular focus on conservation listed species.

3.2.7 Individual informant discussions

Local knowledge concerning mammals was also gathered through individual discussions with field assistants. As a preliminary to individual discussions, information was sought as to the place of birth of each person as a significant number of the field assistants were not born locally and in some cases, they were quite recent immigrants to the study area. Information and *tok ples* names obtained from these people generally was regarded as less reliable than that obtained from long-term residents.

3.3 Handling and sampling of captures

3.3.1 General handling protocols

For this study, captured animals were handled in accordance with the ethical guidelines of the American Society of Mammalogists (Gannon et al. 2007).

No species listed in a Threatened category or listed as Near Threatened by the International Union for Conservation of Nature (IUCN) were captured.

3.3.2 Voucher preparation

Individuals captured in Snap-E traps were preserved in 10% formalin following recovery of appropriate DNA/RNA (deoxyribonucleic acid/ribonucleic acid) samples. Individual labels were allocated to each animal and the same sample number was attached to each tissue sample as well as the voucher specimen.

3.3.3 Genetic sampling

Every captured individual had a DNA sample taken as a means of verifying taxonomic identity in the event that there is an important ambiguity that needs to be resolved and to maximize their future value for taxonomic research. Animals captured in live-capture 'Elliott' traps were sampled by removal of a small portion of skin (1–2 mm) from the end of the tail ('tail clip'); this is a widely used method of sampling and marking captures.

A liver sample was taken from all Individuals captured in Snap-E kill traps. In addition, a wider range of tissue types was sampled from a selection of rodents captured at Site 1, focusing mainly on the species captured in the camp and its immediate environs (*Rattus rattus* and *R.leucopus*). This sampling was undertaken as a way of genetically benchmarking the current pathogen assemblages of the introduced and native rat species, which will allow retrospective investigation in the event that wildlife disease becomes a matter of future concern.

The genetic samples are archived in the Australian Biological Tissue Collection (ABTC) of the South Australian Museum (SAM) and are available for future applications such as verification of identifications made during monitoring programs.

Genetic analysis utilizing material collected during Project surveys is underway in relation to two issues—the identity of the various populations of Black Rat within the study area; and the identity of the population of the Grey Dorcopsis in the study area. Both are being carried out through opportunistic inclusion of samples from the study area in broader research projects that were already underway, include materials from outside of the study area, and have independent academic research funds. The time frame for completion of these studies is 3–6 months.

3.3.4 Permits, export and sample lodgement

Export of the collections was carried out under permits issued by the PNG Conservation and Environment Protection Authority (CEPA). All genetic samples were lodged in the ABTC of the SAM where they are stored at optimum conditions for DNA and RNA preservation.

3.4 Protocols used

3.4.1 Mapping coordinate systems

All coordinates used in the maps and listed in tables are given in PNG94 geographic coordinate system (datum).

3.4.2 Taxonomy and nomenclature

The scientific nomenclature used in this report generally follow the usage embodied within the current IUCN Red List (http://www.redlist.org/). However, for some groups of New Guinean mammals the taxonomy embodied within the IUCN Red List is known to understate the true species diversity, sometimes quite substantially. This insight derives from taxonomic revisions in progress by various members of the international scientific community and is generally underpinned by recent field collections and/or molecular genetic analyses.

The following system of abbreviations is applied in this report to account for various levels of taxonomic uncertainty.

- **'sp.'** (singular) or **'spp.'** (plural)—These abbreviations are used in cases where one or more taxa were not able to be identified to species level, for example if a camera trap image can be referred to a genus but lacks sufficient detail to distinguish among two or more possible species; or where reference is made to multiple species within a genus without the need for more specific information, for example where the ecology of all species of a genus share a common behavior (e.g. 'all *Rattus* spp. share high reproductive rates').
- **'cf.'**—for example: *Paramelomys* cf. *levipes*. This abbreviation is used for a species that is clearly allied to a named taxon but where there is uncertainty over the accuracy of the allocation. Uncertainty is most often due to observed differences in morphology or behavior that suggest the presence of a distinct species. In such cases, further specimens and/or analysis (such as genetic work) would often be required to clarify the identity of the taxon.
- **'sp. 1', 'sp. 2', etc.**—for example: *Pseudohydromys* sp. 1. The numeric system is used where taxonomic identity is confidently resolved and the species is scientifically undescribed. Distinction is made between: (a) species newly discovered during the Papua LNG Project surveys ('new-to-science') and therefore presently known only from within study area; (b) other species which lack a scientific name ('undescribed') but are known to occur outside of the study area.

The common names used in this report are derived from the IUCN Red List (http://www.redlist.org/). These often conflict with the common names used in the main popular compilations on New Guinea mammals by Menzies and Dennis (1979), Flannery (1995) and Menzies (2011) but usage also differs between these sources. For common names, there is no formal system of arbitration of usage equivalent to the International Code of Zoological Nomenclature (ICZN 1999) which governs the use of scientific names; hence, there is no agreed basis for favoring any one terminology over another.

3.4.3 Conservation status

The conservation status of species is reported here against three different systems: 1) the IUCN Red List of Threatened Species; 2) the PNG *Fauna* (*Protection and Control*) *Act 1996* (hereafter PNG Fauna Act); and 3) Appendices I and II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Species that are accorded special status under one or more of these systems are collectively termed 'conservation listed' species.

Definitions for each of the conservation categories recognized under these authorities are provided in the Baseline Characterization Report.

There are various situations that might complicate the application of these categories:

- Where a species has been divided into two or more species subsequent to formation of the conservation lists.
- Where an entirely new species has been described subsequent to formation of the conservation lists.
- Where a species has been recognized subsequent to formation of the conservation lists but remains undescribed.

The impact of taxonomic changes is particularly evident in consideration of the PNG Fauna Act listings which were last revised 20 years ago (1996). To illustrate this point, the genus *Zaglossus* (long-beaked echidnas) now contains more species than was listed in 1996. In this case, it seems reasonable to propose that any species that is recognized through subdivision of a listed species should inherit the status of its parent taxon (e.g. *Z. bartoni* taken out of the Protected *Z. bruijnii* should also be regarded as Protected).

A similar logic is here applied to recently recognized species yet to be evaluated under IUCN Red List criteria. For example, the recently described Southern Groove-toothed Shrew Mouse (*Microhydromys argenteus*; Helgen et al. 2010) which was distinguished taxonomically from the Data Deficient (DD) *M. richardsoni*, is also assumed to be DD. As a general principle, a newly recognized species (whether named or not) is here assumed to warrant a rank at least equal to that of its parent species or closest relative, if not higher.

This principle works well where the parent or related taxon is ranked in an IUCN Red List Threatened, Near Threatened (NT) or DD category. By contrast, if the parental form is ranked Least Concern there is much less certainty that a newly recognized taxon would be similarly assessed. Greater caution is applied in such cases, with careful consideration given to whether the newly recognized species would qualify as 'restricted-range' (see Section 3.4.4) or whether it might satisfy various IUCN Red List criteria.

'Informal' evaluations of this kind have no formal status either with the PNG Fauna Act or the IUCN Red List. However, they are preferred over the alternative of simply listing the taxa as 'not evaluated' (NE) which contains no information that might assist with determining the potential degree of threat.

3.4.4 Level of endemism and 'restricted-range' taxa

Endemism is an important consideration for determining conservation sensitivities. For example, a species that occurs only within one nation's boundaries has a higher intrinsic sensitivity than one that spans two or more nations and thus falls under the influence of multiple legislative jurisdictions. For the present purpose, the level of endemism of each species was rated according to the 5-part classification scheme applied across all Project terrestrial biodiversity technical studies and shown in Table 4.

The term 'restricted-range' is applied to those species which have an extent of occurrence of 50,000 km^2 or less (IFC 2012).

Table 4. Category definitions for levels of endemism relevant to the study.

Category	Definition
1	Occur more widely in the Indo-Pacific.
2	Are endemic to New Guinea, its satellite islands, the Bismarck Archipelago and the Wallacean region.
3	Are endemic to New Guinea and its satellite islands (Waigeo, Misool, Yapen, Biak, Aru, d'Entrecasteaux and Louisiade groups).
4	Are endemic to mainland New Guinea.
5	Endemic to southern mainland New Guinea, south of the central cordillera, and the southeast peninsula but not occurring west of Huon Gulf in the northern lowlands.

3.4.5 Invasive alien species

In accordance with International Finance Corporation (IFC) usage the term 'invasive alien species' is used for any species that is introduced beyond its original range of distribution. These may be either native or alien to New Guinea.

3.4.6 Vegetation terminology

Vegetation types are referred to in the text using a set of Forest Inventory Management System (FIMS)-equivalent terms developed specifically for the Biodiversity Study. These closely follow the formal FIMS descriptors of the founding vegetation descriptions (Paijmans 1976; Hammermaster and Saunders 1995) but are generally less cumbersome. A full list of FIMS vegetation types present within

the study area, and equivalent terms used in the Biodiversity Study, is presented in the Upstream Terrestrial Biodiversity Baseline Summary Report.

Where a specific vegetation type is referred to in the text it is capitalized and followed in brackets by its FIMS code. In this way reference is made to vegetation mapping units present in surveyed areas, for example 'Hill forest (Hm)' and 'Open alluvial forest (Po)'.

Specific vegetation types surveyed at each site are listed in Section 3.1. In most cases, however, more general terms are used that apply to multiple possible variants within the study area (and more widely in PNG). These appear without capitals or a FIMS code, for example 'hill forest' and 'alluvial forest'. These generic descriptors follow the various basal FIMS vegetation types, in these examples coded 'H' and 'P' respectively.

3.5 Data analysis

The quantitative datasets obtained from camera trapping and small mammal trapping might shed light on how non-volant mammal communities in the study area vary in relation to forest type and, to a lesser extent, the degree of natural and anthropogenic disturbance. The camera trapping dataset gives the broadest perspective because it samples the full range of terrestrial and scansorial mammals.

To explore broad patterning in the camera trap dataset, each camera position was assigned categorical scores for forest type and disturbance regime. Habitat was scored as hill forest, alluvial forest or swamp woodland. Disturbance was scored under a four-part system that combines information on the natural disturbance regime, the occurrence of prior logging activity, and the intensity of 'extractive' disturbance, which was inferred from general signs of human extractive activity (e.g. walking trails, snares, campsites, cutting of timber, sago-palm processing). The 'disturbance' categories are:

S – low natural disturbance and minimal to slight extractive disturbance.

M – low natural disturbance and moderate extractive disturbance.

L – previously logged; these areas are generally subject to ongoing moderate levels of extractive disturbance due to the presence of road networks.

N – moderate to heavy natural disturbance (primarily due to landslips on inherently unstable substrate) and minimal to slight extractive disturbance.

The sampling coverage for these factors is shown in Table 5 (see Appendix Table 2.2 for individual camera trap attributions). Sampling was uneven but adequate for both hill forest and alluvial forest if short-term deployments are counted. Swamp woodland was sparsely sampled (two camera traps), reflecting the difficulty of access into this habitat at any of the sites. Minimally to slightly disturbed sites received proportionally more sampling effort in both forest types. This reflects the emphasis on species inventory during the baseline characterization phase. However, previously logged habitats were moderately well sampled at each of Site 3 (in hill forest) and Site 7 (in alluvial forest).

The possible influence of long-term (unbaited) vs short-term (baited) camera trap deployment on the results is discussed in Section 4.7.1.

A Relative Abundance Index (RAI) was calculated for each species per camera as follows:

RAI = Total encounters/hours of camera operation x 100.

Statistical analysis of the camera trap dataset was limited to a calculation of means and ranges of RAI values and visual comparison of the results. While more rigorous comparisons methods such as Analysis of Variance might be used to compare the means, the results would be questionable given

the variety of other factors that might contribute to variance, including the duration of deployment/ provision of baits, and the influence of prior visits by particular species (e.g. a pig consuming a bait on night 1 will presumably influence likelihood of subsequent visits by rats).

Table 5. Camera trapping deployment by site, forest type and disturbance category. Numbers in brackets for Sites 4 and 5 and the totals are the number of long-term deployments (see Section 3.2.2). Forest types: HF = hill forest; AF = alluvial forest; Wsw = swamp woodland. Disturbance categories: L – previously logged; M – low natural disturbance and moderate extractive disturbance; S – low natural disturbance and minimal to slight extractive disturbance; N – moderate to heavy natural disturbance and minimal to slight extractive disturbance.

Forest type/ disturbance categories	Site 1	Site 2	Site 3	Site 4	Site 5	Site 7	Site 8	Site 9	No. cameras
Forest type									
HF	15	4	11	-	4 (4)	-	-	2	**36 (4)**
AF	6	7	-	25 (25)	16 (4)	13	9	9	**85 (29)**
Wsw	-	-	-	-	-	-	2	-	**2**
Disturbance category									
S	21	7	-	25	20	3	9	-	**85**
M	-	-	-	-	-	-	2	11	**13**
L	-	-	11	-	-	10	-	-	**21**
N	-	4	-	-	-	-	-	-	**4**
Total # positions	**21**	**11**	**11**	**25 (25)**	**20 (8)**	**13**	**11**	**11**	**123 (33)**

4. Results and Discussion

4.1 Species recorded

The study area contains populations of at least 42 species of non-volant terrestrial mammals and three aquatic mammal species (Table 6). Five of the non-volant terrestrial mammals are introduced species. A selection of the documented species is illustrated on Plates 3–7.

Appendix 2 contains the detailed results obtained during the survey by each of the main quantitative survey methods—small mammal trapping, camera traps, sightings, and firepit sampling.

Nine of the species listed in Table 6 are subject to some form of taxonomic ambiguity or uncertainty as explained in Section 3.4.2. Appendix 3 provides a brief explanation of each of these taxonomic and nomenclatural issues.

The recorded diversity of non-volant terrestrial mammals varied between 12 and 16 spp. for most sites but substantially lower diversity was observed at Site 2 (7 spp.), where there is heavy natural disturbance (see *Section 4.7.2*), and Site 8M (3 spp.) in the Mangroves ecological zone.

Mammal diversity in the study area compares favorably with other well-documented regions of PNG. As reviewed recently by Aplin et al. (2014: Table 9), the highest published regional totals are currently 47 spp. for the lowlands to mid-elevations in the Sepik catchment and 44 spp. for the Strickland catchment but in each case these tallies include species that occur in lower montane forest around 1,500–2,000 m asl.

Table 6. List of non-volant mammals recorded in the study area. Species marked with a superscript A are alien invasive species. C = confirmed by direct observation during Project surveys; P = prior record; T = recorded from reliable landowner testimony. Conservation status is shown for species listed under the IUCN Red List (CR—Critically Endangered; EN—Endangered; VU—Vulnerable; NT—Near Threatened; DD—Data Deficient; LC—Least Concern), species Protected (P) under the PNG Fauna Act (PNG) and species listed under CITES (Appendix I or II). MPH = Middle Purari Hills; SEC = Southeast Coast. Species listed in the MPH and SEC columns are not yet recorded from a precise locality in those ecological zones (information from local landowners) or come from a Project site (*Mus musculus* at Herd Base). The prior study area records of the aquatic mammals come from Liem (1977).

Scientific Name	English Name	IUCN	PNG	CITES	RR	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 7	Site 8	Site 8M	Site 9	Wii Creek Cave	MPH	SEC
Tachyglossidae																			
Zaglossus bartoni	Eastern Long-beaked Echidna	VU	P	II		4												T	
Dasyuridae																			
Dasyurus albopunctatus	New Guinea Quoll	NT				4												T	
Murexia melanurus	Black-tailed Murexia	LC				4				C							C		
Murexia longicaudata	Long-tailed Murexia	LC				4	C			C			C				C		
Myoictis leucura	Woolley's Three Striped Dasyure	DD			RR	5,6		C		C									
Peramelidae																			
Echymipera kalubu	Common Echymipera	LC				3	C			C	C		C	C		C	C		
Echymipera rufescens subsp.	'Purari' Long-nosed Echymipera	LC			RR	5,6	C		C	C	C		C	C		C	C		
Echymipera oriomo	Oriomo Bandicoot	NE			RR	5,6				C	C			C		C			
Peroryctes broadbenti	Giant Bandicoot	EN			RR	5,6							C	C		C			
Macropodidae																			
Dendrolagus goodfellowi	Goodfellow's Tree Kangaroo	EN	P			4												T	
Dendrolagus notatus	Western Montane Tree Kangaroo	EN	P			4												T	
Dendrolagus spadix	Lowland Tree Kangaroo	VU	P		RR	5,6												P,T	

Scientific Name	English Name	IUCN	PNG	CITES	RR	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 7	Site 8	Site 8M	Site 9	Wii Creek Cave	MPH	SEC
Dorcopsis luctuosa subsp.	Grey Forest Wallaby	VU				5	C	C	C	C	C	C	C	C		C			
Acrobatidae																			
Distoechurus pennatus	Pen-tailed Possum	LC				4											C		
Petauridae																			
Dactylopsila trivirgata	Striped Possum	LC				2											C		
Petaurus breviceps	Sugar Glider	LC				2											C		
Pseudocheiridae																			
Pseudochirulus canescens	Lowland Ringtail	LC				4				C							C		
Phalangeridae																			
Phalanger gymnotis	Ground Cuscus	LC				4	C			C	C						C		
Phalanger mimicus	Southern Lowland Cuscus	LC		II		5			C							C			
Spilocuscus maculatus	Spotted Cuscus	LC		II		3								C	C	C		P,T	
Muridae																			
Chiruromys vates	Tree Mouse	LC				5,6											C		
Hydromys cf. *chrysogaster*	Common Water Rat	LC				2				C					C		C		
Hydromys sp.1 (small species; new-to-science)	Small Water Rat	NE			RR	5,6											C		
Lorentzimys nouhuysi	Tree Mouse	LC				4											C		
Melomys cf. *rufescens*	Black-tailed Melomys	LC				3	C						C			C	C		
Melomys leucogaster	White-bellied Melomys	LC				5	C		C		C	C	C	C		C	C		
Mus musculus[A]	House Mouse	LC				1												C	
Paramelomys cf. *levipes*	Long-footed Paramelomys	LC			RR	5,6	C	C		C			C	C		C	C		
Paramelomys platyops	Lowland Paramelomys	LC				3		C	C	C	C		C	C		C	C		

Scientific Name	English Name	IUCN	PNG	CITES	RR	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 7	Site 8	Site 8M	Site 9	Wii Creek Cave	MPH	SEC
Paramelomys cf. naso	Long-nosed Paramelomys	LC				5,6	C				C		C						
Pogonomys cf. *loriae*	Loria's Tree Mouse	LC				4			C	C							C		
Pogonomys macrourus	Chestnut Tree Mouse	LC				4											C		
Pseudohydromys sp. 1 (new-to-science)	Shrew Mouse	NE			RR	5,6											C		
Rattus exulans[A]	Polynesian Rat	LC				1			C										
Rattus leucopus	Southern Lowland Rat	LC				1	C	C	C	C	C	C	C				C		
Rattus rattus[A]	Black Rat	LC				1	C							C		C			
Rattus steini[A]	Small Spiny Rat	LC				4		C											
Uromys cf. *caudimaculatus*	A White-tailed Giant Rat	LC				2	C	C	C	C	C		C	C		C	C		
Xenuromys barbatus	Rock-dwelling Giant Rat	LC				4											C		
Xeromys myoides	False Water Rat	VU				1					C			C	T				
Canidae																			
Canis familiaris[A]	Dog	LC				1						C		C					
Suidae																			
Sus scrofa[A]	Pig	LC				1			C	C	C	C	C	C		C			
Total excluding aquatic spp.							**12**	**7**	**10**	**16**	**12**	**5**	**13**	**14**	**3**	**14**	**23**		
Dugongidae																			
Dugong dugon	Dugong	VU	P	I		1										P,T			P
Delphinidae																			
Orcaella heinsohni	Australian Snubfin Dolphin	NT		I		1										P,T			P
Tursiops aduncus	Indo-Pacific Bottlenose Dolphin	DD		II		1										P,T			P
Total including aquatics							**12**	**7**	**10**	**16**	**12**	**5**	**13**	**14**	**3**	**17**	**23**		

Lower values are recorded for each of the Kikori catchment (32 spp.; Leary and Seri 1997) and the Lakekamu basin (15 spp.; Wright et al. 1998).

Thirteen of the species listed as potentially occurring in the study area were not detected. These are listed in Table 7 with comments on the most likely reason for their absence.

Table 7. Species listed as potentially occurring in the study area but not detected. A brief explanation for their absence is provided. English names are provided for each species in Table 1.

Scientific name	English name	IUCN Status	Likely reason for non-detection
Tachyglossus aculeatus	Short-beaked Echidna	LC	Rarity or genuine absence.
Murexia naso	Long-nosed Murexia	LC	Probably found only at higher elevations.
Microperoryctes ornata	Striped Bandicoot	LC	Probably found only at higher elevations.
Thylogale brunii	Dusky Pademelon	VU	Possibly present but with patchy distribution.
Cercartetus caudatus	New Guinea Pygmy Possum	LC	Probably found only at higher elevations.
Leptomys elegans	Large Leptomys	LC	Absent or found only at higher elevations than any sampling site.
Leptomys signatus	Fly River Leptomys	LC	Suitable habitat adequately surveyed, including by owl pellet sample; probably a genuine absence.
Melomys lutillus	Grassland Melomys	LC	Unknown, might still be detected especially in coastal habitats.
Microhydromys argenteus	Southern Groove-toothed Shrew Mouse	DD	Rarity or genuine absence.
Pogonomelomys brassi	Brass's Pogonomelomys	LC	Suitable habitat adequately surveyed, including by owl pellet sample; probably a genuine absence.
Rattus verecundus	Slender Rat	LC	Absent or found only at higher elevations.
Rattus sp. 1, Fly + Kikori uplands	An unnamed *Rattus*	NE	Absent or found only at higher elevations than any sampling site.
Rattus sp. 2, Kikori uplands + Mount Karimui	An unnamed *Rattus*	NE	Absent or found only at higher elevations than any sampling site.

4.2 Conservation listed species

Table 8 lists the conservation-listed species recorded by direct observation or from landowner testimony during the surveys or that are considered likely to occur in the study area based on regional records.

The list includes three species listed by IUCN as Endangered, six as Vulnerable, two as Near Threatened, and three as Data Deficient. Five of these species are Protected under the PNG Fauna Act. Three species are listed in CITES Appendix I and four in Appendix II. Two of the latter are listed as Least Concern by IUCN and are not Protected under the PNG Fauna Act

Accounts for each species are provided below, with ordering first by IUCN category and then by taxonomic convention.

Table 8. Conservation listed non-volant mammal species that are either confirmed by direct observation (C), confirmed by reliable landowner testimony (T), or that are likely to occur (L; see species accounts below) in the study area.

Scientific Name	English Name	IUCN	PNG	CITES	RR	Status in study area
Zaglossus bartoni	Eastern Long-beaked Echidna	VU	P	II		T
Dasyurus albopunctatus	New Guinea Quoll	NT				T
Myoictis leucura	Woolley's Three-striped Dasyure	DD			RR	C
Peroryctes broadbenti	Giant Bandicoot	EN			RR	C
Dendrolagus goodfellowi	Goodfellow's Tree Kangaroo	EN	P			T
Dendrolagus notatus	Western Montane Tree Kangaroo	EN	P			T
Dendrolagus spadix	Lowland Tree Kangaroo	VU	P		RR	T
Dorcopsis luctuosa subsp.	Grey Dorcopsis	VU				C
Thylogale brunii	Dusky Pademelon	VU				L
Phalanger mimicus	Southern Lowland Cuscus	LC		II		C
Spilocuscus maculatus	Spotted Cuscus	LC		II		C
Microhydromys argenteus	Southern Groove-toothed Shrew Mouse	DD				L
Xeromys myoides	False Water Rat	VU		I		C
Dugong dugon	Dugong	VU	P	I		T
Orcaellaheinsohni	Australian Snubfin Dolphin	NT		I		T
Tursiops aduncus	Indo-Pacific Bottlenose Dolphin	DD		II		T

4.2.1 Giant Bandicoot *Peroryctes broadbenti – IUCN Endangered*

This is the largest living bandicoot, with males weighing up to 5 kg; females are smaller (Aplin et al. 2010). It lacks any strong patterning on the face or limbs but the reddish-brown fur is paler on the belly than on the sides and back. In the related and better-known Raffray's Bandicoot *Peroryctes raffrayana* the belly fur is occasionally all white and the same variation is likely to occur in the Giant Bandicoot.

This restricted-range species is endemic to PNG and is restricted to the southeastern peninsula where it occurs in two potentially discrete populations—one on the south coast in Central Province

between the Port Moresby region and the Vanapa River to the west, and the other on the north coast in Oro and Milne Bay Provinces (Aplin et al. 2010). Most records of the species predate 1970 and it appears to be in serious decline or extinct across much of its former range. The last confirmed record anywhere in PNG is from Tufi District, Oro Province and dates from around 2010 (Westerman et al. 2012). The last records of Giant Bandicoot from the southern lowlands in the vicinity of Port Moresby are from 1970. No population is known from any protected area.

Virtually nothing is known of the ecology or behavior of the Giant Bandicoot. However, all well-studied bandicoots are solitary. Litter size is usually 2-3 young but the combination of short gestation period, rapid development and weaning, and early sexual maturation tends to result in high reproductive potential. Population densities might thus be expected to fluctuate markedly over quite a short time frame in accordance with changes in resource availability.

