Endemic Birds in Papua New Guinea's Montane Forests: Human Use and Conservation

Thesis submitted by

Miriam Supuma

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College of Science and Engineering

James Cook University

Townsville, Queensland 4811

Australia

Raggiana (*Paradisaea raggiana*) and Lesser Bird of Paradise (*Paradisaea minor*) plumes sold during the annual Goroka Show (2015) in the Eastern Highlands Province, Papua New Guinea. Photographed by Miriam Supuma

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Advisory Panel

Associate Professor David King, College of Science and Engineering, JCU
Professor Andrew Krockenberger, Centre for Tropical Biodiversity and Climate Change, JCU
Associate Professor Alison Cottrell (Adjunct), College of Science and Engineering, JCU
Dr. James Moloney (Adjunct), College of Science and Engineering, JCU

Statistical, analytical and modelling support

Dr. James Moloney and Dr. Elodie Ledee (GIS)
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Thesis Abstract

Escalating anthropogenic impacts on tropical biodiversity have increased the vulnerability of endemic species. Selective harvesting of species is one of the major threats to birds and mammal species in the tropics. Many indigenous cultures, however, have long established cultural associations with certain species. The hunting and trade of species have been mainly for subsistence and socio-cultural ties within their communities. However, contemporary threats associated with human population increase from within such societies and externally driven demand such as wildlife trafficking exacerbate the pressure particularly for vulnerable species.

Threats to endemic tropical species are not isolated to one but often synergies between many factors simultaneously affecting changes to species distribution. In addition to immediate anthropogenic impacts such as population pressure exerted on species numbers and species habitats, there is growing evidence that demonstrates that climate change is causing shifts in species distribution. Such cases have been demonstrated in tropical island montane forests.

The island of New Guinea is the largest tropical island in the world and accommodates the third largest tropical rainforests. New Guinea has over 600 bird species (195 endemic), but some species are under threat from unsustainable hunting practices, climate change, and landscape modification. The central highlands is one of the most populous areas and has undergone thousands of years of human modification. The biodiversity of the island of New Guinea remains one of the understudied sites in the world. Looming threats necessitate an assessment of the vulnerability of species important to subsistence and culture.

This thesis addresses the need for further understanding of the vulnerability of species to anthropogenic impacts associated with hunting and trade and the effects of climate change on endemic montane species. The thesis begins first by improving the contemporary understanding of trade of bird species in the central highlands (large scale) of Papua New Guinea. The contemporary costs of species traded were delineated from this study and compared to the known records over 40 years. Next, case study sites (fine scale) were conducted to understand how rural forest communities hunt and trade wildlife and the social nuances that affect their choice and locality of hunting activities. The study then uses species identified from trade and hunting to conduct a vulnerability assessment of species most at risk from selective harvesting. This assessment may also serve as a guide to conservation efforts in the central highlands. Finally, a rare endemic species, *Paradisornis rudolphi* (Blue Bird of Paradise) was selected from the vulnerability assessment to make predictions of its distribution change due to climate change.

Overall, this thesis demonstrates the importance of applying an interdisciplinary approach that is relevant to the region, context of culture, society, and conservation. This study suggests that vulnerable species used in culture are also at risk from effects of climate change. This information, in addition to other extrinsic factors such as land use change (not studied), is vital for conservation of the endemic montane species, rural food security, as well as the persistence of cultural diversity in New Guinea.

There are limitations to this study which include the lack of a better climate model for Papua New Guinea. The species distribution model should serve as a conservative prediction of the outcome of a rare endemic species. However, even with a conservative approach, there is indication of the need for proactive approaches at the rural and national levels. A way forward would be to consider means of income generation that also support the conservation of species, such as eco-tourism. At the policy level, there is a need to revise the policy to reflect species management and the enforcement of monitoring of unlawful trade particularly those that may be destined for international markets.

CHAPTER 1: Introduction

Eighty percent of the world's threatened bird species are found in tropical rainforests. In terms of figures, that is 960 threatened tropical rainforest birds out of the total (1200) world's vulnerable species (BirdLife 2013). Global bird population decline is often attributed to complex factors acting independently or synergistically (Brook et al. 2008, BirdLife 2013). The main threats to birds are forest degradation, unsustainable harvesting practices, and invasive species (Sodhi et al. 2011). While there is evidence of climate change causing species to shift elevation range (Both et al. 2006, Maclean et al. 2008, Freeman et al. 2013), pressing concerns stemming from anthropogenic impacts such as hunting, and habitat conversion are also of great concern for endemic species populations. Endemic birds in tropical montane areas and islands with restricted ranges are particularly vulnerable (Sekercioglu et al. 2008a).

Disturbances to habitats have been the main driving factors threatening species (Garnett and Brook 2007, Sodhi et al. 2010, BirdLife 2013). By nature, some species are more susceptible to population decline from habitat loss than others (Colles et al. 2009); these include species that have a narrow ecological range or are specialised to a particular habitat. As an example, some understorey species are adapted to a certain light level requirement, their microhabitat. In the event that forest structure is altered by activities such as forest clearance, the elevated light into the forest from increased exposure affects light sensitive species of birds (Castelleta et al. 2000, Pearson et al. 2010). The adaptation to the forest strata may be for predator avoidance (e.g. larger avian prey species), or a specialised feeding guild (e.g. insectivorous birds). Insect eating birds' numbers have shown a decline as a result of reduced forest cover as identified in tropical studies (Castelleta et al. 2000, Sigel et al. 2006).

1:1 Anthropogenic Threats to Species

Species populations can recover if perturbations to environment or populations are minimal. Disturbances either anthropogenic or natural events (e.g. land slides) can alter the conditions of species' habitat changing species numbers at various guilds (Marsden and Symes 2008). Species within the fragmented habitats respond variably. Understanding the support each guild's service offers to another elucidates how forest conversion influences species presence (Sekercioglu 2012).

The ability of species to disperse from larger areas (source) to smaller habitats or reserves (MacArthur and Wilson 1967) enables the continuity of populations provided that the disturbance to habitat is minimal (Ricklefs and Miller 1999, Cox and Moore 2000). Some species composition can recover from pressures exerted by low human population densities; for example, shifting cultivation or nomadic hunters and gatherers (Yalden 1996, Allen and Filer 2014).

Improvements to geospatial technology and the use of satellite imagery allows researchers to quantify the loss of tropical forest (Fearnside 1990, Skole and Tucker 1993, Shearman et al. 2008) and subsequently the habitats of species (Buchanan et al. 2008, Buchanan et al. 2009). Whilst forest disturbances are detectable from improved geospatial technology, other anthropogenic activities such as hunting within a landscape are difficult to detect (Benítez-López et al. 2017). Recent studies postulate that hunting is the main driver of species decline in tropical forests by comparison to habitat loss (Harrison et al. 2016, Benítez-López et al. 2017). A sound knowledge of how Indigenous communities interact with their environment to sustain themselves is vital in the broader perspective of conservation (Mack 2014, West 2016, Benítez-López et al. 2017). Such nuances within a landscape require a clearer discernment of the intricate relationship between human-environment dimensions.

1:2 Unsustainable Hunting or Harvesting Practices

There are approximately 10,000 species of birds in the world; 4173 of the global species are used by humans (Butchart 2008, BirdLife 2013). The main reasons for harvesting birds are pet trade, food, sport, apparel and accessories, medicine, and handicrafts, in decreasing order of reason for harvest (Butchart 2008); the order of use is as per species count. The harvesting of wild birds in tropical third world nations for trade to western affluent nations is a thriving business. Five to ten million birds are exported from developing countries to developed nations on an annual basis (Gilardi 2006). A large proportion of species of birds harvested (3337) is targeted for the pet trade; this is equivalent to 80 percent.

A high proportion of birds harvested for the pet trade stem from Southeast Asian countries particularly Malaysia, Indonesia, Thailand, and Vietnam with the main importers being Japan, European countries and Malaysia (Nijman 2010). During a nine-year period (1998-2007), an estimated one million birds were exported from Asia, with 27 percent (269,000) harvested from the wild. Examples of targeted species or families include parrots (Psittacidae), for example, Spinx's Macaw (Beissinger 2001), and West African Hornbills (Traill 2007). Low reproductive rates, late age of first reproduction, and the keystone species roles in rainforest regeneration such as the hornbills are salient aspects of population size. Additionally, the ecological roles for seed dispersal and survivorship of plant diversity are reduced when bird populations are reduced (Traill 2007, Lindsell et al. 2015).

Hunting wildlife for food (bush meat) is practised by millions of Indigenous communities in Africa, Asia, South America, Australia, and Oceania (Milner-Gulland et al. 2003). The dependence on forest for protein may vary from one community to another in the context of geography, subsistence agriculture, alternative forms of income (Shively 1997, Liang et al. 2013), human population density (Yalden 1996, Robinson and Bennett 2000a), weapon choice of hunting (Kwapena 1985, Satterthwait 1986, Pangau-Adam et al. 2012, Shepard et al. 2012), and knowledge of species (Pangau-Adam et al. 2012, Padmanaba et al. 2013).

Human population density is an important factor in the sustainability of wildlife hunted. In indigenous communities where human population density was less than 1 person per km^2 (Yalden 1996), the wildlife hunted were at sustainable levels. However, higher densities coupled with the use of modern weapons pose a threat to wildlife (Robinson and Bennett 2000b, Robinson and Bennett 2004).

In some Indigenous communities, as much as 70 percent of their protein consumption is derived from wildlife in their forests (Olupot et al. 2009). For instance, Kayapo Indians (Amazonia) hunted 256 birds in addition to mammal species over a 20-month period within an expansive area that encompassed source-sink dynamics (Peres and Nascimento 2006). Large forest tracks with low human populations allowed species to be harvested at sustainable levels (average of 0.17 person/km^2). On the island of New Guinea, studies revealed that birds were an important part of diet although much of the biomass hunted came from mammals (Hide 1984, Dwyer 1985, Mack and West 2005).

Many Indigenous communities value birds not only for bush meat, but also for their cultural significance either as local currencies or traditional adornment (headdress). For instance, the harvest of the Scarlet Honeyeater was a common practice in Santa Cruz (Solomon Islands). The red feathers were rolled into a form of currency by a small group of skilled families for trade with the neighbouring Pacific Islanders (Houston 2010). As many as 20,000 male species were hunted on an annual basis during the height of the practice. Despite this, the species continues to survive though, with no sign of declining population. The use of feathers as part of traditional regalia is a common practice among some indigenous cultures.

1:3 Indigenous Ecological Knowledge

Species utilisation by Indigenous communities requires the knowledge pertaining to the practice to be consistently reaffirmed through intergenerational education and dissemination (Berkes 1993). Indigenous ecological knowledge (IEK) is the practice of a belief system inherently linked to indigenous communities' customs connecting people to their environment (Berkes 2008, Martin et al. 2010). IEK is often described as holistic (Freeman 1992), integrating the physical and spiritual into a worldview comprehension of Indigenous people and their cosmology (Houde 2007).

Traditional ecological knowledge has a longer timescale of harbouring, adapting, and keeping learned experiences within a community. This knowledge is mostly in the form of an oral repository, communally held, rather than the transcribed repositories of scientific ecological knowledge (Berkes 1993). Often IEK is specific to an area and can be particularly useful in complementing scientific ecological knowledge (SEK). The level of IEK held by its community members varies by gender, status or social position , and age (Houde 2007) and is transmitted through a common spoken language. The use of IEK and SEK can improve the understanding of historical and current use of species within a landscape thereby contributing towards conservation measures (Sinclair et al. 2010,

Ziembicki et al. 2013). An appreciation of the historical impacts on landscapes provides vital clues. Information such as past extent of species distribution, human settlements, and cultural practices in relation to the environment and species are useful to position current knowledge.

Archaeological evidence suggests New Guinea was colonised approximately 50,000 years ago. Hunting for mammals in the higher elevations, greater than 1500 meters above sea level (m.a.s.l) (Flannery et al. 1983, Mountain 1993, Hope 1998) is evident through remnant bones found in highland caves, as well as records of vegetation change through burning. Early agricultural records date back to 9000 years ago in the highlands of Papua New Guinea (Denham et al. 2003).
The central highlands of Papua New Guinea are presently one of the most populous areas of the country. More than 50 percent of the human population live above 1800 meters (Humphreys and Brookfield 1991). Thus, habitat modification, such as clearance of forest for subsistence agriculture continues to persist.

Hunting of vertebrates to supplement the diet of local Indigenous remote communities in Papua New Guinea is an important part of culture and livelihood in rural forest communities (Dwyer 1985, Mack and West 2005, Pangau-Adam et al. 2012). The island of New Guinea has a depauperate large endemic vertebrate fauna by comparison to other rainforests in Africa, SE Asia, and South America. Vertebrates such as the tree kangaroos and the cassowaries are the only large terrestrial fauna available and are subjected to hunting pressure. In the last four decades, over 150 species of birds (26 families) in New Guinea have been used either for food (bushmeat), trade, and or for cultural purposes (Sillitoe 1988a, Healey 1990). Of these species 28 have been listed by IUCN as decreasing in wild population numbers; 8 listed as Vulnerable, 3 near threatened, and 17 are least concerned but with decreasing population trends.

The most commonly hunted species are the cassowaries (all three species), Birds of Paradise (20 out of 41 species), parrots (20 out of 46 species), pigeons and doves (16 out of 25 species). The island of New Guinea has the highest diversity as well as endemism of these species hunted (Mack and Dumbacher 2007, Pratt and Beehler 2015). Of the hunted Birds of Paradise, 16 species are found at elevations varying from 1000 meters to 3500 meters. These ranges also overlap with high human density settlements in the central highlands (Humphreys and Brookfield 1991). The highest diversity of BOPs in PNG is concentrated in the central highlands of the country (Pruett-Jones and Pruett-Jones 1986, Heads 2001a, 2002, Pratt and Beehler 2015). Apart from cassowaries, Birds of Paradise (BOP) are the main species associated with human social practice (Sillitoe 1988a, O'Hanlon 1989). Males of the Birds of Paradise are known globally for having elaborate courtship plumage (LeCroy 1981). The two life history traits that have enabled BOP populations to persist are: young males without full plumage are capable of mating with adult females, and the species polygynous mating system.

The initiation of modern conservation efforts in Papua New Guinea has been through the global recognition of the Birds of Paradise (Swadling 1996, Kirsch 2006). Efforts to curtail the trade export of skins to supply the millinery industry were halted following trade sanctions. However, the Birds of Paradise have been an important cultural species for generations. For example, early exchange with Magellan's voyage upon reaching the Spice Islands as well as cultural exchange in the form of trade and traditional headdress. Indigenous people continued to hunt and trade species despite laws prohibiting such activities (Healey 1990).

1:4 Gaps in Knowledge of Anthropogenic use of Species in Contemporary Culture

The current landscapes within the central highlands are relicts from thousands of years of human activities (Gaffney et al. 2015b, Barton and Denham 2016). In the most recent 40 years, land use changes have become intensified particularly in subsistence agriculture as a result of increasing human population (NSO 2012). The updated growth rate of PNG is 2.13 % as of 2015 (Roser and Ortiz-Ospina 2017) which makes it one of the highest along with Central African counties such as Democratic Republic of Congo, Kenya, and Tanzania.

Unsustainable harvesting is a pressing issue in the global tropical communities (Peres et al. 2006, Harrison et al. 2016, Benítez-López et al. 2017). Pressures from subsistence wildlife consumption coupled with external demand has increased the traffic of wildlife over the last decade in neighbouring countries (Pangau-Adam and Noske 2010, Shepherd et al. 2012) . In the context of wildlife trade (or trafficking), Papua New Guinea has inadequate data to situate itself in a regional and global scale to draw comparison in terms of species involved. This is concerning, as the lack of knowledge poses risks to biodiversity. Low governance capacity has hindered monitoring and enforcement efforts (Melick et al. 2012) hence potentially increasing the vulnerability to external threats.

Identifying patterns of hunting and trade is essential to interpret the perceived value of resources used by Indigenous communities. Furthermore, whether the traditional associated use continues to be consistent with traditional practices, for instance hunting fauna during the sago harvest (Dwyer and Minnegal 1991b) allows an understanding of the nuances of resource use on a landscape scale. Previous studies focused on hunting techniques and efforts (Dwyer 1974, Dwyer 1985), wildlife consumption in rural central highlands communities (Hide 1984, Mack and West 2005), trade of birds (Healey 1973, 1990), and hunted fauna and their connection to cultural expression (Sillitoe 1988a, O'Hanlon 1989, Sillitoe 2001). Only one study (Mack and West 2005) used kill localities (site of harvest- point location) to measure the average distance hunters travelled to hunt.

There remain gaps in knowledge regarding intensity of hunting along a geographic sphere of influence by communities. Further to this, some species have strong cultural value both on a community and at a national level where these species have iconic status (e.g. Birds of Paradise). An interdisciplinary research approach is crucial as it elucidates natural resource use in remote areas of the central highlands allowing conservation practitioners to interpret emerging regional trends that can contribute towards the conservation of species and cultural heritage.

This research brings noteworthy insights of contemporary trends in species use in the central highlands, Papua New Guinea. The interdisciplinary nature of this research incorporates both social and ecological methods to interpret the human-environment dimension within a landscape and attempts to assimilate the linkages of the holistic nature of conservation. This dissertation contributes to the growing body of knowledge pertaining to Indigenous use of resources in the tropics and conservation.

1:5 Aims of this study

The overarching goal of this study is to develop a conservation priority assessment of endemic birds in subsistence use and trade by local people in the central highlands of Papua New Guinea. In line with this goal, there are four broad aims of this study: (1) improve understanding of current of trends in trade, particularly price of species, (2) integrating knowledge of species hunted and patterns of hunting and trade, (3) assessment of conservation priority of species, and (4) predictions of species distribution of a rare endemic species. To achieve these aims, my study has four specific objectives outlined below.

AIM 1: Improve current knowledge of endemic bird species traded

Objective 1: Situating current trends in price of species traded in informal markets to delineate and quantify by comparison to records within the last 40 years.

In this Chapter, current prices were obtained for species traded from traders in market places and local people in cultural annual shows to understand prices of selectively harvested species. I put forward recommendations regarding current protected species lists in reference to monitoring of protected species and the possible improvement to the country's current species list (Chapter 3).

AIM 2: Integrating knowledge of species hunted and patterns of hunting and trade - (Case study)

Objective 2: To understand the socio-environmental variables that influence hunting patterns in a fine scale landscape.

The spatial distribution of hunted wildlife provides a measure of distance a hunter travels to make a kill from his village. Where rare or threatened species are captured may provide information about their habitats as well as external pressures that drive hunter behaviour (Chapter 4).

AIM 3: Assessment of conservation priority of species

Objective 3: Develop a priority species list based on the selective harvest of bird species in the central highlands

An assessment of the vulnerability of 172 bird species from selective harvesting (subsistence and cultural use) in the central highlands of Papua New Guinea is made. I prioritise species for conservation efforts and propose a list for the Central Papuan Endemic Bird Area (Chapter 5).

AIM 4: Predicting endemic species distribution

Objective 4: Predict the impact of climate change on rare endemic species

The impact of climate change on a rare montane endemic bird of paradise species, *Paradisornis rudolphi* is predicted by projecting species distributions based on current climate to 2070, based on a future climate scenario. I make predictions on the impact of climate change on this individual species' distributions (Chapter 6).

1:6 Overview of Main Study Sites

The research was conducted in Papua New Guinea. The central highlands is the principal study region, particularly Chimbu and Eastern Highlands Provinces. The study does not cover the entirety of provinces but select sites within these provinces. **Figure 1.1** indicates the main study sites in the central highlands whilst **Figure 1.2**, indicates trade sites particularly at the National Capital District (N.C.D).

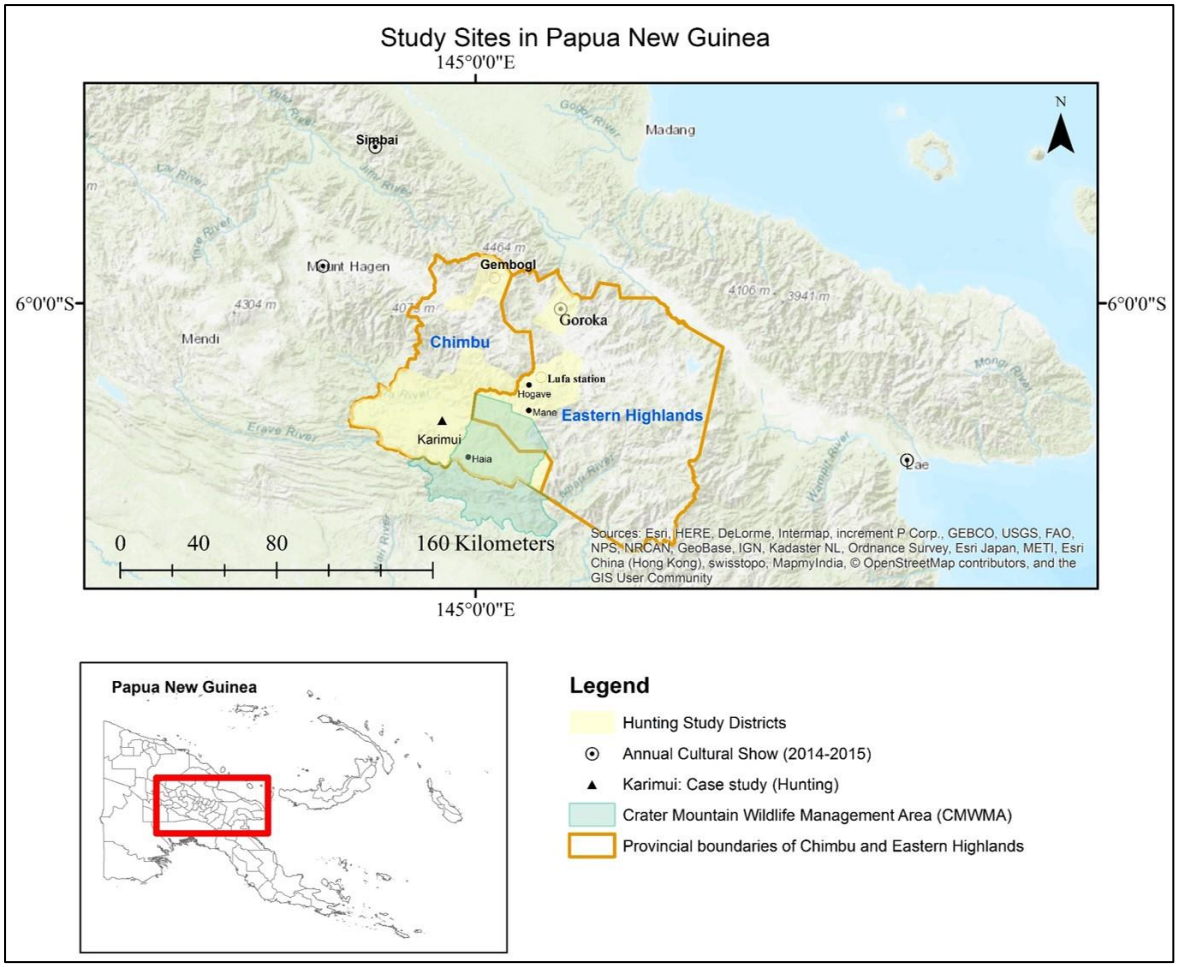

Figure 1.1: Map of main study sites in the central highlands for market, annual cultural festival, and hunting studies.

For Chimbu Province, the districts include Gembogl and Karimui. Lufa and Goroka were the sites for Eastern Highlands. Within these districts, smaller local sites were studied. In Chapter 4, Karimui was selected as the main case study site for hunted species and comparison of hunting sites over 35 years.

The elevation encompassing these two provinces' boundaries ranges from 300 m to 4500 meters above sea level (m.a.s.l). As such, the study sites generally experience cooler climate with temperatures ranging from a minimum of 22 °C (highlands) to maximum of 32 °C (lowlands) (Standish and Richard 2017).

Eastern Highlands Province (E.H.P) has a larger human population (579, 825 versus 376, 473) and larger land area (11157 km^2 versus 6112 km^2) by comparison to Chimbu (NRI 2010, NSO 2012). However, within each of the rural sites, there are some differences. For example, Mt. Wilhelm Rural has a similar density to Mt. Gahavisuka rural communities (80.3 versus 83.2) (**Table 1.1**). The main form of livelihood is subsistence farming with small scale coffee plantations. The people of the study

sites speak at least 5 language groups; Kuman (Gembogl, Chimbu), Pawaii and Daribe (Karimui, Chimbu), Gahuku (Goroka Rural, Eastern Highlands Province), and Fore (Lufa, Eastern Highlands Province). A translator was engaged at each site when necessary. The two provinces are connected by the main highlands highway that runs from the northern coastline into the interior linking the five highlands provinces.

Table 1.1: Population size and densities of the rural government's constituencies within which the study sites are located.

Site	Approx. area (km^2)	Total Population (2011)	Density (person per km^2)
Karimui Rural, Chimbu	2600	23596	9.1
Mt. Wilhelm Rural, Chimbu	297	23860	80.3
Lufa (Mt. Michael Rural), E.H. P	1358	22135	16.3
Mt. Gahavisuka (Goroka Rural), E.H.P	150	12486	83.2
Source: Papua New Guinea 2011 National Population Census for population data, and National Research Institute for information on political boundaries and areas.			

Within the Chimbu Province, two sites were selected for the hunting study. The first site was Toromambuno village, at Denglagu Mission Station in the Gembogl District. The elevation ranges from 2000 m.a.s.l to 4509 m.a.s.l. The latter elevation is the highest summit in the country and is that of Mt. Wilhelm, a national park (Mt. Wilhelm National Park). Gembogl District Station is located approximately 25 km northeast from the province's main town of Kundiawa and is connected by road.

The primary case study site was Karimui (Chimbu Province), which is located 55 km southwest (straight line distance) from Kundiawa town. There is currently no road access to Karimui. At the time of this study, construction of a road linking Karimui to Kundiawa had been initiated, but it remains incomplete. Walking tracks connect Karimu to Bomai, Salt, and Nomane, the latter two of which are on the road network to Kundiawa. There are four airstrips within Karimui servicing three large villages and the station; Yuro-Pinero, Negabo, Walasibe, and Karimui District station. The oldest airstrip is located on the Karimui plateau and was constructed in 1960 at about the same time of the establishment of the patrol post (Hide 1984) which is now the District Administration Headquarters. There are flights from the main township of Goroka (Eastern Highlands Province) servicing the communities with the transport of people, coffee, trade store goods, and supplies for schools and aid posts. There are at least 12 villages scattered around the base of Mt. Karimui (2531

m.a.s.l), an extinct volcano. The lowest elevation at Karimui is approximately 320 m.a.s.l to the south along the Waghi (Tua) River. Generally, Karimui has an interesting geomorphology that comprises an extinct volcano, limestone areas towards the lower southern areas, and in the lowland southwest are small scattered villages who rely on sago palms as a staple food.

Annual cultural festivals were held at main towns in central highlands between August – October. Market surveys and cultural festivals were conducted in these towns; Goroka (Eastern Highlands), Mt. Hagen (Western Highlands), Lae city (Morobe) and Simbai (Madang), the only rural cultural show. Market surveys were also carried out in the National Capital District (N.C.D) often referred to as Port Moresby.

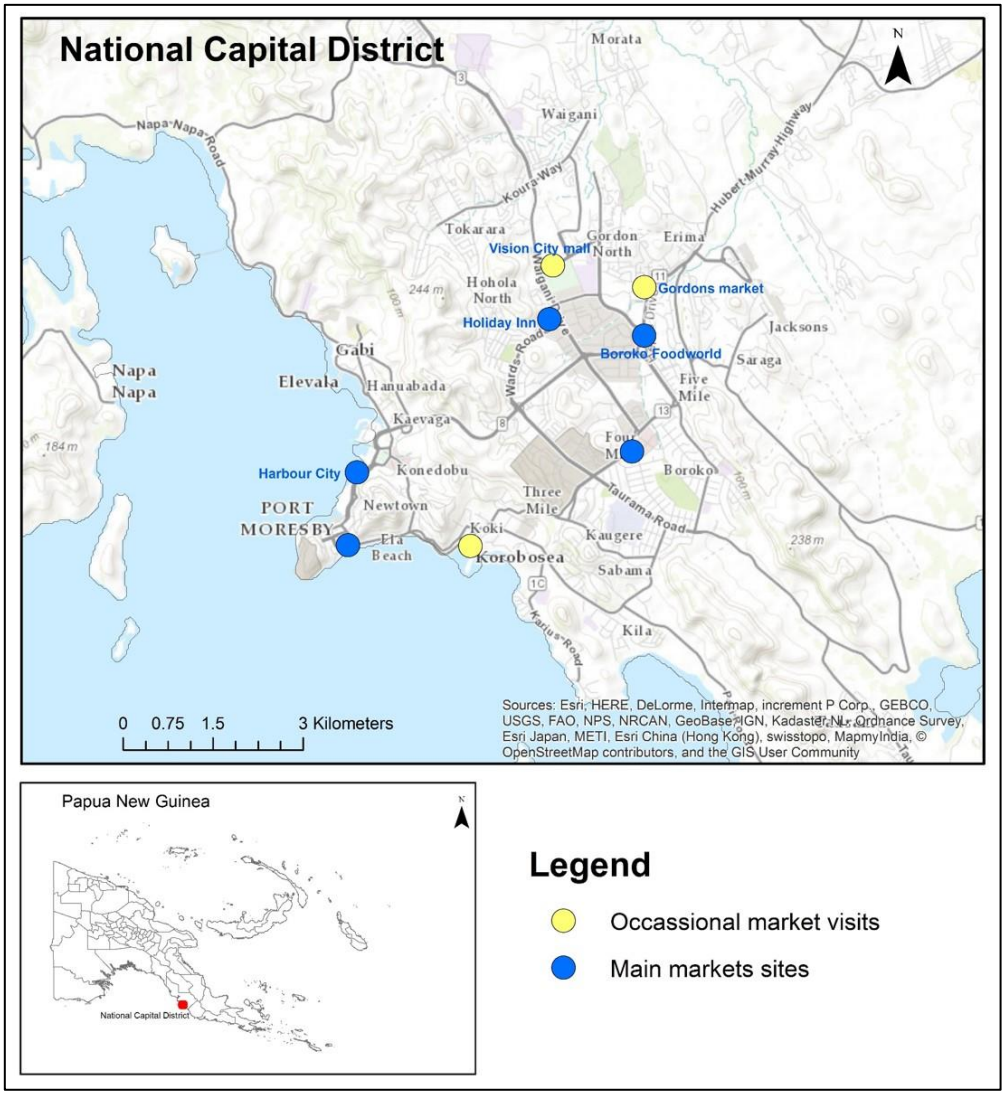

Figure 1.2: Main markets in the National Capital District, Papua New Guinea

THESIS STRUCTURE

The structure of the thesis as indicated in Figure 1.3 below.

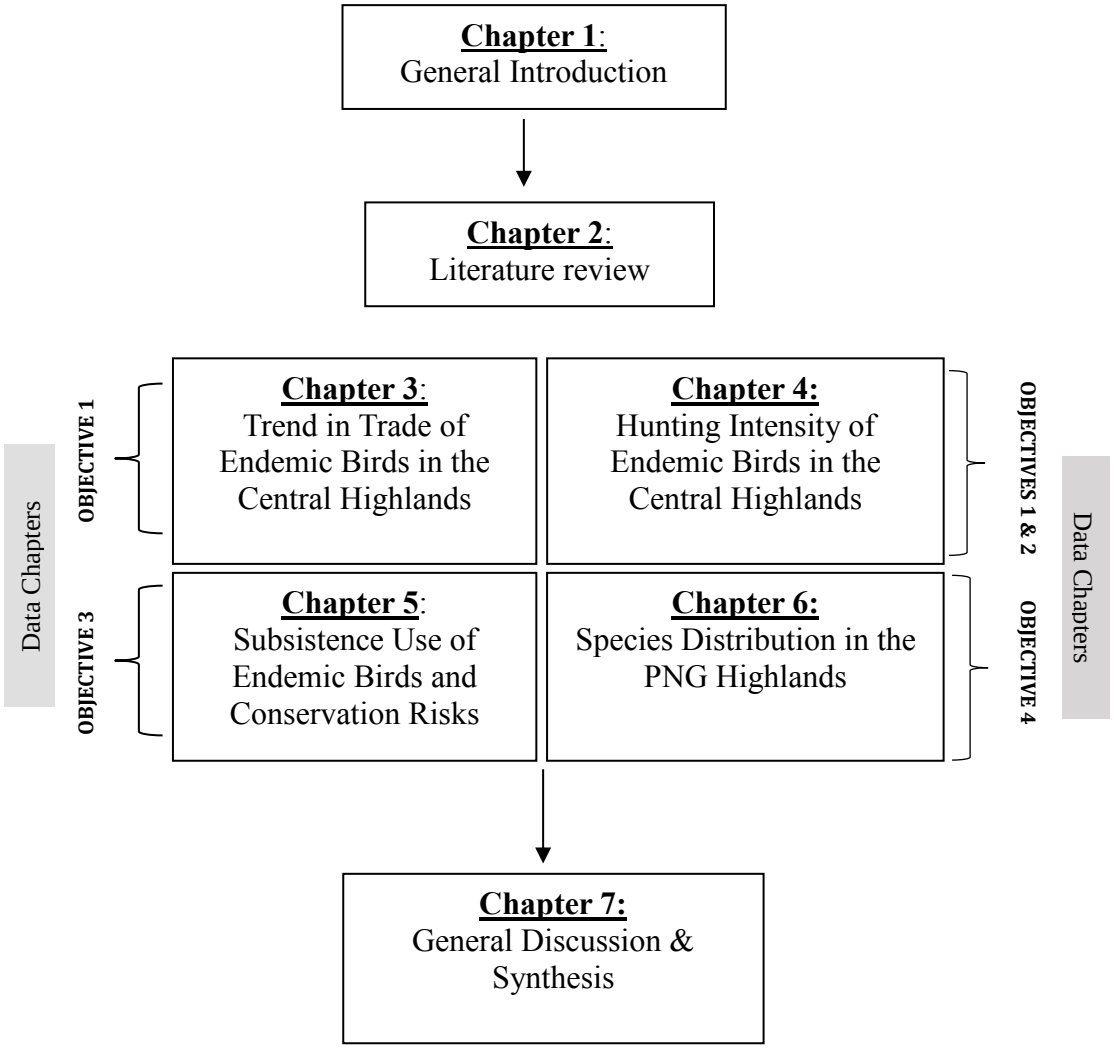

Figure 1.3: Schematic diagram of the thesis structure.

CHAPTER 2: Humans, environment, and birds in New Guinea culture

LITERATURE REVIEW

2:0 Early Humans to New Guinea

Humans are believed to have arrived on the primordial landmass of Australia and New Guinea (Sahul) over 50,000 years ago. This arrival coincided with the Last Glacial Maximum (LGM) when sea levels were considerably lower than present. Predominantly hunters and gatherers, these humans adapted and exploited the environment for available food including Pandanus and yams (*Dioscorea* sp.) (Summerhayes et al. 2010). The presence of yams in charcoal at high elevations (~ 2000 metres) indicates the transportation of plants from lower elevations to higher elevations and indicates early human movement through the landscape. Excavated remnants of stone tools, charcoal of plants, and animal bone fragments found were within proximity to prehistoric highlands swamps specify a timeframe between 49,000 – 44,000 years before present (BP) (ibid:).

Paleo records infer that fire was an important tool used by humans to alter the montane forest landscape (Haberle et al. 2001, Summerhayes et al. 2016). Archaeological remains in montane swamplands of New Guinea portray a higher diversity of plants; various pollen remains over 30,000 years BP show rich plant families including Fagaceae (*Northofagus, Castanopsis, Litocarpus)* Myrtaceae (mostly *Syzygium*), Podocarpaceae (*Dacrydium*), and Pandanaceae (*Pandanus*). After 14 000 years BP, there appears to be a decline in variety of the pollen records and an increase in *Casuarina* pollen records. This period also coincides with deglaciation - warming of climate and sea level rise. This increase in *Casuarina* shows alterations to the environment and a link to management of certain plant species considered of significance to early agriculture and domestication efforts (Haberle 2003, Fairbairn et al. 2006, Summerhayes et al. 2016). Charcoal presence in swamp core samples suggest an increased amount of the use of fire as a tool over 12 000 years BP.

Furthermore, from archaeological evidence it is postulated that early humans of New Guinea processed starchy vegetables such as yams, taro (*Colocasia esculenta*), and banana (*Musa* spp.) over 10,000 years ago (Fullagar et al. 2006). Securing and consumption of food is a process which requires searching, harvesting using tools, and methods to enhance flavour or to soften fibres or destroy harmful enzymes to enable ease of digestion. Fire played an important role not only for food preparation but also for warmth during the cooler (LGM) climate and an effective tool for hunting and

the management of the landscape. Thousands of years of interaction between humans and the environment has evolved into an inextricable link that has allowed Indigenous people to manage ecosystems as a way to hunt and forage (Bird et al. 2008). For instance, in Australia, the cyclic burning of the desert ecosystem (Spinifex grass) creates a mosaic of patches of varying intervals that accommodate a variety of flora and fauna. Over thousands of years the landscape has progressed in synchrony with continuous human intervention; fire is an effective management tool in what has been hypothesised as the fire stick farming hypothesis (Bird et al. 2008).

2:1 The Hunted Fauna

Fauna hunted by humans after their arrival elucidates the state of the environment at the time. Throughout New Guinea, archaeological finds have accounted for many key families that have been extirpated. At least 16 mammals from four Families are now extinct; Diprotodontidae (4 species), Macropodidae (10 species, tree kangaroos and wallabies), Thylacinidae (2 species) and Pteripodidae (*Aproteles bulmerae*) (Flannery et al. 1983, Mountain 1993, Flannery 1995, Sutton et al. 2009). The large fruit bat species, *Aproteles bulmeraes*, was previously thought to have gone extinct 10,000 years ago (Menzies and Ballard 1994, Gaffney et al. 2015a) until a small population was found at Crater Mountain Wildlife Management Area (CMWMA), Eastern Highlands Province in 2005 (Tau and Wright, unpublished data).

The sites at which archaeological excavations were undertaken are presently montane grassland at elevation ranges from 1500 to 2500 m.a.s.l. Thousands of years ago, large extinct mammal species such as the extinct tree kangaroo, *Dendrolagus noibano* and carnivorous dog-like marsupial, *Thylacinus cynocephalus* resided in what would have been an extended forest range. Similar findings of cassowary eggshells at some localities suggest exploitation of forest fauna. Bones of small avifauna were present in Nombe cave (Chimbu Province) but identification of species could not be determined (Mountain 1993).

The New Guinea Islands (NGI), a series of islands north-west of mainland New Guinea, have had human occupation for over 30,000 years BP. The NGI is perhaps the only site in Papua New Guinea where remains of 50 species representing 15 families have been discovered at sites throughout the main island of New Ireland (Steadman et al. 1999). From the 50 species records from archaeological remains, at least 12 species (cockatoo, petrel, hawk, megapod, quail, four rails, two owls, and crow) have not been recorded as current avifauna (Steadman et al. 1999). Whilst humans' exploitation may have been responsible for the decline of large mammal fauna, it is also probable that climate change was responsible for some of the extinctions (Sutton et al. 2009, Johnson et al. 2016).

2:2 The Second Wave of Humans: Early Trade and Agriculture

A second wave of humans (Austronesian language speakers) arrived in New Guinea over 3300 years ago from the sub-tropical areas of South East Asia. These sea faring horticulturists brought along with them pigs, chicken, pottery (Lapita) and settled first on New Guinea Islands (NGI) before spreading to the coasts of mainland New Guinea. Chards of the Lapita pottery have been found at two southern coastal locations of Papua New Guinea. The South East Asian sea farers continued to disperse to Vanuatu and the rest of the Pacific Islands. Archaeological studies in Asia point to similar forms of starch-rich plant food such as taro, bananas, and sago having been consumed by early humans in subtropical Asia (Yang et al. 2013).

