PAPUA LNG PROJECT

UPSTREAM ENVIRONMENTAL IMPACT STATEMENT

VOLUME 2: ENVIRONMENTAL AND SOCIAL BASELINE STUDIES

Part 6: Upstream Terrestrial Biodiversity Baseline Report
Annex 4: Upstream Avifauna Baseline Study Report

TOTAL E&P PNG LIMITED

December 2019
(Report No. 01215B_1-1_v7)

Upstream Avifauna Baseline Study Report

Papua LNG Project

Total E&P PNG Limited

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August 2017

Report Reference Number: 01215B_25-1-1_v7

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Acronyms and Abbreviations

Term	Definition
asl	above sea level
Terrestrial Biodiversity Study	project terrestrial biodiversity study
c.	abbrev. ‘circa’; approximately
CEPA	Conservation and Environment Protection Authority
CPF	Central Processing Facility
dbh	diameter at breast height
DD	Data Deficient (IUCN threat category)
EBA	Endemic Bird Area (BirdLife International zoning)
EIS	environmental impact statement
EN	Endangered (IUCN threat category)
ERIAS Group	ERIAS Group Pty Ltd
ESBS	Environment and Social Baseline Study
ESHIA	environmental, social and health impact assessment
FIMS	PNG Forest Inventory Mapping System
GPS	Global Positioning System
Hm	Hill forest (FIMS vegetation type)
IFC	International Finance Corporation
IOC	International Ornithological Congress
IUCN	International Union for the Conservation of Nature
km	kilometers
km^2	square kilometers
LC	Least Concern (IUCN threat category)
LIDAR	Light Detection and Ranging; a light-based remote detection method
LNG	Liquefied Natural Gas
m	meters
mm	millimeters
NT	Near Threatened (IUCN threat category)
pers. comm.	abbrev. ‘personal communication’
PGK	Papua New Guinea Kina
PNG	Papua New Guinea
Po/Fsw	Open alluvial forest/Swamp forest (FIMS vegetation type)
PRL-15	Petroleum Retention Licence-15
Project	Papua LNG Project
RAI	relative abundance index
sp.	abbrev. ‘species’ (singular)
spp.	abbrev. ‘species’ (plural)
study area	upstream terrestrial biodiversity study area
TEP PNG	Total E & P PNG Limited
Upstream PAOI	upstream project area of influence
WMA	Wildlife Management Area
WWF	World Wide Fund for Nature

Glossary of Technical Terms

Term	Definition
Alien invasive species	Species non-native to an ecosystem that have the potential to establish a viable local population and that may adversely affect local biodiversity values.
Anthropogenic	Originating from human activity.
Asymptote	A straight line approached but never crossed by a curve (species recorded versus survey effort in the context of this report).
Biogeographic zone	An area that is characterized by a specific geographical distribution of plants and/or animals.
Central cordillera	Refers to the central mountainous spine of New Guinea that runs from the eastern edge of the Vogelkop Peninsula in Indonesian New Guinea to the eastern tip of mainland Papua New Guinea.
Community structure	The taxonomic composition of a community; species assemblage.
Conservation listed species	Includes: (1) species listed under the IUCN Red List as threatened (Critically Endangered, Endangered or Vulnerable), Near Threatened or Data Deficient; (2) species listed as Protected under the PNG *Fauna (Protection and Control) Act 1966*; (3) species listed under CITES Appendix I or II.
Endemic	Belonging exclusively or confined to a particular place.
Endemism	Describes the proportion of endemic taxa occurring in a place; e.g. a high level of endemism.
Frugivore	A species that includes fruit as a significant component of its diet.
Protected	Species listed as Protected under the Papua New Guinea *Fauna (Protection and Control) Act 1966.*
Raptor	A bird of prey. Includes diurnal (eagles, hawks, falcons, etc.) and nocturnal species (owls).
Restricted-range	Species which have a total historical breeding range of less than 50,000 km^2.
Taxa	Plural of taxon; a systematic division (i.e. more than one species, genera, etc.).
Taxonomic	Taxonomy is the science of identifying, naming and classifying living organisms.

Executive Summary

Birds were surveyed at 13 sites (Project surveys) within the Papua LNG Project (the Project) study area (hereafter 'study area'), providing coverage of multiple vegetation types within each of five ecological zones. Surveys were conducted in two phases to provide a seasonal sampling perspective—the Phase 1 surveys were conducted in January–February 2016 during the 'northwest season'; the Phase 2 surveys in June–July 2016 during the 'southeast (trade wind) season'. The main survey program was based on sampling over multiple days (range: 3−11 days, excluding transfers) at eight 'principal' survey sites provided with field-based accommodation (Sites 1−5, 7, 8 and 9), in most cases (n = 7) at temporary 'fly camps' constructed specifically for the Project surveys. Shorter expeditionary visits were made to five additional sites of interest (Sites 6A−D and 8M) while based at the principal survey sites.

Prior surveys conducted within the study area are summarised, and their data combined with those of Project surveys for analysis and discussion of the study area's avifauna.

A total of 183 bird species was recorded during the Project surveys using a combination of field observations (311.75 search hours), camera trapping (>64,700 hours), mist netting (>10,800 net-metre-hours), automated sound recording (893 hours) and discussions with local Papua New Guinea (PNG) residents.

Species richness was highest at Site 4 (106 species) and Site 5 (109 species), located in alluvial/swamp forest on the Delta Swamps and Plains ecological zone in the southwest of PRL-15, and in logged areas within the export pipeline corridor at Site 3 (102 species) and Site 7 (113 species). Species richness was lowest in hill forest at Site 1 (90) and Site 2 (81) in the centre of PRL-15.

Combining data from Project and prior surveys, 214 bird species have been recorded in the study area. Twenty-one (21) conservation listed species are confirmed present, including 10 species listed by the IUCN as globally threatened, Near Threatened or Data Deficient, and 14 species that are Protected under PNG law.

Four resident bird species recorded in hill forest and/or alluvial forest environments are listed as threatened by the International Union for the Conservation of Nature (IUCN)—Southern Cassowary *Casuarius casuarius* (Vulnerable—VU), Papuan Eagle *Harpyopsis novaeguineae* (VU), Scheepmaker's Crowned Pigeon *Goura scheepmakeri* (VU) and Pesquet's Parrot *Psittrichas fulgidus* (VU). Of these, the Scheepmaker's Crowned Pigeon is of the highest conservation concern; it is a restricted-range species, has been extirpated from parts of its former range, and shows a marked preference for forest on gentle alluvial terrain, a vegetation type that is under significant pressure from industrial logging operations in southern mainland PNG, including within the species' stronghold area in Gulf Province.

Four other resident IUCN listed bird species have been recorded: Gurney's Eagle *Aquila gurneyi* (Near Threatened—NT) in hill and alluvial forest in the south of PRL-15; the New Guinea Flightless Rail *Megacrex inepta* (NT), present in mangroves and freshwater swamp forest environments, especially where sago is present, along the export pipeline corridor; the rare Starry Owlet-nightjar *Aegotheles tatei* (Data Deficient—DD) in alluvial forest in the southwest of PRL-15; and the rare Blue-black Kingfisher *Todirhamphus nigrocyaneus* (DD) in mangrove forest in the extreme southwest of the export pipeline corridor. The Starry Owlet-nightjar is also a restricted-range species.

The other two IUCN listed species, the Far Eastern Curlew *Numenius madagascariensis* (Endangered—EN) and Black-tailed Godwit *Limosa limosa* (NT), are migratory Palaearctic shorebirds that visit tidal flats and estuaries along the study area's coast.

Based on current knowledge of avian distributions and habitat preferences, an additional 21 conservation listed species may occur within the study area, including a further 18 IUCN listed species.

For all conservation listed species recorded or potentially occurring in the study area, summary accounts are provided of their distribution, habitat preferences, occurrence in the study area (recorded and potential) and known threats/susceptibilities.

The study area's diverse and integrated forest environments are recognized for their importance to maintaining a species rich tropical avifaunal community that includes a high proportion of New Guinea endemics and a suite of IUCN threatened and Near Threatened taxa. Within this ecosystem complex: (1) alluvial forest is singled out for its regionally limited extent (compared to hill forest), for its vulnerability to current logging practices, and for its importance to a high proportion of locally resident avifauna, including the IUCN threatened Southern Cassowary and Scheepmaker's Crowned Pigeon; (2) hill forest is recognized for its importance to a high proportion of resident bird species, including the IUCN threatened Pesquet's Parrot, and; (3) Mangrove forest is notable for its support of a suite of habitat-specialist and near specialist taxa. Among important wetland environments: (1) tidal wetlands (tidal flats, lagoons and estuaries) along the shorefront and in subcoastal zones provide focal habitat for a variety of migratory and resident bird species that congregate in these environments, prominent among which are 23 migratory Palaearctic shorebirds, including eight IUCN listed species, that may regularly occur; (2) off-river waterbodies provide focal habitat for a variety of migratory and resident freshwater wetland bird species. Local landscape features that provide important bird habitat include caves and rock overhangs, large trees in low nutrient or disturbed environments, and large fig trees.

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 S.A (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.

As part of the Project environmental, social and health impact assessment (ESHIA), a terrestrial biodiversity 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 avifauna (birds) conducted as part of the terrestrial biodiversity 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, 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 objectives

The objectives of this technical study are:

- To collate and assess existing information relevant to bird communities in the vicinity of the study area.
- To survey bird communities present in the study area.
- To describe and discuss the composition, condition and conservation significance of bird 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 bird communities.
  - The presence of non-native bird species.
- To summarise knowledge gaps in relation to bird communities present within the study area.

[1] The boundary of the PAOI is shown in figures for context only.

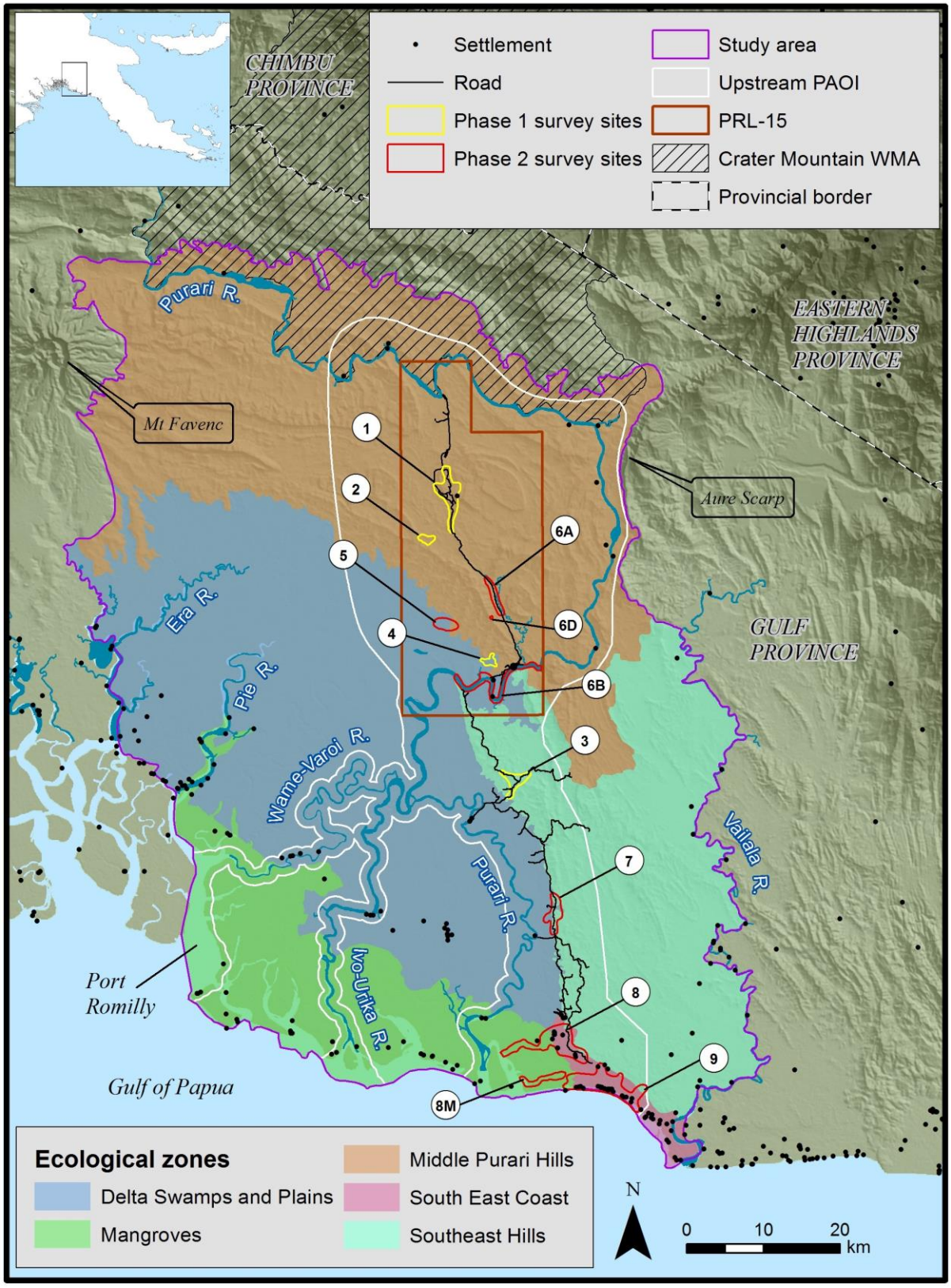

Figure 1 The study area and its component ecological zones, the Upstream PAOI and the location of Phase 1 and 2 Terrestrial Biodiversity Study survey sites (numbered 1–9).

2 Existing Information

2.1 Avian diversity and endemism in New Guinea

New Guinea and its satellite islands support the world's highest concentration of endemic birds (Gregory 2013). The region is exclusively home to most species of bird-of-paradise (Paradisaeidae), bowerbirds (Ptilonorhynchidae), Australasian robins (Petroicidae), cassowaries (Casuariidae) and owlet-nightjars (Aegothelidae), and is the only place in which berrypeckers and longbills (Melanocharitidae, Paramythiidae), satinbirds (Cnemophilidae), melampittas (Melampitta spp., Incertae sedis) and pitohuis (Pitohui spp. Pachycephalidae) are found (del Hoyo et al. 1999, 2007, 2008; Mack & Dumbacher 2007). Of nearly 800 bird species recorded in the New Guinea region, nearly 60% are endemic (365 species: Pratt and Beehler 2015).

BirdLife International has defined a series of Endemic Bird Areas (EBAs) across the globe to identify geographic centres of bird endemism. EBAs comprise distinct geographical regions that support populations of at least two 'restricted-range' bird species (total global breeding range less than 50,000 km^2; Stattersfield et al. 1998). The study area is located at the eastern end of the South Papuan Lowlands EBA:

> **"**This EBA includes the south-west lowlands and foothills bordering the Snow and Star mountains from the Mimika River (in the Indonesian province of Irian Jaya [now Papua]) to the drainages of the Kikori and Purari rivers (in Papua New Guinea)." (Stattersfield et al. 1998, p. 556).

The South Papuan Lowlands EBA covers 160,000 km^2 of predominantly forested habitats below 1,000 m asl.

2.2 Ornithological studies in the study area and surrounds

Current knowledge of the distribution, status and ecology of New Guinea's avifauna is patchy (Beehler 2007; Frodin 2007). While some areas have been the subject of detailed ecological research (e.g. Section 2.2.2), many regions have not been surveyed for the better part of a century or remain entirely unexplored. New bird species have been discovered on the island as recently as 2006 (Beehler et al. 2007) and further discoveries are considered a real possibility (Fjeldså 2013). Ornithological studies conducted in recent decades within the study area and in neighbouring regions are briefly reviewed below.

2.2.1 Existing data from within the study area

Birds featured heavily among the collections of naturalists visiting southeast New Guinea in the 19th and early 20th centuries. However, most of this early work was conducted east and west of the Gulf Province's deltaic region due to a scarcity of suitable landfalls, and it was not until the 1970s that documentation of the Purari lowlands avifauna began.

2.2.1.1 1970s hydroelectric scheme environmental studies

In the 1970s a series of environmental studies was initiated to examine the potential impacts of developing a hydroelectric project in the study area upstream of Wabo (Middle Purari Hills ecological zone) (Petr 1983). Ornithological research was not a focus, and relevant data from this period are limited. Liem and Haines (1977) listed 59 bird species known locally from mangrove and coastal areas, based (at least in part) on surveys conducted in 1975–77 by the PNG Fisheries and Wildlife Division[2]. In 1978 Ashford (1978, 1979) collected opportunistic records of 70 species from between

[2] Birds collected were deposited in the Wildlife Division Museum and the PNG National Museum and Art Gallery in Port Moresby.

Wabo and Baimuru, mostly from open habitats. Other studies listed some birds among the natural resources used by local residents (Egloff and Kaiku 1978; Warrillow 1978; Toft 1980; Liem 1983).

2.2.1.2 Prior studies commissioned for development of the Elk-Antelope gas field

Following discovery of the Elk-Antelope gas field in 2006, a number of biological assessments were conducted within the study area as part of a series of environmental impact statement and preconstruction studies commissioned by the previous operator (InterOil).

Douglas Environmental Services (DES) conducted two site-based flora and fauna studies during the period 2008–2010. Records were acquired mostly via field observation with mist nets deployed during the site-based surveys and bird calls recorded during the preconstruction survey. Inventories of 50 and 34 species were produced for each of the studies across all sites surveyed (DES 2008, 2010). These tallies under-represent the diversity of birds typically resident in the lowland forests of PNG, and include a number of misidentifications.

An unpublished study coordinated a survey of six sites in the Middle Purari Hills and Southeast Hills ecological zones east of PRL-15 and the currently proposed export pipeline corridor. Coverage at each site was limited (three days) and the total study list of 38 birds (all sites) is less than that (<50%) normally occurring at a single lowland forest site. Some conspicuous conservation listed species (International Union for the Conservation of Nature (IUCN) and nationally Protected) were recorded and a list of those potentially occurring was provided.

Another unpublished study conducted a five-day preconstruction survey along a proposed pipeline right-of-way (ROW) between Herd Base and the Elk-antelope gas field. A total of 68 bird species was recorded.

2.2.1.3 Purari Hydropower Project environmental studies

In 2011, development of a hydro-electric dam in the northern study area upstream of Wabo was again considered. A series of cross-seasonal, multi-disciplinary biodiversity surveys was undertaken for the Purari Hydropower Project (PHP) on behalf of PNG Energy Developments Limited (PNG EDL). Birds were surveyed by the present author, resulting in the most detailed assessment of avifauna and associated habitat and species-level sensitivities conducted to date within the study area. However, an environmental impact statement (EIS) was not submitted to government authorities and the data are not currently available for use; no further reference can be made to the locations or results of those surveys.

2.2.1.4 Other data

In addition to these efforts, a minor collection of bird records gathered by individual observers from coastal sites within the study area exists in the PNG Bird Society Newsletters (e.g. Anon. 1966; Cameron 1994).

This is the sum of ornithological data collected from within the study area. Detailed, reliable and publicly available information on bird communities within the study area is extremely limited—available inventories are incomplete and remain virtually non-existent for certain habitats, and for those species that have been recorded, the information provided is insufficient to assess the distribution and relative abundance of sensitive species within potentially affected ecosystems.

2.2.2 Data from surrounding areas

2.2.2.1 Kikori basin

West of the study area, the Kikori lowlands include a similar range of habitats to those found in the study area, and together these regions comprise the bulk of the ‘Kikori–Purari’ biogeographic district

(Beehler 1993a). Over the last 20 years the avifauna of the Kikori lowlands[3] has been surveyed by a number of experienced ornithologists including Ian Burrows (1995), Jared Diamond and David Bishop (Diamond and Bishop 2000, 2003) and Roger Jaensch (Jaensch, undated; Jaensch and Kulmoi, undated; Jaensch and Watkins, undated). Some bird records have also been included in the reports of mammal surveys conducted in the area (Leary and Seri, undated; Leary, undated). Habitats covered include forest on alluvial and hilly terrain, freshwater swamp habitats, mangroves and mudflats. While the results appear as unpublished reports (to the World Wide Fund for Nature (WWF) and Wetlands International) they are nonetheless available for reference.

2.2.2.2 Lakekamu basin

East of the study area, Bruce Beehler initiated a long-term study conducted by multiple ornithologists over nearly 20 years (10 surveys) into bird communities inhabiting the Lakekamu basin lowlands (below 100 m asl) (Beehler et al. 1994, 1995; Safford and Attwood 1996; Mack and Igag 1998; Beehler and Mack 1999). Although the Lakekamu basin is outside of the 'Kikori–Purari' biogeographic district (Beehler 1993a), together with the Kikori basin studies these surveys provide useful context on the potential occurrence of a variety of sensitive bird species in the study area's intervening lowland expanse.

2.2.2.3 Crater Mountain Wildlife Management Area

The Crater Mountain Wildlife Management Area (CMWMA) covers some 2,700 km^2 across three provinces (Eastern Highlands, Chimbu and Gulf) at elevations between c. 50 m and 3,000 m asl (Sekhran and Miller 1994; Mack and West 2005). The northern rim of the study area overlaps the CMWMA, covering c. 445 km^2 of the Middle Purari Hills ecological zone north of the Purari River (Figure 1).

Since the mid-1990s a good deal of ornithological research has been conducted in the CMWMA. This has produced at least five postgraduate degrees (Mack 1995a; Wright 1998; Sinclair 2000; Igag 2002; Legra 2005) and 25 peer-reviewed scientific publications[4]. However, most of this work has been conducted north of the study area in montane or upper hill environments above 800 m asl. Elevation exerts a marked influence on the structure of tropical bird communities (Wells 1985; Kattan et al. 2006), including those in New Guinea (Diamond 1972; Beehler 1982), so that these results are less relevant to present purposes than those of studies conducted in adjacent lowland regions (Kikori and Lakekamu basins).

Relevant work at least partly conducted below 600 m asl for which information is publicly available is restricted to a study on cassowaries (Mack and Jones 2003), single papers on Pesquet's Parrot *Psittrichas fulgidus* (Mack and Wright 1998) and the Papuan Eagle *Harpyopsis novaeguineae* (Watson and Asoyama 2001), two papers on geophagy by 12 bird species (Symes and Marsden 2003; Symes et al. 2006) and an account of 31 bird species visiting fruits at a single species of tree (Marsden et al. 2006). Northwest of the study area, Andrew Mack and Debra Wright visited Lake Teburu (c. 600 m asl) in 1991 (Mack and Wright 1993), and are still the only ornithologists to have done so. Unfortunately, their visit was brief and yielded only 16 species.

Prior to its establishment but still within the CMWMA, in the 1960s Jared Diamond studied birds at various localities in the Karimui basin, including in 1965 near Soliabeda (Soliabedo) village, reaching as low as 410 m asl along the Wi River (Diamond 1972). The Soliabeda site is less than 15 km north of the study area boundary.

[3] The studies listed here report data from below 700 m asl.

[4] Excluding studies concerning wildlife use by local residents: Mack (1990, 1994, 1995b); Mack and Wright (1996, 1998); Sinclair (2001, 2002); Watson and Asoyama (2001); Igag and Murphy (2002); Mack and Druliner (2003); Mack and Jones (2003); Mack and Scholes (2003); Symes and Marsden (2003, 2005, 2007); Johnson et al. (2004); Wright (2005); Mack and Oppel (2006); Marsden and Symes (2006, 2008); Marsden et al. (2006); Scholes (2006); Symes et al. (2006); Oppel and Mack (2010); Sinclair et al. (2010).

2.2.2.4 Other data

In addition to these surveys, a minor set of bird records gathered from within Gulf Province by individual observers exists in the publications of the PNG Bird Society, notably the journals *Muruk* and *PNG Bird Society Newsletters* (e.g. Tolhurst 1991; Burrows 1993; Richardson 1995; Gregory 1996).

2.3 Summary of existing knowledge

Collating all available sources, prior ornithological work conducted within the study amounts to reliable records of 128 bird species (see Section 4.1.2). Avian inventories are far from complete in all sectors of the study area, with the Delta Swamps and Plains, Southeast Hills, Mangroves and Southeast Coast ecological zones most notably under-sampled. Numerous additional species are expected to occur, including many common birds as well as species of conservation significance. Moreover, for those species that have been recorded, distributional and abundance data are often lacking and the information provided is insufficient to assess potential Project-related impacts and to inform the development of sound management strategies.

3 Methods

Information on the study area's avifauna was collected through a combination of literature review and field surveys. Reviewed material includes the results of local surveys described above (Section 2), broader regional summaries of New Guinea's birdlife (e.g. Coates 1985, 1990; Pratt and Beehler 2015; Beehler and Pratt 2016) and international conservation assessments (IUCN 2015). Field survey locations and methods are described below.

3.1 Survey sites and timing

Birds were surveyed at 13 sites within the study area, providing coverage of multiple vegetation types within each ecological zone. Surveys were conducted in two 'phases' to provide a seasonal sampling perspective (Section 3.2). Table 1 lists the location, timing and elevations covered at each survey site.

The main survey program was based on sampling over multiple days (range: 3−11 days, excluding transfers) at eight 'principal' survey sites provided with field-based accommodation (Sites 1−5, 7, 8 and 9). Accommodation at most principal sites (n = 7) was provided at temporary 'fly camps' constructed specifically for the purpose of the present study. Accommodation at Site 1 was provided at an existing Project facility (Antelope 3 operations base). Shorter expeditionary visits were made to five additional sites of interest (Sites 6A−D and 8M) while based at the principal survey sites.

A brief description of each survey site (chronological order) and the habitats surveyed for birds is given below (Sections 3.1.1–3.1.2). A detailed description of the vegetation (types, structure and floristics) present at each survey site is presented in the flora technical report (Venter et al, 2017).

Table 1 Location and time spent at each fly camp/accommodation base during bird surveys.

Site	Base location[A]	Base elevation[B]	Trail elevations[B]		Arrival (2016)	Departure (2016
			Min	Max		
Phase 1						
Site 1	294689 9209644	100	50	305	19 Jan, 14:30	27 Jan, 11:00
					8 Feb, 16:45	9 Feb, 13:50
Site 2	291894 9202769	95	55	230	27 Jan, 11:15	2 Feb, 10:30
Site 3	303459 9171560	130	40	170	2 Feb, 10:45	8 Feb, 16:00
Site 4	300251 9186944	30	20	65	9 Feb, 14:20	16 Feb, 09:30
Phase 2						
Site 5	294432 9191260	20	15	45	21 Jun, 17:00	2 Jul, 10:45
Site 6A	300655 9195465*	n/a	30	75	27 Jun, 09:20	27 Jun, 16:10
					28 Jun, 08:20	28 Jun, 15:00
Site 6B	299876 9184880**	n/a	5	30	25 Jun, 10:00	25 Jun, 15:00
Site 6C	n/a	n/a	n/a	n/a	30 Jun, 11:00	30 Jun, 11:30
Site 6D	300280 9192765*	n/a	185	310	26 Jun, 10:15	26 Jun, 16:00
Site 7	308305 9153930	15	5	90	2 Jul, 11:00	9 Jul, 12:25
Site 8	308835 9138610	5	0	70	9 Jul, 12:40	15 Jul, 09:20
Site 8M	M1 309575 9133025** M2 309180 9132980** M3 308595 9132770**	0	0	5	11 Jul, 08:45	11 Jul, 12:00
					12 Jul, 08:45	12 Jul, 14:25
					13 Jul, 11:35	13 Jul, 14:50
Site 9	315970 9131180	0	0	25	15 Jul, 09:30	19 Jul, 13:45

[A] Camp/insertion points: UTM PNG94 (easting northing). * Helicopter landings. ** Boat landings.
[B] All elevations in m asl from LIDAR digital elevation model (DEM) to the nearest 5 m.

3.1.1 Phase 1 surveys

The Phase 1 surveys were conducted in January–February 2016 from three sites in PRL-15 and one site in the northern sector of the export pipeline corridor.

3.1.1.1 Site 1

Site 1 was located in the Elk-Antelope gas field in the northern half of PRL-15 within the Middle Purari Hills ecological zone. The surveyed area lies within the Mena River catchment in the upper Era River drainage. Accommodation was provided at the Antelope-3 operations base, located above Boa Creek and providing access to a network of existing Project roads. Foot surveys were conducted on roads (active and disused), forest trails and along Boa Creek and minor tributary streams (Figure 2). A vehicle survey was undertaken further south of camp to reconnoitre habitat type and condition.

The surveyed area is characterised by steep low elevation terrain. The Antelope-3 base was located within the western rim of a broad sub-circular basin with gentle (generally <20%) dip-slopes rising to sheer escarpments and draining inward to Boa Creek. Escarpment ridges to the north (330 m asl) and west (235 m asl) of Antelope-3 were among the highest points surveyed within the study area. Terrain outside of the basin is less strongly featured, with soft Tertiary mudstones and siltstones deeply incised to a local relief commonly in excess of 100 m.

Natural vegetation in surveyed areas is mapped as 'Hill forest' (FIMS code Hm) (Plate 2A). The area is remote from landowner settlements, the closest being Ura village approximately 19 km north-northwest of the Antelope-3 operations base. Accordingly, most or all anthropogenic disturbance is attributable to the Project through the construction and operation of roads, wellpads and associated camp facilities. According to local informants, Pawaian residents do pass through the area, utilising Project roads and wellpads to facilitate passage between Wabo and Poroi 1, and hunting and overnighting in bush camps *en route*. A fire-pit and shelter at the Antelope-1 wellpad were the only signs of local resident activity observed in this area.

3.1.1.2 Site 2

Site 2 was located along the proposed trunkline west route option approximately 7.5 km south-southwest of the Antelope-3 operations base. The surveyed area is in the Mena River catchment headwaters near the Era–Pie River catchments divide in the Middle Purari Hills ecological zone (Figure 2). Five complete sampling days (excluding site transfer days) were spent at this site, with surveys conducted on foot along forest trails and along an unnamed secondary tributary of the Mena River.

The area is characterized by steep and unstable terrain associated with the Orubadi Beds geological formation, the soft Tertiary sediments being deeply incised and prone to landslip and slumping. Natural vegetation is mapped as Hill forest (Hm) and included numerous areas of regeneration following natural disturbance events (Plate 2B). Even in its climax form, much of the forest was relatively small statured with a dense understorey of climbing palms (*Calamus*, *Korthalsia* spp.) making trail cutting difficult.

The Site 2 survey area is very remote. Apart from a seismic line cut along the creek there was no sign of prior human activity. The nearest settlement (Nea Creek) is approximately 17.5 km to the south on the Purari River. The surveyed area is difficult to access/traverse on foot and is apparently little visited, if at all, by local landowners.

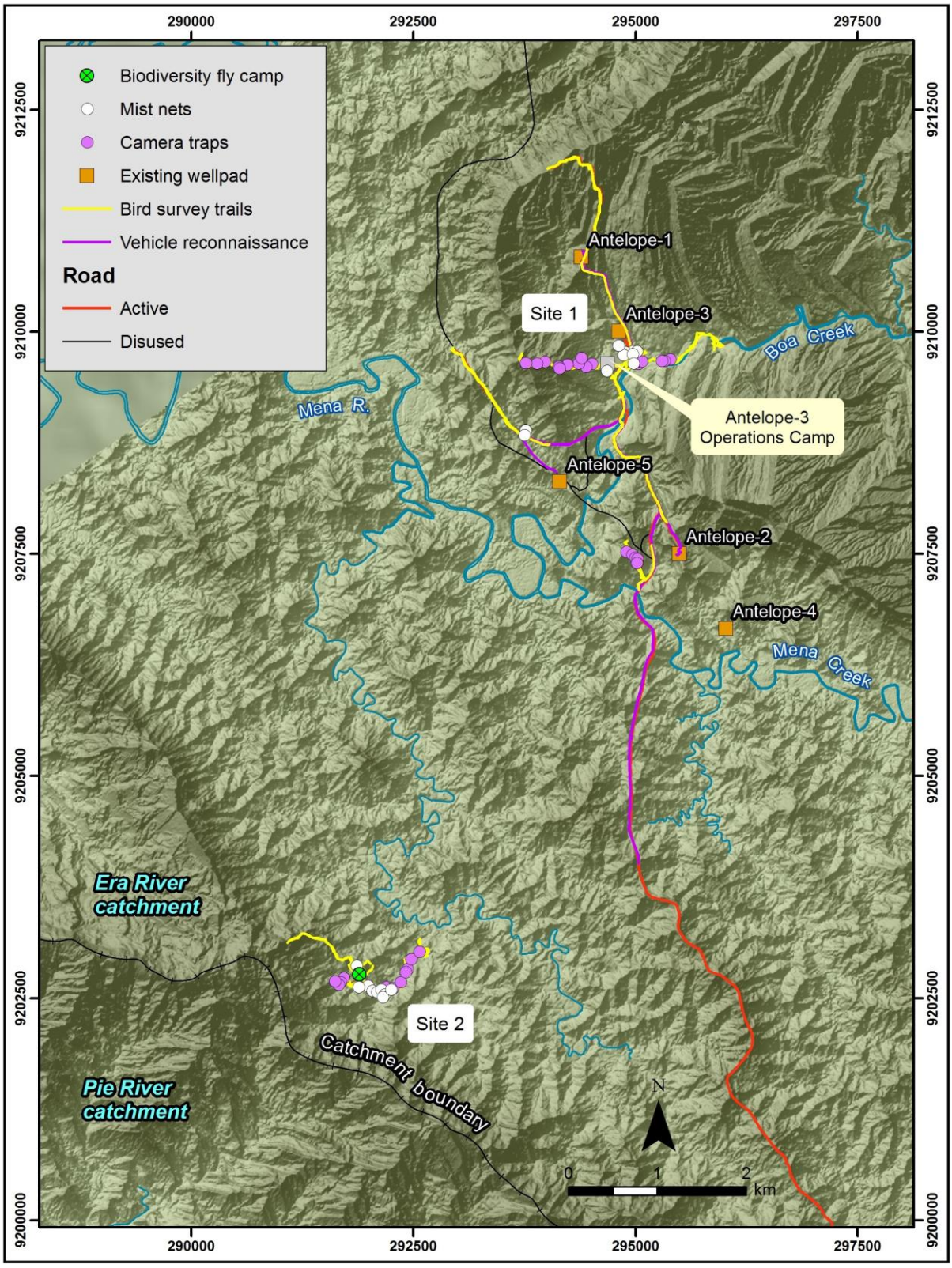

Figure 2 Bird survey coverage at Sites 1 and 2.

3.1.1.3 Site 3

Site 3 was located along the northern section of the proposed export pipeline corridor in the Southeast Hills ecological zone approximately 8.5 km south of PRL-15. The fly camp was located below a low elevation ridge (<200 m asl) dividing headwater tributaries of the Purari Creek to the north and smaller creek systems that flow directly onto the Delta Swamps and Plains ecological zone approximately 2.5 km southwest of camp. Five complete sampling days were spent at this site, with surveys conducted on foot along logging roads and forest trails (Figure 3).