The Giant Bandicoot is probably one of New Guinea's most endangered vertebrates and the discovery of any new population presents new opportunities for its global conservation.

Occurrence in the study area

The Giant Bandicoot is recorded in the study area on the basis of camera traps images obtained at Site 7 near the boundary between the Delta Swamps and Plains and Southeast Hills ecological zone and Sites 8 and 9 in the Southeast Coast ecological zone. These are the first records of the Giant Bandicoot from Gulf Province and the first from southern PNG in more than 40 years.

Identification of bandicoot species from camera trap images depends on obtaining particular views and many images lack diagnostic features. However, images recorded on at least one camera trap at each of Sites 7, 8 and 9 clearly depict a species of *Peroryctes* rather than a species of *Echymipera*, based on the relatively large ears, lack of facial markings (Plate 4.5), and strongly contrasting coloration of the flanks and belly in one individual at Site 9 (Plate 4.6). White-bellied individuals are unknown in any species of *Echymipera* but occur as a color variant in *Peroryctes*. Although a *Peroryctes* was tentatively recorded for one other camera trap at Site 9, no images resembling a *Peroryctes* were noted from any other site including the long-term deployments at Sites 4 and 5. Accordingly, species of *Peroryctes* are confidently considered either absent or extremely rare in the more northerly portions of the study area.

Two species of *Peroryctes* are found in New Guinea—the IUCN Endangered Giant Bandicoot *P. broadbenti* and the smaller and more widespread Raffray's Bandicoot (*P. raffrayana*), which is IUCN Least Concern. The images from Sites 7–9 are referred to Giant Bandicoot for two reasons. Firstly, whereas the Giant Bandicoot has been recorded from near sea level in several parts of its range (Aplin et al. 2010), Raffray's Bandicoot is typically found at elevations above 850 m asl (only one record lower; Flannery 1995). Secondly, Raffray's Bandicoot was not recorded at any camera-trapping site in the Middle Purari Hills or the Southeast Hills ecological zones, nor is it represented in the owl roost sample from Wi'i Creek Cave, despite the presence of other similar-sized bandicoots in this material (typically represented by juveniles). Given these observations, a low elevation population of a *Peroryctes* in the Purari catchment is most likely to be *P. broadbenti*. While this implies a substantial range extension of c. 250 km from the closest record on the Vanapa River (Aplin et al. 2010), it is relevant to note that no obvious physical barriers exist between the Purari River lowlands and areas to the east that were historically occupied by the Giant Bandicoot. Further certainty can only be obtained by examination of a live example or trophy specimen.

All three records of the Giant Bandicoot were obtained in alluvial forest (see Appendix 2, Table 2.2). At Site 7 the camera trap was positioned in an area of logged alluvial forest. At Site 8 the camera trap was positioned in an area of primary alluvial/swamp forest but near to an active garden. The general environs of Site 8 had been logged only a few years before and the entire area was subject to occasional human visitation and a low to moderate level of extractive activity. At Site 9 the two

cameras were positioned in primary alluvial forest subject to regular human visitation and a moderate level of extractive activity. The fact that all records of the Giant Bandicoot come from areas with significant human disturbance does not imply an affinity for disturbed habitats, but rather suggests a degree of tolerance to local human activity and a capacity to persist in disturbed and/or secondary vegetation.

While it is clear that the Giant Bandicoot occupies alluvial forest in at least two of the ecological zones the lower Purari catchment, the fact that it was not detected at Sites 4 or 5 suggests that it is not broadly distributed within the extensive alluvial and swamp forest habitats of the Delta Swamps and Plains ecological zone. Rather, its occurrence in this ecological zone at Site 7 is interpreted as a product of proximity to the Southern Hills ecological zone to the east, and suggest that the Giant Bandicoot may be more characteristic of the hill forest habitat of the Southeast Hills and Southeast Coast ecological zones, but with populations extending into flanking alluvial forest habitats. This possibility cannot be tested from the available data due to lack of sampling effort in the hill forest habitats of these zones. However, it must be considered an option in any further considerations of this species. A habitat range that includes low elevation hill forest as well as alluvial forest but possibly not more regularly inundated swamp forest would be consistent with the wider distributional records of the species (Aplin et al. 2010).

Threats and susceptibilities

All bandicoots are commonly targeted by hunters using bow and arrow and/or dogs, and by snaring around fruiting trees, especially figs. Their shared behavior of constructing simple leaf nests above ground means that they are readily located and flushed by dogs. In many areas of PNG men and women both regularly encounter and kill bandicoots during the course of general extractive activities. As a rule, larger species are probably easier to kill, being a bigger target and less agile than smaller species.

Most bandicoot species seem to be moderately tolerant of forest disturbance and can persist in gardens and secondary forest. However, some species appear to be more resilient than others and the Common Echymipera *E. kalubu* is known to inhabit anthropogenic grasslands. Habitat simplification probably leads to reductions in the diversity and abundance of food resources and more intense competition, which in turn might lead to loss of species diversity. Larger species such as the Giant Bandicoot and the Long-nosed Echymipera *E. rufescens* may be more at risk of local extirpation than smaller species such as the Common Echymipera.

The decline of the Giant Bandicoot in other parts of its range is probably due to hunting pressure combined with conversion of forest habitats for plantations.

The Giant Bandicoot might be threatened by spread of the alien invasive Cane Toad *Rhinella marina*. Some marsupials including the Northern Quoll *Dasyurus hallucatus* have suffered heavy declines in northern Australia following the arrival of the Cane Toad, which has toxins in its skin and some other organs (Woinarski et al. 2008). Bandicoots as a group are among the most omnivorous of all mammals (Wilson and Mittermeier 2015) and it is likely that the Giant Bandicoot would include amphibians in its diet, potentially including all life stages from eggs to adults. All life stages of the Cane Toad are potentially toxic but the degree of sensitivity to the toxin is not well understood for any bandicoot. As a precautionary measure, it should be assumed that the Giant Bandicoot is susceptible to Cane Toad toxin until proven otherwise.

The Cane Toad is present in the study area (Richards, 2017) but appears to be still largely confined to areas of human habitation, logging roads and some Project infrastructure sites, and the riparian zone along some sections of the Purari River. If it were to spread more broadly through the region it might pose a serious threat to any carnivorous or omnivorous mammals as well as other components of the vertebrate fauna.

4.2.2 Goodfellow's Tree Kangaroo *Dendrolagus goodfellowi* – *IUCN Endangered, nationally Protected*

Goodfellow's Tree Kangaroo is a large (9–10 kg) arboreal species with reddish brown fur on face, sides and back, paired cream to yellow stripes on the lower back, cream fur on the lower limbs, and tail with distinct cream and brown rings (Groves 1982; Flannery et al. 1996; Wilson and Mittermeier 2015). It is endemic to eastern New Guinea and is recorded from near sea level to lower montane elevations. The nearest vouchered records are from the Purari upper catchment (Mount Karimui and Crater Mountain) and on the lower slopes of Mount Bosavi to the west. Three subspecies are distinguished with the most widely distributed form *D. g. buergersi* being the one found in the Purari catchment.

Tree kangaroos are active primarily at night but will also move around during the day under cloudy conditions. During the day, they usually shelter on the ground, either under a fallen tree or among the buttresses of a large standing tree, and daytime sightings in the canopy are most likely of animals that have been disturbed and taken to the trees for refuge. At night, they ascend into the canopy to feed.

In captivity Goodfellow's Tree Kangaroo appears to be a non-seasonal breeder. A single young is usually produced, rarely twins. Females enter estrous soon after the young leaves the pouch (8–10 months after birth). Unlike most other kangaroos, tree kangaroos seem not to display embryonic diapause (stasis of a fertilized egg), which means that a new offspring cannot be produced rapidly after accidental loss of the young. Sexual maturity is reached after c. 24 months, which is about twice the period among most other kangaroos. Given these parameters, reproductive potential of tree kangaroos is lower than for most kangaroos and wallabies, and their capacity to respond to resource booms or to recover from population mortality are also correspondingly lower.

No field studies have been carried out on Goodfellow's Tree Kangaroo. One study of a closely related New Guinean tree kangaroo, *D. matschiei* of the Huon Peninsula, reported home ranges of around 1 km^2 with no difference between males and females (Porolak et al. 2014). Home ranges of *D. matschiei* thus appear to be 40–100 times larger than those of Australian tree kangaroos, possibly due to the impact of hunting reducing density, or possibly also reflecting low productivity of their high-altitude habitat. Information on the biology of free-living Australian tree kangaroos and on captive colonies of various New Guinean species is reviewed in Martin (2005) and Wilson and Mittermeier (2015).

Occurrence in the study area

While no direct observation of Goodfellow's Tree Kangaroo has been made within the study area, there are strong grounds to infer its local occurrence.

Local residents, particularly of villages to the north and northwest of the study area (i.e. Uraru, Wabo, Ura, Subu 1 and 2), are aware of tree kangaroos and distinguish three different kinds. One of these is clearly Goodfellow's Tree Kangaroo based on descriptions of its characteristic and distinctive markings on the lower back, limbs and tail. The others are described as an 'unmarked' version of Goodfellow's Tree Kangaroo—presumably the Lowland Tree Kangaroo *D. spadix*—and a larger, darker and thickly furred animal found in 'cold places'—presumably the Western Montane Tree Kangaroo *D. notatus*.

The two reddish-brown tree kangaroos are both called *Bu* in Pawaia language and some people do not distinguish subcategories. Other people use two names, for example at Wabo: *Samwa Bu* for the colorful kind and *Sene Bu* or just *Bu* for the 'plain' kind. Whether they are distinguished or not, most people regard them as color variants of one species and are unclear about their distributions. However, among those who distinguish two kinds, there is general agreement on two points: firstly, that both kinds occur within the study area; and secondly, that neither kind is very common.

Gathering reliable information on the distributions of tree kangaroos (and other large mammals) is made difficult on account of two main issues. The first is the very low incidence of encounters. Even the most experienced hunters at Wabo and Subu villages were able to recall only occasional encounters, usually no more than 4–5 in the last 10–15 years. Given the amount of time that many of these people spend away from villages in pursuit of game and other natural resources, it is clear that these animals are very scarce, very elusive or both. The second issue is that people are generally reluctant to talk about these encounters, particularly in group situations (this may be linked to social issues such as sharing obligations). Information can be slow to emerge, requiring smaller group discussions or one-on-one conversations, and may well be incomplete. In addition, memory of events that took place 10 years or more ago may be understandably incomplete regarding details.

Further south, where tree kangaroos are probably naturally even less abundant, the individual and collective experience is even less robust. By way of illustration, one middle-aged clan leader and long-term resident in Poroi 1 village described how he had come across a large brown animal while hunting in c. 2005. His first thought was that it could be a 'monkey' (that he knew from school books), but after killing it with a bow and arrow he decided that it must be a *Bu* that he had heard of but never seen. This animal was remembered as being a plain brown color and was probably a Lowland Tree Kangaroo.

Residents of Subu 2 and Poroi 1 villages reported a number of recent encounters (since 2005) with *Bu* tree kangaroos within PRL-15. These included sightings or kills in the hills near ANT-4 and around Herd Base. One informant was able to recall sufficient detail of a kill to identify the animal as a Lowland Tree Kangaroo. Other informants either could not recall or did not see the animal well enough to make this distinction. As a precautionary measure, it should be assumed that both species might occur within PRL-15.

Considering all available information, the following interpretation of the distribution of Goodfellow's Tree Kangaroo in the study area is made:

- It is almost certainly present in the rugged and rarely-visited country north of the Purari River between Subu and Hathor Gorge, most of which lies outside of the study area.
- It is almost certainly present in the northwest part of the study area, in the remote and rarely-visited foothills and flanks of Mt Favenc, to the west of the study area.
- It may be present in the rarely-visited Kereru Range, to the west of the study area.
- It may be present in the low ranges and hills that comprise the Middle Purari Hills ecological zone within PRL-15.
- It is very likely absent from the low hills to the southeast of PRL-15, in the clan territories of residents of Evara and Aivai villages. These people were generally aware of tree kangaroos but did not know of any local records.
- It is almost certainly absent from the low hills inland of Orokolo Bay. Residents of the coastal villages as well as Avavu and Paevera villages were generally aware of tree kangaroos but did not know of any local records.

To summarize, Goodfellow's Tree Kangaroo is probably present in various parts of the Middle Purari Hills ecological zone, especially in the more remote areas of the study area to the north and west of the study area. However, it may occur at low population densities within the study area and within PRL-15, where it is likely to co-occur with the Lowland Tree Kangaroo. It is very unlikely to occur in any of the other ecological zones.

Threats and susceptibilities

All tree kangaroos are threatened by a combination of subsistence hunting (especially with dogs) and forest degradation and loss. They are sensitive to disturbance and are rarely observed close to areas of human activity (Flannery et al. 1996).

Feral dogs almost certainly represent a threat to populations of tree kangaroos. Immature tree kangaroos are likely to be particularly susceptible but adults are also sometimes killed by groups of hunting dogs and so can presumably be killed by feral dogs.

According to local accounts, tree kangaroos are usually located with the help of dogs that can locate the animals in their daytime retreats. They are either pursued on the ground and brought down by dogs or shot with a bow and arrow (or gun if available) if they have escaped into a tree. Elsewhere in PNG, they are also captured in snares set on suspended fallen trees (Dwyer 1990) but this method was not mentioned during any of our discussions in the study area.

There appear to be no major proscriptions in Pawaian communities regarding the hunting or consumption of Goodfellow's Tree Kangaroo.

4.2.3 Western Montane Tree Kangaroo *Dendrolagus notatus* – *IUCN Endangered, nationally Protected*

The Western Montane Tree Kangaroo is a large (>10 kg), heavily built arboreal kangaroo with dark brown fur on the face, sides and back, and a cream spot at the base of the tail. It is endemic to eastern New Guinea and is usually present only above 1,500 m. However, in areas of high rainfall combined with rugged terrain it can extend to lower elevations, with recorded occurrences of *D. notatus* down to 900 m asl and of the closely related *D. dorianus* to 600 m asl (Wilson and Mittermeier 2015). The nearest vouchered records are on Mount Karimui and Crater Mountain to the north, and on the upper slopes of Mount Bosavi to the west.

In montane forest, remote from human settlement the Western Montane Tree Kangaroo can occur at moderately high population densities such that individuals are often observed during daytime walks (Aplin and Kale 2011). Closer to human settlements it is usually either locally extinct or restricted to areas of rugged terrain that afford it some protection against hunters (George 1978; Flannery et al. 1996).

Occurrence in the study area

This species is called *Ju* in Pawaia language and is clearly distinguished from other tree kangaroos by landowners in the northern portion of the study area. However, it is universally stated to be found only in the highest forests within the region, and few people appear to have any first-hand experience with the species. Landowners of Uraru and Wabo villages with clan territories that extend into its range reported encounters during the past five years in several parts of the study area—in the 'Tatu' area to the north of the Purari River and east of Hathor Gorge, and to the southwest of Uraru village, on the flanks of Mount Favenc. Both of these areas are rarely visited due to their remoteness from current village sites.

This species thus is confined within the study area to the Middle Purari Hills ecological zone, in higher elevation hill forest at the base of the central cordillera and Mount Favenc. It is not expected to occur in the study area.

Threats and susceptibilities

Threats and sensitivities for this species are essentially the same as for Goodfellow's Tree Kangaroos. The Western Montane Tree Kangaroo is currently protected against over-exploitation by

the remoteness of its habitat and the small number of people with access and hunting rights over the areas in which it lives.

4.2.4 Eastern Long-beaked Echidna *Zaglossus bartoni* – *IUCN Vulnerable, nationally Protected, CITES Appendix II*

A heavily built, slow-moving mammal of the forest floor with a long snout and hard spines concealed within brown to black fur. Body lengths to c. 75 cm and body weights to 10 kg are recorded.

The three species of long-beaked echidnas are endemic to New Guinea and some close satellite islands. They are commonly misrepresented as montane forest mammals but actually range from near sea level to the highest mountains, with records in lowland to montane forests, sub-alpine grasslands and scrub. There are no records from terrain that experiences regular inundation.

Until very recently all species of *Zaglossus* were listed by the IUCN as Critically Endangered. In 2016 this was revised to Vulnerable for the Eastern Long-beaked Echidna, after taking into account new observations at multiple sites across their range (Leary et al. 2016a).

The nearest confirmed record of the Eastern Long-beaked Echidna to the study area is at 600 m asl within the Crater Mountain WMA to the north of the study area (Flannery 1995; Opiang 2009). Further west, there are records from c. 100 m asl in the Strickland catchment (K. P. Aplin unpublished).

Population densities of Eastern Long-beaked Echidna are probably highest in remote mid- to upper montane localities (Aplin and Kale 2011; Leary et al. 2016a) and they may be naturally much less abundant in hill forest at lower elevations, even in remote areas. However, this contrast might also reflect differences in detectability—in montane forests the 'nose pokes' often penetrate a thick layer of soft organic–rich soil whereas in lowland and hill forests the leaf litter is generally coarser and overlies a harder, rocky or clay-rich substrate—or the operation of other threats such as predation by pigs (see below).

Long-beaked Echidnas are active at night and spend the day in hollow logs, among rocks or simply buried in thick litter or soft soil. Their diet consists mainly of worms but also includes other invertebrates which they locate by digging with their powerful forelimbs or probing with their long snout. 'Nose pokes' and other signs of foraging activity provide the best means of detecting Long-beaked Echidna populations (Opiang 2009).

One study of home range and movements of Eastern Long-beaked Echidnas, conducted by radio-tracking methods in the Crater Mountain WMA, documented home ranges up to 1.7 $km^2$and a pattern of distribution suggestive of exclusive territoriality (Opiang 2009), such as occurs also in the better-studied Short-beaked Echidna *Tachyglossus aculeatus* in Australia (Wilson and Mittermeier 2015).

Although little is known of the reproductive biology of any species of Long-beaked Echidna, the available data suggests conformity with the Short-beaked Echidna which usually rears a single young from the egg, has an extended period of maternal care (5–7 months) and delayed onset of sexual maturity (5–6 years) (Augee et al. 2006; Wilson and Mittermeier 2015). Lifespan in the wild is thought to be 40-50 years for the Short-beaked Echidna and may be even longer for the larger-bodied species of *Zaglossus*.

Occurrence in the study area

The Eastern Long-beaked Echidnais well known to landowners in the northern portion of the study area. It is called *Se'a* in Pawaia language. Identification of *Se'a* as a long-beaked echidna rather than the Short-beaked Echidna is substantiated by consistent descriptions of large-bodied, densely furred animals. Short-beaked echidnas are smaller and have shorter fur, therefore appearing to have more spines. The spines of long-beaked echidnas are buried in their long fur.

Pawaian people consider Long-beaked echidnas to be excellent eating and they are clearly a highly prized game animal. The species may also have special cultural significance (this seemed to be the case at Haia, north of the study area in the Crater Mountain WMA, where Ken Aplin witnessed capture and consumption of an Eastern Long-beaked Echidna kill by Pawaian hunters in 1984). Questions asked around this issue at Wabo village in 2016 suggest that there are no major proscriptions regarding the hunting or consumption of Long-beaked Echidnas though some men said that it was 'good food for men'. As with the tree kangaroos, most people can recount only a few encounters with this elusive species.

Within the study area, recent sightings of Eastern Long-beaked Echidnas were reported from rugged terrain in the 'Tatu' area, to the southwest of Uraru village, and on the slopes of the Auer Scarp, east of Subu 1 village. Sightings within the last 2 years were reported in each of these areas. It was also stated to occur on the flanks of Mount Favenc to the west of the study area.

Residents of Poroi 1 village with hunting territories in the southern portion of PRL-15 know of this species but claim that it is not found within their lands. Residents of Evara and Avavu villages were also generally aware of the species but did not know of any local records. Ura village landowners of the rugged Kereru Range to the west of PRL-15 were unsure about its status in this rarely visited area.

During a Social Team community interview at Hurutu village near Muro Mission a resident mentioned that 'echidnas' were formerly present in that area but 'no longer'. Although this record is of interest, it is not possible to accept it as evidence (or absence) of Eastern Long-beaked Echidna in the Southeast Hills ecological zone because it cannot be determined that the memory does not refer to the Short-beaked Echidna. On the other hand, the claim that echidnas no longer occur in the area is also ambiguous due to the fact that such a rare and elusive species might easily go undetected for many years, especially in areas that are rarely visited. For the present, it is thus considered that Eastern Long-beaked Echidnas once occupied, and may even now occupy, parts of the Southeast Coast ecological zone.

Given its wide elevational range and broad habitat tolerance Long-beaked Echidnas might occur in most of the ecological zones within the study area. However, the fully terrestrial lifestyle of echidnas makes them unlikely to thrive in any area that undergoes seasonal or even occasional flooding unless it contains higher elevation refugia of sufficient size. Large areas of the Delta Swamps and Plains and the entire Mangroves ecological zone are very likely unsuitable although it may occur around the periphery of the Delta Swamps and Plains ecological zone. The Middle Purari Hills, Southeast Hills and parts of the Southeast Coast ecological zones probably all present areas of suitable habitat, at least in their original form.

Whether or not Eastern Long-beak Echidnas occur today in any particular part of the study area is probably a consequence of local extractive history, tempered to a degree by variation in the natural productivity of different habitats. Areas that were a focus for human extractive activities in the past are likely to have suffered hunting depletion of echidna populations. However, some areas that were once quite heavily exploited are today rarely visited, as local settlement patterns have changed dramatically over the past 35 years or so with many smaller communities amalgamating into larger villages. In these areas, echidna populations may be making a slow come back unless numbers had already dropped below the point of recovery. However, the low reproductive potential of echidnas means that recovery will be naturally slow, even when major threats are removed, and it may take decades for populations to return to natural carrying capacity.

By contrast, areas that were formerly remote and essentially unvisited may have become more accessible following cessation of internecine conflicts and the more recent creation of new ROWs. In such areas, the rate of predation on echidnas may have increased, either by people or potentially also by feral dogs and pigs (see below).

To summarize, the Eastern Long-beaked Echidna today may be confined within the study area to the Middle Purari Hills ecological zone where recent sightings are concentrated in a variety of relatively remote areas outside of the study area. Although there is a large area of suitable habitat within PRL-15 and the study area it is uncertain whether the Eastern Long-beaked Echidna persists in these areas. As a precautionary measure, they should be treated as potentially present anywhere in hill forest habitat within the study area, and in adjacent areas of intact, well-drained alluvial forest on the eastern and northern margins of the Delta Swamps and Plains and Southeast Coast ecological zones.

Threats and susceptibilities

Long-beaked echidna populations are probably more sensitive to impacts of predation than any other New Guinean mammal. This is primarily a function of their low reproductive potential (small litter size, slow growth and delayed sexual maturation), coupled with naturally low population densities and a lack of effective defense against most predators. In Australia, predators of the Short-Beaked Echidna include native snakes and goannas but also a range of alien invasive species, namely dogs, foxes, cats and pigs (Augee et al. 2006; Holderness-Roddam and McQuillan 2014; Wilson and Mittermeier 2015). Young echidnas are particularly prone to predation by dogs and pigs while still confined to burrows and during early independent life (Rismiller and McKelvey 2000). Evidence from Tasmania suggests that predation by dogs is relatively common (Holderness-Roddam and McQuillan 2014) while on Kangaroo Island in South Australia predation by dogs and pigs is regarded to be a major contributor to recent declines in populations of the Short-beaked Echidna (Rismiller and McKelvey 2000).

Subsistence hunting, especially with the assistance of dogs, is commonly cited as the major threat to the survival of long-beaked echidna populations (George 1978; Flannery 1995; Wilson and Mittermeier 2015; Leary et al. 2016a). For montane regions, this assumption is supported by the very clear relationship between distance from human settlements and the likelihood of detecting echidnas (Leary et al. 2016a). However, extrapolating from what is known about Short-beaked Echidnas in Australia, it is possible that other factors threaten the survival of Long-beaked Echidnas in New Guinea. Specifically, predation by feral pigs and dogs may be an important factor in in lowland and hill forest habitats across New Guinea where the density of feral predators is high and echidnas of both kinds are scarce.

Although this suggestion is speculative, it is founded in reasonable inference and worthy of further consideration. If substantiated, it may imply that regional conservation of long-beaked echidnas might require more than limitations on human hunting; rather, it may also require control of alien invasive species, specifically feral dogs and pigs.

4.2.5 Lowland Tree Kangaroo *Dendrolagus spadix – IUCN Vulnerable, nationally Protected*

The Lowland Tree Kangaroo is a large (9–10 kg) arboreal species. It has reddish brown fur that is shorter and somewhat coarser than other, locally-occurring tree kangaroo species. There is little patterning other than a pinkish face due to sparse furring and indistinct black barring of the tail in some individuals (Flannery et al. 1996; Wilson and Mittermeier 2015). It is a restricted-range species endemic to the hinterland of the Gulf of Papua in PNG and is recorded from near sea level to c. 650 m asl. Although the IUCN Red List account for this species mentions an association with ‘karst habitat’, this is an incomplete view of its habitat associations that include hill forest on many different substrates including elevated Quaternary alluvium in the upper Strickland catchment (K. P. Aplin, unpublished data).