Sago was perhaps more important than rice due to its low maintenance, and less labour associated with cultivation. Previously, researchers assumed sago to have high diversity centred in New Guinea. However, DNA analysis has revealed only one species, *Metroxylon sagu* Rottb (KjÆR et al. 2004). This assumption of diversity may have been due to the records of subspecies within the genus *Metroxylon*. The sago palm is propagated either by seed or suckers (clonal vegetation). The commonality of most plants transported and processed in archaeological records in New Guinea, were by suckers. For instance, the sago, taro, and banana. These plants are also considered to have strong cultural ties with the Indigenous communities that cultivate these crops (Barton and Denham 2016). For example:

"Entire social histories may be written into the long-term engagements between people and plants within a particular landscape. The biological properties of plants appear deeply woven into social lives expressed within cosmological understandings of the world; expressions of 'place' as historic records of land use; land tenure; rights of resource access (often expressed through kinship); ceremonial practices; and, as places linked to birth, death and the ancestors." (Barton and Denham 2016): Page 1

There is no earlier record of sago processed by early humans in New Guinea, although exploitation is considered to be ancient (Gillieson et al. 1985). The only record though is that of sago starch granules along the Papuan coast with Lapita pottery chards dating 1500 years BP (Rhoads 1980). That time frame also coincides with evidence found in montane archaeological sites of marine organisms and pig bones. The records of shells in montane sites, stone tools, and pig bones around this era assumes early trade.

The sago palm (*Metroxylon sagu)* has a distribution mainly within New Guinea and Moluccas (part of Indonesia). It has also been introduced to other areas outside of its natural distribution (Flach 1997). The benefits of sago palm are many. It is a plant that withstands swamp peats, requires no

maintenance, acts as a barricade to strong winds, and sequesters carbon. The palm fronds are woven into baskets for food storage, stacked as roofing on houses, whilst the hard trunk is used for walls and flooring for coastal houses. A sago palm requires at least 8-10 years to reach full maturity; when the starch content is at its maximum for harvest. Given the years it takes to mature, sagos constitute one of the culturally significant plant species that tie humans to a geographic realm (Glazebrook 2008).

Sago groves also serve as a habitat for diverse species of aquatic and terrestrial fauna. The harvest of the sago species requires at least 2-3 days of walking to the site, and at least an additional 3 - 5 day of labour; pounding and sieving the starch. Sago has low protein content but is high in carbohydrates. Often wild game is hunted not only to supplement the diet but also to add flavour to the bland taste of sago (Hide 1984). The remaining pith and trunk of the harvested sago attracts wild pigs and beetles whose larvae are sought after by locals as a delicacy.

Communities who depend on sago often have low population densities and have also adopted a shifting cultivation form of living; gardening for a short period, hunting, and harvesting from the vicinity of their settlement before moving on to the next or returning to harvest when sagos are mature (Ohtsuka 1994). The area cleared for shifting cultivation is small by comparison to those who have settled into a more sedentary lifestyle in montane areas in New Guinea and in parts of South East Asia (Sasaoka et al. 2014). Humans in the highlands have intensified their exploitation of the environment. Domestication of pigs was an important means to acquire protein. This in turn meant that a constant supply of starch for humans and the pigs needed to be in place, hence large areas of the highlands valleys were cleared for cultivation of crops. One of the staple crops which allowed locals to remain upland was the cultivation of crops such as sweet potato (*Ipomea batatas*) which arrived in New Guinea less than 500 years (Ohtsuka 1994, Allen and Filer 2014, Golson et al. 2017).

Prior to the introduction of sweet potato by early European explorers, varieties of taro, yam, and plantain banana were the main staple crops of highland societies (Fullagar et al. 2006). By comparison to sago, sweet potato was readily harvested within a few months and allowed surplus to be fed to domesticated animals, for example pigs (Hide 1981, Bayliss-Smith et al. 2017). The surplus production of pigs were used in ceremonial exchanges in the highlands societies (Hide 1981). Hence, the sweet potato revolutionised highlands societies by enabling increased production of protein by the domestication of pigs which in turn also enriched forms of cultural associations. For instance, the pig killing ceremonies included, people's adornment in traditional regalia comprising of bird plumes and animal pelts.

The cultivation of a high yielding crop and less disease such as malaria, allowed upland human populations to flourish by comparison to lowland areas. Societies that had access to landscapes that

shared both features, transitional environmental elevation, experienced seasonal migration for harvest and use of crops.

Whilst people in the different landscapes have adapted different staple crops, shifting cultivation in a way serves as a land management practice (Ohtsuka 1994, Fox 2000). Similar to the fire stick farming hypothesis, varying phases of vegetation mosaic from the intermittent shifting cultivation practices creates a range of habitat along a landscape ideal for promotion of biodiversity (De Jong 1997). This form of subsistence agriculture practice has supported New Guineans for millennia. Whilst the practise has benefits, it has also been stigmatised as contributing to deforestation (De Jong 1997, Shearman et al. 2009).

2:3 Situating Birds in Trade - New Guinea

The Birds of Paradise (BoPs) have had a long history of trade into Asia with estimates of over 5000 years (Swadling 1996). Areas involved in the trade included islands in what are now Indonesia including the Moluccas, Malaysia, mainland Asia and other parts of New Guinea. There are no biological specimens to validate this timeframe, however, inscriptions of traded ornaments bearing resemblance to striking birds with elaborate plumes infer Birds of Paradise were traded between islands (Swadling 1996 and Doustar 2014).

During this trading era, some notable plant species from the South East Asia (SE Asia) region have been adopted as part of the subsistence livelihood in New Guinea. For example, the betel nut (*Areca catechu*) and sugar cane (*Saccharum sp)* both remain well-used. Furthermore, this era approximates around the time of agricultural expansion in New Guinea. The trade of plumes in the Southeast Asian region declined around 1750 BP (Swadling 1996). Centuries later (1500s), the trade of Birds of Paradise plumes recommenced in SE Asia (see section **2:3.2 Spice and plumes trade commences with Europeans**). Native inhabitants of New Guinea continued to use the plumes as part of their tradition regardless of the decrease in demand in SE Asia. To inhabitants, the use of plumes has been and appears to remain an integral part of local traditional culture, something of valued significance that connects a person to the environment (Strathern 1979, Sillitoe 1988a, O'Hanlon 1989).

2:3.1 Trade in Central Highlands of New Guinea

Trade routes were well established in the central highlands, by 3000 years BP (Burton 1989, Gaffney et al. 2015b). Research suggests that the items mainly exchanged on these routes were salt and stone axes (Hughes 1977). Most of the production came from the central highlands (Western Highlands), which is one of the world's earliest agricultural societies (Denham et al. 2003). Evidence of pig's jaw (*Sus scrofa*) dating back approximately 5000 years, and evidence of Lapita-like pottery in the New Guinea highlands may further indicate the possibility of trade routes to the interior and the

domestication of animals in conjunction with plants (Bulmer 1966, Gaffney et al. 2015b). This places the New Guinea highlands as having one of the earliest organised human societies.
Traditional New Guinean societies relied on their environment for items of trade, and the necessities that shaped their societies and cultural identity. Societal norms relating to land and its resources were governed by strict cultural codes. For example, practices relating to rituals specific to courtship, marriage, funerals, and even to the extent of activities such as a successful hunt in their forest (Glasse and Meggitt 1969, Majnep and Bulmer 1977, O'Hanlon 1989, Gillison 1991, West 2006).

The exchange of goods is integral to societal relations in New Guinean. The traditional practice of exchange or gift is quite complex, particularly with respect to the significance of the act itself - the exchange. As an example, the Trobriand islanders undertook a dangerous seafaring trade route to exchange traditional necklaces and armbands that were considered valuable. The Kula Ring Exchange was mainly headed by chiefs from the eighteen islands of the Trobriands. The exchange of these objects linked different ethnic groups and strengthened social relationships (Malinowski 1920). The central part of the act was reciprocity; nothing was free and there was an understanding that an item of equal value or greater was given in return. The Kula Ring Exchange varied slightly with the trade that took place in the central highlands' communities. The Kula Ring occurred within a closed group of people within the islands—mostly chiefs or those of higher status. In the central highlands, however, the trade of transactable objects occurred with anyone who had valuable items and was willing to make an exchange (Strathern 1971), and was considered a private matter, not done in public (Healey 1990). Often though, the accumulation of valuables was undertaken to demonstrate wealth and place in society (e.g. political affiliations) during large festivals such as the pig killing festivals. However, for items such as feathers or plumes, their collection was not related to a man's political wealth (Healey 1990).

Examples of items traded were salt, stone axes, crude oil (petroleum seep), bird plumes, shells, pottery, and pigs (Hide 1981, Burton 1989). Papua New Guinea's traditional form of trade or exchange did not conform to an institutional economic exchange system, but the clear benefit of such a system was that it served the communities involved through the development of stronger kinship or tribal relations, and political functions which encouraged the practice (Malinowski 1920).

2:3.2 Spice and plumes trade recommences with Europeans

During the 1500s, spices were at the centre of the global economy. The main spices sought after were clove, nutmeg, black pepper, and cinnamon. Unfortunately, these spices could not be grown in the European climate but were known to thrive on the tropical islands of the Moluccas and Tidore, collectively known as the Spice Islands (Swadling 1996). When Magellan arrived in the Spice Islands in 1521, he was presented a gift for King Charles I of Spain who funded his expedition. The gift

consisted of dried skins of a species of the Greater Birds of Paradise (*Paradisea apoda*). The Greater Bird of Paradise was a species of unknown beauty, unlike any other in Europe. In 1600, dried Birds of Paradise cured by villages in the Moluccas and Papua (Indonesia) were shipped to Europe (Swadling 1996). The naturalists outside Indonesia and New Guinea were fascinated by the Birds of Paradise. Scientific descriptions of the species did not occur until Alfred Wallace visited the Spice Islands in 1854 (Swadling 1996, Wallace 2011). This western fascination of the Birds of Paradise culminated to commodification of endemic New Guinea birds and the subsequent initiation of conservation in Papua New Guinea.

2:4 The Meaning of the Headdress

The interpretation of the headdress varies amongst highlands societies. Traditionally, it is the men who hunt the birds, prepare the skins, trade the birds, and mount the feathers on a head piece that constitutes the headdress (Sillitoe 1988b, Sillitoe 1988a, Healey 1990). For the Southern Highlands, the foundation of the headdress is said to symbolise the Macgregor Bowerbird's (*Amblyornis macgregoriae*) bower (Sillitoe 1988a). The same reference has also been made to the dance arena in which dance festivals are held. The motions of the dance movements by the performing men depict certain species, notably the King of Saxony Bird of Paradise (*Pteridophora alberti*) during its courtship display (Sillitoe 1988a). In some parts of the highlands though (e.g. Jimi), the headdress is mainly for aesthetics (Healey 1990) and for others (Chimbu and Eastern Highlands) it is a display of strength as warriors (Spring 1977).

Most traditional dances were initiated and largely performed by men who had more extravagant headdress, when compared to female counterparts, to depict beauty, virility, power, and to display tribal political power. An important aspect of group dances was to indicate the group's strength which had a perceived reflection on the clan's strength. The dance performances, therefore, created a perceived protection over clansmen who travelled for trade (Sillitoe 1988a, O'Hanlon 1989). On a few occasions though, men would allow young unmarried women to join them in dance festivals. It was only during these occasions that male relatives loaned young women plumes to wear (Sillitoe 1988a). Married women would have plumes acquired through bride price ceremonies (Brown 1969). These observations represent accounts pre-independence (ibid:).

The elaborate headdress and the face paint on men during ceremonial dances in Western Highlands served as facemasks to conceal the identity of the wearer. It was not an individual participant's identity, but rather the group's communal identity and the message depicted by their songs and dances that reveal the intentions of the clan to spectators, particularly in relation to politics (Strathern 1979). Within the same province, men traditionally wore the Raggiana Bird of Paradise (*Paradiseaea raggiana*) when in battle with close tribal enemies. The colour red which is prominent on the flank

plumes of Raggiana Bird of Paradise was said to represent aggression (Strathern 1979, O'Hanlon 1989).

The bird is depicted as a symbol of masculinity. For example, a woman, shortly after labour would make reference to the gender of her newborn as either a bird for a male or rat for a female child if she were asked the gender (O'Hanlon 1989). It is common practice to name a male child after birds. For example, *Paraka*, is the word in the Melpa language in Western Highlands for the Raggiana Bird of Paradise as *Iambake* is to the Kuman language in Chimbu Province. The Vulturine Parrot (*Psittrichas fulgidus*), or *Kawage* in the Kuman language, is the most favoured bird and an honour for a son to be named after the species (Thomas and Jope 2008). The species can often be exchanged for a piglet (Brown 1969, Healey 1990).

In the past, not many men in their villages owned headdress sets (Strathern 1979, Sillitoe 1988b, Healey 1990). Only a few craftsmen could dedicate time into harbouring plumes, assembling a set of head piece, maintaining them, and storing them. It was a common practice for these craftsmen to hire out headdresses to clansmen who participated in important festivals and which in turn provided a means of earning income (Plate 2.1).

Plate 2.1: A Simbai man (border of Jiwaka and Madang Province) assembling his plume collection for his headdress to participate in the annual Simbai (Kalam) Festival. Photo taken by Marc Dozier © 2007 used with permission (http://marcdozier.com/portfolio-papua-new-guinea/#1/4).

Long feathers such as Astrapia (*Astrapia stephanae*) and the Brown and Black Sicklebill (*Epimachus meyeri* and *E. fastuosus*) were kept in bamboo tubes. Some locals in urban areas are now using polyvinyl chloride (PVC) pipes as an alternative. Other species of birds are wrapped in pandanus, and banana leaves and stored carefully above rafters. This practice is quite common as the smoke from traditional round houses acts as a fumigant to ward off insects. Other durable storage containers include the metal patrol boxes (Sillitoe 1988b).

2:5 Bird Trade in Papua and New Guinea During and After Colonial Administration.

The northern half of what is now Papua New Guinea was administered by Germany from 1884-1914 (German New Guinea), and the south (Papua, or British New Guinea) by Britain. The administration of Papua was later transferred to Australia in 1906 following Australia's Independence from Britain in 1901. Two important commodities exported from Papua and New Guinea during this era (1884-1914) were copra from the numerous coconut plantations established along the coasts and the Birds of Paradise plumes (Swadling 1996). Fashion trends in the early 20th century increased international trade of exotic bird skins and plumes for the millinery industry (Hornaday 1913). The peak of the trade was termed the 'Plume Boom' era; an estimated range of 450 000 to over a million birds were killed and exported to supply this fashion industry (Swadling 1996, Kirsch 2006).

The international trade of plumes began to decline following two main events. Firstly, many naturalists advocated an end to the harsh treatment of animals. The Royal Society for the Prevention of Cruelty to Animals (RSPCA), for example, began its operation in Britain in the 1820s. Its activism on the cruelty of animals began to gain support in Britain and gradually spread to areas where it had established colonies. The Wild Bird Protection Ordinance 1894 was enacted in British New Guinea (British Papua) to protect wild bird species (Swadling 1996). This legislation came into effect in coastal areas of the colony (e.g. Port Moresby, Daru, and Samarai) (ibid:). Meanwhile in Germany, naturalists also debated consequences for the birds, particularly with respect to potential decline from overharvesting; for example, the Birds of Paradise, cassowaries, and Goura pigeon. In order to minimise the reduction in population of species, the German administration in New Guinea put two measures in place starting in 1912 (Sack and Clark 1979, Hahl 1980).

The first measure was the issuance of hunting permits to control hunting. The second was the establishment of the first Conservation Areas in New Guinea. There were three Conservation Areas; in the Sepik to protect Lesser Birds of Paradise (*Paradisaea minor*), in Huon Peninsula to protect the Emperor of Germany's Bird of *(Paradisaea guilielmi),* and in the South-East Peninsula of the central range mountains particularly bordering what is now Central and Morobe Provinces to protect the Blue Bird of Paradise *(Paradisaea rudolphi)* and the Raggiana Bird of Paradise *(Paradisaea raggiana).*

The names associated with the species were typically in honour of the ruling European monarchs at the time (Frith and Frith 2010).

Awareness eventually led to the establishment of the Lacy Act (1913) in North America (U.S.A). This legislation prevented the unnecessary harvest of large quantities of birds for trade between western countries (Foster and Patchett 2011). In addition to international laws, a change in fashion trend (the bob hair style) reduced species traded. Further to the Lacy Act, when the First World War (WW1) commenced in 1914, there was a gradual decline in the harvest and commercial sale of Birds of Paradise plumes. The export of plumes was the highest between 1900 and 1914, Plum Boom era. The world's leading economic powers were in the centre of this Great War. The Allies (Britain, France, and Russia) fought the Central Powers (Germany and Austria-Hungary) and became victorious towards the end of 1918. Following the victory, Germany withdrew control over northern New Guinea. Subsequently, the Eastern half of New Guinea was then administered by the Australian Administration. With Papua and New Guinea now under the control of Australia, there was much interest by prospectors from Australia to investigate the possibility of gold in the areas previously under German rule. The onset of the Great Depression in the 1920s was an added boost for daring foreign explorers to venture into the central highlands of Papua and New Guinea—an area least explored.

The first foreigners (non-Indigenous) to enter the interior of the central highlands societies were two Australian gold prospectors, Michael Leahy and Michael Dwyer, and a government Patrol Officer, Jim Taylor in 1933. This entry progressively led the way for further foreign exploration and eventually the establishment of government posts in the interior of the Protectorate of Papua and New Guinea. The central highlands were found to be surprisingly populated. A reason for the highlands being accessed later than other parts of Papua and New Guinea may have been due to the rugged terrain, high rainfall, and tribal warfare, including lack of interest and limited resources on the part of colonial government (Diamond 1999). In the 1940s, the small town of Goroka in the Eastern Highlands hosted a government station and an airfield that serviced the area in addition to the American and Australian armies during World War II (WW2) (Brown 1995). World War II was not a tribal war - the locals who were engaged in it to some extent would have been traditional enemies. Nevertheless, in the highlands, locals cooperated with the Australians and Americans to prevent the Japanese military from gaining a stronghold of strategic locations along the Protectorate of Papua and New Guinea. Ironically, this bloody war led to cooperation from the locals that initiated the slow process of unifying a culturally diverse country.

Traditional practices of Indigenous people that would normally take place were altered during and after WW2. For instance, the trade of certain valuable objects such as the pearl shell was slow to

make its way to the highlands during the war. It was also around the time when steel axes replaced stone axes, and salt fell out of trade (Hide 1981). There was noticeable increase in the plumes in the years after WW2. The long black plumes of the Astrapia and the Sicklebill Birds of Paradise were more preferred over the Raggiana and the Lesser Bird of Paradise (Brown 1969, Hide 1981, Healey 1990). Highlanders who worked in coconut plantations along the coasts between the 1950s - 1970s often took marsupial skins and bird plumes to exchange with coastal people (see Plate 2.2). The species highly sought after were bright plumes such as the Vulturine Parrot (*Psittrichas fulgidus*).

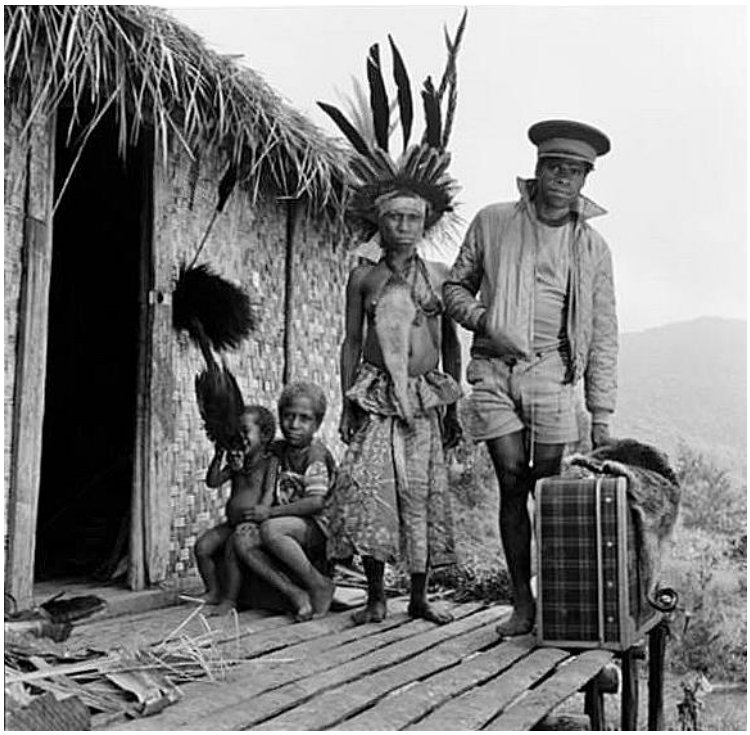

Plate 2.2: A man with his family from Ubaigubi in the Eastern Highlands Province (early 1970s). The man is ready to travel to the coast to work on plantations. He has packed marsupial fur (on suitcase) and bird skins (some in his suitcase and two held by his children) for trade along the coast. The man's wife stands beside him in her traditional headdress. Photographed by David Gillison.

The trade of stone axes, pigs, shells, and bird plumes was deeply entrenched with males. Trade of stone axes declined in the 1950s – however, the use of cash in transactions and the trade of plumes and its use in traditional ceremonies such as the marriage (bride price) increased in the 1950s. The act of ceremonial exchange of plumes and pigs symbolises the recognition of the union between two individuals that also has binding ties to the clans and anyone that benefits from the distribution of the exchange.

In the highlands society, the production of valuable items such as stone axes, the trade of valuable items, and consumption or use of these items were limited to men. Hence, highlands societies are patrilineal as opposed matrilineal in some island societies in Papua New Guinea. Males in the highlands had ownership of land rights, and dominated important meetings in the highlands societies that were linked to management and status in the household, the clan, and the community (Hughes 1977, Feil 1987). Women's voices were not heard. Men were involved in important affairs. These included decision making within the communities, where they hosted traditional gatherings (e.g. pig killing ceremonies), and took centre stage during festival dances (O'Hanlon 1989) while women danced in the fringes of the arena (Healey 1990). Men hunted large animals and birds. Men had access to and controlled the by-product of the hunted fauna; mammal skins or plumes from birds and the craft involved in headdress construction. Women were not allowed to handle the plumes until after they were married (Sillitoe 1988b, 2001).

The practice of adorning a bride in elaborate headdress appears to be a trend recorded in Chimbu in the 1950s (Brown 1969). The practice extended to other areas such as upper Waghi and Jimi in the 1970s (Healey 1990). The plumes and the pearl shells which adorned the bride were kept by her after the bride price ceremony (Brown 1969). The pigs, cash, and other valuable items were distributed by her father or male relative to their kinship group (Brown 1969, Glasse and Meggitt 1969, Hide 1981). During the 1940s -1950s, women participated in church ceremonies in traditional attire more than men in Chimbu (Brown 1969). The inception of Christianity and early missionary work reduced tribal fights (Brown 1969, Hide 1981). Apart from fostering peace, churches also promoted gender equality. It may be the case that such practices accepted by the church spread with improved establishment of infrastructure such as the highlands highway in 1953 linking the central highlands and the coastal areas.

The work of Australian Patrol Officers (Kiaps) in the isolated parts of Papua and New Guinea was essential to establish baseline knowledge of natural resources and geography, census, languages, and the expansion of administrative powers. Furthermore, the Kiaps also explained any new laws to communities with the aid of interpreters and acted as judge in communities to settle disputes. Law enforcement, and the establishment of the annual cultural festival in 1957 by the Australian Patrol Officers ('Kiaps') in Goroka, Eastern Highlands Province, further promoted peace, unity, and diversity. By this time, a main road was already established and linked Mt. Hagen (Western Highland), Jiwaka, (Waghi Valley), and Chimbu. This Goroka Annual Cultural Festival (or Goroka Show) is now the oldest in the country. The second oldest cultural show is the Mt. Hagen Annual Show. The Port Moresby show in the National Capital District (N.C.D) ran for a short while from the 1980s and stopped in the late 1990s. As such, the oldest cultural shows are in the central highlands.

Cultural objects valued by local people continued to be traded among local populations in the 1960s. The items traded gradually changed over time, reflecting a preference for durable items (e.g. stone axes for steel axes) and the use of coins (cash) in the modern cash economy. As locals started to work in government stations, either as assistants, or as labourers for coastal plantations, they earned money which they used for trade including bride price ceremonies (Brown 1969, Hide 1981, Healey 1990, Brown 1995). The British pound was the currency used before 1966 and later the Australian dollar (Hide 1981). The use of pearl shell in exchange fell by early 1970. Pigs continue to be a valued item of trade today. Although the slaughter and contribution of live pigs during elaborate festivities such as the traditional pig killing ceremonies (Strathern 1971, Strathern 1979, O'Hanlon 1989) died out in the late 1970s, to this day a few contending political candidates put up smaller versions of such within their villages or clans to demonstrate their intention to contest the election.

2:6 Legislative Protection of Species and Trade

Following the end of WW2, the Papua and New Guinea Act of 1949 enabled Australia to oversee the governance of the two separate administrations to unite as a Territory under the United Nations International Trusteeship. The Act of 1949 opened the pathway for preparations to establish a legislative council, which subsequently became the House of Assembly in 1964. Hence, this initiated the process for Australia to put into place a legislative framework for Papua and New Guinea's imminent Independence in 1975.

The present legislation governing the protection of species in Papua New Guinea was partly adopted from the concerns from colonial legislation (German and Australia) with knowledge from expeditions to New Guinea by ornithologists such as Ernst Mayer in 1920s and Thomas Gilliard in the 1960s (Swadling 1996). The Fauna (Protection and Control) Act was passed in 1966. Among some of the animals deemed as protected, all 39 species of Birds of Paradise were included. Protected species were considered the property of the State. Penalties were imposed on anyone caught hunting protected species with explosives (e.g. guns), nets, and with the use of dogs. Part of the introduced legislation was to protect locals from overharvesting protected species using explosive-type weapons (Healey 1986). From the 1960s, Indigenous people had been permitted to own guns. However, Gillard recommended that Indigenous people hunt only using traditional weapons as they had done so for millennia without detriment to populations. This amendment was adopted in 1974, and locals were permitted to hunt using traditional weapons, although trading the species was and still is illegal.

After Papua New Guinea gained Independence, Australian Kiaps were replaced with national officers and this meant duties previously performed by the Kiaps were now performed by nationals. One of the duties of the Kiaps was to uphold and translate the laws to the communities. There were some adjustments into the new roles within the administrations. The new national officers appeared more

distant to some of the outposts (remote communities), and more distant than the colonial administration (Healey 1990). The interpretation of the law to communities on the hunting of protected species also proved challenging. For instance:

Councillors have been told in Tok Pisin by government officers that it is illegal throughout Papua New Guinea to shoot kumul with a gun. To Jimi people kumul means only the Lesser Bird of Paradise and not the wider category of birds of paradise in general. It is therefore permissible, they say, to shoot other valuable birds of paradise [9] with a gun, provided this is done only by the licensed holder of the gun and that he hunts only in areas where he has rights to kill valuable birds. This misconception, the result of inadequate communication between government officers and councillors….(Healey 1990). Page 114

Tok Pisin is the lingua franca spoken in Papua New Guinea. The Tok Pisin (Melanesian Pidgin) language is a mix of words adapted from European and Chinese sailors who traded along the Pacific Islands. Indigenous islanders who came into contact with these sailors either through trade activities or labour on plantations learned a simplified way of communicating with other Indigenous people (Volker 2017). The word *kumul* in the excerpt is the communal term in Tok Pisin for Birds of Paradise in Papua New Guinea.

The trade of plumes in the highlands began to decrease after the 1970s. While the Act was considered necessary to protect species, there was little consideration as to what the species meant to the people of Papua New Guinea and its connection to culture. Furthermore, without foresight, the State hindered locals from exercising centuries of traditional governance over their own land; over 80% of land in Papua New Guinea is owned by traditional custodians. This draconian section of the legislation was ill-conceived and restricted traditional hunting rights. Hunting allowed locals to gather fauna for their consumption, for the maintenance of social ties, and to construct material objects (e.g. headdress) for cultural expression.

The International Trade (Fauna and Flora) Act was passed in 1979. This was the State's response to the fulfilment of its obligations as a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora or CITES. Export of protected species is illegal unless approval is obtained from the Government Mandated body; the Department of Environment and Conservation (DEC), renamed Conservation Environment and Protection Agency (CEPA) in 2014. The export of Birds of Paradise for commercial gain (trade) remains illegal in Papua New Guinea but is permitted for scientific research, education, and conservation (e.g. zoos) if a permit is approved by authorities – the Papua New Guinea National Museum and Art Gallery, National Quarantine and Inspection Authority, and CEPA.

Almost 20 years after Papua New Guinea's independence, the Government passed the National Cultural Commission's Act (PNG 1994). This Act encourages the expression and promotion of Indigenous Papua New Guinean culture and heritage (tangible and intangible) via traditional festivals, films, and exhibitions. Within the same period, Papua New Guinea became a party to the Convention on Biological Diversity (CBD). In addition to the protection of biodiversity, *Article 8 (j)* of CBD promotes traditional Indigenous cultural knowledge and heritage. Whether there was a general pause in knowledge transference from one generation to another over the 20-year period for the legislation to promote cultural expression has not been investigated.

Policing both Acts has been a challenge for a few reasons. First, most land is owned by traditional custodians, who for the most part live in very remote areas making it an expensive exercise to enforce the law. Second, the Mandated department's annual budgets throughout the years have not been sufficient to enforce the law (e.g. employment of Park Rangers), let alone conduct monitoring and maintenance on established protected areas. As such, even after the Acts were passed, locals were still hunting and trading protected species from 1979 to 1983 in the Southern Highlands Province (Kwapena 1984a, 1985). Third, there was a lack of basic scientific data on species ecology, distribution, and population size. This represented the need for building national scientific capacity without relying on international researchers. An added challenge was the fashion in which parks were designed during earlier colonial administrations (Hahl 1980) which did not consider aspects of traditional land tenure systems, and species ecologies. Some of the protected areas that were established between the 1970s and 1980s no longer exist (Shearman et al. 2008) as a result of pressures from land owners. Such situations indicate a mismatch in priorities for the landowners and the intentions of the State and emphasises the importance of dialogue with traditional custodians.

2:7 Bird Trade in PNG Over the Last 40 years

a) Trade in the National Capital District, Papua New Guinea's Capital (1974-1975)

The New Guinea Bird Society conducted a five-month survey (August 1974 – January 1975) on birds sold in the main markets in Port Moresby. The survey encountered 23 species (from 292 birds) (**Figure 2.2**). The only live birds sold then were cassowaries (2 species). Cassowary prices were the highest amongst the birds sold at the time followed by the New Guinea Harpy Eagle (**Table 2.1**). Cockatoos and parrots were the species most frequently sold at the markets and these species were all well skinned and dried. The capture of large numbers of parrots was attributed to the method of traditional hunting in which locals used nets. No Birds of Paradise were observed during the survey and this may have been a result of awareness and enforcement of the The Fauna (Protection and Control) Act that was passed in 1966.

Table 2.1: Bird species sold in the capital of Papua New Guinea (Port Moresby) between August 1974 – January 1975.

	Species Name	Common name	IUCN Status	Cost $AU in 1974	Quantity
1	*Aviceda subcristata*	Crested Hawk (Pacific Baza)	LC	0.70 - 3	4
2	*Henicopernis longicauda*	Long-tailed Buzzard	LC	6	1
3	*Haliastur indus*	Brahminy Kite	LC	3-5	5
4	*Megatriorchis doriae*	Doria's Hawk	**NT**	6	4
5	*Harpyopsis novaeguineae*	New Guinea Harpy Eagle	**VU**	8-10	7
6	*Rhyticeros plicatus*	Papuan Hornbill	LC	0.45 - 2	3
7	*Probosciger aterrimus*	Palm Cockatoo	LC	2-3	8
8	*Cacatua galerita*	Suphur Crested Cockatoo	LC	2	65
9	*Casuarius bennetti?*	Dwarf cassowary?	LC		2
10	*Casuarius casuarius*	Double Wattled Cassowary	**VU**	60	2
11	*Ducula sp. - muellerii or pinon*	Imperial Pigeon	LC	3	1
12	*Ptilinopus perlatus*	Pink-spotted Fruit Dove	LC		1
13	*Gymnophaps albertisii*	Papuan Mountain-pigeon	LC		1
14	*Megapodius (freycinet?) jobiensis*	Common Scrub Hen (Red-legged Brush turkey	LC	1	1
15	*Talegalla fuscirostris*	Dark-billed Brush Turkey (Yellow legged brush turkey)	LC		1
16	*Chalcopsitta scintillata*	Greater Streaked Lorikeet	LC	1	5
17	*Trichoglossus haematodus*	Rainbow Lory	LC	0.30	3
18	*Lorius lory*	Black-capped Lorikeet	LC	1	4
19	*Charmosyna stellae*	Stella's Lorikeet	LC	2 -10	56
20	*Eclectus roratus*	Eclectus Parrot	LC	2	113
21	*Psittrichas fulgidus*	Vulturine Parrot	**VU**		2
22	*Mino dumontii*	Yellow-faced Myna	LC		2
23	*Platalea regia*	Royal Spoonbill	LC		1

Source: The market survey was conducted by the New Guinea Bird Society. Table constructed by Supuma from Patterson's observations (Patterson 1974). There were 23 species (N = 292 birds) observed over the 6 months' survey. The International Union of Conservation of Nature (IUCN) status recorded on the table refers to status (2016) of species in the world (LC = Least Concerned, NT = Near Threatened, VU = Vulnerable). Exchange rate: 1 AUD =1 PNG Kina, The World Bank (http://data.worldbank.org/indicator/PA.NUS.FCRF).

For some species, prices were not recorded by the observer(s) at the time, as such the only identification made was of the bird sold and the state in which it was sold (only feathers, skins as in whole dried bird, or live). The traders were from villages in the Central Province surrounding Port Moresby; Rigo sub-districts, Kairuku, Sogeri and Koiari Uplands, Kokoda, and Brown River).

b) Birds Traded in the Central Highlands, Papua New Guinea (1965 - 1985)

The plume trade began to increase around the 1950s and continued through to 1973 (**Figure 2.1**) (Hide 1981). From Chimbu, the number of animal skins, cassowaries, and birds harvested from Karimui rose as a result of increased demand from people closer to more developed areas (Hide 1984). Similarly, plumes were sought from Baiyer and Jimi in the Western Highlands and Jiwaka Province. Chimbu plume traders formed trading parties and travelled to Baiyer, Jimi, Simbai, and Madang when there was less threat to safety (Hughes 1977, Healey 1990). The trends in plume preferred were noticeable: people in Chimbu preferred Birds of Paradise species with long black plumes such as Astrapia and Sicklebills compared to Raggiana. There was an increase in price for the preferred species (**Table 2.2**)

Coffee as a cash crop was introduced in the central highlands between 1952-53 about the same time the Highlands Highway was opened (Hide 1981). In the years following, coffee production brought better financial returns, which led to a decline in the plume trade. Men who had land and could grow the cash crop invested more time on cultivation and trade of coffee. Market surveys in 1974 indicated that women in the highlands (Western and Eastern) begin to take an active role in trade of vegetables, although some items seen as traditionally valuable, such as pigs and cassowaries were still traded by men (Jackson and Kolta 1974). Women whose husbands were employed in town also had money to make purchases. As such, women began to take an active role in buying and selling of vegetables. While the objects of trade were different from what was a traditional male dominant role, this period indicates a gradual increase in women taking an active role in transactions—an area of livelihood that was typically a male stronghold.

Table 2.2: The cost of birds sold in the central highlands of Papua New Guinea from 1965 - 1985. The cost of birds and plumes are in Kina.

			1965-1974		1974-1978		1979-1985		
Scientific Name	**Common Name**	**IUCN Status**	range	mean	range	mean	range	mean	Ref.
Aliterus cholopterus	Papuan King-parrot	LC						2	(S)
Amblyornis macgregoriae	Macgregor's Bowerbird	LC					1.50 - 2	2	(S)
Astrapia stephanae	Princess Stephanie Bird of Paradise	LC	2-20	11.25	4-22	10.67	10-20	12.73 (40)	(O,S)
Cacatua galerita	Sulphur Crested Cockatoo	LC		1			4 - (5)	4.5	(S)
Casuarius bennetti (chick)	Dwarf Cassowary	LC	20-50	32.5			(40-100)	100	(H)
Casuarius sp.	Cassowary (loose plumes, quills)	LC						2	(S)
Charmosyna josefinae	Josephine's Lorikeet	LC						2	(S)
Charmosyna pulchella	Fairy Lorikeet	LC	0.40-0.50	0.44		1.43	1.66 -2.40	1.8	
Charmosyna stellae	Stella's Lorikeet	LC	0.40-2	1.67			2-5	2.60	(S)
Eclectus roratus	Eclectus Parrot	LC						2	(S)
Epimachus fastuosus	Black Sickelbill Bird of Paradise	**VU**	10-60	25		10.67	20-100	72.22	
Epimachus meyeri	Brown Sickelbill Bird of Paradise	LC		2		10	(40-60)	50	(O,S)
Lophorina superba	Superb Bird of Paradise	LC	1-10	2.07		2	2-6	4	
Paradisaea minor	Lesser Bird of Paradise	LC	1-10	2.42	0.50-10	5.13	3-20	12.73	
Paradisaea raggiana	Raggiana Bird of Paradise	LC	2-3	2.25				(5)	(S)
Psittrichas fulgidus	Vulturine Parrot	**VU**	4-20	10	10.22	4-14	10-12	10.36	
Pteridophora alberti	King of Saxony Bird of Paradise	LC	0.50-10	3	2-10	6	(2) 3-10	7.75	(S)
Tanysiptera sp.	Kingfisher	LC		1.7		10			
Trichoglossus haematodus	Rainbow Lorikeet	LC						2	(S)

Source: The figures are adapted from Healey (1990). For the information to be representative of the central highlands, other references were sought and price (PNG Kina) of species were adapted. This is denoted by values in brackets () and the initial of accompanying references (Hide 1984, Sillitoe 1988b, O'Hanlon 1989, Healey 1990). For example, cost obtained from Sillitoe was represented by (S), O'Hanlon (O), and Hide (H).

The gradual connection of the interior to the outside because of improved road networks, education, improved hunting technology, employment opportunity, and acceptance of alternate belief systems allowed locals to adapt to the changing social setting.

Improvement in the variety of agricultural staples, and introduction of cash crops such as coffee diversified economic activities for locals (Howlett et al. 1976, Hide 1984). Trading production that involved valuables such as stone axes, shells, and salt began to fade between 1933 – 1950 (Hide 1981). The trade of plumes increased in the 1950s and remained on a steady trend till the 1970s. Records in the 1990s suggest that the number of species traded has declined between the 1980s - 1990s (Bourke and Harwood 2009).

2:8 The Informal Sector Economy

The trade of produce and service by the large informal or subsistence population has been recognised by the Papua New Guinea Government as contributing to the informal economy of the country. The *Informal Sector Development and Control Act* (ISA) was introduced in May 2004. In 2011, the

Government of Papua New Guinea launched the country's National Informal Economy Policy (2011 - 2015) (Conroy 2010, Develpment and Affairs 2011). This policy established the Government's recognition of the collective informal economic activities of the majority of Papua New Guinea who are unemployed but are engaged in ways that are deemed 'economically active' (Conroy 2010). The policy framework stimulates informal economic growth, which subsequently fosters a financially inclusive society (Develpment and Affairs 2011). The trade of subsistence agricultural produce and wildlife is part of the informal economy. The differences of the formal and informal economy are outlined in **Table 2.3**.