Landform at this site is similar to that surveyed in the Middle Purari Hills ecological zone (Sites 1 and 2) with sharply dissected hilly terrain having a local relief (within 1 km^2) in excess of 50–100 m. All forest in the surveyed area, mapped as Hill forest (Hm), had been intensively logged some 10–15 years previously (Plate 3A). While in most areas forest structure and floristics had been severely altered, in some places large, non-commercial trees had been left standing so that small patches of forest retained an open, multi-layered understorey structure characteristic of more mature forest.

The fly camp was sited close to an active logging road. A logging operations base was located on the Purari River 5 km to the southwest, and Evara village, the closest local resident settlement, was situated downstream about 8 km southwest of the fly camp. Evara village, the logging camp and surveyed areas were all connected by the logging road network. Gardens were established along the logging road to a point about 1.3 km south of the fly camp, and during the surveys the logging road was used by Evara residents to access areas north of the fly camp for hunting and fishing.

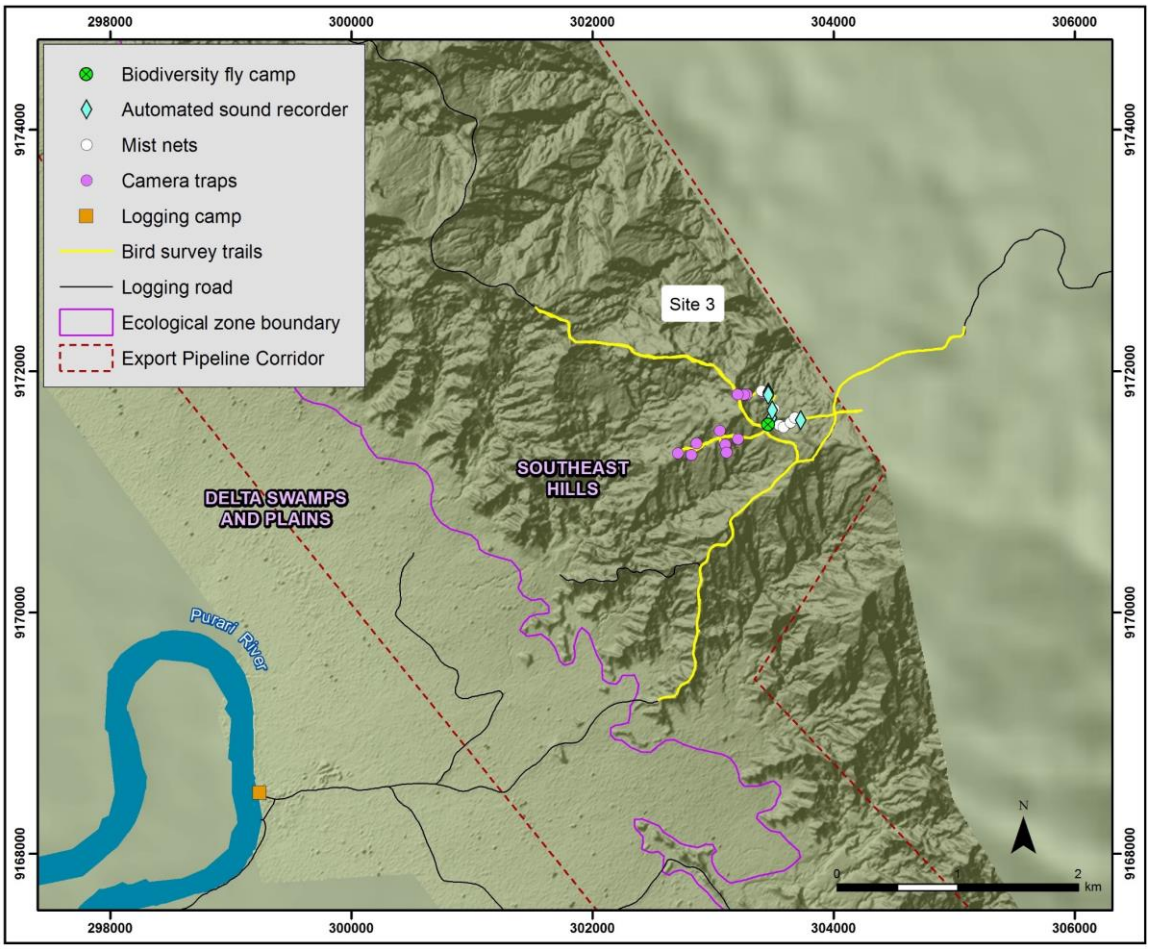

Figure 3 Bird survey coverage at Site 3.

3.1.1.4 Site 4

Site 4 was located in the eastern half of the proposed 'Central Processing Facility (CPF), logistics base and airstrip area' at the southern end of PRL-15. The fly camp was located on an alluvial plain at the eastern edge of the Delta Swamps and Plains ecological zone near its border with the Middle Purari Hills (Figure 4). The surveyed area lies within the Oyomo Creek drainage, a small tributary system that drains the low elevation hills (<350 m asl) to the immediate north and east of the fly camp and flows across the alluvial plain to the Purari River approximately 2.7 km to the southwest. Surveys were conducted over six complete days on foot along forest trails and streams and from clearings at geotechnical assessment sites.

Natural vegetation around the fly camp, and in most areas surveyed at this site, is mapped as a complex of Open alluvial forest, Swamp forest and Hill forest (FIMS code Po/Fsw/Hm). On this gently undulating alluvial terrain, forest structure and floristics change markedly with minor changes in elevation and associated shifts changes in drainage pattern. The tallest Open alluvial forest (Po) was observed on better-drained sites (Plate 3B); the canopy in these areas reached 30–35 m in height with large emergent trees to 40–50 m. Treefall is more common in poorly drained sites (Whitmore 1984); such areas supported a smaller statured forest with denser understorey vegetation. Within the Po/Fsw/Hm complex, the hill forest component occurred on isolated raised sites mostly near the adjacent hill zone. Hill forest (Hm) proper was present on the surrounding slopes of the Middle Purari Hills ecological zone. The fly camp was located within a series of forest clearings and interconnecting trails associated with geotechnical assessment of a proposed CPF site. Residents from Poroi 1 village stated that they hunt in this area, though no other sign of anthropogenic disturbance was noted.

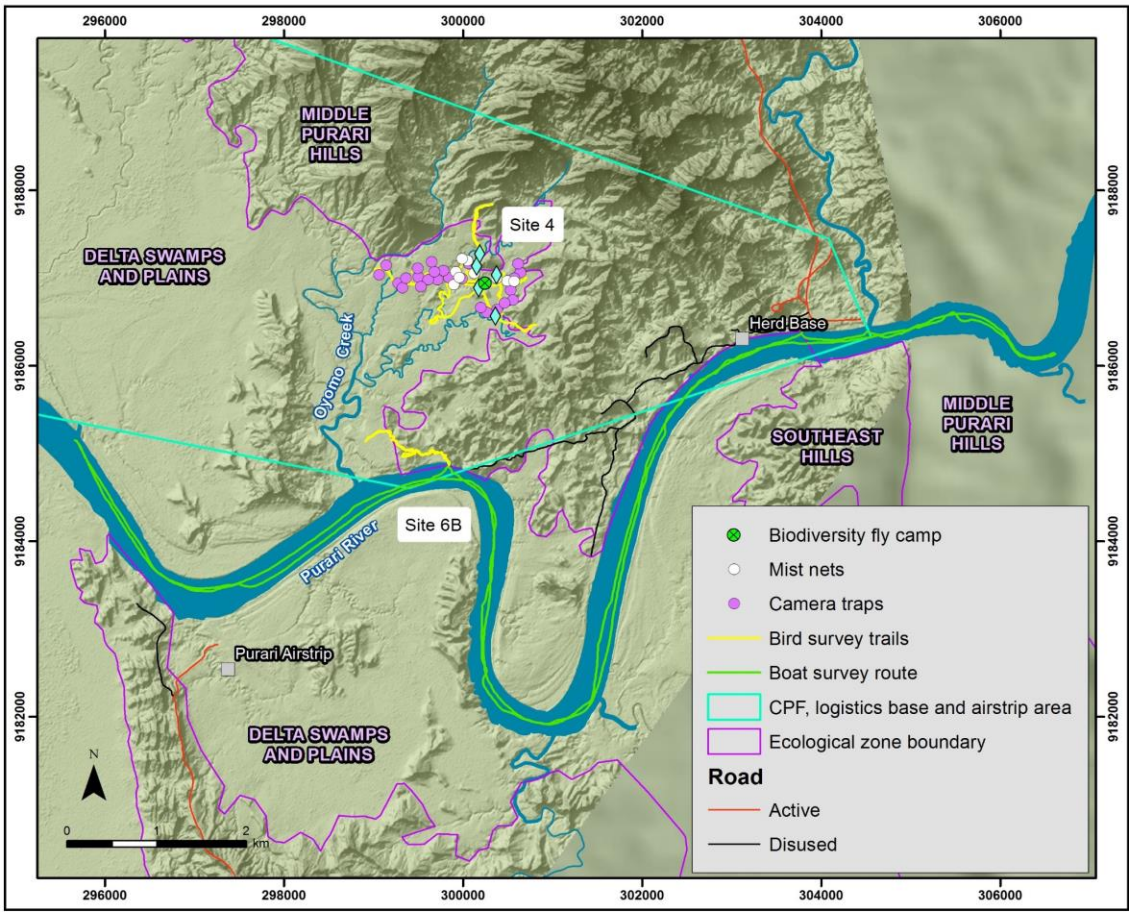

Figure 4 Bird survey coverage at Sites 4 and 6B.

3.1.2 Phase 2 surveys

The Phase 2 surveys were conducted in June–July 2016 from 5 sites in PRL-15 and 4 sites along the export pipeline corridor.

3.1.2.1 Site 5

Site 5 was located in the Purari River catchment in the southern half of PRL-15. The fly camp was located in the northwest of the 'CPF, logistics base and airstrip area' on an alluvial plain at the eastern edge of the Delta Swamps and Plains ecological zone near its border with the Middle Purari Hills (Figure 5). Surveys were conducted over ten days along forest trails and streams, including five complete days and five partial survey days during which other sites (6A−D; Section 3.1.2.2) were visited from this accommodation base.

The terrain and vegetation at Site 5 were similar to those surveyed at Site 4, with Open alluvial forest/Swamp forest/Hill forest complex (FIMS code Po/Fsw/Hm) present in most surveyed areas and Hill forest (Hm) on the slopes of the Middle Purari Hills east of the fly camp. Areas of sago swamp woodland, too small for mapping at the FIMS scale, were present in poorly drained low lying areas west of the fly camp. Immediately east of camp was an extensive area of rattan scrub with scattered emergent trees. The area is remote from human settlement and navigable waterways and according to local informants is not visited by local landowners.

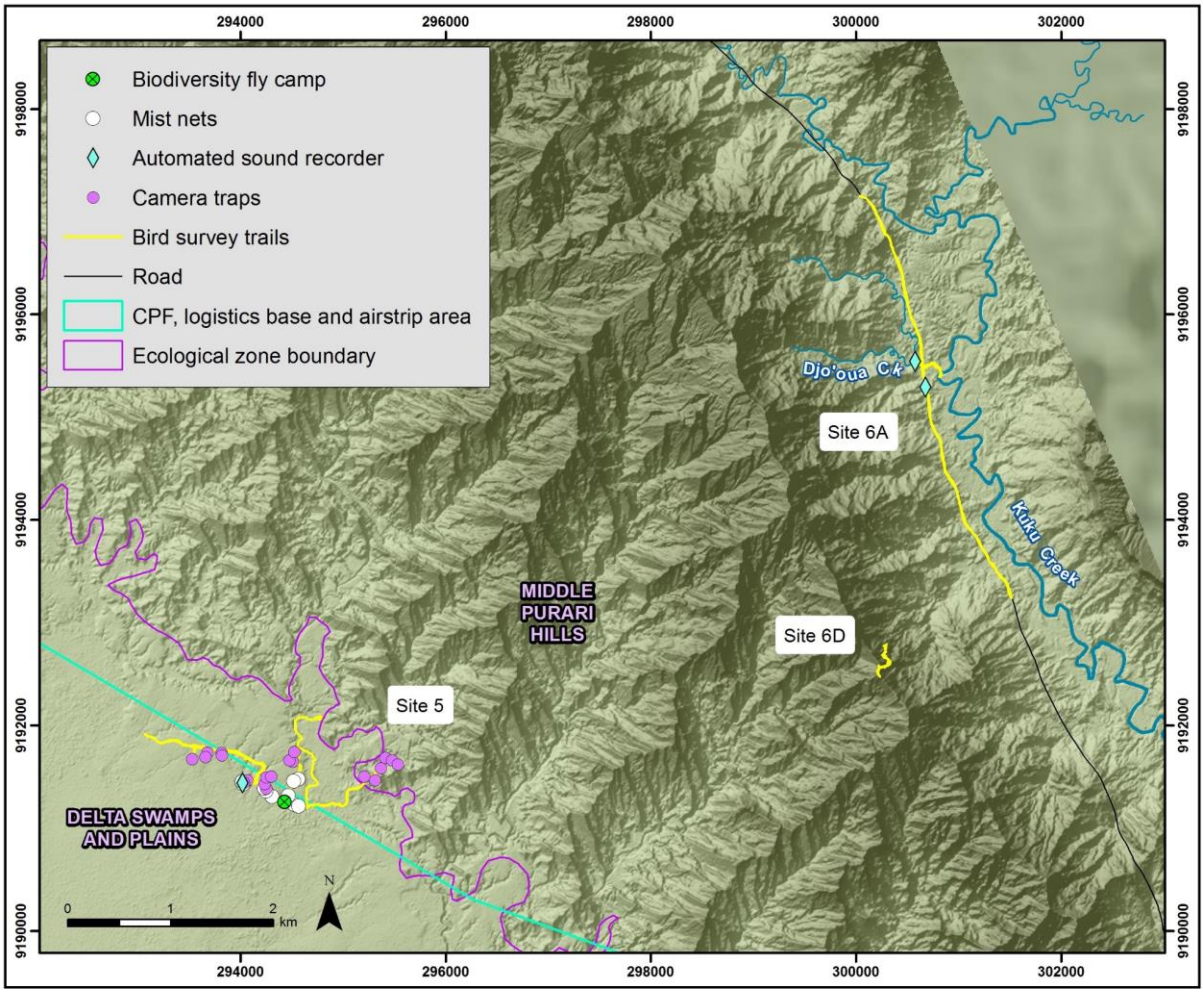

Figure 5 Bird survey coverage at Sites 5, 6A and 6D.

3.1.2.2 Sites 6A−D

Sites 6A−D were surveyed while based at the Site 5 fly camp.

Site 6A was located in the Kuku Creek (Purari River) catchment in the Middle Purari Hills ecological zone in the southern half of PRL-15. Surveys were conducted over two consecutive days along the existing road, in flanking Hill forest (Hm) and in riparian habitats along Kuku Creek and its tributary Djo'oua Creek (Figure 5). No permanent settlements were present, though the area is visited by local landowners and a hunting camp was located at the southern end of the surveyed area approximately 7 km north of Herd Base.

A day-visit to Site 6B, located in the south of PRL-15 (Figure 4), included:

1. Boat survey of approximately 17.5 km of riparian habitats along the Purari River.
2. Foot survey of Hill forest (Hm) and Open alluvial forest/Swamp forest/Hill forest (Po/Fsw/Hm) habitats present in a potential wharf site located on the northern bank of the Purari River approximately 4.5 km west-southwest of Herd Base.

Boat-based records from the Purari River are presented separately in the results along with incidental observations made from Herd Base and the Purari airstrip during both survey phases. Records from the potential wharf site are presented independently as Site 6B.

Site 6C comprised oxbow wetland systems present in the southwest of PRL-15 (Plate 5B). These were surveyed from helicopter on 30 June 2016. Most information about birds using the oxbow wetlands was collected by the mammal team (K. P. Aplin and J. Novera) during a visit to Mapaio Fish Camp located on the Purari River in the southwest of PRL-15.

Site 6D, located in the Middle Purari Hills between Sites 5 and 6A, spanned the ridge line separating the Purari River sub-catchments of Kuku Creek and those draining directly onto the Delta Swamps and Plains (Figure 5). The single-visit survey included Hill forest (Hm) up to 310 m asl, the highest point surveyed for birds within the study area. Forest along the ridge line had been cleared previously for seismic exploration.

3.1.2.3 Site 7

Site 7 was located in the central section of the export pipeline corridor approximately 25 km south of PRL-15. The fly camp was constructed on a former logging road at the border of the Southeast Hills and Delta Swamps and Plains ecological zones (Figure 6). Surveys were conducted over six complete sampling days along logging roads, forest trails and creek lines in a variety of natural vegetation types, including Hill forest (Hm), Small crowned hill forest (Hs), Open alluvial forest (Po), Swamp forest/Swamp woodland (Fsw/Wsw) and Swamp woodland/Swamp grassland (Wsw/Gsw). Hill and alluvial forest in the surveyed area had been intensively logged about 10–15 years previously (local resident information). However, examples of remnant primary forest were accessed—alluvial forest at the edge of swamp complexes west of the logging road (Plate 4A), and hill forest in a steep walled ravine a few hundred metres east of camp.

The fly camp was sited approximately 3.5 km northeast of Aivai village, a journey of almost 6 km via former logging roads (no longer used by vehicles). During the surveys the logging road was used by Aivai residents to access areas north of the fly camp for hunting and fishing.

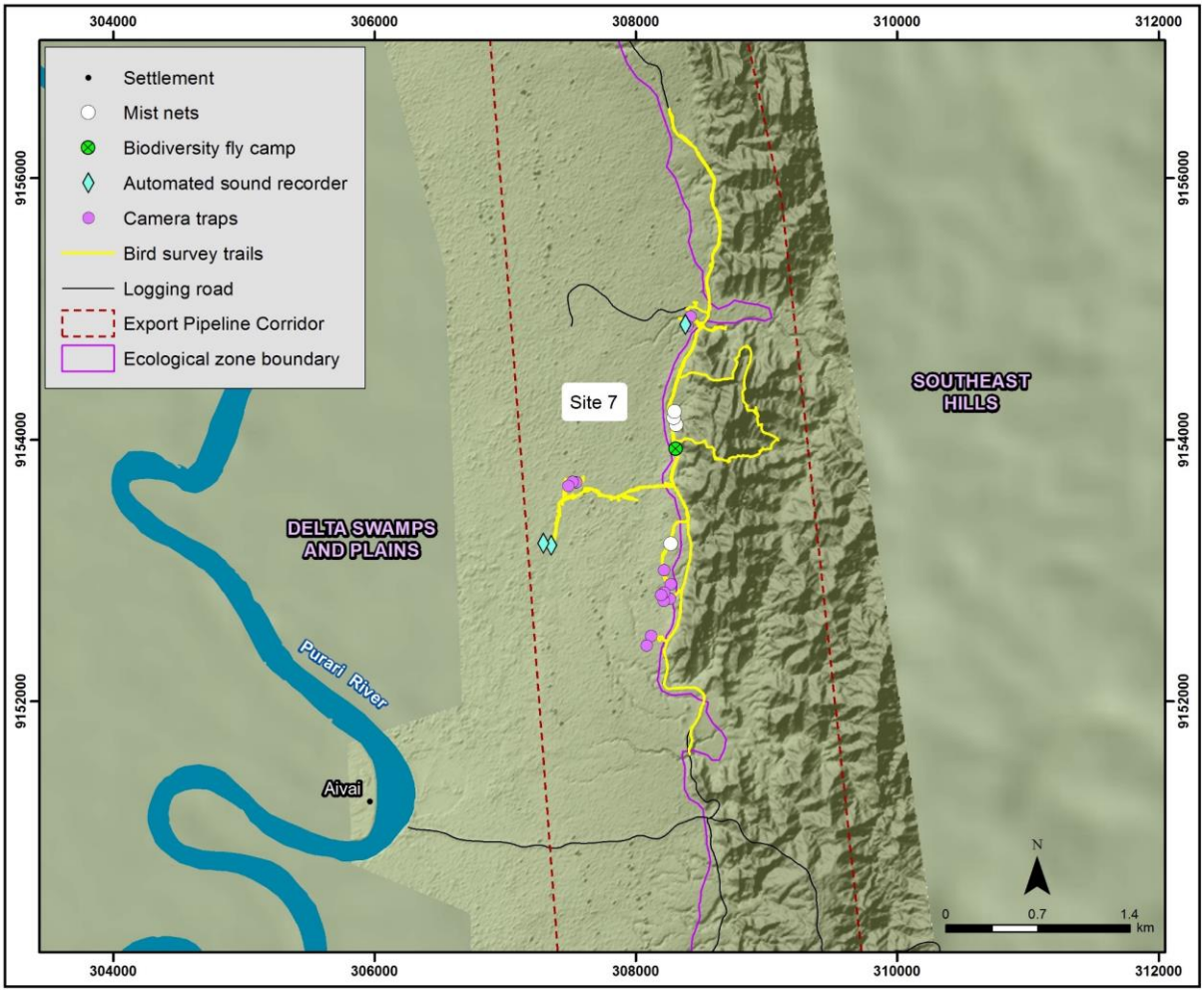

Figure 6 Bird survey coverage at Site 7.

3.1.2.4 Site 8

Site 8 was located a few kilometers inland from the coast at the southern end of the export pipeline corridor (Figure 7). The fly camp was located approximately 7 km from the coast between Ere and Kilavi villages in an area of shifting cultivation and agroforestry plantations. Surveys were conducted over five days, including two complete days and three partial survey days during which Site 8M (Section 3.1.2.5) was visited from this accommodation base.

Foot surveys were conducted primarily on gentle terrain of the relict beach ridges and plains landform that characterises the Southeast Coast ecological zone (Bryan and Shearman 2008), and extended in the southeast to the foothills of the Southeast Hills ecological zone. Natural vegetation in these areas is mapped as Alluvial forest (Pl), Swamp forest/Swamp woodland (Fsw/Wsw) and Small crowned hill forest (Hs). However, this region is densely populated and well drained areas supported few examples of remnant natural vegetation. Non-swamp vegetation on gentle terrain had mostly been converted for shifting agriculture, agroforestry or village developments, while intensive logging in 2013−2014 (local resident information) had removed much of the local hill forest as well as remnant alluvial and commercial swamp forest approved for harvesting by local landowners (Plate 4B). Patches of remnant alluvial forest were present along the Muro River north of Avavu, Ere and Kilavi villages, retained by local landowners for a continuing supply of natural resources, and remnant hill forest remained in some areas of steep terrain unsuitable for logging.

Return boat trips were made over three consecutive days from Avavu village to Site 8M in the southeast of the Mangroves ecological zone. Birds recorded in riparian habitats along the Muro River between Avavu village and the main Purari River channel are incorporated into the Site 8 results.

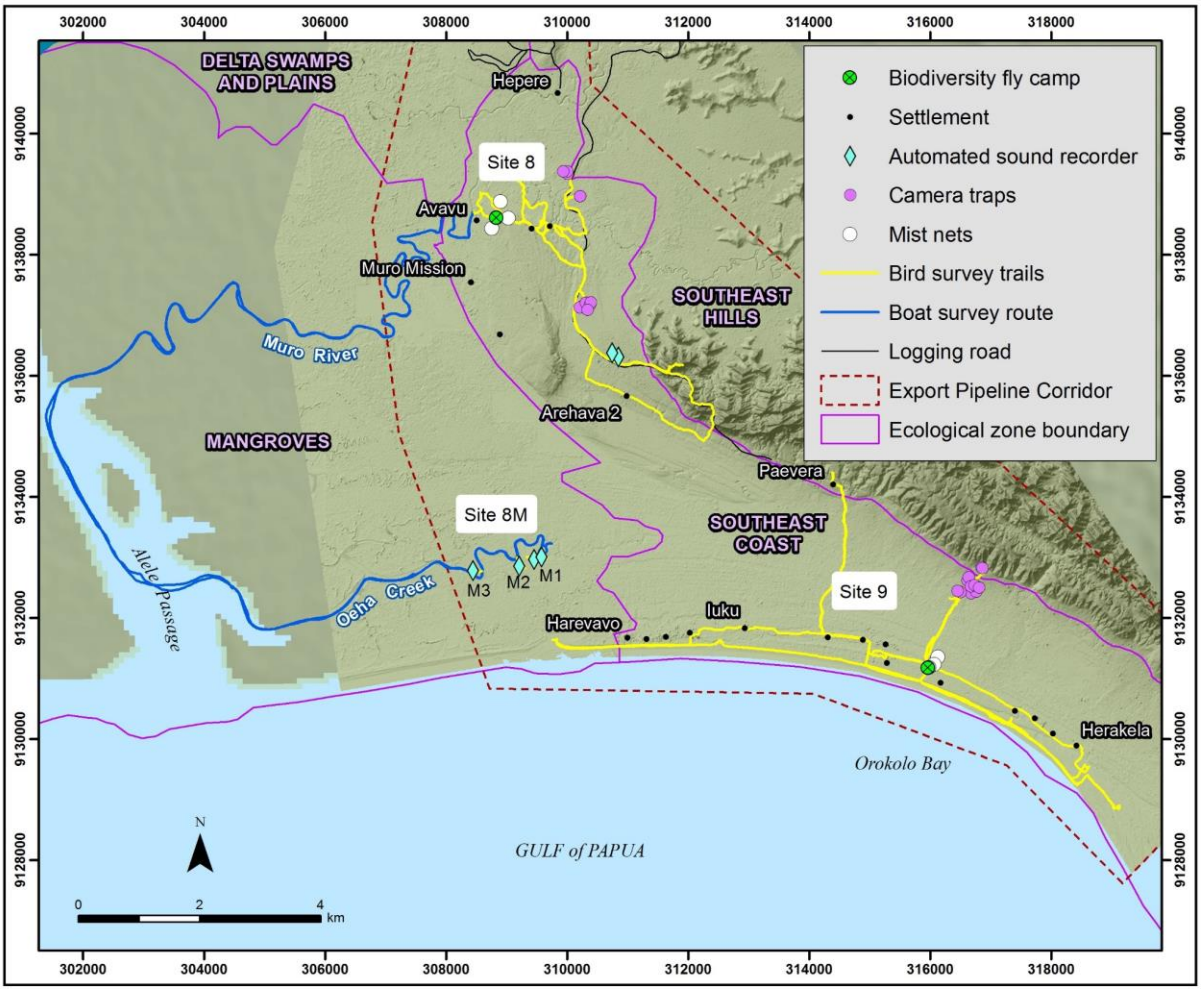

Figure 7 Bird survey coverage at Sites 8, 8M and 9.

3.1.2.5 Site 8M

Site 8M was located in the southwest corner of the export pipeline corridor in the southeast corner of the Mangroves ecological zone (Figure 7). The region is characterised by a mosaic of mangrove and Nypa palm (*Nypa fruticans*) tidal swamp forests (Plate 5A). This site was visited by boat on three consecutive days while based at Site 8, with foot surveys conducted in mangrove forest at three landing sites within the export pipeline corridor (Table 1). Birds recorded from the boat along Oeha Creek between the export pipeline corridor and the main Purari River channel are incorporated into the Site 8M results.

3.1.2.6 Site 9

Site 9 was located at the coast at the southern end of the export pipeline corridor in the Southeast Coast ecological zone (Figure 7). The fly camp located less than 300 m from the coast of Orokolo Bay between Kavava and Miha Kavava villages. Birds were surveyed on foot over three complete sampling days along a c. 12 km coastal expanse and in a mix of cultivated and forest environments to 2−3 km inland.

This is the most densely populated region in the study area; the coastal strip supports a dense array of settlements, gardens and agroforestry plantations and few examples of natural coastal vegetation remain. A notable exception was present in the southeast corner of the export pipeline corridor, where a recently aggraded shorefront southeast of Herakela village included developing Littoral forest (B) with Mangroves (M) along the landward margin and a series of coastal freshwater lakes behind the primary dune system. Elsewhere along the coast, tidal watercourses running parallel to the coast were lined with mangroves, though these were often heavily disturbed. Inland from the coast, a sub-parallel array of interdune swales supported a series of sago swamp woodlands. Much of the better drained land on the intervening relict dune was subject to shifting cultivation. Further inland the relict dunes and swales evened into plains that rose gradually towards the foothills of the hinterland. These supported Alluvial forest (Pl) with isolated garden patches. The forest matrix was subject to some harvesting of forest products (e.g. timber extraction, hunting) by local residents but was otherwise intact.

3.2 Climate and seasonality

The Phase 1 surveys were conducted during the 'northwest season' of December–March. The Phase 2 surveys were conducted during the 'southeast (trade wind) season' of May–October. Weather conditions characterising these seasons, and the possible effects of the 2015–16 El Niño event, are described in the Terrestrial Biodiversity Baseline Report. Rainier conditions experienced during the Phase 2 surveys did not notably inhibit bird survey activity.

In terms of migrant bird activity, the Phase 1 surveys were conducted at a time when northern hemisphere migrants are wintering in New Guinea, while the Phase 2 surveys coincided with the presence of southern non-breeding migrants from Australia.

3.3 Field techniques and survey effort

Bird survey methods included 'active' searches, mist netting, camera trapping, call recording and discussions about birds with local resident field assistants. These techniques were combined to maximise completeness of the bird species inventory and the likelihood of locating species of conservation significance in the time available at each site. Survey efforts for each method are summarized in Table 2. Surveys were conducted by Dr Iain Woxvold with mist netting activities supported by Pita Amick and Junior Novera.

Bird surveys were conducted in accordance with the permitting procedures of the PNG Conservation and Environment Protection Authority (CEPA; formerly Department of Environment and Conservation). The relevant permits are presented in Appendix 1.

3.3.1 Active searches

Active searches included walks along forest trails, roads, rivers and creeks through forest and along beaches, and static surveys from helipads, geotechnical assessment pads or other sites that afforded good views of surrounding habitat. Boat surveys of riparian and riverine environments were conducted at Sites 6B, 8 and 8M. Survey trails ranged from <500 m to more than 8 km in length, with most trails surveyed more than once (range 1 to 6 times). Individual search periods ranged from 0.5 to more than 7 hours.

Hourly counts were made of all birds seen or heard during active searches. To avoid double counting within search periods, only species previously unrecorded within the search period were recorded during the return journey along survey trails.

Surveys were conducted throughout daylight hours and included time before dawn and after dusk to cover active periods of both diurnal and nocturnal birds. Effort was weighted to periods of peak bird activity during the early morning and late afternoon. Survey trails are shown in Figures 2−7.

Table 2 Per-site survey effort summaries. The eight 'principal' survey sites are listed in bold.

Site	Active search hours[A]	Mist nets		Camera traps		Automated sound recorders[C]	
		No.	Diurnal net-m-hrs[B]	No.	Hrs	No.	Hrs
Phase 1							
Site 1	42.25	16	555.00	21	6,832.75	–	–
Site 2	30.75	12	702.75	11	1,064.75	–	–
Site 3	35.25	8	2,536.50	11	1,344.00	4	370
Site 4	33.5	18	1,785.75	25	40,615.00	3	244.75
Phase 2							
Site 5	43.25	24	3,049.00	18	11,383.25	2	57.5
Site 6A	13.25	–	–	–	–	2	38.25
Site 6B	3	–	–	–	–	–	–
Site 6D	5.75	–	–	–	–	–	–
Site 7	44.5	11	918.50	12	1,419.75	3	67.5
Site 8	24.5	15	752.25	11	926.25	2	26.25
Site 8M	11.25	–	–	–	–	4	88.75
Site 9	24.5	6	527.25	11	1,118.50	–	–
Totals	**311.75**	**78**	**10,827.00**	**120**	**64,704.25**	**20**	**893**

[A] Measured in hours, and excluding informal survey periods (e.g. incidental observations from camp).

[B] Diurnal period taken from 06:30 to 18:30.

[C] Automated sound recorders not routinely deployed at all principal survey sites (see Section 3.3.4).

3.3.2 Mist nets

Up to 18 mist nets (range 8–18; Plate 1A) ranging in size from 9 to 12 m (31 mm mesh) were deployed at each of the eight principal survey sites. Nets were deployed in a variety of habitats, including forest on hill slopes, ridges and gullies, on alluvial flats, along or across minor watercourses, in sago swamps and in gardens and secondary growth. Nets were mounted singly or in linear series (up to four nets) on poles close to the ground (top not higher than 4 m). All nets were checked regularly during daylight hours and at least once within 1.5 hours after nightfall.

Mist nets were deployed for a total of more than 10,800 diurnal net-metre hours (Table 2). Mist net locations are shown in Figures 2–7. Most captured birds were brought back to camp and stored in the shade in calico bags for subsequent processing including photography, biometric measurement, blood sampling and plumage marking prior to release. Recaptures were released at the net site at time of capture.

3.3.3 Camera traps

Eleven to 25 digital camera traps (Reconyx HC550/PC850; Plate 1B) were deployed at each of the eight principal survey sites along animal trails and at apparent feeding stations in an effort to photograph terrestrial birds and mammals. All camera traps were programmed to maximum detection sensitivity and to take three photographs on each 'trigger event' with the minimum amount of rest time between triggers (<2 seconds). Units were deployed for a total of more than 64,700 camera trap-hours (Table 2). Camera trap locations are shown in Figures 2–7.

Sampling design varied between sites. At most sites cameras were deployed at the start of the sampling period and collected before transfer to the next site. Sampling effort was expanded at Sites

1, 4 and 5. Of 21 cameras deployed at Site 1, 14 camera traps were left to operate during the Site 2 and Site 3 surveys for a total period of 15−20 days (variable deployment date, collected 9 February 2016). At Site 4, 25 camera traps were left to operate unbaited in alluvial forest for 76–80 days (collected 30 April 2016). At Site 5, 11 cameras were left to operate in alluvial forest (n = 5) and hill forest (n = 6) for 65−66 days (collected 28 August 2016).

Most cameras were baited with cooked rice or raw '*kaukau*' (sweet potato) to increase the detection probability of terrestrial fauna during short-term deployments. Cameras left to operate for more than two months at Sites 4 and 5 were unbaited in order to provide baseline data with unaffected (repeatable) detection probabilities suitable for input to a possible future monitoring program.

3.3.4 Automated sound recorders

Automated sound recorders (Bioacoustic Audio Recorder (BAR), Frontier Labs; Plate 1C) were deployed in forest environments at seven survey sites. The BARs recorded audible sounds, including bird calls, continuously for periods of up to 48 hours. All recordings were screened for the presence of birds not detected during active survey periods.

Recording localities included Sites 6A and 8M, the only two sites without field-based accommodation that were visited over multiple days. This provided opportunity to screen bird vocalizations from the peak periods of bird activity (early morning and late afternoon) that would otherwise have been missed. BARs were not deployed routinely at principal survey sites because (1) sufficient time was spent at these sites to survey birds directly and (2) screening BAR recordings for bird calls takes a considerable amount of time. However, BAR units were deployed at some principal survey sites to supplement existing datasets.