Less is known about the ecology and behavior of Lowland Tree Kangaroos than any other tree kangaroo species. There are no field studies and it has never been kept in captivity. Information

obtained from Pawaia hunters interviewed by Ken Aplin at Haia village in 1984 and at Wabo and Subu villages in the study area in 2016 is consistent with the ecology and behavior of Goodfellow's Tree Kangaroo in this same general area and Pawaia people consider the two species to be color variants of effectively the same kind of animal. The general account of reproductive biology and potential provided for Goodfellow's Tree Kangaroo can be assumed to apply also to the Lowland Tree Kangaroo.

Until very recently the Lowland Tree Kangaroo was listed in the IUCN Red List as Least Concern, commensurate with the remoteness of large parts of its known geographic range. However, it is now listed as Vulnerable due to the increased proportion of its range that is under logging concessions and the recent development of a more extensive regional road network (Leary et al. 2016b; see below).

Occurrence in the study area

Flannery (1995) mentions a voucher specimen of the Lowland Tree Kangaroo from 'the Wabo area' but this record actually refers to two dry skins purchased by Robin Hide in 1982 at Yuro village on the Karimui Plateau and stated to have come from the country to the north of Wabo, probably near the confluence of the Pio and Tua rivers (R. L. Hide, pers. comm. to K. P. Aplin May 2016).

As documented in Section 4.2.2, local accounts of tree kangaroos do not always clearly distinguish between the Lowland Tree Kangaroo and Goodfellow's Tree Kangaroo that also occurs within the study area. This makes it difficult to reliably map the distributions of the two species and to assess their relative abundances. However, from information obtained from experienced Pawaian hunters who did distinguish the essentially unpatterned Lowland Tree Kangaroo (*Sene Bu*) from the more colorful Goodfellow's Tree Kangaroo (*Samwa Bu*) and from residents of other villages to the east and south of PRL-15 it appears that the Lowland Tree Kangaroo is the more widespread and common of the two species.

Given the limitations of evidence discussed in *Section 4.2.2*, the following interpretation of the distribution of Lowland Tree Kangaroo in the study area is made:

- It is present in the rugged and rarely-visited country north of the Purari River between Subu and Hathor Gorge, most of which lies outside of the study area.
- It is present in the northwest part of the study area, in the remote and rarely-visited foothills and flanks of Mt Favenc, to the west of the study area.
- It may be present in the rarely-visited Kereru Range, to the west of the study area.
- It is present in the low ranges and hills in the Middle Purari Hill ecological zone within PRL-15.
- It is very likely absent from the low hills to the southeast of PRL-15, including along the export pipeline route corridor, in the clan territories of residents of Evara and Aivai villages. These people were generally aware of tree kangaroos but did not know of any local records.
- It is almost certainly absent from the low hills inland of Orokolo Bay. Residents of the coastal villages as well as Avavu and Paevera villages were generally aware of tree kangaroos but did not know of any local records.
- The absence of Lowland Tree Kangaroos from hill forest within each of the Southeast Hills and Southeast Coast ecological zones is probably an artefact of past over-exploitation in these areas which are more densely settled than any other part of the study area.
- Because of its habit of sleeping on the ground, it is almost certainly absent from habitats that are subject to seasonal or even occasional flooding, unless they contain higher ground

refugia of sufficient size. Large areas of the Delta Swamps and Plains and the entire Mangroves ecological zone thus are unlikely to support Lowland Tree Kangaroos.

Threats and susceptibilities

Threats and sensitivities for this species are essentially the same as for Goodfellow's Tree Kangaroos.

There appear to be no major proscriptions in Pawaia communities regarding the hunting or consumption of the Lowland Tree Kangaroo.

4.2.6 Grey Dorcopsis *Dorcopsis luctuosa* subsp. – *IUCN Vulnerable*

The Grey Dorcopsis is a medium-sized wallaby with short greyish-brown fur, a distinctive V-shaped hair tract pattern on the neck, and an unusual way of resting the tail, with only the tip in contact with the ground. Males are substantially larger than females, with maximum body weights of males of c. 12 kg.

Breeding in captivity is non-seasonal with young spending c. 6 months in the pouch and reaching sexual maturity at c. 15 months (Wilson and Mittermeier 2015). The Grey Dorcopsis displays embryonic diapause (stasis of a fertilized egg) which means that a new offspring can be produced very soon after accidental loss of a suckling offspring. No ecological data are available from field studies of this species and nothing is known of its diet or social behavior.

The Grey Dorcopsis is endemic to New Guinea and occurs at lowland and hill forest elevations south of the central cordillera and around the southeast peninsula. Two subspecies are recognized—*D. l. luctuosa* in the east and *D. l. phyllis* in the west (Groves and Flannery 1989). Recent mapping is highly discordant; it either shows a major gap in distributions with no populations of Grey Dorcopsis in the hinterland of the Gulf of Papua (Wilson and Mittermeier 2015) or a single broad distribution (Leary et al. 2016c). Preliminary genetic analysis suggests that the subspecies are quite divergent and perhaps better regarded as separate species (Dr M. Eldridge, pers. comm. to K. P. Aplin, May 2016). Populations of *P. l. luctuosa*in Central, Milne Bay and Oro Provinces are severely impacted by hunting and habitat loss and fragmentation. Populations of *D. l. phyllis* remain locally abundant in remote areas of Western Provinces (K. P. Aplin, unpublished data).

Occurrence in the study area

The Grey Dorcopsis was imaged on camera traps at Sites1–5 and 7, 8 and 9 (Plates 5.4 and 6.1) and it was well known to landowners interviewed at Evara, Aivai and Poroi 1 villages. It thus appears to be genuinely widespread and present in most ecological zones within the study area, with the likely exception of the Mangroves ecological zone. These are the first definite records from the Purari River catchment and, together with other recent records from the Strickland catchment (K. P. Aplin, unpublished data), they effectively close the previous distributional gap between the two populations.

The taxonomic identity of the Purari Grey Dorcopsis population is uncertain. As discussed in Appendix 3, while the two subspecies of *D. luctuosa* are morphologically alike, they are genetically divergent and may represent distinct species (Dr M. Eldridge, Australian Museum, pers. communication). If so, the lowlands of the Gulf of Papua might be an overlap or contact zone between two taxa, with scope for complex interactions. Genetic analysis of the small number of samples obtained from within the study area are underway and should provide further insights into the taxonomic identity of this population.

Although the Grey Dorcopsis occurs in all major habitat types within the study area, camera trap encounter rates (RAIs) were consistently higher in alluvial forest compared with hill forest. Furthermore, they were higher in alluvial forest with low levels of anthropogenic disturbance (such as Sites 4 and 5) than in sites where the alluvial forest had either been intensively logged (e.g. Sites 7

and 8) or was very close to a dense human population (e.g. Site 9). However, even the logged alluvial forest sites had higher RAIs than areas of relatively undisturbed hill forest. Further comments and interpretation of the camera trap data are provided in Section 4.7.

Within its favored alluvial forest habitat and away from areas of disturbance, Grey Dorcopsis appears to be quite common[5]. At Sites 4 and 5 it was the most frequently imaged of all mammals, higher even than the bandicoots and rats. Many natural factors probably influence the RAIs, including mobility and social behavior (Grey Dorcopsis were often imaged in 'family' groups of 2-3 whereas all other species are rarely imaged even in pairs; Plate 6.1). However, a telling point is that all but six of the 45 cameras set at these sites captured images of Grey Dorcopsis, and many of these imaged more than one individual or group. Many images captured during both survey phases (January-February and June-July) showed females with young in their pouches or at heel (sometimes both) which suggests that breeding activity is not strongly seasonal in the Purari lowlands environment; this is consistent with their behavior in captivity (Wilson and Mittermeier 2015).

These findings provide three new insights into the hitherto poorly known ecology of the Grey Dorcopsis. First, that it shows a strong habitat preference for alluvial over hill forest, at least in the study area; second, that the Grey Dorcopsis is able to sustain reasonably high population densities in the face of fairly regular hunting; and third, that alluvial forest that has been heavily logged can support moderately dense populations of Grey Dorcopsis, especially after a decade or so of regeneration. However, in regard to this last point, it is important to stress that recovery might not occur unless some nearby patches of habitat were not heavily impacted, thereby preserving source populations of adequate size.

Suitable habitats for the Grey Dorcopsis in the study area are found in the Middle Purari Hills, Southeast Hills and Southeast Coast ecological zones, and probably around the periphery of the Delta Swamps and Plains ecological zone. It might also occur in riparian habitats along elevated levee banks within the Delta Swamps and Plains ecological zone but is probably absent from parts of this zone that are subject to regular, extensive inundation.

The widespread occurrence and local abundance of Grey Dorcopsis in the study area clearly contrasts with its status elsewhere in southern PNG. Around Port Moresby and along the Southeast Papuan Peninsula this species appears to be in widespread decline and there are only a few recent records. To the west of the study area, Grey Dorcopsis is present at low density in the hill forests of the Kikori and Strickland catchments, and it is patchily distributed in the alluvial forest habitats of the Fly River lowlands (K. P. Aplin, unpublished data). Although further data are needed to cement this impression, the study area appears to be a significant potential conservation refuge for Grey Dorcopsis.

Threats and susceptibilities

All wallabies are threatened by a combination of subsistence hunting (especially with dogs) and forest degradation and conversion. Residents of Evara and Poroi 1 village claimed to hunt wallabies on a regular basis and several fresh kills were observed during the field surveys (Plate 5.5). These reports might also relate to the Dusky Pademelon (*Thylogale brunii*) which may also occur in the study area, albeit probably in lower numbers.

According to local accounts, Grey Dorcopsis are usually killed with the help of dogs that locate and flush the animals from their daytime retreats. They are either pursued on the ground and brought down by dogs or shot with a bow and arrow (or gun if available). People also described capture of

[5] IUCN categories are sometimes an imprecise indicator of relative abundance and population security, especially in New Guinea where detailed information on population status is lacking for many taxa. While this species is listed as Vulnerable by the IUCN, it is clearly common in the study area based on camera trapping data and local landowner testimony. The local (study area) population status of all species of conservation significance is assessed independently based on available information and is often variable among species having the same IUCN threat category.

Grey Dorcopsis by approaching them at night with a torch and club. Wallabies are also captured in dead-fall traps and snares set on animal trails.

There appear to be no major proscriptions in any community regarding the hunting or consumption of the Grey Dorcopsis.

Feral dogs almost certainly represent a threat to populations of Grey Dorcopsis. Most wallabies are subject to stress myopathy and will die of heart failure if pursued for any extended period. Adults as well as juveniles are likely to be equally susceptible. Elsewhere in PNG, feral dog scats often contain the remains of wallabies as well as bandicoots and cuscuses, and it is clear that they pursue larger game rather than subsisting on small vertebrates such as frogs and rats (K. P. Aplin, unpublished data).

The level of threat from predation by people or dogs is probably lower for the Grey Dorcopsis than for the tree kangaroos and Eastern Long-beaked Echidna. This is because the Grey Dorcopsis has higher reproductive potential based on its shorter pouch life and more rapid growth to sexual maturity. This notion is supported by its occurrence in recently logged forest and in relatively close proximity to human settlements.

4.2.7 Dusky Pademelon *Thylogale brunii – IUCN Vulnerable*

A medium-sized wallaby with a short face and shaggy brown fur. At rest, the tail curves downward with the last 10 cm or more in contact with the ground. All pademelon species are primarily grazers (they feed predominantly on grasses) and are more commonly associated with forest edge than with closed forest habitats.

The Dusky Pademelon is endemic to New Guinea. Its distribution is usually mapped as having three disjunct populations—on the Aru Islands (probably secure), in the Trans-Fly region (probably secure), and on the southeast peninsula west to Port Moresby region (no records since 1980s) (Wilson and Mittermeier 2015). However, there is a well-documented population on the Karimui Plateau (Hide et al. 1984) and an isolated record from near Haia village in the Purari catchment upland (AMS specimen collected in 1984 by K. P. Aplin).

Occurrence in the study area

The Dusky Pademelon was not detected during the surveys but is considered likely to occur in the study area. This assessment is based on its confirmed occurrence north of the study area in the Purari upland catchment and on landowner accounts at Wabo village where hunters described two kinds of locally occurring wallabies of approximately the same size (the other being the Grey Dorcopsis). Occurrence in this area would fall within the Middle Purari Hills ecological zone.

To the east of the study area there are historic records from riparian forests in the Port Moresby region where it is now thought to be locally extinct (Flannery 1995). Given these records, suitable habitat for this species might also be present in the Southeast Hills ecological zone. If populations exist in either of these ecological zones they may be restricted to areas remote from settlements.

The primarily grazing diet of the Dusky Pademelon probably restricts its capacity to thrive across large parts of the study area, especially if it competes for any critical resources with the more widely distributed Grey Dorcopsis. Any populations of this species in the study area are thus likely to be fragmented and/or existing under sub-optimal conditions.

Threats and susceptibilities

Elsewhere across its range the Dusky Pademelon is threatened by a combination of subsistence hunting (especially with dogs) and forest degradation and conversion. Feral dogs may also represent a threat to populations of the Dusky Pademelon, especially if they favor more open habitats created

by anthropogenic disturbance that also facilitate movement of dogs across the landscape. Most wallabies are subject to capture myopathy and will die of heart failure if pursued for any extended period. Adults as well as juveniles are likely to be equally susceptible.

The level of threat from predation by people or dogs is probably lower for the Dusky Pademelon than for the tree kangaroos and Eastern Long-beaked Echidna. This is because the Dusky Pademelon can be assumed to have a higher reproductive potential based on its shorter pouch life, more rapid growth to sexual maturity and possession of embryonic diapause.

4.2.8 False Water Rat *Xeromys myoides* – IUCN Vulnerable, CITES Appendix I

The False Water Rat is a small rodent with body weights up to 64 g (Gynther and Janetzki 2008). It has very small eyes, sleek grey fur on the back and a strongly contrasting white belly. It is carnivorous, feeding mainly on aquatic, littoral and marine invertebrates and fish, with small crabs and mollusks making up the bulk of its diet in a mangrove community of southeast Queensland. In Queensland mangrove communities, it occupies communal burrow complexes in mounds of soil at the bases of trees. In other contexts, it occupies a range of simpler burrow systems. It is surprisingly mobile for an animal of its size, with nightly movements of up to 2.9 km and a home range of 0.7 ha recorded in southeast Queensland (Gynther and Janetzki 2008). The maximum-recorded litter-size is four which is also the number of teats in females.

This species is widely but patchily distributed in coastal and riverine swamp and mangrove habitats of Queensland and the Northern Territory, Australia. There is only one prior record from PNG, from the Trans-Fly region of Western Province (Hitchcock 1998). In Australia, the False Water Rat evaded detection across most of its range until recently when its characteristic mounds and other signs were established. There has been no systematic survey of potentially suitable habitats in New Guinea.

A genetic assessment of the species within Australia found little genetic structure and some evidence of recent range expansion (Benfer et al. 2015). Some populations contained very low genetic diversity.

Occurrence in the study area

The False Water Rat was detected on camera traps deployed at two sites in the study area. At Site 8, in the Southeast Coast ecological zone, the camera trap was positioned in disturbed alluvial forest. At Site 5 the camera trap was placed in low elevation hill forest in the Middle Purari Hills ecological zone but close to an expanse of alluvial and swamp forest habitats of the Delta Swamps and Plains ecological zone. Failure to detect this species at any of Sites 1 to 3, coupled with its absence from the Wi'i Creek Cave owl roost sample, suggests that it is not widely distributed within the Middle Purari Hills ecological zone but occurs in this zone only where it abuts more suitable habitat.

The False Water Rat probably also occurs within the Mangroves ecological zone of the study area. Site 8M in this zone was searched without success for its characteristic footprints and nesting mounds but a resident from Avavu village who accompanied us to the site described a small grey rat that runs at night on the mud surfaces but does not climb—an excellent description of the False Water Rat.

Within the study area suitable habitat for the False Water Rat occurs in the Delta Swamps and Plains, Southeast Coast and Mangroves ecological zones. The record at Site 5 suggests use of hill forest habitats but this may depend on proximity to core alluvial or swamp forest habitats. Judging from observations on this species in Australia, it may exist at naturally low densities and its range may be naturally fragmented, dependent on adequate food resources.

These are the first records of the False Water Rat in PNG since its initial detection in Western Province (Hitchcock 1998). Discovery of the species in Gulf Province is a major range expansion and its occurrences in alluvial and hill forest also represent expansions of its known habitat range. One

feature shared between the forest habitats it occupies in the study area and the mangrove and coastal wetland habitats occupied elsewhere is the abundance of small crabs and mollusks. It is likely that the False Water Rat will prove to be widespread in the Gulf of Papua, once targeted surveys are carried out.

Threats and susceptibilities

The False Water Rat is declining in parts of Australia where its narrow and fragmented habitat is impacted by urban development, predation by invasive alien species (foxes and pigs), and chemical pollution (Gynther and Janetzki 2008). Its current IUCN Vulnerable status reflects these threats as well as its low genetic diversity. By contrast, the deltaic habitats of the Gulf of Papua are not only areally extensive but also relatively undisturbed; accordingly, this newly discovered population may offer one of its best prospects for long-term survival.

4.2.9 Dugong *Dugong dugon* – *IUCN Vulnerable, nationally Protected, CITES Appendix I*

The Dugong is a large (up to 300 kg), heavily built and slow moving aquatic herbivorous mammal. It is widespread in tropical Indo-Pacific waters where it inhabits near-shore marine and deltaic reaches of larger rivers (Heinsohn 2008). In areas where the continental shelf is wide and protected it also frequents offshore waters to depths of more than 30 m.

The distribution and local abundance of the Dugong is closely linked with sea-grasses which represent its exclusive food item (Heinsohn 2008). Sea-grass beds are present along sections of the southern PNG coastline, wherever in-shore habitats are sheltered by a barrier reef. In river passages, the growth of sea-grasses is restricted by high water turbidity and flow energy.

Australia has the largest Dugong populations left anywhere in the world. In PNG, the Dugong occurs around the entire coast but in many areas, it is now uncommon or locally extinct due to overhunting, or naturally relatively uncommon due to poor conditions for sea-grass growth.

The lifespan and reproductive pattern of the Dugong closely mirrors that of humans, with a lifespan of more than 70 years, sexual maturity reached at ages of 10–17 years, and birth of a single young which suckles for up to two years. The interval between births of calves in Queensland populations is 3–7 years (Heinsohn 2008).

Occurrence in the study area

The Dugong was included by Liem and Haines (1977) in a list of animals hunted in the lower Purari catchment but no indication was given of frequency of exploitation. It is still well known to residents of the Purari delta and Orokolo Bay but few people interviewed during the Phase 2 surveys had first-hand experience of this species. The general view was that Dugongs are not resident in the Purari delta or along the immediate coast but occasionally pass through the area during movements along the coast. One resident of Marea village described a recent offshore sighting.

Neither the Mangroves ecological zone nor the near-shore marine zones within the study area provide the resources needed to sustain a resident population of the Dugong. As mentioned above, the Dugong is entirely dependent for its survival on access to seagrass beds. The high turbidity of the Purari River and the lack of a barrier reef along this section of coastline both inhibit the local growth of seagrass communities. Dugongs thus are unlikely to be more than occasional visitors to the study area, though they may make brief stopovers during long-shore dispersals or movements to avoid heavy seas.

Threats and susceptibilities

Natural predators of the Dugong include large sharks and crocodiles. However, the main threat to its survival is hunting by humans, which has reduced its populations to critical levels in many parts of the world. Where it is not hunted, it is threatened by injuries from boat traffic, by drowning in fishing nets, and by damage to its vital sea-grass beds by siltation and pollution.

The low reproductive potential of the Dugong makes its populations vulnerable to any increase in mortality, whether caused by hunting or loss of critical food resources leading to starvation.

4.2.10 New Guinea Quoll *Dasyurus albopunctatus* – *IUCN Near Threatened*

The New Guinea Quoll is a medium sized (to 0.5 kg) marsupial carnivore that feeds primarily on small mammals and other vertebrates (Flannery 1995; Wilson and Mittermeier 2015). It has red-brown to chocolate brown fur with white spots. It is a scansorial mammal, primarily moving around on the forest floor but capable of climbing in pursuit of prey.

The New Guinea Quoll is endemic to the main island of New Guinea. It probably occurs from sea level to the highest elevations but most records come from above 1,000 m asl (Flannery 1995). Its ecological range is similarly broad, with records in primary and secondary forests at all elevations, and in subalpine heath. It is not known whether the New Guinea Quoll can inhabit areas subject to periodic inundation, such as alluvial forest, swamp forest and mangroves.

There are no field studies of this species and no information available from captive animals. However, its general biology can be reasonably inferred from knowledge of its close relatives within the Australian fauna (Wilson and Mittermeier 2015). All quolls are solitary animals, with large territories covering tens of hectares, and large litter sizes but poor long-term survival of the young. Typical life-spans may be around 4-5 years. Marked fluctuations in population density are reported, probably a reflection of higher than usual survival rates of quolls following booms in natural resources.

Occurrence in the study area

The New Guinea Quoll was not recorded at any of the survey sites but it is known to residents of communities in the north of the study area. It probably occurs in most of the ecological zones within the study area but at very low population densities, making it difficult to detect.

There are confirmed records from areas to north (Mount Karimui), east (Central Province) and west (Kikori catchment) of the study area.

Threats and susceptibilities

Quolls have declined precipitously in Australia and several species are now extinct across much of their original ranges (Wilson and Mittermeier 2015). The causes are often obscure but apart from general habitat loss, there are grounds to identify novel alien diseases, competition with alien invasive carnivores and, more recently, the spread of the toxic Cane Toad, as contributing factors.

As a top-level predator, population densities of the New Guinea Quoll will be limited by the natural abundance of its major prey items—small mammals, reptiles and ground birds of the forest floor and understorey. Population densities of these groups are generally low in tropical lowland rainforests due to a combination of low light penetration (which limits primary productivity below the canopy), competition for canopy resources from birds and bats, and competition for fallen fruit and other products from invertebrates (Kikkawa and Dwyer 1992). Low natural abundances of small ground mammals have been confirmed by consistently low capture rates across numerous survey sites in lowland PNG over the past decade (Aplin and Kale 2011; Aplin and Opiang 2011; Aplin et al. 2014; K. P. Aplin unpublished data).

In lowland habitats, the New Guinea Quoll probably competes for food resources with the Long-tailed Murexia *Murexia longicaudata* which is a similar size. The latter species was imaged on a small number of camera trap positions at Sites 1, 4 and 7, thus including sites with hill forest and alluvial forest habitat.

Pernetta (1983) reported a possible decline in the New Guinea Quoll population of the Karimui area in the upper Purari catchment which he tentatively linked to the penetration of the area by feral cats. Dwyer (1982) made a similar suggestion based on his experience in Eastern Highlands Province in the early 1970s.

Quolls are sometimes taken opportunistically during hunting with dogs and through use of snares. They appear to be tolerant of forest modification and are sometimes captured in gardens.

Quolls in northern Australia have suffered heavy declines following the arrival of the Cane Toad which has toxins in its skin and some other organs and causes poisoning if consumed (Woinarski et al. 2008). The Cane Toad is present in the study area (Richards, 2017) but is still largely confined to areas of human habitation, some roads and Project infrastructure sites, and the riparian zone along some sections of the Purari River. If it were to spread more broadly through the region it might pose a serious threat to the two larger marsupial carnivores as well as other components of the vertebrate fauna.

4.2.11 Australian Snubfin Dolphin *Orcaella heinsohni* – *IUCN Near Threatened, CITES Appendix I*

The Australian Snubfin Dolphin is a small cetacean with a rounded snout that lacks a discrete 'beak' and a distinctive neck crease. Maximum recorded length is 2.7 m but most adults are around 2 m long (Parra and Arnold 2008). The species is endemic to the coastal tropical and subtropical waters of northern Australia and southern New Guinea (Parra and Arnold 2008). A closely related species, the Irrawaddy Dolphin *Orcaella brevirostris,* occurs in Southeast Asia.

The Australian Snubfin Dolphin is usually found in brackish estuarine waters and usually at depths of less than 10m. It is a generalist feeder, taking fish, cephalopods and crustaceans from the sea floor and the water column. Its social organization includes the 'schools' that usually contain around five individuals but sometimes as many as 21.

Populations are thought to be in decline across much of its geographic range but there is little information available from PNG.

Occurrence in the study area

This species was recorded (as *O. brevistroris*) in the lower reaches of the Purari River in the mid-1970s, during the initial Purari Hydropower investigations (Liem and Haines 1977). Present day residents of the coastal villages of Orokolo Bay report occasional captures of two kinds of dolphins (presumably this species and the Indo-Pacific Bottlenose dolphin *Tursiops aduncus*; Hammond et al. 2012).

Informants were not always sure about the distinction between the two species of dolphins and so no firm conclusions can be drawn regarding their relative abundances. Liem and Haines (1977) included both species in a list of animals hunted in the lower Purari catchment but no indication was given of frequency of exploitation. The Indo-Pacific Bottlenose Dolphin has a broader ecological range that includes clear water marine habitats and it is not usually found in water with high suspended load. Captures in the estuarine waters thus are probably of the Australian Snubfin Dolphin, while those from off-shore may include both species.

The pattern of habitat use by the Australian Snubfin Dolphin in the Purari delta and in the adjacent coastal waters is not documented. It is possible that the Purari delta in general might provide suitable

habitat for this species. However, high turbidity in the main channels of the Purari River undoubtedly reduces the biological productivity of these parts of the system, and the species may be dependent on other portions of the delta where turbidity might be lower, such as systems that drain smaller and less modified catchments.