People engaged in the informal economy can conduct their activities at designated areas (for example, the sale of betel nut or handicrafts) and their service or product is subjected to the rules and regulations of the constitution. For example, while a license system has not been introduced, traders by law are not allowed to trade illegal items and or services. Since the introduction of the ISA in Papua New Guinea, the policy has had a diverse reaction from public and private sectors from very positive (e.g. engagement of wider public in economic growth) to very negative (e.g. increase in unmonitored illegal activities) (Kavan 2013).

Table 2.3: Differences between formal and informal economies in urban areas

The formal economy is:	**The informal economy is:**
Where people work for wages in government, or in private sector firms, or where they own such firms	Where people 'get by', earning money or producing for their own consumption, without having 'jobs'
Where they pay income taxes and where firms pay value-added tax	Where they do not pay income taxes and do not collect value-added tax on what they sell
Where what they produce is counted in national production (GDP)	Where what they produce is not counted in national production (although they put food on most urban tables)
Where they are counted in the workforce	Where they are not counted in the workforce, because they work in self-employment and/or household-based activities
Where their time is structured	Where their time is unstructured: 'I work whenever I can', 'I work as long as it takes'
Where they have legal protection and rights	Where they are without rights and protection, or their rights are ignored

Source: The Department of Community Development and Institute of National Affairs 2011

2:9 Illegal Trade of New Guinea Birds

Monitoring international borders is essential to ensure that countries protect their biodiversity, and for the custodians that depend on it. Biosecurity measures safeguard native flora and fauna from introduced pests and diseases that might otherwise threaten food security. Rural communities in New Guinea derive much of their protein intake from fauna hunted from within their forests (Mack and West 2005). The illegal trade or trafficking of wildlife across transnational boarders has the potential to introduce threats to biodiversity (Trader 2013). Asia has been at the epicentre of illegal wildlife exploits (Eaton et al. 2015). The lucrative bird trade industry of Indonesia attracts such good payment that even law enforcers have been caught with species intended for trade in West Papua (Hidayat and Siniwi 2016). While Asia has received a lot of attention, a recent report published by TRAFFIC has indicated Solomon Islands to be a trading centre for birds in the Melanesian region. CITES and National protected species such as the Birds of Paradise and parrots native to Papua New Guinea and Indonesia were encountered during the survey period (2000-2010), in which these birds were exported by Solomon Islands (Shepherd et al. 2012) to countries overseas **(Table 2.4).**

Many species in the study by Shepherd et al. (2012) were listed as captive bred from data retrieved from the United Nations Environment Program – World Conservation Monitoring Centre (UNEP-WCMC) CITES Trade Database. However, some of the species were unlikely to be captive-bred considering that these species are difficult rear in captivity: for instance the Birds of Paradise (Shepherd et al. 2012). The distribution of Birds of Paradise is restricted to the New Guinea Island, the Moluccas, Aru Island in Indonesia, and Australia in the northern parts (Cape York) and the eastern side (Queenland). Given no import records of the captive species were provided, it is possible the species were transported into the Solomon Islands from Papua New Guinea and Papua (Indonesia).

It appears that numerous species were tagged as captive bred to bypass international trade regulations, hence birds endemic to New Guinea and Solomon Islands were laundered into the global wildlife trade (Shepherd et al. 2012). Cockatoos and parrots appeared to be in large numbers. Records indicate that Malaysia and Singapore were the main destination of export (re-export) from the Solomon Islands. Singapore re-exported the species to other countries.

Table 2.4: CITES species traded out from Solomon Islands

No.	Species	Captive bred	Wild caught	Species Distribution Range	Red List Status
1	Solomons Cockatoo (*Cacatua ducorpsii*)	10649	5345	SB, PNG	LC
2	Suphur- Crested Cockatoo (*Cacatua galerita*)	1060	0	PNG, ID	LC
3	Blue-eyed Cockatoo (*Cacatua Ophthalmica*)	40	20	PNG	**VU**
4	Cardinal Lory (*Chalcopsitta cardinalis*)	4502	1301	SB, PNG	LC
5	Brown Lory (*Chalcopsitta duivenbodei*)	350	0	PNG, ID	LC
6	Yellow-streaked Lory (*Chalcopsitta sintillata*)	150	0	PNG, ID	LC
7	Duchess Lorikeet (*Charmosyna margarethae*)	0	240	SB, PNG	**NT**
8	Papuan Lorikeet (*Charmosyna papou*)	150	0	PNG, ID	LC
9	Red-flanked Lorikeet (*Charmosyna placentis*)	70	0	PNG, ID	LC
10	**King Bird of Paradise** (*Cinncinuru regius*)	10	0	PNG, ID	LC
11	**Magnificent Bird of** Paradise (*Diphyllodes magnificus*)	10	0	PNG, ID	LC
12	Eclectus Parrot (*Eclectus roratus*)	6406	1644	SB, PNG, ID	LC
13	Singing Parrot (*Geoffroyus heteroclictus*)	13	352	SB, PNG	LC
14	Yellow-bibbed Lory (*Lorius chlorocercus*)	15254	3190	SB, PNG	LC
15	Black-capped Lory (*Lorius lory*)	1150	0	PNG, ID	LC
16	**Greater Bird of Paradise** (*Paradisaea apoda*)	20	0	PNG, ID	LC
17	**Lessor Bird of Paradise** (*Paradisaea minor*)	8	0	PNG, ID	LC
18	**Blue Bird of Paradise** (*Paradisaea rudolphi*)	10	0	PNG	**VU**
19	Dusky Lory (*Pseudeos fuscata*)	250	0	PNG, ID	LC
20	**Vulturine (Pesquet's) Parrot** (*Psittrichas fulgidus)*	60	0	PNG, ID	**VU**
21	Papuan Hornbill (*Rhyticerous plicatus*)	660	280	SB, PNG, ID	LC
22	**Twelve-wired Bird of Paradise** (*Selecidis melanoleucus*)	10	0	PNG, ID	LC
23	Rainbow Lorikeet (*Trichoglossus haematodus*)	3617	1340	SB, PNG, ID	LC

Source: UNEP-WCMC CITES Trade Database, IUCN; Shepherd et al 2012.
Key to countries: Indonesia = ID, Papua New Guinea = PNG, Solomon Islands = SB

2:10 CURRENT THREATS TO ENDEMIC BIRDS

Globally, 1200 species of birds are threatened; over 960 of these species are found in the tropical rainforest areas (BirdLife 2013). The three main threats to avian fauna in tropical forest regions include change in native habitat either through loss, conversion or fragmentation, unsustainable harvesting practices, and invasive species (Sodhi et al. 2011). Recent systematic review of hunting in the tropics indicates that unsustainable hunting poses the most immediate threat to decline to birds and mammal populations (Benítez-López et al. 2017). While climate change may cause species to shift elevation range (Both et al. 2006, Freeman et al. 2013, Freeman and Freeman 2014b), immediate concerns are directed towards anthropogenic pressure, due to its high impact on forests or species habitats. Endemic birds in tropical montane areas and islands with restricted ranges are particularly vulnerable (Sekercioglu et al. 2008a).

2:10.1 Species Threats from Habitat Loss or Degradation

Species loss is often attributed to complex factors acting independently or synergistically (Brook et al. 2008), **Figure 2.1.** A key factor of species demise is the loss of habitat (BirdLife 2013). Habitat loss may occur as a result of forest degradation (or conversion). Disruption of ecosystems causes subsequent changes to the structure of habitats, and thereby incites varying responses from species.

By nature, some species are more susceptible to the effects of habitat loss than others (Colles et al. 2009). These include species with a narrow ecological range or specialised to a niche, or guild. As an example, some understorey species are adapted to certain light level requirements which dictate their microhabitat. Activities such as logging lead to increased level of light, and consequently reduces the number of light sensitive bird species in the forest (Castelleta et al. 2000, Pearson et al. 2010). The adaptation of birds to certain forest strata such as the understorey, may be for predator avoidance (e.g. larger avian prey species), or a specialised feeding guild; for example, birds, whose diet consists largely of insects or insectivores. A reduction in forest cover has been shown to result in a decline in numbers of insectivorous birds in Costa Rica (Sigel et al. 2006), and Singapore (Castelleta et al. 2000). Refer to **Table 2.5** for the main hypotheses (non-mutually exclusive) that explain bird losses. Hence, disturbances to habitat is one of the main driving factors threatening bird species in Australia (Garnett and Brook 2007, Sodhi et al. 2010, BirdLife 2013).

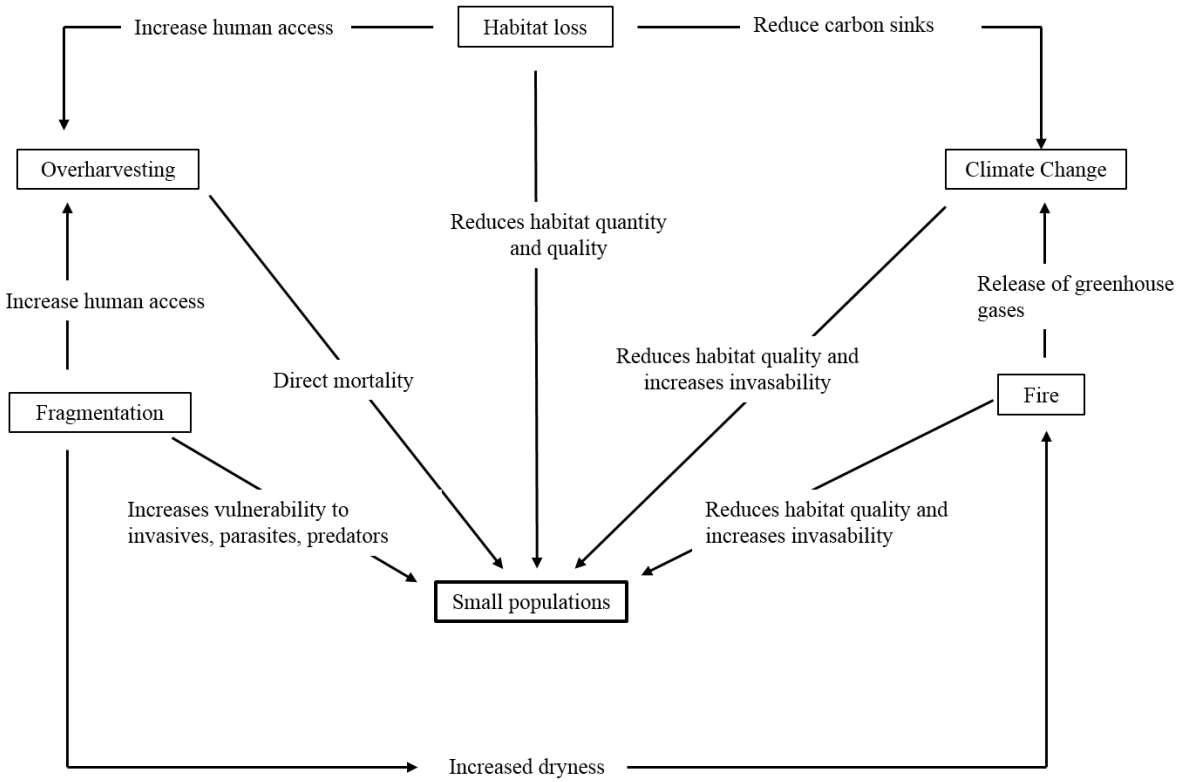

Figure 2.1: Synergistic feedback that threaten species in disturbed tropical rainforest, adapted from (Brook et al. 2008)

Natural environment perturbations (e.g. drought, fire, landslide, volcanic eruption etc.) affect populations of species. Environment perturbations are generally followed by a recovery process. There are three main phases which affect the turnover of species; the gap phase following a disturbance, building phase, and the mature phase. Once a tree falls, it creates an opening in the canopy which allows shade tolerant species (primary forest species) to utilise the sunlight. Seeds stored in soil banks (pioneers) are fast growing yet do not usually become the dominant species in the equilibrium phase of the forest.

There are trade-offs in the life-history of these tree species. Within the gap phase, some seeds are dispersed by animals or in the case of some tropical regions, volant mammals, or avian frugivores, such as hornbills or cassowaries (Mack 1995). Over time there can be many species occupying this gap (building phase) until equilibrium is reached where only certain species dominate the canopy, then mid and understory. This process was first described by Connell (1978) as the Intermediate disturbance hypothesis. During the gap phase, understorey bird species that are light sensitive (Pearson et al. 2010) can have their foraging behaviour affected. A similar study has indicated gaps inhibit the dispersal ability of birds (Stratford and Robinson 2005).

2:10.2 Biotic interactions

Species can coexist by using the same resources. The limiting factor though would be the recruitment of the species given the resources available (Hubbell et al. 1999). This implies that recruitment limitation will operate on certain local scales (for example micro site heterogeneity, soil nutrient availability) (Wright et al. 1997, Givnish 1999): for example, tree species preference for soil types observed to occur in patches in the forest (Wright et al. 1997). This may seem to support the competition exclusion principle, where several species compete for the same resources resulting in exclusion of the others and the dominance of one. However, within the same site mycorrhizal association may promote certain species to exist thus leading to another biological phenomenon, resource partitioning (niches).
On a single tree, different species of insects may utilise the same tree species differently. For example, some species of insects specialise in feeding on different structures of the same plant. On the same tree each species has its own niche, microhabitat which allows different species to utilise the same guild (Erwin 1982). Similar results on niche partitioning and diversity were observed in Papua New Guinea (Basset et al. 1996, Basset and Novotny 1999).

Environmental variables such as edaphic factors, moisture, humidity, sunlight all help facilitate different relationships.

2:10.3 Productivity

Productivity in this scenario refers to the amount of energy stored by photosynthetic plants (Ricklefs and Miller 1999). Since the equatorial regions receive more direct sunlight than areas towards the pole, the energy stored in the lower levels of the food web (by plants, algae etc.) are high and support many more organisms. This theory was first suggested by Connell and Orias in 1964. The relationship higher up in the food web between species is also related to the level of productivity. For example, predator-prey numbers may depend on the abundance of productivity at the lower trophic level. If there is high productivity, there are more prey and more predators, thus the ratio of predator and prey increases with productivity (Rosenzweig 1995). Although it applies well to the tropics, it is only evident in some cases (Currie and Paquin 1987, Currie 1991).

Table 2.5: Main hypothesis that explain bird species loss following disturbances to habitat

	Hypothesis	Prediction	Possible mechanisms(s)	References
1	Habitat specialisation influences extinction	Forest species disappear disproportionately	Loss in habitat quality and quantity	(Castelleta et al. 2000, Pearson et al. 2010)
2	Foraging specialisation influences extinction	Guilds such as insectivores and frugivores will suffer losses	Reduction in food availability, poor dispersal	(Castelleta et al. 2000, Sigel et al. 2006)
3	Body size affects extinction	Larger sized species will be lost	Low productive output, large area requirement	(Castelleta et al. 2000, Johnson et al. 2004, Brook et al. 2008)
4	Range size influences extinction	Small-ranged species are extirpated	Low abundance, high specialisation	(Kattan et al. 1994, Christeniansen and Pitter 1997)
5	Abundance affects extinction	Rare species disappear	Low population replacement, high specialisation	(Newmark 1991, Feely et al. 2007)
6	Home range sizes influences extinction	Species with large home range disappear	Lack of adequate habitat	(Kattan et al. 1994, Harris and Pimm 2008)
7	Bird dispersal abilities affect extinction	Species with poor dispersal abilities are lost	Poor chances of recolonization	(Newmark 1991)
8	Bird physiology affects extinction	Light-sensitive birds disappear	Alteration of microhabitat	(Lees and Peres 2009)
9	Complex social behaviour influences extinction	Species such as mixed-flock members and those following army ants are lost	Loss of affiliate, loss of suitable habitat	(Bierregaard and Lovejoy 1989, Van Houtan et al. 2007, Lees and Peres 2008)

Adapted from (Sodhi et al. 2011)

2:11 ANTHROPROGENIC FOOTPRINT WITHIN A LANDSCAPE: PAPUA NEW GUINEA

Deforestation due to anthropogenic activities is a major driving force in tropical rainforest contributing to landscape change and reduction of biological diversity. Forest cover losses have been quantified for rainforests such as the Amazon, Congo, and Papua New Guinea (Fearnside 1990, Skole and Tucker 1993, Mayaux et al. 2005, Shearman et al. 2008). Improvements to techniques used, as well as interpretation of the data, are important to enable a clearer understanding of the state of forest in those regions (Downton 1995, Shearman et al. 2008, Mayaux et al. 2013).

The first comprehensive assessment of forest loss in Papua New Guinea (PNG) was conducted in the early 2000s using remote sensing techniques (Shearman et al. 2008). The study incorporated high resolution 7-band digital satellite data including 4 band (SPOT 4 & 5), new SRTM 90 m resolutions that measured forest loss between 1972 and 2002, map forest boundaries more accurately, and generated an updated forest cover map. This research did not use existing Papua New Guinea data created by Commonwealth Scientific and Research Organisation (CSIRO) Australia from 1960s – 1980s. The data from CSIRO include Forest Inventory Map Systems (FIMS), the MASP (Mapping Agricultural Systems in PNG), and PNG Resource Information System (PNGRIS) (Filer et al. 2009). The difference in scale and resolution of maps and satellite imagery rendered the established data set incomparable (Shearman et al. 2008). The baseline map used by Shearman and others in the State of the Forest of Papua New Guinea was 1:100,000 topographical maps (series T601). The mappers responsible for T601 1:100,000 series did not distinguish between forest types; especially tall secondary regrowth forest that had been previously cultivated versus undisturbed primary forest. Comparison of time series analysis can potentially over estimate the size of forest loss (Allen and Filer 2014).

A significant finding of the research indicated that PNG's forests were degraded at an annual rate of 1.41 percent annually and by 2002 accessible lowland primary forest was degraded at 2.6 percent per annum. If continued at the current rate, an alarming 83 percent of the country's existing forest will have been cleared by the year 2021. The study further revealed that forests within some of the designated protected areas were converted to subsistence use, hence, rendering current efforts by the government, local conservation practitioners, and traditional custodians as inadequate. A follow up country wide forest assessment is needed to verify the extend of forest loss as we approach the year 2021.

Anthropogenic factors continue to be an issue with tropical rainforest regions. For instance, road accessibility into the interior of forest resulted in forest loss for Cameroon (Mertens and Lambin 2000) whilst agriculture expansion, and fuelwood demand were the major drivers for the Congo Basin and Madagascar (Mayaux et al. 2013). For the case of Papua New Guinea, forest cover loss between 1972 and 2002 has been mainly attributed to subsistence agriculture and logging (Shearman et al. 2008). More research is needed to elucidate forests that have regenerated from decades of subsistence agriculture pre 1970s by comparing to untouched primary forests (Allen and Filer 2014), particularly where human population density is low, and where shifting cultivation is still practised.

In areas where conversion of forest overlaps into protected areas, follow up assessment is needed to measure the extent of change. Papua New Guinea currently has 34 protected areas that offer inadequate area to conserve endemic and vulnerable species with restricted ranges (Chatterton et al.

2006, Benítez-López et al. 2017). Over 30 years, five protected areas in the central highlands have, on average, converted 21.6 percent of the forest for subsistence agriculture. Such forest loss can further enhance the threats to species with restricted range (Shearman et al. 2008). The analysis of Papua New Guinean protected areas is consistent with global assessments (Rodrigues et al. 2004).

Coarse grain studies of forest loss are useful for a regional understanding of forest loss (Hansen et al. 2013). Improvements in spatial tools have enabled analysis of areas with minimal forest loss (Tyukavina et al. 2015) but this also cannot detect minimal anthropogenic activities or natural disasters. While most major disturbances such as logging, old slash and burn agriculture, and deforestation can be detected using conventional remote sensing tools, hunting habits that do not utilise fires have low detectability (Peres et al. 2006). Hunting is responsible for over 50% of bird decline in abundance, and over 80% of mammals in the tropics (Benítez-López et al. 2017). Hunting patterns of local people can be used to indicate the human footprint throughout a landscape. Global analysis of hunting communities indicate wildlife were depleted within 7 – 40 kilometres of hunters' access points (that is either settlement or roads) (Benítez-López et al. 2017). Within Papua New Guinea, the average is 5 km from hamlets (Mack and West 2005) in very remote areas. Studies in New Guinea are yet to be conducted of areas within proximity to road networks or towns. Hence, these patterns can also be used to understand the distribution of species and Indigenous people's intimate knowledge in relation to species, space (their extent of influence) and connection to cultural practices.

Integrative research is essential to depict patterns such as species distribution (section 2.5), and human spatial dimensions, for instance, hunting intensity within a landscape. Humans and species existence are intertwined, within a cultural context. An interdisciplinary approach establishes a coarse to fine scale examination of questions that need to be answered to explicate information needed for improved natural resource management.

2:12 INDIGENOUS KNOWLEDGE AND RESOURCE USE

Indigenous ecological knowledge (IEK) is a knowledge practice belief system inherently linked to Indigenous communities' customs connecting people to their environment (Berkes 2008, Martin et al. 2010). IEK is often described as holistic (Freeman 1992), integrating the physical and spiritual into an understanding of Indigenous peoples' view of their world or cosmology (Houde 2007). The evolution and persistence of IEK is through oral history transmission, over human generations, with emphasis on practical application of skills using knowledge base (Berkes 1993).

There are criticisms of the use of the word "traditional" which can be perceived as an unchanging or non-adaptive body of knowledge (Berkes 1993, Warren 1995). However, the term "traditional" has

been widely recognised. For instance, the Indigenous Peoples Working Group of International Union for Conservation of Nature (IUCN) uses the following definition;

"Traditional (ecological) knowledge refers to the knowledge, innovations and practices of indigenous and local communities around the world. Developed from experience gained over the centuries and adapted to the local culture and environment, traditional (ecological) knowledge is transmitted orally from generation to generation. It tends to be collectively owned and takes the form of stories, songs, folklore, proverbs, cultural values, beliefs, rituals, community laws, local language, and agricultural practices, including the development of plant species and animal breeds. Traditional knowledge is mainly of a practical nature, particularly in such fields as agriculture, fisheries, health, horticulture, and forestry." (Convention on Biological Diversity, Article 8 (j))

Arguments relating to the use of IEK in relation to modern conservation practices have been made on the grounds that its belief system is unable to complement environmental assessment (Howard and Widdowson 1996). While this may be the case, philosophical lessons that exhibit characteristics within proximity to IEK learned over years by Indigenous people (Haraway 1988, Massey 1999) can inform modern science: for instance, adaptation strategies for environmental climate resilience in present times (Roös 2015). Hence, Indigenous ecological knowledge can contribute effectively to natural resource management (Berkes 1993, Berkes et al. 2000, Chapman 2007). Furthermore, comparison of IEK to scientific ecological knowledge (SEK) has shown that Indigenous communities' knowledge gained from years of observation has merit in the conservation of species (Sinclair et al. 2010). Hence, involving local Indigenous assistants as experts in projects of conservation can also reduce the costs of conservation (Padmanaba et al. 2013) and further allow for an holistic understanding of natural resource use in a landscape.

2:12.1 The Epistemology of Indigenous Ecological Knowledge

Epistemology refers to a system of ideas (theory) that seek an explanation founded on certain principles (Bernard 2006). Epistemology is also concerned with how theories are constructed, encoded, and transferred on to the next knower or generation. IEK acquisition is mainly from direct observation and their inferences by the observers (*rationalism* or *empiricism* in this regard). Scientific ecological knowledge on the other hand, is from deductive reasoning (*positivism*), and employs standardised techniques of measuring, and recording observations (often called *humanism* or *interpretivism* in social sciences). IEK is holistic and has depth in the context of the community that uses and values it (Berkes et al. 1998, Berkes et al. 2000) .

Indigenous ecological knowledge has a longer timescale of harbouring, adapting, and keeping knowledge within a community, a form of oral repository by comparison to scientific ecological

knowledge (Berkes 1993). Often IEK is specific to an area and can be particularly useful for complementing scientific knowledge. The level of IEK held by its community members varies by gender, status or social position , and age (Houde 2007). The dissemination of IEK is through oral transmission.

Indigenous and scientific knowledge differ in two main ways. The epistemology and methodology shapes their worldviews. **Table 2.6** below outlines the main difference between IEK and SEK adapted after Berkes (1993).

Table 2.6: Summary of different characteristics of Traditional and Scientific Ecological Knowledge

IEK characteristics	SEK characteristics
Mainly Qualitative data	Mainly Quantitative data
Has an intuitive component	Purely rational
Is holistic, spiritual and morally bound	Reductionist, mechanistic and (supposedly) value free
Acquired from empirical observations and accumulation of facts by trial-and-error	Derived from experimentation and systematic, deliberate accumulation of fact.
Dynamic in nature, i.e. can be quick to adapt to change	Slow to change established norms
Based on diachronic data, i.e. long time-series on information on one locality	Usually synchronic data, i.e., short time-series over a large area

Adapted from (Berkes 1993)

Social Research Methods in Indigenous Ecological Knowledge

Understanding IEK using research techniques mostly yields qualitative data (Berkes 1993). Qualitative research is defined as a method of inquiry that employs a suite of techniques to gather information to understand human behaviour and motivations that induce such behaviour. The data can be descriptive or quantified. The researcher can decide whether to analyse the data in a qualitative or quantitative manner depending on data coding and themes.

There are six main methods for research in IEK. These methods are key respondent interviews, semi-directed group interviews, mapping interviews, self-reporting, questionnaires, and participation observation (Miraglia 1998, Huntington 2000, Bernard 2006). The *key respondent interviews identify*

people in the community knowledgeable about the research theme. The interviewer must be prepared to allow more time to learn as much as possible from the interviewee. This technique of interview is open ended and may be conducted in a conversational manner. Whilst the conversation takes place, the attentive researcher listens, interprets, and reviews whilst formulating questions to allow to the discussion to flow. The data are qualitative. Comparison of IEK and SEK can be tested quantitatively. This entails survey of knowledgeable individuals from a community using structured interviews (or semi-structured interviews). Data collected can be either descriptive or inferential and requires processing of the information gathered to construct worldviews by the research of the emerging themes. Such an approach has been tested for SEK and IEK from megapodes for knowledge precision and accuracy (Sinclair et al. 2010).

A Semi – directive group interview involves the interview of key respondents who are knowledgeable about a research theme (Nakashima 1990, Davis and Wagner 2003). The participants are pooled together for a group interview where the format of interview is open ended. The method's strength allows communities' view (consensus) on a topic, and make an assessment of the most knowledgeable people (IEK experts) within the community (Miraglia 1998).

The third method of IEK research is the *mapping interview technique*. This technique allows local participants to mark their observations or activities, for instance localities of species hunted (kills), fishing spots, onto a map. The map or data points can be scanned and incorporated into a GIS system for spatial analysis (Balram et al. 2004). Balram et al further mention that a qualitative way to assess the level of consensus by local IEK experts is to use the overlap areas of map polygons to indicate the location and extent of the knowledge agreement. The quantitative way is to use the Spearman rank correlation coefficient to measure the correlation between the overlap polygons. Practical applications of this method integrated with SEK can be used in mapping fisheries zones for marine resource management (De Freitas and Tagliani 2009).

The self-reporting method involves the researcher handing out a form to participants to fill out the activities or observations (Miraglia 1998). This case works best if the participants are constrained by time and can be conducted as a focus group or community meeting. This method is also suited for communities with high literacy rates. For remote communities in developing countries where literacy levels are low, this method may not work well unless the researcher is prepared to invest time in recording responses from participants.

Structured questionnaires are another method where the researcher has enough knowledge about the research subject (Miraglia 1998). Responses to carefully constructed questions are received and recorded. However, one drawback is that there is a likely chance that key information was left out, or

a participant mentioned something that was not captured in the questionnaire. A typical questionnaire may contain; lists of questions, usually requiring either short answers or a selection of multiple-choice responses, or a selection within a Likert scale. The researcher can either ask the participant questions (interview) or even allow the participant to fill out the questionnaire if the participant is able to do so.

Credibility of information gathered from interviewees or participants of the research is important. Example of ways to filter information include build-in data triangulation and focus groups to verify accounts or events (Neuman 2011). Built in data triangulation in an interview or questionnaire includes the presentation of the same question to the participant in different manner. Disparity in responses indicate that data may not be suitable for consideration or warrants further probing.

Participation Observation is a technique used in ethnography. Ethnography is a research technique that involves the researcher being immersed in the typical daily life events of a place, community, culture, and learn by observing and participating (Bernard 2006). During the process, the researcher may part-take in the daily life activities. This technique has been credited to Bronislaw Manlinowski, an anthropologist who studied culture and way of life of the Trobriand Island people of Papua New Guinea in the early 1900s.

When SEK and IEK are used together, the approach provides a holistic understanding of conservation particularly to a locality. The inclusion of IEK, involving local Indigenous people in the process of engagement creates a sense of unity towards a common purpose, conservation, despite the apparent difference in epistemological acquisitions.

2:13 SPECIES DISTRIBUTION MODELLING: MAXENT

Forest coverage alone cannot provide information about habitats of species. Ecological models are an important tool for mapping out species distribution (habitat) in a geographical context and the resources (variables) that define its habitat (niche). A scale representation with key information enables conservation practitioners to make informed decisions towards conservation planning and management.

For models to work, data input such as abiotic environmental variables (rainfall, temperature) and data in the form of biological observations which can be obtained from museum specimens or herbaria serve as good records of historical distributions (Remsen Jr 1995). Gaining an understanding of where and why species occur in each space aids in the management of species and within the landscapes. One of the fundamental theories in ecology, the niche concept, is concerned with where species occur in the environment (Begon, et al. 2006). The niche concept predicts species distribution given conditions that are specific to the species. The fundamental niche concept is described as ‘n-

dimensional hypervolume' where a species can exist in each space under suitable conditions (Hutchinson 1957).

However, the specific conditions (biotic and abiotic factors) that are suitable for one species can also be shared by another species. Furthermore, the resources that define the occurrence of a species can be unevenly spread along a continuum for instance, an elevation gradient. This can result in interactions such as competition or predation which act as constraints contributing to how a species can occupy a space (Hutchinson 1957). This is termed the realised niche, or its potential distribution (Pearson, Raxworthy et al. 2007).

Human interactions with the environment have been a main driver in shaping the current landscape. For instance, anthropogenic practices such as agriculture, logging, or expansion of human settlements alter the natural habitats of species. This results in fragmentation of habitats, which affects how species are dispersed in relation to resources. The movement between patches of habitats or from "source" population to "sinks" is another key ecological concept relating to populations of species in the theory of island biogeography (MacArthur and Wilson 1967).

Such ecological concepts were postulated for a broad spatial context in the field of ecology and were derived from observation of events that were measured or monitored over a short period. Periods of observations, enable better understanding of how species interact or behaviours in their environment (e.g. breeding, feeding ecology, dispersal ability). This set of knowledge acquired though a systematic acquisition of facts through observation by quantifiable data is what merits scientific ecological knowledge (SEK).

To understand how a species is distributed within a landscape, understanding its ecology, biotic and abiotic factors can enable us to make estimations about its occurrences using species distribution models (SDM). Species distribution models serve many purposes including; response to environmental changes, predicting species range and determinants (Guisan and Thuiller 2005, Elith, Kearney et al. 2010). SDM uses also extend to predicting potential locations of species with restricted ranges or those considered rare (Hoegh-Guldberg, Hughes et al. 2008, Elith, Kearney et al. 2010) (Elith & Burgman, 2002; Hoegh-Guldberg et al., 2008).

Maxent is a species distribution model that uses presences-only data. The Maxent program has been shown to outperform other species distribution modelling techniques (Elith, Graham et al. 2006, Guisan, Graham et al. 2007, Pearson, Raxworthy et al. 2007). The Maxent program functions on the principle of maximum entropy, where probabilities of species presence are statistically tested with their occurrence of an environmental variable. There are two main ways to assess a model; i) model

fit, which refers to how well the data fit to a model (also called *training data*) and ii) prediction, the accuracy of projection of independent data (also referred to as *test data*). A measure of the strength of the model(s) performance is by the comparison of the area under the curve (AUC) of a receiver operating characteristic (ROC) plot. The scores are rated from 0 to 1. An AUC score represents perfect fit of the data, and 0.5 represents a random occurrence (Elith et al. 2006, Phillips et al. 2006). Inferential statistics can be employed to test for difference between AUC values for multiple models. An essential component of Maxent is the jackknife test which assesses the model fit by measuring the importance of the individual variables and their contributing effects on species occurrence (Elith et al. 2011). Under jackknife, the relative importance of each variable can be measured in terms of decrease or increase in gain. For instance, a high gain by a variable indicates that the variable is a good predictor for the species survival.

An alternate that provides a better utility for assessing model fit is the Environmental Niche Model Tool (ENM Tools). Two values from the ENM Tool identify which of the models in comparison is the most parsimonious; Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC). The AIC is a measured estimate of the goodness-of-fit of a dataset and its fitted likelihood function (parsimony) in reference to other models. The model with the lower AIC score is closer to the true model (Warren et.al. 2010). BIC is essentially a criterion for model selection among a set of models and often used in conjunction with AIC in ENM Tools (ibid.)

There are limitations of using Maxent as a SDM. These include uncertainty of projecting into novel environments, the non-use of absence data when it is available, and the assumption that a species is in equilibrium with its environment (Phillips and Dudík 2008, Elith and Leathwick 2009). Measures that can be used to resolve the limitations include selection of samples, within a buffer, of a defined group, to detect sampling bias. Alternately, an option is to use fade by clamping particularly for projections into novel space (Phillips and Dudík 2008). Additional steps can be taken by incorporating climatic data which can create a more representative output of reality (Reside 2011).

2:14 SUMMARY

Thousands of years of association with the land, hunting and gathering, horticulture, and trade establishments have allowed New Guineans to use their environment to sustain them in a manner that also supported a diversity of ethnic identity. The early development of an independent horticulture practice and the introduction of sweet potato over 500 years ago allowed New Guineans to become settled and transformed the highlands societies. For low density communities, the harvest of staples such as sago allowed movements of people during seasons along the landscape for lowland areas and maintained connection with the environment. The literature indicates that sago is an important plant crop for lowland settlers. Communities in Papua New Guinea that have geographical custodianship

extending from lowland coastal forest to mid-montane appear to be less densely populated by comparison to those in the central highlands. Comparing these communities' hunting patterns with the central highlands is essential to gain insights of species that are most at risk of over hunting either for consumption, trade, or the expression of cultural identity.

Recent global studies indicate hunting pressure in the tropics is the main contributing factor to bird and mammal species loss (Benítez-López et al. 2017). More research from Papua New Guinea is needed to situate contemporary hunting practises within a fine to landscape scale to fully understand how the impacts of hunting have ramifications on species and culture. Trade is the conduit that allows for hunted species to be transacted along traditional routes.

Trade remains an important part of traditional societies. Trade allowed relationships to thrive between tribes, met the needs of those exchanging items and allowed the transacted items to be used in ways that encouraged the arts and expression of cultural identity such as the headdress. The use of fauna (e.g birds) in culture was central to human association with the environment, a depiction of gender roles, authority, and status.

The knowledge of bird fauna in current cultural use needs to be updated to reflect the contemporary society. Research is needed to understand the current threats globally, regionally, and locally. It is crucial to gain insights into the contemporary trends in trade of species to allow policy makers, practitioners, and traditional custodians to navigate the best path to manage species which are intricately linked to subsistence livelihood and cultural identity. It is apparent from the literature that international conventions and agreement such as CITES have done little to protect the trade of endangered or protected species such as the Birds of Paradise that are culturally significant.
The following chapter addresses changes in the trade of birds in the central highlands of Papua New Guinea over the last 40 years.

CHAPTER 3: Changes in the trade of birds in the central highlands of Papua New Guinea over 40 years

3:0 INTRODUCTION

The trade of birds is considered to be one of the significant factors contributing to global bird population decline (Gilardi 2006, Benítez-López et al. 2017). Most species traded are exported live from developing countries to affluent nations for a market demand in exotic pets (Butchart 2008). The trade of birds within indigenous communities is also common. Unlike western nations, often the trade or use of bird species by indigenous communities is related to food security and cultural practices (Tidemann and Gosler 2010). Some uses of birds by Indigenous cultures are for medicinal purposes (Fernandes-Ferreira et al. 2013, Williams et al. 2013).

Larger birds are usually valued for their meat which can provide an important source of protein in the diet of local communities (Mack and West 2005, Pangau-Adam et al. 2012, Harrison et al. 2016). However, while many species provide little nutritional value, their plumes are valued for their aesthetics (Sillitoe 1988a, O'Hanlon 1989, Van Den Bergh et al. 2013). Such is the case for the Birds of Paradise and the New Guinea Parrots. New Guinea has had a long history of trade in birds and their plumage extending over 5000 years suggesting trade activities between mainland Asia, South East Asia, and connections to New Guinea (Swadling 1996). No specimens of birds can survive for thousands of years and as such, other forms of evidence are referred to such as the ancient trade routes from Asia to Indonesia (and Island of New Guinea) and relicts with incriptions of objects traded (Swadling 1996, Doustar 2014).

Trade is an essential part of Papua New Guinea's diverse cultures. It is from trading that people create social relationships that extend beyond their traditional clan boundaries. Hence, trade acts to unify clans and tribes. Further to this, the species typically traded have cultural associations predominantly to the male gender. This is indicated in hunting, the assembling of bird plumes and skins that constitute a headdress, the names given to men linked to species, and the actual act of trade of the species (see Chapter 2).

By law, the hunting of Birds of Paradise in PNG is permitted only by traditional custodians, and only with the use of traditional weapons. However, the trade of all protected species is prohibited (Healey 1990). The trade of Birds of Paradise was still ongoing in the central highlands between the 1970s and the 1980s partly due to a misunderstanding of the species permitted to hunt; the Lesser Bird of Paradise (*Paradisaea minor*) is commonly referred to as the '*Kumul*' and featured on the National

Crest. As such, hunters in remote areas of the country assumed this was the only species not permitted to be hunted by law (Healey 1990). In urban areas where policing of the legislation was effective, there was no trade of Birds of Paradise (Patterson 1974).

There has been little research and policy discussion regarding the protection of Birds of Paradise since the Fauna (Protection and Control) Act 1966 (Downes 1977, Peckover 1978, Kwapena 1985, Healey 1986). A few studies have assessed wildlife trade in urban markets (Patterson 1974), and the plume trade studies of the Maring people in the central highlands in the 1970s (Heaney 1982). Additionally, other research covered use of wildlife in crafts, their conservation, myths, and cultural transactions in Southern Highlands. Over the last three decades only three hunting studies were conducted in the central highlands (Hide 1984, Dwyer 1985, Sillitoe 2002, Mack and West 2005).

The thriving International commercial trade is recognised as a major threat to species survival in south east Asia (Eaton et al. 2015). Commercial trade of protected species has not been recorded in Papua New Guinea since the 'Plume Boom' era of the late 19th and early 20th centuries (Peckover 1978, Swadling 1996). Studies are needed to detect any concerns such as the unlawful export of protected species to a country that re-exports overseas (laundering). The first documented case of laundering was between Papua New Guinea and Solomon Islands which involved protected species of Birds of Paradise among other CITES endemics (Shepherd et al. 2012) and subsequently re-exported to other SE Asian countries. As a country, an assessment of endemic species trade is necessary to delineate the context of contemporary trade in Papua New Guinea and its associations with culture and conservation. Hence, the aim of this chapter is to improve current understanding of potential threats associated with the trade of species that may also be salient in a cultural context.

3:1 METHODS

3:1.1 Study Site

Four sites were selected for researching the current trade of plumes; two towns in the central highlands (Goroka and Mt. Hagen) and two cities on the coast – the National Capital District (N.C.D. incorporating Port Moresby) and Lae city on the north-west coast (**Figure 1.1**). These places were selected for their history in relation to hosting annual cultural shows: the Goroka and Mt. Hagen shows and their geographical location in the central highlands provinces where the market study was carried out. Goroka town in the Eastern Highlands Province was the location of where the trade took place due to its central position in the highlands and because of its long history with the Goroka cultural show. The time spent at each location is summarised in **Table 3.1**.