3.3.5 Community knowledge

Direct observations were supplemented with data gathered opportunistically during conversations with local Papua New Guinean residents. Conversations about birds were held with Pawaian residents from Poroi 1 village at Sites 2, 4, 5 and 6A, with Ahia residents of Evara village at Site 3, Iare residents of Aivai village at Site 7, and with Orokolo residents from Ere, Kilavi and Avavu villages at Site 8, and multiple coastal villages at Site 9. Most information came from conversations that I. Woxvold had with local residents who had been assigned to assist with the Phase 1 terrestrial biodiversity surveys. Additionally, information about which waterbirds occur in the oxbow lake wetland in the southwest of PRL-15 was collected in Phase 2 by the mammal team (K. P. Aplin and J. Novera) at the nearby Mapaio Fish Camp.

As an adjunct to the biodiversity surveys, the purpose of these discussions was not to provide a detailed understanding of the use of avifauna by local communities, but rather to gain additional insight into the status and distribution of various species, and to supplement information about the use of local wildlife collected by the EIS socioeconomic team during household interviews and that will be collated in a separate report covering ecosystem services (Land and Natural Resources). Discussions focused on the distribution and status of recognisable species of conservation significance (e.g. cassowaries, crowned pigeons) and on the use and importance of bird species to local communities.

Information provided by local residents must be carefully interpreted. Viewing pictures in a field guide regularly leads to misunderstanding over which species is being discussed. Most reliable are those identifications based on (for example):

- Distinctive and/or culturally important species such as cassowaries, megapodes, hornbills, cockatoos, large parrots and birds-of-paradise.
- Birds seen or heard together in the field for which the local informant can provide an accurate visual and/or behavioural description.
- Birds in the hand (e.g. mist netted) for which the local informant can provide an accurate vocal and/or behavioural description.

Preference was given to these forms of identification as a basis for discussion.

3.4 Analysis

3.4.1 Species accumulation curves

Species accumulation curves were generated for each site in Excel by matching accumulated species richness against survey time (hours).

3.4.2 Relative abundance calculations

Relative abundance indices (RAIs) were calculated:

1. Per site for individual species detected during active searches (active search RAI), from the proportion of hourly counts in which each species was recorded. For this analysis partial hour counts at the end of active search periods, often during the return journey along survey trails, were bundled with records from the previous hour.
2. For individual species detected by camera trap (camera trap RAI), from the rate of independent photographic capture 'events' (per hour x 100), summed across cameras within sites (and within vegetation type where applicable—e.g. hill forest, alluvial forest). Events were considered independent where consecutive pictures of the same species were taken more than 30 minutes apart. Multiple events were scored within 30-minute periods only where more than one individual was seen in a single photograph and/or where plumage differences permitted identification of separate individuals in successive photographs.

The following abundance rankings and their abbreviations appear in text, tables and appendices:

- Occasional (O) – species encountered only once or twice despite sufficient time spent in suitable habitat; active search RAI <0.08, camera trap RAI <0.05 given sufficient camera trap sampling effort (here defined as ≥3,000 camera trap hours from ≥12 cameras).
- Fairly common (FC) – species encountered with some regularity given sufficient time in suitable habitat; active search RAI 0.08–0.22, camera trap RAI 0.05–0.15 and from at least two cameras, and/or at least four captured in mist nets.
- Common (C) – active search RAI 0.22–0.35, camera trap RAI >0.15 and from at least three cameras, and/or at least six captured in mist nets.
- Very common (VC) – active search/camera trap RAI >0.35.
- Present (X) – recorded but abundance not ranked.

Where there was discrepancy between abundance rankings generated from active search and camera trap RAIs, the higher ranking was taken.

The thresholds used to apply these rankings have been developed specifically for this report to communicate the relative abundance of various species both within and between sites. For reasons well documented (e.g. Bibby et al. 2000; O'Brien 2011) they are not intended to provide an accurate estimate of population size. Relative abundance estimates reflect encounter rates, and behavioural differences between species influence their detection probabilities. For example, some vagile and/or conspicuously vocal species (e.g. some large parrots) may be over-represented where single individuals are repeatedly encountered. Conversely, other species may be under-recorded as detectability through vocalisations varies seasonally and/or with resource availability (e.g. terrestrial columbids, cuckoos, pittas). Thus a direct comparison of RAI numerics between species will in many cases not provide an accurate estimate of relative population densities. However, by categorizing RAIs into a limited number of broad-scale classes, relative abundance rankings are expected to provide a more reliable inter-species comparison.

A number of species and sites were not surveyed sufficiently to accurately rank abundance. These include:

- Shy/cryptic species that may be more abundant but are not easily detected (e.g. crakes and rails).
- Species for which insufficient time was spent in suitable habitat (e.g. waterbirds).
- Species detected only by trapping (mist nets and/or camera traps) at frequencies below those used to trigger fairly common or common status as described above.
- Night birds (owls, frogmouths).
- Alien invasive species restricted to anthropogenic habitats (e.g. Eurasian Tree Sparrow *Passer montanus*).
- All birds at Sites 6A–D, 8, 8M and 9 (insufficient time in single habitats).

3.5 Protocols used

3.5.1 Taxonomy and nomenclature

Nomenclature (common and scientific names) and family arrangements follow the International Ornithological Congress (IOC) World Bird List (version 6.1) (Gill and Donsker 2016) for most species. The single exception follows the recent split of Southern Crowned Pigeon *Goura scheepmakeri* to Scheepmaker's Crowned Pigeon *G. scheepmakeri* and Sclater's Crowned Pigeon *G. sclateri* proposed by del Hoyo and Collar (2014) and adopted by BirdLife International and the International Union for the Conservation of Nature (IUCN). As this split involves a species of conservation significance present within the study area the more conservative taxonomic approach is here followed.

Where species are mentioned in the text the scientific name appears with the common name on first mention and only the common name is used thereafter.

Species appearing in square brackets (in text, tables and appendices) were only provisionally identified to species level. Though not definitively identified, encounters are considered most likely to have involved the species named.

3.5.2 Conservation listed species

Conservation listed species referred to in this report are of three general kinds:

- Species listed by the International Union for the Conservation of Nature (IUCN) in The IUCN Red List of Threatened Species (IUCN 2016) as:
  - 'Threatened'. IUCN threatened categories include (in descending order of conservation significance) **Critically Endangered** (CR), **Endangered** (EN) and **Vulnerable** (VU).
  - **Near Threatened** (NT).
  - **Data Deficient** (DD).

  These species are hereafter collectively referred to as 'IUCN listed' species. Most species appearing in this report are classified as 'Least Concern' by the IUCN and thus are not presently considered to be at risk. This IUCN category does not appear subsequently in the text but is included in the taxonomic appendices.

- Species listed as Protected under the PNG *Fauna (Protection & Control) Act 1966* (Fauna Act), hereafter referred to as 'nationally Protected' species and denoted by the abbreviation (P). The list of nationally Protected species was obtained from Kula and George (1996).

- Species listed under Appendix I or Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Regardless of their status and distribution, there is a blanket application of CITES II listing on all diurnal birds-of-prey (Accipitridae, Falconidae), owls (Tytonidae, Strigidae), hornbills (Bucerotidae), cockatoos (Cacatuidae), parrots (Psittacidae) and current (Paradisaeidae) and former (taxonomically: satinbirds—Cnemophilidae; melampittas *Melampitta* spp.) birds-of-paradise. Only CITES I listed species are mentioned specifically in the text of this report. CITES II species are listed in the taxonomic appendices, or appear incidentally in the text where they are also listed under one or more of the above IUCN listed or nationally Protected categories. Unless listed separately under a relevant IUCN category, they are not considered to be a conservation risk.

3.5.3 Endemic and restricted-range species

Restricted-range species are those with a distribution covering less than 50,000 km^2 (Stattersfield et al. 1998; IFC 2012). Restricted-range bird species considered in this report include those defined by BirdLife International (Stattersfield et al. 1998; http://www.birdlife.org/datazone/eba) plus any additional species whose range is considered to be less than the threshold size based on more recent data.

A broader regional endemism ranking is provided for all species recorded in the study area, according to the following numeric codes:

1. Occur more widely in the Indo-Pacific.
2. Endemic to New Guinea, its satellite islands, the Bismarcks and Maluku.
3. Endemic to New Guinea and its satellite islands (Waigeo, Misol, Yapen, Biak, Aru, d'Entrecasteaux and Louisiades).
4. 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.

3.5.4 Vegetation terminology

Vegetation types are referred to in the text using a set of FIMS-equivalent terms developed specifically for the terrestrial biodiversity study. These follow closely the formal FIMS descriptors; they are based on the founding vegetation descriptions (Paijmans 1976; Hammermaster and Saunders 1995) but are generally less cumbersome. A full list of vegetation types present within the study area, and equivalent terms used in the terrestrial biodiversity study, is presented in the Terrestrial Biodiversity Baseline Report.

Where a specific vegetation type is referred to in the text it is capitalized and followed in brackets by its FIMS code, 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.

3.5.5 Mapping and coordinates

A Garmin 60CSx GPS unit was used to record tracks and coordinates of individual locations in the field. All maps and coordinates appearing in this report use the PNG94 zone 55 geographic coordinate system (datum), with coordinates presented as easting followed by northing. All elevations are given as metres above sea level (m asl).

4 Results and Discussion

4.1 Diversity summaries

4.1.1 Project surveys

A total of 183 bird species[5] from 52 families was recorded within the study area during the Phase 1 and 2 Project surveys. Site records for all species are presented in Appendix 2 together with their conservation status. Table 3 lists the number of bird species recorded at each site.

Table 3 The number of bird species recorded at each survey site.

Site	No. species	Main vegetation types
Site 1	90	Hill forest (Hm)
Site 2	81	Hill forest (Hm)
Site 3	102	Hill forest (Hm)
Site 4	106	Open alluvial forest/Swamp forest/Hill forest (Po/Fsw/Hm); Hill forest (Hm)
Site 5	109	Open alluvial forest/Swamp forest/Hill forest (Po/Fsw/Hm); Hill forest (Hm)
Site 6A	62	Hill forest (Hm)
Site 6B – logistics base	39	Open alluvial forest/Swamp forest/Hill forest (Po/Fsw/Hm); Hill forest (Hm)
Site 6C – oxbow wetlands	11	Swamp woodland (Wsw); Herbaceous swamp (Hsw)
Site 6D	32	Hill forest (Hm)
Site 7	113	Open alluvial forest (Po); Hill forest (Hm); Small crowned hill forest (Hs); Swamp forest/Swamp woodland (Fsw/Wsw); Swamp woodland/Swamp grassland (Wsw/Gsw)
Site 8	96	Alluvial forest (Pl); Swamp forest/Swamp woodland (Fsw/Wsw); Small crowned hill forest (Hs); Mangrove (M); Land use (O)
Site 8M	39	Mangrove (M)
Site 9	92	Alluvial forest (Pl); Small crowned hill forest (Hs); Mangrove (M); Littoral forest (B); Land use (O)
Herd Base, Purari River and Purari airstrip	18	Hill forest (Hm); Open alluvial forest/Swamp forest/Hill forest (Po/Fsw/Hm) and Alluvial forest/Swamp forest (Pl/Fsw) (riparian associations); Land use (O)
All sites	**183**	

One hundred and forty-four (144) birds from 37 species were mist-netted and 1,761 birds/events from 19 species were photographed remotely by camera trap. Mist net captures are summarised for each site in Appendix 3. Camera trap event summaries, including RAIs for individual sites and habitats, are presented in Appendix 4. A selection of species mist netted and camera trapped is included in Plates 6–10.

[5] Including provisional identifications where there is no confusion with species already recorded.

Figure 8 shows bird species discovery curves for each of the eight principal survey sites (insufficient time was spent at other sites to plot meaningful curves). While a final asymptote was not reached at any site, the rate of species accumulation at sites with more than 30 active search hours had slowed markedly towards the end of each survey period, indicating that most locally occurring species had already been detected at those sites.

Rates of discovery and final tallies were highest:

- In logged areas at Sites 3 and 7 in the Southeast Hills ecological zone.
- In areas with undisturbed alluvial forest and adjacent foothill forest at Sites 4 and 5, at the border of the Delta Swamps and Plains and Middle Purari Hills ecological zones in the south of PRL-15.

Species richness was lowest in hill forest environments of northern PRL-15 at Sites 1 and 2.

Counts of 90–100+ species at Sites 1, 3 and 4 are consistent with tallies recorded by this author over similar periods at comparable elevations elsewhere in southern PNG (I. Woxvold, unpublished data). The total of 81 species at Site 2 was lower than that typically encountered at other lowland forest sites given similar survey effort.

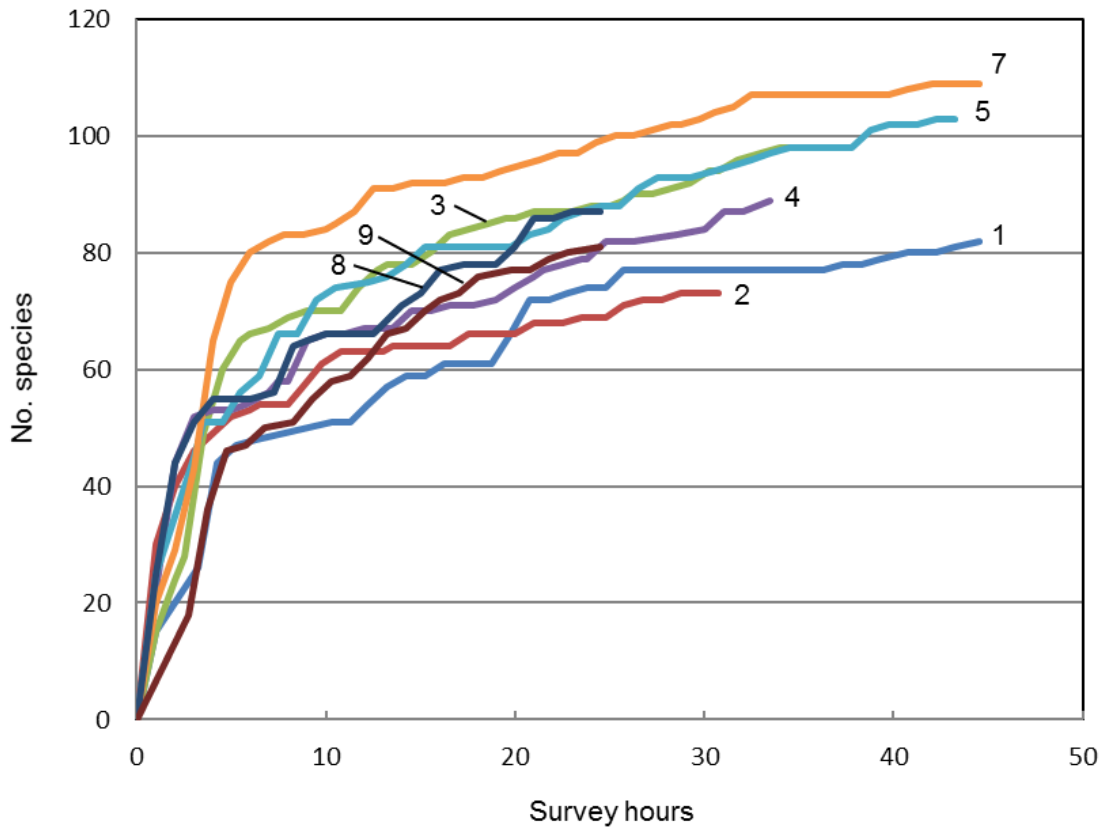

Figure 8 Bird species discovery curves for each principal survey site (site numbers indicated). Data from active search periods (trapping data excluded).

4.1.2 Prior surveys

One hundred and twenty-eight (128) bird species from 48 families were reliably recorded during prior surveys conducted within the study area (data from sources cited in Section 2.2.1). Species recorded in each ecological zone during prior surveys are listed in Appendix 5 and the totals are summarised in Table 4.

Data from prior surveys require careful interpretation. Conservative totals are provided, with a number of species discounted due to apparent errors in identification (Appendix 5). The results of prior surveys are further incorporated into various analyses and discussion appearing in following sections.

Combining data from Project and prior surveys, 214 bird species have been recorded in the study area to date. Ninety-seven (97) species were recorded during both Project and prior surveys, while 86 species were recorded only during Project surveys and 31 species were recorded only during prior surveys.

Table 4 The number of bird species recorded during prior surveys by ecological zone.

Ecological zone	No. species[1]
Middle Purari Hills	79(91)
Southeast Hills	24
Delta Swamps and Plains	43(83)
Mangroves	8(66)

[1] Figures in brackets include all possible records in light of uncertain location data (see Appendix 5).

Most species recorded only during Project surveys are resident New Guinea forest species (68/86). Given that most bird species listed during prior surveys were recorded locally in hill forest environments (Table 4), and that newly listed taxa include many of the region's most common and conspicuous hill forest species[6], this difference reflects the generally low survey effort previously expended (Section 2.2.1).

In contrast, most species recorded only during prior surveys occur in habitats not subject to extensive survey under the Project itinerary (26/31). They include five species of coastal forest environments (including mangroves), five species of open and disturbed habitats, one oceanic tern and 15 species of wetland and/or marine coastal environments, eight of which are not present during the austral winter when coastal and boat-based surveys were conducted. Only five previously recorded forest bird species were not encountered during Project surveys. All species recorded only during prior surveys are assumed still to occur in the study area either as breeding residents or as migrants.

[6] For example: Pink-spotted Fruit Dove *Ptilinopus perlatus*, Beautiful Fruit Dove *P. pulchellus*, Pacific Koel *Eudynamys orientalis*, Chestnut-breasted Cuckoo *Cacomantis castaneiventris*, Red-bellied Pitta *Erythropitta erythrogaster*, Hooded Piita *Pitta sordida*, Streak-headed Honeyeater *Pycnopygius stictocephalus*, Puff-backed Honeyeater *Meliphaga aruensis*, Rusty Mouse-warbler *Crateroscelis murina*, Yellow-bellied Gerygone *Gerygone chrysogaster*, Green-backed Gerygone *G. chloronota*, Boyer's Cuckooshrike *Coracina boyeri*, Grey-headed Cuckooshrike *C. schisticeps*, Black Cicadabird *C. melas*, Little Shrikethrush *Colluricincla megarhyncha*, Southern Variable Pitohui *Pitohui uropygialis*, Sooty Thicket Fantail *Rhipidura threnothorax*, Spot-winged Monarch *Symposiachrus guttula*, Golden Monarch *Carterornis chrysomela*.

4.2 Conservation listed species

4.2.1 Conservation listed species recorded in the study area

Conservation listed species recorded in the study area are summarised as follows:

- Twenty-one (21) conservation listed species have been recorded to date within the study area during Project surveys (19 species) and/or prior surveys (15 species) (Table 5). They include 10 species listed by the IUCN as globally threatened (five species), Near Threatened (three species) or Data Deficient (two species), and 14 species that are Protected under PNG law (some of which also have an IUCN listing above Least Concern). IUCN threatened taxa recorded in the study area include:
- One Endangered migratory shorebird – the Far Eastern Curlew *Numenius madagascariensis*.
- Four Vulnerable resident forest species – the Southern Cassowary *Casuarius casuarius*, Papuan Eagle *Harpyopsis novaeguineae*, Scheepmaker's crowned Pigeon *Goura scheepmakeri* and Pesquet's Parrot *Psittrichas fulgidus*.

Detailed accounts for conservation listed bird species (excluding those listed only under CITES Appendix II; see Section 3.5.2) recorded in the study area are presented in the following sections. Accounts include a summary of the distribution, status and threats faced by each species and the availability of suitable habitat within the study area.

Table 5 Conservation listed and restricted-range (RR) species recorded in the study area.

Scientific name	English name	Status				Project surveys														
		IUCN	PNG	CITIES	RR	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herb Base, Purari River & Purari airstrip	Prior surveys
Casuarius casuarius	Southern Cassowary	VU				FC	FC	FC	VC	C	X	X		X	FC	L		X		X
Ardea alba	Great Egret	LC	P			?			X	X			L			X	X	X	X	X
Egretta intermedia	Intermediate Egret	LC	P										L		X			X	X	X
Egretta garzetta	Little Egret	LC	P							X			L			X		X	X	X
Harpyopsis novaeguineae	Papuan Eagle	VU	P	II			O								O					X
Aquila gurneyi	Gurney's Eagle	NT		II							X								X	
Megacrex inepta	New Guinea Flightless Rail	NT														L		L		
Limosa limosa	Black-tailed Godwit	NT																		X
Numenius madagascariensis	Far Eastern Curlew	EN																		X
Goura scheepmakeri	Scheepmaker's Crowned Pigeon	VU	P	II	RR	FC	X		C	VC	X	X			FC	X		L		X
Aegotheles tatei	Starry Owlet-nightjar	DD								X										
Todirhamphus nigrocyaneus	Blue-black Kingfisher	DD															X			
Rhyticeros plicatus	Blyth's Hornbill	LC	P	II		C	C	C	C	FC	X	X		X	C	X	X	X	X	X
Probosciger aterrimus	Palm Cockatoo	LC	P	I		FC	O	O	FC	FC	X			X	FC	X				X
Psittrichas fulgidus	Pesquet's Parrot	VU	P	II		FC	FC	FC	FC	O	X									X
Manucodia ater	Glossy-mantled Manucode	LC	P	II		FC	FC	FC	O	FC	X				FC	X	X	X		X
Phonygammus keraudrenii	Trumpet Manucode	LC	P	II		FC	FC			FC	X	X			C	X		X		
Ptiloris magnificus	Magnificent Riflebird	LC	P	II				O							O					
Cicinnurus regius	King Bird-of-paradise	LC	P	II		FC	C	O	C	C	X				C	X		X		X
Seleucidis melanoleuca	Twelve-wired Bird-of-paradise	LC	P	II					O	C					FC					X
Paradisaea raggiana	Raggiana Bird-of-paradise	LC	P	II		FC		C	O	C	X	X		X	FC	X		X		X

[A] Abbreviations for conservation listing categories are explained in Section 3.5.2.

[B] Relative abundance codes (O, FC, C, X) are explained in Section 3.4.2. '?' denotes uncertain records (possibly this species).

4.2.1.1 IUCN threatened species

Southern Cassowary *Casuarius casuarius* (VU) (Plate 6)

Cassowaries are a family of large, flightless birds that inhabit Australo-Papuan tropical forests. The world's largest avian frugivores, they are solitary and territorial, with individual birds occupying a large home range that provides a constant supply of fruit all year round. Cassowaries play a critical role in forest ecosystem dynamics by dispersing the seeds of many rainforest plant species, including those with large fruits that lack alternative biological dispersal vectors (Mack 1995b; Mack and Wright 2005; Westcott et al. 2008). The Southern Cassowary occurs in southern New Guinea and Australia in lowland and foothill forest, normally below 300 m asl but occasionally higher (Coates 1985; Beehler and Pratt 2016).

Breeding in New Guinea is poorly documented, variously stated to begin at "end of dry season" (HBW 2017) or the latter part of the "wet season" (Coates 1985, p. 57). Frugivores more generally are reported to breed throughout the year (Bell 1982; Coates 1985). With a clutch observed in July (I. Woxvold, unpublished data), the nesting season in the lower Purari basin certainly includes the wetter months.

Occurrence in the study area

Cassowaries were present at all sites subject to ground survey other than in mangroves at Site 8M. They were recorded as fairly common to very common at all principal survey sites in the Middle Purari Hills, Southeast Hills and Delta Swamps and Plains ecological zones (Sites 1–5 and Site 7). They were less common in the more densely settled and disturbed environments at Sites 8 and 9 (Southeast Coast ecological zone). Most evidence occurred as faeces or footprints so the species could not be identified. However, Southern Cassowary was positively identified at Sites 1–5 and at Site 7 through camera trapping and no evidence of the Dwarf Cassowary *Casuarius bennetti* was found. Moreover, elevation, habitat, terrain, information from prior surveys (I. Woxvold, unpublished data) and provided by local informants all suggest that the Southern Cassowary was the only species present at surveyed sites. Cassowaries were recorded in hill forest, alluvial forest and swamp forest and in both primary and logged forest. The Southern Cassowary was the most frequently camera trapped of all bird species. Combining data across sites, camera trap RAIs for hill forest and alluvial forest[7] respectively were 0.351 and 0.857 (Appendix 4), indicating that alluvial forest supports a higher density of cassowaries at surveyed sites. RAIs were lower in logged/disturbed forest than in primary forest, though a definitive comparison would require more extensive sampling in logged/disturbed environments.

There are prior records from multiple sites in the Middle Purari Hills and the Delta Swamps and Plains ecological zones, including within PRL-15 (Ashford 1978, 1979; Liem 1983; Mack and Jones 2003; DES 2008, 2010; and unpublished data).

Based on these results, suitable habitat is widespread in the study area and present in all ecological zones, predominantly as alluvial forest, swamp forest and hill forest. It is likely to be most abundant in primary alluvial forest. It is not reported from mangroves (Coates 1985; Marchant and Higgins 1990).

Threats/susceptibilities

Habitat loss and hunting present the major threats to cassowaries. Other threats include habitat degradation, dogs, pigs and, in areas with roads, collisions with traffic.

The Southern Cassowary's threatened status is based largely on declines in the Australian population (Garnett et al. 2011; BirdLife International 2016). By contrast, extensive areas of remote lowland forest remain in southern New Guinea where human population and hunting pressure are low. Large

[7] Camera traps were specifically placed in Alluvial forest (P) rather than the Swamp forest (Fsw) or Hill forest (Hm) components within the vegetation complex surveyed from Sites 4 and 5.

areas of suitable lowland forest have been logged in recent decades in PNG's Western, Gulf and Central Provinces (Shearman et al. 2009; Bryan and Shearman 2015). Cassowaries persist in structurally damaged forest (Crome and Moore 1990; Marchant and Higgins 1990; Mack et al. 2000; this study), but occur in lower densities after logging (Pangau-Adam et al. 2015).

All cassowary species are hunted in New Guinea for their meat, plumes and other body parts, and captive chicks are reared by hand for food or trade (Bulmer 1968; Coates 1985; Johnson et al. 2004; I. Woxvold, unpublished data). Consequently, cassowaries are now rare or have been extirpated from the vicinity of many settled areas. Hunting of cassowaries for food and/or economic reward is common in the study area. All Pawaia, Ahia, Iare and Orokolo residents interviewed about birds indicated that cassowaries are an important wildlife food source (Plate 6B). In addition, cassowaries captured in the study area are regularly sold locally or in markets as far away as Port Moresby. Cassowaries are currently in high demand as bride price gifts in PNG highland communities, providing opportunity for large financial rewards for some local hunters. The following information was collected during Project surveys:

- A Pawaian resident from Poroi 1 village stated that he regularly sold live cassowaries and body parts. Prices: Live adults 3,000 PGK each; wings from dead birds 50 PGK each.
- An Ahia resident from Evara village stated that he sold cassowaries to workers on the logging barge that visits the 'Evara logging camp' and occasionally in Port Moresby. Prices: 'baby' 300–400 PGK; adult 1,000–2,000 PGK; one 'baby' cassowary was sold to a highlands man in Port Moresby for 2,000 PGK.
- An Orokolo resident from Kilavi village indicated that others had sold cassowaries in Port Moresby for "big money", again to highlanders for bride price. Prices: 'small one' 500 PGK; adult 1,000 PGK.

Despite these incentives, cassowaries persist in suitable habitat in most parts of the study area, including in areas regularly visited by hunters.

Papuan Eagle *Harpyopsis novaeguineae* (VU, P)

The Papuan Eagle is New Guinea's largest bird of prey, reaching up to 90 cm in length (Coates 1985). Not a soaring raptor, it hunts mammals and birds on the ground, in trees or from tree hollows by flying through or low over the canopy (Coates 1985; Watson and Asoyama 2001). Visually inconspicuous, it is most readily detected by its distinctive call (Watson and Asoyama 2001).

The Papuan Eagle is endemic to New Guinea where it occurs throughout the island in forested habitats from sea-level to over 3,000 m asl (Coates 1985). It occurs at low population densities with breeding pairs occupying extensive territories (estimated at 13.0 ± 3.9 km^2 at Crater Mountain WMA: Watson and Asoyama 2001). While most records are from undisturbed forest, it also persists in logged forest (I. Woxvold, unpublished data), presumably where suitable prey remains.

Breeding is reported to occur "during the late wet season and through much of the dry" (Coates 1985, p. 128), consistent with breeding by other diurnal raptors during the drier months (Bell 1982; Coates 1985). However, available data are few and nesting may thus occur at any time of year.

Occurrence in the study area

Single Papuan Eagles were heard in hill forest at Site 2 in the Middle Purari Hills ecological zone (PRL-15) and in alluvial forest at Site 7 on the Delta Swamps and Plains (export pipeline corridor). It was reported previously from the study area by a unpublished study, with one bird seen in the Southeast Hills ecological zone near the Vailala River.

Suitable habitat is widespread in the study area, with the highest densities likely to occur in primary hill forest and alluvial forest in the Middle Purari Hills, Southeast Hills and Delta Swamps and Plains ecological zones.

Threats/susceptibilities

Habitat loss and hunting present the major threats to this species. In many areas it is actively targeted by hunters for its plumes which are used for ceremonial purposes (and sold on the black-market). As a result, it is now rare or extirpated from areas near human settlement where hunting persists (Coates 1985; Watson and Asoyama 2001). Within the study area there was no evidence that the Papuan Eagle is actively targeted by local hunters, and regionally the study area forms part of a much larger area of remote forest habitat where human population and hunting pressure are low. The regional population is therefore secure, though given this species' very low population density any losses through hunting or accident would represent a disproportionate loss to the local population.

Far Eastern Curlew *Numenius madagascariensis* (EN)

The world's largest shorebird, the Far Eastern Curlew breeds in northeast Asia (Siberia, Mongolia and Manchuria) and migrates south to spend the austral summer in Australia and New Zealand (Bishop 2006; Stewart et al. 2007). Predominantly a near-coastal species, it forages for invertebrates on tidal mudflats on the shoreline and in sheltered bays, estuaries and lagoons (Coates 1985; Higgins and Davies 1996).

Occurrence in the study area

A recent review surmised that "New Guinea supports important numbers of Far Eastern Curlew on passage to Australia" (Bishop 2006, p. 119). Liem and Haines (1977) listed the Far Eastern Curlew among 11 migratory shorebird species occurring in the Purari delta, though information on the date, location and number of birds was not provided. Suitable habitat occurs along the shorefront and tidal estuaries of the Purari delta in the Mangroves ecological zone, and to a lesser extent along the Southeast Coast (Section 4.8.2). It is likely to be most common in transit during August–November and March–April (Coates 1985).

While no counts have been made in the Purari delta, in March 2000 Jaensch and Watkins (undated; also reported in Bishop 2006 and Bamford et al. 2008) recorded 343 Far Eastern Curlews across parts of the c. 80 km shorefront span of the Kikori delta. Given that the Kikori counts were conservatively an underestimate, it is reasonable to expect that the c. 65 km span of shorefront habitats of the Purari delta within the study area (including the estuarine flats of Port Romilly in the west) may on occasion support similar counts of Far Eastern Curlew. While this is yet to be determined, numbers in excess of 380 birds (1% of the estimated East Asian–Australasian Flyway (EAAF) population) at any one time would qualify the Purari delta as an internationally important wetland 'staging' site based on Criterion 6 of the RAMSAR Convention, and numbers more than 95 (0.25% of the estimated flyway population) would qualify the Purari delta as an internationally important 'staging' site based on prior application of Criterion 6 in the Australasian region (Bamford et al. 2008; see Section 4.8.2).

Threats/susceptibilities

The conservation of migratory shorebirds and their habitats is the focus of elevated international concern, since a large proportion of species is in decline and continues to be threatened by a wide range of environmental changes, notably the destruction of tidal foraging habitat and associated roosting sites along migratory routes and at wintering grounds (Gosbell and Clemens 2006; Wilson et al. 2011; Szabo et al. 2016; see Section 4.8.2). Persistent declines have been recorded for the Far Eastern Curlew (Gosbell and Clemens 2006; Wilson et al. 2011; Clemens et al. 2016) resulting in its recent elevation to Endangered status (BirdLife International 2016).

Scheepmaker's Crowned Pigeon *Goura scheepmakeri* (VU, P, RR) (Plate 8A)

The world's largest pigeon, Scheepmaker's Crowned Pigeon is a terrestrial-foraging species endemic to the lowlands (below c. 500 m asl) of southern PNG west to at least as far as Purari River (Beehler and Pratt 2016). Its western counterpart, Sclater's Crowned Pigeon *G. sclaterii*, occurs east at least

as far as the Hegigio River catchment (I. Woxvold, unpublished data). There is no available information on which species occupies the intervening expanse (including the lower Kikori River basin).

Scheepmaker's Crowned Pigeon is now rare or has been extirpated from much of its former range around Port Moresby and the southeast peninsula (Coates 1985; King and Nijboer 1994). It is reported as still fairly common in the Lakekamu basin (Mack and Igag 1998).

Scheepmaker's Crowned Pigeon occurs in groups of up to 10–30 birds (usually less than seven) in closed-canopy evergreen forest, preferring areas of gentle alluvial terrain including seasonally flooded habitats (Coates 1985; Gibbs et al. 2001). It is not reported from mangroves or permanently inundated areas.

Breeding is poorly documented (King and Nijboer 1994). Nesting of *G. scheepmakeri*, presumably on the southeast peninsula, is reported for August (HBW 2017), and that of the closely related *G. sclateri* for September–November in the Trans-Fly (Western Province) (Coates 1985; Gibbs et al. 2001). While these are relatively dry periods in these regions, frugivores more generally are reported to breed throughout the year (Bell 1982; Coates 1985), and more extended nesting periods are expected (Gibbs et al. 2001).

Occurrence in the study area

Scheepmaker's Crowned Pigeon was confirmed present in all ecological zones other than the Mangroves. It was found at most principal survey sites (all except Site 3) and was also seen at Sites 6A and 6B. It was encountered as singles, duos and groups of up to five birds.

Project records are consistent with reports that this species prefers forest on alluvial terrain (Gibbs et al. 2001). Most records are from camera traps located in alluvial forest at Sites 1, 4, 5, 7 and 8. Where present near hill terrain this species was recorded mostly from riverine forest in alluvial infill valleys—along Boa Creek at Site 1, the Mena Creek tributary at Site 2, a Kuku Creek tributary at Site 6A and the banks of the Purari River at Site 6B (near the potential wharf site). While summary camera trap RAIs show a higher trap rate in hill forest than in alluvial forest (Appendix 4), this is the result of artificially high photographic rates from two cameras located near the alluvial plain at Site 5; *Pandanus* fruits ripened there after deployment, dropping a continuous supply of fruit in front of these cameras that attracted groups of up to five birds over multiple consecutive days. Of 38 cameras deployed in hill forest at five principal sites, Scheepmaker's Crowned Pigeon was photographed only at Site 5 with 80% (83/104) of the images coming from these two cameras. By contrast, crowned pigeons were photographed on more than 50% (42/83) of cameras deployed in alluvial forest at seven principal sites. Crowned pigeons are thus more widespread in alluvial forest and are typically rare or absent in steep hill terrain. There were some sight records from logged alluvial forest at Site 7 and remnant disturbed alluvial forest at Site 8, but no records (camera trap or otherwise) from logged hill forest at Sites 3 and 7. Data are too few to assess the effects of forest disturbance, though crowned pigeons are likely to be uncommon in recently logged areas where dense regrowth makes it difficult for these large birds to move about on the forest floor and to fly to safe perches when disturbed.