Threats and susceptibilities

Australian Snubfin Dolphins are primarily threatened by hunting and accidental mortality in nets and through boat collisions. Populations are thought to be in decline across much of their geographic range. There is little information yet available from PNG but a research project is underway in the Kikori River.

Based on evidence from landowner testimony, in the Purari delta Australian Snubfin Dolphins are probably captured on a fairly regular basis, mostly as by-catch in seine nets set primarily for fish, sharks and rays. Some residents of the Orokolo villages stated that captured dolphins were released; however, others said that they were consumed. The latter claim is supported by the results of the Social survey in which respondents in two out of 27 villages had consumed dolphin meat during the two weeks before the survey and respondents in seven out of 27 had consumed dolphin meat during the previous year. The latter group included villages in the Delta Swamps and Plains (e.g. Kairimai and Evara villages), Southeast Coast (e.g. Herekela) and the Mangroves (e.g. Kapai 2) ecological zones. One resident of Wabo village to the north of PRL-15 also claimed to have eaten dolphin but it was not clear whether this was consumed locally or during a visit to the southern part of the catchment.

Whether or not this level of exploitation is having any impact on the local population is unknown. The incidence and impact of boat collisions is also unknown.

4.2.12 Woolley's Three-striped Dasyure *Myoictis leucura – IUCN Data Deficient*

Woolley's Three-striped Dasyure is a brightly colored, medium-sized marsupial carnivore with bold stripes along the back and a white tail tip (Wilson and Mittermeier 2015). Unlike the majority of New Guinean mammals, it is active during the day and this has been taken as indication that it preys chiefly on birds rather than mammals. As a medium-level predator, it probably occurs at low population densities.

This restricted-range species is endemic to PNG where it is known from the Mount Bosavi/Mount Sisa area and further east in Central Province. Previous records come from hill and lower montane forests at 650–1,600 m asl. Almost nothing is known of the ecology or reproductive behavior of Woolley's Three-striped Dasyure or any other member of this poorly known genus.

Occurrence in the study area

Woolley's Three-striped Dasyure was imaged by camera traps set in alluvial forest at Sites 2 and 4 and on two cameras at each site. While these are substantially lower elevation sites than any of the published records for the species (Wilson and Mittermeier 2015), similarly low elevation populations have been detected by recent surveys in the Strickland and Fly catchments (K. P. Aplin, unpublished data). No images were obtained on cameras set in hill forest; however, given prior records of the species, it is likely that it occurs in hill forest habitats in the study area. In this regard, it might be noted that the alluvial forest at Site 2 is an isolated habitat surrounded by hill forest.

This species appears not to be represented in the Wi'i creek owl roost sample, despite the occurrence of bones and teeth of the larger-bodied and even more formidable Long-tailed Murexia. This is regarded as sampling bias owing to the diurnal behavior of this species.

The study area contains large areas of suitable hill forest and alluvial forest habitat for Woolley's Three-striped Dasyure, including parts of the Middle Purari Hills, Southeast Hills, Southeast Coast

ecological zones and more low-lying habitats of the Delta Swamps and Plains ecological zone. It is not known whether alluvial or swamp forest that experiences regular or occasional inundation represents suitable habitat for this species.

Threats and susceptibilities

This species is probably threatened only by large-scale habitat loss or conversion. If it conforms with other species of *Myoictis*, it is probably tolerant of lower level forest disturbance and can even exist in a garden/secondary forest mosaic.

Hunting and snaring probably result in occasional captures of Woolley's Three-striped Dasyure but the species is too small and too rarely encountered to represent a specific target for these activities.

The susceptibility of Woolley's Three-striped Dasyure to poisoning after consumption of Cane Toad skin is unknown. However, if it is similar to quolls in its response (*Dasyurus* and Myoictis are quite closely related), then it is likely to be highly susceptible. The Cane Toad is present in the study area (Richards 2017) but is still largely confined to areas of human habitation, some Project infrastructure sites, and the riparian zone along some sections of the Purari River.

4.2.13 Southern Groove-toothed Shrew Mouse *Microhydromys argenteus* – IUCN Data Deficient

The Southern Groove-toothed Shrew Mouse is New Guinea's smallest terrestrial mammal with body weights of c. 10 g. It has sleek grey fur above and below, very small eyes and a distinctive groove down the front of each upper incisor (Helgen et al. 2010). It is endemic to southern New Guinea and is known from scattered localities between Mount Sisa in Southern Highlands Province and Sogeri in Central Province. It is recorded across a broad elevational range (380–1,450 m asl) but is likely to occur at even lower elevations, probably down to sea level.

Nothing is known regarding its diet but other shrew mice are known to be insectivorous and/or vermivorous (worm-eating) (Helgen and Helgen 2009). The groove-toothed shrew mice have shorter snouts than other shrew mice and may be generalized insectivores rather than vermivores. All prior records come from areas of primary or advanced secondary forest (Helgen et al. 2010).

Occurrence in the study area

The Southern Groove-toothed Shrew Mouse was not detected by small mammal trapping or camera trapping at any site. To date, it has not been identified in the Wi'i Creek owl roost sample; however, its remains are extremely small and fragile and it may turn up with further sorting effort.

This species is clearly difficult to census by any standard method, though the rarity of this species and the related Northern Groove-toothed Shrew Mouse *M. richardsoni* in other regional owl pellet samples (Helgen et al. 2010; K. P. Aplin, unpublished data) suggests that they may be genuinely uncommon in most contexts.

Based on other regional capture records this species is likely to occur in the Middle Purari Hills and Southeast Hills ecological zones, and perhaps also in the Southeast Coast ecological zone. It is probably a terrestrial species and as such is less likely to occur in habitats that are subject to regular inundation, including large parts of the Delta Swamps and Plains ecological zone and the entire Mangroves ecological zone.

Threats and susceptibilities

This species is too small to be threatened by human hunting or snaring. It is probably subject to opportunistic predation by feral pigs, dogs and cats, but whether this has impacted the distribution or abundance of the Southern Groove-toothed Shrew Mouse is not known.

There are too few records to assess its degree of sensitivity to habitat modification but one capture on Mt Sisa in the upper Strickland catchment was made in advanced secondary forest growing in a former garden site and surrounded by primary forest.

4.2.14 Indo-Pacific Bottlenose Dolphin *Tursiops aduncus* – IUCN Data Deficient, *CITES Appendix II*

The Indo-Pacific Bottlenose Dolphin is a small cetacean with a short 'beak' and a large dorsal fin. Maximum recorded length is c. 2.4 min both sexes (Krützen and Allen 2008). The species is widely distributed in the tropical and subtropical waters of the western Pacific and Indian Oceans where they occupy shallow, inshore waters. Total global population size is likely to be in the mid to high 1,000's.

Although the Indo-Pacific Bottlenose Dolphin prefers clear water conditions they are known to forage in estuaries provided the water is not too turbid. Their preferred diet consists mainly of schooling fish and cephalopods but they are also known to consume crustaceans and rays. They forage on sandy as well as reef substrates and can dive for long periods in deeper water.

The Indo-Pacific Bottlenose Dolphin has a complex social system that includes relatively stable 'alliances' between individuals but changeable group or 'pod' composition. They have been intensively studied and monitored in Australia but little is known of their distribution and status in New Guinea. They live 40–50 years and give birth to a single young that is nurtured for up to five years.

Despite the wealth of information on some aspects of its biology, the Indo-Pacific Bottlenose Dolphin is listed as Data Deficient on account of the lack of available information on threats and population trends across most of its geographic range (Hammond et al. 2012).

Occurrence in the study area

This species was recorded (as *T. truncatus*) in the lower reaches of the Purari River in the mid-1970s, during the initial Purari Hydropower investigations (Liem 1977). Present day residents of the coastal villages of Orokolo Bay report occasional fishing net captures of two kinds of dolphins (presumably this species and the Australasian Snubfin Dolphin).

Informants were not always sure about the distinction between the two species of dolphins and so no firm conclusions can be drawn regarding their relative abundances. Liem and Haines (1977) included both species in a list of animals hunted in the lower Purari catchment but no indication was given of frequency of exploitation. The Indo-Pacific Bottlenose Dolphin has a broad ecological range that includes clear water marine habitats and it is likely that the bulk of the dolphins caught in fish nets set offshore are of this species. By contrast, captures in the estuarine waters are more likely dominated by the Australasian Snubfin Dolphin.

The wider distribution of the Indo-Pacific Bottlenose Dolphin in New Guinean waters is not documented.

Threats and susceptibilities

This species' near-shore distribution makes it vulnerable to environmental degradation, direct exploitation, and fishery conflicts (Hammond et al. 2012). Hunting has been outlawed across most of its range but it still regularly falls victim to incidental catches in seine and gill nets (Reeves *et al*. 2003). Residents of the coastal villages of Orokolo Bay mentioned that captured dolphins were released but other people described consumption of dolphin meat on a fairly regular basis. A significant number of captured dolphins probably drown in gill nets that are typically unattended for several hours or longer. Boat collisions are a second major cause of injury and mortality. Occasional mortality through these factors can have a significant effect on a long-lived, slow maturing species, especially one like the Indo-Pacific Bottlenose Dolphin that has low reproductive potential.

Populations are thought to be in decline across much of its geographic range but there is little information available from PNG.

4.2.14 Southern Lowland Cuscus *Phalanger mimicus*- CITES Appendix II

Lowland cuscuses are medium-sized (body weight to 2.2 kg) arboreal possums. They are strictly nocturnal and are generally solitary, feeding on a variety of leaves and fruits, and nesting in hollow trees or in epiphytes (Wilson and Mittermeier 2015).

Three species of lowland cuscuses are currently distinguished in New Guinea—*Phalanger intercastellanus* in the southeast, *P. mimicus* in the southwest, and *P. orientalis* in the north (Colgan et al. 1993; Norris and Musser 2001; Wilson and Mittermeier 2015). These species are not known to co-occur anywhere but the distributional limits of each form are poorly defined. The Southern Lowland Cuscus *Phalanger mimicus* also occurs on Cape York Peninsula of Australia.

The contact between *P. intercastellanus and P. mimicus* is assumed to fall somewhere in Gulf Province but exactly where is unclear. A population on the Karimui Plateau to the north of the study area is referred to *P. intercastellanus* (reported by Menzies and Pernetta 1986 as *P. orientalis vulpecula*), while populations at similar elevations on Mounts Sisa and Bosavi and in the lowlands of the Fly River catchment to the west are referred to *P. mimicus* (Norris and Musser 2001; AMS specimens from Mount Sisa). According to Norris and Musser (2001), the two species are very similar in external morphology and examination of skulls and teeth is necessary to distinguish them. Males of the Southern Lowland Cuscus are greyish brown and females are reddish brown.

Occurrence in the study area

A trophy jaw from Paevera village between Sites 8 and 9 was identified as *P. mimicus* on the basis of its very small molars. This represents the first record of the Southern Lowland Cuscus from Gulf Province.

A female lowland cuscus was observed and photographed at Site 3 on 15 February 2016 (Plate 5.1). While this individual might conceivably represent *P. intercastellanus*, it is listed in Table 6 as *P. mimicus* given proximity to the confirmed record from Paevera village and the occurrence of *P. mimicus* at similar elevation in the Kikori catchment to the west.

These records confirm Southern Lowland Cuscus in the Middle Purari Hills and Southeast Coast ecological zones of the study area. It is very likely present in the Southeast Hills and Delta Swamps and Plains ecological zones. There are no records of this species in mangrove habitats in New Guinea or on Cape York in Australia where its ecology is better documented (Wilson and Mittermeier 2015).

Threats and susceptibilities

All cuscuses are highly prized for their meat and their fur and skin is also commonly used for personal decoration and other crafts. During the day, they can be captured by locating nests sites with the assistance of trained hunting dogs. At night, they can be located by following the sounds of feeding or movement in the canopy, or through the use of a torch to detect their eye-shine. Cuscuses make a range of vocalizations, including occasional barks and growls, and they can also be located by these calls.

The reproductive potential of lowland cuscuses is moderately high compared to many larger-bodied marsupials due to the common birth of twins (Wilson and Mittermeier 2015). Pouch-life probably lasts for c. 6 months but the young probably stay with the female for a further 10-12 months. This long period of association with the adult female affords them some defense against natural predators but makes them more susceptible to human predation. Young cuscuses are sometimes kept as village ‘pets’ though they are usually eaten once mature.

Southern Lowland Cuscus will consume a variety of food items and can thrive in secondary habitats. However, populations near to human settlements are usually depleted through opportunistic hunting.

Persistence of this species in the study area is guaranteed by its broad ecological range, combined with its tolerance of a moderate level of environmental disturbance.

4.2.15 Spotted Cuscus *Spilocuscus maculatus* - CITES Appendix II

The Spotted Cuscus is a moderately large (body weight to 6 kg) arboreal possum. Both sexes are strongly patterned with a base color of white or cream and irregular yellow, brown and black blotches (Wilson and Mittermeier 2015). They are solitary and strictly nocturnal. They feed on a variety of leaves and fruits, and usually sleep curled up in an exposed position, high in the canopy.

Various forms of the Spotted Cuscus occur throughout New Guinea and on some nearby islands, with an elevational range on the main island of sea level to at least 1,500 m asl. The current arrangement of subspecies is unsatisfactory and will be replaced by a multi-species arrangement (Kris Helgen, pers. comm. to K. P. Aplin, December 2015). The form present in the hinterland of the Gulf of Papua is broadly distributed in the southern lowlands and along the southern slopes of the central cordillera.

Occurrence in the study area

This species was recorded in the lower reaches of the Purari River in the mid-1970s, during the initial Wabo Hydroelectric Scheme investigations (Liem 1977). It was considered particularly common in the mangrove forest.

This species is well-known throughout the study area. Trophy jaws were seen at Wabo village and at Paevera Village between Sites 8 and 9. Bones and teeth were identified in a firepit sampled at Site 8 (Appendix 2 Table 2.4).

The Spotted Cuscus probably occurs in all ecological zones of the study area. Occurrence in the Mangroves zone is supported by observations elsewhere within its geographic range (Wilson and Mittermeier 2015).

Threats and susceptibilities

The Spotted Cuscus is highly prized for its meat and also for its colorful fur which is used for personal decoration and for handicrafts. During the day, they can be located with the assistance of trained hunting dogs or by visually scanning the canopy. At night, they can be located by following the sounds of feeding or movement in the canopy, or through the use of a torch to detect their eye-shine. Spotted cuscuses make a range of vocalizations, including loud brays, hisses and growls, and they can also be located by these calls.

The breeding behavior of the Spotted Cuscus is probably similar to that of the lowland cuscuses except that twins are less frequent (Wilson and Mittermeier 2015). Pouch-life probably lasts for c. 6 months but the young probably stay with the female for a further 10-12 months. This long period of association with the adult female affords them some defense against natural predators but makes them more susceptible to human predation. Young Spotted Cuscuses are sometimes kept as village ‘pets’ though they are usually eaten once mature.

Spotted Cuscus can thrive in secondary habitats but populations near to human settlements are usually depleted through opportunistic hunting.

Persistence of this species in the study area is guaranteed by its broad ecological range, combined with its tolerance of a moderate level of environmental disturbance.

4.3 New-to-science and undescribed taxa

None of the non-volant mammals recorded as living animals during the survey appears to be new-to-science. However, as explained in Appendix 3, species within each of the rodent genera *Hydromys*, *Melomys*, *Paramelomys, Pogonomys* and *Uromys* are known to contain more species than are currently listed. Most of these will already have scientific names that can be resurrected from synonymy; however, a few may represent genuinely undescribed species that will require the proposal of new names. Among these taxa, available information is insufficient to determine whether the species present within the study area are scientifically undescribed or whether an available name is applicable.

Two species represented in the Wi'i Creek owl roost sample—a small water rat and a shrew mouse—are probably entirely new-to-science and neither has been collected as a living animal.

4.3.1 A Small Water Rat *Hydromys* sp. 1

This taxon is represented in the Wi'i Creek owl roost sample by a few isolated upper and lower molar teeth. These are identified from their morphology as belonging to a 'water rat'—a species of *Hydromys* or *Baiyankamys*—and are provisionally referred to *Hydromys* on the basis of habitat association (see below).

The teeth are certainly those of an adult animal, and are much smaller than those of the Common Water Rat (*H. chrysogaster*) that is also represented in the Wi'i Creek sample and is the only species of *Hydromys* known to occur in southern New Guinea (Flannery 1995; Helgen 2005). Two other species of *Hydromys* have similarly small teeth but their known populations are remote from the study area: *H. hussoni* known only from the Wissel Lakes area at 1,750–1,765m asl in far western New Guinea (Indonesia); and *H. ziegleri* from one locality at 213 m asl in the foothills of the Prince Alexander Range, East Sepik Province (Helgen 2005). The genus *Baiyankamys* also contains species with similar-sized teeth but the two species are found only at high elevations: *B. shawmayeri* (1,500–3,600m asl) of eastern New Guinea and *B. habbema* of west-central New Guinea (2,800–3,600m asl) (Helgen 2005). While referral of the Wi'i Creek specimens to *H. ziegleri* cannot be entirely ruled out, the wide geographic separation of the two localities makes it more likely that they represent a different species. This will only be resolved by capture of a live animal.

All of the small water rats are probably semi-aquatic and most are associated with fast-flowing streams (the habitat of *H. ziegleri* was not recorded). Judging by its rarity in the bone deposit the Purari small water rat may be a relatively uncommon species in the study area. In the vicinity of the cave it probably lives along the main channel of Wi'i Creek that flows over a coarse gravel bed, or along its steeper tributaries.

Suitable habitats for the Small Water Rat are widely distributed in the Middle Purari Hills and in the Southeast Hills ecological zones. It is less likely to occur in any of the lower elevation ecological zones within the study area, although this assessment could alter with the addition of further information.

Given the apparent natural rarity of the Small Water Rat, it is possible that it has been overlooked elsewhere. However, it is noted that some nearby localities, including the Karimui Plateau in the Purari uplands catchment, and the flanks of Mount Bosavi and Mount Sisa in the Kikori and Strickland catchments, rank among the most intensively sampled localities in PNG for mammals—and that no small water rat species is known from any of these areas.

For the present, this species is conservatively treated as not only new-to-science but also as a potential restricted-range taxon and local endemic (see *Section 4.5*).

4.3.2 Shrew Mouse *Pseudohydromys* sp. 1

This species is thus far represented in the Wi'i Creek owl roost sample by a single lower jaw that is clearly morphologically distinct from that of other known shrew mice (*Microhydromys* spp., *Pseudohydromys* spp.). Jaws of shrew mice are unmistakable on account of their small size and the presence of only one or two molars, rather than the usual three of most other rats.

Shrew mice are a poorly known but remarkably diverse group of New Guinean rodents (Helgen 2005; Helgen and Helgen 2009; Helgen et al. 2010). Most are mouse-sized and at least primarily terrestrial. All appear to be insectivorous and thus fill niches more commonly occupied by shrews in Eurasia and Africa—hence the collective common name. Only a few species are well represented in collections; many others are represented by only one or a few specimens and more than half of the currently recognized species were described only within the last decade. Discovery of additional species is fully anticipated.

The highest diversity of shrew mice occurs in high elevation mossy forests and only a few species are known to occur in hill forest habitats. These include the species of *Microhydromys* (Helgen et al. 2010) and two species of *Pseudohydromys* (*P. sandrae*, recorded only from 800–850m asl on Mount Sisa, Hela Province; and *P. berniceae*, recorded between 590–1,570 m asl in the Owen Stanley Range of Central and Milne Bay Provinces; Helgen and Helgen 2009). The geographically closest shrew mouse to the study area is *P. pumehanae* which is known from higher elevations on Mount Karimui (1,550m asl) and Mount Bosavi (2,100 m asl; Helgen and Helgen 2009). Each of these species as well as the genus *Microhydromys* can be ruled out on size and/or morphological differences.

This species clearly occurs in the Middle Purari Hills ecological zone. With so little information currently at hand, little more can be inferred regarding its breadth of occurrence within this ecological zone or its likelihood of occurrence in most of the other ecological zones within the study area. However, given that all shrew mice appear to be terrestrial it is unlikely to occur in habitats that are subject to regular inundation, including large parts of the Delta Swamps and Plains ecological zone and the entire Mangroves ecological zone.

Too few shrew mice have been collected from the southern foot-hills of the central cordillera of New Guinea to be certain that this shrew mouse species does not occur in other regional catchments. However, for the present, this species is conservatively treated as a new-to-science species and as a potential local endemic and a restricted-range taxon (see *Section 4.5*).

4.4 Newly recognized species

Two of the bandicoots encountered during the survey are currently unrecognized or are treated as subspecies based on their occurrence elsewhere. Both are treated here as probable full species of potential special conservation concern. They are distinct from new-to-science and undescribed species in that a scientific name is already applied, although their current taxonomic rank likely warrants elevation to full species status. Their conservation status has not been assessed for the IUCN Red List.

4.4.1. The Oriomo Bandicoot *Echymipera oriomo*

The Oriomo Bandicoot was described as a distinct species in 1936 but was subsequently treated as a regional population of *E. kalubu* or sometimes as a subspecies (*E. k. oriomo*; e.g. Flannery 1995). It is recognized here as a full species because it is morphologically distinct and occurs together with *E. kalubu* in both the Fly and Purari catchments (see Appendix 3 for details; and see Plates 4.1–4.3). It is the shortest-nosed and most brightly patterned member of the genus *Echymipera*.

All previous records of the Oriomo Bandicoot come from sites in the Fly River catchment. Its discovery in the study area represents the first known occurrence in Gulf Province and a range extension of c.

250 km. It is not known from the Kikori or Strickland River catchments but may be present in the poorly sampled alluvial forest habitat within these catchments. Thus far, it has not been detected in any archaeological faunal collections from sites in the lower Kikori catchment (David et al. 2010; K. P. Aplin, unpublished data).

Occurrence in the study area

The Oriomo Bandicoot was recorded from sightings of live and freshly killed individuals at Site 8, from diagnostic camera trap images at Sites 4, 5, 8 and 9, and from trophy jaws at Aivaru and Paevera villages (Appendix 2 Table 2.3). It thus occurs in the Delta Swamps and Plains and Southeast Coast ecological zones. As a terrestrial mammal, it is unlikely to occur in the Mangroves ecological zone or in parts of the Delta Swamps and Plains ecological zone that experience prolonged and extensive periods of inundation.

At Site 5 this species was imaged in both alluvial and hill forest; hence, it also occurs at the periphery of the Middle Purari Hills ecological zone. However, no images of the Oriomo Bandicoot were obtained at any of Sites 1- 3 further north in this ecological zone, and no examples are present in the Wi'i Creek Cave owl pellet sample (despite many examples of the slightly larger-bodied Common Echymipera *E. kalubu*). Accordingly, the Oriomo Bandicoot is considered to be absent from the Middle Purari Hills ecological zone except where it abuts other lower-lying ecological zones.

At Sites 8 and 9 this species inhabits the mosaic of disturbed primary and secondary forests. It is not known whether it also occurs in the associated garden and swamp habitats. At Sites 4 and 5 it occurs in primary alluvial forest with minimal anthropogenic disturbance, and at Site 5 in low elevation primary hill forest.

Threats and sensitivities

Comments provided for the Giant Bandicoot in *Section 4.2.1* regarding general threats and sensitivities of bandicoots, all apply to the Oriomo Bandicoot.

As the smallest member of its genus, the Oriomo Bandicoot may be more resilient than the other, larger species to impacts including hunting, predation by alien invasive species, and general habitat disturbance. However, until more information is known regarding its ecological associations, this species should not be assumed to be secure in any of the habitats that it currently occupies.

For the present, this 'newly recognized' species is conservatively regarded as a potential restricted-range taxon (see *Section 4.5*) and a species of potential conservation concern.

4.4.2. The Purari Long-nosed Bandicoot *Echymipera rufescens* subsp.

A morphologically and genetically distinctive 'population' of the Long-nosed Bandicoot (*Echymipera rufescens* subsp.) is present in the Purari River catchment. This form is more brightly patterned than typical examples of the Long-nosed Bandicoot, it has a less elongate snout and males are smaller, resulting in less pronounced sexually dimorphism. Examples of typical *E. rufescens* (a longer-snouted and less 'rufescent' taxon, with larger males) are known from sites in the Kikori and Strickland basins and from Brown River near Port Moresby (museum records; K. Aplin, unpublished data). The 'Purari' form and the 'typical' form of the Long-nosed Bandicoots might co-occur but given their very similar morphologies, they are more likely to display competitive exclusion.

An example of the 'Purari Long-nosed Bandicoot' was captured by Ken Aplin in 1984 near Haia Village in the foothills of Crater Mountain and genetic analysis suggested closer affinity to the Cape York population of Long-nosed Bandicoot *E. rufescens australis* than to other New Guinea populations of this species (Westerman et al. 2012). Subsequent morphological studies by Ken Aplin supported this interpretation but further genetic studies are required before the results can be published. In the interim, it is suggested that the Purari catchment population of *E. rufescens* should be considered a 'newly recognized' taxon. It is listed here as a subspecies of *E. rufescens* but may

prove to be a distinct species ('*E. australis*' if it also includes the Cape York population; otherwise an undescribed species).