3:1.2 Trade Data Collection

Traders in market places and participants at annual cultural shows were interviewed (Rao et al. 2005, Pangau-Adam and Noske 2010, Pangau-Adam et al. 2012). Completing the interviews was voluntary and only individuals aged ≥ 20 years were involved. Permission was also sought to take photographs of species sold or their headdresses for identification purposes. *The Birds of New Guinea Guide* was used to identify species (Pratt and Beehler 2015). The data acquired through interviews included, demography of the participants and how species were acquired. Information on where the species was brought in from (its location), the cost of plumes or birds, hunting weapon or strategy, participant's general perceptions of the hunting intensity, as well reasons for their activity; either by trade or via cultural practice or headdress wear.

The questions asked of participants involved in the trade of species as well as those of annual cultural festivals are indicated in the appendices (**Appendix 3.1** and **3.2**). The questions had built-in data triangulation to detect bias (Neuman 2011). There were similarities in the two components of the interviews which involved cost of the plumes traded by the trader or as per the end user (cultural show participant). Other questions included the suitable trading times. The main difference however, was that one component was the trader at a market place, and the other the end user of the product, that is the species worn as headdress adornment.

3:1.3 Data Collection of Species on Headdress Adornment -Annual Cultural Festivals

Interviews of participants in cultural adornment were conducted in Goroka, Mt. Hagen, Lae, and Simbai (on the border of Jiwaka and Madang Province) (**Figure 1.1**). These surveys took place in the months of August, September, and October of 2014 (**Table 3.1**). At each show, at least three (3) members in traditional attire per cultural group (from the central highlands) from the four highlands provinces were interviewed. Over the four shows, 77 individuals representing 22 ethnic cultural groups from the central highlands were surveyed. The Kalam Cultural Show (Simbai, Madang Province) was the only show that was rural; the only means of reaching the site was by aircraft.

Responses to interviews were entered into an excel spreadsheet and coded to enable quantitative analysis using SPSS Software.

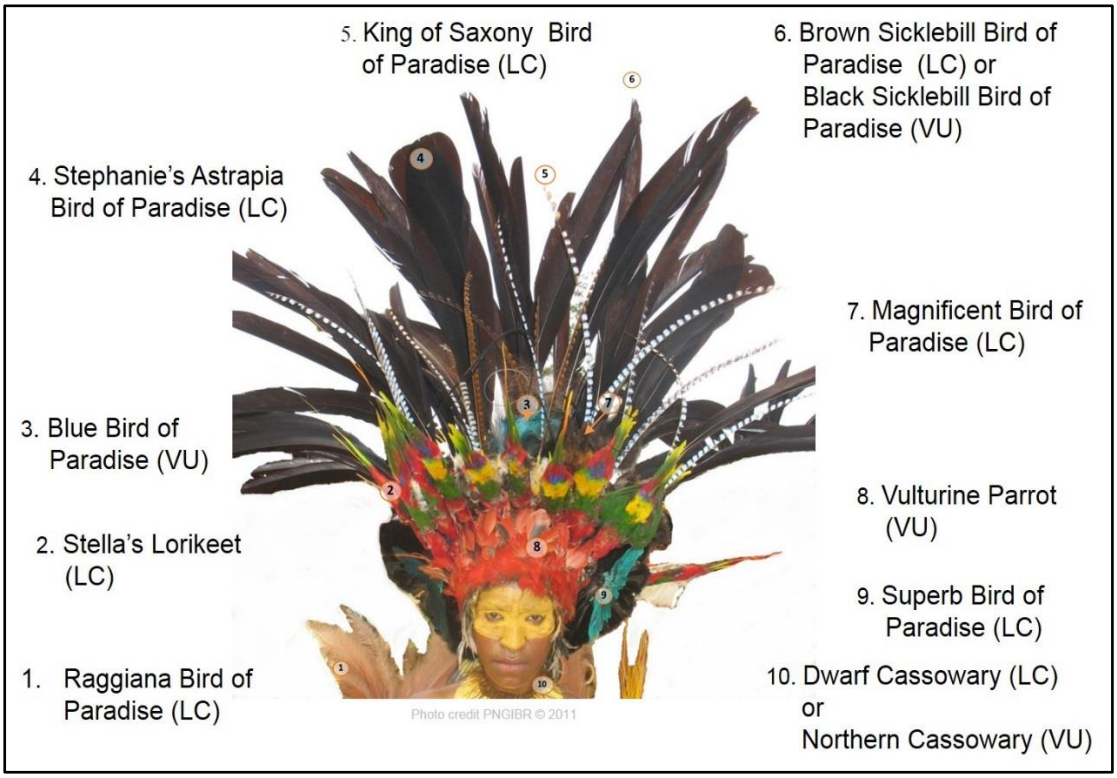

Plate 3.1: Atypical headdress worn by the Kuman speaking people of Chimbu Province. The letters in brackets () indicate the International Union of Conservation of Nature (IUCN) species status: LC = Least Concerned, VU = Vulnerable. This Plate 3.1 is of part awareness material (poster) from Papua New Guinea Institute of Biological Research Inc. (2012).

Table 3.1: Summary of field sites, and social survey, and the duration of field work for this Chapter. The numbers under the columns of Market and Cultural Show indicate the number of informants surveyed.

Site	Market Survey[a]	Cultural Show Survey[b]	Field work period	Duration
National Capital District, (The Capital) Papua New Guinea	30	n.a	20th September 2014 - 3rd January 2015; 3rd August 2015 - 20th January 2016[a]	41 weeks[a]
Goroka, Eastern Highlands Province	29	31 Goroka Cultural Show	12th September 2014 - 2nd Febuary 2015[a]; 12 September - October 2015[a] 15-17 September 2014[b]	27 weeks[a]
Lae, Morobe Province	8	12 Morobe Show	12th October - 30th December 2014[a] 12th - 14th October 2014[b]	14 weeks[a]
Mt Hagen, Western Highlands Province	2	21 Mt. Hagen Cultural Show	16th -19th August 2014[a] 12th – 15th August 2014[b]	
Simbai, Madang Province	1	13 Kalam Festival	15th-17th September 2015[b]	
Total number of people surveyed:	**70**	**77**		

Note: The superscript [a] and [b] are used to differentiate the field work dates for each type of surveys. Research assistants were engaged in the National Capital District to conduct weekly surveys (August – January/February) for the years 2014 and 2015.

3:1.4 National Capital District Market Survey

a) 1974-1975

The market survey undertaken in 1974 by the New Guinea Bird Society in Port Moresby (Patterson 1974) was mainly observation of species and quantity sold. The general area from where the species were sourced was recorded although demographic data of tradespersons (craftsperson or seller) were not recorded. The survey commenced in August 1974 and ended in January 1975. An hour was invested per day (89 days) on the survey over 5 months (between August 1974 – February 1975) for observations of species sold at Koki, Waigani, and Gordons Market. No surveys were conducted in the month of December 1974 and January 1975.

b) 2014-2015

Prior to conducting the survey, a preliminary fieldtrip was undertaken in June 2014 to assess the frequency of birds (live birds, skins, and plumes) on sale at various market sites in N.C.D. Live birds and feathers were sold infrequently. Occasionally, live birds were sold on weekends or towards the end of the week (i.e. Thursday through to the weekends). This information aided the strategy of the

survey such that the survey was undertaken for 2 days a week (Thursday or Friday and a day of the weekend) lasting at least 2 hours per day. The survey commenced in September 2014 and ended in January 2016. The locations of main craft markets in N.C.D included the front of certain shopping centres such as the Boroko Food World Shopping Centre in the suburbs of Gordons and Konedobu. Two other craft markets were surveyed once a month at certain locations (e.g. Ela Beach Craft Market and Holiday Inn Craft Market). These latter markets attracted locals, expatriates, and tourists' due to the secure locations (**Figure 1.2**, Chapter 1).

3:1.5 Data Analysis

Monetary values, or price of birds were standardised for comparison; the official exchange rate from the World Bank was used. The annual average exchange rate for the countries of concern (especially Papua New Guinea) was used against United States of America (USA) Dollar given its annual average consistency (**Figure 3.1**). The Papua New Guinea currency was on par with the Australian Dollar in 1974-1975.

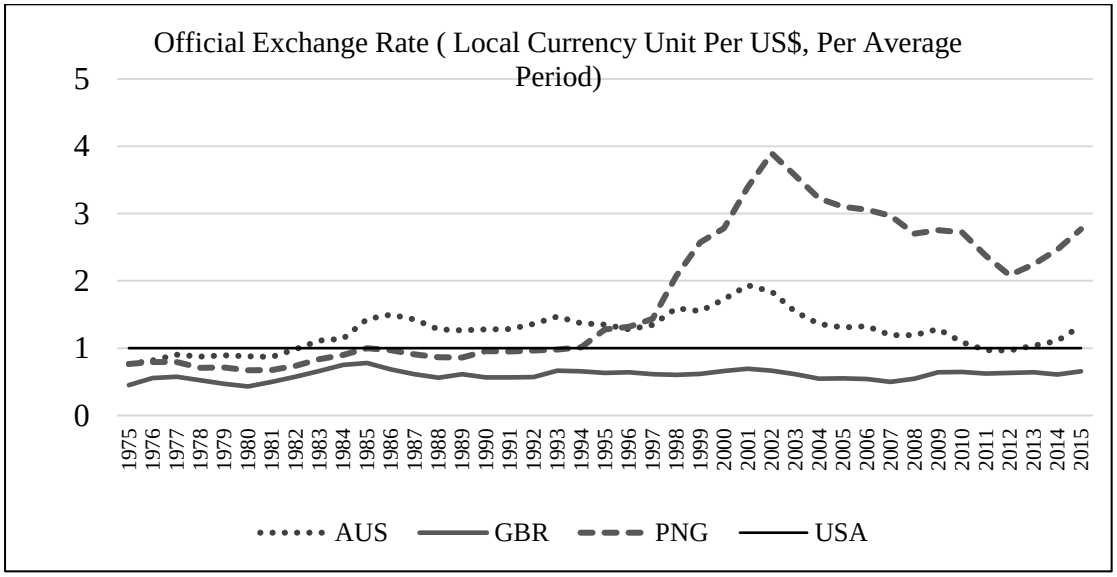

Figure 3.1: Official exchange rate for currencies from 1975 – 2015. The United States Dollar exhibits a consistent annual average of 1USA$ where Papua New Guinea (PNG) Kina and Australian (AUS) Dollars are converted to standardise prices of birds or plumes. The British pounds (GBR) was used in PNG prior to 1966. The currency exchange rates were obtained from the International Monetary Fund, The World Bank (http://data.worldbank.org/indicator/PA.NUS.FCRF), 2017.

From the mid-1980s to the late 1990s, the country experienced its first civil unrest led by traditional custodians of the Panguna mine in Bougainville Island in relation to environmental damage. The Panguna mine was the largest open pit copper mine in the Southern hemisphere operated by the Rio

Tinto company between 1972 – 1989. The unrest halted operations of the mine for over 20 years contributing to an annual 20% loss in Government revenue. Political instability coupled with the loss in Government revenue, and increasing expenditure pressured the Government to devalue the country's currency in 1996 (**Figure 3.1**).

To compile a profile for the average cost of birds for the central highlands region, costs gathered from species traded in the markets as well as cultural participants (**Table 3.1**) were combined. This profile excluded National Capital District (including Port Moresby). The National Capital District refers to the main jurisdiction for which the main city authority extends its influence including alienated land for extensions for development.

Detailed analysis of price trends is not feasible given that there is no established annual monitoring program of species of birds sold in markets. Instead, information on species that have been traded over the years has been collated from various sources (refer to Chapter 2, Section 2:7 Bird Trade in PNG Over the Last 40 years and Table 2.2). This study will only go so far as providing an overview of the species that have been traded as far as 40 years ago and comparing the change to this research period. The trend in species traded over the 40 years will be compared to this study only for species that had records (average costs) in the central highlands. To test for difference in means of the prices of each species of plumes, an ANOVA test was used.

To understand where species were sourced from, participants from the cultural festivals and traders were asked to identify, if they knew, the locations (source) of the species in their possession; for a trader, this would be the species sold, while for a person in traditional adornment this was about the species worn on their headdress. Valid responses were expressed as the proportion of total responses identifying a locality. The localities were identified to Districts within Provinces.

3:2 RESULTS

In this study, 70 people (23 women, 47 men) were surveyed selling birds and other traditional craft items. The highest number of women selling crafts (15) including plumes, was in the National Capital District. When considering regions, the highlands region had the highest number of people who sold birds and associated products; thirty-four (34) people were surveyed in the central highlands. Of this figure, only 9% were women, while 91% were male.

During the research period (2014 – 2015), I surveyed four (4) annual cultural festivals: Mt. Hagen Cultural Show (12 – 15 August 2014), Goroka Cultural Show (15-17 September 2014), Morobe Cultural Show (12 - 14 October 2014), and Kalam Festival, Simbai (15-17 September 2015). I mainly

interviewed members of cultural groups from the central highlands who had headdresses with at least two or more species of bird of focal interest. Seventy-seven individuals were interviewed in these cultural festivals (representing ethnic groups from these provinces; Eastern Highlands = 14, Enga = 1, Hela = 2, Jiwaka = 6, Simbai = 13, Morobe = 7, Chimbu = 13, and Western Highlands = 21. The numbers next to the provinces indicates the number of individuals representing these provinces during the cultural shows. There was less representation of Southern Highlands and Enga cultural groups in the shows from the sites surveyed.

Thirty-five females surveyed belonged to cultural groups that mostly constituted women, and 13 males surveyed belonged to cultural groups that were comprised of men. These groups were noticed to have at least 3-4 children each participating with them. Fifteen groups had approximately equal gender representation and more children (15 children) involved in the cultural dances.

Most of the locals (54% or 41 respondents) surveyed from the annual cultural festivals were subsistence farmers, while a few had formal employment (9 respondents). Four people volunteered their time with village cultural centres, while six were home makers. Two of the respondents were students in high schools (> 20 years old).

Source Areas from which Birds Species were Obtained for Headdress Adornment

The most commonly mentioned localities from which species were sourced was Jimi Western Highlands Province), followed by Bena, which is more towards the south side to Ramu (Madang Province) (**Figure 3.2).** Participants referred to this area as '*Wasan*'. The Wasan area is the long stretch of forests on the Bismarck Range, which is situated northwards from the Eastern Highlands Province bordering the Ramu area (from the Bismark Range). Thirteen species were harvested from Jimi and Baiyer, while Wasan had 11 species. Karimui, Wasan, and Jimi-Baiyer were mentioned as the source for Vulturine Parrots.

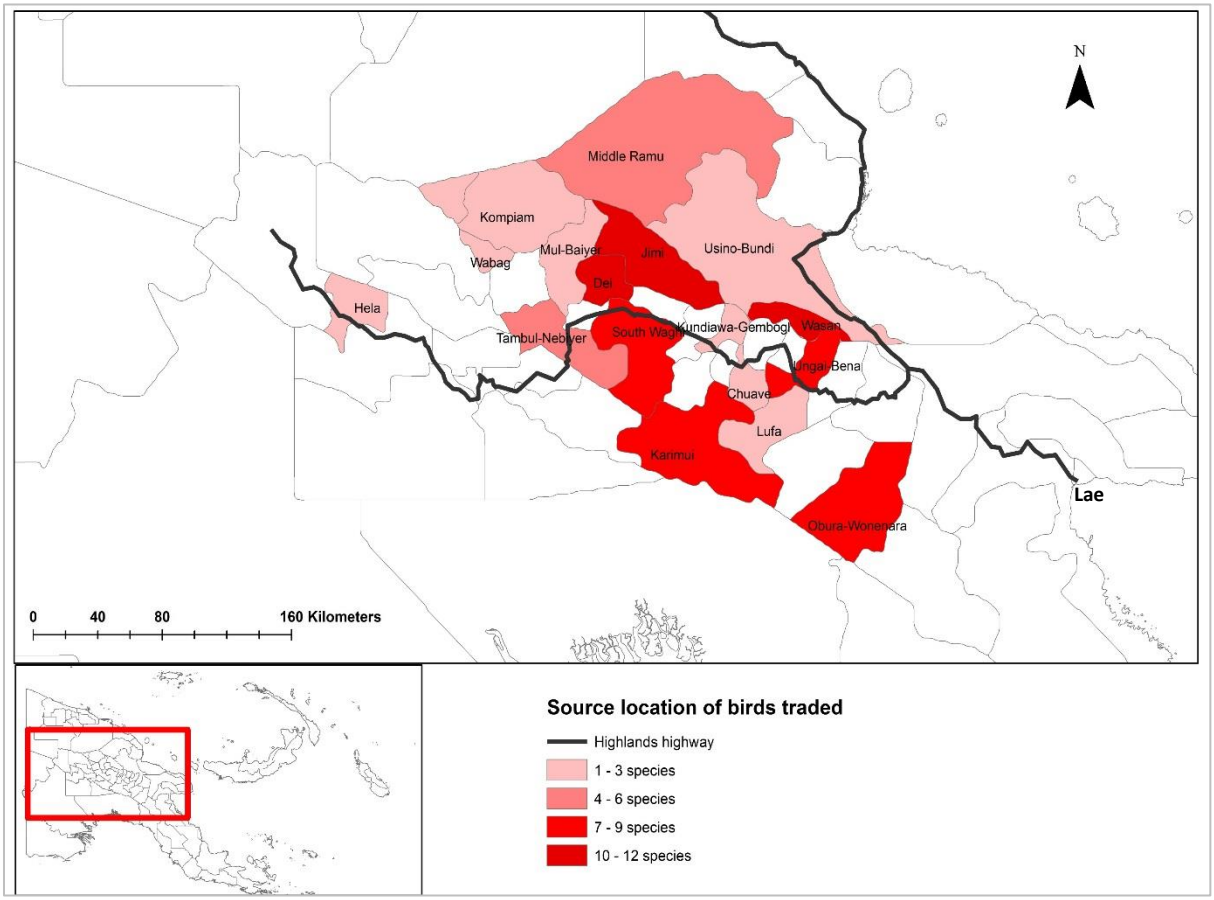

Figure 3.2: Locations in the central highlands for the source of plumes identified from annual cultural shows and market surveys in Goroka (2014, 2015), Mt. Hagen (2014), and Lae (2015).
Refer to **Appendix 3.3** for species by source site. Using the IUCN criteria, the vulnerable species identified were the Black Sicklebill, Vulturine Parrot, New Guinea Harpy Eagle, Victoria Crowed Pigeon, and cassowaries. With the cassowaries, it was often difficult to distinguish which species unless it was sold live or if the trader gave a good description.

3:2.1 Traders

Traders were asked about their opinion on the role of the trade of plumes in their livelihood (importance), and only 54 of the 70 participants responded. Sixteen of the participants did not provide an answer. Forty-three people mentioned that the trade of plumes was important. One respondent indicated that trade kept him engaged and provided a service to those people who live in the city and do not have access to the birds. A further nineteen of the responses identified the trade of plumes and handicrafts as a means of income. Seventeen crafts persons (40%) mentioned that the sale of plumes is important as it provides a service and additionally promotes cultural preservation. Only two people said the trade of plumes was not important whilst nine considered it was neither important nor unimportant.

There was an almost equal level of participant's awareness on the protected status of certain species allowable for trade. Thirty-three participants (47%) were not aware of the protected status of species, whilst 30 participants (43%) responded that they were aware and mentioned the Birds of Paradise were one of the group of birds under trade restrictions. Within the Birds of Paradise family, three traders referred to the Raggiana and the Astrapia Birds of Paradise as prohibited for sale. Two people mentioned that the Government has no right to prevent them from hunting on their own customary land. One person said he was aware that the law prohibits the export of species. Several traders considered it illegal to trade parrots (5 responses), cockatoos (2), and one response each for Harpy eagles, and hornbills. Only one trader mentioned that he has a license from the city council, hence he believes he can sell any crafts and birds species. There is no issue of licenses by city councils to informal sector traders as it is not a regulated industry. The license being referenced to was the user-fee for the designated facility to sell crafts in Mt. Hagen town.

To understand if there was a preference for the sale of certain species, we asked "*Which species of bird sells the fastest*?" Out of the 70 traders, only 31 responded to this question. Of these responses, Birds of Paradise (28), Parrots and Lorikeets (6), Cassowaries (6), and Vulturine Parrots (4) were the main species.

Bird plumes and skins that were large, new, and in prime condition sold the fastest. The main Birds of Paradise species sold included Raggiana Bird of Paradise (8), Stephanie's Astrapia (7), Black and Brown Sicklebill (4), Lessor Bird of Paradise (3), Superb Bird of Paradise (1), King Bird of Paradise (1). The values in brackets indicate the number of traders' responses. The Blue Bird of Paradise was very rare in markets surveyed, although a few were encountered in the survey of hunters (Chapter 4). Altogether, we found 34 species of birds traded during this survey.

3:2.2 Who Purchases the Birds Sold in the Markets in Urban Areas?

Fifty-six people provided responses to the category of their customers: central highlanders (13), customers from the coastal/ lowland regions (1), mixture of Papua New Guinea regions (12), mixture of Papua New Guinea nationals and International Tourists/ Expatriates (27). Three of the remaining mentioned that it was either their first time selling or that they did not keep track of their customers.

It is here that I make mention of a person selling an individual of the Hooded Pitohui (*Pitohui dichrous*) in September 2015 during the Annual Cultural Festival in Goroka, Eastern Highlands Province. The species sold in the market was intended for Japanese tourists who requested the species in 2014. The Pitohui bird is endemic to New Guinea and is the only known species of bird that harbours neurotoxin alkaloids for chemical defence similar to the poison dart frog in South America (Dumbacher et al. 1992).

3:2.3 The Trend in Cost of Bird Species for Headdress Adornment

The prices of species sold in urban areas versus rural areas in the central highlands were compared. Port Moresby, the capital was treated separately. The urban areas in the central highlands included the craft markets in towns (e.g. Mt. Hagen Craft Market, and Goroka Craft Market). The rural areas were villages away from town settings. There was a significant difference in the average cost of plumes/birds sold when compared between urban and rural areas ($F_{(1, 367)} = 10.990$, $P = 0.001$). Birds sold in urban areas cost more than those sold in a rural setting. When grouped, there was also a significant difference in the costs among the groups of birds (**Table 3.2**).

Table 3.2. The seven-main groups of birds sold (live as well as plumes) and their average prices in Papua New Guinea currency Kina (K) in the central highlands. The data combines market surveys and festival participants.

Main Bird Grouping	Mean Cost (PNG Kina)	N	Std. Dev	Sum	Std. Error of Mean
Hawks & Eagles	34.17	6	17.44	205.00	7.12
Birds of Paradise	66.93	222	53.34	14858.00	3.58
Cassowaries	33.33	24	18.04	800.00	3.69
Pigeons and Doves	55.50	10	28.13	555.00	8.9
Vulturine Parrot	93.80	50	77.56	4690.00	10.97
Papuan Hornbill	12.27	11	15.39	135.00	4.64
Parrots and Lorikeets	24.26	125	15.32	3032.00	1.37
			Total Kina	**24275.00**	

The Vulturine Parrot was the most expensive species (parts) sold ($\bar{x}$ = K 93.80). A live Vulturine Parrot (*Psittichas fulgidus*) will fetch as much as K250 (the equivalent cash value when traded for a piglet in rural Karimui). Feathers of this bird are sold in parts woven into headdress: the accumulated sales can earn a trader as much as K400.The Birds of Paradise are the second most expensive birds

with a $\bar{x} =$ K66.93 following the Vulturine Parrot. The Birds of Paradise accounted for the highest percentage (61%) of the total value of birds surveyed over the research period, K 24, 275 (**Table 3.2**).

3:2.4 The Trend in Costs of Birds in the Central Highlands over 40 years

A few species demonstrate a fluctuating trend (**Figure 3.3**). This may reflect rarity of species but also the practicality of use. One Chimbu female interviewee made a comparison between the Stephanie's Astrapia and the Sicklebills, stating that the former is the most preferred as the tail lengths are slightly shorter to Sicklebills. Hence, the Astrapia plumes experience less breakage during cultural performances when worn on the headdress by contrast to the Sicklebills.

The preference for Vulturine Parrot was evident in the 1970s market surveys (Patterson 1974) (**Figures 3.3 and 3.4)**) and this reflected the preference of labourers from the Central Highlands that were brought to the coasts to work on plantations during that period (Hide 1981). In the 1980s, the cost of Vulturine Parrots dropped but during the study period, this species and the cassowary were considerably more valuable when sold as individuals followed by the Birds of Paradise. No Vulturine Parrots were encountered in the market surveys in the National Capital District during this study.

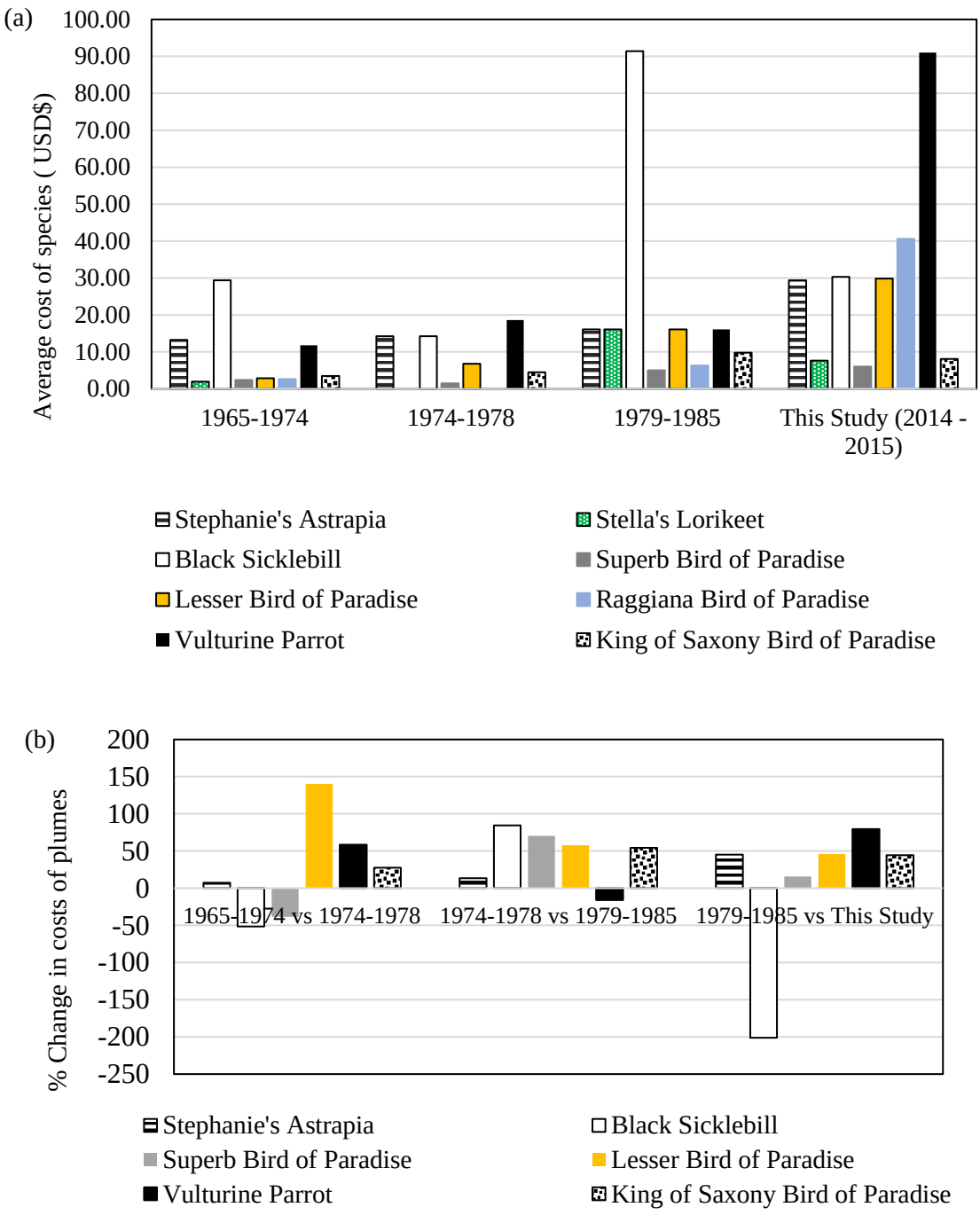

Figure 3.3: The trend in species trade over 50 years in the central highlands of Papua New Guinea indicates (a) fluctuating trend of species traded such as the Raggiana Bird of Paradise, Black Sicklebill Bird of Paradise, Superb Bird of Paradise, and the Vulturine Parrot (b) the difference in mean prices (USD$) expressed as percentage for each period.

3:2.5 Bird Trade in the National Capital District

The market survey in Port Moresby started in June 2014 and ended in January 2016 and spanned over 7 months. Eleven species were sold in the markets in this survey (**Table 3.7**). Live birds were sold on several occasions, particularly the Eclectus Parrot (*Eclectus roratus*) and Swamp Harrier (*Circus approximas*), in addition to skins of Birds of Paradise and cassowary plumes (**Plate 3.2**). The Swamp Harriers and parrots were sold between December 2014 and January 2015.

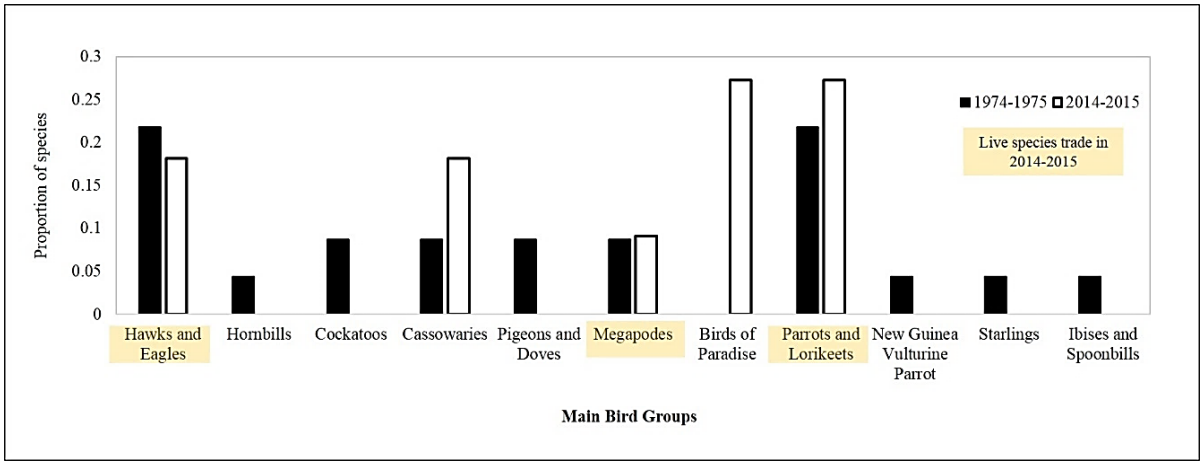

Figure 3.4: The main families of birds surveyed in 1974 (dark bars) versus those encountered in this study (2014-2016).

There were 23 species from 11 families in 1974 versus 11 species from five families in the current study. Birds of Paradise were sold in the current survey unlike that of 1974. The faded orange shades indicate species that were sold live during this survey in the National Capital District.

Plate 3.2. Some of the species of birds sold during the survey period May 2014 – January 2016. (a) live Brown Sicklebill sold (K 200) in Goroka, Eastern Highlands Province, in September 2015. (b) Two live Swamp Harriers (K80 each) and (c) 5 live Eclectus Parrot chicks sold for K80 each at Port Moresby in December 2014. (d) Skins of Raggiana Bird of Paradise (left) and Lessor Bird of Paradise (right) each skin sold for K200 at Goroka Annual Show, September 2015. Photo credits (a) Jebson Kare, (b-d) Miriam Supuma.

Table 3:3: Species of birds sold in the National Capital District and their average prices (2014 - 2016).

Species	Common Name	IUCN Status	Range	Mean cost in PNG K (US$ 1=PNG K2.77)*	Quantity
Circus aproximans spilothorax (pied)	Swamp Harrier (L)	LC	80-100	86.7 (31.3)	3
Milvus migrans	Black kite (L)	LC		15 (5.4)	2
Paradisaea minor	Lesser Bird of Paradise	LC	200-500	300 (108.3)	9
Paradisaea raggiana	Raggiana Bird of Paradise	LC	50-400	210 (75.8)	20
Casuarius juvenile (*casuarius* or *bennetti*?)	Southern or Dwarf Cassowary (L)	VU/LC	150-300	225 (81.2)	2
Casuarius sp parts (c*asuarius* or *bennetti*?)	as above	VU/LC	30-150	98.75 (35.65)	7
Charmosyna josefinae	Josephine's Lorikeet	LC	30-200	115 (41.5)	2
Talegalla sp	Megapode (L)	LC	N/A	N/A	2
Trichoglossus haematodus	Rainbow Lorikeet (L)	LC		100 (36.1)	1
Eclectus roratus	Eclectus Parrot (L)	LC	50-200	92.2 (33.3)	11
Lophorina superba	Superb Bird of Paradise	LC	N/A	100 (36.1)	1

Note: The (L) next to the common name of the species indicates whether the sale was for a live bird (not dried skin or plumes/feathers). The asterisks (*) indicates costs of birds (parts or live) in local currency (Kina). At the time of the survey, 1 US Dollar = 2.77 Kina. The mean costs of birds have the local currency mean and the average in US$ is in parentheses (). Under IUCN status, the letters indicate species status assessment; LC = least concerned, and VU = vulnerable.

3:2.6 Live Bird Trade

From the 73 people interviewed, 16 people (21 %) have sold live birds in the previous year (2013-2014) before this survey took place. These include the following species: juvenile cassowaries (4), Northern Cassowary (1), Rainbow Lorikeet (1), unidentified parrot species (numerous), Little Egret, Ribbon Tailed Astrapia (1), Vulturine Parrots, Lesser Bird of Paradise (1), Raggiana Bird of Paradise (5), and Scrub fowl (1).

3:2.7 Preferred Trading Months

Seventy-eight percent of tradespersons (out of 64 respondents), indicated the month of September was the best time to sell plumes due to the annual cultural show in Goroka. A further 20 % preferred any

time between September and December was ideal as it over lapped with more than one cultural show. Only five people mentioned that anytime of the year was suitable to sell plumes.

3:2.8 Age of Headdress

Only those participants who owned a personal collection of bird plumes or a headdress set were asked to provide an estimate in years of the collection in their possession. Forty percent of the number of traders responded (28 responses from 70), while 78 percent of informants that participated at annual cultural shows could provide a timeframe (60 responses from 77). The figures in **Table 3:4** indicate counts of participants who responded. Forty-five percent of all participants who responded (tradesperson and cultural show participant) have estimated the age of most of the bird skins (and plumes) to be over 20 years old. Replacement of damaged or worn out plumes is done at least once every 5 years.

Table 3:4 Participants and the years of feathers (plumes) in their possession.

Years in Possession of Headdress	**Traders** (N = 28)	**Show Participants** (N = 60)
< than 5 years	2	4
≥ or equal to 5 years	2	2
> 5 or equal to 10 years	n.a	11
> 10 years and less than 20	8	22
> 20 and less than 30 years	10	9
> 30 years	4	12
uncertain	2	n.a

3:3 DISCUSSION

These surveys showed that the species currently valued most highly in terms of price are the Birds of Paradise, the Vulturine Parrot, and cassowaries. Whilst the Birds of Paradise continue to be valued culturally, there appears to be a value more akin to the aesthetics and their iconic flagship status. The main species traded were the Raggiana Bird of Paradise, Lesser Bird of Paradise, the King of Saxony, and Princess Stephanie's Astrapia Bird of Paradise, and the Superb Bird of Paradise in the central highlands. Most of the Birds of Paradise are least concerned under the IUCN criteria. However, the Blue Bird of Paradise and the Black Sicklebill Bird appeared to be sold infrequently in markets. This may be indicative of the species being generally rare. Sightings of the Blue Bird of Paradise have not been detected even in intensive bird surveys (Freeman and Freeman 2014b). Whilst the Black Sicklebill is rare in parts of the Eastern Highlands and Chimbu Province, they appear to be few sites with healthy populations in isolated montane forest that have low human populations (AMNH 2015).

The Blue Bird of Paradise is endemic to Papua New Guinea (1100 -2000 m.a.s.l) whilst the Black Sicklebill can be found at montane forest at elevations from 1300 – 2600 m.a.s.l within New Guinea (Pratt and Beehler 2015).

Overall, in terms of costs, the average percentage change of costs of plumes from 1965-1974 vs 1974-1978 was a 24% increase, from 1974 -1978 vs 1979 -1985 there was a 44% increase, and a drop of 4% change from the 1980s vs this study (**Figure 3.5**). Over the last 40 years, the prices of plumes had the highest increase between the periods of 1979-1985. For instance, certain species such as the Princess Stephanie's Astrapia, Black Sicklebill, and Lesser Bird of Paradise, and Vulturine Parrot were recorded in some areas in the central highlands such as the Southern Highlands Province (Kwapena 1984b), Jimi (Healey 1973), and Chimbu (Hide 1981, Hide 1984). This increase between 1979 -1985 may have been due to the increased trade of Birds of Paradise in some parts of the highlands. Another possible explanation may have been attributed to the Pacific Festival of Arts which took place in Port Moresby in 1981 (David King pers.com). Similarly, the 15th South Pacific Games hosted in Papua New Guinea in July 2015 triggered a very strong cultural response (pers. obs).

The preference of species use for adornment has undergone some change over the decades (**Figure 3.5**). These shifts can be attributed to the sparse distribution of certain species (e.g Black Sickelbill) and the result of practicality of use. For instance, longer plumes such as Sicklebills may experience easy breakage during performances as opposed to Stephanie's Astrapia which has slightly shorter plumes and commonly worn by Chimbu, Jiwaka, and Eastern Highlands' tribes.

It is apparent that there was a demand for the Vulturine Parrot as indicated in the 1970s market surveys (Patterson 1974) (**Figure 3.4**). The trade of Vulturine Parrot, a species with lowland to midmontane distribution, was accessible to highlanders with the improved road networks in 1950s and employment opportunities (e.g labourer on coconut plantations) (Hide 1981). Individual Vulturine Parrot chicks were traded by locals in remote Crater Muntain Wildlife Management Area (lower elevation of Chimbu Province) in the early 1990s with an approximate value of K50 (roughly equivalent US $40) (Mack and Wright 1998). I did not encounter any live Vulturine Parrots traded in the market surveys in the National Capital District by comparison to the 1970 survey (Patterson 1974).

Generally, over the last 40 years, the Vulturine Parrots' costs increased, then decreased in the 1980s, and has increased over the last 20 years to present. This trend is obvious in the plumes sold in markets, but also on cultural show participants surveyed. In rural areas such as Karimui (Chimbu Province), a live Vulturine Parrot can be exchanged for a piglet. Such transactions continue to exist,

although the trade of the live species is not prevalent and may reflect declining populations of the Vulturine Parrot.

The effectiveness of policing the legislation can be observed in the case of the municipality of National Capital District. In the 1970s, the trade of the Birds of Paradise was not detected in surveys; however, in this study the trade of plumes of Birds of Paradise and other CITES species were encountered in craft markets. The decrease in diversity of species sold over the 40 years is also reflected in the reduction in diversity of species worn by ethnic groups at present. For instance, Sillitoe and Healey each documented over 25 species used by locals in Wola (Southern Highlands Province) and Kalam (upper Jimi) in the late 1970s. However, species diversity worn on headdress has been reduced by over 50% and now reflects the narrower preference for certain groups of birds. There appears to be a general trend in decrease of diversity of species used. At the time of the study, the central highlands particularly the Western Highlands, and Jiwaka had high diversity which is perhaps reflective of the relicts of traditional trade networks (existed years before outside influence) which have now been improved by road linkages.