Crowned pigeons were previously reported from the study area by Liem (1983) who identified them among the fauna utilised by local residents in the Wabo area and in the mangroves/freshwater swamp forest areas of the Purari delta (no further spatial or habitat data provided). Subsequently DES (2008, 2010) recorded crowned pigeons at a number of sites within PRL-15—in the Middle Purari Hills at Mena Creek (Elk-Antelope gas field) and in alluvial forest on the Delta Swamps and Plains.

Suitable habitat is widespread in the study area as alluvial and nearby swamp forest on the rim of the Delta Swamps and Plains and in the Southeast Coast ecological zone, and in hill forest, especially on alluvial terrain alongside watercourses and at the hill base near alluvial forest, in the Middle Purari Hills and the Southeast Hills.

Threats/susceptibilities

Habitat loss, degradation and hunting present the major threats to crowned pigeons. All *Goura* species are susceptible to hunting, being easily captured and highly prized for their meat and plumes (Coates 1985; King and Nijboer 1994). Consequently, they are now rare or have been extirpated from the vicinity of many settled areas, including much of their former range around Port Moresby and the southeast peninsula (Coates 1985; King and Nijboer 1994). Hunting of large pigeons for food is common in the study area, and most Pawaia, Ahia, Iare and Orokolo residents interviewed about birds indicated that they hunt crowned pigeons. Two Orokolo residents independently listed crowned pigeons among the most important avian wildlife food sources, and one of these men stated that he had previously sold them in Port Moresby for 50−100 PGK. Despite this, crowned pigeons were still recorded in remnant forest near active gardens at Sites 8 and 9 (Orokolo territory), and in areas visited by hunters (albeit less frequently) further north in the study area.

Further study is required to understand their tolerance of logged forest, though logging is regularly cited as a major threat to crowned pigeons (King and Nijboer 1994; BirdLife International 2016). Other threats include habitat fragmentation, dogs and, in areas with roads, collisions with traffic.

Scheepmaker's Crowned Pigeon has been listed as one of PNG's rarest birds (Beehler 1993a). Of all resident forest bird species recorded within the study area, Scheepmaker's Crowned Pigeon is of the highest conservation concern. Compared with other IUCN threatened forest species (Southern Cassowary, Papuan Eagle, Pesquet's Parrot *Psittrichas fulgidus*), Scheepmaker's Crowned Pigeon occupies a much more limited geographic range (it is a restricted-range species; Section 4.3) and shows a marked preference for forest on alluvial terrain, a vegetation type that is under significant pressure from industrial logging operations in southern mainland PNG, including within the study area. It has been hunted to extinction across parts of its range in the densely populated southeast peninsula (BirdLife International 2016), and the study area supports the largest remaining expanse of undisturbed suitable habitat within its currently known range.

Pesquet's Parrot *Psittrichas fulgidus* (VU, P)

This unusual, large black-and-red parrot is a nomadic and specialist frugivore feeding on a select variety of figs (Mack and Wright 1998). It is endemic to New Guinea where it inhabits hill and lower montane forest up to 1,200 m asl (occasionally to 2,000 m) (Coates 1985). Pesquet's Parrots excavate their own nest cavity in the trunk of a tall dead tree (Mack 1994; Igag 2002). They breed seasonally in the Crater Mountain WMA. The egg is laid between June and October (Mack 1994; Igag 2002), and the period from hatching to fledging is at least 76 days (Mack 1994). Nest hollows may thus be occupied from June–January, possibly longer; frugivores more generally breed throughout the year (Bell 1982; Coates 1985), and fig trees typically suppy a year-round 'local' supply of fruit (O'Brien et al. 1998; Shanahan et al. 2001). The chicks are prone to starvation (Igag 2002).

Occurrence in the study area

Pesquet's Parrot was fairly commonly encountered in the northern two-thirds of the study area. Singles and duos were seen or heard regularly in hill forest at Sites 1 and 2 and groups of up to three birds were seen in logged hill forest at Site 3. One was detected by automated sound recorded in hill forest at Site 6A. In forest on alluvial plains near the base of the Middle Purari Hills singles and duos were seen and heard on most days at Site 4 and one was heard at Site 5.

As estimates of abundance reflect encounter rates, they should be interpreted with caution when considering vagile and vocally conspicuous species such as Pesquet's Parrot. Although encountered regularly at Sites 1−4, this is an easily detected species and multiple records at each site may have involved repeat encounters with the same individuals. Thus although widespread, this species may be present in fairly low numbers. As a nomadic frugivore, numbers present in any one area are also likely to change with seasonal patterns in food availability.

During prior surveys, Pesquet's Parrot was recorded:

- In the Middle Purari Hills—in the Elk-Antelope gas field (DES 2010; and unpublished data), on the Project road north of Herd Base and east of PRL-15 (unpublished data).
- In the Southeast Hills in the Vailala River catchment (unpublished data).

These records suggest that Pesquet's Parrot is widespread in small numbers in hill forest throughout the Middle Purari Hills and the northern half of the Southeast Hills ecological zone, and occurs less commonly in alluvial forest on the rim of the Delta Swamps and Plains near the base of the foothills.

Threats/susceptibilities

Hunting presents the major threat to Pesquet's Parrot. In some areas Pesquet's Parrot is heavily hunted for its plumes which are used for traditional ceremonial and trade purposes. As a result of hunting pressure, it is now rare or extirpated from the vicinity of many settled areas, particularly in PNG (Coates 1985; Kocher Schmid 1993; Mack and Wright 1998; Igag 2002). Within the study area, there was no evidence that Pesquet's Parrot is an important food item or that it's plumes are used for ceremonial finery ('*bilas*') among local communities. However, an Ahia resident from Evara village who sells wildlife locally to logging company employees and in Port Moresby stated that he regularly obtains 500–600 PGK for an adult Pesquet's Parrot and less commonly up to 1,000 PGK.

Other threats include habitat loss and loss of food trees (*Ficus* spp.) and nest trees. Logging appears not to present a major threat as this species was observed frequently in 10-year regrowth in heavily logged areas at Site 3, though the birds may rely on more mature forest for nest sites.

Pesquet's Parrot has been listed as one of PNG's rarest birds (Beehler 1993a), though recent surveys indicate the species remains secure in large areas of suitable habitat in central and western mainland Papua New Guinea, much of which occurs in rugged terrain in areas with a low human population density (I. Woxvold, unpublished data).

4.2.1.2 IUCN Near Threatened species

Gurney's Eagle *Aquila gurneyi* (NT)

Gurney's Eagle is a very large bird of prey with a wingspan to 1.85 m. It occurs throughout New Guinea and in the Moluccas where it is widespread though sparsely distributed in all forest habitats, mostly in the lowlands and hills and locally in lower montane areas to at least 1,300 m asl. Aspects of its ecology including habitat, nesting and prey requirements are poorly known. In New Guinea most diurnal raptors breed during the drier months (Bell 1982; Coates 1985).

Occurrence in the study area

One was seen soaring high over hill forest at Site 6A, and two were seen cruising over the Purari River in the south of PRL-15 downstream from Herd Base (during the Site 6B boat survey). The birds crossing the Purari River apparently disturbed a roosting camp of large flying foxes (*Pteropus* sp.) which they may have been hunting. There are no prior records from the study area.

Suitable forest habitat is widespread in the study area wherever suitable prey may be found—hill forest, alluvial forest and swamp vegetation in all ecological zones.

Threats/susceptibilities

Forest loss and degradation are the major threats, particularly where they reduce prey availability. It is not a specific hunting target. While it seems to prefer primary forest it has been seen foraging in cleared and cultivated areas (Coates 1985) and crossing extensive grasslands to reach forest areas (I. Woxvold, unpublished data).

New Guinea Flightless Rail *Megacrex inepta* (NT)

The New Guinea Flightless Rail is a large, flightless ground-bird endemic to the lowland swamp forests of central New Guinea. Breeding habits are almost entirely unknown; two young were collected in September, towards the end of the dry season near Lake Daviumbu (Western Province) (Coates 1985; HBW 2017).

Occurrence in the study area

This species was well known to a number of local residents questioned about birds at Kilavi (Site 8) and Paevera (Site 9) villages. In all cases this distinctive bird was recognized for its large size, flightless habit and tendency to consume harvested sago. Suitable habitat is widespread in the study area as mangroves and freshwater swamps, including Swamp woodland (Wsw), Swamp forest (Fsw) and the margins of smaller statured swamp vegetation types; predominantly in the Mangroves and Delta Swamps and Plains ecological zones, but also in the Southeast Coast and Southeast Hills.

Threats/susceptibilities

Potential threats include habitat loss and hunting. New Guinea Flightless Rails are often targeted by hunters, and an Orokolo resident from Kilavi village listed them among the five most important avian wildlife food sources, but stated they are still commonly found in nearby sago harvesting areas.

The preferred habitat is not a priority logging target. However, habitat loss and habitat degradation may result from firewood collection (including in mangroves), changes to hydrology or sediment/nutrient flow and contamination of waterways.

Black-tailed Godwit *Limosa limosa* (NT)

The locally occurring subspecies (*melanuroides*) of the Black-tailed Godwit breeds in northeast Asia (Russia, Mongolia and China) and migrates south to spend the austral summer in Australia and Southeast Asia (Bishop 2006; Stewart et al. 2007). It is found along the coast and the margins of brackish and freshwater wetlands where it forages for invertebrates in soft substrates (Stewart et al. 2007).

Occurrence in the study area

Large numbers of Black-tailed Godwit are reported to stopover in New Guinea in transit to and from Australia (Bishop 2006). While the importance of coastal habitats in the Purari delta remains unknown (Section 4.8.2), Liem and Haines (1977) listed the Black-tailed Godwit among 11 migratory shorebirds species occurring there. Information on the date, location and number of birds is lacking. Suitable habitat occurs along the shorefront, tidal estuaries and subcoastal wetlands of the Mangroves ecological zone and to a lesser extent along the Southeast Coast. It is likely to be most common in transit during October–November and April–May (Coates 1985).

Threats/susceptibilities

As a migratory shorebird the Black-tailed Godwit is subject to the same threatening processes that have impacted the Far Eastern Curlew (Section 4.2.1.1). Notable declines have been recorded (BirdLife International 2016; Clemens et al. 2016) resulting in its Near Threatened status.

4.2.1.3 IUCN Data Deficient species

Starry Owlet-nightjar *Aegotheles tatei* (DD, RR) (Plate 9A)

The Starry Owlet-Nightjar is a poorly known night-bird endemic to the lowlands of southern New Guinea. Although first collected in 1920s, it was only recently recognised as a full species based on examination of the four known museum specimens (Pratt 2000). It is rarely encountered, with records from four widely scattered localities spanning all of southern mainland PNG—the southeast peninsula (1) at Amazon Bay (Central Province) and (2) Brown River near Port Moresby, (3) eastern Gulf

Province lowlands, and (4) a series of sites near Kiunga (Western Province) including the extreme east of Papua Province, Indonesia (Verbelen 2014; Beehler and Pratt 2016). Given the unobtrusive nature of these shy night-birds and the fact that its call (the key to discovery) was only recently recorded, it is unknown whether the population is fragmented or continuous across this 1,000 km expanse. It is conservatively here considered to be a restricted-range species (Section 4.3).

The nest is undescribed, but, as noted for other aegothelids (Pratt and Beehler 2015), is presumably placed in a tree cavity. The timing of breeding is unknown.

Occurrence in the study area

One Starry Owlet-Nightjar was mist netted in alluvial forest at Site 5 (Plate 9A).

The habitat requirements of this shy nocturnal species are poorly known. All records are from below 125 m asl in alluvial forest environments, including alluvial plains near the central range foothills and riverine forest amid hilly terrain (Pratt 2000; Pratt and Beehler 2015) and in “selectively logged forest” along the Kali Muyu River in eastern Papua (Verbelen 2014). Comparable habitat within the study area occurs as primary and logged alluvial forest on the northern and eastern margins of the Delta Swamps and Plains ecological zone, and among adjacent foothills in alluvial forest on watercourse margins in the Middle Purari Hills and Southeast Hills.

Threats/susceptibilities

Given the lack of knowledge of the bird's ecology, threats are difficult to determine. It is not targeted by hunters, and habitat loss and degradation are presumed to present the major threats. Tolerance of disturbed habitats is poorly known; while it has been recorded in logged forest (Verbelen 2014), it is uncertain to what degree habitat degredation, including logging of various intensity and age of regrowth, affects its population status. May be susceptible to the loss of large trees with nest hollows. Based on the breeding bology of the Australian Owlet-nightjar *A. cristatus* (Brigham and Geiser 1997), Starry Owlet-nightjar may be susceptible to nest predation by mammals including alien invasive rodents, populations of which are more likely to become established in disturbed forest environments.

The Starry Owlet-Nightjar is one of PNG’s least known birds, and with so few records it is arguably one of the rarest (scientifically described after the ranking of rarest birds by Beehler 1993a). Of the forest bird species recorded within the study area it is among those of highest conservation concern. Compared with IUCN threatened forest bird species residing in the study area (Southern Cassowary, Papuan Eagle, Scheepmaker's Crowned Pigeon, Pesquet’s Parrot), it: (1) occupies a more restricted elevational range (not recorded above 125 m asl); (2) shows a marked preference for forest on alluvial terrain, a vegetation type that is under significant pressure from industrial logging operations in southern mainland PNG, including within the study area, and; (3) is here considered to qualify for restricted-range status (Section 4.3). While it has a broad extent of occurrence, its population may be fragmented.

Blue-black Kingfisher *Todirhamphus nigrocyaneus* (DD)

The Blue-black Kingfisher is a rare and poorly known New Guinea endemic occupying lowland forest to c. 600 m asl (Beehler and Pratt 2016). The distinctive subspecies occupying southern mainland PNG, *Todirhamphus nigrocyaneus stictolaemus*, is known from a handful of records from the Trans-Fly (Western Province) east to near Port Moresby. There is one prior published record from Gulf Province—a single bird mist netted in alluvial forest in the Lakekamu basin (Beehler and Mack 1999). Nesting has not been reported, but as with many other kingfishers may take place inside a tree hollow. The timing of breeding is unknown.

Occurrence in the study area

The distinctive call of this species was detected via automated sound recorder in mangrove forest in the Mangroves ecological zone. Suitable habitat within the study area occurs as mangroves, alluvial

forest and tall swamp vegetation, including Swamp forest (Fsw) and Swamp woodland (Wsw) in the Mangroves and Delta Swamps and Plains ecological zones. Potentially also in forest along watercourses in adjacent foothills in the Middle Purari Hills and Southeast Hills.

Threats/susceptibilities

It is not targeted by hunters, and habitat loss and degradation are presumed to present the major threats. Tolerance of disturbed habitats is poorly known. The preferred swampy habitats area not a priority logging target (cf. alluvial forest), though habitat loss or degradation may result from firewood collection (including in mangroves), changes to hydrology or sediment/nutrient flow and contamination of waterways. May be susceptible to the loss of trees with nest hollows.

4.2.1.4 Nationally Protected species

Great Egret *Ardea alba*, Intermediate Egret *Egretta intermedia*, Little Egret *E. garzetta* (P)

Three egret species—large white herons of rivers and wetlands—have been recorded in the study area, all of which are Protected under PNG law. They are conspicuous, easily recognised and often well known to local residents. All three species occur widely from Africa through Eurasia to Australasia, with the Great Egret also present in North and South America. Local subspecies occur from India (Great Egret) or Indonesia (Intermediate and Little Egrets) to Australasia.

Each of these species occurs throughout New Guinea in a variety of wetland habitats, predominantly in the lowlands but occasionally up to montane elevations (Coates 1985). Their breeding status in New Guinea is poorly understood; some birds are present in all months, but each year there is a significant exchange of waterbirds between Australia and New Guinea with many birds occurring locally as non-breeding visitors (Coates 1985; Dingle 2004). Breeding at specific locations has been confirmed for the Great Egret (Aroa River, Trans-Fly) and Intermediate Egret (Trans-Fly) but not for the Little Egret (Bishop 2005; Beehler and Pratt 2016).

Occurrence in the study area

Egrets were recorded in a variety of habitats in all ecological zones. Records for each species are as follows:

- Great Egret—singles along creeks flowing through alluvial forest at Sites 4 and 5, four along the Purari River in the south of PRL-15 at Site 6B, 1−3 birds along the Muro River on three consecutive days at Site 8, two roosting in trees near the main logging road at Site 8, 1−2 birds along Oeha Creek on consecutive days at Site 8M, and singles on the beach and in coastal freshwater wetlands at Site 9. At Site 1 a large ardeid footprint along Boa Creek was possibly of this species. During prior surveys: recorded in the Middle Purari Hills along the Purari River (Ashford 1978, 1979) and near Herd Base (unpublished data), and on the Delta Swamps and Plains in the oxbow wetland swamp system c. 13 km west of Herd Base (DES 2010). Also listed by Liem and Haines (1977) among aquatic birds present in the Purari delta's mangroves/freshwater swamp habitats (no further spatial data provided).

- Intermediate Egret—singles along the Purari River at Site 6B, along a creek flowing through alluvial forest at Site 7 and in coastal freshwater wetlands at Site 9, 1−3 observed in grassland at Herd Base and Purari airstrip. During prior surveys: recorded in the Middle Purari Hills in the Elk-Antelope gas field and at Herd Base (DES 2008; and unpublished data) and at various sites along the Purari River (Ashford 1978, 1979; DES 2010) and on the Delta Swamps and Plains at Baimuru (Ashford 1978, 1979).

- Little Egret—singles along a creek flowing through alluvial forest at Site 5 and along the Purari River at Site 6B, 2−6 birds along the Muro River on three consecutive days at Site 8, 1−2 birds on the beach and in coastal freshwater wetlands at Site 9. During prior surveys:

recorded by Ashford (1978, 1979) as common along watercourses between Wabo and Baimuru though less numerous than the previous species.

In addition, more than 250 egrets were counted (from photographs) during aerial survey of the oxbow wetlands west of Herd Base (Site 6C), including one flock of more than 210 birds on a lake in the west of this wetland system. The species were not able to be identified, though yellow-billed birds (Great and/or Intermediate Egrets) were certainly present, and local residents stated (to Ken Aplin at Mapaio Fish Camp) that both large and small kinds occur there. There is little doubt that all three species use these wetland habitats.

Additionally, Liem and Haines (1977) listed all three species among aquatic birds present in the Purari delta's mangroves/freshwater swamp habitats (no further spatial data provided).

Suitable habitat within the study area occurs in all ecological zones as freshwater wetlands, rivers, wet grasslands and coastal and estuary margins.

Threats/susceptibilities

Habitat loss and degradation, including via changes to hydrology or sediment/nutrient flow and contamination of waterways.

Blyth's Hornbill *Rhyticeros plicatus* (P)

Blyth's Hornbill occurs throughout New Guinea in a variety of forest types up to 1,500+ m asl, but is most common in the lowlands and hills (Coates 1985; Kemp 2001). As New Guinea's only hornbill species, and one of the region's largest and most mobile frugivores, Blyth's Hornbill plays a critical role in forest ecosystem dynamics (Mack and Wright 2005; Kinnaird and O'Brien 2007); in the Crater Mountain WMA, Blyth's Hornbill was ranked as the second most important keystone frugivore (behind Dwarf Cassowary) in terms of dispersing the seeds of a high proportion of local plant species (Mack and Wright 2005). Breeding in the wild is poorly documented (HBW 2017)—nesting takes place in the hollow of a large tree, normally at least 18 m above the ground (Coastes 1985); the season may span August–May in eastern New Guinea (HBW 2017), though frugivores more generally may breed at any itme (Bell 1982; Coates 1985).

Occurrence in the study area

Blyth's Hornbill occurs widely across the study area. It was present at all sites subject to ground survey, including in mangroves (Site 8M), and was recorded as common at Sites 1−4 and Site 7, and fairly common at Site 5. It has been reported previously from multiple sites in the Middle Purari Hills, Southeast Hills and Delta Swamps and Plains ecological zones (Ashford 1978, 1979; Liem 1983; DES 2008, 2010, 2011; and unpublished data).

Suitable habitat is widespread in the study area in all ecological zones, predominantly as hill forest, alluvial forest and swamp forest, and including logged and fragmented forest habitats. They are absent from densely populated coastal areas.

Threats/susceptibilities

Habitat loss and hunting present the major threats. Hornbills require large areas of habitat with ample supply of fruiting trees and trees with large nesting holes, and most species occur in low densities and reproduce slowly (Kemp 1995, 2001; Kinnaird and O'Brien 2007). Removal of forest reduces the availability of critical resources. However, extensive areas of suitable forest remain within the study area, and the status of Blyth's Hornbill in New Guinea is fairly secure, particularly given that the island boasts the largest contiguous area of forest in the Asian hornbill realm (Kinnaird and O'Brien 2007). Where hunting levels remain low, Blyth's Hornbill persists in logged and fragmented forest environments (for example at Sites 3, 7 and 8).

Blyth's Hornbills are hunted for food, ornamental use, trade or to be kept as pets, and have thus become scarce near many settled areas (Coates 1985). Two Orokolo residents from Kilavi and Avavu villages independently listed Blyth's Hornbill among the most important avian wildlife food sources, and an Ahia resident from Evara village stated that he had sold live adult hornbills for 200−300 PGK each. Hornbills are fairly tolerant of one another and sometimes congregate in large numbers at feeding or roosting trees (up to at least 56: Woxvold, unpublished data). Increased access and a higher concentration of hornbills at fewer fruiting trees may increase their vulnerability to hunting. Despite these sensitivities, hornbills persist, albeit in lower numbers in fragmented habitats not far from settlements at Sites 8 and 9.

Palm Cockatoo *Probosciger aterrimus* (P) (Plate 10A)

This is a large and conspicuous species occurring throughout the New Guinea lowlands and hills (to 1,300 m asl) in rainforest, secondary forest and tropical savannah where birds feed on a variety of seeds and fruit. Palm Cockatoos reproduce slowly, breeding infrequently and typically laying only one egg at a time, thereby making them vulnerable to population decline (Igag 2002; Murphy et al. 2003). Their population density further depends on the availability of hollow-bearing trees, with birds visiting and maintaining more nest hollows than they require for breeding (Igag 2002; Murphy et al. 2003).

Palm cockatoos breed seasonally in the nearby Crater Mountain WMA. The egg is laid between June and October (Igag 2002), and the period from hatching to fledging may be up to 20 weeks (Higgins 1999). Nest hollows may thus be occupied from June–March.

Occurrence in the study area

Palm Cockatoos are widespread in the study area—they were recorded at all principal survey sites other than near the coast at Site 9, and were present at Sites 6A and 6D. They were fairly common at Site 1, 4, 5 and 7, with the highest encounter rates in alluvial forest at Sites 5 and 7. Additionally, singles were photographed once or twice on most camera traps (16/25) in alluvial forest at Site 4 (Plate 10A). However, multiple records within sites likely involved repeat encounters with the same individuals, and population densities are expected to be low.

Palm Cockatoo has been reported previously from multiple sites in the Middle Purari Hills, Southeast Hills and Delta Swamps and Plains ecological zones (Ashford 1978, 1979; Liem 1983; DES 2008, 2010; and unpublished data).

Suitable habitat is widespread in the study area in most ecological zones, predominantly as hill forest, alluvial forest and swamp forest. It is not reported from mangroves (Coates 1985; Higgins 1999).

Threats/susceptibilities

Threats and susceptibilies are similar to those described for hornbills, though Palm Cockatoos are less common. Forest loss and degradation reduce the availability of critical resources and increase susceptibility to hunting. Palm Cockatoos are hunted for their meat and plumes (e.g. Kocher Schmid 1993), and in many places have suffered population declines or local extinction (Coates 1985; Igag 2002). An Orokolo resident from Kilavi village stated that he had sold Palm Cockatoos in Port Moresby for up to 500 PGK. While these sensitivities have led to downward trends in settled areas, the study area still retains vast areas of remote and intact forest where Palm Cockatoo populations are expected to remain secure.

Glossy-mantled Manucode *Manucodia ater* (P) (Plate 13A)

The manucodes comprise an ancestral group of glossy black, rather crow-like birds-of-paradise (Coates 1990; Frith and Beehler 1998). Unlike most birds-of-paradise, they are monogamous pair-forming and sexually monomorphic (males and females appear the same). Manucodes present the most difficult problem of field identification among all birds-of-paradise, with vocalisations often the most reliable diagnostic feature.

The Glossy-mantled Manucode is endemic to New Guinea and satellite islands where it inhabits forest, forest edge, secondary growth, swamp forest, woodlands and scrub in the lowlands and foothills, locally up to c. 900 m asl (Coates 1990; Frith and Beehler 1998). It is the most common manucode in open and disturbed habitats. The breeding season is extensive, spanning at least August–March (HBW 2017) and with scattered records from other months (May, Port Moresby: Coates 1985). Frugivores more generally may breed at any itme (Bell 1982; Coates 1985).

Occurrence in the study area

Glossy-mantled Manucode is widespread in the study area, being recorded in a variety of habitats in all ecological zones. They were present at all principal survey sites and at Sites 6A and 8M, with their diagnostic song fairly common in hill forest at Sites 1 and 2, alluvial/swamp forest at Site 5, and in logged forest at Sites 3 and 7. Additional call notes not identifiable to species were heard on multiple occasions at most principal sites. Glossy-mantled Manucode was reported previously from the Middle Purari Hills (at Wabo) by Ahsford (1978, 1979) and for the Purari delta's mangroves/freshwater swamp habitats (no further spatial data provided) by Liem and Haines (1977) and Liem (1983).

Suitable habitat is widespread in the study area in all ecological zones, in hill forest, alluvial forest, swamp forest, mangroves and disturbed/cultivated areas.

Threats/susceptibilities

Large-scale habitat loss presents the major threat to this species. It is tolerant of habitat degradation and is not specifically targeted by hunters.

Trumpet Manucode *Phonygammus keraudrenii* (P)

The Trumpet Manucode occurs in forest from the lowlands to 2,000 m asl where it feeds mainly on figs (Coates 1990; Frith and Beehler 1998). It often co-occurs with other manucodes, from which it is readily distinguished by voice or with good views.

Breeding has been recorded during May–January (Frith and Beehler 1998). Frugivores more generally may breed at any itme (Bell 1982; Coates 1985).

Occurrence in the study area

The Trumpet Manucode was recorded in a variety of forest environments in most ecological zones. In primary forest habitats it was fairly common in hill forest at Sites 1 and 2 and in alluvial/swamp forest at Site 5, and was recorded in hill forest at Sites 6A and 6B (logistics base and wharf site). In disturbed environments it was common in logged forest at Site 7, displayed frequently in remnant forest along the main logging road at Site 8, and was present in alluvial forest at Site 9. There are no prior records from within the study area.

Suitable habitat is widespread in the study area in all ecological zones, in hill forest, alluvial forest and, less commonly, swamp forest and mangroves.

Threats/susceptibilities

Habitat loss and fragmentation present the major threats. It is tolerant of habitat disturbance and is not specifically targeted by hunters.

Magnificent Riflebird *Ptiloris magnificus* (P)

The Magnificent Riflebird inhabits lowland and hill forests across most of New Guinea, east in the south as far as the Purari basin, and Cape York Peninsula (Australia) (Coates 1990; Frith and Beehler 1998). A shy species, its presence is usually revealed by the male's distinctive call.

The breeding season in New Guinea is poorly documented and variable across the extensive range of this species and the closely related Growling Riflebird *G. intercedens* (HBW 2017). The northern

Australian population is said to breed Agust–February (Higgins et al. 2006), spanning both dry and wet seasons in that area. In the Crater Mountain WMA, a female in breeding condition was collected in late July (Diamond 1972).

Occurrence in the study area

Uncommon—one heard singing in logged hill forest at Site 3 and another from the logging road near the hill/alluvial forest boundary at Site 7. There are no prior records from within the study area. These records are surprisingly scarce given the availability of suitable habitat, even considering seasonal reductions in call rates reported for some areas (Frith and Beehler 1998).

Suitable habitat is widespread as hill forest in the Middle Purari Hills and Southeast Hills ecological zones, and as alluvial forest, and less commonly swamp forest, on the interior margins of the Delta Swamps and Plains.

Threats/susceptibilities

Habitat loss and fragmentation present the major threats. It is somewhat tolerant of habitat disturbance and is not specifically targeted by hunters.

King Bird-of-paradise *Cicinnurus regius* (P)

The King Bird-of-paradise is a common resident of lowland and foothill forests (to c. 300 m asl, less common higher), including swamp forest, of New Guinea and nearby islands. Its diet consists of fruit and invertebrates (Frith and Beehler 1998). Breeding occurs in all months across the species' range (Frith and Beehler 1999). Records from the Port Moresby area (climatically different from the study area) include fledglings in early May (early dry season), carrying of nest material in June and mating in October (late dry season) (Coates 1990). Nesting may thus span both wet and dry periods, with a possible lull in the wettest months (June–August in the study area).

Occurrence in the study area

The King Bird-of-paradise was recorded at all principal survey sites. It was most abundant in forest on alluvial plains—common in undisturbed alluvial/swamp forest at Sites 4 and 5, common in alluvial forest, including logged areas, at Site 7, and present in remnant alluvial forest at Site 9. In hill terrain it was fairly common to common in undisturbed hill forest at Sites 1 and 2, and was heard once or twice in undisturbed hill forest at Site 6A and in logged forest at Sites 3 and 8. It was reported previously from the study area by Liem (1983) though with no reference to forest type or location.

Suitable habitat is widespread in all ecological zones, in hill forest, alluvial forest, swamp forest and (less common) mangroves (Coates 1990; Frith and Beehler 1998).

Threats/susceptibilities

Susceptibilities are similar to those described above for Magnificent Riflebird.

Twelve-wired Bird-of-paradise *Seleucidis melanoleuca* (P)

The Twelve-wired Bird-of-paradise is endemic to New Guinea and Salawati Island where it inhabits lowland forest, especially swamp forest with sago *Metroxylon sagu*, mostly near sea level but in places up to 180 m asl (Coates 1990; Frith and Beehler 1998). Males occupy dispersed display areas that include multiple advertising posts (emergent, bare, near-vertical branches). The breeding season spans most of the year in the Port Moresby area (January–early November; HBW 2017), and a similarly extensive period is expected in the study area.

Occurrence in the study area

Twelve-wired Bird-of-paradise was common in alluvial/swamp forest at Site 5, fairly common in alluvial forest at Site 7, and heard twice in alluvial/swamp forest at Site 4. It was reported previously

from the study area by Liem and Haines (1977) and Liem (1983) though with no reference to forest type or location.

Suitable habitat occurs as alluvial forest, swamp forest and swamp woodland, especially where sago or pandanus is present, mostly on the Delta Swamps and Plains, and less commonly in poorly drained alluvial terrain in the Middle Purari Hills, Southeast Hills and Southeast Coast ecological zones.

Threats/susceptibilities

Susceptibilities are similar to those described above for Magnificent Riflebird.

Raggiana Bird-of-paradise *Paradisaea raggiana* (P)

The Raggiana Bird-of-paradise is endemic to southern and northeast PNG where it inhabits primary and disturbed lowland, hill and lower montane forest to c.1,800 m asl. It belongs to a well-known group (genus *Paradisaea*) whose members engage in elaborate and conspicuous group-male displays. Up to 10 or more males may perform at a 'lek' which may be temporary or used continuously for many years. Leks may be formed in any habitat type, but usually in the upper portion or top branches of a canopy tree, often in a prominent position in the local topography (e.g. ridge crest) (Coates 1990; Frith and Beehler 1998).

Breeding records span at least April–December across its range, with nesting recorded outside of the wettest months in various districts—late July–August near Port Moresby and October–November near Wau (HBW 2017). Within the study area nesting is perhaps least likely during the wettest months of June–August.

Occurrence in the study area

Raggiana Bird-of-paradise was recorded at most principal survey sites (absent only from Site 2) and at Sites 6A, 6B and 6D; in a variety of forest environments and in most ecological zones. In primary forest it was fairly common in hill forest at Site 1, present in hill forest at Sites 6A, 6B (logistics base and wharf site) and Site 6D, common in alluvial/swamp forest at Site 5, and occasional in alluvial/swamp forest at Site 4. In disturbed environments, it was fairly common to common in logged forest at Sites 3 and 7, heard frequently in remnant forest along the main logging road at Site 8, and was present in alluvial forest at Site 9.

It was reported previously from the Middle Purari Hills at Wabo (Ashford 1978, 1979) and within PRL-15 at Hou Creek Base, along the Project road north of Herd Base and along the proposed western trunkline route (DES 2008; and unpublished data). It was also listed by Liem and Haines (1977) among the birds present in forest habitats of the lower Purari delta (no further spatial data provided).

Suitable habitat is widespread as hill forest in the Middle Purari Hills and Southeast Hills ecological zones, and as alluvial forest, and less commonly swamp forest, on the interior margins of the Delta Swamps and Plains and in the Southeast Coast and Mangroves ecological zones. Present in disturbed environments (Coates 1990).

Threats/susceptibilities

Susceptibilities are similar to those described above for Magnificent Riflebird, though the Raggiana Bird-of-paradise is more tolerant of habitat disturbance and more commonly targeted by hunters.

4.2.2 Possible additional conservation listed species

Based on current knowledge of avian distributions and habitat preferences, an additional 21 conservation listed species may occur within the study area (Table 6), including a further 18 IUCN listed species (two threatened, 12 Near Threatened and four Data Deficient). No Critically Endangered bird species are expected to occur in the study area.

Brief accounts of each possible additional conservation listed species are provided below.

Table 6 Possible additional conservation listed and restricted-range (RR) species and potential ecological zones of occurrence.

Scientific Name	English Name	Status				Ecological zone				
		IUCN	PNG	CITES	RR	MPH	SH	DSP	Mv	SEC
Salvadorina waigiuensis	Salvadori's Teal	VU	P			X				
Zonerodius heliosylus	Forest Bittern	NT				X	X	X		X
Pandion cristatus	Eastern Osprey		P	II		X	X	X	X	X
Erythrotriorchis buergersi	Chestnut-shouldered Goshawk	DD		II		X				
Megatriorchis doriae	Doria's Goshawk	NT		II		X	X	X	X	X
Esacus magnirostris	Beach Stone-curlew	NT							X	X
Limnodromus semipalmatus	Asian Dowitcher	NT							X	X
Limosa lapponica	Bar-tailed Godwit	NT							X	X
Tringa brevipes	Grey-tailed Tattler	NT							X	X
Calidris tenuirostris	Great Knot	EN							X	X
Calidris canutus	Red Knot	NT							X	X
Calidris ruficollis	Red-necked Stint	NT					X	X	X	X
Calidris ferruginea	Curlew Sandpiper	NT					X	X	X	X
Uroglaux dimorpha	Papuan Hawk-Owl	DD		II		X	X	X	X	X
Aegotheles wallacii	Wallace's Owlet-nightjar	DD				X	X			
Aerodramus papuensis	Three-toed Swiftlet	DD				X	X			
Charmosyna multistriata	Striated Lorikeet	NT		II		X				
Manucodia chalybatus	Crinkle-collared Manucode		P	II		X	X			
Diphyllodes magnificus	Magnificent Bird-of-paradise		P	II		X	X			
Poecilodryas placens	Banded Yellow Robin	NT			RR	X				
Aplonis mystacea	Yellow-eyed Starling	NT				X	X	X		

[A] Abbreviations for conservation listing categories are explained in Section 3.5.2.