Occurrence in the study area

Long-nosed bandicoots with the distinctive 'Purari' morphological features were captured at Sites 1 (Plate 3.4) and 8, and imaged on camera traps at Sites 1, 4, 5, 7 and 8 (Plates 3.5–3.6). It was represented among trophy jaws recorded at Avavu and Paevera villages, and was also found in the Wi'i Creek Cave owl pellet sample. This taxon thus appears to be widespread in the study area, spanning the Middle Purari Hills, the Delta Swamps and Plains, Southeast Hills and Southeast Coast ecological zones. As a terrestrial mammal, it is unlikely to occur in the Mangroves ecological zone or in parts of the Delta Swamps and Plains ecological zone that experience prolonged and extensive periods of inundation.

This species was imaged slightly more often in hill forest than in alluvial forest habitats (see *Section 4.7.1*). It appeared to be slightly less abundant in logged habits than in relatively undisturbed forests, but is clearly able to persist regionally in the presence of logging activity.

Where they co-occur, the Purari Long-nosed Bandicoot appears to be somewhat less abundant than either of the Common Bandicoot or the Oriomo Bandicoot, based on camera trap imaging rates (see *Section 4.7.1*).

Threats and sensitivities

Comments provided for the Giant Bandicoot in *Section 4.2.1* regarding general threats and sensitivities of bandicoots, all apply to the Purari Long-nosed Bandicoot. Considering its wide ecological range, this species will be more resilient to local impacts than other, more restricted bandicoot species such as the Oriomo and Giant Bandicoots. However, its larger size compared with the Common and Oriomo Bandicoots may make it more susceptible to impacts.

For the present, this 'newly recognized' species is regarded to be a potential restricted-range taxon (see *Section 4.5*).

4.5 Endemic and restricted-range species

The poor distributional and ecological knowledge for many species tempers any consideration of endemism or estimates of range of occurrence among New Guinean non-volant mammals. The calculations provided here are approximations based on inference, rather than secure estimates based on robust data.

4.5.1 Endemism

The study area is likely to support populations of up to 14 species that are endemic to the southern lowlands of New Guinea (Endemism category 5; see Table 4). Most of these species are relatively widespread and also have relatively broad elevational ranges.

Ten of the terrestrial non-volant mammal species[6] that occur in the study area are placed in Category 5—endemic to the southern lowlands of New Guinea. Each of these species is also endemic to Papua New Guinea, though some of these (e.g. the Oriomo Bandicoot, the Southern Groove-toothed Shrew Mouse) might be expected to range west into the Indonesian Province of Papua. Table 9 shows the known or likely distribution of these species in the various catchments that make up the southern lowlands of New Guinea.

Eight of these species also qualify as restricted-range species and will be discussed in more detail below. Although the geographic ranges of the Southern Lowland Cuscus *Phalanger mimicus* and the

[6] All marine aquatic mammals occurring in the study area are wide-ranging species with Endemism category 1.

Long-nosed Paramelomys *Paramelomys* cf. *naso* within PNG probably qualify them as restricted-range, both are thought to also have quite large ranges in the Indonesian Province of Papua, which in each case would push them over the arbitrary 50,000 km^2 for restricted-range status. More detailed information on their occurrence in Indonesia is needed before they can be meaningfully mapped and assessed.

Table 9. Potential examples of restricted endemism among non-volant mammal species that are recorded or are likely to occur in the study area, based on occurrence in New Guinea's major southern catchments (some species also have restricted occurrences in the northern watershed (e.g. Giant Bandicoot). Confirmed occurrences are shown by a '+' and shading; confident absences by a '-'; questionable absences by a '?'. Species that probably qualify as restricted-range species are indicated by an asterisk.

Species	Southwestern catchments central cordillera	Fly River catchment	Strickland River catchment	Kikori River catchment	Purari River catchment	Southern catchments of Owen Stanley Range	Cape York Peninsula
Woolley's Three-striped Dasyure*	?	?	+	?	+	+	-
Giant Bandicoot*	-	-	-	-	+	-	-
Oriomo Bandicoot*	?	+	?	?	+	-	-
'Purari' Long-nosed Bandicoot*	-	-	-	?	+	?	+
Lowland Tree Kangaroo*	-	+	+	+	+	-	-
Southern Lowland Cuscus	+	+	+	+	+	-	+
Long-footed Paramelomys*	-	-	-	+	+	+	-
Long-nosed Paramelomys	+	+	+	+	+	-	-
Southern Groove-toothed Shrew Mouse	?	?	+	+	?	+	-
New Small Water Rat*	?	?	?	?	+	?	-
New Shrew Mouse*	?	?	?	?	+	?	-

4.5.2 Restricted-range species

Eight species are here considered candidates for restricted-range status. These are listed in Table 10, which also provides information on the estimated area of occurrence, the likely degree of continuity of populations within this area of occurrence, the likely population density (expressed only in relative terms due to complete lack of actual estimates), and the state of distributional and ecological knowledge for the species.

The geographic and habitat criteria used to calculate the area of occupancy for each of the species listed in Table 10 is as follows:

- Woolley's Three-striped Dasyure – western flanks of Mount Bosavi to eastern flanks of Mount Victoria, in all forest types from 50 m to 1,500 m asl.
- Oriomo Bandicoot – Fly River and Purari catchments only, all alluvial forest types, hill forest on relict alluvial plains, and areas with occasional flooding similar to that occurring at the type locality in the Trans-Fly (Fly River catchment), from sea level to 100 m asl.
- 'Purari' Long-nosed Bandicoot – Purari catchment, Purari catchment and Vailala catchments, east to Kerema and the Kukukuku lobe area, from sea level to 700 m asl.
- Giant Bandicoot – Purari catchment to Milne Bay and northern lowlands to Oro Province, all habitats from 0–750 m asl.
- Lowland Tree Kangaroo – Strickland, Kikori, Purari and Vailala River catchments, east to Kerema and the Kukukuku lobe area, from sea level to 700 m and including all hill forest types.
- Long-footed Paramelomys – 1) western flanks of Mount Bosavi east to the tip of the southeast peninsula and from sea level to c. 1,000 m asl, including all hill forest types. This terrestrial forest-dwelling rodent was widespread in the study area where it was captured in all ecological zones except the Mangroves. It was the fifth most commonly captured of 11 trapped rodent species (Appendix 2). Threats and susceptibilities are similar to those described above for the Southern Groove-toothed Shrew Mouse (Section 4.2.13).
- New Small Water Rat – 1) Purari catchment only, west to and including Mount Favenc, all hill forest types (to 1,000 m asl); or 2) Kikori + Purari + Vailala River catchments, between Mount Bosavi and the Kerema and Kukukuku lobe area, all hill forest types (to 1,000 m asl).
- New Shrew Mouse – same criteria as for New Small Water Rat.

4.6 Migratory/congregatory species

No Melanesian terrestrial non-volant mammals are known to be migratory although many have large individual territories and undertake substantial movements in pursuit of scattered resources.

Most are also solitary except during courting behavior and when females are rearing young. Where congregations have been observed, these behaviors are usually associated with ephemeral food resources such as fruiting trees. Interestingly enough, even where surplus food is provided such as in the case of baited camera traps, most species of non-volant mammals display a natural aversion to interactions with members of either their own species or of other species, as few images ever show more than one individual.

The Dugong and the two dolphins have more complex behavioral repertoires that might include migratory and congregatory behaviors. No local congregations of either species were reported by residents of the coastal or Purari delta communities.

Table 10. Potential restricted-range species recorded in the study area.

Species	Estimated area of occurrence	Likely degree of continuity within this area	Likely population density where present	Comments on state of distributional and ecological knowledge
Woolley's Three-striped Dasyure	c.40,000 km^2	Probably continuous	Very low	Poor
Oriomo Bandicoot	c. 35–40,000 km^2	Probably fragmented	Moderate	Poor outside of Purari catchment
Giant Bandicoot	<45–50,000 km^2	Very fragmented	Low	Poor
'Purari' Long-nosed Bandicoot	c. 10–12,000 km^2	Probably continuous	Low	Poor outside of Purari catchment
Lowland Tree Kangaroo	c. 50,000 km^2	Probably fragmented due to variable habitat suitability to support large herbivore	Very low	Moderately good
Long-footed Paramelomys	<45,000 km^2	Probably continuous	Moderate	Poor outside of Purari catchment
New Small Water Rat	1)<10,000 km^2 2) c. 25,000 km^2	Probably fragmented, restricted to certain parts of drainage networks	Probably very low	Extremely poor
New Shrew Mouse	1)<10,000 km^2 2) c. 25,000 $km^{2)}$	Probably continuous	Probably very low	Extremely poor

4.7 Invasive alien species

Four groups of invasive alien mammal species occur in the study area either as feral or domestic animals: various rodents, the cat (*Felis catus*), the dog (*Canis familaris*), and the pig (*Sus scrofa*).

4.7.1 Rodents

Four exotic alien rodent species were detected during the survey:

- Pacific Rat (*Rattus exulans*).
- Black or Roof Rat (*Rattus rattus*).
- House Mouse (*Mus musculus*).
- Small Spiny Rat (*Rattus steini*).

Their recorded distribution within the study area is shown in Table 11.

Table 11. Recorded occurrence of invasive alien rodent species in the study area. Where it is remembered by local residents, the date of arrival is indicated. '+' = present, '-' = not recorded.

Location	*Rattus exulans*	*Rattus rattus*	*Mus musculus*	*Rattus steini*
Herd Base	-	+	+	-
Antelope-3 Operations Camp	-	+	-	-
Site 2 former seismic camp	-	-	-	+
Site 3 active forestry road	+	-	-	-
Wabo village	-	+ (2015)	-	-
Evara village	+(post-2000)	+(post-2000)	-	-
Poroi village	-	-	-	-
Avavu village	-	+(pre-1970s)	-	-
Kavava village, Orokolo Bay	-	+ (pre-1970s)	-	-

The **Pacific Rat** is native to eastern Indonesia (Thomson et al. 2014) and it spread through the Pacific around 3,000 to 4,000 years ago. Although it may have colonized New Guinea at this time, it is still absent from many parts of the country and is generally restricted to heavily modified areas of intensive agriculture or industrial disturbance (Flannery 1995; Aplin et al. 2003). As a rule, it seems to be absent from areas of primary forests if they also retain a suite of native rodent species. However, where the native fauna has declined for whatever reason, the Pacific Rat seems capable of invading any habitat including primary forest (Aplin and Ford 2013; Timm et al. 2016). It thus appears to be a poor competitor but nonetheless very adaptable in the absence of competition.

Pacific Rat was captured at only one village—Evara, where residents stated that the introduced rats had arrived soon after the construction of the nearby logging camp in 2000. In addition, this species was trapped at Site 3, c. 7 km by road from the logging camp. At this site, Pacific Rats were trapped along the active logging road but not along an abandoned logging track where thick grass and shrub gave captures of two native species associated with early regrowth habitats—*Rattus leucopus* and *Melomys leucogaster*. At no site was the Pacific Rat trapped in any forest habitat.

The **Black or Roof Rat** is actually a group of closely related species that originated on mainland Asia and spread at various times and in various directions but most likely always with human assistance (Aplin et al. 2011; K. P. Aplin et al. unpublished data). Preliminary genetic sampling of New Guinean samples indicates that it has received Black Rats from multiple sources including animals of both European and Asian derivation (K. P. Aplin et al unpublished data). Until recently these animals were confined to the major towns but in the past decade or two they have invaded rural communities in both lowland and highland provinces of PNG (K. P. Aplin et al, unpublished data). In several areas, the recent arrival of these pest species is attributed by local people to the activities of resource development projects. Given that long-distance dispersal of invasive rodents is primarily by road and/or air, this perception is probably correct, at least for formerly remote localities.

The Black Rat was captured in several different contexts within the study area (Plate 6.2). In the coastal villages of Orokolo Bay and at Avavu Village they were trapped inside houses. Residents of these villages considered them a serious pest but also described them as a 'custom' rat, i.e. to have always been present. A long history of infestation in these villages is certainly plausible given the

early establishment of missions and coconut plantations in this area, with regular vehicle traffic through to Port Moresby up until a few decades ago. Despite this long invasion history, Black Rats were not detected in the nearby garden or forest habitats.

In the northern part of the study area Black Rats were trapped at several Project facilities and in one village (Wabo), with several other villages also reporting rat infestations. These invasions appear to be quite recent and may be independent of the populations present in villages along the coast and in the lower delta (see below).

At Herd Base a Black Rat was captured on 18 June 2016 inside the main complex. More intensive trapping in January 2016 at the ANT-3 OC produced captures in the building and container complexes, along drains, and in areas of piled, cut timber. By contrast, none were trapped along the roadside running south from the ANT-3 OC, in the forest to the west of the camp, or at the abandoned ANT-2 drilling pad and adjacent campsite. Instead, these trapping lines produced two native species associated with early regrowth habitats—*Rattus leucopus* and *Melomys leucogaster*. Trapping in the camp area at ANT-3 OC also produced captures of *Rattus leucopus*. In the case of ANT-2 it is not known whether Black Rats were formerly present at this camp and declined since decommissioning or alternatively, whether they were never present. On the other hand, the rarity or absence of Black Rats along the roadside or in the nearby forest suggests exclusion by 'disturbance tolerant' native species such as *Rattus leucopus* (Plates 6.3 and 6.4) and *Melomys leucogaster* (see Section 4.7.3 for further discussion).

An important observation is the evidence for close cohabitation of Black Rats and a native species—*Rattus leucopus*. At ANT-3 OC these species were very likely engaging in direct interspecific interactions such as fighting, attempted mating, sequential sharing of nest sites, thereby providing regular opportunities for transfer of zoonotic diseases (Henttonen et al. 2008). Examples of the decline of native rodent faunas following the introduction of novel diseases through interspecific interactions are provided by Goodman (1994) for Madagascar and Wyatt et al. (2008) for Christmas Island.

Residents of Wabo, Uraru (who were interviewed at Wabo), and Subu 2 villages stated that rats arrived within the last 1-2 years and are now numerous. They are regarded as the cause of much hardship, especially through bites and damage to food and clothing. Trapping at Wabo confirmed that these were Black Rats, with 18 captured from deployment of 40 traps for one night. Apart from the obvious discomfort and damage caused by this new pest, there are significant health risks to a population with no prior exposure to the many diseases carried by Black Rats. Although no Black Rats were captured in forest habitat in PRL-15, residents of Wabo claimed that they are present in some of their seasonally occupied 'bush camps'.

The Black Rats captured at Wabo differ in fur texture and color from those captured in the coastal villages and it is likely that they represent a different form of *Rattus rattus* and derive from a separate invasion event. This possibility is being investigated genetically with independent funding from a research grant to K. P. Aplin and a collaborator at the University of Adelaide/South Australian Museum.

The **House Mouse** (*Mus musculus*) is a small species of Middle Eastern origin that spread worldwide with European colonial shipping. According to Menzies and Dennis (1979) it is common in some coastal towns and villages and in grasslands around Port Moresby, and Flannery (1995) reported its occurrence in the isolated montane town of Telefomin in West Sepik Province, where it must have arrived by aircraft. Its wider distribution in PNG is poorly documented but recent reports suggest that it is actively spreading through settlements in Central, Eastern Highlands and Hela provinces (Aplin, unpublished). In Hela Province in 2014, a House Mouse was collected in an isolated garden hut surrounded by forest (K. P. Aplin, unpublished data). The small size of the House Mouse makes it particularly susceptible to accidental transport with bagged food or household items such as bedding.

A House Mouse was observed at close quarters (inside a neon light cover where it was feeding on insects) by K. P. Aplin at Herd Base on 8 July 2016. Staff reported 'mice' to be common in the camp but it is uncertain whether this refers to the House Mouse or juvenile rats that are often mistaken for mice. It is not known whether this species has invaded any other Project infrastructure sites, or any local villages or camps.

The **Small Spiny Rat** (*Rattus steini*) is a native New Guinean species that is widespread in montane areas of New Guinea (Taylor et al. 1982) and is most abundant in gardens and other disturbed contexts (Flannery 1995; Aplin et al. 2003). Although there are some lower elevation records, these come from the northern lowlands of PNG (Taylor et al. 1982) and are probably unreliable (K. P. Aplin, unpublished). The lowest record from southern PNG comes from 700 m asl on the northern flanks of Mount Bosavi (Taylor et al. 1982) and the lowest in the Purari catchment is from the western flanks of the Karimui Plateau at c. 850 m asl (AMS specimens). Importantly, trapping in 1984 in gardens as well as forest around Haia village at c. 600 m asl in the Purari catchment uplands failed to result in any capture of this species which suggests that it was absent at that time (K. P. Aplin, unpublished data). Garden habitats through the lower Purari catchment generally support populations of the Southern Lowland Rat (*Rattus leucopus*) which is similar in size and morphology to the Small Spiny Rat and may exclude it from lower elevations through competition.

The Small Spiny Rat was encountered only once in the study area—at Site 2 where it was trapped in regrowth scrub on a former seismic campsite. While it is possible that this represents a natural occurrence of the species, the fact that it was not trapped at any other regional site and also appears to be more broadly absent from the Purari catchment below 850 m asl suggests otherwise. There is at least one other recent isolated and unexpected record of the Small Spiny Rat from a seismic camp (at high elevation in Hela Province; K. P. Aplin unpublished) and it seems likely that it is moving with equipment and/or other freight, presumably from a source area in the highlands where it is extremely abundant in disturbed habitats (Taylor et al. 1982).

4.7.2 Feral pig

Pigs were introduced into New Guinea as domestic animals around 2,500 years ago. Since then feral populations have become established in many areas and across a wide elevational range (Hide 2003).

Where feral pigs occur at high density they cause extensive physical damage to the forest floor and to wetland habitats. Their full impact on natural ecosystems is not documented in PNG but in some areas, it must be substantial given their abundance and the scale of observed structural changes.

The distribution of feral pig populations across the various ecological zones and its relationship with various disturbance factors is of interest given the potential of this species to cause damage and structural change to natural habitats. Signs of feral pig activity were observed at every survey site within the study area but the scale of habitat damage was quite variable.

The camera trap results provide some insight into the distribution of feral pigs in the study area (Tables 11 and 12). Average RAIs at each site vary from 0 to 0.38, with the highest values in relatively undisturbed alluvial forest in Sites 4 and 5, followed by logged hill forest in Site 3 and logged alluvial forest in Site 7 (Plate 7.6). No images of pigs were obtained at Sites 1, 2, 8 and 9.

The high RAIs at Sites 4 and 5 might reflect the fact that some cameras were deployed for long periods at these sites, thereby recording activity outside of the disruptive period during which field camps were occupied (although at all sites an effort was made to place cameras some distance from regular survey trails). However, this does not account for the contrasts between Site 3 and the remaining sites, all of which had similar periods of camera deployment. More likely explanations for these patterns are that the low values at Sites 8 and 9 are due to hunting pressure out of nearby human settlements; the low value at Site 1 might be due to vehicle disturbance perhaps combined

with hunting based out of roadside camps (3 of 5 firepits sampled at Site 1 contained remains of pigs; Appendix 2 Table 2.4); and the low value at Site 2 might be due to low productivity of the naturally disturbed forest at this site.

A reasonable interpretation of these data is that feral pigs exist at high densities in relatively undisturbed alluvial forest habitats of the study area (Tables 12 and 13), and that they are less abundant in the hill forest habitats and wherever they are subject to hunting by local communities. Whether or not pig numbers are affected by logging *per se* is not clear as the areas of logged alluvial forest at Site 8 and of logged hill forest at Site 3 were both visited on a regular basis by hunters from nearby communities.

4.7.3 Feral dog

Dogs have also been present in New Guinea since prehistoric times but their status as feral animals has attracted little attention. In part this is due to the emphasis on the question of the identity and conservation status of the high elevation 'singing dog' populations (e.g. Koler-Matznick et al. 2007). In addition, there is often no clear boundary between domestic and feral populations, with village dogs often leaving to enter the feral population and feral dogs entering the village population as a result of the capture and rearing of wild pups (Dwyer and Minnegal 2016).

Where feral dogs are present they represent the apex predator within New Guinean ecosystem. As such, they can be expected to influence population densities and dynamics of their prey items—medium-sized to large omnivores and herbivores, such as bandicoots and wallabies. Through such mechanisms, feral dogs have the potential to influence many aspects of local ecology; accordingly, any factor that might influence feral dog distributions or population densities is of concern.

A dog was imaged only once on a camera trap (at Site 8; Table 12) but footprints of dogs were noted at other sites including Site 6A along the Herd Base–Hou Creek road. In this case, the dog footprints were not accompanied by those of people and, in the opinion of our local field assistants, the prints were probably those of feral dogs that they said were common in this area. At some other surveyed localities within PNG there are indications that feral dogs may be using project infrastructure such as road networks to access or expand their foraging and/or residential ranges into formerly remote areas (K. P. Aplin, unpublished data). Whether or not this is occurring in the study area is not known.

4.7.4 Cats

In Australia, feral cat populations have had a devastating impact on native wildlife in almost every habitat and region. Although New Guinean rainforest environments have been thought to be too wet for feral cats to thrive, there are now several regions of PNG where feral populations appear to be widely established including the Karimui Plateau (Pernetta 1983; citing information from R. L. Hide) and Manus Island, New Ireland Province (Timmet al. 2016).

No evidence was obtained of feral cats in the study area. However, cats are being kept in 23 of 27 villages surveyed during the social survey (ERIAS Group, 2017) and people interviewed by K. P. Aplin and J. Novera about this in nine villages confirmed that the usual motivation was to control rodent pests. Cats are also kept at some Project facilities (e.g. Herd Base and formerly ANT-3 OC).

Cats also pose health risks to people, livestock and wildlife, most notably through their pivotal role as a primary reservoir of the globally distributed protozoan parasite *Toxoplasma gondii*, the pathogenic agent of toxoplasmosis (Dabritz and Conrad 2010). All warm-blooded animals (birds as well as mammals) are susceptible to infection by this pathogenic organism that can be transmitted through consumption of infected meat, through contact with soil or water contaminated by cat feces, or by cross-placental transfer (at least in cats, humans and rodents; Webster 1994). Once established in a mammal or bird community, *T. gondii* can persist in the absence of its definitive cat host, probably due to its alternative means of infection (Meerburg et al. 2009).

4.8 Community Structure

A consideration of community structure at this stage of the investigation is useful as a means of comparing and contrasting the non-volant mammal biodiversity values for the major habitat types, and to gain an understanding of the potential resilience of local mammal communities to disturbance of various kinds and intensities.

4.8.1 Analysis of camera trapping data

Table 12 shows average Relative Abundance Index (RAI) values calculated from camera trap data for each of the eight principal survey sites. Table 13 compares RAI values for areas of hill forest and alluvial forest with 'minimal to slight extractive disturbance' (hereafter called 'low disturbance' and for areas of the same habitats but with prior logging activity (see Appendix 2 Table 2.2 for full dataset). The variation among sites and between these habitats is also summarized graphically in Figures 9–11.

Interpretation of the results requires some further consideration of the comparability of data from short-term (baited) camera traps *vs* long-term (unbaited) camera traps. Whether or not these factors had any strong influence on the RAIs seems to differ among the various groups of mammals.

The provision of bait clearly influenced the RAIs for rodents that were frequently imaged feeding on the bait; furthermore, at many sites the same individual (recognizable by unique damage to the tail or an ear) would be seen to revisit the bait several times each night, presumably owing to the bait being placed in proximity to a burrow or nest. By contrast, baits typically were ignored by wallabies and bandicoots that generally moved through the imaging area or, if they stayed for any length of time, were imaged feeding on fruits or leaves, or in the case of bandicoots, digging for worms and grubs. Given this contrast, RAIs for most rodent species will be inflated on baited camera traps.

Length of deployment of a camera trap clearly increases the chance of detecting any species that is less common, especially if it is also relatively mobile (larger home range). However, for the more commonly imaged species such as wallabies and pigs, examination of the data across all cameras does not reveal any strong relationship between first imaging and the number of days since setup. For example, wallabies and pigs were imaged on any night after setup including the first; it thus appears that the effort taken to place cameras away from areas of general survey disturbance was successful and that the single visit needed to deploy the camera trap was not itself very disturbing.

4.8.2 Forest type

The 'low disturbance' hill forest camera traps produced the highest overall RAIs (average 4.56 for all taxa combined; maximum of 9.15) but relatively low diversity, with eight of the 14 native taxa imaged. 'Low disturbance' alluvial forest produced lower RAIs (average 2.70 for all taxa combined; maximum 8.60) but higher diversity (13 of 14 native species).

One species was recorded in 'low disturbance' hill forest but not in the 'low disturbance' alluvial forest—Long-tailed Murexia *Murexia longicaudata* (Plate 3.1). Like the New Guinea Quoll, it is probably naturally uncommon in lowland New Guinean forests due to low abundances of its major prey items. Notably, this species was imaged in logged alluvial forest (Table 13).

Five additional species were imaged in 'low disturbance' alluvial forest—Woolley's Three Striped Dasyure (Plate 3.3), Giant Bandicoot (Plates 4.5–4.6), Common Water Rat, False Water Rat (Plate 7.5) and Lowland Ringtail (Plate 5.3). Some of these contrasts are clearly sampling artifacts—Common Water Rat and Lowland Ringtail are recorded in the Wi'i Creek owl roost sample and thus are confirmed present in hill forest in the northern part of the study area, while Woolley's Three Striped Dasyure is known from hill and lower montane forest outside the study area. However, the pattern may be genuine for the False Water Rat and the Giant Bandicoot, neither of which is represented in the Wi'i Creek owl roost sample (despite the occurrence of juvenile remains of other

bandicoots and of the Common Water Rat and new-to-science small water rat) and show a similar preference for true lowland habitat types outside of the study area (see Section 4.2 for further details).