The customers of birds in urban areas are primarily nationals with a few expatriates (including tourists and visitors). The species traded during the study include the protected Birds of Paradise which were not recorded in the 1974 -1975 study. Furthermore, the number of species sold has decreased by half compared to 40 years ago and may reflect habitat loss due to expansion of the National Capital District or decrease in the number of skilled hunters. The accessibility to a diverse means of income to sustain livelihood apart from subsistence agriculture and hunting could also be a contribution. It is likely though, that there may be a combination of factors which have not been covered in this research.

3:3.1 Social and cultural change

Religion and education have had a profound influence on the shift in cultural beliefs and etiquette. For example, in the early 1950s, the Catholic church encouraged women to participate in traditional attire for certain church processions (Chapter 2). While local men also attended church, it was the women who participated most (Brown 1969). Whether the church intended to demonstrate equality in gender or perhaps women were more engaged in church activities is uncertain. This study indicates that women are also playing an active role in the trade of plumes in urban markets and are involved in organising women's participation in cultural festivals. This change can only be attributed to the diverse economic activities associated with the change in contemporary society and the encouragement of the Informal Sector economy (Chapter 2).

Not all Christian faiths encourage cultural practices associated with traditional dance and festivity. Followers of the Seventh Day Adventist Church (or SDA), for instance, did not keep plumes for

traditional headdress adornment in remote sites such as Karimui. Hence, lower prices of plumes (in rural areas) may reflect changing traditional beliefs resulting in fewer rural populations actively hosting cultural festivities, or the gradual erosion of symbolic practices such as initiations; initiations were discouraged more by churches.

Trade of wildlife products is not the only means to sustain most people involved in the informal economy. Most traders have a combination of other activities to sustain themselves including subsistence agriculture, small holder cash crops such as coffee, trade of handicrafts, or a working relative. Some of the people engaged in the trade of birds believe that they provide a service that contributes to preservation and persistence of cultural identity.

3:3.2 Conservation of species and need for research

Western science has had an input in environmental policy development relating to conservation prior to and shortly after PNG's Independence. Since independence, Papua New Guineans are now in the position to govern their natural resource and safeguard livelihood, although, still using colonial legislations that are not fully encompassing of society and environmental associations within the current political framework (Filer 2011a).

The continued trade of protected species is indicative of Papua New Guinean's strong attachment to culture and the sense of identity. The Fauna (Protection and Control) Act 1966, needs to be reviewed and updated as there appears to be contradictory legislations similary experienced in other sectors (King 2002). For example, the country advocates promotion of cultural identity through the National Cultural Commission's Act (1994), and the Convention of Biological Diversity (CBD) further promotes *Article 8 (j)* traditional Indigenous cultural knowledge and heritage. Awareness is vital to provide information to rural communities about which species are vulnerable from continued unmonitored pressure. This study indicates that the most preferred time for trading plumes is between September and December coinciding with annual cultural shows. The courtship seasons of most species of Birds of Paradise is during the drier periods (June-December) (Beehler 1983, Beehler 1987). Locals who are well versed on display leks (trees used by Bird of Paradise for courtship display) know where to hunt. However, knowing the right time to hunt (in this case, October-December) and to be specific with kills (only hunt fully plumed birds) allows persistence of population. Although, for certain species such as the Blue Bird of Paradise and the Black Sicklebill, Dwarf cassowary, and Vulturine Parrot, population studies need to be done to further understand the densities of species per location for conservation and management of species (Mack and Wright 1998, Mack 1999, Mack and West 2005). Hence, there is a need for continued research and monitoring of species on a regular schedule.

Tourism awareness is also needed to inform visitors to the country of species protected by CITES as this study has shown that tourists have purchased skins or plumes of birds. Whether these species are taken out of the country successfully or confiscated at the airport is something that needs adequate detection and reporting at ports (shipping and air). Joint country enforcement is needed to protect species, detect illegal exploitation, and reduce potential biosecurity threats (Shepherd et al. 2012).

Museums can play important roles during cultural festivals to educate cultural performing groups on best practices to extend the longevity of headdresses such as improved storage of plumes. This study indicates over 40% of cultural performers have maintained their plumes for over 20 years. Improved preservation techniques can reduce the need for replacement of plumes hence less pressure on wild populations. Strengthening the roles of museums in cultural preservation in the national context and supporting local cultural associations at the rural level is needed. For the latter, support in the form of awareness on species storage techniques, conservation of cultural knowledge, and incentives to associations to deliver important messages through their art.

This study demonstrates the role of craft persons (traders) as one that provides a service to urban dwellers for the promotion of the country's rich cultural heritage. Balancing cultural heritage and ensuring that species are sustainably harvested is essential for the conservation of both. This study also hints a shift in women's cultural roles in highlands societies, as depicted by women's involvement in plume trade. Hence, contemporary change in culture impacts species quantity harvested for trade. The upward trend in the costs of plumes and the continued trade of the Birds of Paradise (esp. restricted range montane species) along with the Vulturine Parrot requires further understanding of species population sizes.

In addition to awareness and the annual monitoring of ports and markets, improved understanding of hunting patterns in rural communities is essential to gauge pressure on species. Chapter 4 will explore hunting patterns at select remote sites identified from **Figure 3.2.**

CHAPTER 4: Patterns of hunting in montane forests in Papua New Guinea

A CASE STUDY

4:0 INTRODUCTION

Hunting wildlife for food (bush meat) is practised by many Indigenous communities (Robinson and Bennett 2000b, Milner-Gulland et al. 2003, Robinson and Bennett 2004, Mack and West 2005). Dependence on forest resources for protein varies between communities according to such factors as geography, subsistence agriculture, alternative forms of income (Shively 1997, Liang et al. 2013) , human population density (Yalden 1996, Robinson and Bennett 2000a) , hunting weaponry (Kwapena 1985, Satterthwait 1986, Pangau-Adam et al. 2012, Shepard et al. 2012) , and knowledge of species (Pangau-Adam et al. 2012, Padmanaba et al. 2013).

The majority of New Guinea's human population live in rural or remote areas and are often heavily reliant on the environment for sustenance (Bulmer 1968, Hide 1984, Dwyer 1985, Healey 1990, Dwyer and Minnegal 1991a, Mack and West 2005). Despite increases in introduced domesticated animals over the last 60 years in Papua New Guinea, hunting of wildlife continues to play an important role in supplementing the diet and to some extent the economy of remote communities (Dwyer 1974, Mack and West 2005, Rao et al. 2005, Pangau-Adam et al. 2012). Estimates of wildlife consumption show animal protein intakes of 22-23 g per person per day for remote communities without road access (Hide 1984, Mack and West 2005). This indicates the significance of biodiversity to rural livelihood for communities further away from access to the formal economy.

4.1 Hunting in Montane Forests in Papua New Guinea: Issues and Context

In the highlands of Papua New Guinea, some forests (or areas within them) are considered taboo as they are believed to be places where deceased relatives' spirits find their final resting place and may take the form of fauna or flora such as large trees (West 2006). For the Gimi people of Eastern Highlands Province in Papua New Guinea, such taboo sites are often found in areas of mid to upper montane forests. Often these taboo sites have hunting restrictions placed on them (West 2016). The sizes of taboo areas are variable. Most importantly, the symbolism associated with such a place or space is of importance to the surrounding communities and to some extent affects behaviour of custodians (Wagner 1972).

Taboo areas have long been established by traditional cultural practitioners in many areas of Papua New Guinea. Taboo sites have been a result of cultural practices that are not necessarily intended for the conservation of species. For example, Foale (Foale 2002) surmised that traditional reef closure in

some parts of Melanesia has been associated with the death of clan members holding ownership rights to reef or coastline. The closure over a certain period of months was observed to stockpile marine reserves. This then enabled locals to harvest for a cycle of feasting associated with the death of a clan member. Although, this practice was not specifically intended for conservation (e.g. persistence of genetic diversity), it may have resulted in an increased quantity to carry out the festivity.

There are obvious changes to livelihood in remote communities such as better accessibility to intact forest given road networks (Peres et al. 2006), use of modern weapons in hunting such as guns (Kwapena 1985) as well as influence of religion on local people's behaviour towards hunting of certain species. It is crucial to understand the pattern of hunted wildlife particularly those with cultural and livelihood significance. The human footprint of wildlife hunted can reveal the extent to which Indigenous communities extend their governance over customary ownership of land and the intensity of areas harvested (Read et al. 2010a).

Clan boundaries of land under customary tenure are usually well known by community members. Community members exert their influence within their landscape in many ways including settlement, subsistence gardening, and hunting. Custodians of land may move in response to the seasonality of traditionally valued plants such as pandanus nuts (Bourke 1996, Sillitoe 2002) in the central highlands (Bourke 1996) or sago for those communities living in low-mid montane areas (Hide 1984, Dwyer and Minnegal 1991b). The early historical movement of local people in response to traditionally valued tree species seasons was discussed in Chapter 2. Whether communities' movement within their clan borders demonstrates governance is not currently fully understood (Sillitoe 2002), although, as a general rule, traditional custodians only hunt or utilize forest resources within their clan land.

To understand the extent of endemic bird species hunted within the main case study site, I attempt to answer three main questions in this Chapter. The first is to understand the spatial distribution of hunted species within a transition ecotone adjacent to an existing Wildlife Management Area (WMA). Gauging the distribution of hunted species by knowledgeable experienced hunters will indicate where species are sourced. Second, the spatial distribution will also provide a measure of distance a hunter travels from his village to make a kill. Third, identify the hotspots of threatened species. In this instance, the hotspot identifies areas of high occurrence of successful hunts of threatened endemic species. This spatial evaluation will provide insights into habits of hunters and elucidate how culture and environmental factors such as weather may play a role in shaping contemporary use of birds and their plumage in headdresses.

4:2 METHODS

4:2.1 Study Sites

The primary case study site is Karimui in the Chimbu Province. Karimui has been identified by traders (Chapter 3, **Figure 3.2**) as a source location of species. By contrast to upper northern Chimbu, much of the land (~ 80 %) in Karimui, is below 1400 meters (Hide 1984). Whilst **Table 4.1** gives the general density of Karimui Rural constituency, it should be noted that the 2011 census states Karimui Rural Population (inclusive of Bomai, Pio-Tura) to be 23,596 people (NSO 2012). However, due to lack of information for current population, only population density (person per km^2) was established to the year 2000.

Table 4.1: Population densities of the smaller constituents of the main case study area, Karimui Rural.

Karimui Rural Population Density (person per km^2)			
Year	**1960**	**1980**	**2000**
Karimui	4.3	6.75	11.72
Bomai	1.3	2.10	4.77
Pio-Tura	0.3	0.38	0.78

Population figures for the years 1960 – 1980 were obtained from Research Report of the Simbu Land Use Project (SLUP) Volume VI (Hide 1984).

The geographically unique landscape of Karimui and its biodiversity has not gone unnoticed. In the early 1970s, there was a proposal by the Officer in Charge (OIC) of Karimui to reserve two parks which included Mt. Karimui and areas to the West of Mt. Karimui (Hide 1984). The proposed reserves were mainly to protect wildlife from being over harvested by an influx of possible migration from the northward moving population. This was the initial interest for conservation, but plans were not followed through since the 1970s. The plans for a local conservation area were put aside until 2007 when it was taken up again by the Karimui Conservation Resource Management Program Initiative (KCRMPI). An additional site in Chimbu for comparison was Toromambuno (Gembogl Distric), ~76 km north from Karimui. Toromambuno is located at the foothills of Mt. Wilhelm National Park.

The first comparative sites in Eastern Highlands Province (E.H.P) are located within the constituency of Goroka Rural. These main villages include Nagamizah, where clan's boundaries extend into the Mt. Gahavisuka Provincial Park, and the second village was Nupaha, approximately three kilometers

south east of Mt. Gahavisuka Park. The park encompasses an area of 77 hectares and has anthropogenic grassland, secondary and primary montane forests. The elevation ranges from 1800 – 3 400 m.a.s.l, where the highest peak is Mt. Otto, along the Bismarck Range which links to Mt. Wilhelm. The Nupaha and Nagamizah villages are approximately six kilometres from the township of Goroka and are connected by road links to the main highlands highway.

Hogave and Mengino were selected as two village representatives within Lufa District (E.H.P). Lufa is located approximately 65 kilometers south west of Goroka township and has road linking off from the main highlands highway. The Crater Mountain Wildlife Management Area (CMWMA) lies between Lufa and Karimui. This WMA encompasses an area of 2700 km^2 and hosts lowland rainforests from 80 m.a.s.l to montane forests up to an elevation of 3300 m.a.s.l at the highest peak, Crater Mountain (Mack and West 2005). The CMWMA was gazetted in 1994 to conserve the diverse array of Birds of Paradise (Saulei and Ellis 1998, Johnson et al. 2004).

The traditional headdress of the Karimui people consists of cockatoo feathers sewn onto a rattan arch. This type of headdress is shared by the Pawaiia people at Haia, Baimuru and extending further West into Western Province as well as the Torres Strait Islands (Australia). Cassowary plumes and those of Birds of Paradise are worn on special occasions such as in a traditional marriage ceremony (as a bride price). **Plate 4.1** depicts the typical headdress of men from Karimui (or the Pawaiian speaking people). The headdress worn by many Chimbu people and to some extent the Lufa people of Eastern Highlands Province has been shown in **Plate 3.1** (Chapter 3).

Plate 4.1: Karimui men participating in the Chimbu Cultural Show in Kundiawa, 1978. Photo Paul Barker.

The traditional custodians of Goroka (Gahuku) who speak the Alekano language wear a headdress that displays the prized Vulturine Parrot and cassowary plumes **(Plate 4.2**). Similar headdresses are also worn by the Bena Bena people of the Eastern Highlands province.

Plate 4.2: A man from either the Bena Bena or the Goroka vicinity in his traditional finery. The feathers worn on his headdress are from the Vulturine Parrot, a threatened species. The species is sought from the Ramu area in Madang Province) or from lower montane forests in areas such as Karimui or Haia (Chimbu Province). Photo: Bega Inaho, PNGIBR 2010.

4:2.2 Avifauna of the study sites

The Karimui and CMWMA encompass a number of ecotones and habitats which host a wide variety of birds (Diamond 1972, Marsden et al. 2006) and mammal species (Flannery 1995). This contributes to a high species diversity in Papua New Guinea (Tallowin et al. 2017). The main case study site, Karimui, has had avifauna elevation studies conducted in 1965 (Diamond 1972); 234 bird species. In 2012, a follow up survey was conducted at the same site (Freeman and Freeman 2014a) updating species accounts to 245. Altogether, the site hosts some 271 species.

4:2.3 Hunting Data Collection

This section employed the use of semi-structured questionnaires (Miraglia 1998, Huntington 2000, Bernard 2006) conducted in an interview manner given the low literacy of rural participants (**Appendix 4.1**). Experienced hunters from the communities were identified by key community

members (including councillors, pastors, conservation officers, village chiefs, and elders). The participation of identified hunters in the study was voluntary. Those involved in the survey were men (≥ 20 years old) who actively hunt. Whilst most rural people do not have an official birth record, important historical occasions were used to estimate hunters' age such as the second world war in 1942-1945, national independence in 1975, or the establishment of Karimui Patrol Post and airstrip in 1960 (Hide 1984). For example, in 1942, local people were aware of aeroplanes from the allied forces in New Guinea as well as that of the Japanese army. Around this period, few able-bodied men were involved in some parts of New Guinea as porters and guides to aid each side of the warring parties. Hence, these first-hand observations were significant and memorable to those who were witnesses.

Hunters were shown either pictures/photographs (Whitehead 1995) or specimens of birds (Ziembicki et al. 2013) and asked questions about known localities of species occurrence and ecological knowledge (e.g habitat of species, feeding habits, leks, taboo sites)(Read et al. 2010b). Informants were also asked to estimate the time of the year the successful hunt occurred and described the type of weapon used. Localities of species hunted were recorded using GPS by trained local assistants at the sites. For sites that were isolated or had difficult terrain, hunters estimated on printed maps the kills as well as known taboo sites; for example, Masi and South Yuro in Karimui. Nomenclature of birds was according to Birds of New Guinea Guide second edition (Pratt and Beehler 2015). Mammals identification was by use of Mammals of New Guinea guide (Flannery 1995).

This study involved 91 hunters from the four sites possessing knowledge and skills in relation to hunting within their clan areas. In the interviews, 38 hunters from Karimui were involved. The guiding questions for interviews were designed in a similar format to that in Chapter 3 (Trade) which included triangulation questions to detect bias (Neuman 2011). Only successful hunts between October 2013 – October 2015 were considered in this study. As such, two (2) years of successful kills by hunters were only considered for this study.

Karimui has a larger area of coverage by hunters in comparison to other sites (**Table 4.1).** Geolocations were obtained with the use of GPS from hunters' sites whilst the remaining were estimated on printed maps with consensus between hunter and on ground conservation officer (KCRMPI). The maps included 1:100,000 topography maps (series T601) in combination with Google Earth with known ground control points as reference.

Attempts to engage in interviews with hunters in the other sites was not feasible since the field season in 2015 was during the height of the El Nino period (May – November 2015) where some high elevation communities were affected (e.g higher elevations of Gembogl > 2 400 m.a.s.l). Instead, trained local assistants who were also clan members and fluent in local language were engaged to

collect information on hunters, their kills, and collect GPS locations of species killed (**Table 4.2**). Refer to **Appendix 4.2** for data sheet for sites outside Karimui. This option allowed for ease of data collected given the constraints on movement and hardships faced by communities (Kanua et al. 2016). During my field work, I observed frequent fires in the grassland mountains of the highlands extending to the Karimui plateau. Local accounts indicate shortage of fresh water to the extent that sago starch could not be extracted by Karimui people west of the station (e.g. Dobe and Tilige villages).

Table 4.2: Sites and the number of participating hunters in the study**.**

Site	Number of hunters	Survey interview	Taxa	Field work period
Karimui, Chimbu	37	survey interview + GPS of kills + estimates	Mammals and Birds	28 September - 4 October 2014; 12-28 October 2015
Toromambuno,Mt. Wilhelm Rural, Gembogl, Chimbu	9	Demographic data + GPS of kills	Birds	6 -18 November 2015; 10-16 January 2016
Mt. Gahavisuka, Goroka Rural, E.H. P	32	Demographic data + GPS of kills	Mammals and Birds	31 July - 28th August 2015; January 2016
Lufa, E.H. P	13	Demographic data + GPS of kills	Only Birds of Paradise	15th December 2014 -15 January 2015

4:3 DATA ANALYSIS

4:3.1 Least Cost Path Analysis

The least - cost path tool within the Esri ® ArcMap™ 10.3.1 (ArcGIS) Software ascertains the optimal path from one point, the origin (or more) to one or more destinations (Stucky 1998). Unlike the Euclidian distance (a straight-line distance), the least cost path considers variables, for example slope or friction in which raster data (digital elevation model or DEM) is employed. In order to derive the needed distance calculations, the Cost Path tool uses two rasters, the least cost path distance raster and the back link raster (ESRI 2015).

The least-cost path allows computation of the distance traversed by a hunter from his village (origin) to the destination, which is the location where a species was harvested. The least-cost path identifies the most cost-effective route relative to the cost units. To compute least-cost path for this study, Shutter Radar Topography Mission (SRTM) DEM data (1 sec, 30 m) were obtained from United States Geological Survey (USGS) platform. **Figure 4.1** shows the process taken for data collection to

conduct analysis. The output produced by least cost path was a raster of the distance traversed by the hunter. This raster distance was converted to polyline via converter and polyline nodes were summed – this gives the total distance from origin to kill site (one way). This analysis was performed for each species killed by a hunter. A similar method has been used for mapping the distance fishers travelled to fishing locations on the Great Barrier Reef (Lédée et al. 2012).

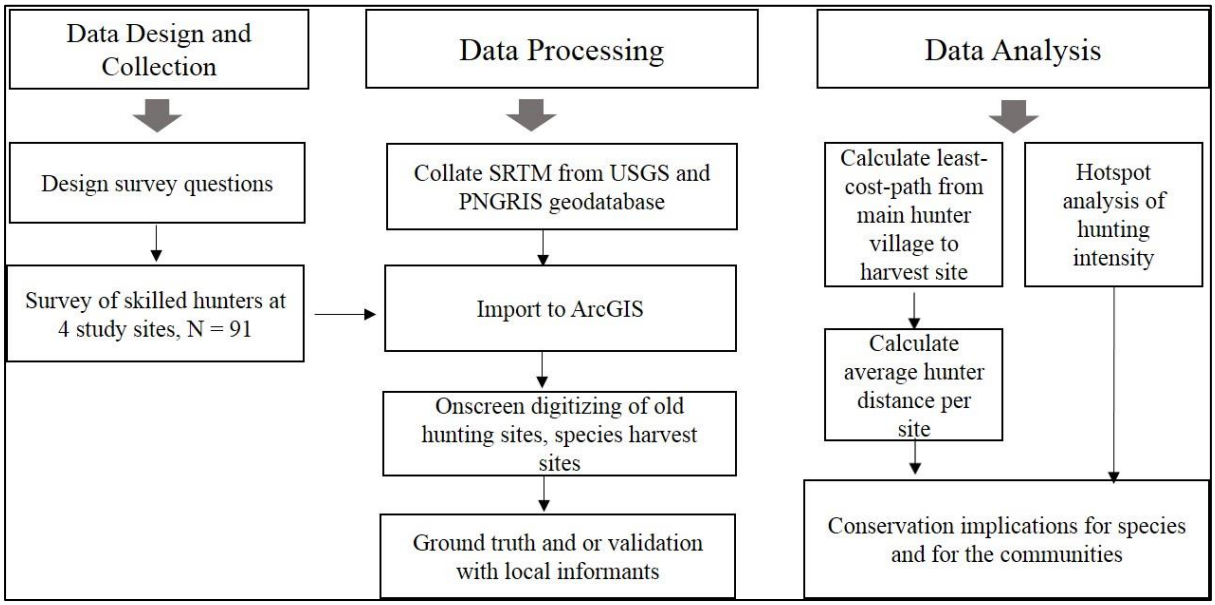

Figure 4.1 Schematic diagram of data processing.

Data for distance travelled by hunters to their kill sites were totalled for each site and compared using One-way ANOVA (Kruskal Wallis H test).

4:3.2 Mapping areas of high hunting intensity of threatened species

To analyse patterns of hunting intensity of endemic species, the Hot Spot Analysis under Spatial Analyst Tool was used to delineate map clusters of high (hot spot) and low values (cold spot). The cluster map indicates events on a spatial scale that have occurred not by random chance, rather, the patterns are based on statistical analysis, the Getis-Ord Gi* Statistics (Getis and Ord 1992). Given this, the outcome map produced is not subjective to the interpreter, unlike that of the heat map or the density map produced by points. The kernel density estimate (KDE) differs from the Hot Spot analysis in that KDE uses a band width (search radius) which produces a result which is subjective to interpretation whereas the latter has statistical validation that accompany the output, cluster map (ESRI 2015).

In Hot Spot analysis, each feature has a value. Each of these features is surrounded by a neighbourhood of other raster cells where the number of features (values) in the neighbourhood is summed and divided by the area of the neighbourhood. If the value of the weighed neighbourhood (local average) is significantly different from the study area (global average), it is a hot spot (Getis and Ord 1992, ESRI 2015).

The statistics, p-value, and the z-scores (or standard deviation) are both associated with the normal distribution. As such as a z -score of + 2.5 indicates a standard deviation of 2.5 at the tail of a normal distribution and indicates a significant p-value of 0.01 (a hot spot).

In this study, species were assigned a weighted rank according to its IUCN status and an Optimized Hotspot analysis (Mapping Clusters) was performed. The weighted rank was as follows; Critically Endangered/ Endangered = 4, Vulnerable = 3, Near Threatened = 2, Least Concerned = 1. Each of the species with the assigned rank, has a geolocation. These events are converted into a point shape file for analysis.

The map clusters of hot spot and cold spot output generate statistically significant probability values, called the GiBin. These values were run under inverse distance weight (IDW) interpolation to create a raster continuous surface that averaged the sample data points. To calculate the area of the hotspot and cold spot (continuous surface), the raster output data were converted to integers. Using spatial statistics conversion, the raster output was converted to polygons and the area of the hotspot was calculated according to these categories; Cold Spot - 99 % Confidence, Cold Spot - 95 % Confidence, Not Significant, Hot Spot - 95 % Confidence, and Hot Spot - 99 % Confidence.

4:3.3 A 35-year Comparison of Hunting Areas – Karimui

Earlier accounts by Roy Wagner at Karimui indicates hunting to be very prevalent within the Karimui plateau (Wagner 1967). However, no records exist as far back in the 1960s which delineate the extent of the core hunting areas. As such, current hunting areas were compared to 1981-1982 hunting areas identified by Hide (Hide 1984). Eight core hunting areas were demarcated on a map by Hide 35 years ago (Hide 1982, pp 292). Hide worked on a two-year study, as part of the Simbu Land Use Project, involving surveys of population, nutrition and subsistence. The core hunting areas were drawn by free hand to illustrate approximately the areas from which trophy mammal material was purchased from hunters in eight general locations. These eight study sites are; Noru, Masi, Yuro, Karimui, Mengino, Karimui Plateau, and Bomai (Talabakul and Unani) (**Figure 4.2**). For this study, Masi, Yuro, and Karimui Plateau were considered.

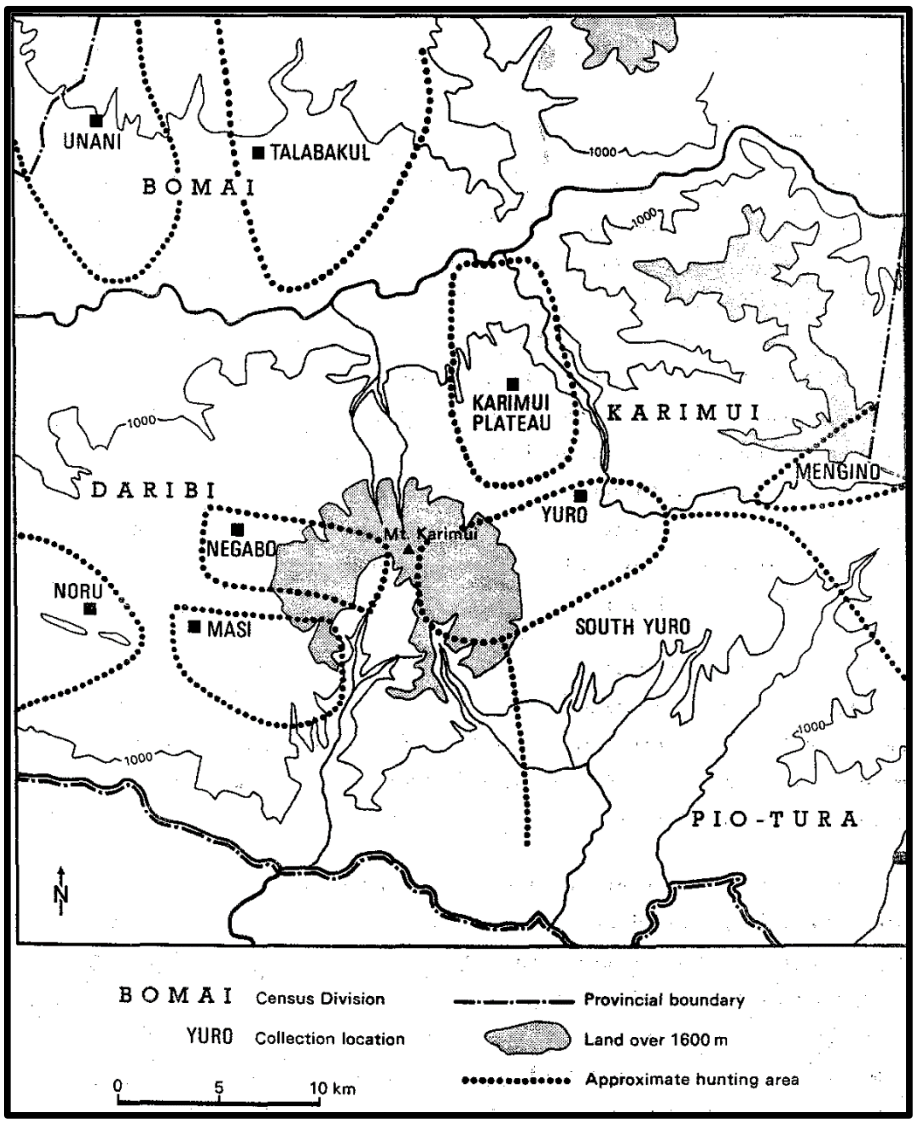

Figure 4.2. Approximate hunting areas identified by Hide in 1982 (Hide 1984). The original figure in text is Figure 7.1 (page 292). At the time of Hide's study, there was only one established airstrip located at Karimui Plateau.

To examine the changes in the spatial distribution of hunting areas since early 1980s, a scanned map of hunting areas (Hide, 1982, page 292) was imported into ArcGIS. Seventy-two (72) control points were used to georeference the map (RMS = 0.00153). Polygons of hunting grounds used in 1982 were digitized and the area was calculated for each hunting area. To compare the main hunting area of 1982 to this study, minimum convex polygons (MCP) of kills by main village (as per Hide 1980) were constructed using minimum bounding geometry (convex hull). The difference over 35 years was then extracted using the Clip function.

4:4 RESULTS

4:4.1 Taboo areas

There were 41 taboo sites identified by locals throughout the four study areas. Over half of the sites were in the Karimui area (26) which is the only site without links to the central highland's road network (**Figure 4.3**). The remaining taboo areas were; Lufa (9), Gahavisuka (4) and Toromambuno (3). The area of taboo sites was not measured due to time, and funding constraints. More significantly, women (including myself) were prohibited from entering some areas; for example, caves and sinkholes. If any member of the research team (including local assistants) fell ill, a cleansing ceremony would need to be performed to comply with local tradition. This often entailed the slaughter of a domesticated animal.

In Goroka, Lufa, and Gembogl, many taboo sites were at higher elevations (on mountains) which locals believe to have spirits of the forests or spirits of deceased ancestors. These include the Bismarck mountain range including Mt. Otto, Mt. Wilhelm and Mt. Michael. Mount Karimui is a traditional taboo area where it is believed to have a large two tailed snake (Wagner 1972).

Karimui plateau had the larger area and more taboo sites; the distance of the nearest species hunted to a taboo site ranged from 0.65 – 6.35 km (average = 1.56 km).

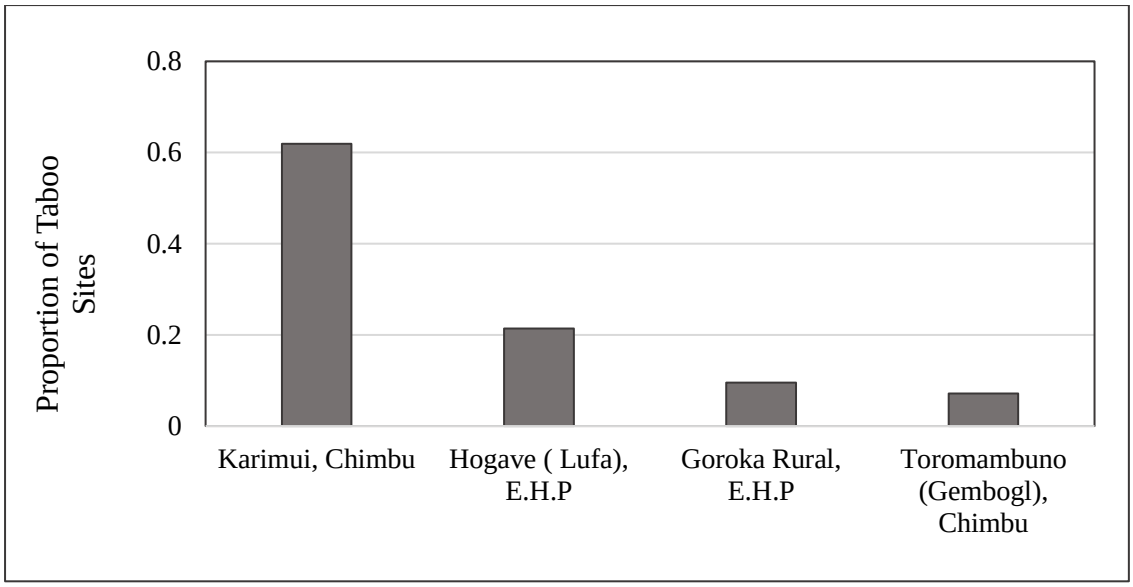

Figure 4.3. Comparison of taboo sites of the study locations in Eastern Highlands (E.H.P) and Chimbu Province.

To understand the status of taboo areas and hunters' perception to this traditional form of conservation, Karimui hunters were asked to indicate their views (**Table 4.3**).

Table 4.3: Responses of Karimui hunters to current attitudes to taboo sites.

Taboo sites still maintained by strict traditional beliefs?		*Do you think traditional taboo areas are a good idea and should be maintained?*	
Still maintained by strict traditional beliefs	11 (29 %)	Good idea	17 (44.7 %)
Protection not very strict	24 (63 %)	Bad idea	15 (39.5 %)
Not aware	1 (2.6%)	Neither	6 (15.8 %)
No, not any more	2 (5.3 %)		

Most skilled hunters indicate that the beliefs surrounding taboo sites are not strictly adhered to. Religion appears to have had an impact on traditional beliefs. Two hunters stated that their church, the Seventh Day Adventist, had conducted a blessing ceremony at two taboo sites to cleanse them; one belief system is used to counteract the beliefs of another. Church members now cultivate sago and hunt in these sites.

4:4.2 Hunting weapons

Unlike in the 1980s where there appeared to be an increase in the use of shotguns in hunting in some highlands region (Kwapena 1984b), I found a low incidence of gun use in the study areas. Only two hunters in Karimui claimed to use guns, and only when needed to kill large game (e.g. pig or cassowary). One informant mentioned that the cost of cartridges was expensive. Guns were not used to kill birds for two main reasons. First, their smaller body size by comparison to larger game such as wild pig or cassowary could easily cost them cartridges with a missed target. Second, hunters were reluctant to ruin skins (and feathers) of beautiful plumed birds from holes created by impact of pellets.

Over half (53.2 %) of 224 records of hunted birds from the four sites were acquired with the use of sling shots. Bow and arrows accounted for 38.6 percent of kills, whilst the use of bird blinds during the dry season and the use of dogs accounted for 3.2 percent each. Two hunters from Karimui used a traditional bark as an accompaniment to their hunting apparel. The bark was said to have properties

that attracted prey to hunter. Hunters in remote Karimui employed a more diverse use of weapons for hunting by comparison to Gahavisuka where hunters used mainly bows and arrows and slingshots.

The successful capture of cassowaries required a sound knowledge of the seasonality of fruiting plants such as the pandanus (P*andanus conoideus* and *P. brosimos*). The nuts are ready around October – January and cassowaries often feed on the protein rich nut. Traps (e.g snares) are placed at fruiting trees. For species such as the Vulturine Parrot, a few hunters in this study were aware of tree cavities frequented by the species. At least two hunters captured chicks and an adult bird for trade from climbing up to the tree hollow.

The use of bows and arrows accounted for 60 % of the mammal captures whilst the use of bows and arrows with the aid of a dog accounted for 34.8 % of the harvest. There were numerous bandicoots harvested as indicated by hunters. One hunter captured 43 bandicoots during one week of hunting with the aid of his dog. Small ground dwelling marsupials such as the ground cuscus (*Phalanger gymnotis*) were easily tracked by dogs. Fifty-one ground cuscuses and 15 feral pigs were dog assisted captures.

4:4.3 Seasonality of hunting

Dry season is usually from May through to October, with the wet season from November to April (Hide 1984). However, from 2014 -2016, Papua New experienced a prolonged drier season due to the El Nino in 2015 (Kanua et al. 2016). As such the dry season referred to in this context was from May – December and the wet season from January – April **(Appendix 4.3**). There were 230 records of animals hunted in the extended dry season; 34 % mammals and 66 % birds. The wet season had 63 records of which 40 % were mammals and 60 % were birds. Similar proportions of mammals and birds were hunted by seasons ($\chi^2 = 0.615$, df = 1, $P > 0.05$), with far higher hunting activity during the dry season for both groups ($\chi^2 = 95.18$, df = 1, $P < 0.001$) (**Figure 4.4**).

Culturally valued species with young litters or fledglings were easy to locate and capture with better visibility and observation of animal behaviour during the dry season (May – November). This time frame coincides with the Spring season in the southern hemisphere. Other reasons attributing to wildlife hunted during dry season include ease of covering longer distance to hunt. A few skilled hunters preferred hunting in the wet season; they attribute their preference to detectability of hoof and claw prints (wild pigs and cassowaries) on wet forest floor.

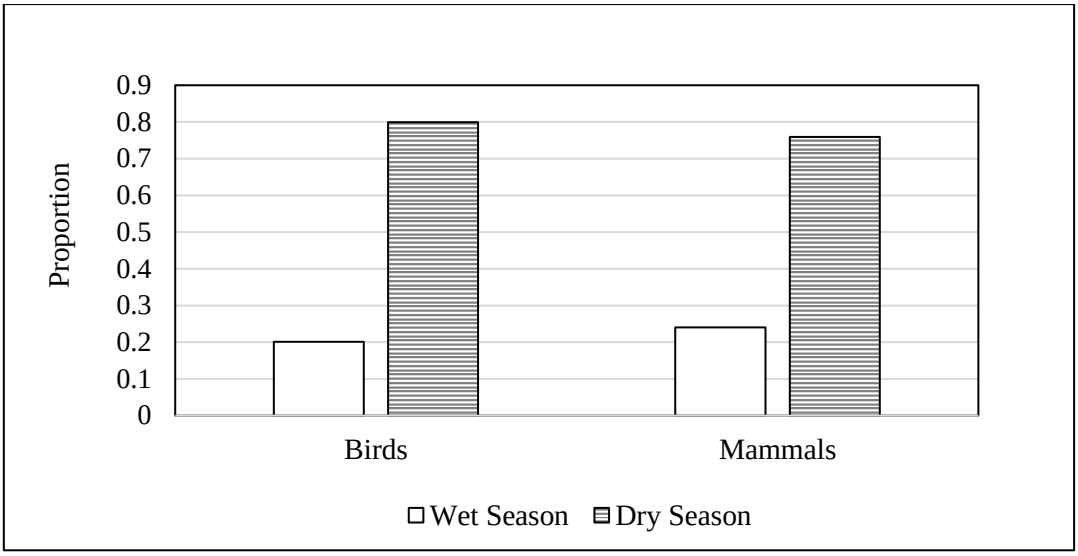

Figure 4.4. The dry season appeared to be the most preferred time for hunters to hunt.

4:4.4 Hunted Birds and Mammals

Sixty-two bird species were recorded from the four study sites. From these sites, Karimui had 25 species, Gembogl 22, Goroka and Lufa 19 and 18 species. As indicated, only Birds of Paradise with GPS locations were recorded for Lufa and for Gembogl (**Table 4.2**). Mammal data for two sites, Karimui and Mt. Gahavisuka surrounds showed 14 species and one monotreme (*Zaglossus bartoni*) were hunted over the study period (**Appendix 4.4**). For the main study site, the number of species hunted constitutes 9.2 % of the approximate total bird species (271) recorded in the Karimui region.

4:4.5 Hunted Birds of Paradise

Eleven species of Birds of Paradise were recorded as hunted. The total number of Birds of Paradise was 121 of which Lufa had the highest (57.8 %), followed by Karimui 27.2 %, Gembogl 8.3 %, and Goroka (Nupaha and Nagamizah) 5.7 %. The top three species hunted were Princess Stephanie's Bird of Paradise (41.77 %), Raggiana Bird of Paradise (20.25 %), and the Superb Bird of Paradise (10.13%) (**Table 4.4**).