[B] MPH—Middle Purari Hills; SH—Southeast Hills; DSP—Delta Swamps and Plains; Mv—Mangroves; SEC—Southeast Coast.

4.2.2.1 IUCN threatened species

Salvadori's Teal *Salvadorina waigiuensis*—Endemic to New Guinea in cool streams and lakes in hill and montane forest along the central cordillera, mostly above 600 m asl but occasionally below 500 m. Not present in the study area. Potentially only in watercourses at the base of the cordillera proper, northern rim Middle Purari Hills.

Great Knot *Calidris tenuirostris*—A migratory shorebird of tidal flats, lagoons and estuaries. Recorded previously in the Kikori delta (Jaensch and Watkins, undated). Likely seasonal presence, over-wintering or *en route* between Northern hemisphere breeding grounds and wintering stations in Australia, occurring in coastal and subcoastal tidal environments in the Mangroves and (less commonly) Southeast Coast ecological zones.

4.2.2.2 IUCN Near Threatened species

Forest Bittern *Zonerodius heliosylus*—A rare heron endemic to New Guinea in forest swamps, streams and pools from the lowlands to 1,430 m asl. May occur in freshwater pools and streams in hill forest, alluvial forest and swamp forest in all ecological zones except the Mangroves, including within the study area in PRL-15 and the export pipeline corridor.

Doria's Goshawk Megatriorchis doriae—A rarely encountered bird of prey endemic to lowland and hill forest throughout New Guinea, from sea level to at least 1,650 m. Suitable habitat widespread across the study area—hill forest, alluvial forest, swamp forest and (less commonly) mangroves in all ecological zones, including within the study area in PRL-15 and the export pipeline corridor.

Beach Stone-curlew *Esacus magnirostris*—A large, resident shorebird of beaches, tidal flats, reefs and mangroves. May occur on shores and subcoastal habitats away from frequent disturbance, predominantly in the Mangroves ecological zone, potentially also the Southeast Coast.

Asian Dowitcher *Limnodromus semipalmatus*, Bar-tailed Godwit *Limosa lapponica*, Grey-tailed Tattler *Tringa brevipes*, Red Knot *Calidris canutus*, Red-necked Stint *C. ruficollis*, Curlew Sandpiper *C. ferruginea*—Six migratory shorebird species breeding in the northern hemisphere and seasonally present in New Guinea throughout the austral winter or *en route* to wintering grounds in Australia. They are most likely to occur in tidal flats, lagoons and estuaries in the Mangroves and (less commonly) Southeast Coast ecological zones. The Red-necked Stint and Curlew Sandpiper also occur on the margins of freshwater swamps and may additionally occur in suitable habitat on the Delta Swamps and Plains and in the Southeast Hills ecological zone.

Striated Lorikeet *Charmosyna multistriata*—Endemic to the southern slopes of New Guinea's central cordillera from the Snow Mountains (Indonesia) east to Crater Mountain (PNG) (Mack and Wright 1996). Rare and nomadic in hill and lower montane forest at 800–1,700 m asl, recorded once in the lowlands (Coates 1985). The nest is undescribed but is presumably located in a tree hollow. Rare or absent from the study area. Potentially only in hill forest at the base of the cordillera proper, northern rim Middle Purari Hills.

Banded Yellow Robin *Poecilodryas placens*—Endemic to New Guinea and Batanta Island (Indonesia), isolated populations scattered across New Guinea in hill and lower montane forest at 100–1,450 m asl. Occupies the dark understorey of primary forest interior (Diamond 1972; Coates 1990; Boles 2007). Probably not present in the study area. Potentially only in hill forest at the base of the cordillera proper, northern rim Middle Purari Hills, including footslopes of Mount Favenc in the northwest (see Section 4.3).

Yellow-eyed Starling *Aplonis mystacea*—Endemic to south New Guinea lowlands, from Bird's Neck (Indonesia) east to Gulf Province, PNG. Preferred habitat is alluvial forest, including flood disturbed riparian zones, but also observed in hill forest to about 300 m asl (Craig and Feare 2009; Woxvold 2008). A congregatory species, it breeds communally (Section 4.4.2). This species is likely to occur within the study area, in PRL-15 and/or the export pipeline corridor, in alluvial forest and hill forest near watercourses in the Middle Purari Hills, Southeast Hills and Delta Swamps and Plains ecological zones.

4.2.2.3 IUCN Data Deficient species

Chestnut-shouldered Goshawk *Erythrotriorchis buergersi*—A large bird of prey. One of New Guinea's rarest birds (Beehler 1993a). Known from hill and lower montane forest at c. 450 to 1,600 m asl. Not recorded from Gulf Province. Probably absent from the study area, with suitable habitat potentially restricted to the base of the cordillera proper at the northern rim of the Middle Purari Hills.

Papuan Hawk-Owl *Uroglaux dimorpha*—Endemic to New Guinea where recorded throughout from the lowlands to 1,500 m asl, including in Gulf Province (Beehler and Pratt 2016). Occupies a wide range of habitats including rainforest, forest edge and gallery forest in savannah (Coates 1985; Pratt and Beehler 2015). The nest is undescribed, but as with most other owls occurring in the region, is

likely to be placed inside a tree hollow. This species is highly likely to occur within the study area in both PRL-15 and the export pipeline corridor, in alluvial forest and hill forest, including intact and disturbed environments, and potentially in all ecological zones except Mv.

Wallace's Owlet-nightjar *Aegotheles wallacii*—A rare species endemic to New Guinea and the Aru Islands, with scattered occurrences from lowlands up to c. 1,100 m asl, though predominantly a hill forest species (Beehler and Pratt 2016). The nest is located in a tree cavity (Cleere 2010). There are no records from Gulf Province, though its distribution is poorly known. Suitable habitat potentially restricted to the Middle Purari Hills and Southeast Hills ecological zones, potentially overlapping the study area.

Three-toed Swiftlet *Aerodramus papuensis*—Very difficult to distinguish in the field from three other all-dark New Guinea swiftlets. Endemic to New Guinea where recorded with certainty from only four localities between sea level and 2,400 m asl. Most likely to occur in hill forest in the Middle Purari Hills and Southeast Hills. Suitable roosting and breeding caves potentially occur in limestone areas of the Middle Purari Hills, including Kereru Range and northern rim.

4.2.2.4 Nationally Protected species

Eastern Osprey *Pandion cristatus*—From Sulawesi to Australasia, the Solomon Islands and New Caledonia. Widely though sparsely distributed around New Guinea's coastline with occasional records inland along major rivers (Pratt and Beehler 2015). Most likely to occur in near-shore marine and estuarine waters, potentially breeding in forest near the coast, Mangroves and Southeast Coast ecological zones. Possible occasional occurrences along larger watercourses in any ecological zone.

Crinkle-collared Manucode *Manucodia chalybatus*—Endemic to mainland New Guinea and Misool Island (Indonesia), in forest and forest edge from the lowlands to 1,700 m asl, though most common in hill forest above 500 m. This shy bird is similar in appearance to the Glossy-mantled Manucode but (unlike the latter species) is not easily distinguished based on vocalizations alone. Predominantly frugivorous, specializing in figs (Frith and Beehler 1998). Suitable habitat within the study area is restricted to hill forest in the Middle Purari Hills and Southeast Hills ecological zones. It may occur within the study area, though it is most likely to occur at the base of the cordillera proper at the northern rim of the Middle Purari Hills.

Magnificent Bird-of-paradise *Diphyllodes magnificus*—Endemic to New Guinea and satellite islands where common and widespread in forest from the lowlands to 1,780 m asl (Frith and Frith 2009). Suitable habitat within the study area includes hill forest in the Middle Purari Hills and Southeast Hills ecological zones. It may occur within the study area, particularly in undisturbed hill forest within PRL-15. Surprisingly scarce given the availability of suitable habitat and their high detectability.

4.3 Endemic and restricted-range species

The New Guinea region is rich in avian endemics (Section 2.1). More than one third of the bird species recorded in the study area (Project and prior surveys combined: 81/214; 37.9%) are found only on New Guinea and its satellite islands. Of these, 19.8% (16/81) occur only on mainland New Guinea, and two species – Scheepmaker's Crowned Pigeon and Starry Owlet-nightjar – are found only in the southern watershed (south of the central cordillera). Two species are endemic to mainland PNG—Scheepmaker's Crowned Pigeon and Raggiana Bird-of-paradise.

Two restricted-range bird species (<50,000 km^2; Stattersfield et al. 1998) have been recorded in the study area (Table 5).

- Scheepmaker's Crowned Pigeon has not been assessed for restricted-range status by BirdLife International, but is described as having a distribution size of 15,700 km^2, with the western limit of its known range quoted as Lakekamu basin (BirdLife International 2016). Its

range is certainly larger, with published records from the lower Purari basin (Beehler and Pratt 2016), and current records from further inland in the Purari River and Era River catchments (this study). Its distribution may extend west to the Kikori drainage, though it may not occur further west of there given the known occurrence of its western counterpart, Sclater's Crowned Pigeon *Goura sclateri*, near the Hegigio River (Woxvold, unpublished data). Taking a conservative maximum, suitable habitat across its entire potential range amounts to less than 35,000 km^2.

- Starry Owlet-Nightjar has also not been assessed for restricted-range status by BirdLife International, but is described as having a distribution size of just 3,700 km^2 (BirdLife International 2016). The BirdLife assessment is based on two known sites of occurrence separated by some 1,000 km. However, its actual area of occupancy is considerably larger given records from two intervening localities—Brown River near Port Moresby (Pratt 2000) and eastern Gulf Province (Pratt and Beehler 2016; this study). Nevertheless, given the narrow elevational range within which records have been obtained (below 125 m asl), and its possible absence from swamp forest environments (e.g. Verbelen 2014), a conservative maximum estimate of the area of potentially suitable habitat across its known extent of occurrence amounts to somewhere between 40,000 and 50,000 km^2. While its range may extend further into Indonesian New Guinea (Papua) than is currently recognized, its population may be fragmented (accounting for the paucity of records), and the overall area of occupancy is here precautionarily considered to amount to less than 50,000 km^2.

At least one additional restricted-range species may occur in the study area (Table 6).

- The Banded Yellow Robin *Poecilodryas placens* is a Near Threatened restricted-range species known from a small number of widely scattered isolated populations. It occurs in the understorey of primary hill and lower montane forest between 100 and 1,450 m asl, with the elevational range of individual populations changing with locality (Diamond 1972; Coates 1990; Boles 2007). It has not been recorded in the study area but has been recorded approximately 20 km to the north at c. 600–1,100 m asl (at Soliabeda, Karimui area: Diamond 1972). Similar habitat extends unbroken to near the northern rim of the study area, where it may occur in primary hill forest of the Middle Purari Hills ecological zone, at the base of the central cordillera and/or on the footslopes of Mount Favenc. Given the extreme patchiness of its distribution, without survey in this area its probability of occurrence cannot be safely predicted.

4.4 Migratory and congregatory species

4.4.1 Migratory species

Most bird species recorded in the study area are present in New Guinea only as breeding residents (Project and prior surveys combined: 171/214; 79.9%). The remaining 43 species, listed in Table 7, occur in New Guinea at least partly as non-breeding visitors. They include 28 species of freshwater and/or marine coastal environments and 15 species of forest and/or open terrestrial habitats.

4.4.1.1 Migrants to freshwater and marine coastal environments

Most freshwater and marine migrants (27/28) breed in Australia or in the northern hemisphere (Table 7).

Most Australian breeding species (all but Gull-billed Tern *Gelochelidon nilotica* and Greater Crested Tern *Thalasseus bergii*) predominantly occupy freshwater environments. They include 13 terrestrial or surface-feeding waterbirds (Pacific Black Duck *Anas superciliosa**, Australasian Grebe *Tachybaptus novaehollandiae**, Royal Spoonbill *Platalea regia*, Great, Intermediate and Little Egrets, White-faced Heron *Egretta novaehollandiae*, Australian Pelican *Pelecanus conspicillatus*, Little Pied Cormorant *Microcarbo melanoleucos*, Little Black Cormorant *Phalacrocorax sulcirostris**, Australasian Darter

*Anhinga novaehollandiae**, Purple Swamphen *Porphyrio porphyrio**, White-headed Stilt *Himantopus leucocephalus**) and one aerial foraging tern (Whiskered tern *Chlidonias hybrida*). The residency/migratory status of many of these species is still poorly understood (Dingle 2004; Beehler and Pratt 2016), and at least six of the non-aerial foraging species (those marked * above) may have local resident breeding populations in the study area. Considering all such potential migrants, while most of these species have been recorded along the Purari River and its tributaries, they tend to appear there as scattered occurrences in rather small numbers; the greatest congregations are likely to occur in off-river freshwater wetlands such as oxbow lakes and swamps (see Section 4.4.2; Section 4.8.3.2).

In contrast to Australian breeding waterbirds, most northern hemisphere migrants recorded in the study area predominantly or commonly occur in coastal environments[8]. These include ten migratory shorebirds (Charadriidae, Scolopacidae) and the Common Tern *Sterna Hirundo*. The conservation of migratory shorebirds is of increasing international concern due to ongoing population declines (Section 4.8.2). Those recorded to date are among at least 31 migratory shorebird species (excluding vagrants: Pratt and Beehler 2015), listed in Table 8, that may regularly occur in the study area. Within the study area, migratory shorebirds are expected to congregate in the greatest numbers along the tidal flats, lagoons and estuaries of the Mangroves ecological zone and to a lesser degree the Southeast Coast (see Section 4.4.2).

Non-breeding visitors to coastal environments include one species—the Great Frigatebird *Fregata minor*—that breeds on islands in tropical seas throughout the Pacific and Indian oceans.

4.4.1.2 Migrants to terrestrial environments

All 15 migrants to terrestrial habitats are Australian breeding species. Ten of these species occur in the study area solely or predominantly as non-breeding visitors (Channel-billed Cuckoo *Scythrops novaehollandiae* (Plate 8E), Oriental Dollarbird *Eurystomus orientalis*, Buff-breasted Paradise Kingfisher *Tanysiptera Sylvia*, Forest Kingfisher *Todirhamphus macleayii*, Sacred Kingfisher *T. sanctus*, Rainbow Bee-eater *Merops ornatus*, Nankeen Kestrel *Falco cenchroides*, Black-faced Cuckooshrike *Coracina novaehollandiae*, Common Cicadabird *Coracina tenuirostris*, Black-faced Monarch *Monarcha melanopsis*). Four species occur mostly as breeding residents with numbers augmented seasonally by non-breeding visitors from Australia (Pacific Koel *Eudynamys orientalis*, Little Bronze Cuckoo *Chrysococcyx minutillus*, Brush Cuckoo *Cacomantis variolosus*, Leaden Flycatcher *Myiagra rubecula*). The Hobby *Falco* sp. was not identified to species (Ashford 1978, 1979) and may have been the migrant Australian Hobby *F. longipennis* or the resident Oriental Hobby *F. severus*.

All migrants to terrestrial habitats occur widely across southern New Guinea and most either predominantly occupy or are tolerant of open and disturbed environments (Table 7). The study area does not include habitat for these species requiring specific conservation action.

4.4.2 Congregatory species

The International Finance Corporation (IFC) defines congregatory species as “species whose individuals gather in large groups on a cyclical or otherwise regular and/or predictable basis” (IFC 2012: Performance Standard 6, GN86). This behaviour makes congregatory species susceptible to a variety of potential impact processes.

At least 32 species recorded to date within the study area (Project and prior surveys combined), as well as a number of additional potentially occurring species (listed in the following sections), are likely to congregate in specific habitats as single- or multi-species aggregations. These are divisible into four main groups.

[8] Also: grasslands and/or inland freshwater environments—Pacific Golden Plover *Pluvialis fulva*, Snipe *Gallinaggo* sp., Common Sandpiper *Actitis hypoleucos*.

Table 7 Migratory species (not breeding on mainland New Guinea) recorded in the study area.

English name	Scientific name	Migratory status	Habitat	Source
Pacific Black Duck	*Anas superciliosa*	BR(+M)	W	A
Australasian Grebe	*Tachybaptus novaehollandiae*	BR(+M)	W	A
Royal Spoonbill	*Platalea regia*	BR*+M	W	A
Great Egret	*Ardea alba*	BR*+M	W,C	A
Intermediate Egret	*Egretta intermedia*	BR*+M	W	A
White-faced Heron	*Egretta novaehollandiae*	M	W	A
Little Egret	*Egretta garzetta*	M	W,C	A
Australian Pelican	*Pelecanus conspicillatus*	M	W,C	A
Great Frigatebird	*Fregata minor*	M	C	TS
Little Pied Cormorant	*Microcarbo melanoleucos*	BR*+M	W,C	A
Little Black Cormorant	*Phalacrocorax sulcirostris*	BR+M	W,C	A
Australasian Darter	*Anhinga novaehollandiae*	BR(+M)	W	A
Purple Swamphen	*Porphyrio porphyrio*	BR+M	W	A
White-headed Stilt	*Himantopus leucocephalus*	BR+M	W,C	A
Pacific Golden Plover	*Pluvialis fulva*	M	W,C,O	N
Lesser Sand Plover	*Charadrius mongolus*	M	C	N
Greater Sand Plover	*Charadrius leschenaultii*	M	C	N
Snipe sp.	*Gallinago* sp.	M	W,O	N
Black-tailed Godwit	*Limosa limosa*	M	C	N
Whimbrel	*Numenius phaeopus*	M	C	N
Far Eastern Curlew	*Numenius madagascariensis*	M	C	N
Wandering Tattler	*Tringa incana*	M	C	N
Common Sandpiper	*Actitis hypoleucos*	M	W,C	N
Ruddy Turnstone	*Arenaria interpres*	M	C	N
Gull-billed Tern	*Gelochelidon nilotica*	M	C	A
Greater Crested Tern	*Thalasseus bergii*	BR*+M	C	TS
Common Tern	*Sterna hirundo*	M	C	N
Whiskered Tern	*Chlidonias hybrida*	M	W	A
Pacific Koel	*Eudynamys orientalis*	BR+M	F,O	A
Channel-billed Cuckoo	*Scythrops novaehollandiae*	M(+BR)	F,O	A
Little (Malay) Bronze Cuckoo	*Chrysococcyx minutillus*	BR+M	F,O	A
Brush Cuckoo	*Cacomantis variolosus*	BR+M	F,O	A
Oriental Dollarbird	*Eurystomus orientalis*	BR+M	F,O	A
Buff-breasted Paradise Kingfisher	*Tanysiptera sylvia*	BR*+M	F	A
Forest Kingfisher	*Todirhamphus macleayii*	BR*+M	O	A
Sacred Kingfisher	*Todirhamphus sanctus*	M	O	A
Rainbow Bee-eater	*Merops ornatus*	BR*+M	O	A
Nankeen Kestrel	*Falco cenchroides*	BR*+M	O	A
Hobby sp.	*Falco* sp.	BR/M	F,O	A
Black-faced Cuckooshrike	*Coracina novaehollandiae*	BR*+M	F,O	A
Common Cicadabird	*Coracina tenuirostris*	BR*+M	F,O	A
Black-faced Monarch	*Monarcha melanopsis*	M	F,O	A
Leaden Flycatcher	*Myiagra rubecula*	BR+M	F,O	A

[A] M – species that occur in New Guinea only as non-breeding migrants; M(+BR) – non-breeding migrants with possible (unknown) breeding populations in New Guinea; BR+M – breeding residents with populations seasonally augmented by non-breeding visitors, and with widespread local breeding range potentially overlapping the study area; BR*+M – breeding residents augmented by non-breeding visitors, but known breeding sites are localised and not known within the study area; BR(+M) – breeding residents possibly (unknown) seasonally augmented by non-breeding visitors. Data from Coates (1985, 1990), Beehler and Pratt (2016).

[B] C – marine coastal environments; F – forest; O – open and disturbed areas; W – freshwater wetlands.

[C] Breeding grounds outside of New Guinea: A – Australia; N – northern hemisphere; TS – Islands in tropical seas.

Table 8 Migratory shorebirds potentially occurring in the study area, their IUCN status and preferred habitats.

English name	Scientific name	IUCN[1]	Habitat[2]
Pacific Golden Plover	*Pluvialis fulva**	LC	W,C,O
Grey Plover	*Pluvialis squatarola*	LC	C
Lesser Sand Plover	*Charadrius mongolus**	LC	C
Greater Sand Plover	*Charadrius leschenaultii**	LC	C
Oriental Plover	*Charadrius veredus*	LC	O
Latham's Snipe	*Gallinago hardwickii*	LC	W,O
Swinhoe's Snipe	*Gallinago megala*	LC	W,O
Asian Dowitcher	*Limnodromus semipalmatus*	NT	C
Black-tailed Godwit	*Limosa limosa**	NT	C
Bar-tailed Godwit	*Limosa lapponica*	NT	C
Little Curlew	*Numenius minutus*	LC	O
Whimbrel	*Numenius phaeopus**	LC	C
Far Eastern Curlew	*Numenius madagascariensis**	EN	C
Marsh Sandpiper	*Tringa stagnatilis*	LC	W
Common Greenshank	*Tringa nebularia*	LC	C
Wood Sandpiper	*Tringa glareola*	LC	W
Grey-tailed Tattler	*Tringa brevipes*	NT	C
Wandering Tattler	*Tringa incana**	LC	C
Terek Sandpiper	*Xenus cinereus*	LC	C
Common Sandpiper	*Actitis hypoleucos**	LC	W,C
Ruddy Turnstone	*Arenaria interpres**	LC	C
Great Knot	*Calidris tenuirostris*	VU	C
Red Knot	*Calidris canutus*	NT	C
Sanderling	*Calidris alba*	LC	C
Red-necked Stint	*Calidris ruficollis*	NT	C
Long-toed Stint	*Calidris subminuta*	LC	W,C
Pectoral Sandpiper	*Calidris melanotos*	LC	W
Sharp-tailed Sandpiper	*Calidris acuminata*	LC	W,C
Curlew Sandpiper	*Calidris ferruginea*	NT	W,C
Broad-billed Sandpiper	*Limicola falcinellus*	LC	C
Ruff	*Philomachus pugnax*	LC	W

[1] Abbreviations for conservation listing categories are explained in Section 3.5.2.

[2] Preferred habitat: C – marine coastal environments; O – open and disturbed areas, including grassland; W – freshwater wetlands.

* Species recorded in the study area (Liem and Haines 1977; Ashford 1978, 1979).

4.4.2.1 Freshwater wetland species

First are those species that congregate at off-river freshwater wetlands. Of the species recorded to date within the study area, these include all 14 freshwater species that occur in New Guinea at least partly as Australian breeding migrants (12 terrestrial or surface-feeding waterbirds and Whiskered Tern; Section 4.4.1.1) and four wetland birds that are known only as breeding residents (Spotted Whistling Duck *Dendrocygna guttata*, Raja Shelduck *Tadorna radjah*, Nankeen Night Heron *Nycticorax caledonicus*, Comb-crested Jacana *Irediparra gallinacean*)[9]. Another 18 potentially

[9] Three additional wetland species recorded in the study area – Striated Heron *Butorides striata*, Great-billed Heron *Ardea sumatrana* and White-bellied Sea Eagle *Haliaeetus leucogaster* – are typically more solitary and do not commonly join aggregations of waterbirds in open lake environments.

occurring waterbirds are yet to be recorded in the study area, including a variety of breeding residents and both northern hemisphere and Australian breeding migrants[10].

Within the study area the largest aggregations of freshwater wetland species are expected to occur in standing-water wetlands associated with former channels of the Purari and Vailala rivers, respectively in the Delta Swamps and Plains and Southeast Hills ecological zones. The location and potential importance of these habitats is discussed further in Section 4.8.3.2.

4.4.2.2 Coastal species

Second are those species that congregate on beaches and in tidal environments along the study area coast. Of the species recorded to date within the study area, these include all 11 northern hemisphere migrants (ten migratory shorebirds (Charadriidae, Scolopacidae) and the Common Tern; Section 4.4.1) and the Gull-billed Tern and Greater Crested Tern. Another 21 potentially occurring species that may join coastal aggregations are yet to be recorded in the study area, including 14 migratory shorebirds (Table 8), four terns (Laridae; migratory or locally breeding: Lesser Crested Tern *T. bengalensis*, Little Tern Sternula albifrons, Bridled Tern Onychoprion anaethetus, White-winged Tern *Chlidonias leucopterus*) the Australian breeding Pied Oystercatcher *Haematopus longirostris* and the resident breeding Pacific Reef Heron *Egretta sacra* and Beach Stone-curlew *Esacus magnirostris* (NT).

Within the study area the largest aggregations of coastal species are expected to occur along the tidal flats, lagoons and estuaries of the Mangroves ecological zone, and to a lesser degree the Southeast Coast. The potential importance of these habitats is discussed further in Section 4.8.2.

4.4.2.3 Cave roosting swiftlets

At least two cave roosting swiftlets have been recorded in the study area—the Glossy Swiftlet *Collocalia esculenta* and the Uniform Swiftlet *Aerodramus vanikorensis*. *Aerodramus* swiftlets were among the most common and widespread bird species recorded during the Project surveys and up to three additional species may occur (Mountain Swiftlet *A. hirundinaceus*, Bare-legged swiftlet *A. nuditarsus*, Three-toed Swiftlet *A. papuensis*)[11].

All potentially occurring swiftlets for which relevant data are available (cf. Bare-legged Swiftlet) nest and roost colonially in caves, with the Glossy Swiftlet also reported to use overhanging boulders or stream banks, *Pandanus* foliage and buildings of various kinds (Coates 1985; Chantler and Driessens 2000). For those taxa recorded in the study area, there are few data on colony sizes for either species in New Guinea. Throughout their range, colony size of Glossy Swiftlets was reported by Chantler and Driessens (2000, p. 125) to be “small”, though a colony studied in Malaysia by Hails and Amiruddin (1981) comprised about 700 pairs. Uniform Swiftlet may be observed in feeding flocks of many hundreds of birds (Coates 1985), though colony sizes of that scale are unreported.

The potential distribution of caves and rock overhangs in the study area is discussed further in Section 4.8.4.1.

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[10] Based on current knowledge of distribution and habitat preferences (Coates 1985; Pratt and Beehler 2015): Wandering Whistling Duck *Dendrocygna arcuata*, Green Pygmy Goose *Nettapus pulchellus*, Grey Teal *Anas gracilis*, Hardhead *Aythya australis*, Australian White Ibis *Threskiornis moluccus*, Black Bittern *Dupetor flavicollis*, Pied Heron *Egretta picata*, Spotless Crake *Porzana tabuensis*, White-browed Crake *P. cinerea*, Dusky Moorhen *Gallinula tenebrosa*, Marsh Sandpiper *Tringa stagnatilis*, Wood Sandpiper *T. glareola*, Pectoral Sandpiper *Calidris melanotos*, Broad-billed Sandpiper *Limicola falcinellus*, Common Greenshank *Tringa nebularia*, Sharp-tailed Sandpiper *Calidris acuminata*, Curlew Sandpiper *Calidris ferruginea*, White-winged Tern *Chlidonias leucopterus*.

[11] The four *Aerodramus* species are difficult to reliably distinguish in the field without birds in the hand. While it is possible that more than one species has already been observed, the Uniform Swiftlet is the only species reported to be common in these lowland environments (Coates 1985; Pratt and Beehler 2015) so it is assumed that this species is among those encountered, and may account for all of them.

4.4.2.4 Colonial starlings

Two colonially breeding starling species have been recorded in the study area—the Metallic Starling *Aplonis metallica* in forest environments of the interior study area (Project surveys: principal Sites 3−9) and the Singing Starling *A. cantoroides* of predominantly coastal areas (prior surveys: Ashford 1978, 1979).

The Metallic Starling is strongly colonial. Feeding flocks of "hundreds of birds" (Coates 1990, p. 354) have been reported in New Guinea, and 3,000–5,000 birds in Australia (Higgins et al. 2006). Nesting colonies are typically packed into a single tree, containing up to 50+ (Higgins et al. 2006) and "sometimes hundreds" (Pratt and Beehler 2015, p. 504) of nests, and may be used repeatedly over multiple years.

The Singing Starling is less gregarious, reported to only "sometimes breed colonially" (Craig and Feare 2009, p. 717) and then in small numbers (Pratt and Beehler 2015).

One additional colonially breeding starling is expected to occur in the study area. The Yellow-eyed Starling *Aplonis mystacea* is a Near Threatened species that generally occurs in small groups (commonly c. 10–25 birds; I. Woxvold, unpublished data) and occasionally in large flocks of up to 200 birds. It breeds in colonies that occupy one or a cluster of large trees in lowland forest, with a preference for alluvial forest, with the one colony recorded consisting of about 150 nests (Safford 1996; Craig and Feare 2009). Near the study area the Yellow-eyed Starling has been recorded in the Lakekamu Basin (Beehler and Bino 1995; Safford 1996).

4.4.2.5 Lekking birds-of-paradise

A final example of congregatory bird species present in the study area is the Raggiana Bird-of-paradise (*Paradisaea raggiana*). In this species, up to ten or more males display simultaneously at traditional display sites termed 'leks' (Frith and Beehler 1998). Leks are usually formed in the upper portion or top branches of a canopy tree, often in a prominent position in the local topography. A lek may be temporary or used continuously for many years. The Raggiana Bird-of-paradise and the forest environments in which leks are located are widespread within and beyond the study area.

4.5 Invasive alien species

One non-native bird species was recorded, the Eurasian Tree Sparrow (*Passer montanus*) having established colonies at Herd Base, the Antelope-3 Operations Camp (at least seven individuals present during Phase 1) and in coastal villages of Orokolo Bay (Site 9). Eurasian Tree Sparrow was first recorded in mainland PNG at Port Moresby in April 2009 (Gregory 2009a, b). An accomplished colonist, its recent arrival has been followed by a rapid expansion into settled areas with the first record from Gulf Province at Kerema in 2011 (Woxvold et al. 2015).

Two other invasive bird species may occur—the Rock dove *Columba livia* and the House Sparrow *Passer domesticus*. These are most likely to inhabit densely populated coastal areas in the southeast of the study area.

All invasive bird species occurring in New Guinea are closely associated with areas of human settlement and almost exclusively occupy open and disturbed habitats (Pratt and Beehler 2015). Should they become established within the Project area none is expected to pose a serious threat to native fauna populations—they do not enter forest environments and do not compete with native birds or other native fauna for what are often artificial sources of food or nest sites within the developed/urbanized habitats that they occupy (Higgins and Davies 1996; Higgins et al. 2006). However, the House Sparrow is considered minor agricultural pests and all three species may contribute to the spread of weeds (Higgins et al. 2006).

4.6 Range extensions

Project survey records include extensions to the known geographic range of three species.

The Peaceful Dove *Geopelia placida* is a bird of woodlands, grasslands, towns and gardens in seasonally drier parts of New Guinea. In the southern watershed it has not been reported between the Trans-Fly and southeast peninsula (Coates 1985; Pratt and Beehler 2015). On 16 February 2016 a single bird was observed at a helipad clearing at Site 4.

The Double-eyed Fig Parrot *Cyclopsitta diophthalma* is a widespread and geographically variable species with eight distinct subspecies currently recognised from New Guinea, its satellite islands and northeast Australia (Gill and Donsker 2016). It is considered absent from much of southern New Guinea, where it is largely replaced by the Orange-breasted Fig Parrot (Coates 1985). There are no published southern lowland records from east of the Fly River (Coates 1985; Pratt and Beehler 2015). Double-eyed Fig Parrots are widespread within the study area. Sightings were made:

- In PRL-15—in hill forest at the edge of the helipad clearing at Site 2 and in alluvial forest and flood disturbed habitats at Site 5.
- In the export pipeline corridor—from logging roads in logged forest and gardens at Sites 3, 7 and 8.

The Tawny Straightbill *Timeliopsis griseigula* (Plate 11A) is a rare honeyeater endemic to New Guinea lowland forest. There are no published records from across the c. 600 km expanse between Kiunga (Western Province) and the base of the southeast peninsula (Coates 1990; Pratt and Beehler 2015). One Tawny Straightbill was mist netted in alluvial forest at Site 4, and another detected via automated sound recorder in logged hill forest at Site 3.

4.7 New-to-science and undescribed species

No new-to-science or scientifically undescribed bird species were recorded during the Project surveys.

The subspecific identity of Double-eyed Fig Parrots observed within the study area (Section 4.6) has not been determined. Photographs of a male from Site 3 show a bird conforming both to *C. d. aruensis* and to *C. d. virago*, with no blue eye spot and the red of the forehead and cheek meeting broadly across the lore. All known mainland New Guinea subspecies have a blue spot in front of the eye (Pratt and Beehler 2015). A closer examination of both male and female specimens would be required to determine whether the Purari basin fig parrots belong to one of the island subspecies (*C. d. aruensis* or *C. d. virago*) or to a new subspecies.

4.8 Important bird habitats

The study area includes a variety of habitats that support multiple resident and/or migratory bird species of conservation significance.

4.8.1 Important forest environments

4.8.1.1 Overview of forest environments

Forest habitats support the vast majority of bird species residing or regularly occurring in the study area—of the 214 bird species recorded, nearly three quarters (155; 72.4%) occur in forest environments, most of which are forest-dependent (cannot persist in converted or secondary habitats alone). All resident IUCN listed and restricted-range species and most nationally Protected species (all except egrets) confirmed present in the study area are dependent on forest habitats.

Compared to many other taxa under consideration in this study (e.g. plants, herpetofauna, non-volant mammals), birds are highly vagile and broad ranging species, most of which occupy a suite of different microhabitats at different times or periods of their life cycle. Such movements may occur on a local scale at different times of day (e.g. between valleys and ridges in hill forest), and at a broader scale (e.g. landscape level movements) across seasons (predictably or unpredictably). With the dynamics of ecological and microspatial requirements of most New Guinea bird species still poorly known, in most cases a detailed assessment of the relative importance of various microhabitats (e.g. valleys, slopes and ridges in hill forest, forest structural variants, associations with particular plant species) present within each of the broad forest types cannot be put forward. The importance to select taxa of caves (Section 4.8.4.1), large trees (Section 4.8.4.2) and large fig trees (*Ficus* spp.) (Section 4.8.4.3) are notable exceptions.

Consequently, the importance of forest habitats/areas to bird communities and to individual species in the study area is discussed here primarily in the context of broader habitat types. Within the study area landscape three forest types are identified as being of particular importance to locally occurring bird communities.