Among the species that occur in 'low disturbance' areas of both forest types, RAIs are very similar for almost all species (Figure 9). A notable exception is Grey Dorcopsis (Plates 5.4 and 6.1) which was imaged almost three times as often in 'low disturbance' alluvial forest as in 'low disturbance' hill forest. By contrast, 'spiny' bandicoots *Echymipera* spp. (including the potentially distinct local form of the Long-nosed Echymipera) and the Ground Cuscus *Phalanger gymnotis* were imaged more frequently in hill forest than alluvial forest, although the contrasts are less marked in each case.

Even greater contrast is observed for the Southern Lowland Rat which was imaged more than ten times as often in the 'low disturbance' hill forest as in 'low disturbance' alluvial forest. Contrasting duration of imaging does not explain the marked differences in RAI for this species—the highest RAI values for Lowland Rat in the hill forest habitat came from baited camera traps deployed at Site 1 for only 90–91 hours (RAIs of 7.71 and 7.76; Appendix 2 Table 2.2); however, an RAI of 5.06 was obtained on an unbaited deployment lasting 1,562.75 hours at Site 5. An interesting point is that two of the four highest values for 'low disturbance' alluvial forest came from cameras at Site 1 where this habitat is at higher elevation than most of the other sites. Although the Southern Lowland Rat is best known from alluvial forest habitats (Taylor et al. 1982), the present data suggest that is may be better regarded as a hill forest species that extends into alluvial forests. This is more consistent with its documented habitat preferences on Cape York in Australia (Moore and Leung 2008).

Pigs were imaged at very similar rates in the 'low disturbance' hill and alluvial forests (Table 13).

To summarize these results, areas of 'low disturbance' hill forest in the lower Purari catchment appear to support lower terrestrial non-volant mammal diversity than areas of 'low disturbance' alluvial forest. Alluvial forest also supported higher densities of the IUCN Vulnerable Grey Dorcopsis. However, population densities of certain species appear to be higher in the hill forest, most notably the Ground Cuscus and the spiny bandicoots including the potentially distinctive local form of the Long-nosed Echymipera.

4.8.3 Areas of natural and artificial disturbance

The naturally disturbed hill forest at Site 2 had the lowest species diversity (only 5 native taxa) but the overall RAI for all taxa was moderately high (2.75) due to the frequent imaging of two rodents, the Giant White-tailed Rat and one or more species of *Paramelomys* (Table 12), both of which were attracted to the baits. Small mammal trapping at this site resulted in a low capture rate (2.5%) with most captures being of *Paramelomys platyops* (Appendix Table 2.1) but including one Giant White-tailed Rat. The Grey Dorcopsis was not imaged at this site and no other signs of wallabies such as footprints or feces were noted.

The logged hill forest produced images of fewer native taxa than the 'low disturbance' hill forest (6 *vs* 8); the overall RAI was also lower (1.68 *vs* 4.56). Despite these contrasts, the Grey Dorcopsis was imaged at almost the same rate in logged as in 'low disturbance' hill forest (0.15 *vs* 0.22). *Echymipera* spp. were imaged slightly more often in logged forest, while the Lowland Rat was imaged far less often (average RAI of 0.21 *vs* 2.17). The Ground Cuscus was not imaged at all in the logged hill forest.

The logged alluvial forest produced a lower average RAI across all taxa than 'low disturbance' alluvial forest (1.45 *vs* 2.70) and lower species diversity (7 *vs* 13 species). In this case, the contrast in diversity might be due to the much larger effort devoted to sampling the 'low disturbance' alluvial forest (64 camera traps and 49,862.75 hours) than the logged alluvial forest (10 camera traps and 1,230 hours).

Seven species were imaged in the 'low disturbance' alluvial forest but not in the logged alluvial forest—Woolley's Three Striped Dasyure, Lowland Ringtail, Common Water Rat, False Water Rat, Southern Lowland Rat, False Water Rat, and Giant White-tailed Rat (Plates 7.1 and 7.2). Most of these contrasts are probably sampling artifacts due to the much lower imaging effort in the logged forest type. However, the contrasts are probably significant for two species—Southern Lowland Rat and Giant White-tailed Rat with average RAI of 0.20 and 0.69 respectively, in 'low disturbance' alluvial forest compared with 0.00 in logged alluvial forest (Table 13). This result makes sense for the Giant White-tailed Rat, which is probably limited by access to particular fruit and nut resources, and perhaps by availability of tree hollows. However, it is difficult to interpret for the Southern Lowland Rat, which was found in highly disturbed contexts in the Middle Purari Hills ecological zone.

One species was recorded exclusively in the logged forest—Long-tailed Murexia. As noted above, this is probably a sampling artifact due to the natural rarity of this species in lowland New Guinean forests.Among the taxa represented in both disturbance categories of alluvial forest, lower RAIs were recorded in logged habitat for Grey Dorcopsis, Giant Bandicoot and *Paramelomys* spp. (Figure 10). The most striking contrast is for Grey Dorcopsis, which was imaged, more than four times as often in 'low disturbance' alluvial forest (0.64) than in logged alluvial forest (0.14).

To summarize these results, logged hill and alluvial forests show evidence of lower terrestrial non-volant mammal diversity as well as reduced abundances for many taxa including the terrestrial Grey Dorcopsis and the scansorial Giant White-tailed Rat.

4.8.4 Rodent communities as indicators of disturbance

Table 14 illustrates the strongly contrasting rodent communities found in various natural and artificial habitats in the study area. This tabulation combines data obtained from small mammal trapping and camera trapping and includes some habitat categories not sampled by camera trapping alone, such as the operations camp, road verges and ROW habitats, and the alluvial forest with high natural disturbance (represented at Site 5 by alluvial forest with severe dieback following flooding).

The rodent communities are clearly sensitive to both natural and anthropogenic disturbances. Sites with relatively undisturbed hill forest or alluvial forest support diverse rodent communities dominated by species of *Paramelomys* and *Melomys* but with other, rarer elements as well (e.g. *Xeromys myoides*). Fewer species occur in areas of naturally disturbed hill or alluvial forest. Rodent communities in disturbed hill forest are dominated by *Rattus leucopus* and *Melomys leucogaster*; while in disturbed alluvial forest these are joined by *Paramelomys platyops*. These species represent a 'disturbance tolerant' guild in the Purari catchment. In other parts of New Guinea, the same role is played by different species of the same genera, for example by *Rattus steini, Melomys* cf. *rufescens* and *Melomys lutillus* in the agricultural landscape of the New Guinea highlands (Dwyer 1984; Flannery 1995).

Rattus leucopus and *Melomys leucogaster* were also abundant in all road verge habitats trapped in several sites, including both active and disused roads. Uniquely, at Site 3 they were joined along an active forestry road by the introduced Pacific Rat. Although this species was abundant in this habitat, it was not trapped in nearby forest habitats or along a disused track within 0.5 km and directly connected to the active road. The active camp at ANT-3 OC produced abundant captures of the introduced Black Rat and the native *Rattus leucopus*. Both species were trapped immediately adjacent to buildings and containers as well as in the surrounding clearings and drains. Remarkably, the Black Rat was not trapped along the road that leads south from the camp, even though trapping commenced within 100 m of the camp margin. Instead this habitat produced captures of *Rattus leucopus* and *Melomys leucogaster.* These species may be capable of excluding the Black Rat through competition in areas where there is not an overabundance of food resources. In the camp, food was available in disposal skips as well as rubbish pit.

Table 12. Summary of Relative Abundance Index (RAI) data from the eight sites where camera traps were deployed. RAIs are shown for each taxon and for the total number of encounter events. Values shown are the Average RAI across all cameras at that site. For each site the number of camera traps is shown in brackets.

Site	No. cameras	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens subsp.*	*Echymipera* sp. indet.	*Peroryctes broadbenti*	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys* cf. *chrysogaster*	*Melomys leucogaster*	*Paramelomys* sp.	*Rattus leucopus*	*Uromys* cf. *caudimaculatus*	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	Total events
1	21	0.09	0.00	0.04	0.12	0.19	0.00	0.13	0.00	0.14	0.00	0.00	0.59	1.97	0.83	0.00	0.00	0.00	4.10
2	11	0.00	0.18	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	1.25	0.09	1.13	0.00	0.00	0.00	2.75
3	11	0.00	0.00	0.00	0.08	0.70	0.00	0.15	0.00	0.00	0.00	0.07	0.24	0.08	0.16	0.00	0.00	0.21	1.68
4	25	0.00	0.01	0.01	0.16	0.21	0.00	0.95	0.00	0.09	0.02	0.00	0.40	0.26	0.56	0.00	0.00	0.33	3.01
5	20	0.00	0.00	0.20	0.03	0.09	0.00	0.67	0.09	0.04	0.00	0.07	0.23	0.36	0.49	0.00	0.00	0.38	2.55
7	13	0.05	0.00	0.19	0.05	0.06	0.26	0.38	0.00	0.00	0.00	0.07	0.19	0.00	0.30	0.00	0.00	0.13	1.68
8	11	0.00	0.00	0.20	0.10	0.22	0.00	0.19	0.00	0.00	0.00	0.25	0.77	0.00	0.10	0.13	0.10	0.00	2.14
9	11	0.00	0.00	0.19	0.00	0.19	0.19	0.45	0.00	0.00	0.00	0.42	0.10	0.00	0.79	0.00	0.00	0.00	2.33

Table 13. Summary of Relative Abundance Index (RAI) data grouped by forest type and disturbance categories. Values shown for each combination of forest type/disturbance category are: Average RAI across all camera traps; Minimum RAI and Maximum RAI for any camera trap. The number of camera traps deployed in each habitat type is shown in brackets.

Habitat/ measure	No. cameras	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens subsp.*	*Echymipera sp. indet.*	*Peroryctes broadbenti*	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys cf.chrysogaster*	*Melomys leucogaster*	*Paramelomys sp.*	*Rattus leucopus*	*Uromys cf. caudimaculatus*	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	Total events
Low disturbance hill forest																			
Average	19	0.1	0	0.13	0.15	0.26	0	0.22	0	0.17	0	0	0.61	2.17	0.59	0	0	0.15	4.56
Minimum RAI	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1
Maximum RAI	19	1.7	0	2.11	1.11	0.89	0	0.76	0	1.11	0	0	3.78	7.76	2.45	0.06	0	1.36	9.15
Logged hill forest																			
Average	11	0	0	0	0.08	0.7	0	0.15	0	0	0	0.07	0.24	0.08	0.16	0	0	0.21	1.68
Minimum RAI	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum RAI	11	0	0	0	0.9	4.48	0	0.88	0	0	0	0.73	0.88	0.88	0.87	0	0	1.46	5.38
Low disturbance alluvial forest																			
Average	64	0	0.03	0.07	0.08	0.13	0.02	0.64	0.03	0.04	0.01	0.02	0.53	0.2	0.69	0.02	0.02	0.19	2.7
Minimum RAI	64	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum RAI	64	0.05	1.08	2.16	1.05	1.41	1.05	2.9	1.57	0.32	0.19	0.6	8.42	3.49	6.45	1.41	1.08	1.58	8.6
Logged alluvial forest																			
Average	10	0.07	0	0.25	0.07	0.08	0.34	0.14	0	0	0	0.09	0.24	0	0	0	0	0.17	1.45
Minimum RAI	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum RAI	10	0.69	0	0.84	0.69	0.84	3.35	1.39	0	0	0	0.87	1.73	0	0	0	0	0.87	5.86

Figure 11. Average RAIs for each mammal taxon in the 'low disturbance' habitats for each of the two main forest types in the study area, calculated across all camera trap positions in these habitats.

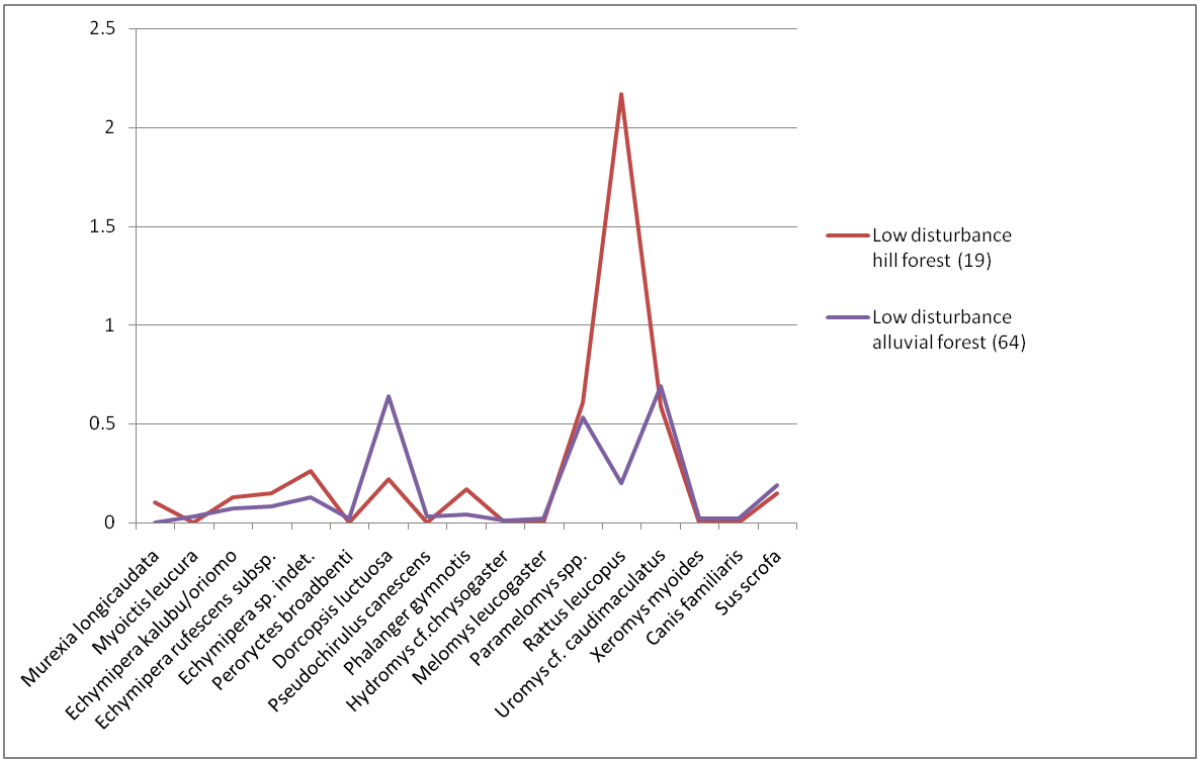

Figure 12. Average RAIs for each mammal taxon in 'low disturbance' hill forest and logged hill forest, calculated across all camera trap positions in these habitats.

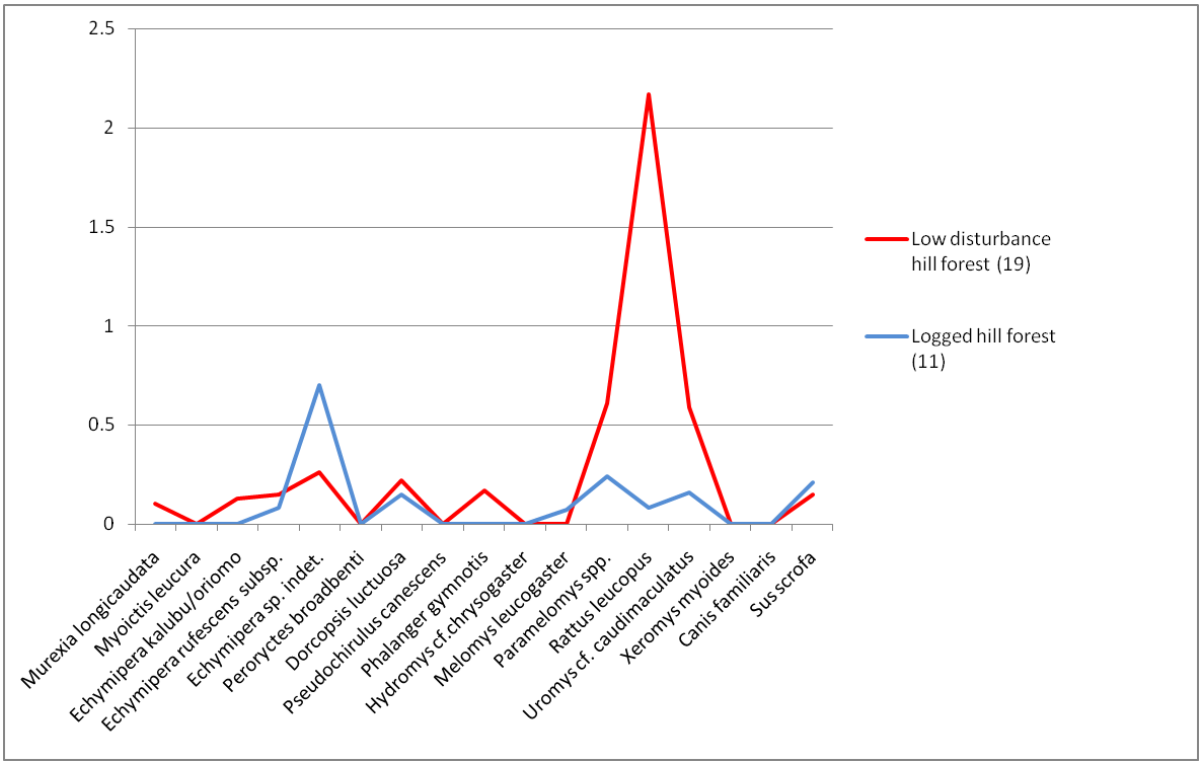

Figure 13. Average RAIs for each mammal taxon in 'low disturbance alluvial forest and logged alluvial forest, calculated across all camera trap positions in these habitats.

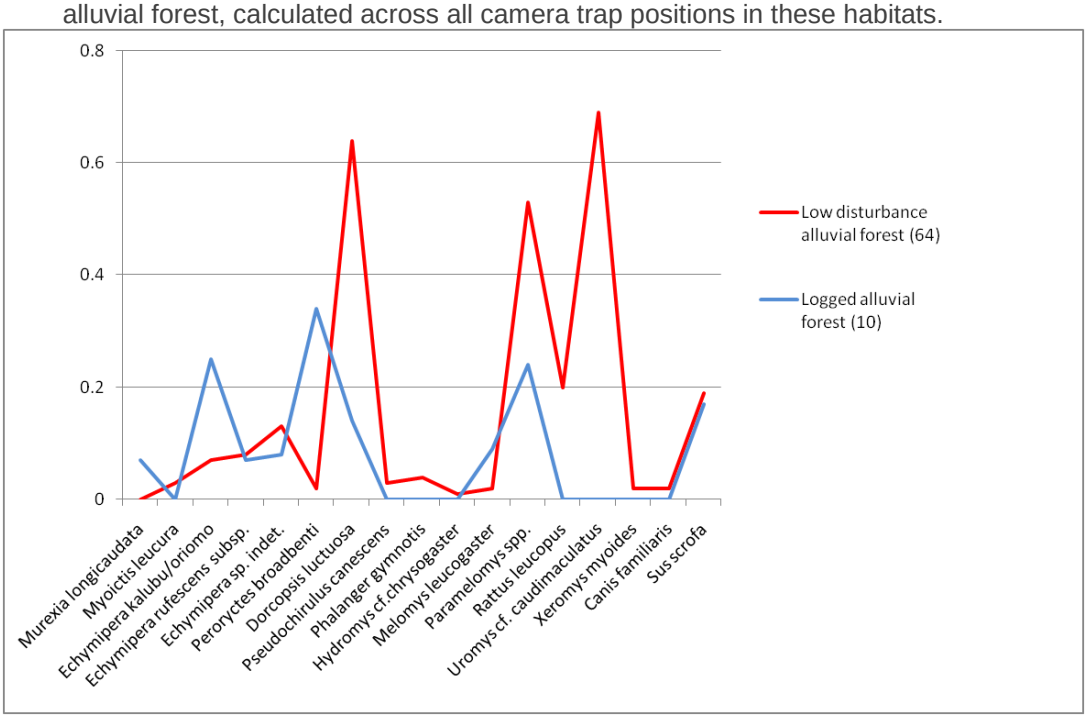

Table 14. Composition of the rodent communities in various forest and anthropogenic habitats in the study area, as documented by trapping and deployment of camera traps. Species highlighted in red are alien invasive rodents.

Species	Hill forest – minimal to slight disturbance	Hill forest - high natural disturbance	Alluvial forest - minimal to slight disturbance	Alluvial forest - high natural disturbance	Active road-verge– Project road	Active road-verge– forestry road	Disused road– forestry road	Abandoned drilling pad and campsite	Plantaions/gardens	Active project operations camp	Village houses
Paramelomys* cf. *levipes	+	+	+								
Paramelomys* cf. *naso	+		+								
Paramelomys platyops	+	+	+	+	+						
Melomys* cf. *rufescens	+		+								
Uromys* cf. *caudimaculatus	+	+	+								
Xeromys myoides			+								
Rattus leucopus	+	+	+	+	+	+	+	+		+	
Melomys leucogaster		+		+	+	+	+	+	+		
Rattus steini		+									
Rattus exulans						+					+
Rattus rattus										+	+
Mus musculus										+	

4.8.5 Seasonality

Seasonality appears not to be an important factor in determining the population structure or behavior of terrestrial non-volant mammal species present within the study area—no trends were observed in the rates of small mammal trapping or camera trapping between the Phase 1 and 2 surveys (Appendix 2), no Melanesian terrestrial non-volant mammals are known to be migratory, and knowledge of the breeding biology of marsupials (Wilson and Mittermeier 2015) and murid rodents (Flannery 1996) either indicates little or no breeding seasonality or is too poor to infer any trends.

4.9 Important Habitats/Landscape Features

The biodiversity values of the study area relevant to non-volant mammal communities are diffuse rather than associated with particular landscape features. This reflects the fact that across much of the landscape, habitats are generally in good to excellent condition and retain most of their original biodiversity values. Even by New Guinean standards, these values have proven to be outstanding—an attribute that reflects the diverse lithology and topography of the study area as well as its position in the Gulf of Papua where animals of different biogeographic associations come together to produce exceptional biodiversity.

The survey has identified high biodiversity values for non-volant mammals in three of the main forest types and in all of the ecological zones that are present in the study area.

4.9.1 Hill forest habitats

The hill forest in the study area is of particular importance for its populations of the Vulnerable Eastern Long-beaked Echidna and the three locally occurring species of tree kangaroo, especially the Endangered and Protected Goodfellow's Tree Kangaroos and the Vulnerable, Protected and restricted-range Lowland Tree Kangaroo, both of which are very likely present in the study area and in PRL-15. The Vulnerable Grey Dorcopsis and Near Threatened New Guinea Quoll are also present in the hill forest habitats. Remoteness is a key consideration for all of these species as hunting pressure and possibly also predation by feral dogs, represent major threats to their survival.

Other species of special interest that occur in the hill forest habitat are the two new-to-science rodents identified in the Wi'i Creek Cave owl roost sample—the 'small water rat' *Hyrdomys* sp. 1 and the 'shrew mouse' *Pseudohydromys* sp. 1.

4.9.2 Alluvial forest habitat

Alluvial forests in the study area have been given particular prominence through the discovery of populations of three conservation-listed species—the Endangered and restricted-range Giant Bandicoot, the Vulnerable False Water Rat and the Vulnerable Grey Dorcopsis—and for one previously unrecognized species, the restricted-range Oriomo Bandicoot. For each of these species the study area records represent major range extensions of c. 250 km and the first records from Gulf Province. For the Giant Bandicoot the study area records are first in more than 40 years from the southern part of its range.

The population of the Giant Bandicoot is only the second record from anywhere in New Guinea within the past decade. This species is quite possibly one of New Guinea's most endangered vertebrates and the identification of a new population is an important development that opens new opportunities for its global conservation. It was recorded from three sites, one in relatively undisturbed alluvial forest and two in quite heavily disturbed alluvial forest, and spanning the Delta Swamps and Plains and Southeast Coast ecological zones. Hunting pressure coupled with habitat simplification after disturbance probably represent the major threats to this species, and Gulf Province with its low human population density and large tracts of relatively undisturbed alluvial forest may represent an important conservation refugium for this species.

The population of the Vulnerable False Water Rat is only the second from PNG and an important range extension into the extensive alluvial, swamp and mangrove forests of the lowlands of the Gulf of Papua. Compared with its ecological range in Australia, the newly discovered population in the study area has considerably wider ecological scope, even extending narrowly into hill forest where this abuts alluvial or swamp forest. The significance of this population is accentuated by the fact that the species is experiencing ongoing declines along the northeast Australian coastline.

The Vulnerable Grey Dorcopsis appears to be quite abundant in relatively undisturbed alluvial forest habitats, and it maintains good numbers in disturbed alluvial forest habitat provided this is remote from human settlements. Given the evidence for decline of this species in other parts of its range, the abundance of the Grey Dorcopsis highlights the importance of alluvial forest habitats in the study area as a potentially important refuge for this species.

The Oriomo Bandicoot is a potentially restricted-range species now known from alluvial forest habitats in the Fly River and Purari River catchments. Whether it occurs anywhere in the intervening catchments is unknown. It appears to be locally abundant in the Purari catchment and is present in disturbed forest habitats close to human settlements as well as remote, undisturbed alluvial forests.