Comparing counts of birds hunted by family within three main sites (Karimui, Goroka, and Toromambuno - excluding Lufa), the Birds of Paradise (Paradisaeidae) had the highest (23.5%) representation by family harvested. Pigeons and Doves (Columbidae) at 21.2 %, Cassowaries (Casuaridae) 12 %, montane Honeyeaters (Meliphagidae) 8.3 %, Parrots (Psittaculidae) 5.5 %, and Megapodes (Megapodidae) 5. 1 % (**Figure 4.5**).

Table 4.4. Birds of Paradise hunted over the study period

Species	Common Name	Chimbu		Eastern Highlands		No. of individuals	%
		Karimui	Gembogl	Goroka	Lufa		
Astrapia stephaniae	Stephanie's Astrapia	2	9	6	16	33	41.77
Cicinnurus regius	King Bird of Paradise	1				1	1.27
Diphyllodes magnificus	Magnificent Bird of Paradise	3			1	4	5.06
Ephimachus fastosus	Black Sicklebill	1			3	4	5.06
Lophorina superba	Superb Bird of Paradise				8	8	10.13
Paradisaea raggiana	Raggiana Bird of Paradise	9			7	16	20.25
Paradisornis rudolphi	Blue Bird of Paradise	2			1	3	3.80
Parotia carolae (?)	Carola's Parotia	1				1	1.27
Parotia lawesii	Lawes Parotia				2	2	2.53
Phonymaaus keraudrenii	Trumpet Manucode			1		1	1.27
Pteridophora alberti	King of Saxony Bird of Paradise				6	6	7.59
				Total		**79**	**100**

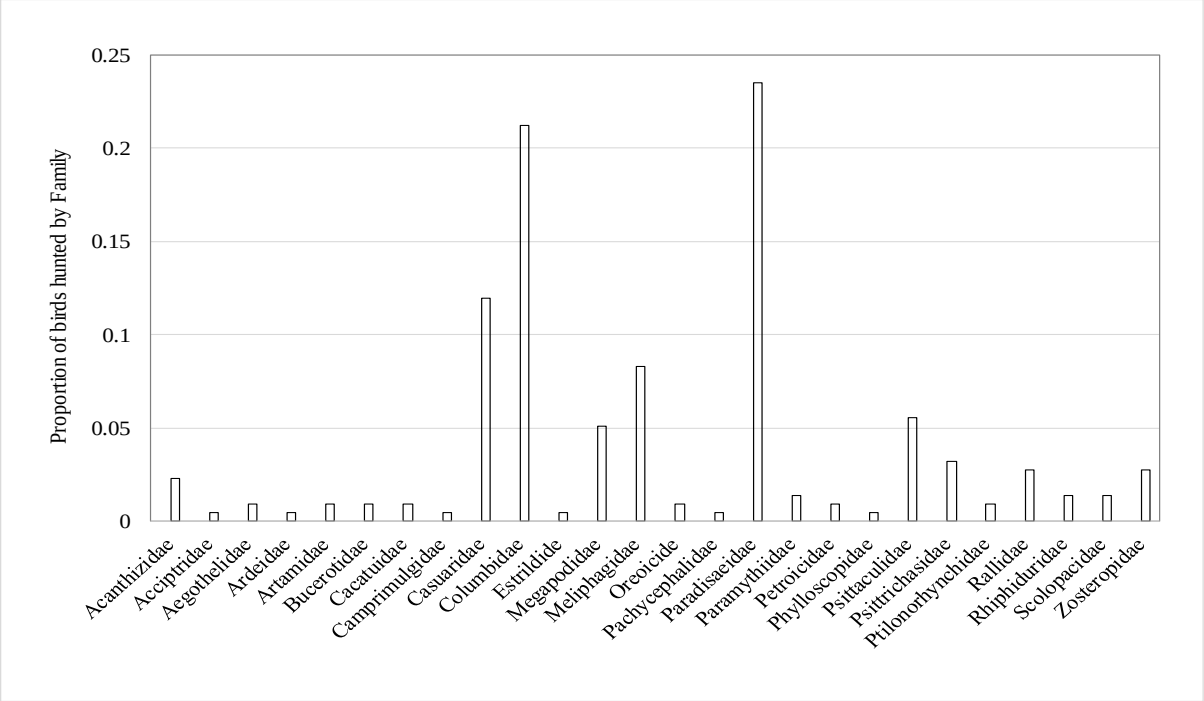

Figure 4.5: Proportions of birds hunted by Family within Karimui, Goroka, and Toromambuno (Gembogl).

4:4.6 Species Traded

Eight birds, including four species of Birds of Paradise, and two mammal species were traded by skilled hunters in Karimui during this study (**Appendix 4.5**). Notable culturally important species were Cassowaries and Vulturine Parrots which were traded with people in the local level government (LLG) constituents: at Bomai and Kelau in Salt-Nomane. Cassowaries, Vulturine Parrots, and Birds of Paradise continue to be traded in exchange for piglets. The trade value of piglets in monetary terms, according to informants, ranges from K150 – K300 (~ AUD$ 60 – 120). Although hunters generally traded birds northwards, a case of live cassowary chicks was taken southwards to Baimuru (Gulf Province), to be given as gifts to relatives of the hunter.

Twenty-five cassowary captures were recorded by this study. Seven of these were traded live; three Southern Cassowaries and four Dwarf Cassowaries were traded for pigs. The others were either consumed (8) or given away as gifts (2). The quills and feathers in six cases were kept by the hunters for personal use. Two other hunters gave cassowary plumes as gifts to relatives and two hunters mentioned their cassowary plumes were destroyed by rats.

Eight Vulturine Parrots were captured live by skilled hunters during the period of this study. Only two were traded for piglets whilst another two were given away as gifts. Four hunters kept the dry skins and plumes for personal use, although two mentioned that their plumes were destroyed by large rats.

Although Cockatoo plumes are the main feathers used for headdresses by the Karimui people, this study indicates that very few Cockatoos were harvested. Only two hunters captured two individuals, and none were traded.

Fifty-five Birds of Paradise, representing six species, were harvested by skilled hunters in the Mane, Lufa. Twenty-three of the bird skins were kept by the hunters while 27 were sold to locals within their village and to their relatives (2) in Goroka Town. Only one hunter shared five of his Birds of Paradise plumes between his relatives in the village and in Goroka Town.

4:4.7 Distance Travelled for Successful Harvest

Age of hunters were recorded for 39 hunters from Lufa and Karimui. The ages ranged from 20 to one person over 70 years old. Hunters who had actively hunted for less than 10 years constituted 23 % while 13 % below 20 years, and 64 % had more than 20 years of hunting experience (mean 22.8, ± 12.2 SD).

Hunters greater than 50 years of age travelled the furthest from their village to hunt ($\bar{x} = 7915.23$ m) with the 20-30 years cohort travelling the shortest distances. Kruskal- Wallis H ($X^2_{(3)} = 21.280$, $P < 0.00$). Karimui hunters covered a longer range 1.64 km – 20.19 km by comparison to other higher montane sites with elevations exceeding ≥ 2000 m.a.s.l. **Table 4.5** shows the summary statistics of elevation and distance (meters) covered by hunters for successful kills.

Table 4.5 Summary statistics of elevation and distance covered by hunters for successful harvest (events)

		Karimui	Mane (Lufa)	Goroka	Gembogl	Total
Elevation (m)	N (events)	77	39	140	64	320
	Range	626 - 2022	1478 - 2334	1818 - 2478	2378 - 3057	626 - 3057
	Mean	1173.10	2126.21	2197.93	2758.20	2045.64
	Std. dev	360.00	282.51	194.88	199.35	601.09
	Std. error of mean	41.03	45.24	16.47	24.92	33.60
Distance (m)	Range	1638.05 - 20193.32	262.41 - 12664	100 - 5184.8	229.79 - 2443.3	100 - 20193.32
	Mean	11271.64	7437.68	2372.88	1626.73	4982.19
	Std. dev	6373.93	3126.85	1765.91	736.62	5276.60
	Std.error of mean	726.38	500.70	149.25	92.08	294.97

4:4.8 Hunting Areas over 35 years and Hotspot Analysis

In comparing the 1982 hunting sites to the current (2015), it is essential to point out that the techniques used in 1982 were to indicate, by estimate, collection sites of trophies of wildlife

harvested. This recent study, 2015, is the first attempt to measure the extent of hunting areas at Karimui. Whilst measurements have been calculated for the old and new hunting areas, they serve as qualitative information to understand the extent of activities. These should provide the basis of interpretation for the comparison.

Minimum convex polygon (MCP) of hunting areas in this study were compared with Masi, Yuro, and Karimui Plateau. The old core hunting sites of 1982 were calculated as follows; Masi (**A.** 4011.48 ha), Yuro (**B**. 6692.63 ha) and Karimui (**C**. 6009 ha). The current hunting areas are larger in size by comparison to 1982 (**Figure 4.2**). The main hunting areas in 2015 were; Masi (**A**. 9102 ha), Yuro (**B**. 17195 ha) and Karimui (**C**. 12075 ha). The overlapping area of hunting site for Karimui (1982 and 2015) was 4832.95 ha, whilst that of Yuro was 4169.82 ha. Masi had no overlap with the old site. The current overlap in Karimui plateau (and Yuro) is now mostly human settlement around the airstrip and district administration services. As per the different techniques employed, the hunting sites in 2015 are much larger than previously estimated. The difference in the estimates are; Karimui (100.95 %), Yuro (156.92 %), and Masi (126.9 % increase). **Figure 4.6** shows the old and new hunting areas.

The Optimised Hotspot analysis produced five categories of statistically significant areas according to their probability values. Grid code (gridcode_f) values were used to calculate the areas covered. The Hotspot 99 % Confidence had an area of 78.59 ha (or 0.78 km^2) while the Hotspot 95 % Confidence was 8458.65 ha. The yellow, Not Significant areas was equivalent to 6779.09 ha, whilst the Cold Spot 95 % covered an area of 628.75 ha.

It should be noted that the IDW creates an interpolated surface (continuous surface) and as such the output extends beyond the clan boundaries into the CMWMA. When only the areas of which hunters from this study area are considered (excluding Hot Spot extending into CMWMA), the Hot Spot 99 % Confidence remains unchanged as it is outside the CMWMA, however, the area Hot Spot of 95 % Confidence decreased to 2400.59 ha (or 24 km^2), whilst the Not Significant area losses 54 percent of its area.

Large threatened cryptic species were hunted within the Hot Spot 95-99 % Confidence area. These species were mostly tree kangaroos (Doria's, Spadix, and Good fellow's tree kangaroos), two species of cassowaries (Dwarf and Southern), and the Long Beaked Echidna. Other hunts within the area included feral pigs, bandicoots, and Eclectus parrot. Larger game such as cassowries can cover fairly wide altitudinal span (Wright 2005).

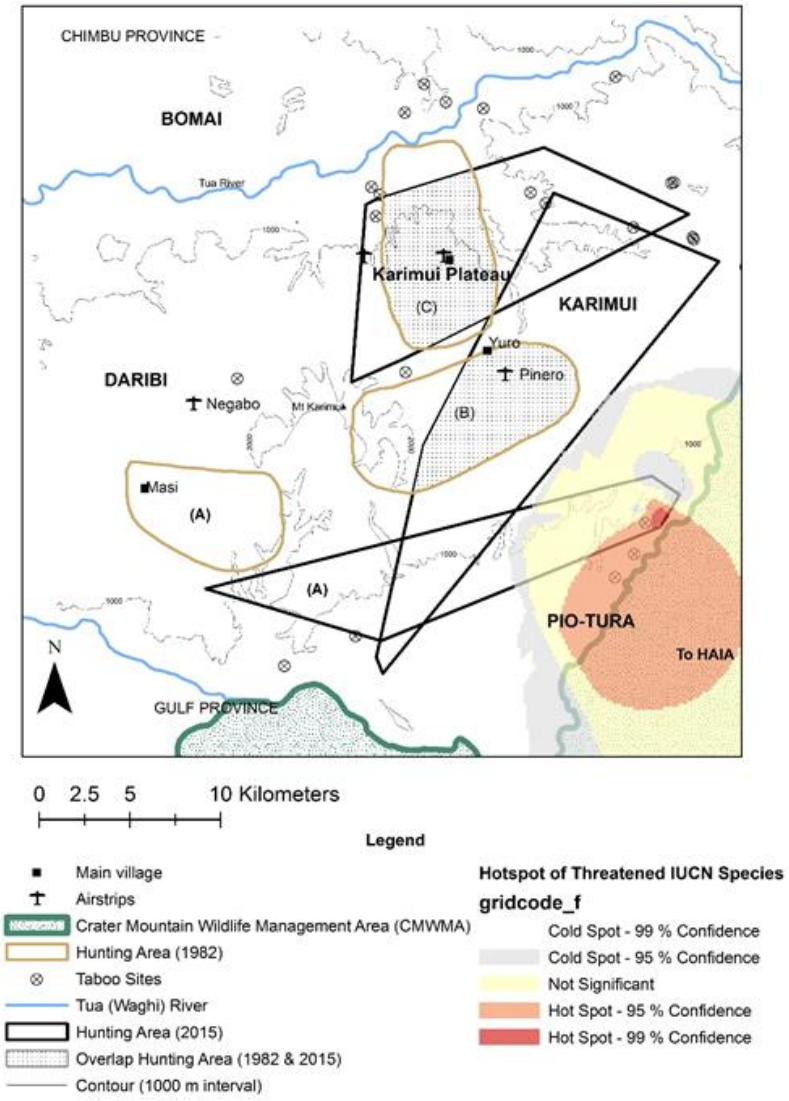

Figure 4.6: The map depicts a composite of two different analyses. The first, is the MCP of the old and new hunting sites overlap (1982 and 2015), spatial distribution of hunting areas in Karimui, and the second analysis of the habitat hotspot of IUCN Threatened species, (Mapped by Supuma 2017). The hunters of MCP region (A) now travel the furthest to hunt larger species as they have opted to have their hunting zone on Mt. Karimui range designated towards the proposed conservation area. The ecotones covered by (A) includes limestone karst, transitional lowland to montane forests (circa 300 – 2000 m.a.s.l), and sago swamps. As indicated in **Figure 4.6,** the region where these large species were hunted (Hotspot 95 -99 % Confidence) was less than 1 km outside of the CMWMA.

4:5 DISCUSSION

The types and proportions of bird families harvested in this study have the same main species of bird groups as identified in the literature reviewed, 1970 – 2013, (**Figure 4.5**), which also agrees with other studies (Mack and Dumbacher 2007). The quantity and species harvested varies with elevation. There appears to be a focus more on the Raggiana Bird of Paradise, Cassowaries, and the Vulturine Parrots in Karimui as these species provide a financial incentive but also retain kinship and social ties with neighbours. Hide observed trade practices with northern villages 35 years ago which continue today. However, the cost of species (in terms of the value of the transactable object) has increased in this study. Larger species such as the cassowaries provide rewards in terms of protein, and plumes for adornment. As the only site without road linkages, hunters of Karimui continue to supplement their livelihood with hunting. Relatively isolated from the central highlands and infrastructure services, Karimui hunters continue to uphold beliefs related to taboo sites. However, it is evident traditional beliefs are gradually being lost within Karimui due to competing belief systems (e.g. Christianity). The Seventh Day Adventist (SDA) church has a significant following within the Karimui area, leading to the 'cleansing' of evil spirits from two sago swamp patches, previously considered traditional taboo sites prior to the commencement of this study.

Whilst Karimui hunters hunt Birds of Paradise, the numbers are not as high as those of Lufa. The difference could be due to Lufa being a District of Eastern Highlands Province which has an annual Cultural Festival for over 60 years. The annual show attracts a host of international tourists and cultural participants from other highlands provinces. However, it is significant that neither of the rural areas in this study (Karimui, and Mane in Lufa), have held their own cultural ceremonial dances for over 30 years. This may be a result of the impact of modern Christian beliefs held by the communities (West 2016). In contrast to Karimui, Lufan hunters retained most of the plumes from birds they hunted for their personal collections. Whether these were for later exchange or trade is not known.

The Karimui plateau has a higher human population density (**Table 4.2**) compared to the Pio-Tura (e.g. South Yuro, Soliabedo, and Haia) area to the south, where there is less than 1 person per km^2 (Warrillow 1978). Locals of Karimui plateau cultivated a variety of staples for carbohydrates (rice, sweet potatoes, cassava, taro, plantain banana) yet they treated sago as a luxury. This observation has been similarly noted by Hide 1982 (pp 222). Yuro villagers have designated family sago patches further south (between South Yuro and Soliabedo). During the dry season, (mostly between May and October) locals make a trip down to maintain sago patches at family owned sago swamps and to harvest. Harvesting sago is labour intensive and requires efforts from both genders; men fell the tree and women beat the pith to loosen the starch. The starch extraction process takes 1-2 weeks depending on the trunk length. The sago plant is deeply intertwined with people that depend on it

(Barton and Denham 2016). Folklore regarding the harvest of sago and hunting of wildlife to supplement the starchy staple is indicative of a lifelong practice (Wagner 1972). Similar ties to sago are not limited to Yuro (Pio -Tura) or the Papuan coast but are also shared by refugees from West Papua (Indonesia) to Western Province (Papua New Guinea), who view sago planting in another land as a long term commitment to remain or to be 'rooted' (Glazebrook 2008). As such, whilst some residents of Karimui may take up settlement closer to or within the Karimui Plateau and Yuro, there remain cultural ties to return to and utilise hunting grounds and sago patches at lower altitudes in the south.

Hunters from areas with low human population density, for example South Karimui, tended to hunt more of large threatened species (hotspot analysis) by comparison to the high density on the Karimui Plateau. Hunters from sites located at altitudes over 2000 m.a.s.l, (Nagamizah and Nuphaha, Goroka), harvested a greater number of smaller mammals and birds by comparison to Karimui. This finding agrees with previous studies (Dwyer and Minnegal 1992, Mack and West 2005). Endemic species with restricted ranges such as the Blue Bird of Paradise, Dwarf Cassowary are particularly vulnerable.

Low population densities associated with swidden agriculture in areas such as Pio -Tura and Haia, within CMWMA appears to be form a of traditional management system. This strategy may not be intentional for conservation (Foale et al. 2011) and works well in low human population densities. Intermarriages between highlands communities and the people on Karimui Plateau and towards the South of Karimui may potentially increase land use intensity.

This study indicates that hunting areas in Karimui are much larger (over 100 percent) than previously estimated. The size and distribution of clan land varies across a spatial scale. For example, a hunter might have his village closer to a larger village (e.g. Karimui Plateau) consisting of other clans (a micro diaspora) but has his hunting grounds 5 km away. When a hunter from Karimui (A) goes hunting, he may pass through the hunting grounds of villages in area (B) to reach his clan's hunting zone. Land is communally owned by a clan unit and any decisions pertaining to the land are made by the clan body (Wagner 1967).

Traditional land boundaries in Papua New Guinea are often delineated by geographical features such as rivers, mountains, burial or spiritual sites, hence do not conform to the land boundaries acquired by the government that designates linear boundaries (or boxed in measurements). As such, this is a possible explanation for the polygons of hunting areas (2015) that appear as overlapping for Masi and Yuro hunters in the Pio-Tura area (**Figure 4.6**).

Larger fauna, such as cassowaries and tree kangaroos, were hunted at distances more than 5 kilometres from the villages. Given the expanded hunting grounds in this study, this may explain hunting pressure of larger species on the Karimui plateau, hence, a few skilled hunters now travel longer distances to hunt as indicated by the Hot Spot analysis (**Figure 4.6**). The hotspot is located approximately 600 meters from the boundary of the CMWMA and can be reached from where locals harvest sago during dry seasons. Species mostly hunted within the hotspot were cassowaries, echidna, and tree kangaroos. This indicates that the area towards the CMWMA is an intact habitat for many of the larger threatened species. In contrast, the Bird of Paradise species were hunted mostly in secondary forest closer to villages.

Unlike reports of overharvesting of Birds of Paradise with the use of guns in the 1980s (Kwapena 1984b), guns were used less in this study; bows and arrows were the primary weapons. The dry season played an important role in the general harvest of wildlife (including Birds of Paradise).

Having a dog in a remote location like Karimui was considered an asset. Within a week in the dry season, one hunter captured 43 bandicoots with the aid of dogs. Another hunter was said to have purchased a dog from further south (Baimuru) for K200. The importance of dogs in hunting have been noted by other studies in Papua New Guinea (Hide 1984, Mack and West 2005).

Traditional belief systems relating to hunting grounds, taboo areas (e.g. certain sago swamps, streams, karsts/ sinkholes) and rituals were followed by Karimui hunters in the past and these practices were thought to enable successful hunts (Wagner 1972). Such customary restrictions are gradually phasing out. Compared to Karimui, the other study areas, Lufa, Goroka (Nagamizah and Nupaha), Toromambuno (Gembogl) appear to have fewer taboo sites, especially on high elevation montane forests over 2300 m.a.s.l.

4:5.1 Birds of Paradise Harvested

The main Bird of Paradise species harvested were the Princess Stephanie's Astrapia. Rarer species such as the Black Sicklelbill and the Blue Bird of Paradise were not harvested or traded as often (see Chapter 3), which reflects their narrow range and sparse distribution. Further population studies are required to assess species densities.

Diamond noted the Blue Bird of Paradise as having a sparse distribution during his 1965 survey in Karimui (Diamond 1972). Despite a four months survey by Freeman and Freeman in 2012, the Blue Bird of Paradise was not observed (Freeman and Freeman 2014b). Robin Hide saw fresh kill by a local hunter in 1982 (pers. com). During this study (2015), a youth from Yuro village showed to me two fresh skins of Blue Bird of Paradise which he had killed four weeks ago. A further two

individuals were heard at 1500 meters (approximately 2 km apart). The Blue Bird of Paradise in Karimui occupies areas just 100 meters above the *Castanopsis sp* (Oak tree) margin (c. 1500 m) whereas similar species (*Nothofagus* spp. or Beech tree) in Lufa (e.g remained below 2000 m.a.s.l.

A hunter at Yuro village described a *Parotia* species he hunted matching the description of Carola's Parotia. Local vernacular (local name) was not obtained at the time. This species has not been reported from Karimui during previous intensive bird surveys. This hunter was able to distinguish Carola from Lawes which matched the description (pinkish breast shield versus green) in Beehler's guide (Pratt and Beehler 2015). If this is a correct attribution, it will underline the value of local knowledge of birds and its contribution to future understanding of species distribution ecology (Dumbacher et al. 2000).

Demographic and social kinship ties are complex structures within local communities. They often determine longevity of conservation projects on the ground (Foale 2002, West 2006, Mack 2014). Hence, it is important in determining future land use practices or development projects. Updated demographic data as well as social studies are very much needed prior to commencement of any projects. Social dynamics and spiritual beliefs have a physical manifestation on the environment and resource use – as such, an integrated interdisciplinary approach is needed for conservation or any development projects in communities that have largely remained isolated from government services and road networks. Such an approach can accommodate competing interests in conservation and development (Foale 2002) which has often been lacking in the past (Filer 2004).

4:5.2 Conservation of Species and Culture

Human population growth has resulted in enlarged settlements and cultivated areas in Karimui. The increase in population has had subsequent effects on the extension of hunting areas. Whilst isolated communities continue to maintain some traditional belief systems (taboo sites), these systems are in the process of being eroded with the adaptation of new values and beliefs (e.g. Christianity). To some extent, religion has contributed to hunting expansion and the loss of cultural identity in the Karimui area. For the Catholic Church, traditional adornment was encouraged. Processions within the Church allowed parishioners to dress in traditional adornment during Church events. This allowed for followers to accumulate plumes for such occasions and for other cultural events (e.g. marriages, pig killings during elections). For the Seventh Day Adventist Church (SDA), traditional dance and adornments were discouraged. While this may reduce need to acquire adornments (lessen demand for feathers), the SDA members in Karimui were involved in Church ritual 'cleansing' of taboo sites which enabled extension of gardens. Either way, one church allowed the promotion of cultural heritage, and the other allowed its followers to extend subsitence activities into new forest areas. Both religions have had a direct and indirect connection to species habitat and harvest.

Although traditional inhabitants of Karimui do not actively participate in cultural dances, they clearly continue to value the culturally significant species of Birds of Paradise, Cassowaries, and Vulturine Parrots which are seen in their continued trade. It is ironic that this northward trade has played a part in contributing to locals in urban areas being able to uphold their cultural identity in a larger diaspora setting, whereas those in remote areas, are gradually letting go of this material cultural expression in the form of traditional headdress. The majority of Lufan hunters notably keep most of their plumes although a few are traded. Lufa, by comparison to other sites has the largest proportion of Birds of Paradise hunted. This may reflect the established annual cultural show in the province's town, Goroka.

Among the few hunters who do retain their plumes, improved storage techniques are needed to protect the skins and plumes from being destroyed by rats, insects, or dust. These would enable the longevity of the feathers and hopefully reduce pressure on hunting for personal use.

The Hot Spot analysis firstly indicates that intact habitats are now further removed from human settlements on the Karimui Plateau – in particular, towards and within the Crater Mountain Wildlife Management Area. During the 1982 survey, cassowaries and tree kangaroos were hunted within the plateau. Now it appears that a few hunters travel further to hunt these species – a shift in the distribution of species. Secondly, hunters know where to find these species, and have extended their activities into these areas. An alternate explanation might be that the proposed conservation area (Karimui Conservation Area which encompasses Mt. Karimui), may have caused hunters to shift their activities further away.

In this chapter, extension of hunting areas is attributed to human extirpation of species in areas of high density of settlement, conducive weather, i.e. dry season. For example, Karimui had recorded 25 cassowaries harvested in the space of 2 years by 38 skilled hunters by comparison to the same number recorded within Crater Mountain Wildlife Management Area by 157 hunters (Mack and West 2005). For communities that have sago at the lower elevation, sago harvesting, and hunting are two main activities that appear to be synonymous particularly during the dry seasons. Prolonged dry seasons such as El Nino may pose a significant greater threat to large fauna and to birds species as indicated in this study. From Chapter 3, we know that the Cultural Shows in the central highlands are held between the months of August and October. These months coincide with the dry season. We now know that the dry season is most suited for hunting birds and mammals.

Whilst the number of Birds of Paradise hunted and traded in this case study appear minimal by comparison to Papua (Indonesia) by transmigrants (Pangau-Adam and Noske 2010), data are still needed to compare the proportion of harvested species to the existing population within an area. Such

information is vital and needs long term population research, and harvest rates, as well as monitoring distribution over time (Healey 1990). Only a few studies on monitoring exist for Papua New Guinea.

4:5.3 Climate Change and Human Use

Climate change is an important phenomenon that has already affected species distributions (Walther et al. 2002, Brook et al. 2008). The species most vulnerable to climate change include those with small spatial and narrow elevational ranges and particularly those in montane tropical forests. Recent studies in the tropics, (including Karimui) have indicated strong upslope shifts in birds and importantly show that tropical birds are responding more strongly to climate change than temperate species (Freeman and Freeman 2014b). This study has indicated that anthropogenic impacts such as that of those induced by an increase in population density can also increase the human footprint on the landscape (the extent of hunting). It is imperative nevertheless, to understand how climate change, particularly that which causes prolonged dry seasons, may affect species within the communities that depend on them for sustenance or other cultural purposes. Whilst climate change alone can cause species shifts, some species populations are affected by a number of factors acting together (Brook et al. 2008). For instance, the Magpie geese (*Anseranas semipalmata*) populations in Australia are predicted to decline due to a combination of hunting and climate change (Traill et al. 2009). For the case of isolated rural communities in Papua New Guinea, future research efforts are needed to elucidate this and contribute towards policies that not only safeguard food security, culture and human connection to a landscape but also the persistence of species.

In the next chapter (**Chapter 5**), I use cluster analysis to predict species vulnerability to subsistence use. Chapter 5 will also collate all the knowledge gained from literature review, current cost of plumes, and harvest of species to improve our understanding of subsistence use of endemic bird, risk assessment, and conservation priority.

CHAPTER 5: Potential risks associated with the subsistence use of endemic birds and their conservation assessment, Papua New Guinea

5:0 INTRODUCTION

Wildlife consumption and its use in subsistence is an important part of many indigenous tropical rainforest communities (Robinson and Bennett 2000a). Species loss associated with hunting is currently a major conservation concern in the tropics (Benítez-López et al. 2017). Eighty percent of Papua New Guinea's population live in rural areas and are the most reliant on hunted fauna for sustenance (Hide 1984, Dwyer 1985, Mack and West 2005).

In Papua New Guinea, birds comprise the highest diversity of species hunted by contrast to mammals (Mack and West 2005). Papua New Guinea's diverse cultures have deep symbolic association with certain species of birds (Majnep and Bulmer 1977, Sillitoe 1988b, Sillitoe 1988a, Beehler and Thomas 2017). The display of certain birds' feathers worn as headdress have embedded meaning or messages; ranging from individual or clan identity, virility, power, wealth, to a way of storytelling via bird songs (Strathern 1979, Sillitoe 1988a, O'Hanlon 1989, Beehler and Thomas 2017).

In the last 30 years, there has been an emergence of conservation interest in animals hunted for consumption (Wilkie and Carpenter 1999, Robinson and Bennett 2000b, Robinson and Bennett 2004, Mack and West 2005, Wilkie et al. 2005, Rao et al. 2011). The terms 'bush meat' and 'wild meat' in this case mean different things depending on the intent of the hunter (Bennett et al. 1997, Wilkie and Carpenter 1999, Pangau-Adam et al. 2012). Bushmeat is wildlife hunted and destined for the markets to be traded (Mack and West 2005). Wildmeat is that hunted for local consumption. For many hunted New Guinea birds, although the meat reward might be modest; the reward offered by the plumes (feathers) used for ceremonial headdress is large (O'Hanlon 1989, Healey 1990). The main exception is the cassowary whose large size distinguishes it from other birds (Mack and West 2005, Majnep and Bulmer 2007, Pangau-Adam and Noske 2010).

Over the last forty years, the increase in education and employment has caused a gradual drift of local people out of rural areas in search of opportunities in urban areas; away from a subsistence livelihood (Howlett 1976). The gradual globalization of the rural settings in the form of improved road networks, change in belief systems, improved technology, modern weapons of hunting, and employment, all contribute in the evolution of value, use, and significance of a species (Kwapena 1985, Mack and West 2005). Whilst the majority of the population still practices a subsistence livelihood (Mack and West 2005), their view of certain species of animals once valued by their ancestors and traditional

taboos are also shifting (see Chapter 4). Such observations are not limited to Papua New Guinea and are experienced in other global tropical rainforest communities (Alvard et al. 1997, Wilkie and Carpenter 1999, Wilkie et al. 2005, Aiyadurai et al. 2010).

Contemporary study on the use of birds in Papua New Guinea culture has not been revised since the 1980s (Howlett et al. 1976, Healey 1986, Sillitoe 1988a, O'Hanlon 1989). Whilst very recent literature emphasises the cultural connections via birds to the environment (Beehler and Thomas 2017), the deep connection of birds to life, cosmology (West 2016), and wildlife contribution to rural sustenance (Mack and West 2005), there still remains much to be understood in terms of pressures stemming from wildlife trade within Papua New Guinea. The informal sector trade in Papua New Guinea is often unregulated. Whilst informal sector policy promotes economic activities for people without formal income (Conroy 2010, Kavan 2013), protected species are often sold (Chapter 3) at locations without adequate enforcement. Weakness in institutional governance of biodiversity and enforcement (Melick et al. 2012) as well as policies that promote informal sector trade (without improved measures to regulate) may weaken conservation efforts and increase vulnerability.

Currently, increased hunting pressure is the major cause of bird and mammal decline in the tropics (Belize 2016). Many indigenous communities depend on forest for their subsistence needs. Understanding what species are potentially at risk enables conservation practitioners and custodians to improve conservation measures.

The purpose of this study is to identify risks associated with the subsistence use of New Guinea birds as well as species trade. Assessment of species vulnerability allows us to detect taxa that may be vulnerable to persistent selective harvesting. Furthermore, assessment allows us to prioritise species of conservation concern that are most used by locals in cultural practices and thus are exposed to persistent selective harvest.

5:1 METHODS

A combination of methods was used to gauge the extent of subsistence use of birds in Papua New Guinea. The first entailed a compilation of a list of birds in published accounts between 1970 to 2013 from mainland New Guinea. Refer to previous Chapters 2 (Literature Review), Chapter 3 (Trade), and Chapter 4 (Case Study-Hunting).

Between July 2014 and January 2016, hunter, trade, and cultural festival surveys were conducted (see Chapters 3 and 4). The hunting study was conducted in the Eastern Highlands and the Chimbu Provinces using semi-structured interviews (Miraglia 1998, Huntington 2000, Bernard 2006) of

knowledgeable males (≥ 20 years old) who actively hunted and about their experiences and knowledge of birds. The study sites encompass at least six language groups.

A sample of focal hunters and elders from four districts that were known to the community as particularly possessing in-depth indigenous knowledge of the species, environment, and history of trade were interviewed. Only people who were native residents participated. Participation was voluntary. Hunters were shown either pictures or photographs (Whitehead 1995, Ziembicki et al. 2013) and asked questions about known localities of species occurrence and ecological knowledge (e.g habitat of species, feeding habits, leks, taboo sites)(Read et al. 2010b). In addition, information on distance travelled to hunt, time of the year the successful hunt occurred, type of weapon used, and the perception of the participant of population trends of the focal species was recorded.

To understand what proportion of the species hunted were traded, we surveyed craft markets to assess live birds or plumes (feathers) sold by street peddlers and craftsman. The market survey was carried out in four locations in Papua New Guinea; Eastern Highlands Province and Western Highlands Province at popular craft markets. To further understand the movement of species to urban areas, we surveyed markets in the capital, Port Moresby, and in the second largest city, Lae, Morobe Province.

The third type of survey was performed during annual cultural festivals in three provinces (cultural show survey). This survey involved participants wearing traditional headdress and three popular cultural shows. The oldest cultural show in the country is the Goroka Annual Cultural show which started in 1957. This annual festival was initiated by Australian Patrol officers, to promote culture and peace within the region that had been marked by pronounced tribal wars. The second largest annual cultural show is the Morobe Show held in August followed by Mt. Hagen (Western Highlands Province). These shows were surveyed in August (Mt. Hagen), September (Goroka), and October (Morobe) of 2014. The most recent show survey conducted was that of Simbai Cultural festival (hinterland of Madang Province) in September of 2015.

5:1.1 Ornithological Classification and Enumeration

The Birds of New Guinea Guide (Pratt and Beehler 2015) was used to identify species in the field. Furthermore, we followed the classification and nomenclature of Birdlife International as it is consistent with the International Union Conservation Nature (IUCN) Red List assessment (Williams et al. 2014). Birds were identified as far as species level for analysis. If birds could not be determined to genus level, they were excluded from analysis. This study only considers species that are residents, and endemics. Three exotic species were not used in analysis. These were the Domestic chicken (*Gallus gallus domesticus*), Indian Peafowl (*Pavo cristatus*), and Chinese ringneck pigeon (*Phasianus colchicus*).

5:1.2. Patterns of Rarity and Commonness

The seven forms of rarity model was initially designed to assess the vulnerability of plants (Rabinowitz et al. 1986) using the parameters; abundance, range size, and habitat specificity (Williams et al. 2014). Similarly, we applied the model to measure the likelihood of species vulnerability to harvesting practices of central highlands ethnic groups. The result is a table with eight cells (A-H) depicting their rarity and commonness with an assigned score (1 – 4, most to least rare). For instance, species in cell A are generally common and occupy several habitats over a large geographic area. Species of birds in cell D generally tend to have small populations in specific habitats over a large geographic whilst species in cell H have small populations in species habitats and in a small geographic area. Further description of the arrangement of ranking for analysis using Rabinowitz's forms of rarity is described in section **5:1.5** with illustration in **Table 5.1**. The data used in this section was obtained from the Birdlife International website (http://www.birdlife.org/datazone/country/papua-new-guinea), Birds of New Guinea (Pratt and Beehler 2015), and from this study's field observation.

Additional data obtained from Birdlife International includes population size estimates, population trends, extent of occurrence of species (EOO, km^2), and the number of level 1 habitats under the IUCN Habitat Classification Scheme (Rabinowitz et al. 1986, Yu and Dobson 2000, Williams et al. 2014). In this case, level one habitat refers to forests and woodland. In order to understand the extent of rarity within the three variables, these variables were further separated into large or small (range distribution), broad or narrow (habitat), and species population abundance considered as large extant individuals and generally not dominant (Williams et al. 2014). To assign the inventoried species to broader categories of distribution, the median EOO was used. For this study, the median EOO was 229, 000 km^2 (range: 1900 km^2 to 633,000,00 km^2; n = 172). Any EOO greater than the median was considered as large and below the median were small distributions.

5:1.3 Bird Life International and IUCN Red List Status and Endemic Bird Areas

The organization Birdlife International updates its data on global bird status from information received via its partnerships with 119 not for profit, non-government organisations. The data from Birdlife International assists experts on the panel of the International Union of Conservation of Nature (IUCN) to make assessment on species conservation status. I consulted information from both websites, Birdlife International http://www.birdlife.org and the IUCN http://www.iucnredlist.org/.

The IUCN has various degrees of species classification according to area occupied, extent of occurrence (EOO), rate of decline, and number of individuals. All these give a relative measure contributing to the species status. For instance, species are categorised as threatened (Vulnerable) if

their EOO, which is the measured area of known occurrences within a boundary, is ≤ 20,000 km^2 http://www.iucnredlist.org/.

Papua New Guinea has 13 Endemic Bird Areas (EBA). Whilst the study covers some species that span across the entire island of New Guinea (including Papua, Indonesia), I make emphasis on species within the Central Papuan Mountains Endemic Bird Area (CPM EBA)(BirdLife 2016). The CPM EBA covers an area of 190 000 km^2 (1000 – 4600 m.a.s.l) and is prioritised as a site in need of urgent avian research http://www.birdlife.org.

5:1.4 Body Mass and Guild

Forest specialists (e.g frugivores) that play a key role in seed dispersal are important for the persistence of plant communities (Zaiden et al. 2015). Current trends indicate that large forest specialist birds are most vulnerable to human impacts such as hunting (Pimm et al. 2006) and even more so are tropical endemic montane species (Sekercioglu et al. 2008b). Body mass was obtained from various sources and unpublished accounts from an individual expert while guild categories followed that of the Birds of Papua (Mack and Dumbacher 2007). Very large species such as the cassowaries were not included in the correlation analysis due to much larger proportion of mass (40-60 kg) compared to most of the species.

5:1.5 Cluster Analysis and Conservation Priorities

Cluster analysis was performed to identify species most at risk from continued selective harvesting. The analysis uses three main variables; i) assigned ranks of rarity as per Rabinowitz classification ii) mean body mass iii) number of markets where occurred and number of sites species were traded (Williams et al. 2014). Prior to analysis using *K-means clustering*, variables were scaled and standardised (mass of species is a continuous variable whilst rarity ranks are not). The assigned ranks of rarity were reversed (1 to 4, most abundant to least abundant were switched to 4 = most abundant to 1 = least abundant) before being standardised (**Table 5.1**). This switch in values allowed for rarity to be represented in the standardised score. I only used species with average mass weight and omitted those whose mass were not obtained. Hence, of the 172 species only 166 species were used for the *K-means cluster* analysis.

The standardised variables allowed for each variable to be allocated a score between 0 and 1 (i.e. lowest to highest score, least to most vulnerable). Scores were obtained per column of each variable by dividing each value per column by the highest value of the corresponding column. The total score of the three values when added (per species) was three (max score = 3). Cluster analysis was

performed with IBM SPSS Software 22. The outcome was two groups for 'higher' priority (S = 22) and 'lower' priority (S = 144) for conservation.

Table 5.1. Rabinowitz's forms of rarity based on range, abundance, and habitat specificity.