4.8.1.2 Alluvial forest

Lowland alluvial forest (FIMS code P) occurs in discrete areas at the northern, southern and eastern margins of the Delta Swamps and Plains ecological zone, and as more minor occurrences (often too small to be mapped) along major watercourses in the Middle Purari Hills and the Southeast Hills ecological zones and at the base of the foothills in the Southeast Coast ecological zone. It has a much more restricted distribution than hill forest (FIMS code H), both within the study area and more broadly across Gulf Province, and as a favoured source of commercial timber is under pressure from industrial logging activities, including locally within the study area and more broadly across the Gulf and Western Provinces (Bryan and Shearman 2015; H. Rogers, pers. comm.).

Lowland alluvial forest supports the richest bird communities in the Asia-Pacific realm. Within the study area, the presence of alluvial forest was a key factor in attaining the highest single-site species counts at Sites 4, 5 and 7. Numerous birds recorded in alluvial forest at these sites were not recorded in hill forest at any site, and many species occurring in both hill and alluvial forest were more abundant in alluvial environments. For example, of 12 truly terrestrial bird species camera trapped on multiple occasions during the Project surveys, 10 were photographed more frequently in alluvial forest than in hill forest (Figure 9). Of the two remaining species, (1) the Red-necked Crake *Rallina tricolor* was camera trapped at the same rate in both forest types, and (2) the Southern Crowned Pigeon, which has a documented preference for alluvial forest (King and Nijboer 1994; BirdLife International 2016), was much more widespread in alluvial forest during the Project surveys—its higher overall camera trap RAI from hill forest was attributable to artificially high counts at two cameras (see Section 4.2.2.1; adjusted rate shown in Figure 9). Terrestrial birds (such as those photographed by camera trap) are especially vulnerable to forest disturbance (Munks and Watling 2013), and remaining areas of intact alluvial forest thus provide important habitat for terrestrial species, notably including two IUCN Vulnerable bird species—the Southern Cassowary and Scheepmaker's Crowned Pigeon. The latter of these is here judged to be the most conservation significant bird species resident within the study area (Section 4.2.2.1). Alluvial forest also provides suitable habitat for all other resident IUCN listed species and most nationally Protected species confirmed present within the study area. Among additional potentially occurring IUCN listed species, alluvial forest is the preferred habitat of the Yellow-eyed Starling (NT) (Craig and Feare 2009), a congregatory species (Section 4.4.2.4) of the southern New Guinea lowlands.

Other forest birds recorded in the study area that are likely to be restricted to or more abundant in alluvial forest include White-bellied Thicket Fantail *Rhipidura leucothorax*, Black Thicket Fantail *R. maculipectus*, Shining Flycatcher *Myiagra alecto*, Twelve-wired Bird-of-paradise *Seleucidis melanoleuca* and Black-sided Robin *Poecilodryas hypoleuca*. Alluvial forest at Sites 4 and 5 were also

the only habitats in which the rare Shovel-billed Kookaburra *Clytoceyx rex* and Starry Owlet-nightjar have been locally recorded.

Elsewhere in the Asia-Pacific region, the relative importance of hill and alluvial forest has been well studied in Sundaic Southeast Asia. Following detailed studies on birds in Malaysia, Wells (1985) confirmed that bird species richness is highest in lowland alluvial forests, and further noted that (Wells 1985, p. 221):

> "it cannot be over-emphasized that for the lowland forest bird fauna the extreme lowlands, below the hill-foot boundary, is the key zone".

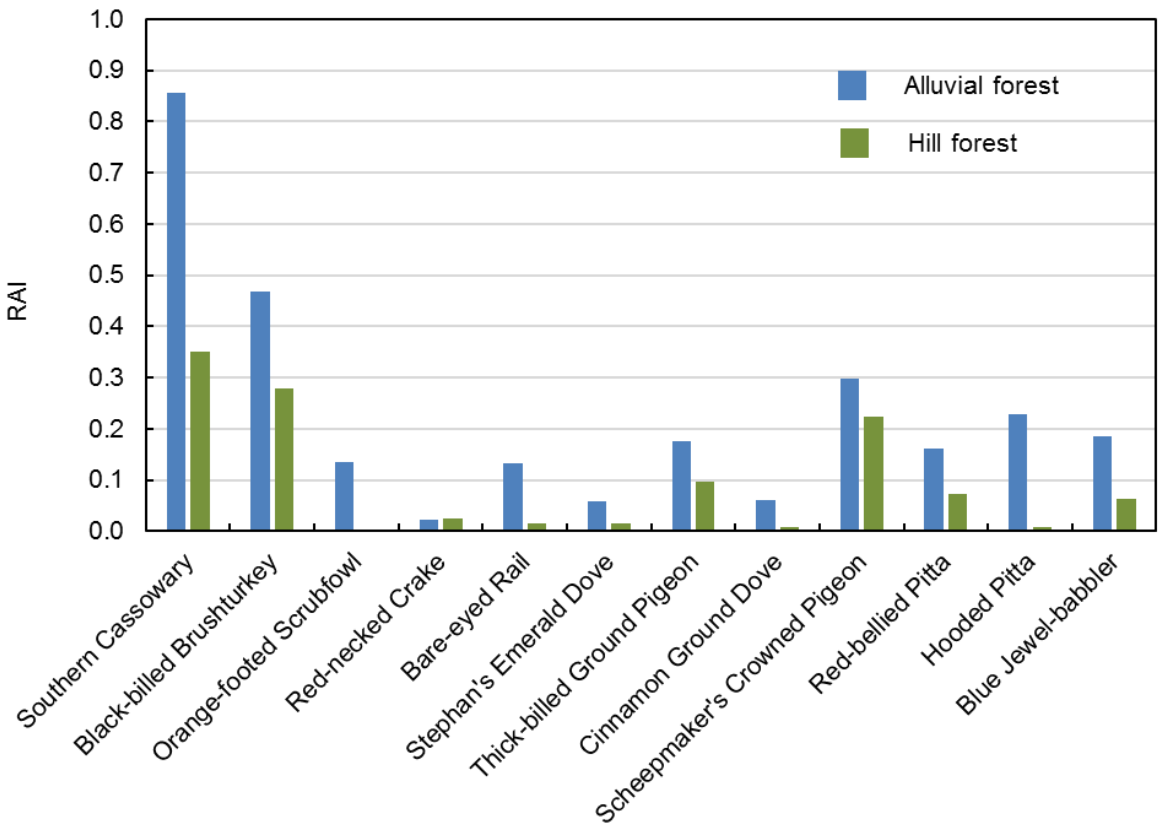

Figure 9 Camera trap RAIs in alluvial forest and hill forest for terrestrial species camera trapped on multiple (>1) occasions.

Adjusted hill forest RAI shown for Scheepmaker's Crowned Pigeon after removing data from two hill forest cameras with artificially high trap rates (due to fruit fall).

4.8.1.3 Hill forest

Compared to alluvial forest, hill forest is much more widespread both locally within the study area and more broadly across PNG. Low elevation hill forests (below 500 m) support among the richest bird communities present in New Guinea (Pratt and Beehler 2015). Detailed comparisons of bird diversity among alluvial and adjacent foothill forest communities are lacking for PNG. However, hill forests within the study area were less species rich than those occurring in alluvial forest. Sites 1 and 2 were located in the Middle Purari Hills ecological zone in the centre of PRL-15. These sites produced the lowest species tallies of all the principal survey sites, despite the presence of extensive areas of undisturbed forest. Not recorded at these sites was a suite of resident forest species normally fairly common in low elevation, high rainfall hill forest of southern New Guinea. Examples include Little

Bronze Cuckoo *Chrysococcyx minutillus*, Hooded Pitta *Pitta sordida*, Black Berrypecker *Melanocharis nigra*, Dwarf Longbill *Oedistoma iliolophus*, Brown Oriole *Oriolus szalayi*, Magnificent Riflebird *Ptiloris magnificus*, Black Cicadabird *Coracina melas*, Grey whistler *Pachycephala simplex*, Northern Fantail *Rhipidura rufiventris* and Olive Flyrobin *Microeca flavovirescens*. Given (1) the conspicuousness of most of these species, and (2) the remoteness of this area and the intact nature of much of the surveyed habitat, the relatively low species richness and the absence or rarity of some normally well represented hill forest species appear to be genuine characteristics of the local bird community structure at these sites. The reasons for this are unclear. High rates of natural forest disturbance (through landslip), moderate soil fertility and potential El Niño effects are not obviously implicated given the higher species count from survey at Site 3, conducted on similar soil profiles in heavily logged forest at the same time of year.

Bird species richness was unexpectedly higher in logged hill forest at Sites 3 and 7. The influence of logging on forest bird communities in New Guinea has been little studied (reviewed in Munks and Watling 2013). In general, results indicate that bird species richness and abundance is lower in logged secondary forest than in unlogged forest (Driscoll 1984, summarised in Lamb 1990; Marsden and Symes 2008; Tvardikova 2010; Dawson et al. 2011). However, studies have also found (1) that species assemblages change with time as the forest regenerates, (2) that species richness is highest in sites with intermediate disturbance, and (3) that species richness is higher in disturbed sites that are near primary forest habitats (Marsden and Symes 2008; Munks and Watling 2013). Ultimately, the high species richness at Sites 3 and 7 is attributable to the logging road network providing good coverage of a variety of habitat types that were represented by multiple vegetation types, each of which varied in condition at the patch-scale. The following were relevant factors:

- At the patch-scale, interior forest specialists persisted in remnant areas of primary (or little disturbed) forest and provided source populations for colonization of surrounding areas of regenerating habitat.
- Logging operations were conducted some 10−13 years prior to survey, allowing time for regeneration to produce a more mature and multi-layered forest structure that provides suitable habitat to a growing number of forest specialist species.
- Fruiting trees were abundant. Most of the hardwood tree species targeted by loggers produce seeds with capsules, so that many of the commercially undesirable trees that are retained are fleshy-fruited species attractive to frugivorous birds. Even compared to other tropical regions, New Guinea's avifauna includes a high proportion of frugivorous species (Pearson 1977; Mack and Dumbacher 2007). Accordingly, relatively high species richness and abundance was recorded among major frugivore groups at Sites 3 and 7, including pigeons and doves (Columbidae), cuckooshrikes (Campephagidae), birds-of-paradise (Paradisaeidae), hornbills (Bucerotidae) and mynas and starlings (Sturnidae).
- At the landscape scale, the location of these sites within a broader landscape that includes extensive areas of undisturbed forest habitat provided further source for recolonization or for temporary feeding forays by mobile species such as a variety of large frugivores and birds of prey.
- Birds preferring open and disturbed habitats were present in converted sites such as along roads, in gardens and in adjacent regrowth sites. Relevant species include Whistling Kite *Haliastur sphenurus*, Brahminy Kite *H. indus*, Forest Kingfisher *Todirhamphus macleayii*, Rainbow Bee-eater *Merops ornatus*, Emperor Fairywren *Malurus cyanocephalus*, Green-backed Honeyeater *Glycichaera fallax*, Olive-backed Sunbird *Cinnyris jugularis* and Streak-headed Mannikin *Lonchura tristissima*.

Hill forest provides suitable habitat for most forest dwelling bird species and for most IUCN listed and most nationally Protected bird species recorded or potentially occurring in the study area. Notably, hill forest is the preferred habitat of the IUCN Vulnerable Pesquet's Parrot (Beehler and Pratt 2016; Section 4.2.1.1).

In general, however, hill forest within the study area is of lower conservation value to birds than undisturbed alluvial forest due to: (1) the greater availability of undisturbed hill forest within and beyond the study area; (2) lower levels of bird diversity in most areas of hill forest (species richness and abundance); (3) lower densities of IUCN Vulnerable Southern Cassowary and Scheepmaker's Crowned Pigeon.

4.8.1.4 Mangroves

Mangrove forests in the study area form the eastern part of the largest area of mangroves in PNG, and part of one of the most extensive pristine mangrove areas in the world (Percival and Womersley 1975; Agardy and Pernetta 1993; Saulei and Beehler 1993; Shearman et al. 2013). The Kikori–Purari region includes the broadest band of mangroves in PNG, extending inland within the study area approximately 30 km from the mouth of Port Romilly to the brackish waters of the Pie River.

Mangrove ecosystems support a unique biota that includes a suite of habitat-specialist bird taxa as well as a large number of predominantly coastal species that rely heavily on this forest ecosystem (Coates 1985; Wells 1985; Hogarth 2015). Locally resident birds that occur only within or that are strongly associated with mangroves include Collared Kingfisher *Todirhamphus chloris*, Red-headed Myzomela *Myzomela erythrocephala*, Mangrove Gerygone *Gerygone levigaster*, Mangrove Golden Whistler *Pachycephala melanura*, Arafura Fantail *Rhipidura dryas*, Mangrove Fantail *R. phasiana*, Broad-billed Flycatcher *Myiagra ruficollis* and Mangrove Robin *Peneoenanthe pulverulenta* (Liem and Haines 1977; Pratt and Beehler 2015). Mangrove forest also provides a favored habitat for two IUCN listed New Guinea endemics confirmed present within the study area — the New Guinea Flightless Rail (NT) and the Blue-Black Kingfisher (DD), and for other coastal riverine bird species such as Striated Heron *Butorides striata*, Great-billed Heron *Ardea sumatrana* and Little Kingfisher *Ceyx pusillus*. Mangroves also provide foraging and roosting habitat for a suite of migratory shorebirds, including nine IUCN listed species confirmed present or potentially occurring within the study area (Section 4.8.2).

4.8.2 Tidal wetlands

Tidal flats, lagoons and estuaries of the Mangroves and Southeast Coast ecological zones, both along the shorefront and in subcoastal zones, provide focal habitat for a variety of migratory and resident bird species that congregate in these environments. Relevant recorded and potentially occurring species are described in Section 4.4.2.2, prominent among which are 23 of the 31 migratory Palaearctic shorebirds listed in Table 8 (Section 4.4.1.1).

The conservation of Palaearctic shorebirds and their habitats is the focus of elevated international concern, since a large proportion of species is in decline and continues to be threatened by a wide range of environmental changes and human-related activities. Each year the birds travel long distances along the East Asian–Australasian Flyway (EAAF) between their northern hemisphere breeding grounds and wintering stations in Australasia. The energy required for migration comes primarily from fat stored at wintering grounds and stopover points (Battley and Rogers 2007; Finn 2007). Consequently, disruptions to foraging behavior and/or habitat can have serious consequences for their survival. Loss and degradation of wetland habitats at important stopover points, for example via urban and industrial development, have been implicated in severe population declines, some more than 50%, of multiple species that travel along the EAAF (Gosbell and Clemens 2006; Wilson et al. 2011; Aharon-Rotman 2015; Szabo et al. 2016). As a result, of the 23 or more migratory shorebird species that are likely to utilize tidal habitats within the study area, more than one quarter (8/23) are currently classified by the IUCN as threatened (Eastern Curlew (EN), Great Knot *Calidris tenuirostris* (VU)) or Near Threatened with extinction (Table 8).

Situated in the southern half of the EAAF, the study area's Mangroves and Southeast Coast ecological zones include extensive areas of suitable migratory shorebird foraging habitat in the form of exposed tidal sand and mudflats along the coast, estuaries and tidally flooded subcoastal lagoon systems. These areas are expected to support the largest congregation of migratory shorebirds in the

study area (Section 4.4.2.2). Unfortunately, the importance of the Purari delta, and indeed much of the broader deltaic system that stretches west across the Gulf of Papua to the Fly River system, to migratory (and resident) shorebirds has not been properly assessed (Bishop 2006). Very few surveys have been conducted in the Gulf of Papua's coastal habitats, with the notable exception of a single-visit survey of the Kikori delta by Jaensch and Watkins (undated). Those species recorded to date within the study area were identified previously under the 1970s hydroelectric scheme environmental studies without data on the location or number of birds (Liem and Haines 1977; Ashford 1978, 1979).

As part of the current Project studies, on 4 November 2015 a single pass fly-over was conducted along approximately 12 km of the study area coast between the Purari River (Aievi Passage) and the border of the Mangroves and Southeast Coast ecological zones. At least 150 migratory shorebirds (not identifiable to species) were counted. While this confirmed their presence, the tally was certainly an underestimate of the number of birds locally present at the time.

Within the study area, the conservation value of tidal wetlands varies with factors such as the area of available foraging habitat, availability of suitable roosting sites, and the frequency of visitation/disturbance by local residents. The highest value sites are found along the Purari delta shorefront in the Mangroves ecological zone and include extensive areas of mudflats fringing the estuarine outlets of the Purari's several major distributaries. In contrast, tidal wetlands along the densely settled shorefront within most of the export pipeline corridor are more limited in extent and more frequently visited by local landowners, particularly along the shorefront but also those areas along the mangrove watercourses which are visited regularly by local hunters and fishermen. These areas are of relatively low conservation value for migratory shorebirds.

Under Criterion 6 of the RAMSAR Convention, a wetland site is internationally important if it regularly supports threshold proportions of a waterbird population. Two thresholds have been applied to migratory shorebirds in Australasia (Bamford et al. 2008):

- Internationally important sites support ≥1% of a species' EAAF population.
- Internationally important 'staging' sites support ≥0.25% of a species' EAAF population on passage to or from destination wintering grounds.

In March 2000, Jaensch and Watkins (undated) surveyed shorebirds across parts of the c. 80 km shorefront spanning the Kikori delta, east to as far as Port Romilly where it borders the Purari delta. Based on this one survey, the Kikori delta was recognized to be an internationally important site for Greater Sand Plover *Charadrius leschenaultia* and Terek Sandpiper *Xenus cinereus*, and an internationally important staging site for the IUCN Endangered Far Eastern Curlew (Table 9; Bamford et al. 2008).

Table 9 Migratory shorebirds qualifying the Kikori delta as an internationally important wetland site, based on the survey of Jaensch and Watkins (undated; reported in Bamford et al. 2008).

English name	Scientific name	EAAF population estimate	1% threshold	Kikori count
Greater Sand Plover	*Charadrius leschenaultii*	110,000	1,100	1,700
Far Eastern Curlew	*Numenius madagascariensis*	38,000	380	343
Terek Sandpiper	*Xenus cinereus*	60,000	600	1,015

While no counts have been made in the Purari delta, it is reasonable to expect that its c. 65 km shorefront within the Mangroves ecological zone (including the estuarine flats of Port Romilly in the west) may regularly support shorebird numbers approaching those found in the Kikori delta, and therefore qualify as an internationally important wetland site.

Most migratory shorebirds visit New Guinea during the northern hemisphere winter, with the highest numbers reported during periods of transit (to and from more southerly wintering grounds) in September–November and March–May (Coates 1985; Bishop 2006). The sensitivity of their host environments is highest at these times.

4.8.3 Freshwater environments

4.8.3.1 Rivers and streams

Rivers and streams provide focal habitat for a variety of waterbirds and other stream-specialist species.

Minor forest streams that flow beneath a closed forest canopy traverse the entire hill zone landscape. Birds associated with these watercourses are sometimes classified as forest-dwelling species, and include the elusive Forest Bittern *Zonerodius heliosylus* (NT; not yet recorded though potential to occur) and some small, predominantly piscivorous kingfisher species such as the Azure Kingfisher *Ceyx azureus*. These watercourses and their associated biota are well represented elsewhere in the local region and wherever lowland hill forest persists across New Guinea's entire southern watershed.

Larger watercourses too wide for canopy closure vary in width from c.10 m across to more than 500 m wide in places along the Purari River. These provide habitat for a suite of additional waterbirds that do not regularly occur along the more minor watercourses, those recorded within the study area including herons and egrets (seven species), cormorants and darters (two species), Spotted Whistling Duck/Pacific Black Duck *Dendrocygna guttata/Anas superciliosa*, Royal Spoonbill *Platalea regia*, Australian Pelican *Pelecanus conspicillatus* and Common Sandpiper *Actitis hypoleucos* (Liem and Haines 1977; Ashford 1978, 1979; Liem 1983; Project surveys).

Watercourses comparable in size and character to the Pie, Era and Vailala rivers and the Purari River's major tributaries are well represented regionally in PNG's southern watershed. By contrast, being PNG's third largest river the Purari River is less well replicated in a regional context. However, despite its size, surveys conducted thus far indicate that this section of the Purari River does not provide important habitat for resident or migratory waterbird species—relevant records from along flowing watercourses have to date involved scattered occurrences with no large congregations or breeding colonies reported.

4.8.3.2 Off-river water bodies

Off-river standing-water or slow-flowing freshwater wetlands provide focal habitat for a variety of bird species that congregate in these environments. Relevant recorded and potentially occurring species are described in Section 4.4.2.1 and include a suite of locally breeding and migratory taxa.

The location of off-river waterbodies within the study area is summarized in the Terrestrial Biodiversity Baseline Report. The largest aggregations of freshwater wetland birds are expected to occur in oxbow wetlands associated with former channels of the Purari and Vailala rivers. The large oxbow wetland system in the southwest of PRL-15, located north of the Purari River on the Delta Swamps and Plains approximately 13 km west of Herd Base (at 29600 9188300), contains the largest off-river water bodies present in the study area. This wetland system includes multiple lakes of varying size connected by various forms of flooded swamp vegetation. This wetland system was not ground surveyed during the Project surveys due to access by foot, boat or helicopter being restricted. However, other information collected during Project and prior surveys indicates that this site regularly supports numerous waterbirds of multiple species. During the Phase 2 surveys, residents at Mapaio Fish Camp identified 11 species of waterbird that use these wetlands, and more than 250 egrets were counted there during aerial survey, by far the largest congregation of waterbirds recorded in any freshwater environment present within the study area. During prior surveys, DES (2010) visited four sites in this wetland system and registered the presence of multiple wetland bird species, though no information was provided on the number of birds recorded.

A separate, smaller lake (250 m long) present in the southwest of PRL-15, located south of the Purari River about 2.5 km northwest of the Purari airstrip (at 295230 9184350), was also visited during the Phase 2 aerial survey. No waterbirds were observed at this site.

In the Southeast Coast ecological zone, the recently aggraded shorefront southeast of Herakela village includes numerous freshwater lakes behind the primary dune system (for example at 319015 9128815). These provide habitat for a variety of wetland birds, including multiple nationally Protected egret species.

Despite these results, based on the number of birds observed during Project and prior surveys, it is considered unlikely that any off-river water bodies within the study area would qualify for internationally important status based on RAMSAR Convention criteria.

4.8.4 Important local landscape features

Local landscape features important to avifauna include various terrain and habitat features upon which multiple species and/or multiple individuals of one or more species are ecologically dependent.

4.8.4.1 Caves and rock overhangs

Caves and rock overhangs provide important habitat for a variety of swiftlets (*Collocalia*, *Aerodramus* spp.) that shelter there to roost and breed in colonies (Section 4.4.2.3). Two such swiftlet species have been recorded in the study area, the Glossy Swiftlet and Uniform Swiftlet, and others may occur, including the rare and poorly known Three-toed Swiftlet (DD).

Large caves are most likely to occur in areas of surface limestone. Geological mapping shows that surface limestone is present in the study area only in limited areas of the Middle Purari Hills ecological zone—in the west along the Kereru Range and in the extreme northwest where it contacts the Purari River at Hathor Gorge and around Mua Creek (Bain and MacKenzie 1974; Pieters 1980). No surface limestone is present in PRL 15 or elsewhere within the study area.

Smaller caves and rock overhangs may occur more widely, though the greatest concentration is again expected to occur in the Middle Purari Hills. Specifically they are most likely to be associated with steep escarpments of major local topographic features that are formed of the sandstone-dominant Era Beds geological formation (Pieters 1980) and that show a high degree of structural control. Examples include the Mena and Kuku basins within PRL-15.

4.8.4.2 Large trees in low-nutrient or disturbed environments

Large trees provide a concentrated source of natural resources that are important for maintaining the diversity of local wildlife. Tree hollows, for example, are larger and more numerous in large, old trees. Large trees are therefore essential for maintaining local populations of a wide variety of mammals, birds, reptiles and amphibians that use hollows for shelter and reproduction, and those bird species (e.g. owls, diurnal raptors) that prey upon them. A number of species of conservation significance recorded in the study area, including Palm Cockatoo (P), Pesquet's Parrot (VU, P) and Blyth's Hornbill (P), require tree hollows for reproduction. Large trees also provide preferred nesting sites for large diurnal raptors (eagles, kites, goshawks, etc.).

Tree size is dependent on a variety of environmental factors including soil type, drainage, terrain and disturbance history. In general, 'large' trees are expected to be relatively common in many parts of the study area where large-statured forest types occur, including many areas of undisturbed hill and alluvial forest. In contrast, landforms (1) deficient in nutrients, (2) with steep, unstable terrain, and/or (3) that experience regular prolonged flooding, often naturally support a lower density of large boled trees. Large tree densities are also much lower in heavily logged forest.

Within the study area, large trees will be of greatest importance in a local landscape context in:

- Logged forest, including hill forest and alluvial forest, along the pipeline export route in the Southeast Hills ecological zone.
- Hill forest on the Orubadi Beds geological formation in PRL-15 in the Middle Purari Hills ecological zone. This formation is characterized by unstable mudstone/siltstones (Pieters 1980). Overlying soils are susceptible to rapid erosion with slumping and land slip common, resulting in extensive areas of naturally occurring regrowth vegetation and a relatively small statured forest in its more mature form (surveyed at Site 2).
- Naturally small statured vegetation types on periodically or permanently inundated landforms, including freshwater swamp habitats.

In these environments, large trees may be defined as those with >75 cm diameter at breast height (dbh).

4.8.4.3 Large fig trees

Large fig trees (*Ficus* spp.) are among the most important food source for tropical frugivores the world over (O'Brien et al. 1998; Shanahan et al. 2001), a fact attributed to their nutrient-rich, unprotected fruits, their production of large crops that ripen synchronously within a tree, consistent production between years, and asynchronous fruiting between trees resulting in a year-round 'local' supply of fruit. New Guinea's wildlife includes a high proportion of frugivorous birds (Pearson 1977; Mack and Dumbacher 2007), many of which rely heavily on figs. Fig-parrots (*Cyclopsitta*/*Psittaculirostris* spp.), Pesquet's Parrot (VU), the manucode birds-of-paradise (P) and some cuckooshrikes (*Coracina* spp.) have all evolved to become fig specialists. Among other frugivores, a number of keystone species that play an important ecological role in dispersing the seeds of rainforest trees (e.g. cassowaries, Blyth's Hornbill, pigeons; Mack and Wright 2005) and a number of birds-of-paradise (Paradisaeidae, in addition to the manucodes; Frith and Beehler 1988) include figs as a major component of their diet.

A productive fig tree need not attain the size of other 'large trees' for it to play an important ecological role in the local landscape. They are here defined as those with >50 cm dbh.

4.9 Timing of breeding

For most New Guinea bird species, the timing of breeding activities is poorly known or is broadly characterized across a geographic range that varies in climate, including both the degree and timing of seasonality. To the extent known (or considered likely), the timing of nesting within the study area is summarized above for conservation listed species recorded in the study area (Section 4.2.1). More generally, optimal breeding times in relation to relative wet and dry periods (which vary regionally) have been characterized for a number of major bird groups (Bell 1982; Coates 1985; Pratt and Beehler 2015):

- Most diurnal raptors breed during the drier season (the northwest season in the study area).
- Most songbirds breed just prior to the wettest season (the southeast season in the study area), with insectivores and 'mixed feeders' often extending into the early wet season.
- Frugivorous species breed at any time, with many pigeons nesting during periods of heaviest rain.
- Many water birds breed mainly from the late wet to the mid dry season.

Transcribing these trends to the study area landscape, the peak breeding period among forest bird communities is expected to span the end of the northwest season and the start of the southeast season, within the period January–June. However, these patterns have not been verified and some nesting can be expected to take place in all months.

4.10 Data gaps

The Project ornithological surveys provide the most detailed dataset currently available on bird communities present in lowland environments (below 500 m asl) in the Purari basin and adjacent

catchments. Survey design was based on the coverage of multiple distinct ecosystems/major vegetation types present across the full range of ecological zones defined within the study area. Within most ecological zones (Middle Purari Hills, Southeast Hills, Delta Swamps and Plains) multiple sites in major forest habitats (hill forest and alluvial forest variants) were visited at different times of year to provide seasonal perspective and to maximise spatial coverage. Survey of coastal and near-coastal environments in the Mangroves and Southeast Coast ecological zones was restricted to a single period during Phase 2. Potential gaps associated with a single-season study in this area were treated with information on sensitive species collected from local residents and with an earlier fly-over survey of coastal migratory shorebird habitats (Section 4.7.2).

After nearly 20 years of surveying lowland bird communities at Lakekamu basin, Beehler and colleagues (Beehler et al. 1994, 1995; Beehler and Mack 1999) concluded that a total survey period of two months spread over multiple seasons is necessary in order to comprehensively census a lowland forest bird community in PNG. Survey time expended within lowland environments of the study area matches this level of effort. However, the study area is much larger, covers more major catchments (Purari, Era, Pie and Vailala rivers) and is much more diverse in ecosystems and habitats than the Lakekamu study area.

However, no single-visit rapid assessment survey can be expected to result in a complete inventory of the avifauna regularly occurring at an individual site. Consequently, a full census at each site was not the objective of these surveys. Rather they were aimed at documenting as many of those species present as possible in the time available at each site, with a special focus on determining the presence and status of high conservation value species, including IUCN listed, nationally Protected and restricted-range species. A variety of survey techniques were combined in an effort to achieve these goals, including aural and visual detection, mist netting, camera trapping, sound recording and discussions with local residents.

Multiple additional conservation listed species may occur within the study area (Section 4.2.2), including 18 IUCN threatened (two), Near Threatened (12) or Data Deficient (four) species. Information on the ecology, status and threats of these species is provided (Section 4.2.2); in all cases where an occurrence in the study area is considered a possibility, other sensitive species with similar ecological requirements have already been recorded and/or relevant priority habitats have been identified, providing for the development of a comprehensive set of relevant avoidance, mitigation and management strategies.

4.11 Conservation value of the study area

At the landscape level, the study area as a whole is of high conservation value due to its large size, remoteness, low human population and high degree of connectivity among a variety of intact habitats that span at least three terrestrial eco-regions (‘Southern New Guinea lowland rain forests’, ‘Southern New Guinea freshwater swamp forests’, ‘Southern New Guinea mangroves’) (Wikramanayake et al. 2002) and a variety of topographies and soil types.

Notably, the study area covers a complete ecosystem complex that extends from hill forests at the base of New Guinea’s central cordillera c.120 km south through swamp forest and alluvial systems to coastal mangroves and intertidal mudflats in the Purari delta. In addition, to its north the study area overlaps with intact hill and montane forest ecosystems that reach over 3,100 m asl and that are protected within the Crater Mountain WMA. The Crater Mountain WMA extends south to the Purari River and thus overlaps the study area and parts of PRL-15. The study area thus covers a major portion of a complete and partially protected ecosystem complex that extends from montane to coastal habitats, thus providing for vital evolutionary processes, ecosystem services and opportunity for climate change adaptation among local biotic communities.

In terms of avifauna, the study area is set in one of the world’s most biologically diverse and endemically rich terrestrial regions (Olson and Dinerstein 1998; Brooks et al. 2006) and nearly one

third of all bird species residing or regularly occurring in the New Guinea region (including satellite islands: 214/677; 31.6%) have to date been recorded there. It supports viable resident populations of a large number of conservation listed species, including four globally threatened bird species confirmed present (Southern Cassowary, Papuan Eagle, Scheepmaker's Crowned Pigeon, Pesquet's Parrot) and a suite of additional Near Threatened, Data Deficient, nationally Protected, rare and endemic species.

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Plates

Plate 1 Equipment used during bird surveys: (A) mist net; (B) camera trap; (C) automated sound recorder.

Plate 2 Major bird habitats: (A) interior Hill forest (Hm) at Site 1; (B) Hill forest (Hm) at Site 2, showing frequent natural disturbance from land slumping.

Plate 3 Major bird habitats: (A) Logged Hill forest (Hm) at Site 3; (B) Open alluvial forest (Po) edge at Site 4.

Plate 4 Major bird habitats: (A) Interior primary Open alluvial forest (Po) at Site 7; (B) recently logged alluvial forest (Pl) at Site 8.

Plate 5 Major bird habitats: (A) Mangrove (M) forest along Oeha Creek at Site 8M; (B) oxbow wetland in the southwest of PRL-15, with Herbaceous swamp (Hsw) and Swamp woodland (Wsw).

Plate 6 Southern Cassowary *Casuarius casuarius*: (A) adult camera trapped at Site 4; (B) juvenile taken by hunters near Site 7.

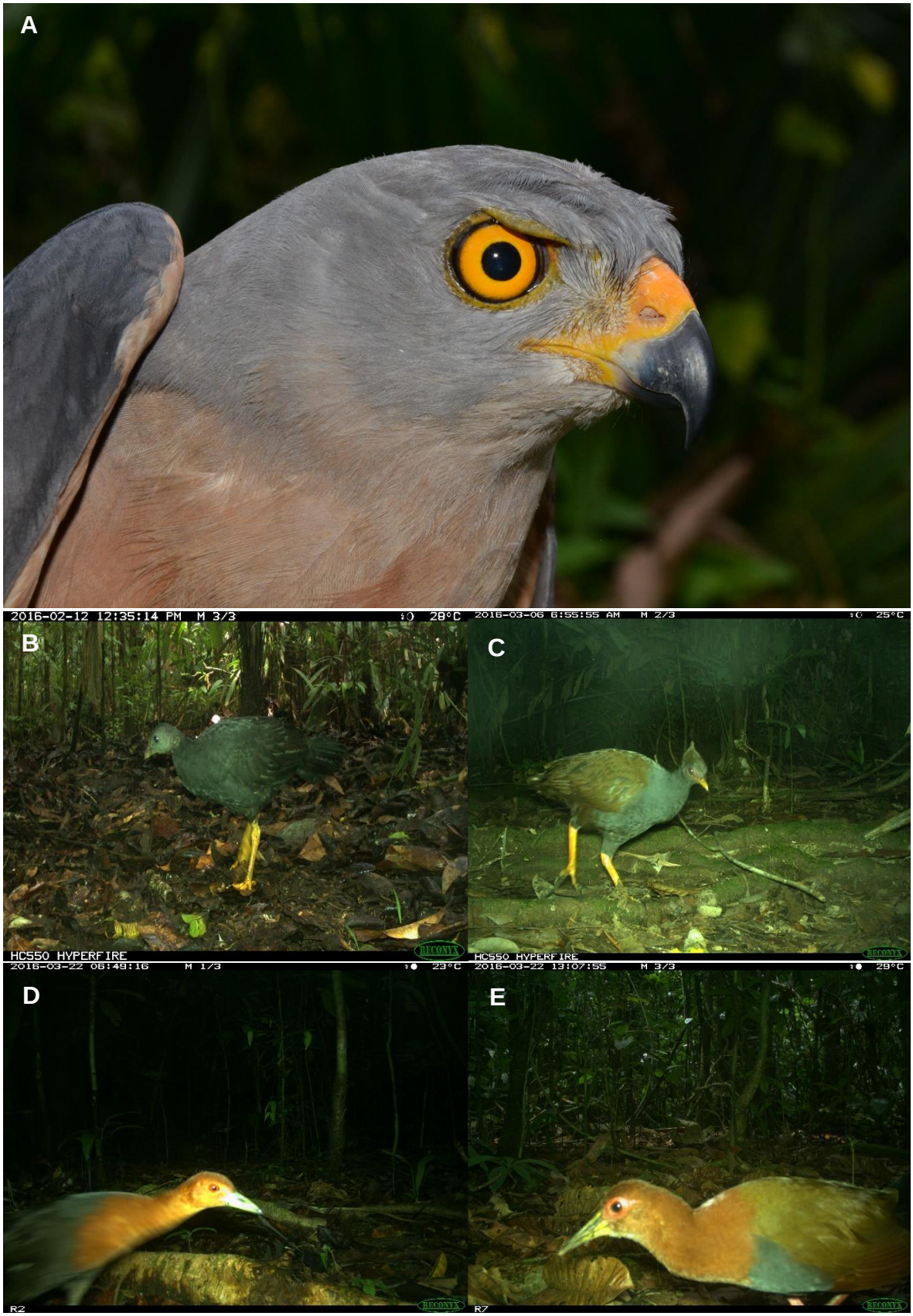

Plate 7 (A) Variable Goshawk *Accipiter hiogaster*; (B) Black-billed Brushturkey *Talegalla fuscirostris*; (C) Orange-footed Scrubfowl *Megapodius reinwardt*; (D) Red-necked Crake *Rallina tricolor*; (E) Bare-eyed Rail *Gymnocrex plumbeiventris*.