The occurrence of the Giant Bandicoot, False Water Rat and Oriomo Bandicoot within the Southeast Coast ecological zone, in such close proximity to long-standing human settlements along Orokolo Bay as well as in more remote sites in other ecological zones, is particularly interesting as it offers opportunities to understand the factors that determine its local survival.

4.9.3 Mangrove forest habitats

The mangrove forest supports a small number of non-volant mammals. Significantly, this probably includes the Vulnerable False Water Rat (see Section 4.2.8); if confirmed, this would expand the potential global range of this ecologically specialized species by a significant factor.

The waterways of the mangrove forest habitat also support a population of the Near Threatened Australasian Snubfin Dolphin.

4.10 Conservation Value of the study area and its Fauna/Flora

The study area supports a diverse and abundant non-volant mammal fauna and possesses a number of noteworthy conservation values. These include:

- Populations of the Endangered and Protected Western Montane and Goodfellow's Tree Kangaroos, confirmed through local landowner sightings in the Middle Purari Hills ecological zone.
- A population of the Endangered Giant Bandicoot confirmed by camera trap observations at Sites 8 and 9 in alluvial forests of the Southeast Coast ecological zone and at Site 7 near the boundary between the Delta Swamps and Plains and Southeast Hills ecological zones.
- A population of the Vulnerable and Protected Long-beaked Echidna confirmed through local landowner sightings in the Middle Purari Hills ecological zone.
- A population of the Vulnerable and restricted-range Lowland Tree Kangaroo, with recent landowner sightings in the Middle Purari Hills ecological zone at multiple localities to the north of PRL-15 and within PRL-15 south at least to the vicinity of Herd Base.
- A widespread and locally abundant population of the Vulnerable Grey Dorcopsis, with direct observation in all ecological zones except the Mangroves ecological zone, and with peak population densities in undisturbed alluvial forest habitats of the Delta Swamps and Plains ecological zone.

- A population of the Vulnerable False Water Rat, confirmed by direct observation for the Southeast Coast ecological zone and peripherally in the Middle Purari Hills ecological zone, and probably also present in the Mangroves ecological zone. This is only the second known occurrence of the species in New Guinea and the first from the hinterland of the Gulf of Papua.
- A population of the New Guinea Quoll, confirmed through local landowner testimony for the Middle Purari Hills ecological zone but possibly also present in other areas.
- A population of the Data Deficient Woolley's Three Striped Dasyure, confirmed by direct observations in the Middle Purari Hills and Delta Swamp and Plains ecological zones, and representing the first records of the species from elevations below 500 m asl.
- A population of the newly recognized and potentially restricted-range Oriomo Bandicoot, a poorly known species that seems to occur locally in the Delta Swamps and Plains, Southeast Hills and Southeast Coast ecological zones. These are the first records of this distinctive bandicoot from outside of the Fly River catchment.
- Populations of various other restricted-range species including the Long-footed Paramelomys and the distinctive regional population of the Long-nosed Bandicoot, a form with possible links to a population on Cape York, Queensland, Australia.
- Two new-to-science rodent species—the 'small water rat' and the 'shrew mouse', both known only from skeletal remains from a cave in the Middle Purari Hills ecological zone.

Key attributes of the study area that probably underpin the majority of these conservation values are:

- The low human population density of the entire Middle Purari region.
- The relatively low levels of disturbance to large tracts of hill, alluvial and swamp forest that are visited infrequently if at all and retain essentially intact mammal communities, affected only by the presence of some alien invasive species, most notably the pig.
- The persistence of many native species in parts of the landscape that are regenerating after recent logging activity, indicative of a generally resilient mammal community.
- The extreme remoteness of large parts of the northern sector of the study area, particularly the virtually unvisited country to the west of PRL-15 on the flanks of Mount Favenc and in the Kereru Range.
- The historical low socio-economic status and general remoteness of the region, with consequences including the general absence of firearms from the region and its isolation from commercial markets.

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PLATES

Unless otherwise stated all photographs were taken by K. Aplin.

PLATE 1

1.1 Typical understorey in alluvial forest. Site 4.

1.2 Shallow stream flowing through alluvial forest and flanked by elevated terraces, Site 2.

1.3 The abandoned Antelope 2 drilling pad (Site 1), habitat of *Rattus leucopus* and *Melomys leucogaster*.

1.4 Disused helipad at Site 4, habitat of *R. leucopus* and *M. leucogaster*.

1.5 Verge of forestry road, Site 3, habitat of *R. leucopus, R. exulans* and *M. leucogaster*.

PLATE 2

2.1 Snap-E rat trap with sweet potato bait set for *Rattus rattus* at ANT-3 OC (Site 1). Photo P. Amick.

2.2 Junior Novera setting 'Elliott' rat traps along road verge near Antelope 3 (Site 1). Photo P. Amick.

2.3 Footprints of an adult wallaby with young, presumably *Dorcopis luctuosa*, on margin of helipad at ANT-3 OC (Site 1).

2.4 Camera trap in position.

2.5 Abandoned 'seismic' camp on road near Site 3, with firepits being sampled by J. Novera.

PLATE 3

3.1 *Murexia longicaudata*. Camera trap image, Site 1.

3.2 *Murexia melanurus*, Site 3. Photo P. Amick

3.3 *Myoictisleucura*. Camera trap image Site 2.

3.4 *Echymipera rufescens* subsp., captured by hand at Site 1.

3.5 *Echymipera rufescens* subsp. Camera trap image, Site 4.

3.6 *Echymipera rufescens* subsp. Camera trap image, Site 7.

PLATE 4

4.1 *Echymipera oriomo*. Camera trap image. Site 5.

4.2 *Echymipera oriomo*. Camera trap image, Site 9.

4.3 Juvenile *Echymipera oriomo*, Site 8. Photo F. Venter.

4.4 *Echymipera kalubu*. Camera trap image, Site 1.

4.5 *Peroryctes* sp. probably P. *broadbenti*. Camera trap image, Site 7.

4.6 *Peroryctes* sp. probably P. *broadbenti*. Camera trap image, Site 9.

PLATE 5

5.1 *Phalanger* sp. probably S. *mimicus*, Site 3, Photo S. J. Richards.

5.2 *Phalanger gymnotis*. Camera trap image, Site 1.

5.3 *Pseudochirulus canescens*, camera trap image, Site 4.

5.4 *Dorcopsis luctuosa*, adult male. Camera trap image, Site 1.

5.5 *Dorcopsis luctuosa*, adult male, hunted in vicinity of Site 3. Photo P. Amick.

PLATE 6

6.1 *Dorcopsis luctuosa*, adult female and young. Camera trap image, Site 1.

6.2 *Rattus rattus*, Antelope 3 camp (Site 1).

6.3 *Rattus leucopus*, road verge beside ANT-3 Operations Camp (Site 1). Photo P. Amick.

6.4 *Rattus leucopus*. Camera trap image, Site 1.

6.5 *Paramelomys* sp. Camera trap image, Site 1.

6.6 *Paramelomys* cf. *naso*, Site 1, hill forest to west of ANT-3 Operations Camp (Site 1).

PLATE 7

7.1 *Uromys* cf. *caudimaculatus*. Camera trap image, Site 1. Short-tailed form.

7.2 *Uromys* cf. *caudimaculatus*. Camera trap image, Site 1. Long-tailed form.

7.3 *Rattus leucopus* (left) and *Uromys* cf. *caudimaculatus*. Camera trap image, Site 1.

7.4 *Pogonomys* cf. *loriae*, Site 4. Photo P. Amick.

7.5 *Xeromys myoides*. Camera trap image, Site 8.

7.6 *Sus scrofa*, most likely a feral animal. Camera trap image, Site 3.

APPENDICES

Appendix 1. Details of small mammal trapping sites and small mammal trapping effort at each of the survey sites.

Site	Trapline	Trapline habitat	date setup	date down	no. nights	no. snaps	no. elliots	snap trap nights	elliott trap nights
Site 1 (ANT-3 OC)	1	Camp environs	20-Jan	21-Jan	1	70	0	70	0
Site 1 (ANT-1)	2	Abandoned drilling pad	21-Jan	23-Jan	2	72	22	144	22
Site 1 (ANT-1)	3	Abandoned camp site area	21-Jan	23-Jan	2	28	26	56	26
Site 1 (road between ANT-3 OC and ANT-1)	4	Roadside grass/scrub	23-Jan	25–26-Jan	2–3	97 or 7 (date dependent)	48	201	96
Site 1 (ridge behind ANT-3 OC)	5	Hill forest, relatively undisturbed	25-Jan	27-Jan	2	97	0	180	0
Site 1 totals								651	144
Site 2	6	Hill forest, heavy natural disturbance	28-Jan	30-Jan	2	97	0	180	0
Site 2	7	Streamside in hill forest	29-Jan	1-Feb	3	0	48	0	144
Site 2	8	Streamside in hill forest	30-Jan	1-Feb	2	97	0	194	0
Site 2 totals								374	144
Site 3	9	Hill forest	3-Feb	5-Feb	2	97	0	194	0
Site 3	10	Active forestry road, roadside garden with cassava	5-Feb	7-Feb	2	90, 74 (date dependent)	0	164	0
Site 3	11	West track, overgrown forestry road	7-Feb	8-Feb	1	74	26	74	26
Site 3 totals								432	26
Site 4	12	Helipad clearing	10-Feb	12-Jan	2	74	0	128	0
Site 4	13	Sling pad below camp	10-Feb	13-Feb	3	0	26	0	78
Site 4	14	Streamside habitats	13-Feb	15-Feb	2	74	0	128	0
Site 4	15	Streamside habitats	14-Feb	15-Feb	1	0	26	0	26
Site 4 totals								256	104

Site	Trapline	Trapline habitat	date setup	date down	no. nights	no. snaps	no. elliots	snap trap nights	elliott trap nights
Site 5	16	Alluvial forest	22-Jun	24-Jun	2	31–62	0	93	0
Site 5	17	Hill forest	24-Jun	26-Jun	2	62	0	124	0
Site 5 totals								217	0
Site 6A	18	Roadside grass/scrub	26-Jun	28-Jun	2	57	10	114	20
Site 6A	19	Streamside in hill forest	26-Jun	28-Jun	2	10	10	20	20
Site 6A totals								134	40
Site 7	20	Alluvial forest, most areas logged	3-Jul	7-Jul	4	59	10	236	40
Site 7	21	Roadside grass and vines	7-Jul	9-Jul	2	49	0	98	0
Site 7 totals								334	40
Site 8	22	Alluvial forest, intensively logged	10-Jul	12-Jul	2	43–53	0	96	0
Site 8	23	Houses, Avavu Village	11-Jul	12-Jul	1	10	0	10	0
Site 8	24	Alluvial forest near stream, moderately disturbed	12-Jul	14-Jul	2	53	0	106	0
Site 8 totals								212	0
Site 9	25	Garden/plantation zone	15-Jul	16-Jul	1	50	0	50	0
Site 9	26	Alluvial forest/ecotone with hill forest moderately disturbed	16-Jul	18-Jul	2	62	29	124	58
Site 9	27	Coastal scrub	17-Jul	18-Jul	1	0	10	0	10
Site 9	28	Houses in Hururu Village	17-Jul	18-Jul	1	10	0	10	0
Site 9 totals								184	68
STUDY TOTALS								2,794	566
Off-site effort									
Evara Village		Houses	7-Feb	8-Feb	1	20	0	20	0
Poroi 1 Village		Houses and gardens	9-Feb	10-Feb	1	20	0	20	0
Herd Base		Camp environs	18-Jun	19-Jun	1	20	0	20	0
Wabo Village		Houses	19-Jun	20-Jun	1	45	0	45	0

Appendix 2. Results obtained by each of the individual survey methods.

Table 2.1 Small mammal trapping results.

Site	Trapline location and habitat	Trapping dates	Trapping Effort (trap nights)	*Rattus leucopus*	*Rattus steini*	*Rattus rattus*	*Rattus exulans*	*Hydromys chrysogaster*	*Melomys leucogaster*	*Melomys rufescens*	*Paramelomys platyops*	*Paramelomys* cf. *levipes*	*Paramelomys* cf. *naso*	*Uromys* cf. *caudimaculatus*	Total captures	Captures/100 trap nights
Site 1	ANT-3 OC – camp environs	20-21 Jan	70	6		7									13	18.60
Site 1	ANT-1 – abandoned drilling pad	21-23 Jan	166	2					6						8	4.80
Site 1	ANT-1 – abandoned camp	21-23 Jan	82	2					3						5	6.10
Site 1	ANT-3 OC road verge through Hill forest (Hm)	23-26 Jan	297	5					3						8	2.70
Site 1	ANT-3 OC - Hill forest (Hm) on ridge	25-27 Jan	180	3						1		2	2		8	4.40
Site 1 Total			**795**	**18**		**7**			**12**	**1**		**2**	**2**		**42**	**5.20**
Site 2	Naturally disturbed Hill forest (Hm)	28-30 Jan	194	1							5	1		1	8	4.10
Site 2	Alluvial forest (Pl) and river banks	29-Jan – 1-Feb	324	2	1						2				5	1.50
Site 2 Total			**518**	**3**	**1**						**7**	**1**		**1**	**13**	**2.50**
Site 3	Hill forest (Hm) on mudstone	3-5 Feb	180	2					1		2				5	2.80
Site 3	Active forestry road through Hill forest (Hm)	5-7 Feb	164	6			9		8						23	14.00
Site 3	Overgrown road through Hill forest (Hm)	8-9 Feb	100	3					1						4	4.00
Site 3 Total			**444**	**11**			**9**		**10**		**2**				**32**	**7.20**

Site	Trapline location and habitat	Trapping dates	Trapping Effort (trap nights)	*Rattus leucopus*	*Rattus steini*	*Rattus rattus*	*Rattus exulans*	*Hydromys chrysogaster*	*Melomys leucogaster*	*Melomys rufescens*	*Paramelomys platyops*	*Paramelomys* cf. *levipes*	*Paramelomys* cf. *naso*	*Uromys* cf. *caudimaculatus*	Total captures	Captures/100 trap nights
Site 4	Clearings in mosaic Alluvial forest (Po)/Hill forest (Hm)	10-13 Feb	206	2								1			3	1.50
Site 4	Streamside through Po/Hm	13-15 Feb	154					1			1				2	1.30
Site 4 Total			**360**	**2**				**1**			**1**	**1**			**5**	**1.40**
Site 5	Alluvial forest (Po)	22-23 Jun	93						2						2	2.15
Site 5	Hill forest (Hm)	24-25 Jun	124	2					2		1		2		7	5.65
Site 5 Total			**217**	**2**					**4**		**1**		**1**		**9**	**4.15**
Site 6A	Roadside in Hill forest (Hm)	26-27 Jun	134	3					4						7	5.22
Site 6A	Streamside in Hill Forest (Hm)	26-27 Jun	40	1					1						1	2.50
Site 6A Total			**174**	**4**					**5**						**9**	**5.17**
Site 7	Alluvial forest (Po)	2-6 Jul	276	1					2	3	3	3	1		13	4.71
Site 7	Road verge, ecotone of Hm/Po	7-8 Jul	98						2						2	2.04
Site 7 Total			**374**	**1**					**4**	**3**	**3**	**3**	**1**		**15**	**4.01**
Site 8	Alluvial forest (Po) – heavily disturbed by logging	10-13 Jul	212								1	1		1	3	1.42
Site 8	Houses in Avavu Village	11-Jul	10			4									4	40.0
Site 8 Total			**222**								**1**	**1**		**1**	**7**	**1.42**
Site 9	Garden/plantation zone	15-Jul	50						11						11	22.0
Site 9	Alluvial forest (Po)	16-17 Jul	162						6	3	3	4			16	9.88
Site 9	Alluvial/ Hill forest (Hm) ecotone	17-Jul	20						1	1					2	10.0
Site 9	Coastal scrub	17-Jul	10													0.0

Site	Trapline location and habitat	Trapping dates	Trapping Effort (trap nights)	*Rattus leucopus*	*Rattus steini*	*Rattus rattus*	*Rattus exulans*	*Hydromys chrysogaster*	*Melomys leucogaster*	*Melomys rufescens*	*Paramelomys platyops*	*Paramelomys* cf. *levipes*	*Paramelomys* cf. *naso*	*Uromys* cf. *caudimaculatus*	Total captures	Captures/100 trap nights
Site 9	Houses in Hururu Village	17-Jul	10			5									5	50.0
Site 9 Total			**252**						**18**	**4**	**3**	**4**			**34**	**11.98**
ALL SITES			**3,356**	**41**	**1**	**16**	**9**	**1**	**53**	**8**	**18**	**12**	**4**	**1**	**166**	**6.31**

Table 2.2. Camera trapping results – encounter rates for each species, calculated as Relative Abundance Index (RAI).
Codes for forest type: AF – alluvial forest; HF – hill forest. Codes for Disturbance are: L – previously logged; M – low natural disturbance and moderate extractive disturbance; S – low natural disturbance and minimal to slight extractive disturbance; N – moderate to heavy natural disturbance and minimal to slight extractive disturbance.

Site No.	Camera No.	Forest type	Disturbance	Hours of imaging	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens*	*Echymipera* sp. indet.	*Peroryctes* sp.	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys* cf. *chrysogaster*	*Melomys leucogaster*	*Paramelomys* sp.	*Rattus leucopus*	*Uromys* sp.	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	All taxa
1	1	AF	S	157.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.27	0.00	0.00	0.00	**1.27**
1	2	AF	S	157.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.90	0.63	0.00	0.00	0.00	**2.54**
1	3	AF	S	469.75	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	0.43	1.92	0.00	0.00	0.00	**2.77**
1	4	HF	S	451.25	0.00	0.00	0.22	0.00	0.22	0.00	0.22	0.00	0.22	0.00	0.00	1.55	3.55	0.44	0.00	0.00	0.00	**6.43**
1	5	HF	S	451.00	0.00	0.00	0.22	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	1.11	1.77	0.22	0.00	0.00	0.00	**3.55**
1	6	HF	S	450.75	0.00	0.00	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.67	0.22	0.00	0.00	0.00	**2.66**
1	7	HF	S	450.50	0.00	0.00	0.00	0.44	0.89	0.00	0.67	0.00	0.22	0.00	0.00	0.67	0.67	1.11	0.00	0.00	0.00	**4.66**
1	8	HF	S	450.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.78	0.22	0.22	0.00	0.00	0.00	**4.22**
1	9	HF	S	450.00	0.00	0.00	0.00	0.44	0.00	0.00	0.00	0.00	0.44	0.00	0.00	0.44	1.56	0.44	0.00	0.00	0.00	**3.33**
1	10	HF	S	449.50	0.22	0.00	0.00	0.00	0.67	0.00	0.67	0.00	0.00	0.00	0.00	0.44	2.89	2.45	0.00	0.00	0.00	**7.34**
1	11	HF	S	449.00	0.00	0.00	0.00	0.22	0.00	0.00	0.22	0.00	0.45	0.00	0.00	0.45	1.78	2.00	0.00	0.00	0.00	**5.12**
1	12	AF	S	429.75	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	0.23	0.00	0.00	0.47	0.23	0.70	0.00	0.00	0.00	**1.86**
1	13	AF	S	429.50	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.93	3.49	1.16	0.00	0.00	0.00	**6.05**
1	14	AF	S	429.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.00	2.10	0.00	0.00	0.00	**2.33**
1	15	HF	S	90.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.71	0.00	0.00	0.00	0.00	**7.71**
1	16	HF	S	90.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.10	0.00	0.00	0.00	0.00	**1.10**
1	17	HF	S	90.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.76	0.00	0.00	0.00	0.00	**7.76**
1	18	HF	S	90.25	0.00	0.00	0.00	1.11	0.00	0.00	0.00	0.00	1.11	0.00	0.00	0.00	4.43	0.00	0.00	0.00	0.00	**6.65**
1	19	HF	S	90.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	1.11	0.00	0.00	0.00	**2.22**
1	20	HF	S	352.75	1.70	0.00	0.00	0.28	0.28	0.00	0.00	0.00	0.28	0.00	0.00	1.13	0.00	0.85	0.00	0.00	0.00	**4.54**

Site No.	Camera No.	Forest type	Disturbance	Hours of imaging	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens*	*Echymipera* sp. indet.	*Peroryctes* sp.	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys* cf. *chrysogaster*	*Melomys leucogaster*	*Paramelomys* sp.	*Rattus leucopus*	*Uromys* sp.	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	All taxa
1	21	HF	S	352.25	0.00	0.00	0.00	0.00	0.85	0.00	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.00	0.00	0.00	**1.99**
2	1	AF	S	114.50	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.37	0.00	1.75	0.00	0.00	0.00	**6.99**
2	2	AF	S	96.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.13	0.00	0.00	0.00	0.00	0.00	**3.13**
2	3	AF	S	95.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	**1.04**
2	4	AF	S	95.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	**1.05**
2	5	AF	S	95.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.11	0.00	0.00	0.00	0.00	0.00	**2.11**
2	6	AF	S	93.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	**1.07**
2	7	AF	S	93.00	0.00	1.08	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	6.45	0.00	0.00	0.00	**8.60**
2	8	HF	N	96.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.13	1.04	1.04	0.00	0.00	0.00	**5.21**
2	9	HF	N	95.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
2	10	HF	N	95.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	**1.05**
2	11	HF	N	95.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
3	1	HF	L	138.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
3	2	HF	L	137.00	0.00	0.00	0.00	0.00	0.73	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.46	**2.92**
3	3	HF	L	136.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
3	4	HF	L	136.50	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.73	0.00	0.00	0.00	0.00	0.00	0.00	**1.47**
3	5	HF	L	115.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	**0.87**
3	6	HF	L	115.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.87	0.00	0.00	0.00	**2.61**
3	7	HF	L	114.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.88	0.00	0.00	0.00	0.88	**2.63**
3	8	HF	L	114.25	0.00	0.00	0.00	0.00	0.88	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.75**
3	9	HF	L	113.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	**0.88**
3	10	HF	L	112.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
3	11	HF	L	111.50	0.00	0.00	0.00	0.90	4.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**5.38**
4	1	AF	S	1920.75	0.00	0.00	0.00	0.42	0.05	0.00	0.99	0.00	0.21	0.00	0.00	0.05	0.05	0.94	0.00	0.00	1.09	**3.80**

Site No.	Camera No.	Forest type	Disturbance	Hours of imaging	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens*	*Echymipera* sp. indet.	*Peroryctes* sp.	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys* cf. *chrysogaster*	*Melomys leucogaster*	*Paramelomys* sp.	*Rattus leucopus*	*Uromys* sp.	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	All taxa
4	2	AF	S	1920.25	0.00	0.00	0.00	0.52	0.26	0.00	0.89	0.00	0.05	0.00	0.00	0.00	0.05	0.26	0.00	0.00	0.36	**2.40**
4	3	AF	S	1920.00	0.00	0.00	0.00	0.21	0.52	0.00	1.15	0.00	0.16	0.00	0.00	0.10	0.10	0.57	0.00	0.00	0.10	**2.92**
4	4	AF	S	1919.75	0.00	0.00	0.00	0.16	0.05	0.00	0.26	0.00	0.00	0.00	0.00	0.05	2.55	0.73	0.00	0.00	0.26	**4.06**
4	5	AF	S	1919.75	0.00	0.00	0.00	0.21	0.05	0.00	0.78	0.00	0.10	0.00	0.00	0.21	0.00	0.36	0.00	0.00	0.10	**1.82**
4	6	AF	S	1902.00	0.00	0.11	0.00	0.21	0.21	0.00	1.63	0.00	0.26	0.00	0.00	0.58	0.00	0.53	0.00	0.00	0.26	**3.79**
4	7	AF	S	1901.50	0.00	0.00	0.00	0.16	0.26	0.00	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.42	**1.89**
4	8	AF	S	944.00	0.00	0.00	0.00	0.11	0.00	0.00	2.22	0.00	0.00	0.00	0.00	0.32	0.00	0.00	0.00	0.00	0.32	**2.97**
4	9	AF	S	1460.25	0.00	0.00	0.00	0.14	0.27	0.00	2.26	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.07	**2.94**
4	10	AF	S	1892.50	0.00	0.00	0.00	0.05	0.00	0.00	0.26	0.00	0.00	0.05	0.00	0.42	0.05	0.32	0.00	0.00	0.05	**1.22**
4	11	AF	S	1892.00	0.00	0.00	0.00	0.16	0.05	0.00	1.64	0.00	0.05	0.00	0.00	0.00	0.05	0.74	0.00	0.00	0.79	**3.49**
4	12	AF	S	1784.00	0.00	0.00	0.00	0.06	0.17	0.00	0.95	0.00	0.17	0.00	0.00	0.06	0.00	0.45	0.00	0.00	0.11	**1.96**
4	13	AF	S	1613.75	0.00	0.00	0.00	0.00	0.12	0.00	0.43	0.00	0.25	0.06	0.00	1.36	0.31	0.31	0.00	0.00	0.19	**3.04**
4	14	AF	S	1103.00	0.00	0.00	0.09	0.00	0.00	0.00	2.90	0.00	0.00	0.00	0.00	0.54	0.18	0.45	0.00	0.00	0.27	**4.44**
4	15	AF	S	1877.00	0.05	0.00	0.00	0.05	0.11	0.00	2.08	0.00	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	1.01	**3.62**
4	16	AF	S	369.75	0.00	0.00	0.00	0.00	0.54	0.00	1.35	0.00	0.27	0.00	0.00	0.81	0.81	0.27	0.00	0.00	0.00	**4.06**
4	17	AF	S	1849.75	0.00	0.05	0.00	0.11	0.22	0.00	0.38	0.00	0.00	0.11	0.00	0.27	0.00	0.86	0.00	0.00	0.27	**2.27**
4	18	AF	S	1849.50	0.00	0.00	0.00	0.11	0.11	0.00	0.11	0.00	0.00	0.00	0.00	0.92	0.16	0.49	0.00	0.00	0.00	**1.89**
4	19	AF	S	1050.50	0.00	0.00	0.00	0.00	0.19	0.00	0.29	0.10	0.00	0.19	0.00	1.05	0.67	0.67	0.00	0.00	0.00	**3.14**
4	20	AF	S	1848.25	0.00	0.00	0.05	0.22	0.70	0.00	0.00	0.00	0.32	0.00	0.00	0.43	0.32	0.76	0.00	0.00	0.00	**2.81**
4	21	AF	S	474.75	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.21	0.00	1.05	0.00	0.00	0.00	**1.47**
4	22	AF	S	1824.75	0.05	0.00	0.00	0.05	0.05	0.00	0.82	0.00	0.05	0.00	0.00	1.70	0.05	1.15	0.00	0.00	0.66	**4.60**
4	23	AF	S	1823.75	0.00	0.00	0.00	0.11	0.22	0.00	0.33	0.00	0.22	0.00	0.00	0.44	1.10	1.21	0.00	0.00	0.49	**4.11**
4	24	AF	S	1735.00	0.00	0.00	0.00	0.63	0.40	0.00	0.52	0.00	0.00	0.00	0.00	0.23	0.00	0.35	0.00	0.00	0.98	**3.11**
4	25	AF	S	1818.50	0.00	0.00	0.00	0.44	0.71	0.00	0.66	0.00	0.05	0.00	0.00	0.27	0.11	0.66	0.00	0.00	0.44	**3.35**