Geographic Range		***Large***		***Small***	
Local Population Size		Large, dominant somewhere	Small, non-dominant	Large, dominant somewhere	Small, non-dominant
Habitat Specificity					
	Wide	(A) Locally abundant in several habitats over a large geographic area **(4)** (1)	(C) Constantly sparse in several habitats over a large geographic area **(3)** (2)	(E) Locally abundant in *several* habitats over small geograhic area **(3)** (2)	(G) Constantly sparse in several habitats over small geographic area **(2)** (3)
	Narrow	(B) Locally abundant in a specific habitat over large geographic area **(3)** (2)	(D) Constantly sparse over specific habitat over large geographic area **(2)** (3)	(F) Locally abundant in a *specific* habitat over a small geographic area **(2)** (3)	(H) Constantly sparse in a specific habitat over a small geographic area **(1)** (4)

Letters in brackets () indicate the rarity class, whereas the bold numbers in brackets indicate the ranks assigned to each rarity class (Adapted from Rabinowitz 1996, and Dobson & Yu 2006). As such, **(4)** indicates common widespread species whilst **(1)** indicates rare less dominant species confined to small geographic area. The figures inside the blue broken circles indicate the rarity values used in K-Means Cluster analysis. These rarity values were then standardized to allow for comparison by variables.

5:2 RESULTS

5:2.1 Avifauna Richness

I found 153 species documented to have been harvested from the review of literature (1970 – 2013) throughout the entire island of New Guinea. Eighty-seven of these species were also observed during the recent (2014 – 2016) surveys; 55 of these species were previously recorded whilst 32 (17 %) were not previously recorded (including the three exotics). In total, 182 species from 15 Orders and 45 Families that constitutes 24 % of New Guinea's total species which are known to be harvested over a 40-year period.

The order Passeriformes had the highest number of species (91 spp) (**Table 5.2**). The two most diversely harvested families within Passeriformes were Meliphagidae (10 genera, 22 species) and Paradisaeidae (15 genera, 19 species). The second most diverse order was Psittaciformes (three Families,18 Genera, 22 Species) followed by Columbiformes (one Family, 11 Genera, 21 Species). The Accipterformes had one family, five genera, and eight species.

Overall, the top three orders that appeared to be rare were Galliformes (Megapodes, mean rank = 2), Caprimulgiformes (Owlet Nightjars-Frogs, mean rank = 2.33), and Gruiformes (Rails, mean rank = 2.5). Apodiformes (swifts) appeared to be the most common order (mean rank = 4) (**Figure 5.1**). The orders with diverse species Passeriformes (Perching birds, 91 species, mean rank = 2.53), Psittaciformes (Parrots and Cockatoos, 24 species, mean rank = 2.83), and Columbiformes (Pigeons and Doves, 21 species, mean rank = 2.86).

Table 5.2: Mean rarity rank per Order according to harvest. indicates the relative rarity of species.

	Order	Grouping	Species	Mean Rank
1	GALLIFORMES	Megapodes	2	2
2	CAPRIMULGIFORMES	Owlet Nighjars-Frogmouths	3	2.33
3	GRUIFORMES	Rails	2	2.5
4	PASSERIFORMES	Perching birds	91	2.53
5	CASUARIIFORMES	Cassowaries	3	2.67
6	PSITTACIFORMES	Parrots and Cockatoos	24	2.83
7	COLUMBIFORMES	Pigeons and Doves	21	2.86
8	ANSERIFORMES	Ducks, Geese, and Swans	2	3
9	BUCEROTIFORMES	Hornbills	1	3
10	FALCONIFORMES	Falcons	1	3
11	STRIGIFORMES	Owls	3	3
12	CUCULIFORMES	Coucals and Old World Parasitic Cuckoos	3	3.33
13	CORACIIFORMES	Rollers and Kingfishers	7	3.43
14	ACCIPITRIFORMES	Hawks and Eagles	8	3.5
15	APODIFORMES	Swifts	1	4
		Total	**172**	**2.93**

Mean rarity rank by Order was calculated using values assigned in their rarity class; values in brackets in Table 5:1. The rarity Class values of each species per order was summed and divided by the total number of species in each order. Ranks with values closer to 1 indicate a greater relative rarity (Williams et al. 2014).

In this recent study (N=202), I interviewed 55 hunters, 70 tradespersons, and 77 cultural show participants in headdresses. From each of these three categories, I observed 62 (6 vulnerable), 29 (5 vulnerable), and 35 (8 vulnerable) species harvested respectively. The 17 species most often utilised by locals for trade and headdress are the Birds of Paradise (0.47), parrots (0.18), cassowaries (0.18), New Guinea Vulturine Parrot (0.06), Sulphur Crested Cockatoo (0.06), and Blyth's Hornbill (0.06) (**Table 5.3**). Most of these species (69 %) have a decreasing population trend.

5:2.2 Patterns of Rarity and Commonness

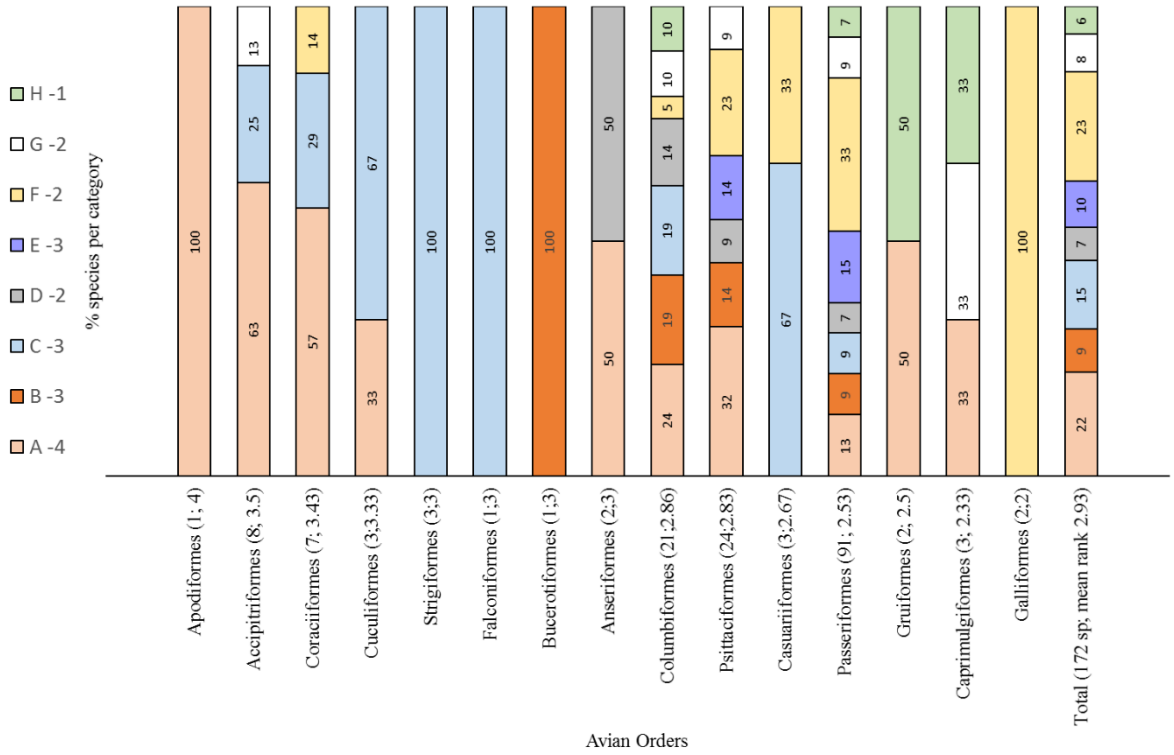

Figure 5.1. The proportion of birds used in subsistence livelihood in the eight Rabinowitz rarity classes. Figures in parenthesis indicate number of species in the order followed by the mean rank (Table 5:2). The order of species starts with widespread species (Apodiformes) to rare (Galliformes). The figures within bars indicate species % within order according to its rarity.

Forty-seven species have a small geographic range (i.e. less than median EOO, 229 000 km2). Thirty-five percent have a low population and are non-dominant within their range, and 45 % of species have specific habitats. Chi-square pairwise comparisons indicate no significant difference between EOO (range) of species and population of species (χ^2 = 2.31, d.f. = 3, P = 0.13). There were no differences in the association between habitat specificity and population (χ^2 = 3.29, d.f. = 3, P = 0.07). However, there was a significant difference between EOO (range) and habitat (χ^2 = 16.59, d.f. = 3, P = 0.00).

IUCN Red List Status and Population Trends

Of the 172 species that were used by locals, 16 species were predominantly used (**Table 5.3**). Over six percent have a threatened status under IUCN (**Table 5.4**). One hundred and sixty species (93 %) are “Of Least Concern”. Fifty-five percent of the species are stable in terms of population trends, whilst 23 % are decreasing (**Table 5.4**).

Table 5.3. Species often hunted, traded, and used as headdress.

Family	Species	Common name	# sites use reported (n = 7)	2016 IUCN Red List Status[a]	Population Trend[b]
Burcerotidae	*Rhyticerous plicatus*	Blyth's Hornbill (Papuan Hornbill)	6	LC	D
Cacatuidae	*Cacatua galerita*	Sulphur-crested Cockatoo	5	LC	D
Casuaridae	*Casuarius bennetti*	Dwarf cassowary	6	LC	S
Casuaridae	*Casuarius casuarius*	Southern cassowary	6	VU	D
Paradisaeidae	*Paradisaea minor*	Lesser Bird of Paradise	6	LC	S
Paradisaeidae	*Paradisaea raggiana*	Raggiana Bird of Paradise	7	LC	S
Paradisaeidae	*Epimachus fastuosus*	Black Sicklebill Bird of Paradise	7	VU	D
Paradisaeidae	*Lophorina superba*	Superb Bird of Paradise	7	LC	S
Paradisaeidae	*Astrapia stephaniae*	Stephanie's Astrapia Bird of Paradise	5	LC	D
Paradisaeidae	*Pteridophora alberti*	King of Saxony Bird of Paradise	5	LC	D
Paradisaeidae	*Epimachus meyeri*	Brown Sicklebill Bird of Paradise	4	LC	S
Paradisaeidae	*Paradisornis rudolphi*	Blue Bird of Paradise	4	VU	D
Psittaculidae	*Eclectus roratus*	Eclectus Parrot	4	LC	D
Psittaculidae	*Trichoglossus haematodus*	Rainbow Lorikeet (or Coconut Lorikeet)	4	LC	D
Psittaculidae	*Charmosyna stellae*	Stella's Lorikeet	4	LC	D
Psittichasidae	*Psittrichas fulgidus*	Vulturine Parrot (Pesquet's Parrot)	5	VU	D

[a]LC = Least Concerned; VU = Vulnerable and [b]D = Decreasing, S = Stable (http://www.birdlife.org).

Table 5.4. Species and their rarity categories and population trends as observed by IUCN.

	IUCN Red List Status[a]				Total *N*	Population Trends			
Rarity	**EN**	**VU**	**NT**	**LC**		**Stable**	**Decreasing**	**Increasing**	**?**
A				38	**38**	23	9	0	6
B				16	**16**	8	4	0	4
C		2		23	**25**	14	7	0	4
D		2		10	**12**	5	6	0	1
E				17	**17**	9	1	1	6
F		2	2	36	**40**	24	7	1	8
G		2		12	**14**	6	4	0	4
H		1	1	8	**10**	6	2	0	2
Total	0	9	3	160	**172**	95	40	2	35
%	0	5.23	1.74	93.02		55.23	23.26	1.16	20.35

[a]EN = Endangered; VU = Vulnerable, NT = Near Threatened, LC = Least Concerned. The letters A-H are the rarity categories as depicted in **Table 5.1**

5:2.3 Body mass and Guild

Non-parametric one-way ANOVA test was used to compare mean mass of birds within each category of distribution, population, and habitat. There was significant difference in mean mass of species found in large and small EOO (χ^2 = 15.95, d.f. = 1, P = 0.00) (**Table 5.5**). Mean mass was also significantly different for species of high versus low populations (χ^2 = 11.23, d.f. = 1, P = 0.00). There was no difference in means for species mass within broad versus narrow habitat (χ^2 = 2.64, d.f. = 1, P = 0.104).

Table 5.5. Mean mass of species within each Rabinowitz rarity category.

Factor			
Distribution		*N*	Mean mass ± S.D.
Large geographic areas (> 229 000 km^2)	Large	87	292.29 ± 370.5 g
Small geographic area (< 229 000 km^2)	Small	79	146.17 ± 331.3 g
Population			
Large, dominant somwhere, locally dominant	High	108	162.01 ± 269.33 g
Small, non-dominant, constantly sparse	Low	58	335.86 ± 465.36 g
Habitat			
Wide, several habitats	Broad	89	244.77 ± 380.06 g
Narrow, specific habitats	Narrow	77	197.3 ± 333.29 g

The largest proportion of species hunted was from frugivorous and insectivorous guilds (**Figure 5.2**). Over 58 % of species recorded in the literature were observed in the current study with similar patterns of guilds. I observed a few more species of goshawks and kites but did not observe any ducks (including geese or swans) in the recent survey.

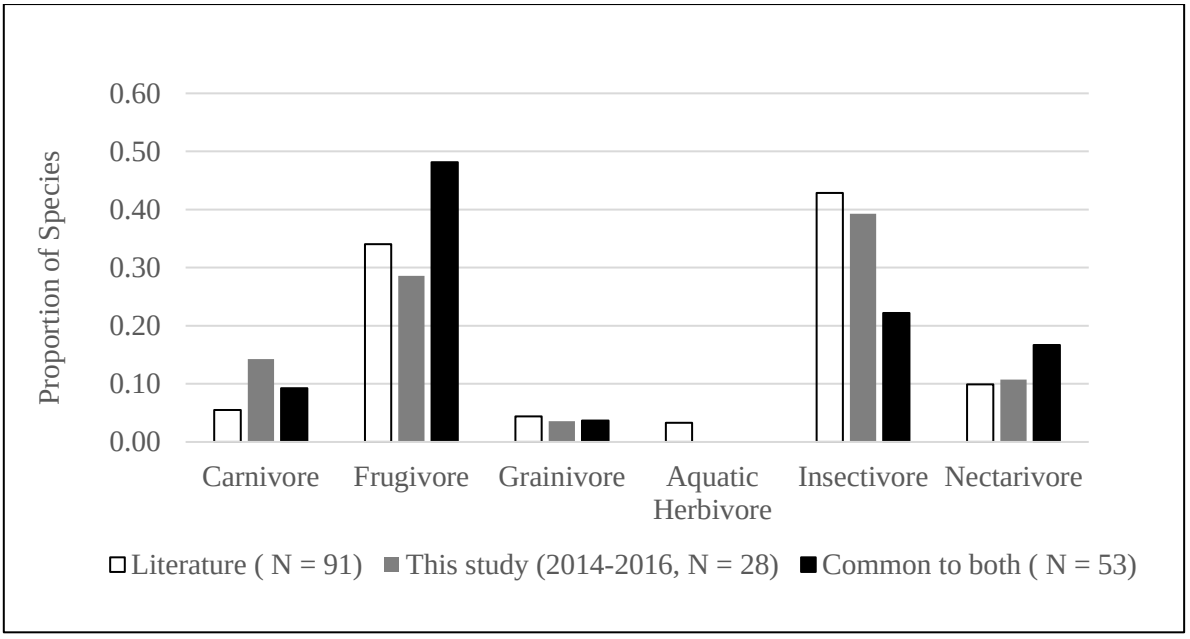

Figure 5.2: Guilds of avian species in subsistence use.

5:2.4 Vulnerability to Selective Harvesting

Cluster analysis measured biological and ecological traits (values) of species vulnerable to selective harvest. With respect to similarity of traits, species were assigned into two groups relative to their conservation priorities; Group 1 (high risk) and 2 (low risk) (**Appendix 5.1**). Group 1 species (22) appear to be larger ($\bar{x}$ = 621.6 g) than Group 2 species (144) ($\bar{x}$ = 161.81 g), ANOVA ($F_{(1,163)}$ = 40.86, P = 0.00). Of the 22 species in Group 1, most were frugivorous (12 spp; 54 %) for example; 9 species of Birds of Paradise, Vulturine Parrot, and Papuan Hornbill. Group 2 species were mostly frugivores (50 spp; 34.7 %) and insectivores (59 spp; 41 %). This is consistent with the observations illustrated in Figure 5.2.

The total importance score (cluster analysis) indicates a right skewed distribution (**Figure 5.3**). The scores have a range of 0.40 – 2.32, mean = 0.93, std. dev = 0.37, and std. error of mean = 0.03. The summary statistics were obtained from the results (**Appendix 5.1**). In order to narrow down the species from Group 1 (high risk) to be considered as highest risk, species with the highest 10 % of the risk scores were considered. This include the top 17 species; Victoria Crowned Pigeon, Black Sicklebill, Red-legged Brush-Turkey, New Guinea Harpy Eagle (Papuan Eagle), Blyth's Hornbill (Papuan Hornbill), Raggiana Bird of Paradise, Superb Bird of Paradise, Vulturine Parrot (Pesquet's Parrot), Palm Cockatoo, Wattled brush-turkey, Carola's Parotia, Blue Bird of Paradise, Rufescent Imperial Pigeon, Stephanie's Astrapia, Salvadori's teal, King of Saxony Bird of Paradise, and Lesser Bird of Paradise.

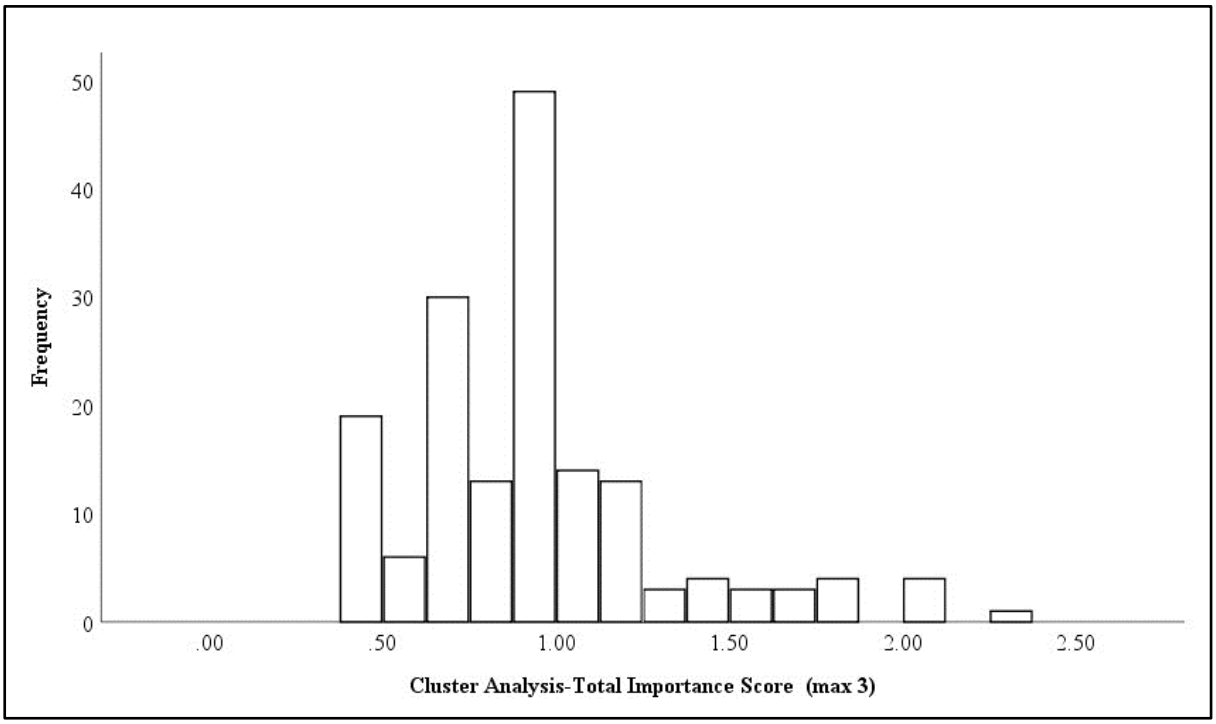

Figure 5.3: Distribution of Total Importance Score – *K -Means* cluster analysis.

I compared the EOO of the species between the Groups 1 and 2. Whilst the high-risk group appeared to have a smaller range ($\bar{x}$ = 413042.86 km^2) versus low risk ($\bar{x}$ = 1240046.81 km^2), there was no significant difference in the mean EOO ($F_{(1,164)} = 0.467$, $P = 0.495$).

5:2.5 Central Papuan Mountains Endemic Bird Area

I found 23 species endemics to the Central Papuan Mountains (CPMEBA). Bird guilds hunted within CPMEBA were of equal proportion of insectivores (0.52) and frugivores (0.5). The threatened species under IUCN category within the CPMEBA includes the Blue Bird of Paradise (1500 -1800 m.a.s.l), Black Sicklebill (1100 – 2300 m.a.s.l), and the Long-bearded Honeyeater (2450 – 3800 m.a.s.l). Two other larger species, the Dwarf Cassowary and the New Guinea Vulturine Parrot, have overlapping ranges with CPMEBA and the lowlands. Whilst they are not categorised as CPMEBA endemics, they are endemic to New Guinea.

5:3 DISCUSSION

5:3.1 Avifauna Richness and Human Use

The avifauna on the island of New Guinea comprise 7 % of the world species 10,000; New Guinea has 717 – 813 species of birds (Mack and Dumbacher 2007, BirdLife 2016). Birds observed to be used by locals for consumption, trade, and traditional adornment comprise 24% of the island's avifauna diversity. This provides an approximate representation of subsistence use of species by people of New Guinea across sites included in this study.

The recent surveys (2014-2016) combined with literature for sites within the central highlands of Papua New Guinea indicate that certain taxa of birds have been most heavily and consistently used over the 40 years and continue to be valued by highlands tribes to this day. Such species include the Birds of Paradise, cassowaries, the Vulturine Parrot, and various colourful parrot species (**Table 5.3**). Most species used by locals were not threatened or were considered of least concern (**Table 5.4**). However, those that were threatened appear to be species that were heavier, conspicuous, and found in low populations with larger ranges.

Whilst the Raggiana Bird of Paradise plumes were observed to be preferred in particular by tribes prior to 1970 (e.g Waghi Valley-Jiwaka, and Chimbu Provinces), there has been a noticeable change (O'Hanlon 1989) in species used since 1964 (Hide 1981). For instance, the long black plumes particularly those of Stephanie's Astrapia, Black Sicklebill, and Brown Sicklebill (Healey 1973, O'Hanlon 1989) have been favoured since the mid-1960s. There are four possible explanations for this change in preference of species from red to black dominance. Firstly, this could be due to increased human access into previously inaccessible montane forest; habitats of montane birds of paradise such as the Stephanie's Astrapia, and the Black and Brown Sicklebills. The second reason may be improved trade networks linking other provinces where such 'newer' species were sought after (Howlett et al. 1976). The third may arise as a result of less tribal conflict, which allows individual hunters to venture further into areas where previously they had limited access (O'Hanlon 1989). The fourth reason has been attributed to the movement of highlanders to work in coastal plantations as labourers in the (1950s and 1960s) who returned to their home provinces with black plumes (Hide 1981, O'Hanlon 1989, Healey 1990). This then started a fashion trend. Current observations indicate that the black plumes (e.g. Astrapia) continue to be greater in quantity on headdresses of many tribes within the areas surveyed compared to those of Raggiana. However, I noticed more of the Raggiana Birds of Paradise were traded in markets and this would also indicate that throughout mainland Papua New Guinea, many tribes outside the focal area of study use the plumes of Raggiana.

As a family, the Paradisaeidae has 19 species recorded in this study with 14 widely used by locals on headdresses. The Parrots (Psittaculidae) has the highest number of species (21) hunted for use in traditional adornment. The beautiful plumage of species from these two families are the main appeal to most tribes in the central highlands. Within these families, the heavier species, or species with elaborate colourful plumes, often worn by ethnic groups in the central highlands were grouped as at most risk in terms of conservation. Within the Paradisaeididae, the Blue Bird of Paradise, and the Black Sicklebill were very rare for hunters. Both species occupy a narrow elevational range (1500 - 1800 m.a.s.l) and (1800 -2600 m.a.s.l) respectively. During a recent (September 2015) visit to one site, Simbai, locals mentioned no sightings of the Blue Bird of Paradise in their forests although it was previously recorded to be used as part of the species adorning their traditional headdress (Healey 1990). The Ribbon-tail Astrapia has a limited distribution and is only confined to the Eastern ranges of the central highlands' mountains. Its plumes are only worn by locals within its immediate vicinity (Enga, Southern Highlands, and Hela Provinces).

Other species that were also described as rare by locals were the Vulturine Parrot, Dwarf Cassowary, and Southern Cassowary particularly at one site, Karimui. The Vulturine Parrot (0-1500 m.a.s.l), is the only relative of the two species of Vasa parrots (Psittrichasidae) in Madagascar (Pratt and Beehler 2015). Highly valued for its red plumes, it is one of the most sought after species in the highlands (Mack and Wright 1998, Mack 1999). An experienced hunter often hired by neighbouring villages to hunt for cassowaries remarked that cassowaries within Karimui and neighbouring forests (including Crater Mountain) were becoming more difficult to hunt and made references to human population increase and activities driving species further away. Such responses highlight that perceptions of locals to species populations indicate the need for awareness within the communities on impacts of hunting pressure. Similar perceptions have been expressed by traditional custodians with regards to extent of remaining primary undisturbed forests (Shearman 2013).

In addition to the Cassowaries, the Megapodes are another group of species under pressure from selective harvest. The large eggs are actively sought by local people for their high protein content.

Meliphagidae were the most species rich bird family in this study. Most were hunted opportunistically for consumption by young men in the communities. I encountered its only vulnerable species, Long-bearded honeyeater (*Melionyx princeps*), a high-altitude species, at Toromambuno, Chimbu Province. Anthropogenic activities into upland forests may only add pressure to this restricted range endemic species. No species in the Meliphagidae were observed to be sold (either skins or feathers) or used in headdress adornment.

The species used by local people in the communities studied mostly fell into two main guilds, the frugivores and the insectivores. Unlike most tropical forests of the world, New Guinea does not have diverse large bodied seed dispersers (mammals and birds). Whilst New Guinea has a high diversity of bird dispersers in a few families, most large mammal families (e.g primate seed dispersers) are absent-restricted to the Asian side of Wallaces's line (Mack and Dumbacher 2007). The continued selective harvest of large species of birds has ramifications for seed dispersal particularly in maintenance of tree species communities.

Factors that increase species vulnerability include life history traits such as parental care, limited nesting sites. Larger species tend to invest more time as well as having extended periods of parental care compared to smaller size species. Parents killed during the period of extended parental care generally affect the survivorship of the chicks. In Chapters 3 and 4, I find that the preferred time for hunters to hunt and traders to sell plumes has been during the dry season. The dry season in Papua New Guinea often starts from May – November, which also coincides with the breeding season for some of the key species used for traditional adornment. Susceptible species include the Vulturine Parrots, cassowaries, and other larger parrot species such as the Eclectus Parrot, and the Papuan King Parrot. Although Megapode plumes have not been recorded in this study for headdresses, their eggs provide a valuable source of protein to many rural communities in New Guinea (Hide 1984, Sinclair 2002, Sinclair et al. 2010). The substantial investment in an obvious mound for egg incubation, and large size of eggs increases susceptibility to predation by natural predators as well as selective harvest of megapode eggs. Populations of megapodes on mainland New Guinea and on the islands provide an important source of protein that needs management.

Vulnerability pertaining to anthropogenic effects, particularly on habitats of montane species needs further research. Endemic species with narrow range that occupy secondary forests such as the Blue Bird of Paradise are most at risk. Birds of Paradise species in general do not invest much time in parental care or cooperative breeding. This may serve as an advantage, however, in addition to increased habitat disturbances, hunting of vulnerable species may continue to decrease species populations.

In the effort to reduce hunting pressure on species, some measures include smaller community initiatives within conservation or proposed conservation areas for reduced hunting activities during certain seasons. For the case of this study, reducing harvest of vulnerable species during a prolonged dry season, for example, El Nino (Chapter 4), or restricting burning for subsistence agriculture may serve as measures to reduce anthropogenic effects on vulnerable species as well as the pressure on their habitats. Community awareness targeting immediate users of species for cultural adornment and consumption both in urban and rural setting is needed.

Plans are underway to improve the protected areas system in Papua New Guinea (Guinea 2014). The main challenge in obtaining large areas for conservation is the customary land tenure system in the country. Gaining consensus by custodians to pledge land for conservation is an arduous process. Many of the existing protected areas have had limited resources in maintenance and as such have been dysfunctional (Melick et al. 2012). Over time, traditional custodians have converted some of the protected areas into subsistence agriculture use (Shearman et al. 2009). Prior to improvement of national parks, an audit on existing national parks should be given priority to identify condition of parks, general ecosystem health, and landowners' views. Even more so, local peoples' associations to the species need to be explored to gauge cultural associations for its incorporation into potential ecotourism ventures.

Whilst this study has identified species used by locals, the paucity of information on the basic ecology of vulnerable species still needs more research (Mack and Dumbacher 2007). The outcome of this study can contribute towards a National Red List Species for the country and aid in prioritising species of conservation concern. Furthermore, the results can fulfill objectives under the Convention on Biological Diversity. Monitoring the trend of species in subsistence use over time is crucial considering that the large majority of Papua New Guineans live a subsistence lifestyle and provides a vital means of understanding the contribution of biodiversity to livelihood and culture. Furthermore, policy changes in protected areas need to consider species range as well as reviewing current conservation areas that have sufficient land area (diverse habitats) that can support species identified as vulnerable.

In the next chapter, Chapter 6, I select an endemic species from the priority species list, the Blue Bird of Paradise (*Paradisornis rudolphi,)*, to understand its future distribution in Papua New Guinea, in the event of climate change.

CHAPTER 6: Predicting future habitat suitability of Blue Bird of Paradise (*Paradisornis rudolphi)*: a rare endemic montane species in the central highlands of Papua New Guinea

6:0 INTRODUCTION

New Guinea's island topography has created a diverse ecosystem contributing to habitat complexity (Pigram and Davis 1987). These habitats along an elevational gradient contribute to its diverse terrestrial biodiversity (Heads 2001b, Heads 2002, Tallowin et al. 2017). Papua New Guinea has over 700 species of birds (Pratt and Beehler 2015); 113 are endemics of which at least 43 species are globally threatened species (BirdLife International 2017).

Current known threats within the Central Papuan Endemic Bird Area (CPEBA) include selective harvest of culturally valued species for headdress adornment. Chapters 3 (Trade) and 4 (Hunting) indicate that at least eight of the globally threatened species are included in the subsistence harvest and trade by local people; Blue Bird of Paradise (*Paradisornis rudolphi*), Black Sicklebill (*Epimachus fastosus*), Long-bearded Honeyeater (*Melioynx princeps*), Vulturine Parrot (*Psittrichas fulgidus*), Harpy eagle *(Harpyopsis novaeguineae*), Goura's Pigeon (*Goura sheepmakeri*), North and Southern Cassowary (*C. unappendiculus and C.casuarius*).

Only in the last decade have studies in Papua New Guinea been conducted on possible effects of climate change on species (Legra 2008, Freeman and Freeman 2014b). Lowland forest birds are likely to be affected by sea level rise, and montane species are likely to be more impacted by changes in temperature, precipitation, habitat, and species assemblage (Legra 2008). It is anticipated that there will be gradual shifts in bird species elevation range particularly in montane forests due to climate change (Freeman and Freeman 2014b).

In New Guinea, species richness generally exhibits a decline with increasing elevation. However, within guilds, species assemblages respond variably to habitat complexity and elevation. For instance, herbivorous bird species richness experience a decline in elevation between 700 m.a.s.l – 1200 m.a.s.l whilst species richness for insectivorous birds reached its plateau between 200 m.a.s.l – 1700 m.a.s.l (Tvardíková 2013). These ranges in elevation have been used to indicate ecotones between circa 200 m.a.s.l to circa 2000 m.a.s.l provide habitats for species diversity.

Climate is an important predictor of bird species diversity in transitional forest ecotones (Tvardíková 2013). As such, climate change is likely to show profound impacts on these tropical island montane

forest birds. Species confined to narrow montane ecological niche are adapted to cooler habitats are most at risk from effects of warming edges of their range (Raxworthy et al. 2008, Forero-Medina et al. 2011). As well as likely to be vulnerable to climate change, New Guinea's avian fauna are also vulnerable to anthropogenic impacts (Sekercioglu et al. 2008b). From the previous chapter (Chapter 5), I identified species that are vulnerable to selective pressure.

Rare vulnerable species such as Blue Bird of Paradise (*Paradisornis rudolphi*) have multiple threats from selective harvest and habitat fragmentation from subsistence agriculture (BirdLife International 2017). Furthermore, in some parts of the highlands, the species has been heavily used in the last 50 years for headdress adornment (e.g Tambul, Western Highlands) (Strathern 1979). It is distributed within Papua New Guinea's highlands. Within the highlands, some locals rarely encounter this species (Healey 1990) which indicates two things. First, the species has a narrow range, and second its occurrence within these narrow-ranged areas over time has not been observed. Extensive field surveys have not detected its presence in sites with known occurrence e.g. Karimui, (Freeman and Freeman 2014a) and may further suggest its declining population. The species is absent in sites with similar habitats to known-occurrence sites (Pratt and Beehler 2015). Hence, the Blue Bird of Paradise has a patchy distribution (Frith and Frith 2010).

Given the Blue Bird of Paradise' rarity and the current known threats, its predicted future distribution still remains unknown. Tools such as environmental niche modelling can enable conservation practitioners to predict future species habitats to make inferences about species vulnerability to climate change. The aim of this chapter is to understand current distributions and predict the future suitable habitat of the Blue Bird of Paradise with reference to future climatic conditions.

6:1 METHOD

The distribution of current and future suitable climate spaces of Blue Bird of Paradise was modelled in Maxent version 3.3.3 (Phillips et al. 2006). Maxent was selected as it has been shown to outperform other distribution models (Elith et al. 2006, Guisan et al. 2007, Pearson et al. 2007). The Maxent program functions on the principle of maximum entropy where probabilities of species presence are statistically tested with their occurrence in relation to an environmental variable. The functions of the Maxent model have been discussed in Chapter 2 (Species Distribution Model: Maxent).
Bioclimatic data were sourced from WorldClim 1.4 (Hijmans et al. 2005). Updated future climate variables were not available at the time of this analysis. The bioclimatic layers used in this study include 19 bioclimatic variables derived from a 30 second (c. 1 x 1 km ^{2}) spatial resolution (**Table 6.1**). All variables' spatial extent was matched in ArcGIS 10.3.1.

Bioclimatic variables represent yearly trends of environmental variables such as average annual temperature, and precipitation as well as the range of precipitation and temperature. To represent the climatic conditions of a region, these variables are calculated as the yearly average across 30 years.

Future climate models used were based on Representative Concentration Pathways (RCPs) are representative scenarios of future climate, depending on emissions of four greenhouse gases (e.g carbon dioxide, water vapor, methane, nitrous oxide), development and the climate system responses (Rogelj et al. 2012). The RCPs range from 2.6 RCP (Low) to 4.5 RCP (Intermediate) and 8.5 RCP (Severe). For this study only 4.5 and 8.5 RCPs were available. Two future time steps were used, 2050 and 2070.

Table 6. 1: 19 Bioclimatic variables used in Species Distribution

BIO1 = Annual Mean Temperature
BIO2 = Mean Diurnal Range (Mean of monthly (max temp - min temp))
BIO3 = Isothermality (BIO2/BIO7) (* 100)
BIO4 = Temperature Seasonality (standard deviation *100)
BIO5 = Max Temperature of Warmest Month
BIO6 = Min Temperature of Coldest Month
BIO7 = Temperature Annual Range (BIO5-BIO6)
BIO8 = Mean Temperature of Wettest Quarter
BIO9 = Mean Temperature of Driest Quarter
BIO10 = Mean Temperature of Warmest Quarter
BIO11 = Mean Temperature of Coldest Quarter
BIO12 = Annual Precipitation
BIO13 = Precipitation of Wettest Month
BIO14 = Precipitation of Driest Month
BIO15 = Precipitation Seasonality (Coefficient of Variation)
BIO16 = Precipitation of Wettest Quarter
BIO17 = Precipitation of Driest Quarter
BIO18 = Precipitation of Warmest Quarter
BIO19 = Precipitation of Coldest Quarter

Source: www.worldclim.org/bioclim

In the absence of country specific projected climate model for Papua New Guinea, Access-1 General Circulation Model (GCM) was employed. Access-1 appears to be most consensus by comparison to other models for future climate scenarios for Australia (Watterson et al. 2013). New Guinea shares similar climates, habitats, and similar species with Australia, including two of its Birds of Paradise *Phonygammus keraudrenii* (Trumpet Manucode) occupying 0-2000 m.a.s.l, and *Ptiloris magnificus* (Magnificent Rifle Bird), 0 – 1200 m.a.s.l. The two-endemic species of Birds of Paradise to Australia are *Lophorina victoriae* (Victoria's Riflebird) and *Loprorina paradiseus* (Paradise riflebird). The Australian species of birds of paradise occupy various lowland to montane tropical rainforests (e.g *Lophorina victoriae*). Therefore, the Access-1 GCM is likely to be a useful approximation of future climate for New Guinea.

I sourced eight (8) occurrence records of Blue Bird of Paradise from VerNet, a biodiversity database platform for vertebrate fauna (http://portal.vertnet.org). Unique spatial records were used for modelling. Records from VerNet database were less than the required minimum (< 10). Four occurrence records were obtained from fieldwork conducted for this study (see point count survey). Point count surveys from the present study provided sufficient geolocator information needed. Occurrence records in total used to model the Blue Bird of Paradise was 11.

6:1.1 Point Count Survey

I conducted point count surveys in four sites in the central highlands in May-August and October 2015. These sites were Toromambuno (Gembogl District) and Yuro village (Karimui District) in Chimbu Province. In the Eastern Highlands, point count surveys were done along the elevational gradient at Mt. Gahavisuka Provincial Park (Goroka District) and at Hogave Conservation Initiative (Lufa District).The avian fauna of Karimui and Lufa were previously studied by Diamond (Diamond 1972). The elevation ranges from 1200 (Karimui) to 3300 m.a.s.l for Toromambuno. A minimum of four weeks was spent at each site. One week for opportunistic sightings and the second week for point count surveys. Two-point count transects were established at each site; each transect was 500 meters with point count stations at 150 m intervals. Point counts started at 0600 hours and took 125 minutes to complete. The surveys were repeated in the afternoon from 1600 hours. Observation time at each point count station was 10 minutes and movement between stations was 15 minutes (**Appendix 6.1** Data sheet). Birds of Paradise were the main species of interest; visual sightings and observation within a 50-meter radius were recorded. Species such as the Blue Bird of Paradise and the Raggiana Bird of Paradise (*P. raggiana*) call and display often from their leks. Understanding the density of leks within a known area gives an estimation of adult male densities. Other non-birds of paradise species that could be positively identified from visual encounters (as well as from calls) were noted.

6:1.2 Model Settings and Simulations

The model was first run with all 19 bioclimatic variables. Based on analysis of variable contribution, I considered the variables with the highest percentage contribution and permutation importance for model projection. Any of the two categories which turned up a value of zero were not considered for further model runs. The following bioclimatic variables that were used to project current as well as future scenarios; mean temperature of coldest month (BIO 6), precipitation of wettest month (BIO 13), precipitation seasonality (BIO 15), and precipitation of coldest quarter (BIO 19). The model performed 1000 iterations and produced 30 replicates. Regularization was set at 1. The average of the replicates was used to define minimum probability of suitable habitat. To determine between areas of suitable habitat and unsuitable habitat, I used the average 10 percentile training presence logistic threshold average score (McFarland et al. 2013). The use of threshold values for species distribution model (SDM) is essential and requires sound understanding of species ecology and natural history (Norris 2014).

In order to assess performance of models, the Maxent output (environment niche model) was resampled using Environmental Niche Modelling (ENM) Tools to measure and identify the most parsimonious model (Warren et al. 2010). The model selection criteria from ENM Tools was executed to produce an AIC and BIC score (Warren and Seifert 2011).