Plate 8 (A) Scheepmaker's Crowned Pigeons *Goura scheepmakeri* camera trapped at Site 4; (B) Stephan's Emerald Dove *Chalcophaps stephani*; (C) Thick-billed Ground Pigeon *Trugon terrestris*; (D) Beautiful Fruit Dove *Ptilinopus pulchellus*; (E) Channel-billed Cuckoo *Scythrops novaehollandiae*.

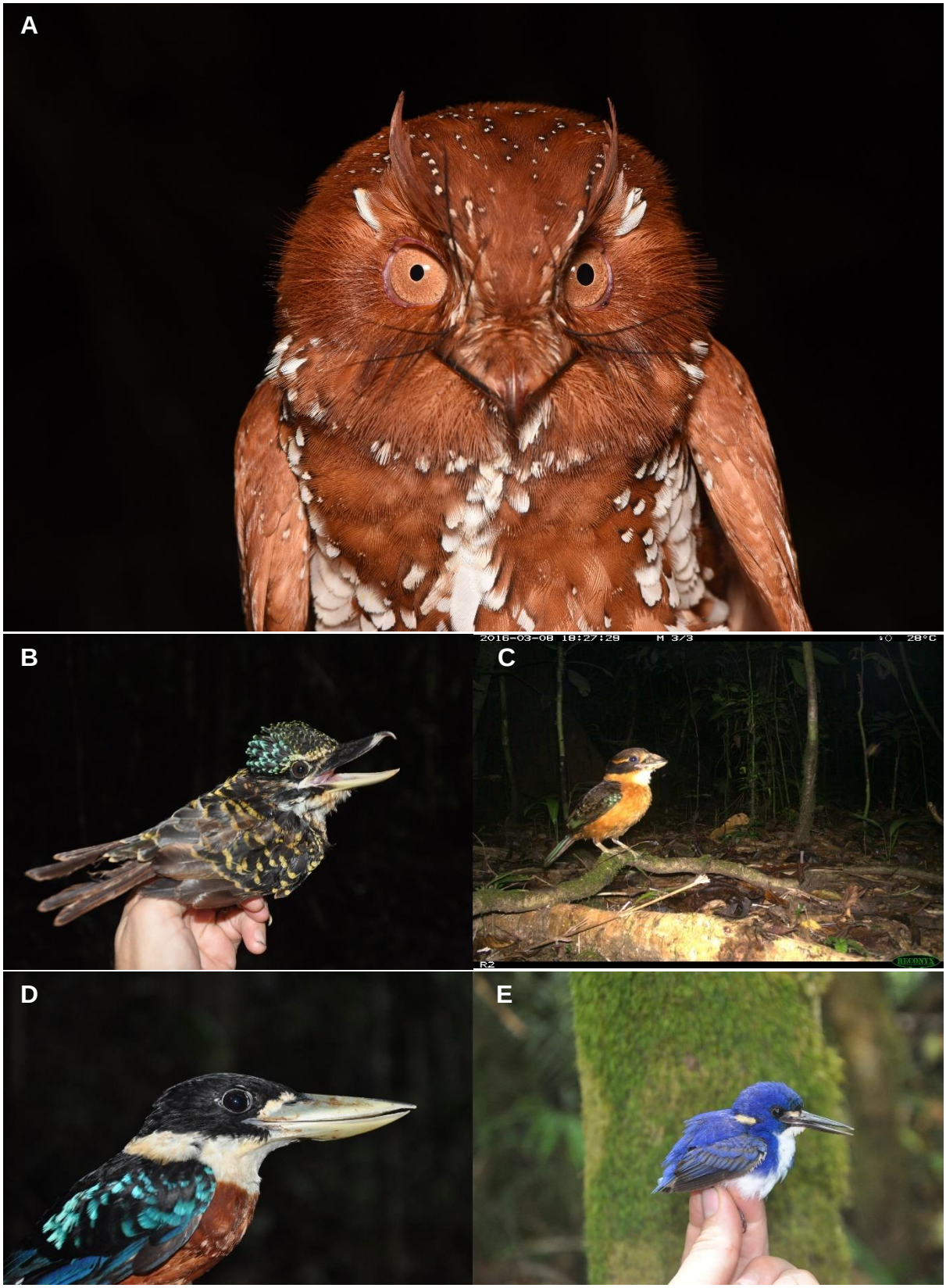

Plate 9 (A) Starry Owlet-nightjar *Aegotheles tatei* mist netted at Site 5; (B) Hook-billed Kingfisher *Melidora macrorrhina*; (C) Shovel-billed Kookaburra *Clytoceyx rex*; (D) Rufous-bellied Kookaburra *Dacelo gaudichaud*; (E) Little Kingfisher *Ceyx pusillus*.

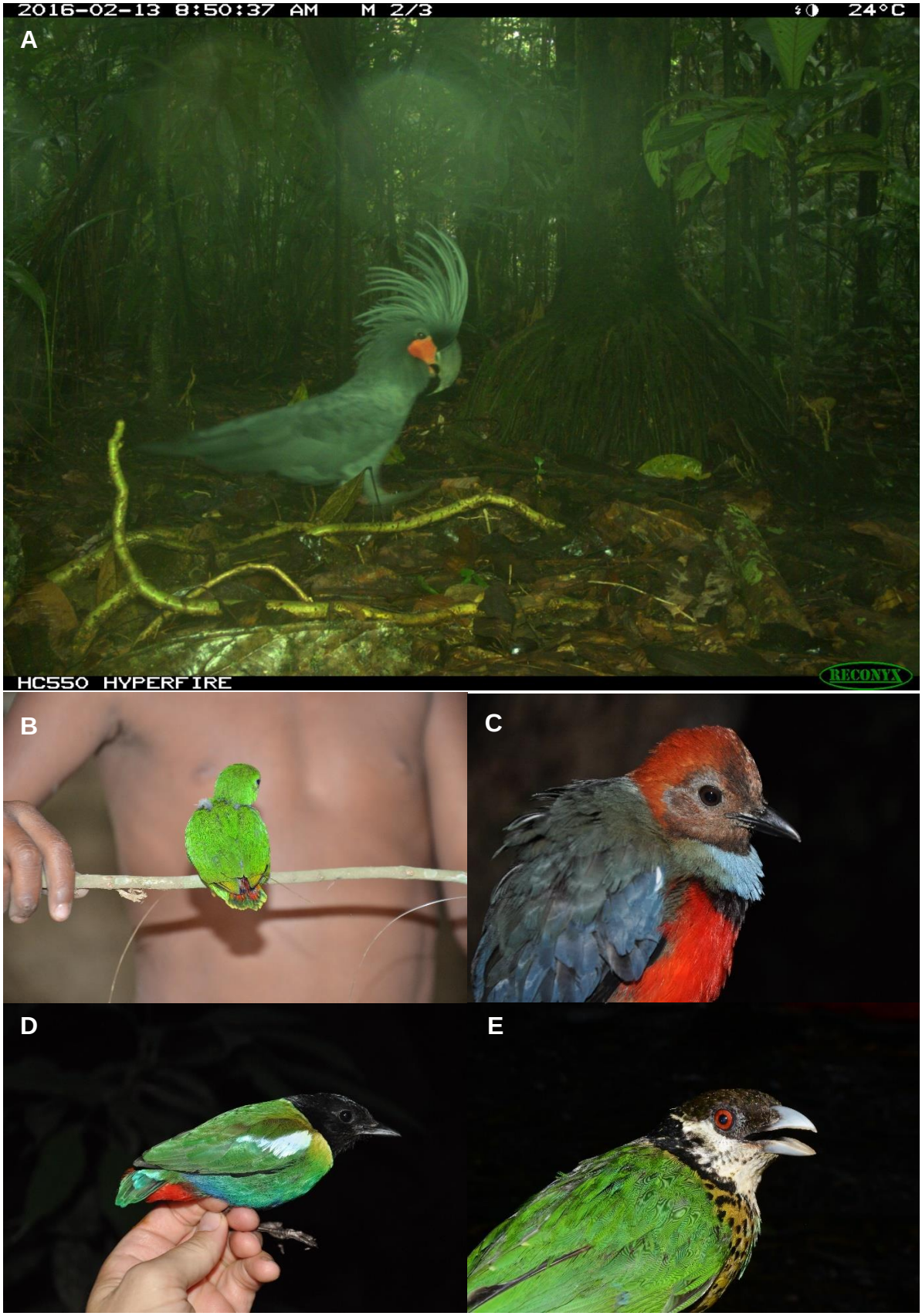

Plate 10 (A) Palm Cockatoo *Probisciger aterrimus*; (B) Orange-fronted Hanging Parrot *Loriculus aurantiifrons*; (C) Red-bellied Pitta *Erythropitta erythrogaster*; (D) Hooded Pitta *Pitta sordida*; (E) White-eared Catbird *Ailuroedus buccoides*.

Plate 11 (A) Tawny Straightbill *Timeliopsis griseigula*; (B) Tawny-breasted Honeyeater *Xanthotis flaviventer*; (C) New Guinea Friarbird *Philemon novaeguineae*; (D) Scrub Honeyeater *Meliphaga albonotata*; (E) Puff-backed Honeyeater *Meliphaga aruensis*.

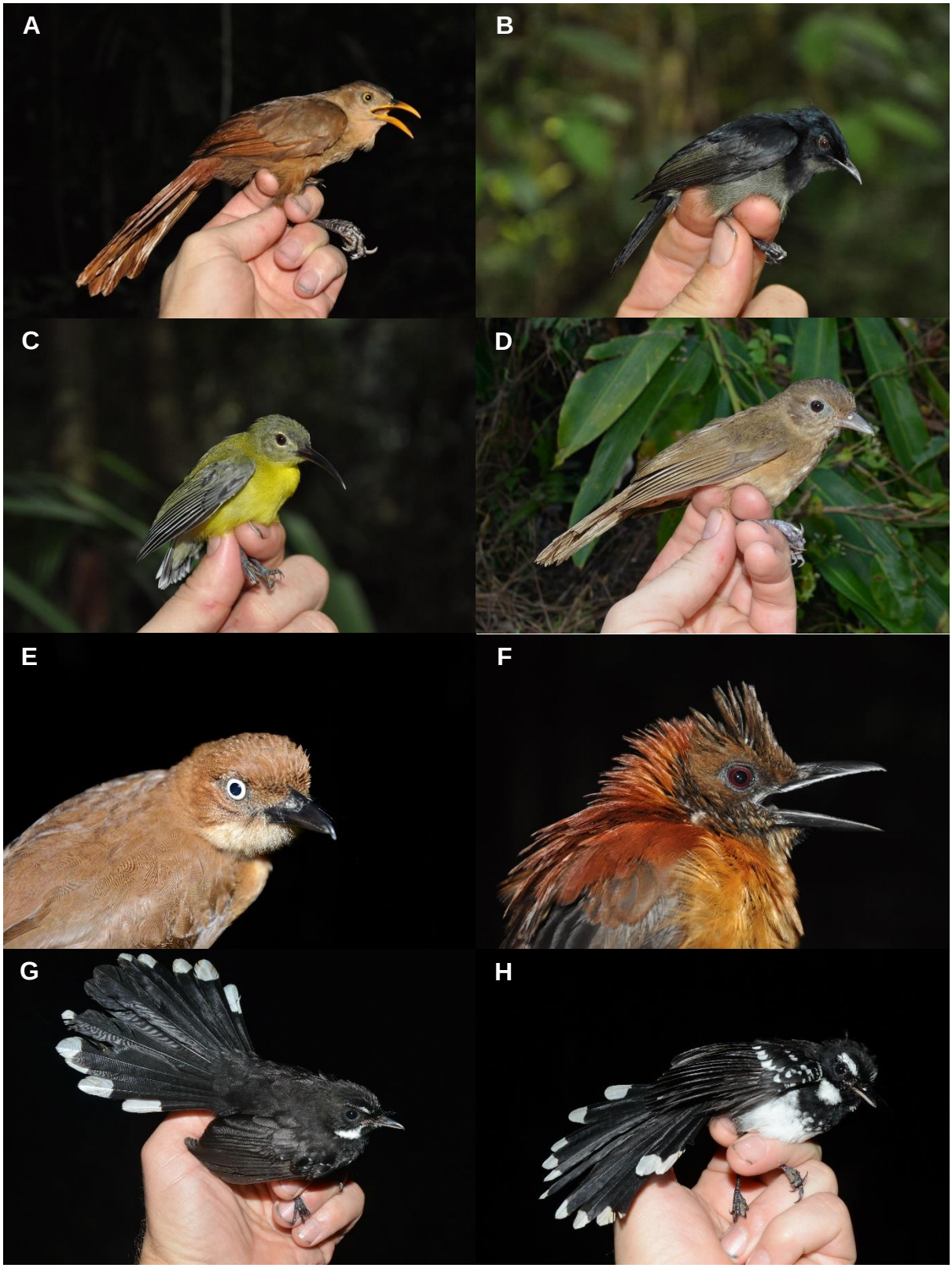

Plate 12 (A) Papuan Babbler *Garritornis isidorei*; (B) Black Berrypecker *Melanocharis nigra*; (C) Yellow-bellied Longbill *Toxorhamphus novaeguineae*; (D) Little Shrikethrush Colluricincla megarhyncha; (E) Rusty Pitohui *Pseudorectes ferrugineus*; (F) Southern Variable Pitohui *Pitohui uropygialis*; (G) Black Thicket Fantail *Rhipidura maculipectus*; (H) White-bellied Thicket Fantail *R. leucothorax*.

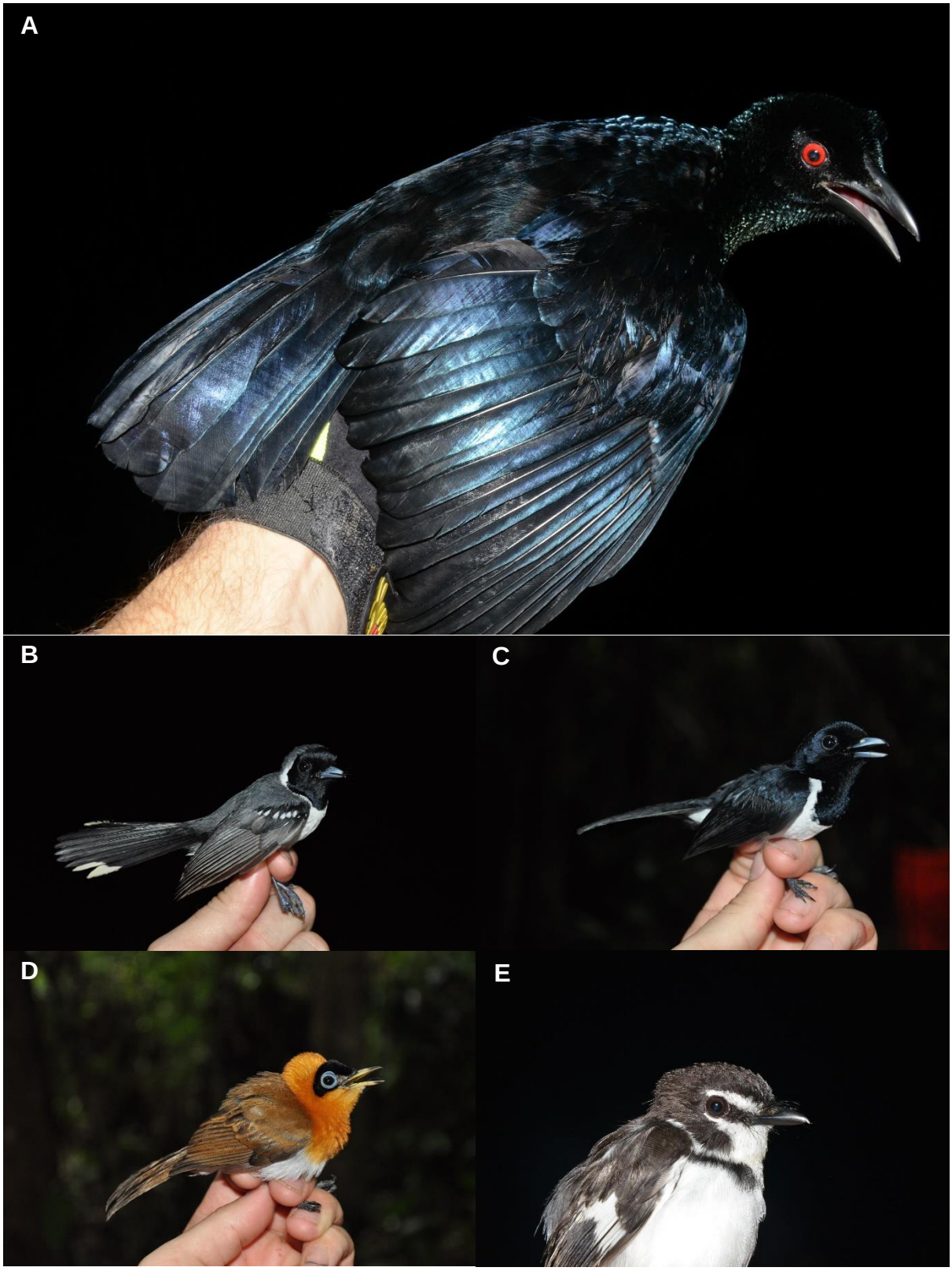

Plate 13 (A) Glossy-mantled Manucode *Manucodia ater*; (B) Spot-winged Monarch *Symposiachrus guttula*; (C) Hooded Monarch *S. manadensis*; (D) Frilled Monarch *Arses telescophthalmus*; (E) Black-sided Robin *Poecilodryas hypoleuca*.

Appendix 1: Conservation and Environment Protection Authority (CEPA) field survey permits

FORM W9

File No

Permit No 015276

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

CUSTOMS (PROHIBITED IMPORTS) REGULATIONS 1973-75

(Regulation 3, Second Schedule, Item 112A)

APPLICATION FOR PERMIT TO IMPORT MIST NETS

Conservator of Fauna,
Department of Environment & Conservation,
P.O. Box 6601,
BOROKO, NCD.
Papua New Guinea

TO BE COMPLETED BY APPLICANT - USE BLOCK LETTERS

I, (1) DR. IAN WOXVOLD ..... of (2) MUSEUM VICTORIA, MELBOURNE, VIC 3001, AUSTRALIA ..... hereby apply to import (3) 24 ..... mist nets under Mist Net Permit No. ..... The nets will be imported by (4) AIR FREIGHT ..... on about (5) 1 DECEMBER .....

9 NOVEMBER 2015 ..... Date

..... Signature of Applicant

OFFICE USE ONLY

Permission is granted to import the above number of Mist Nets into Papua New Guinea within a period of THREE (3) months from the date hereon.

Dated at Port Moresby this 19th day of November 18 2015

This permit is not valid unless the Conservator's stamp occurs here: 19/11/15

CONSERVATOR OF FAUNA

APPROVED

NOTES:
(1) Full name of applicant.
(2) Address of applicant.
(3) Number of Mist Nets to be imported. THIS MUST BE EXACT.
(4) Method of import - air mail, sea freight, etc.
(5) Approximate date of import.

Please forward ONE completed copy of the application to the Conservator. You will receive TWO copies of the import permit if granted.

INDEPENDENT STATE OF PAPUA NEW GUINEA

Papua New Guinea

Form W8

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

FAUNA (PROTECTION AND CONTROL) ACT 1966 - 1970

PERMIT TO USE MIST NETS

No: 015277

I, (1) DR IAIN WOXVOLD of MUSEUM VICTORIA, MELBOURNE, VIC 3001, AUSTRALIA

is hereby permitted to use ..... Mist nets for the trapping of Fauna for the following purposes :

1. ORNITHOLOGICAL SURVEY FOR PAPUA LNG PROJECT EIS SURVEYS
2. .....
3. .....
4. .....

The nets may be used for the above purposes subject to the following conditions :

1. No protected Fauna may be taken without a specific permit issued for that purpose.
2. All nets will be tendered regularly to remove trapped Fauna.
3. The holder of this permit will first advise the owner (s) of land on which he wishes to use the nets the purpose of that use and MUST obtain their consent to enter the land for that purpose .
4. Fauna may mot be taken in a Sanctuary, Protected Area or Wildlife Management Area without the specific permission of the Conservator .
5. The holder of this permit shall carry a copy of this permit when using the nets .
6. No net will be disposed of without the permission of the Conservator .

The Conservator of Fauna
Division of Nature Conservation
Office of Environment and Conservation
P. O. Box 6601, Boroko,
National Capital District,
Papua New Guinea

CITES MANAGEMENT AUTHORITY CONSERVATOR OF FAUNA PAPUA NEW GUINEA DEPARTMENT OF ENVIRONMENT & CONSERVATION

Approved Date 19/11/15

APPROVED

CONSERVATOR FOR FAUNA

Date: 19/11/2015

INDEPENDENT STATE OF PAPUA NEW GUINEA

Form W8

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

FAUNA (PROTECTION AND CONTROL) ACT 1966 - 1970

PERMIT TO USE MIST NETS

No: 016061

I, (1) DR IAIN WOXVOLD of MUSEUM VICTORIA, MELBOURNE, VIC 3001, AUSTRALIA

is hereby permitted to use 20 Mist nets for the trapping of Fauna for the following purposes :

1. ORNITHOLOGICAL SURVEY FOR PAPUA LNG PROJECT EIS SURVEYS.
2. .....
3. .....
4. .....

The nets may be used for the above purposes subject to the following conditions :

1. No protected Fauna may be taken without a specific permit issued for that purpose.
2. All nets will be tendered regularly to remove trapped Fauna.
3. The holder of this permit will first advise the owner (s) of land on which he wishes to use the nets the purpose of that use and MUST obtain their consent to enter the land for that purpose .
4. Fauna may not be taken in a Sanctuary, Protected Area or Wildlife Management Area without the specific permission of the Conservator .
5. The holder of this permit shall carry a copy of this permit when using the nets .
6. No net will be disposed of without the permission of the Conservator .

The Conservator of Fauna
Division of Nature Conservation
Office of Environment and Conservation
P. O. Box 6601, Boroko,
National Capital District,
Papua New Guinea.

11.5.16

APPROVED

.....
CONSERVATOR FO FAUNA

Date: 11 / 05 / 2016

Appendix 2: Project survey records

Birds recorded in the study area during Project surveys and their conservation status. Provisional records (probably the named species) appear in square brackets. Abbreviations used to describe relative abundance at surveyed sites: VC = very common; C = common; FC = fairly common; O = occasional; X = present but relative abundance not assessed. Parameters defining relative abundance rankings are explained in the text (Section 3.4.1). IUCN status indicates species listed as globally threatened (EN—Endangered; VU—Vulnerable), Near Threatened (NT) or Data Deficient (DD) (all other species are Least Concern). PNG status shows those birds listed as Protected (P) under the Papua New Guinea *Fauna (Protection & Control) Act 1966*. CITES status indicates species listed under CITES Appendix I or II. Endemism codes are explained in Section 3.5.3.

Scientific name	English name	IUCN	PNG	CITES	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C - Oxbow	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herd Base, Purari River & Purari airstrip
CASUARIIDAE																			
Casuarius casuarius	Southern Cassowary	VU			1	FC	FC	FC	VC	C	X	X		X	FC	L		X	
ANATIDAE																			
Dendrocygna guttata/Anas superciliosa	Spotted Whistling Duck/Pacific Black Duck	LC			1	[X]													
MEGAPODIIDAE																			
Talegalla fuscirostris	Black-billed Brushturkey	LC			3	C	VC	VC	VC	VC	X	X			C	X		X	
Megapodius reinwardt	Orange-footed Scrubfowl	LC			1	O			FC	FC					X	X	X		
PODICIPEDIDAE																			
Tachybaptus novaehollandiae	Australasian Grebe	LC			1								L						
THRESKIORNITHIDAE																			
Platalea regia	Royal Spoonbill	LC			1								L						
ARDEIDAE																			
Dupetor flavicollis	Black Bittern	LC			1								L			X			
Nycticorax caledonicus	Nankeen Night Heron	LC			1		[X]			X			L				X		
Butorides striata	Striated Heron	LC			1				X							X	X	X	
Ardea alba	Great Egret	LC	P		1	?			X	X			L			X	X	X	X
Egretta intermedia	Intermediate Egret	LC	P		1								L		X			X	X

Scientific name	English name	IUCN	PNG	CITES	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C - Oxbow	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herd Base, Purari River & Purari airstrip
Ardea alba/Egretta intermedia	Great/Intermediate Egret	LC			1								X						
Egretta novaehollandiae	White-faced Heron	LC			1								L						
Egretta garzetta	Little Egret	LC	P		1					X			L			X		X	X
PELECANIDAE																			
Pelecanus conspicillatus	Australian Pelican	LC			1								L						
FREGATIDAE																			
Fregata minor	Great Frigatebird	LC			1													X	
PHALACROCORACIDAE																			
Phalacrocorax sulcirostris	Little Black Cormorant	LC			1													X	
ANHINGIDAE																			
Anhinga novaehollandiae	Australasian Darter	LC			1								L						
ACCIPTRIDAE																			
Aviceda subcristata	Pacific Baza	LC		II	1										O				
Harpyopsis novaeguineae	Papuan Eagle	VU	P	II	4		O								O				
Aquila gurneyi	Gurney's Eagle	NT		II	2						X								X
Accipiter hiogaster	Variable Goshawk	LC		II	1	FC		FC		O	X				O	X	X		
Accipiter poliocephalus	Grey-headed Goshawk	LC		II	3	O			O							X			
Accipiter cirrhocephalus	Collared Sparrowhawk	LC		II	1													X	
Accipiter sp.	Goshawk sp.	LC		II			O												
Haliastur sphenurus	Whistling Kite	LC		II	1			O	O									X	
Haliastur indus	Brahminy Kite	LC		II	1	O		O	O		X			X	O	X	X	X	X
Haliaeetus leucogaster	White-bellied Sea Eagle	LC		II	1													X	
RALLIDAE																			
Rallina tricolor	Red-necked Crake	LC			1		X		O	X					X	X			
Gymnocrex plumbeiventris	Bare-eyed Rail	LC			2				FC	FC								X	
Amaurornis moluccana	Pale-vented Bush-hen	LC			1														X
Megacrex inepta	New Guinea Flightless Rail	NT			4											L		L	

Scientific name	English name	IUCN	PNG	CITES	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C - Oxbow	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herd Base, Purari River & Purari airstrip
Porphyrio porphyrio	Purple Swamphen	LC			1								L						
SCOLOPACIDAE																			
Gallinago sp.	Snipe sp.	LC			1														X
Actitis hypoleucos	Common Sandpiper	LC			1	X												X	
LARIDAE																			
Gelochelidon nilotica	Gull-billed Tern	LC			1													X	
Thalasseus bergii	Greater Crested Tern	LC			1													X	
COLUMBIDAE																			
Macropygia amboinensis	Slender-billed Cuckoo-Dove	LC			1	FC	FC	O	O	[O]						X			
Macropygia nigrirostris	Bar-tailed Cuckoo-Dove	LC			2	O		O											
Reinwardtoena reinwardtsi	Great Cuckoo-Dove	LC			2	FC	FC	FC	O	FC		X			FC	X			
Chalcophaps stephani	Stephan's Emerald Dove	LC			1	O		O	C	X						X		X	
Henicophaps albifrons	New Guinea Bronzewing	LC			2	O				O	X				FC				
Trugon terrestris	Thick-billed Ground Pigeon	LC			2	FC		X	C	X					O				
Geopelia placida	Peaceful Dove	LC			1				O										
Gallicolumba rufigula	Cinnamon Ground Dove	LC			3	O			FC						O				
Otidiphaps nobilis	Pheasant Pigeon	LC			3	FC	O								O				
Goura scheepmakeri	Scheepmaker's Crowned Pigeon	VU	P	II	5	FC	X		C	VC	X	X			FC	X		L	
Ptilinopus magnificus	Wompoo Fruit Dove	LC			1	C	O	C	VC	C		X			C	X		X	
Ptilinopus perlatus	Pink-spotted Fruit Dove	LC			3		FC	C	FC	FC		X			C	X	X	X	
Ptilinopus superbus	Superb Fruit Dove	LC			1	FC	O	O	C					X	O				
Ptilinopus coronulatus	Coroneted Fruit Dove	LC			3			O[FC]	O	FC	X				FC	X	X	X	
Ptilinopus pulchellus	Beautiful Fruit Dove	LC			3	VC	VC	VC	VC	VC	X	X		X	C	X			
Ptilinopus iozonus	Orange-bellied Fruit Dove	LC			3		FC	VC	VC	VC	X				VC	X	X	X	
Ptilinopus nainus	Dwarf Fruit Dove	LC			3	FC	C	C	VC	FC	X				C	X		X	
Ducula rufigaster	Purple-tailed Imperial Pigeon	LC			2	FC	C	FC	VC	VC	X				FC	X		X	
Ducula pinon	Pinon's Imperial Pigeon	LC			3	VC	VC	VC	VC	C	X			X	VC	X		X	

Scientific name	English name	IUCN	PNG	CITES	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C - Oxbow	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herd Base, Purari River & Purari airstrip
Ducula mullerii	Collared Imperial Pigeon	LC			3											X			
Ducula zoeae	Zoe's Imperial Pigeon	LC			3	FC	C	VC	VC	VC	X			X	VC	X	X	X	
Ducula spilorrhoa	Torresian Imperial Pigeon	LC			1											X			
Gymnophaps albertisii	Papuan Mountain Pigeon	LC			2	FC	O	C	O										
CUCULIDAE																			
Centropus menbeki	Ivory-billed Coucal	LC			3	O	FC	FC	O	VC	X			X	FC	X		X	
Microdynamis parva	Dwarf Koel	LC			3	O	O	O	O	O	X				FC	X			
Eudynamys orientalis	Pacific Koel	LC			1	C	C	O	FC	O	X	X		X		X		X	
Scythrops novaehollandiae	Channel-billed Cuckoo	LC			1										FC	X		X	
Chrysococcyx megarhynchus	Long-billed Cuckoo	LC			3			O	O	X		X			O				
Chrysococcyx minutillus	Little Bronze Cuckoo	LC			1			O		FC	X				FC	X	X		
Cacomantis leucolophus	White-crowned Cuckoo	LC			3	O		O	O	FC	X					X			
Cacomantis castaneiventris	Chestnut-breasted Cuckoo	LC			1		O	FC							C				
Cacomantis variolosus	Brush Cuckoo	LC			1	O	FC	O	FC	C	X			X	C	X	X	X	X
PODARGIDAE																			
Podargus ocellatus	Marbled Frogmouth	LC			1	X	X	X	X	X	X				X	X			
Podargus papuensis	Papuan Frogmouth	LC			1			X		X					X		X		
AEGOTHELIDAE																			
Aegotheles tatei	Starry Owlet-nightjar	DD			5					X									
HEMIPROCNIDAE																			
Hemiprocne mystacea	Moustached Treeswift	LC			2					O									
APODIDAE																			
Aerodramus vanikorensis	Uniform Swiftlet	LC			1	C	C	C	C	C	X				C			X	
Mearnsia novaeguineae	Papuan Spine-tailed Swift	LC			4	O		O		FC				X	C	X			
CORACIIDAE																			
Eurystomus orientalis	Oriental Dollarbird	LC			1					O						X	X		X
ALCEDINIDAE																			

Scientific name	English name	IUCN	PNG	CITES	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C - Oxbow	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herd Base, Purari River & Purari airstrip
Melidora macrorrhina	Hook-billed Kingfisher	LC			3	O	FC	FC	FC	FC	X			X	FC	X			
Clytoceyx rex	Shovel-billed Kookaburra	LC			4				O										
Dacelo gaudichaud	Rufous-bellied Kookaburra	LC			3	VC	VC	C	FC	VC	X	X		X	C	X	X	X	
Todirhamphus nigrocyaneus	Blue-black Kingfisher	DD			3												X		
Todirhamphus macleayii	Forest Kingfisher	LC			1										O	X			X
Todirhamphus sanctus	Sacred Kingfisher	LC			1											X	X		
Syma torotoro	Yellow-billed Kingfisher	LC			1	O		C	FC	O	X	X			C	X		X	
Ceyx solitarius	Papuan Dwarf Kingfisher	LC			3	O	FC	O	O	O	X	X			FC				
Ceyx azureus	Azure Kingfisher	LC			1	X	O		X						X			X	
Ceyx pusillus	Little Kingfisher	LC			1				X	X								X	
MEROPIDAE																			
Merops ornatus	Rainbow Bee-eater	LC			1										FC	X	X	X	
BUCEROTIDAE																			
Rhyticeros plicatus	Blyth's Hornbill	LC	P	II	1	C	C	C	C	FC	X	X		X	C	X	X	X	X
FALCONIDAE																			
Falco peregrinus	Peregrine Falcon	LC		II	1			O											
CACATUIDAE																			
Probosciger aterrimus	Palm Cockatoo	LC	P	I	1	FC	O	O	FC	FC	X			X	FC	X			
Cacatua galerita	Sulphur-crested Cockatoo	LC		II	1	FC	C	FC	FC	FC	X	X		X	C	X	X	X	X
PSITTACIDAE																			
Psittrichas fulgidus	Pesquet's Parrot	VU	P	II	4	FC	FC	FC	FC	O	X								
Loriculus aurantiifrons	Orange-fronted Hanging Parrot	LC		II	2											X			X
Micropsitta keiensis	Yellow-capped Pygmy Parrot	LC		II	3					O									
Micropsitta sp.	Pygmy Parrot sp.	LC		II			O		O										
Chalcopsitta sintillata	Yellow-streaked Lory	LC		II	3	FC	FC	C	FC	FC				X	C	X			
Pseudeos fuscata	Dusky Lory	LC		II	4	FC	C	FC	FC	C					VC				
Trichoglossus haematodus	Coconut Lorikeet	LC		II	2	FC	FC	FC	O	O[FC]					FC	X			