Site No.	Camera No.	Forest type	Disturbance	Hours of imaging	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens*	*Echymipera* sp. indet.	*Peroryctes* sp.	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys* cf. *chrysogaster*	*Melomys leucogaster*	*Paramelomys* sp.	*Rattus leucopus*	*Uromys* sp.	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	All taxa
5	1	AF	S	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
5	2	AF	S	1588.50	0.00	0.00	0.19	0.13	0.00	0.00	2.71	0.00	0.00	0.00	0.00	0.25	0.00	0.06	0.00	0.00	0.25	**3.59**
5	3	AF	S	745.00	0.00	0.00	0.00	0.00	0.40	0.00	0.54	0.00	0.00	0.00	0.00	0.40	0.00	0.27	0.00	0.00	0.81	**2.42**
5	4	AF	S	673.25	0.00	0.00	0.45	0.00	0.00	0.00	2.23	0.00	0.15	0.00	0.00	0.15	0.15	0.00	0.00	0.00	1.04	**4.16**
5	5	AF	S	1288.25	0.00	0.00	0.23	0.08	0.00	0.00	0.85	0.00	0.08	0.00	0.00	1.79	0.23	0.23	0.00	0.00	0.39	**3.88**
5	6	HF	S	1562.75	0.00	0.00	2.11	0.00	0.70	0.00	0.13	0.00	0.00	0.00	0.00	0.00	5.06	0.96	0.00	0.00	0.19	**9.15**
5	7	HF	S	1562.25	0.00	0.00	0.00	0.13	0.13	0.00	0.45	0.00	0.13	0.00	0.00	0.06	0.00	0.00	0.06	0.00	0.96	**1.92**
5	10	HF	S	1561.75	0.00	0.00	0.00	0.19	0.19	0.00	0.51	0.00	0.13	0.00	0.00	0.64	0.96	0.26	0.00	0.00	0.26	**3.14**
5	11	HF	S	1177.75	0.00	0.00	0.00	0.00	0.17	0.00	0.76	0.00	0.25	0.00	0.00	0.17	0.08	0.34	0.00	0.00	1.36	**3.14**
5	12	AF	S	169.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.59	0.59	0.00	0.00	0.00	0.00	0.00	**1.78**
5	13	AF	S	169.00	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.59**
5	14	AF	S	169.00	0.00	0.00	0.00	0.00	0.00	0.00	1.18	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.00	0.00	**1.78**
5	15	AF	S	169.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.96	0.00	0.00	0.00	**2.96**
5	16	AF	S	168.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	**1.19**
5	17	AF	S	167.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
5	18	AF	S	64.00	0.00	0.00	0.00	0.00	0.00	0.00	1.56	0.00	0.00	0.00	0.00	0.00	0.00	1.56	0.00	0.00	0.00	**3.13**
5	19	AF	S	63.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	0.00	0.00	1.57	0.00	0.00	0.00	**1.57**
5	20	AF	S	63.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.58	**1.58**
7	1	AF	L	144.25	0.69	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.39**
7	2	AF	L	144.25	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.00	0.00	**2.08**
7	3	AF	L	120.00	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.83**
7	4	AF	L	120.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
7	5	AF	L	120.50	0.00	0.00	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.83**
7	6	AF	L	119.50	0.00	0.00	0.84	0.00	0.84	3.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	**5.86**

Site No.	Camera No.	Forest type	Disturbance	Hours of imaging	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens*	*Echymipera* sp. indet.	*Peroryctes* sp.	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys* cf. *chrysogaster*	*Melomys leucogaster*	*Paramelomys* sp.	*Rattus leucopus*	*Uromys* sp.	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	All taxa
7	7	AF	L	115.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
7	8	AF	L	115.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.73	0.00	0.00	0.00	0.00	0.00	**1.73**
7	9	AF	L	115.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.00	0.00	0.00	0.00	**0.87**
7	10	AF	L	115.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	**0.87**
7	11	AF	S	95.25	0.00	0.00	0.00	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	**3.15**
7	12	AF	S	24.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
7	13	AF	S	70.50	0.00	0.00	0.00	0.00	0.00	0.00	1.42	0.00	0.00	0.00	0.00	0.00	0.00	2.84	0.00	0.00	0.00	**4.26**
8	1	AF	S	95.75	0.00	0.00	0.00	0.00	1.04	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**2.09**
8	2	AF	S	95.50	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.05**
8	3	AF	S	95.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
8	4	AF	S	95.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**
8	5	AF	S	95.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	**2.11**
8	6	AF	S	92.75	0.00	0.00	2.16	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.08	0.00	**4.31**
8	7	SF	M	71.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	**1.39**
8	8	SF	M	71.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.39	0.00	0.00	0.00	0.00	0.00	0.00	**1.39**
8	9	AF	S	71.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.42	0.00	0.00	0.00	0.00	0.00	**8.42**
8	10	AF	S	71.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.41	0.00	0.00	**1.41**
8	11	AF	S	70.75	0.00	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.41**
9	1	AF	M	113.75	0.00	0.00	0.00	0.00	0.00	0.00	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	**2.64**
9	2	AF	M	113.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.00	0.00	0.00	0.00	0.00	0.00	**0.88**
9	3	AF	M	112.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00	1.77	0.00	0.00	0.00	**2.66**
9	4	AF	M	112.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.00	1.78	0.00	0.00	0.00	**3.56**
9	5	AF	M	96.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03	0.00	0.00	0.00	**1.03**
9	6	AF	M	96.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**0.00**

Site No.	Camera No.	Forest type	Disturbance	Hours of imaging	*Murexia longicaudata*	*Myoictis leucura*	*Echymipera kalubu/oriomo*	*Echymipera rufescens*	*Echymipera* sp. indet.	*Peroryctes* sp.	*Dorcopsis luctuosa*	*Pseudochirulus canescens*	*Phalanger gymnotis*	*Hydromys* cf. *chrysogaster*	*Melomys leucogaster*	*Paramelomys* sp.	*Rattus leucopus*	*Uromys* sp.	*Xeromys myoides*	*Canis familiaris*	*Sus scrofa*	All taxa
9	7	AF	M	95.50	0.00	0.00	0.00	0.00	1.05	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**3.14**
9	8	AF	M	95.25	0.00	0.00	1.05	0.00	0.00	0.00	2.10	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	**4.20**
9	9	AF	M	95.00	0.00	0.00	0.00	0.00	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	**1.05**
9	10	HF	M	93.25	0.00	0.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00	1.07	0.00	0.00	0.00	**3.22**
9	11	HF	M	93.50	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.00	0.00	0.00	1.07	0.00	0.00	1.07	0.00	0.00	0.00	**3.21**

Table 2.3 Sightings and other significant observations of non-volant mammals.
Observers are FV – Fanie Venter; JN – Junior Novera; KPA – Ken Aplin; MO – Muse Opiang; SJR – Stephen Richards.

Site	Location	Easting (PNG94)	Northing (PNG94)	Elevation (m asl)	Observer	Date and time of observation	Taxon and nature of observation
Site 1	Margin of ANT-3 OC, beside forest (Plate 2.3)	294565	9209578	138	KPA	20-Jan	Wallaby footprints, several individuals including young.
Site 1	ANT-1 abandoned drilling pad	295516	9207497	140	KPA	22-Jan	Two skeletons, *Echymipera kalubu.*
Site 1	Roadside forest south of ANT-3 OC	n/a	n/a	n/a	SJR	22-Jan	*Phalanger gymnotis* active on forest floor captured by hand and photographed.
Site 3	Gully beside Fly Camp A	303487	9171625	131	KPA	3-Feb, 20:15	*Phalanger* sp., probably *P. mimicus*, adult female in subcanopy, photographed.
Site 3	Fly camp C	n/a	n/a	n/a	KPA	07-Feb	Adult male *Dorcopsis luctuosa*, killed by local resident between camp and Evara Village. Photographed and DNA samples collected.
Site 6A	Road verge	300693	9195255	55	KPA	27-Jun	Skeletal remains of two *Dorcopsis luctuosa*; collected.
Site 6A	Road verge	Several locations on road.		n/a	KPA	27-Jun	Footprints of dogs without accompanying human prints; probably feral dogs.
Site 7	Fly Camp E	n/a	n/a	n/a	KPA	07-Jul	Subadult male *Dorcopsis luctuosa*, killed by local residents on hunting/fishing trip. Photographed and DNA samples collected.
Site 8	Road between Avavu and Paevera villages	310847	9136311	33	FV	10-Jul	*Uromys* cf. *caudimaculatus* caught in snare, photographed by FV.
Site 8	Avavu village	308509	9138574	13	FV	11-Jul	A partially eaten adult *Echymipera oriomo* found dead in garden, probably killed by a dog. Photographed by FV but carcass no longer present when site revisited by KA and JN.

Site	Location	Easting (PNG94)	Northing (PNG94)	Elevation (m asl)	Observer	Date and time of observation	Taxon and nature of observation
Site 8M	Mangroves zone	308529	9132733	4	KPA	13-Jul	Footprints of *Hydromys* cf. *chrysogaster*
Site 8M	Mangrove zone	307301	9138027	4	MO	12-Jul	Scats of *Spilocuscus maculatus*.
Site 8	Avavu village	308879	9138639	13	FV	13-Jul	Juvenile *Echymipera oriomo* shown to FV during walk through village; photographed.
Site 8	Arehava 2 village	308946	9136637	27	KPA	14-Jul	Trophy jaws of bandicoots (*Echymipera kalubu* and *E. oriomo*).
Site 8	Avavu village	308879	9138639	13	FV/JN	14-Jul	Adult male *Echymipera rufescens* killed by dog; photographed and DNA sample taken.
Site 9	Paevera village	n/a	n/a	n/a	KPA	20-Jul	Trophy bones of *Dorcopsis luctuosa*, *Spilocuscus maculatus*, *Uromys* cf. *caudimaculatus*, *Phalanger mimicus*, *Echymipera kalubu*, *E. rufescens* and *E. oriomo*, *Melomys leucogaster*.

Table 2.4 Firepit locations and contents.

Firepit No.	Site	Date sampled	notes	Identified contents
1	Site 1 (ANT-1 wellpad)	23-Jan	Transit camp used after drilling pad abandoned	Crocodile, cassowary, pig, ariid catfish
2	Site 1 (ANT-1 wellpad)	23-Jan	Transit camp used after drilling pad abandoned	Python, fish
3	Site 1 (ANT-1 wellpad)	23-Jan	Transit camp used after drilling pad abandoned	Ariid catfish, Grey Dorcopsis *Dorcopsis luctuosa,* pig
4	Site 1 (ANT-1 wellpad)	23-Jan	Transit camp used after drilling pad abandoned	Ariid catfish
5	Site 1 (ANT-1 wellpad)	23-Jan	Transit camp used after drilling pad abandoned	Ariid catfish, python, *Varanus*
6	Site 3	5-Feb	Logging camp on west road	Unidentified fish; feral pig trophy skull
7	Site 3	5-Feb	Logging camp on west road	Grey Dorcopsis *Dorcopsis luctuosa*
8	Site 4	13-Feb	Small fireplace on sandy river bank, single use	*Goura* sp., ariid catfish
9	Site 6A	28-Jun	Multi-use firepit beside garden hut abandoned 2014	Crocodile, pythons, various fish incl. ariid catfish
10	Site 8	10-Jul	Logging camp beside road to Paevera	Common Echymipera *Echymipera kalubu*
11	Site 8	11-Jul	Garden beside camp; former house site with diffuse firepit remains	Common Echymipera *Echymipera kalubu,* Spotted Cuscus *Spilocuscus maculatus,* chelid turtles

Appendix 3.Taxonomic and nomenclatural issues surrounding the identity of selected non-volant mammals.

Taxon	Taxonomic and distributional notes
Echymipera rufescens subsp.	There is evidence for the occurrence in PNG of the 'Cape York' subspecies of the Rufescent Bandicoot—*Echymipera rufescens australis*—with one prior capture in 1984 near Haia Village in the Purari Catchment Uplands (genetic data reported in Westerman et al. 2012). Bandicoots sharing the features of *E. rufescens australis* were captured at Sites 1 (Plate 3.4) and 8, and images of similar animals were obtained on camera traps set in the vicinity of Sites 1,4, 5, 7 and 8. It appears to be moderately abundant in the study area and was detected in both hill forest and alluvial forest habitats. Examples of typical *E. rufescens* (a larger, longer-snouted animal) are known from sites in the Kikori and Strickland River basins and from Brown River near Port Moresby (museum records; K. Aplin, unpublished data). Further genetic studies are needed to decide whether the Purari catchment population is referrable to *australis* and whether this taxon warrants recognition as a distinct species. In any event, this taxon appears to be confined in PNG to the Purari catchment.
Echymipera kalubu and E. oriomo	*Echymipera oriomo* is usually treated as a regional population of *E. kalubu* or sometimes as a possible valid subspecies (Flannery 1995). It was described in 1936 from the Oriomo Plateau on the Trans-Fly Plateau and has rarely been seen or mentioned since. In 2014 Ken Aplin collected an example of *E. oriomo* from the lower Ok Tedi River where it occurred together with typical *E. kalubu*. *Echymipera oriomo* has a bold yellow facial stripe (less obvious in *E. kalubu*) and white forelimbs (dark in *E. kalubu*) (see Plates 4.1–4.3). It is considerably smaller than *E. kalubu* and has smaller teeth, particularly its incisors. *Echymipera oriomo* will shortly be reinstated as a species distinct from *E. kalubu*. The occurrence *E. oriomo* in the study area is demonstrated by trophy jaws from Arehava 2 and Paevara villages, sighting of live and freshly killed individuals (at Site 8) and diagnostic camera trap images at Sites 5, 8 and 9. Other images may be of this species but it is not always possible to distinguish it from *E. kalubu* in cases where diagnostic features are obscured. None of the numerous images of Echymiperas from Sites in PRL-15 are referrable to *E. oriomo*. With the addition of this new population *Echymipera oriomo* is known from four areas—the Trans-Fly region, the vicinity of Kiunga on the Fly River (AMS specimens), the lower Ok Tedi River, and the Delta Swamps and Plains, Southeast Hills and Southeast Coast ecological zones of the lower Purari catchment. It is convincingly absent from further north in the Purari catchment, or in the middle to upper reaches of the Kikori or Strickland River catchments. There are no survey data from similar habitats to the west of the PNG border to judge the extent of its range in the

Taxon	Taxonomic and distributional notes
	Indonesian Province of Papua.
Dorcopsis luctuosa subsp.	Two subspecies of *Dorcopsis luctuosa* are currently distinguished— *D. l. luctuosa* from southeastern PNG and *D. l. phyllis* from the Trans-Fly region (Groves and Flannery 1989; Wilson and Mittermeier 2015)—with maps showing a large range disjunction between the two populations. In keeping with this mapping, preliminary genetic analysis of this species indicates a relatively deep divergence of the two forms, equivalent to other species pairs within *Dorcopsis* (Dr M. Eldridge, Australian Museum, pers. communication). Surveys over the past 5 years have closed the gap between the two populations of *D. luctuosa*, first with discovery of populations in the Strickland and Kikori catchments (Aplin, unpublished data) and now in the Purari catchment, with camera trap images from every survey site and all ecological zones except Mangroves (Plates 5.4, 5.5 and 6.1). An adult male was killed by a hunter in the vicinity of Site 3 (Plate 5.5) and this provided opportunity to examine and photograph an individual in detail, and to recover a tissue sample and some skeletal remains. Fur colouration of this individual and measurements of its cranium are both consistent with the typical form *D. l. luctuosa* as documented by Groves and Flannery (1989) but the stated diagnostic differences are slight and all are features of degree. What these new observations mean for the taxonomy of *D. luctuosa* is not yet clear. One possibility is that the two populations are ends of a morphological cline that will now be bridged by the new populations. Another is that the two subspecies are really species and that they come into contact somewhere within the hinterland of the Gulf of Papua. Genetic analyses are underway in *Dorcopsis* (see Section 3.3.3) and samples from the study area have been supplied to assess the relationships of this population with those to the east and west. The Grey Dorcopsis as a whole is probably too widely distributed to qualify as a restricted-range taxon. However, if the subspecies prove to be distinct then both will probably qualify for restricted-range status. Until this taxonomic issue is settled it is not here considered to be restricted-range.
Phalanger mimicus/P. intercastellanus	Three species of lowland cuscuses are currently distinguished in New Guinea—*Phalanger intercastellalus* in the southeast, *P. mimicus* in the southwest, and *P. orientalis* in the north (Colgan et al. 1993; Norris and Musser 2001; Wilson and Mittermeier 2015). These species are not known to co-occur anywhere but the distributional limits of each form are poorly defined. The contact between *P. intercastellanus and P. mimicus* is assumed to fall somewhere in Gulf Province but exactly where is unclear. A population on the Karimui Plateau to the north of the study area is referred to *P. intercastellanus* (reported by Menzies and Pernetta 1986 as *P. orientalis vulpecula*), while populations at similar elevations on Mounts Sisa and Bosavi and in the lowlands of the Fly River catchment to the west are referred to *P. mimicus* (Norris and Musser 2001; AMS specimens from Mount Sisa). According to Norris and Musser (2001) the two species are very similar in external morphology and examination of skulls and teeth is necessary to

Taxon	Taxonomic and distributional notes
	distinguish them. A female lowland cuscus was observed and photographed at Site 3 on 15 February 2016 (Plate 5.1). A trophy jaw from Paevera Village is identified as *P. mimicus* on the basis of its very small molars; this represents the first record of this species from Gulf Province. Both records are listed in Table 6 as *P. mimicus* but the Site 3 record might conceivably represent *P. intercastellanus* as this species is recorded from the Purari uplands catchment.
Hydromys cf. *chrysogaster*	There is mounting evidence that the larger water rats of Australia and New Guinea are a species complex. At least two morphologically and genetically distinctive populations occur in New Guinea but too few samples have been available for genetic study to establish their distributions and to establish appropriate taxonomic names (there are 6 available names for Melanesian populations; the name *chrysogaster* probably applies only to the Tasmanian population). At present, there are insufficient data to calculate actual ranges of any of the genetically distinct forms. However, indications so far point to one of the two New Guinean forms being widespread both north and south of the central cordillera and the other form possibly being restricted to southern New Guinea but also occurring widely within Australia. Neither is likely to qualify as a restricted-range taxon or to warrant special conservation listing across their entire ranges.
Melomys cf. *rufescens*	The small black-tailed Melomys of Melanesia are currently grouped as *M. rufescens* but with an uncertain number of regionally distinctive subspecies (Menzies 1996; Musser and Carleton 2005). On recent surveys in PNG more than one form of *M*. '*rufescens*' has been captured in a single region (K. P. Aplin, unpublished data), hence it is probable that the group contains more than a single species. The name *rufescens* was proposed for specimens from the Bismarck Archipelago and this name may not apply to any New Guinean population. A wide-ranging genetic study will be required to clarify species boundaries, to map their distributions and to establish appropriate taxonomic names (there are 10 available names for Melanesian populations); however, present indications are that none of the taxa likely to occur in the study area will qualify as restricted-range nor are they likely to warrant a conservation rating above their current IUCN status as Least Concern.
Paramelomys cf. *levipes* and *P*. cf. *naso*	A small number of *Paramelomys* species are distinguished by a combination of relatively large body size (adult weights > 50 g) and presence of a single hair (rather than the more usual three) emerging behind each of the tail scales. Three such species are currently recorded from lowland New Guinea (Menzies 1996; Musser and Carleton 2005)—*P. platyops*, *P. levipes* and *P. naso*. *P. platyops* is conspicuously smaller than the others but *P. levipes* and *P. naso* are weakly differentiated (*P. levipes* is said to have larger tail scales) and thought to have exclusive

Taxon	Taxonomic and distributional notes
	distributions—*P. naso* in southwestern New Guinea, east to Mount Bosavi, and *P. levipes* in southern New Guinea, with confirmed records from the southeast peninsula west to the Port Moresby region (Menzies 1996) and less well-documented records from sites in the Kikori basin (Leary and Seri 1997). Even if *P. levipes* extends west as far as the Kikori basin, its geographic range is almost certainly much less than 50,000 km^2, hence this species is considered here to qualify as a restricted-range taxon. Three clearly distinguishable *Paramelomys* species were captured during the first survey. Most frequently captured was a small form that is identified as *P. platyops*. The remaining two larger species are of similar size but differ in the coloration of both the back and belly fur and in details of cranial and dental anatomy. It is likely that these forms represent *P. levipes* and *P. naso* (Plate 6.6). One of the two forms is here tentatively assigned to *P. naso* on the basis of morphological similarity to specimens observed from localities on the Papuan Plateau in the Strickland basin (specimens in the AMS and USMN). The second taxon is referred to *P. levipes* although it lacks conspicuously enlarged tail scales and thus may differ from the typical form. This species is more similar in appearance to *P. platyops* but is larger overall and has much larger molars. Both forms were captured on the same trap line at Sites 1 and 7 which constitutes the first potential instances of sympatry between *P. naso* and *P. levipes* forms. Camera trap images usually cannot be assigned below genus level (Plate 6.5). Preliminary genetic data for *Paramelomys* suggest that the genus contains many more species than currently recognized (K. P. Aplin and K. N. Armstrong, unpublished data) and a broad-ranging genetic study would be required to confidently establish the identity of the populations in the study area. Regardless of the outcome of any such studies, the abundance of these species in the study area and their likely broad distributions make it unlikely that they will represent a high priority for the Project.
Pogonomys cf. *loriae*	The larger tree mice of New Guinea, currently grouped as *P. loriae* (e.g. Dennis and Menzies 1979; Musser and Carleton 2005) are morphologically and genetically diverse (K. P. Aplin, K. N. Armstrong and S. Hamilton unpublished data) and it is clear that more than a single species is currently conflated under this name. Recent surveys across the lowlands of southern PNG have produced captures of two forms of *P*. '*loriae*'; these are clearly separable by size and morphology. The smaller of the two is thought to represent *mollipilosus* which was described in 1881 from near the mouth of the Fly River and which has variously been treated as a synonym of *P. loriae* or *P. macrourus*. However, additional morphometric studies are needed to formally link the name *mollipilosus* with this distinctive form and to clarify the restricted identity of *P. loriae*. The distinctive '*mollipilosus*' form was captured at Sites 3 and 4 during the survey (see Plate 7.4) and this taxon is extremely abundant in the Wi'i Creek Cave owl pellet sample (see Plate 7.4). Given its potentially large range in southern New Guinea and its likely occurrence also on Cape York in Australia, this taxon is unlikely to qualify as

Taxon	Taxonomic and distributional notes
	restricted-range or warrant a conservation rating above Least Concern.
Uromys cf. *caudimaculatus*	White-tailed Giant Rats, usually treated as a single taxon—*Uromys caudimaculatus* (Groves and Flannery 1994; Musser and Carleton 2005)—are a species complex with multiple taxa in each of northeast Australia and New Guinea (Aplin et al. unpublished data). The species *caudimaculatus* was described from Cape York but it also occurs in the Trans-Fly region of New Guinea. Other species occupy other various parts of New Guinea, with two species often found in sympatry. More work on museum collections and additional genetic studies are needed to clarify species boundaries, to map their distributions and to establish appropriate taxonomic names (there are 13 available names for Melanesian populations). Camera trap images obtained during the survey document the local occurrence of two different forms of *Uromys* cf. *caudimaculatus* with a substantial contrast in relative tail length and coloration (see Plates 7.1–7.2). This is not always clear on images as it depends on the orientation of the animal, so all *Uromys* images are currently scored as a single taxon.