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Lorius lory	Black-capped Lory	LC		II	3	VC	C		VC										
Charmosyna placentis	Red-flanked Lorikeet	LC		II	1	[O]	O	[O]	O[FC]	O					FC	X			
Geoffroyus geoffroyi	Red-cheeked Parrot	LC		II	1	C	C	C	VC	VC	X	X			VC	X	X	X	
Eclectus roratus	Eclectus Parrot	LC		II	1	C	FC	C	FC	C	X	X			VC	X		X	
Cyclopsitta gulielmitertii	Orange-breasted Fig Parrot	LC		II	3	FC	C	FC	O						FC	X		X	
Cyclopsitta diophthalma	Double-eyed Fig Parrot	LC		II	1		O	FC		O					O	X			
Psittaculirostris desmarestii	Large Fig Parrot	LC		II	3					O					O	X			
Cyclopsitta sp.	Fig Parrot sp.	LC		II		FC	FC		FC	FC	X				FC				
PITTIDAE																			
Erythropitta erythrogaster	Red-bellied Pitta	LC			1	C	C	FC	VC	FC	X	X			O				
Pitta sordida	Hooded Pitta	LC			1			FC	C	X	X				FC				
PTILONORHYNCHIDAE																			
Ailuroedus buccoides	White-eared Catbird	LC			3	O		O	O	O									
MALURIDAE																			
Sipodotus wallacii	Wallace's Fairywren	LC			3					O									
Malurus cyanocephalus	Emperor Fairywren	LC			3			O		O					FC	X	X	X	
MELIPHAGIDAE																			
Myzomela obscura	Dusky Myzomela	LC			1												X	X	
Glycichaera fallax	Green-backed Honeyeater	LC			1		O	O[FC]							O			X	
Pycnopygius stictocephalus	Streak-headed Honeyeater	LC			3	C	FC	C	FC	FC				X	FC	X		X	
Xanthotis flaviventer	Tawny-breasted Honeyeater	LC			1	VC	VC	VC	VC	VC	X	X		X	VC	X	X	X	
Philemon meyeri	Meyer's Friarbird	LC			4										O				
Philemon novaeguineae	New Guinea Friarbird	LC			2	VC	VC	VC	FC	FC	X	X		X	FC	X		X	
Melilestes megarhynchus	Long-billed Honeyeater	LC			3	FC	FC	FC	FC	FC	X	X			FC	X	X	X	
Timeliopsis griseigula	Tawny Straightbill	LC			4			X	O										
Conopophila albogularis	Rufous-banded Honeyeater	LC			1													X	
Ramsayornis modestus	Brown-backed Honeyeater	LC			1													X	

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Gavicalis versicolor	Varied Honeyeater	LC			1													[X]	
Meliphaga albonotata	Scrub Honeyeater	LC			4													X	
Meliphaga analoga	Mimic Honeyeater	LC			3		X	X							[X]			X	
Meliphaga aruensis	Puff-backed Honeyeater	LC			3	X	X	FC	X	X						X			
Meliphaga sp.	Honeyeater sp.	LC				C	C	C	C	C	X	X		X	C		X		
ACANTHIZIDAE																			
Crateroscelis murina	Rusty Mouse-warbler	LC			3	VC	VC	C	VC	FC		X		X	C				
Gerygone magnirostris	Large-billed Gerygone	LC			1					X									
Gerygone magnirostris(/levigaster)	Large-billed(/Mangrove) Gerygone	LC			1					FC						X	X		
Gerygone chrysogaster	Yellow-bellied Gerygone	LC			3	VC	VC	VC	VC	C	X	X			C			X	
Gerygone chloronota	Green-backed Gerygone	LC			1	O	FC	VC	O	FC		X			C	X		X	X
POMATOSTOMIDAE																			
Garritornis isidorei	Papuan Babbler	LC			3	FC	FC	FC	C	FC	X	X			FC				
MELANOCHARITIDAE																			
Melanocharis nigra	Black Berrypecker	LC			3				X										
Oedistoma iliolophus	Dwarf Longbill	LC			3										FC				
Oedistoma pygmaeum	Pygmy Longbill	LC			3				O	O									
Toxorhamphus novaeguineae	Yellow-bellied Longbill	LC			3	O	VC		FC	C				X	O			X	
PSOPHODIDAE																			
Ptilorrhoa caerulescens	Blue Jewel-babbler	LC			3	VC	VC	VC	VC	C	X	X			VC	X		X	
MACHAERIRHYNCHIDAE																			
Machaerirhynchus flaviventer	Yellow-breasted Boatbill	LC			1										O				
ARTAMIDAE																			
Peltops blainvillii	Lowland Peltops	LC			3		C	FC	FC	FC					C	X		X	
Cracticus quoyi	Black Butcherbird	LC			1	FC	O	O	O						FC	X		X	
Cracticus cassicus	Hooded Butcherbird	LC			3	C		C	O	O	X	X		X	O	X	X	X	
CAMPEPHAGIDAE																			

Scientific name	English name	IUCN	PNG	CITES	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C - Oxbow	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herd Base, Purari River & Purari airstrip
Coracina novaehollandiae	Black-faced Cuckooshrike	LC			1											X		X	X
Coracina boyeri	Boyer's Cuckooshrike	LC			3	O		FC	C	FC					FC	X		X	
Coracina papuensis	White-bellied Cuckooshrike	LC			1											X	X		
Coracina tenuirostris	Common Cicadabird	LC			1											X		X	
Coracina schisticeps	Grey-headed Cuckooshrike	LC			3	C	VC	C	VC	VC	X			X	FC	X			
Coracina melas	Black Cicadabird	LC			3			FC	O	O	X	X			C	X		X	
Campochaera sloetii	Golden Cuckooshrike	LC			4	C	FC	FC	C	FC		X		X	FC	X		X	
Lalage leucomela	Varied Triller	LC			1	O	C	C	FC	FC	X	X			FC	X	X		
PACHYCEPHALIDAE																			
Pachycephala simplex	Grey Whistler	LC			1			FC	FC	FC					C	X		X	
Pachycephala leucogastra	White-bellied Whistler	LC			3												X		
Pseudorectes ferrugineus	Rusty Pitohui	LC			3	FC	O	FC	FC	FC	X				FC	X			
Colluricincla megarhyncha	Little Shrikethrush	LC			1	C	VC	C	VC	O	X	X		X	C	X		X	
ORIOLIDAE																			
Pitohui uropygialis	Southern Variable Pitohui	LC			3	C	VC	VC	VC	FC	X	X		X	FC	X		X	
Oriolus szalayi	Brown Oriole	LC			3			FC							FC	X		X	
DICRURIDAE																			
Dicrurus bracteatus carbonarius	(Papuan) Spangled Drongo	LC			1	VC	VC	C	FC	C	X				FC	X		X	
RHIPIDURIDAE																			
Rhipidura leucophrys	Willie Wagtail	LC			1													X	
Rhipidura rufiventris	Northern Fantail	LC			1			C	O	FC	X				O		X	X	
Rhipidura threnothorax	Sooty Thicket Fantail	LC			3	FC		FC	FC	O		X			FC				
Rhipidura maculipectus	Black Thicket Fantail	LC			3				X	X					X	X		X	
Rhipidura leucothorax	White-bellied Thicket Fantail	LC			4		C	VC		X					[X]				
Rhipidura maculipectus/leucothorax	Black/White-bellied Thicket Fantail	LC							FC	C	X	X			C		X		
Rhipidura rufidorsa	Rufous-backed Fantail	LC			3	O	O	C	VC	FC					FC	X			
MONARCHIDAE																			

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Symposiachrus guttula	Spot-winged Monarch	LC			3	O	O	C	O	O					O				
Symposiachrus manadensis	Hooded Monarch	LC			4			O	X	X									
Symposiachrus guttula/manadensis	Spot-winged/Hooded Monarch	LC				FC	O	FC	O	FC					FC			X	
Monarcha melanopsis	Black-faced Monarch	LC			1												X		
Carterornis chrysomela	Golden Monarch	LC			2	O	C	FC	O	FC	X				O			X	
Arses telescophthalmus	Frilled Monarch	LC			3	C	C	FC	FC	FC		X		X	C	X	X	X	
Myiagra rubecula	Leaden Flycatcher	LC			1													X	
Myiagra alecto	Shining Flycatcher	LC			1					FC					FC	X	X	X	
CORVIDAE																			
Corvus tristis	Grey Crow	LC			3	C	C	FC	FC	O	X			X	O	X			
Corvus orru	Torresian Crow	LC			1													X	
PARADISAEIDAE																			
Manucodia ater	Glossy-mantled Manucode	LC	P	II	2	FC	FC	FC	O	FC	X				FC	X	X	X	
Phonygammus keraudrenii	Trumpet Manucode	LC	P	II	1	FC	FC			FC	X	X			C	X		X	
Manucodia/Phonygammus sp.	Manucode sp.	LC				FC	FC	O	FC	FC					O				
Ptiloris magnificus	Magnificent Riflebird	LC	P	II	1			O							O				
Cicinnurus regius	King Bird-of-paradise	LC	P	II	3	FC	C	O	C	C	X				C	X		X	
Seleucidis melanoleuca	Twelve-wired Bird-of-paradise	LC	P	II	3				O	C					FC				
Paradisaea raggiana	Raggiana Bird-of-paradise	LC	P	II	4	FC		C	O	C	X	X		X	FC	X		X	
PETROICIDAE																			
Poecilodryas hypoleuca	Black-sided Robin	LC			3			FC	VC	C					C			X	
Peneoenanthe pulverulenta	Mangrove Robin	LC			1												X		
Microeca flavovirescens	Olive Flyrobin	LC			3			O	C			X			FC				
HIRUNDINIDAE																			
Hirundo tahitica	Pacific Swallow	LC			1														X
STURNIDAE																			
Aplonis metallica	Metallic Starling	LC			1			C	FC[C]	FC					C	X		X	X

Scientific name	English name	IUCN	PNG	CITES	Endemism	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6A	Site 6B	Site 6C - Oxbow	Site 6D	Site 7	Site 8	Site 8M	Site 9	Herd Base, Purari River & Purari airstrip
Mino dumontii	Yellow-faced Myna	LC			1	C	VC	VC	VC	C	X				C	X		X	
Mino anais	Golden Myna	LC			3	FC	FC		O	O					FC	X			
DICAEIDAE																			
Dicaeum geelvinkianum	Red-capped Flowerpecker	LC			3	C	C	FC	FC	O	X			X	O	X	X	X	
NECTARINIIDAE																			
Leptocoma sericea	Black Sunbird	LC			1	C	C	FC	FC	C	X	X		X	C	X		X	
Cinnyris jugularis	Olive-backed Sunbird	LC			1										O			X	
PASSERIDAE																			
Passer montanus	Eurasian Tree Sparrow	LC			1	X												X	X
ESTRILDIDAE																			
Lonchura tristissima	Streak-headed Mannikin	LC			3	O		O							FC	X			
						90	81	102	106	109	62	39	12	32	113	96	39	91	18

Appendix 3: Mist net captures

The number of birds captured in mist nets at each principal survey site.

Scientific name	English name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 7	Site 8	Site 9	Total
Accipiter hiogaster	Variable Goshawk							1		1
Aegotheles tatei	Starry Owlet-nightjar					1				1
Melidora macrorrhina	Hook-billed Kingfisher			1		3		1		5
Dacelo gaudichaud	Rufous-bellied Kookaburra			1		1		2		4
Ceyx lepidus	Variable Dwarf Kingfisher	1		1	1	1				4
Ceyx azureus	Azure Kingfisher	1			1		1		1	4
Ceyx pusillus	Little Kingfisher				2	2			1	5
Erythropitta erythrogaster	Red-bellied Pitta		1			1				2
Pitta sordida	Hooded Pitta			1						1
Ailuroedus buccoides	White-eared Catbird					1				1
Xanthotis flaviventer	Tawny-breasted Honeyeater			2		1	1			4
Philemon novaeguineae	New Guinea Friarbird				2					2
Melilestes megarhynchus	Long-billed Honeyeater		2	1			2			5
Timeliopsis griseigula	Tawny Straightbill				1					1
Meliphaga albonotata	Scrub Honeyeater								1	1
Meliphaga analoga	Mimic Honeyeater		1	2					1	4
Meliphaga aruensis	Puff-backed Honeyeater	1	1	5	1	3		1		12
Crateroscelis murina	Rusty Mouse-warbler	2	1	2		2	2			9
Gerygone chrysogaster	Yellow-bellied Gerygone		1							1
Garritornis isidorei	Papuan Babbler				6					6
Melanocharis nigra	Black Berrypecker				1					1
Oedistoma iliolophus	Dwarf Longbill						3			3
Toxorhamphus novaeguineae	Yellow-bellied Longbill				3	5				8
Ptilorrhoa caerulescens	Blue Jewel-babbler			2	2					4
Pseudorectes ferrugineus	Rusty Pitohui				1	3				4
Colluricincla megarhyncha	Little Shrikethrush	1		6	3		1			11
Pitohui uropygialis	Southern Variable Pitohui			1						1

Scientific name	English name	Site 1	Site 2	Site 3	Site 4	Site 5	Site 7	Site 8	Site 9	Total
Dicrurus bracteatus carbonarius	(Papuan) Spangled Drongo							1		1
Rhipidura threnothorax	Sooty Thicket Fantail			1	3	1				5
Rhipidura maculipectus	Black Thicket Fantail				1		1	1		3
Rhipidura leucothorax	White-bellied Thicket Fantail					2				2
Rhipidura rufidorsa	Rufous-backed Fantail					1				1
Symposiachrus guttula	Spot-winged Monarch			8	4		2			14
Symposiachrus manadensis	Hooded Monarch			2	3	3				8
Arses telescophthalmus	Frilled Monarch			1						1
Manucodia ater	Glossy-mantled Manucode					1				1
Poecilodryas hypoleuca	Black-sided Robin			1			2			3
	Total individuals									**144**
	Total species									**37**

Appendix 4: Camera trap results

Camera trap results (event numbers and RAIs) at each principal survey site and habitat. For each habitat class the number of camera trap events appears above the RAI for each species. Habitat class indicates species photographed in alluvial forest (AF), hill forest (HF) or safo swamp woodland (Wsw).

Site	Habitat class	Habitat description	Time (hrs)	Southern Cassowary	Black-billed Brushturkey	Orange-footed Scrubfowl	Red-necked Crake	Bare-eyed Rail	Stephan's Emerald Dove	Thick-billed Ground Pigeon	Cinnamon Ground Dove	Pheasant Pigeon	Scheepmaker's Crowned Pigeon	Ivory-billed Coucal	Shovel-billed Kookaburra	Palm Cockatoo	Red-bellied Pitta	Hooded Pitta	White-eared Catbird	Rusty Mouse-warbler	Blue Jewel-babbler	Sooty Thicket Fantail
Site summaries																						
1	All	Primary	6,832.75	3	16	3				5	1	1	7				16				3	
				0.044	0.234	0.044				0.073	0.015	0.015	0.102				0.234				0.044	
1	AF	Primary, riverine terrace	2,073.75		7	3							7				12				2	
					0.338	0.145							0.338				0.579				0.096	
1	HF	Primary	4,759.00	3	9					5	1	1					2				1	
				0.063	0.189					0.105	0.021	0.021					0.042				0.021	
2	All	Primary	1,064.75	2	6		3										6				2	
				0.188	0.564		0.282										0.564				0.188	
2	AF	Primary, riverine terrace	682.75	2	5												6				2	
				0.293	0.732												0.879				0.293	
2	HF	Primary	382.00		1		3															
					0.262		0.785															
3	HF	Logged	1,344.00	2	3					2											4	
				0.149	0.223					0.149											0.298	
4	AF	Primary	40,615.00	430	185	49	6	55	25	90	27		87	4	1	21	60	115	1	1	77	1
				1.059	0.455	0.121	0.015	0.135	0.062	0.222	0.066		0.214	0.010	0.002	0.052	0.148	0.283	0.002	0.002	0.190	0.002
5	All	Primary	11,383.25	49	52	13	2	15	2	5			150			2	12	1	59		12	
				0.430	0.457	0.114	0.018	0.132	0.018	0.044			1.318			0.018	0.105	0.009	0.518		0.105	
5	AF	Primary	5,518.75	10	30	13	2	13	1				46			2	5				9	
				0.181	0.544	0.236	0.036	0.236	0.018				0.834			0.036	0.091				0.163	

Site	Habitat class	Habitat description	Time (hrs)	Southern Cassowary	Black-billed Brushturkey	Orange-footed Scrubfowl	Red-necked Crake	Bare-eyed Rail	Stephan's Emerald Dove	Thick-billed Ground Pigeon	Cinnamon Ground Dove	Pheasant Pigeon	Scheepmaker's Crowned Pigeon	Ivory-billed Coucal	Shovel-billed Kookaburra	Palm Cockatoo	Red-bellied Pitta	Hooded Pitta	White-eared Catbird	Rusty Mouse-warbler	Blue Jewel-babbler	Sooty Thicket Fantail
5	HF	Primary	5,864.50	39	22			2	1	5			104				7	1	59		3	
				0.665	0.375			0.034	0.017	0.085			1.773				0.119	0.017	1.006		0.051	
7	AF	Logged & primary	1,419.75	4	10	4	2			2	4		9				1	4			2	
				0.282	0.704	0.282	0.141			0.141	0.282		0.634				0.070	0.282			0.141	
7	AF	Logged	1,230.00	4	7		2			2	4		8					1			2	
				0.325	0.569		0.163			0.163	0.325		0.650					0.081			0.163	
7	F	Primary	189.75		3	4							1				1	3				
					1.581	2.108							0.527				0.527	1.581				
8	All	Remnant alluvial & sago	926.25		4	1	2		4				6								1	
					0.432	0.108	0.216		0.432				0.648								0.108	
8	AF	Local resource use	782.75		4	1	2		4				6								1	
					0.511	0.128	0.256		0.511				0.767								0.128	
8	Wsw	Local resource use	143.50																			
9	All	Local resource use	1,118.50		2			1	1												3	
					0.179			0.089	0.089												0.268	
9	AF	Local resource use	931.75		2			1													3	
					0.215			0.107													0.322	
9	HF	Local resource use	186.75						1													
									0.535													
Habitat summaries																						
All	All	All	64,704.25	490	278	70	15	71	32	104	32	1	259	4	1	23	95	120	60	1	104	1
				0.757	0.430	0.108	0.023	0.110	0.049	0.161	0.049	0.002	0.400	0.006	0.002	0.036	0.147	0.185	0.093	0.002	0.161	0.002
All	AF	All	52,024.50	446	243	70	12	69	30	92	31		155	4	1	23	84	119	1	1	96	1

Site	Habitat class	Habitat description	Time (hrs)	Southern Cassowary	Black-billed Brushturkey	Orange-footed Scrubfowl	Red-necked Crake	Bare-eyed Rail	Stephan's Emerald Dove	Thick-billed Ground Pigeon	Cinnamon Ground Dove	Pheasant Pigeon	Scheepmaker's Crowned Pigeon	Ivory-billed Coucal	Shovel-billed Kookaburra	Palm Cockatoo	Red-bellied Pitta	Hooded Pitta	White-eared Catbird	Rusty Mouse-warbler	Blue Jewel-babbler	Sooty Thicket Fantail
				0.857	0.467	0.135	0.023	0.133	0.058	0.177	0.060		0.298	0.008	0.002	0.044	0.161	0.229	0.002	0.002	0.185	0.002
All	AF	Primary	49,080.00	442	230	69	8	68	26	90	27		141	4	1	23	84	118	1	1	90	1
				0.901	0.469	0.141	0.016	0.139	0.053	0.183	0.055		0.287	0.008	0.002	0.047	0.171	0.240	0.002	0.002	0.183	0.002
All	AF	Logged/ disturbed	2,944.50	4	13	1	4	1	4	2	4		14					1			6	
				0.136	0.442	0.034	0.136	0.034	0.136	0.068	0.136		0.475					0.034			0.204	
All	HF	All	12,536.25	44	35		3	2	2	12	1	1	104				9	1	59		8	
				0.351	0.279		0.024	0.016	0.016	0.096	0.008	0.008	0.830				0.072	0.008	0.471		0.064	
All	HF	Primary	11,005.50	42	32		3	2	1	10	1	1	104				9	1	59		4	
				0.382	0.291		0.027	0.018	0.009	0.091	0.009	0.009	0.945				0.082	0.009	0.536		0.036	
All	HF	Logged/ disturbed	1,530.75	2	3				1	2											4	
				0.131	0.196				0.065	0.131											0.261	

Appendix 5: Prior survey records

Birds recorded in the study area during prior surveys and their conservation status. IUCN status indicates species listed as globally threatened (EN—Endangered; VU—Vulnerable), Near Threatened (NT) or Data Deficient (DD) (all other species are Least Concern). Papua New Guinea status shows those birds listed as Protected (P) under the PNG *Fauna (Protection & Control) Act 1966*. CITES status indicates species listed under CITES Appendix I or II. Records are indicated for the following ecological zones: MPH—Middle Purari Hills; SH—Southeast Hills; DSP—Delta Swamps and Plains; Mv—Mangroves. There are no known prior records from the Southeast Coast. Numbers show records from the following references: 1—Liem and Haines (1977); 2—Egloff and Kaiku (1978); 3—Ashford (1978, 1979); 4—Liem 1983; 5—DES (2008, 2010); 6—unpublished data; 7—Mack and Jones (2003); 8—unpublished data. Where '/' follows a number there is uncertainty over which ecological zone the record was from. Records in brackets: preceded by '–' are rejected as unlikely (e.g. due to very large range extension); preceded by '?' require confirmation before included in totals given number of other spurious records. Endemism codes are explained in Section 3.5.3.

Scientific Name	English name	IUCN	PNG	CITES	Endem -ism	MPH	SH	DSP	Mv
CASUARIIDAE									
Casuarius casuarius	Southern Cassowary	VU			1	2,3,4,5,6,7,8		1/,4/	1/,4/
Casuarius bennetti	Dwarf Cassowary				2	4			
ANSERANATIDAE									
Anseranas semipalmata	Magpie Goose				1			–(1,4)	–(1,4)
ANATIDAE									
Dendrocygna guttata	Spotted Whistling Duck				1	4/		1/,4/	1/,4/
Tadorna radjah	Raja Shelduck				1			5	
Anas superciliosa	Pacific Black Duck				1	4,5		5	1/,4/
MEGAPODIIDAE									
Talegalla fuscirostris	Black-billed Brushturkey				3	3		1/,4/	1/,4/
Megapodius reinwardt	Orange-footed Scrubfowl				1	4/		1/,4/	1/,4/
CICONIIDAE									
Ephippiorhynchus asiaticus	Black-necked Stork	NT			1			–(4)	–(4)
THRESKIORNITHIDAE									
Plegadis falcinellus	Glossy Ibis				1	?(4/)		?(1/,4/)	?(1/,4/)
Platalea regia	Royal Spoonbill				1			3	1/,4/
ARDEIDAE									
Nycticorax caledonicus	Nankeen Night Heron				1			3	1/

Scientific Name	English name	IUCN	PNG	CITES	Endem -ism	MPH	SH	DSP	Mv
Butorides striata	Striated Heron				1			1/	1/
Ardea sumatrana	Great-billed Heron				1	3			
Ardea alba	Great Egret		P		1	3,5,8		5	1/
Egretta intermedia	Intermediate Egret		P		1	3,5,8		3	1/
Egretta novaehollandiae	White-faced Heron				1			3	
Egretta garzetta	Little Egret		P		1	3		3	1/
PELECANIDAE									
Pelecanus conspicillatus	Australian Pelican				1	3		3	1/,4/
PHALACROCORACIDAE									
Microcarbo melanoleucos	Little Pied Cormorant				1	3			
Phalacrocorax sulcirostris	Little Black Cormorant				1	5		5	1/,4/
ANHINGIDAE									
Anhinga novaehollandiae	Australasian Darter				1			5	1/,4/
ACCIPTRIDAE									
Aviceda subcristata	Pacific Baza			II	1	3			
Harpyopsis novaeguineae	Papuan Eagle	VU	P	II	4	4/	6	4/	4/
Accipiter hiogaster	Variable Goshawk			II	1	3,5			
Haliastur indus	Brahminy Kite			II	1	3,5		3,5	1/
Haliaeetus leucogaster	White-bellied Sea Eagle			II	1			5/	
RALLIDAE									
Amaurornis moluccana	Pale-vented Bush-hen				1	3			
Porphyrio porphyrio	Purple Swamphen				1	5			
RECURVIROSTRIDAE									
Himantopus leucocephalus	White-headed Stilt				1			1/	1/
CHARADRIIDAE									
Pluvialis fulva	Pacific Golden Plover				1			1/	1/
Charadrius mongolus	Lesser Sand Plover				1			1/	1/
Charadrius leschenaultii	Greater Sand Plover				1			1/	1/
JACANIDAE									
Irediparra gallinacea	Comb-crested Jacana				1			5	
SCOLOPACIDAE									
Limosa limosa	Black-tailed Godwit	NT			1			1/	1/

Scientific Name	English name	IUCN	PNG	CITES	Endem -ism	MPH	SH	DSP	Mv
Numenius phaeopus	Whimbrel				1			1/,3/	1/,3/
Numenius madagascariensis	Far Eastern Curlew	EN			1			1/	1/
Tringa incana	Wandering Tattler				1			1/	1/
Actitis hypoleucos	Common Sandpiper				1			1/	1/
Arenaria interpres	Ruddy Turnstone				1			1/	1/
LARIDAE									
Gelochelidon nilotica	Gull-billed Tern				1			3	3
Sterna hirundo	Common Tern				1			1/	1/
Chlidonias hybrida	Whiskered Tern				1			5	
COLUMBIDAE									
Columba vitiensis	Metallic Pigeon				1	4/		4/	4/
Macropygia amboinensis	Slender-billed Cuckoo-Dove				1	3,5,6			
Reinwardtoena reinwardtsi	Great Cuckoo-Dove				2	3	6		
Chalcophaps stephani	Stephan's Emerald Dove				1	5,6	6		
Geopelia humeralis	Bar-shouldered Dove				1			?(1/)	?(1/)
Gallicolumba beccarii	Bronze Ground Dove				1	–(3)			
Otidiphaps nobilis	Pheasant Pigeon				3	6			
Goura scheepmakeri	Scheepmaker's Crowned Pigeon	VU	P	II	5	4,5		5	4/
Ptilinopus magnificus	Wompoo Fruit Dove				1	3,5,6	6	5	
Ptilinopus superbus	Superb Fruit Dove				1	5		1/	1/
Ptilinopus iozonus	Orange-bellied Fruit Dove				3	3		3	
Ducula rufigaster	Purple-tailed Imperial Pigeon				2	4/		1/,4/	1/,4/
Ducula pinon	Pinon's Imperial Pigeon				3	5,6	6	5	4/
Ducula mullerii	Collared Imperial Pigeon				3	1/		3	1/,4/
Ducula zoeae	Zoe's Imperial Pigeon				3	3,5		4/	4/
Ducula spilorrhoa	Torresian Imperial Pigeon				1	?(4)		3	3
Gymnophaps albertisii	Papuan Mountain Pigeon				2	3			
CUCULIDAE									
Centropus menbeki	Ivory-billed Coucal				3	3			
Scythrops novaehollandiae	Channel-billed Cuckoo				1	5		3	1/
Cacomantis leucolophus	White-crowned Cuckoo				3			3	
Cacomantis variolosus	Brush Cuckoo				1	3,5		3	

Scientific Name	English name	IUCN	PNG	CITES	Endem -ism	MPH	SH	DSP	Mv
TYTONIDAE									
Tyto delicatula	Eastern Barn Owl			II	1	4/		4/	4/
PODARGIDAE									
Podargus papuensis	Papuan Frogmouth				1	5			
HEMIPROCNIDAE									
Hemiprocne mystacea	Moustached Treeswift				2	3			
APODIDAE									
Collocalia esculenta	Glossy Swiftlet				1	5			
Aerodramus sp(p)	Swiftlet sp(p)				1	3		3	
Mearnsia novaeguineae	Papuan Spine-tailed Swift				4	3		3,5	
CORACIIDAE									
Eurystomus orientalis	Oriental Dollarbird				1	3,5	6		
ALCEDINIDAE									
Melidora macrorrhina	Hook-billed Kingfisher				3	3			
Tanysiptera galatea	Common Paradise Kingfisher				2	?(5)		?(4/)	?(4/)
Tanysiptera sylvia	Buff-breasted Paradise Kingfisher				1	4/		4/	4/
Dacelo leachii	Blue-winged Kookaburra				1			?(1/)	?(1/)
Dacelo gaudichaud	Rufous-bellied Kookaburra				3	3,5,6	6	3	
Todirhamphus macleayii	Forest Kingfisher				1	3		3	1/
Todirhamphus chloris	Collared Kingfisher				1	–(5)			1
Todirhamphus saurophagus	Beach Kingfisher				1				–(1)
Todirhamphus sanctus	Sacred Kingfisher				1	5		1/,3/	
Syma torotoro	Yellow-billed Kingfisher				1	4/		3	4/
Ceyx solitarius	Papuan Dwarf Kingfisher				3	5			
MEROPIDAE									
Merops ornatus	Rainbow Bee-eater				1			3	3
BUCEROTIDAE									
Rhyticeros plicatus	Blyth's Hornbill		P	II	1	3,4,5,6,8	6	3,5	4/
FALCONIDAE									
Falco cenchroides	Nankeen Kestrel			II	1	3		3	
Falco sp.	Hobby sp.				1			3	

Scientific Name	English name	IUCN	PNG	CITES	Endem -ism	MPH	SH	DSP	Mv
CACATUIDAE									
Probosciger aterrimus	Palm Cockatoo		P	I	1	3,5,6,8	6	5	4/
Cacatua galerita	Sulphur-crested Cockatoo			II	1	3,5,6,8	6	5	1/,4/
PSITTACIDAE									
Psittrichas fulgidus	Pesquet's Parrot	VU	P	II	4	4,5,6,8	6		
Micropsitta sp.	Pygmy Parrot sp.			II	3	5			
Chalcopsitta sintillata	Yellow-streaked Lory			II	3	3,6	6		
Pseudeos fuscata	Dusky Lory			II	4	5		4/	4/
Trichoglossus haematodus	Coconut Lorikeet			II	2	3,5,6	6	4/	4/
Lorius lory	Black-capped Lory			II	3	3,5,6	6	1/,4/	1/,4/
Geoffroyus geoffroyi	Red-cheeked Parrot			II	1	3,5,6		3	
Geoffroyus simplex	Blue-collared Parrot			II	4	?(6)			
Eclectus roratus	Eclectus Parrot			II	1	3,5,6	6	3	3
Alisterus chloropterus	Papuan King Parrot			II	4	6			
Cyclopsitta gulielmitertii	Orange-breasted Fig Parrot			II	3	3			
Cyclopsitta diophthalma	Double-eyed Fig Parrot			II	1	6			
PTILONORHYNCHIDAE									
Chlamydera cerviniventris	Fawn-breasted Bowerbird				3			?(1/)	?(1/)
MALURIDAE									
Malurus alboscapulatus	White-shouldered Fairywren				3	3			
MELIPHAGIDAE									
Myzomela erythrocephala	Red-headed Myzomela				1				1
Xanthotis flaviventer	Tawny-breasted Honeyeater				1	3			
Philemon novaeguineae	New Guinea Friarbird				2	3,5,6	6	3,5	
Melilestes megarhynchus	Long-billed Honeyeater				3	5			
Meliphaga sp.	Honeyeater sp.					3,5			
ACANTHIZIDAE									
Gerygone magnirostris	Large-billed Gerygone				1			1/	1/
POMATOSTOMIDAE									
Garritornis isidorei	Papuan Babbler				3	6			
PSOPHODIDAE									
Ptilorrhoa caerulescens	Blue Jewel-babbler				3	3			

Scientific Name	English name	IUCN	PNG	CITES	Endem -ism	MPH	SH	DSP	Mv
CINCLOSOMATIDAE									
Cinclosoma ajax	Painted Quail-thrush				4	–(5)			
ARTAMIDAE									
Cracticus cassicus	Hooded Butcherbird				3	3,5,6	6	3,5	
CAMPEPHAGIDAE									
Coracina tenuirostris	Common Cicadabird				1	–(5)		1/	1/
Campochaera sloetii	Golden Cuckooshrike				4	6			
PACHYCEPHALIDAE									
Pachycephala melanura	Mangrove Golden Whistler				1			1/	1/
Pseudorectes ferrugineus	Rusty Pitohui				3	5			
ORIOLIDAE									
Oriolus szalayi	Brown Oriole				3			1/	1/
DICRURIDAE									
Dicrurus bracteatus	Spangled Drongo				1	3,5	6	3	
RHIPIDURIDAE									
Rhipidura leucophrys	Willie Wagtail				1	3,5			
Rhipidura rufifrons	Rufous Fantail				3	–(5)			
Rhipidura dryas	Arafura Fantail				1			[1/]	[1/]
MONARCHIDAE									
Monarcha frater	Black-winged Monarch				1	–(5)			
Arses telescophthalmus	Frilled Monarch				3		6		
Myiagra ruficollis	Broad-billed Flycatcher				1				1
Myiagra alecto	Shining Flycatcher				1	6		1/,3/	1/,3/
CORVIDAE									
Corvus tristis	Grey Crow				3	3,5,6		4/	4/
Corvus orru	Torresian Crow				1			1/	1/
PARADISAEIDAE									
Manucodia ater	Glossy-mantled Manucode		P	II	2	3		1/,4/	1/,4/
Cicinnurus regius	King Bird-of-paradise		P	II	3	4/		4/	4/
Seleucidis melanoleuca	Twelve-wired Bird-of-paradise		P	II	3	4/		1/,4/	1/,4/
Paradisaea raggiana	Raggiana Bird-of-paradise		P	II	4	2,3,5,8		1/,4/	1/,4/
PETROICIDAE									

Scientific Name	English name	IUCN	PNG	CITES	Endem -ism	MPH	SH	DSP	Mv
Poecilodryas hypoleuca	Black-sided Robin				3		6		
Peneoenanthe pulverulenta	Mangrove Robin				1				1
HIRUNDINIDAE									
Hirundo tahitica	Pacific Swallow				1	3		3	
Petrochelidon nigricans	Tree Martin				1	?(6)	?(6)		
STURNIDAE									
Aplonis cantoroides	Singing Starling				1	?(5)	6	3	
Mino dumontii	Yellow-faced Myna				1	3,5,6	6		
Mino anais	Golden Myna				3	3	6		
DICAEIDAE									
Dicaeum geelvinkianum	Red-capped Flowerpecker				3	3,5			
NECTARINIIDAE									
Leptocoma sericea	Black Sunbird				1	3,6			
Cinnyris jugularis	Olive-backed Sunbird				1	6	6	3	1/
ESTRILDIDAE									
Lonchura tristissima	Streak-headed Mannikin				3	[5]			
						34	10	19	17