6:2 RESULTS

6:2.1 Estimate of Blue Bird of Paradise lek density

The Blue Bird of Paradise was found in two locations within the four study sites. These locations were Hogave (Lufa District) and Yuro village (Karimui District). Within these sites, two display leks were found in Hogave at a density of 2 leks within a 4 km^2; this includes the area of opportunistic observations. Karimui had 1 adult male Blue Bird of Paradise call c. 500 meters away from point count stations. Taking into consideration opportunistic encounters in addition to the transects, I estimate the lek density to be 1 per 5 km^2. Refer to **Appendix 6.2** for bird species observed.

6:2.2 Predicting Contemporary and Future Species Distribution

The model for the Blue Bird of Paradise using current climate had a high performance with an average area under the receiver operating characteristic curve (AUC) of 0.934 (Std. dev = 0.023). The AUC values were further verified for best fit using ENM Tools (Warren et al. 2010). The smallest AIC score of the model for current distribution model was selected to predict future scenarios. The model with the four bioclimatic variables (**Table 6.2**) was used to predict current and future scenarios. Areas that contained high probabilities for suitable environmental conditions were within existing known localities except for the Huon Peninsula. The actual range of the Blue Bird of Paradise does

not extend to Huon Peninsula, but the modelled result predicted the inclusion within the contemporary range.

The 10-percentile training presence logistic threshold average score (0.4171) was used to identify areas of suitability via ArcGIS 10.3.1. Under spatial analyst, the reclassify feature enabled aggregating raster values from 0 to < 0.4171 as unsuitable habitat, and ≥ 0.4171 as suitable habitat for the Blue Bird of Paradise. The ENM predicted contemporary suitable habitat area was predicted to be 52485.66 km^2 (**Figure 6.2**) which is 7.5 % less area than previous climate model for Blue Bird of Paradise (56757 km^2) (Legra 2008).

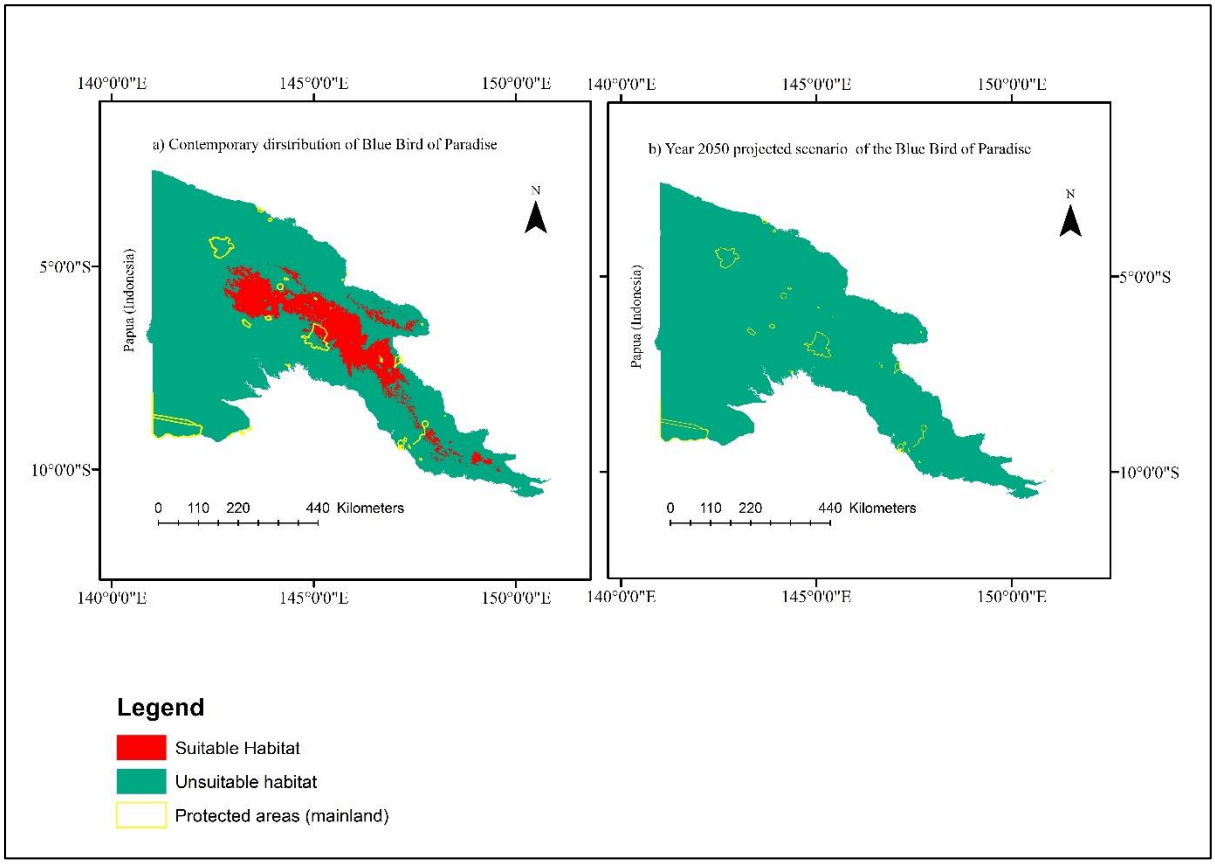

Figure 6.2 (a) Contemporary species distribution model of Blue Bird of Paradise. The existing parks and protected areas are indicated in yellow. **Figure 6.2** (b**)** indicates the predicted distribution, habitat suitability of the Blue Bird of Paradise will be less favourable by 2050, loss of 100 % of suitable habitat. Similarly, for 2070 which is not indicated here. Refer to **Appendix 6.2** for full model results as per Maxent output.

Table 6.2: The AIC and BIC values for ENM for contemporary and future scenarios, 2050 and 2070. Models with four bioclimatic variables had AIC scores indicative of best fit models.

Period	Bioclimatic variables	Log Likelihood	Parameters	Sample Size	AIC score	AICc score	BIC score
Contemporary	All 19	-204.86	7	18	423.72	434.92	429.95
	BIO 6, BIO 13, BIO 15, BIO 19	-206.79	5	18	**423.59***	428.59	428.04
Projected Climate: 2050 and 2070	All 19	-951.42	6	82	1914.84	1915.96	1929.28
	BIO 6, BIO 13, BIO 15, BIO 19	-951.13	4	82	**1910.26***	1910.78	1919.89

The results of Maxent output were tested using Environment Niche Model (ENM Tools) to decide which of the variables (All 19 bioclimatic variables or few specific variables) had a weighted effect on species distribution. Using fewer key variables produced better results (lower AIC) scores than using all variables which tended to mask the predictive power of the output (Elith et al. 2010). The environment variable BIO 6 (mean temperature of coldest month) had the greatest contribution to the model. Using the 4.5 RCP (intermediate) for future climate scenarios (2050 and 2070) indicate an extensive decrease of suitable habitat for the Blue Bird of Paradise.

6:3 DISCUSSION

The future of the Blue Bird of Paradise is quite uncertain, given its restricted distribution, and rarity, coupled with anthropogenic impacts. The Blue Bird of Paradise represents a species vulnerable to anthropogenic activities (hunting and habitat change), which are to some extent influenced by weather, (see Chapters 3 and 4) and predicted to be vulnerable to the effects of climate change.

The contemporary suitable habitat, by area, as generated by Maxent model exceeds (Merow et al. 2013) current known suitable area of occupancy (Frith and Frith 2010, Pratt and Beehler 2015). This indicates the Blue Bird of Paradise actual niche is constrained by specific variables as the species does not occur in some areas that are modelled to be suitable (Pratt and Beehler 2015). There are a few likely explanations. The existing geographic barriers (e.g. mountains and valleys) limits species dispersal. For example, the Markham valley prevents the species from crossing over to the northern most mountain ranges, the Huon Peninsula.

On a fine scale, narrow montane corridors that allow dispersal of species could also become a barrier if prolonged hunting activities and subsistence agriculture are intensified (**Plate 6.1** and **Figure 6.3**). Results from the previous case study, Karimui (Chapter 4), show that the human population has increased over the last 50 years such that although the area is isolated from much of the central highlands, current human population density may shorten the fallow period of subsistence agriculture

land for some clans. This leads to more overlap of Blue Bird of Paradise habitat with human associated activities. Furthermore, hunting activities closer to the villages, approximately 5 km radius (Chapter 4)(Mack and West 2005) have become intensified. A number of bird hides were found scattered along semi-dried stream beds and similar observations were noted by a previous study in the area (Freeman and Freeman 2014a).

Plate 6.1: Photo (1) shows a typical secondary regrowth cleared with aid of fire for planting starchy vegetables such as taro and sweet potato. Photo (**2a).** (a) Bird hide set up close to (b) water hole during dry season 2014-2015, (c) a straight stick placed above the pool serves two purposes -allows the bird to perch upon descent for water and guides the hunter's arrow hidden by dried thick moss (**2b).** A Blue Bird of Paradise was killed from this hide in September 2015.

For the case of Karimui, the above description of gardening and hunting occurs around and within the vicinity of hunting areas previously identified (**Figure 6.3**; (B)-Yuro). Combining the known anthropogenic effects on the species, and the predictive scenario, there is a likelihood that current suitable habitat of the Blue Bird of Paradise will disappear by 2050. As such, the Blue Bird of Paradise represents a species vulnerable to anthropogenic activities which are to some extent influenced by weather (see Chapters 3 and 4) and climate change. Hence, the Blue Bird of Paradise is vulnerable to a number of threats acting in synergy (Brook et al. 2008, Sekercioglu et al. 2008a, Traill et al. 2009).

There are limitations to the interpretation of the Maxent model. A country specific climate model is presently lacking in Papua New Guinea. Earlier records only give some indications of weather at certain locations (McAlpine et al. 1983) but not the full extent of the country. In the last 5 years, over 30 weather stations have been established throughout the country. However, for remote sites particularly in transitional forest communities, smaller community initiatives for weather monitoring stations can be established particularly to understand localized weather and its effects on species

(Reside 2011). With few weather stations and very complex topography, it is likely that the climate model does not accurately reflect all microhabitats across New Guinea. Fine-detailed climate data would be needed to achieve accurate microhabitat conditions, as has been shown in the mountainous Wet Tropics bioregion or north-eastern Australia (Storlie et al. 2013).

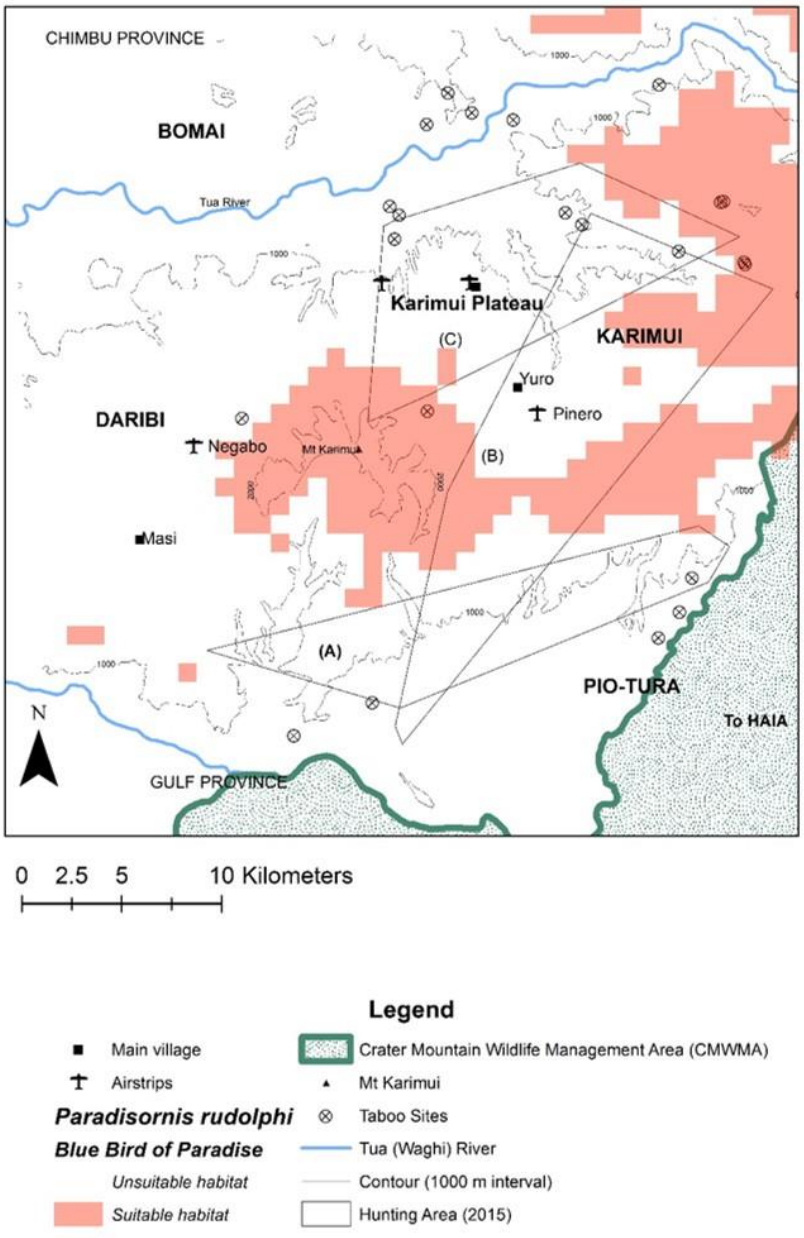

Figure 6.3: The contemporary suitable habitat of the Blue Bird of Paradise at Karimui including current hunting areas of three large village (A) Masi, B) Yuro and C) Karimui as identified from Chapter 4.

Plate 6.2. The view at Yuro village looking southwards past Pinero airstrip (lowland). The chain of mountains in the background represents a potential narrow mountain corridor for endemic montane species linking Mt. Karimui range to Crater Mountain Wildlife Management Area (CMWMA).

6:3.1 Conservation implications and community planning

The Blue Bird of Paradise represents a species vulnerable to the impacts of land use change associated with human population increase. Although the species is known to occupy abandoned gardens, increased land use intensity (e.g. reduced fallow periods in swidden agriculture), hunting pressure associated with dry weather, and climate change are cause for concern for this species. The point count surveys in Karimui further confirm that the Blue Bird of Paradise occurrence is very rare even within areas of known occurrence. In this study, I found 2 leks per 4 km^2 at sites where conservation is practised by the community (Hogave) and 1 lek within c. 5 km^2 where there is no conservation area (Karimui).

Unlike other species of Birds of Paradise which are valued higher, the Blue Bird of Paradise when sold at remote areas costs an approximate amount of K10 (~ AUD 3.00). It is unfortunate that this species inhabits areas of suitable habitat which overlap with human populated areas thus placing them at greater risk.

For rural communities intending to establish smaller conservation areas, planning and design need to first start with custodians (clan members). Such has been the case for Karimui custodians. Results from this study can provide additional information to communities to aid their planning.

An outcome of this study has predicted suitable contemporary habitat for the Blue Bird of Paradise spanning from within the Crater Mountain Wildlife Management Area to Karimui via the chains of mountain ranges (1000-1800 m.a.s.l). From an ecological perspective, including these chains of mountain range as community conservation areas with restricted hunting may help to alleviate the pressure on the species. Reducing hunting during the dry season as well as considering the connectivity in habitat via montane ranges may also provide a refuge for other species with larger elevational ranges.

Existing conservation areas in Papua New Guinea that encompass a diverse range of habitats are essential for the maintenance of species diversity. Where possible, maintaining forest connectivity to such large conservation areas need to be considered for future management measures. Land use plans driven by communities are crucial considering that land tenure in Papua New Guinea is largely under traditional customary ownership. Design or the improvement of conservation areas which allow for traditional custodians to actively practice their cultural rights, particularly in relation to species association to culture is also vital.

Local community conservation and ecotourism initiatives may serve as a form of conservation to communities where species such as the Blue Bird of Paradise occur (Markwell 2018). The incentive from such activities is the generation of income from tourism, scientific research or bird-watchers to conserve species.

CHAPTER 7: Discussion and Conclusion

Pressure from selective harvest for consumption and climate change are two important threats to tropical forest biodiversity (IPCC 2007, Benítez-López et al. 2017). Larger species are most vulnerable to hunting by communities that live a largely subsistence lifestyle. New Guinea has had human occupation and its impacts on the landscape for the last 50,000 years. The movement of humans in the lowlands for trade purposes (Ellen and Latinis 2012) and the upward movement of coastal food crops to montane forest indicate elevational use and exchange of materials significant to livelihood (Summerhayes et al. 2010). Adaptation to the higher elevations included exploitation of large mammal fauna of which at least 16 are extinct (Flannery et al. 1983, Mountain 1993, Sutton et al. 2009) and early agriculture (Denham et al. 2003). Influence of hunting in montane forests may have been responsible for the extinction of large of 16 large mammal species between the elevation range 1500 – 2500 m.a.s.l (Mountain 1993, Summerhayes et al. 2016, Roberts et al. 2017). It is also possible that climate change was accountable for some of these extinctions (Sutton et al. 2009, Johnson et al. 2016).

Expression of cultural identity can be depicted through the following examples; governance of land through kinship lineage, language spoken, as well as the physical adornment in traditional regalia, including the headdress; a subset of a ceremony. The plumes that constitute a headdress are acquired through hunting and trade ties with neighbouring communities (Healey 1986). Trade maintains important relationships and allows communities to meet their needs through consensus.

Hunting for livelihood, subsistence agriculture, and trade are very much intertwined with the culture of Papua New Guineans. Hunted species provides sustenance to these communities and a renewal of cultural associations with the species and the environment (Majnep and Bulmer 1977, Bennett et al. 1997, Sillitoe 2001, Williams et al. 2014, West 2016). Cultural associations include gifts or cultural obligations (Hide 1981, Healey 1990), whilst some species are valued for their aesthetics, and their cultural interpretation particularly when worn as a headdress (Strathern 1979, Sillitoe 1988a, O'Hanlon 1989, Bennett et al. 1997). When worn, the headdress connects a person to their tribe or clan and as such, it serves as a form of cultural identity.

The biodiversity of Papua New Guinea is one of the understudied in the tropics (Wilson et al. 2016). Although systematic studies of terrestrial protected areas have been conducted to improve planning of conservation (Margules and Pressey 2000, Chatterton et al. 2006), years of neglect from Government's involvement within the existing protected areas has weakened management. Minimum

government involvement has resulted in traditional custodians reclaiming areas of gazetted protected areas for subsistence use (Shearman et al. 2008).

Further to this, there has been a deficiency in the overall enforcement and monitoring of the trade of protected species. Present conservation legislation prohibits the trade of protected species of animals which also have high cultural significance. Whilst there has been previous studies on wildlife harvest in the last 40 years (Hide 1984, Dwyer and Minnegal 1992, Sillitoe 2002, Mack and West 2005, Majnep and Bulmer 2007), fewer studies investigated the trade of species (Patterson 1974, Healey 1990).

Threats driven from within New Guinea from potential overharvest as well as the external demand for exotic species through wildlife trade and trafficking (Pangau-Adam and Noske 2010, Shepherd et al. 2012) are imminent. Government support for the promotion of informal economic activity generates income for the majority of Papua New Guineans, however, there remains a lack of capacity to enforce the trade of protected species and further highlights mismatch in policy and enforcement (Shearman 2013).

The Birds of Paradise were one of the earlier groups of protected species (under the Fauna (Protection and Control) Act and the subsequent International Trade (Fauna and Flora) Act 1979. As a result, these species were restricted from international trade under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Compliance requires monitoring and enforcement of national legislation regarding the trade (import and export) across international boundaries of listed species. There are three appendices in the CITES species list; Appendix I includes species considered to be threatened with extinction, by resolution of the International Union for the Conservation of Nature (IUCN). The species listed by the IUCN as Threatened, Endangered, or Critically Endangered are restricted from international trade. The trade of species and their movement across international borders (as with Appendix II and III species) requires special permits to be issued by the mandated authority.

The Conservation of Environment and Protection Agency (CEPA) issues permits for CITES species destined for overseas for trade, education, or captive breeding programs for instance. One of the shortfalls of International Trade (Fauna and Flora) Act 1979 and the Fauna (Protection and Control) Act 1966 is that the former includes flora whilst PNG's internal Act mainly covers protection of fauna. The Fauna Act includes a list of protected species by the Minister of Environment and the implementing body, CEPA. The species list needs to be reviewed and updated periodically to account for research undertaken on the country's biodiversity. As it is, there exists no specification as to the

frequency and timing of improvements to the species list within the Fauna Act. Since its inception, the species list has not been updated.

As a signatory to the Convention on Biological Diversity (CDB) in 1993, Papua New Guinea's government has committed to the terms of the agreement to increase protection of biodiversity and ecosystem services. Membership to CBD indicates support and measures to reduce the loss of biodiversity. One of such measures was to commit 20 % of the country's terrestrial land area for protection of biological diversity through the establishment of protected areas (Filer 2011b). To date, PNG's efforts to establish protected areas has fallen short of reaching the CBD target and the country's promise (Melick et al 2012).

Identifying species vulnerability from selective hunting pressure and for trade is essential to the conservation of biodiversity, subsistence livelihood of the rural population, as well as the promotion and conservation of culture. This study pools together knowledge gained from interdisciplinary research to provide a contemporary understanding of current threats to species in the central highlands. Papua New Guinea lacks comprehensive baseline data on bird species associated with culture and subsistence use that are vulnerable to anthropogenic impacts. My thesis has used an interdisciplinary research approach to understand current trends in trade of birds, fine-scale understanding of species hunted within an elevational gradient (montane and transitional ecotone) as well as the species distribution model of a rare vulnerable endemic montane species, the Blue Bird of Paradise.

This thesis gathered existing knowledge and combined it with contemporary knowledge of species to provide an updated baseline data of species used for subsistence and culture. To do this, first, I gathered prices of species currently traded and used in cultural adornment; secondly, I investigated species hunted in villages representing elevational ecotones and seasonality of hunted species. The outcome of these two steps provided an updated information to the baseline data of species use in the central highlands. For the third aspect to this study, I combined these species with vulnerable threats using weighted ranks (e.g IUCN status, number of sites traded) to create an encompassing vulnerability assessment of species for the central highlands. Hereon, I provide the main findings of this thesis along with the overall aims of this study.

7:1 Summary of the main results

AIM 1: Improve current knowledge of endemic bird species traded

Objective 1: Situating current trend in price of species traded over a 40-year period.

Within the country's capital, the National Capital District, over 40 years there has been a 50 % decline in the diversity of species sold by comparing 1974-1975 market survey to this study (2014-2015).

By contrast to 40 years ago, Birds of Paradise (Raggiana and Lesser) have now surfaced in the National Capital District market place.

Birds and plumes cost less in rural areas and the cost increases in urban areas. The Vulturine and the cassowaries appear to have higher valuation and continue to be traded for piglets in rural areas or used in marriage ceremonies in central highlands. However, of the bird species harvested for trade, the Birds of Paradise were the species that brought in more money by having the most (by counts) sold, particularly of species within the least concerned (LC) IUCN category; Raggiana Bird of Paradise, Lesser Bird of Paradise, and Stephanie's Astrapia. Rare vulnerable (IUCN) species of Birds of Paradise were sold infrequently particularly that of the Blue Bird of Paradise and the Black Sicklebill.

The ideal times for trading plumes according to traders were between July and November. These months overlapped with existing annual cultural festivals which also coincide with the dry season in the central highlands.

AIM 2: Patterns of hunting intensity in montane forests in Papua New Guinea's highlands (a case study)

Objective 2: To understand the extent of social and environmental variables that influence hunting patterns on a fine scale.

I found that birds and mammals were harvested more during the dry season than the wet. This finding appears to coincide with the preferred time for species trade (Chapter 3). Furthermore, conducive weather patterns (dry season) initiate seasonal movement of local people to travel from their high elevation villages to the lowlands to harvest and tend their culturally important food crops - sago. The sago is versatile in use, and often associated with connection to ancestral land (Glazebrook 2008, Barton and Denham 2016). The environment suitable for sago (swampland and along rivers) is also conducive for mosquitoes and water borne diseases which results in high mortality; as a result, sago areas have low human population densities. Many of these communities were traditionally hunters and gatherers. Given establishment of government administration centres (1950s- 1960s), members of these communities moved upwards (e.g Karimui) but continued to maintain influence and traditional governance (hunting and sago harvest) in lowland areas. It is during these hunting trips that larger

species of fauna are harvested by men to supplement the staple carbohydrate, sago. The harvest and processing of sago takes at least a week which involves for the most part, labour by women.

Hunting distances varied within age groups and further indicated that older men (> 50 years) travelled much further to hunt larger fauna. This may reflect knowledge of land boundaries and skills. Hunters in Karimui generally travel longer distances to hunt and covered a larger range of distance by comparison to hunters at elevations above > 2000 m.a.s.l. Overall mean distance for hunters to a successful kill was 4.89 km which is within close proxy to previous studies (Mack and West 2005).

This study also indicates that the hunting areas of Karimui are much larger than previously estimated. Valuable species such as Vulturine Parrots and cassowaries continue to be targeted for a good return on exchange (value in money and exchange for pigs). The sustainability of both species is of conservation concern particularly in reference to the quantities harvested.

This study indicates that the diaspora of communities (especially subsistence farmers) in the fringes of the municipality (settlement) actively participate in cultural dances (annual festivals or shows). Whilst these shows were initially meant to unite warring tribes, they have now become a platform to exhibit the diverse tribes within the highlands as well as coastal groups. It is ironic that actions of hunters in Karimui in supplying a belief system and heritage for which rural hunters hold no values, nevertheless, their actions although distantly, contribute to the thriving cultures of others.

This study futher indicates that remote communities are also going through profound shifts in cultural beliefs. Modern influences such as Christianity, education, and lack of government administration have had varying influences on community members' perceptions of cultural expression (e.g headdress adornment). For example, Seventh Day Adventist (SDA) followers in Karimui discourage the use of traditional adornment. This is contrary to followers of the Catholic Church. While this discouragement may appear as a deterrent to reduce hunting, it does not. A few taboo areas have held religious 'cleansing' ceremonies to extend hunting and subsistence agricultural activities. Followers of both denominations, directly or indirectly, contribute to alteration of the landscape and the associated traditional knowledge, although, followers of the Catholic faith (and similar) are encouraged to retain aspects of cultural heritage.

AIM 3: Assessment of conservation priority of species

Objective 3: Identify risks associated with the subsistence use of birds in central highlands

An assessment of the vulnerability of 172 bird species from subsistence and cultural use in the central highlands prioritise species for conservation in the Central Papuan Endemic Bird Area (CPEBA). Species in Group 1 (high priority) were heavier by comparison to Group 2. Furthermore, a higher proportion of species were found to be birds in frugivorous and insectivorous guilds. Considering that these species guilds overlap in the transitional ecotone (circa 200 - 2000 m) indicates that ideal conservation areas cover larger areas encompassing lowland to montane to cater for species with larger home ranges as well as endemics.

The priority assessment species list generated from this study is particularly for subsistence livelihood; consumption, trade, and cultural expression (headdress adornment).

AIM 4: Predicting endemic species distribution

Objective 4: Predict the impact of climate change on rare endemic species

At least eight globally threatened species have been identified to be hunted and traded in this study. These species are endemic to New Guinea. At least two species are vulnerable rare endemics; the Blue Bird of Paradise and the Black Sicklebill. SDM was used to understand projected species distribution of the Blue Bird of Paradise under varying climatic conditions. The projected future scenario predicts a drastic reduction of suitable habitat. Given that the current species range is estimated to be smaller to the current model generated output, it appears the species with restricted distribution have high sensitivity to climate change. The Blue Bird of Paradise is most responsive to change to the average minimum cold temperatures as indicated in Chapter 6. As the minimum temperature increases (gets warmer) under the intermediate conditions (4.5 RCP), the Blue Bird of Paradise is predicted to lose 100 % of its habitat by 2050.

An outcome of Chapter 6 highlights the vulnerability of rare endemic montane species such as the Blue Bird of Paradise. The Blue Bird of Paradise restricted distribution is under pressure from selective harvest, habitat loss, and the possible effects of climate change. Maintaining connectivity in a fragmented habitat can allow viable populations to persist. With this knowledge in hand, local communities that aspire to establish community conservation initiatives can plan how to achieve their desired outcome of natural resource management.

7:2 Limitation of this study and future potential research

There has been no research on species trade for the last 30 years. The paucity of information since the 1980s whilst provides for the highlands, there is a need for a country-wide assessment at regular intervals. The majority of Papua New Guineans live a subsistence lifestyle, off the land or the sea.

Understanding which species can be harvested and traded sustainably is essential for prioritising conservation efforts as well as management of species.

Annual monitoring and enforcement can also detect if species harvest rate is above the capacity of a species to replenish its population. This is vital for rare endemic species with low reproductive capacity. Furthermore, enforcement of monitoring can also detect CITES species of concern and aid planning to strengthen international collaboration to protect species

More research is needed to understand the seasonal harvest of species in rural communities to assess whether there are shifts with different seasons (wet or dry) and by species. Although hunters' harvests in Karimui were included in the cluster analysis (Hot Spot), future research is still needed to understand fully the impacts of hunting during wet and dry seasons; for example, whether the Hot Spot shifts by season. This study follows suit from previous studies (Hide 1981, Hide 1984, Healey 1990) and is one of the few to measure distance per age category as well as cluster mapping of hunted vulnerable species within a landscape.

The establishment of a CITES monitoring committee is needed to oversee various cross-cutting sectors; conservation, trade, tourism, forestry, marine and fisheries and their management aspects pertaining to species use that have strong cultural associations by traditional custodians.
Further social research is needed in understanding how traditional knowledge in relation to the expression of cultural identity is expressed in the urban diaspora setting and in rural areas such as Karimui; particularly, how urban dwellers appear distant from their traditional environment (villages) yet persist in expressing their cultural identity through dances and traditional regalia. There appears to be a disconnection with the environment, yet they maintain a strong sense of identity. This disconnect with the environment is associated with traditional ecological knowledge of species and environment. This necessitates policy review among multiple agencies (e.g. tourism industry, environment and conservation, and informal sector, extractive industry) to work in synergy with the aim to streamline policies that target sustainable management of livelihood, improve monitoring, protection, raise awareness on species vulnerability, conservation, and cultural heritage.

7:3 Conclusion

The trade and subsistence use of birds maintains a significant role in the culture and livelihood of Papua New Guineans. The association of birds in culture takes many forms; nourishment, transactable value, aesthetics in cultural adornment, and symbolism of beauty and power. Indigenous people who have a sound knowledge of the environment and species can also discern seasonality and the intricate

associations of flora and fauna. Birds, therefore are positioned in the nexus between culture and ecology.

Rural communities are reached by globalisation, in the examples of religion, roads, and alternate education (western education). These associations with species also undergo profound changes, which have a bearing on the traditional knowledge of species and environment, the practice of cultural heritage, and the use and management of natural resources.

An aspect of trade involved the iconic endemic species of birds, the Birds of Paradise. The Birds of Paradise have an embodied connection to the cultural expression of New Guineans and have also captivated the western world to the extent that they were one of the main exports out of New Guinea (1800 -1900s). Through these iconic birds, early conservation initiatives in New Guinea were established in the late 1800s. Remnants of the subsequent protection were also adopted by the self-governing state of Papua New Guinea in 1979 (Fauna Protection Act) which further prohibited the trade of Birds of Paradise. This disassociation with the New Guineans cultural heritage remains a conundrum which needs to be rectified and in synergy with other natural resource departments.

Policing and monitoring of terrestrial fauna has been lacking within Papua New Guinea since the 1980s. The lack of data limits the understanding of the value of biodiversity which hampers understanding of the sustainability of wildlife use by 80 percent of Papua New Guinea's human population. Through this study, we now know that at least 24 % of bird species in the country are used in culture and sustenance (182 of ~ 760 species). Of these, at least 22 species are considered of conservation priority. Some of these species have ecological roles (Cassowaries), whilst a few have restricted distributions (e.g. Blue Bird of Paradise), and others are heavily hunted for their associated value (Vulturine Parrot, Stephanie's Astrapia, and megapodes).

Monitoring species traded is essential to detect trends in the current socio-economic climate. This study detected a loss of 50 % in diversity of species traded in the capital city (National Capital District) and a trade emphasis on taxa such as parrots, cassowaries, and Birds of Paradise. Live bird trade in the National Capital District particularly targets city residents. Although there is a slight increase in pet trade by comparison to 40 years ago, the quantities sold are not as great in comparison to Asia. From an Indo-Pacific regional perspective, Indonesia has a thriving market for trade in live birds where species are sought from the islands including mainland Papua (West). Overharvesting is a threat to species for such marketplaces (Pangau-Adam and Noske 2010). Given the proximity to SE Asia, monitoring of trade species is essential to detect wildlife trafficking out of Papua New Guinea and needs backing by the Government to safeguard its biodiversity and that of the people.

7:4 Associations with hunting in montane forests

Traditional socio cultural practices have created complex relationships (Dwyer and Minnegal 1992). The socio-cultural relationships influence the resources harvested within the realms of influence by communities. Larger endemic wildlife was often hunted within transitional ecotone areas (the zone where communities of lowland flora overlap with montane flora) and higher elevations. Communities in montane areas have lower hunting returns by comparison to those communities at lower elevations (Dwyer and Minnegal 1991b, Sillitoe 2002, Mack and West 2005). Whilst forest (habitat) loss is an important variable that contributes to species loss, equally, or perhaps more important is the over-harvest of wildlife species that play a significant role in forest regeneration (Harrison et al. 2013, Lindsell et al. 2015, Harrison et al. 2016), and have strong cultural ties to Indigenous communities (Healey 1990, Pangau-Adam and Noske 2010, Mack 2014).

On finer scale, this study has deduced the dry season, ~ May – November, as the preferred time for hunting. Hunting activities indicate altitudinal (high elevation to low elevation) movement by forest custodians, which are connected to sago harvests; the men hunt while women process the sago starch.

The corresponding drier months of high hunting activities also coincide with annual cultural festivals in urban centres which further drive the need for animal skins and plumes for such events. Whilst these cultural events promote the diversity of Papua New Guinea's heritage, they also create an opportunity for income through tourism. Often the benefits of such events are constrained within urban settings (Carr et al. 2016) with minimum benefits reaching rural communities. It is evident that the sustainable management of species requires a cross-sectional approach with the participation of stakeholders.

This interdisciplinary research approach in Papua New Guinea has produced a comprehensive knowledge of species vulnerability assessment relating to the subsistence and cultural use. The current threats to species in the Central Papuan Endemic Bird Area (CPEBA) includes anthropogenic activities (hunting) during the dry season (weather driven) and long-term climate change effects on rare vulnerable endemic species. Subsistence use of species is important for rural livelihood and for the persistence of cultural heritage. Improving conservation areas planning to allow for connectivity may benefit sensitive species survival within fragmented habitats. Given the nature of land tenure in Papua New Guinea, it is paramount that the traditional custodians take the lead of such initiatives with backing from the Government.

APPENDICES

Appendix 3.1 Market Survey Instruments (Human Ethics Approval H5610)

Date: _____

Interviewer: _____

Location: _____Clan Name: _____ ID:_____ Gender: M/ F
Age:_____(if known or approximate)

A. Plume trader/vendor

1. How often do you sell here?

i) Weekly or more often
ii) Fortnightly
iii) Once a month
iv) Less often or on holidays

2. How many days in total did you sell plumes in the last year? ____
3. How long have you been selling plumes among others items you sell? _____
4. How did you acquire the plume(s) you are selling?

i) Hunted myself
What is your preferred method of hunting?
a) Snare
b) Bow and arrow
c) Sling shot
d) Gun
e) Other, please specify_____

ii) Bought from someone
Where did the plumes originate from? _____

iii) Family heirloom
How long have the plumes been in the family? Reasons for selling?
_____

iv) Gift

v) Others
Please specify if others_____

5. Is this the only means for you to earn an income? _____

5b. If you have alternate means, what is it? _____

_____

6. How much are you selling the plumes for? List species and costs per plumes
7. Which of these species sells the fastest?
8. Over the past years, has the level of plume trade increased, decreased, or stayed the same?

9. Who are your usual customers?
    a) people from the highlands

10. 8. Who are your usual customers?
    a) people from the highlands
    b) people from the coasts
    c) mixture of highlands and coastal
    d) mixture of nationals including international tourists
    e) I don't keep track of people who purchase.
    f) this is my first time to sell
    g) other, please specify

11. 9. What time of the year is the most preferred to sell plumes?
    _____
12. Why? _____

13. The trade of plumes is;
14. Important
15. Neither
16. Not important
17. Why? _____
18. Have you ever sold any live birds in the last year? Y/N
19. 11 a. If yes, what species was it? _____

B. Perceptions of Birds of Paradise, the environment, and Governance

1970s - 1980s	1990s - 2000s	2010 - current
a. Decreased a lot	a. Decreased a lot	a. Decreased a lot
b. Decreased a little	b. Decreased a little	b. Decreased a little
c. Stayed the same	c. Stayed the same	c. Stayed the same
d. Increased a little	d. Increased a little	d. Increased a little
e. Increased a lot	e. Increased a lot	e. Increased a lot
If increased or decreased why?		

12. Do you think the general trend of the number of Birds of Paradise species in your area has;

a) Decreased a lot

b) Decreased

c) Stayed the same

d) Increased

e) Increased a lot

What are your reasons for the increase or decrease?

---

13. In what way do you think the forest size at your village (clan ownership) has changed in the following way in the last 30 years;

a) Decreased a lot

b) Decreased

c) Stayed the same

d) Increased

14. Are you familiar with the language names of the Birds of Paradise that you are currently selling?

a) Yes, I know them very well b) yes, but not too confident with all the names c) I don't know

15. Do you currently have any plumes for traditional festivity with you in your household? Y/N,

Appendix 3.2 Cultural Festival Survey Instruments (Human Ethics Approval H5610)

Show survey of Birds of Paradise Feathers | **Date (dd/mm/yy)**: | **Observor(s)**:

Group Name: | Province: | Village/Town: | No. of members est: M F Child

Interviewee: Sex:_____ Age:____ Occupation: Where do you live?

1). Brief description of decoration i.e species of birds used:
List of Bird species (& quantity)

a)		l)			Code for how species plume were acquired (X) next to species name
b)		m)			1 = bought in village 5=hire
c)		n)			2=bought in town 6=family heirloom
d)		o)			3=hunted by wearer 7=other (specifiy)
f)		p)			4= gift
g)		q)			
h)		r)			
i)		s)			
j)					
k)					
l)					

2b). If you paid for them, how much did the different plumes for each species cost?

				2c) Estimate total costs for plumes worn:

2d) If you paid for the plumes, do you know which area in PNG the feathers came from?

2e) what do you think is the most common way of harvesting plumes?

i) snare iv) guns
ii) bow and arrow v) others, please specificy
iii) sling shot

3). How old are the feathers, parts you are using today?

4) do you think the general trend of the Birds of Paradise in your area has;

a) Decreased a lot e) Increased a lot
b) Decreased d) Increased
c) Stayed the same

What are your reasons for the increase or decrease?

5). Are you concerned about the numbers of species in the wild?

a) yes, very concerned e) not very concerned
b) concerned
c) Neither What are your reasons for being concerned or not?
d) not concerned

6.) Which of the plumes is rare?

6b). Have you seen any of the birds in the wild? Y/N

7). Are you aware if any of the species of birds you are wearing are protected by the PNG Govt Law? Y/N

7b. If yes, which species do you know /think are protected? _____

8). In your village, are there any active Protected Areas (Govt gazetted) or customary Taboo Areas;

8a. PA	8b.TA
a) yes	a) yes
b) No	b) No
c) don't know	c) don't know

9). Please tell us how much of a threat you believe each of the following is to the health of the numbers of Birds of Paradise;

	No threat	Minor threat	Major threat	Don't know
i) over hunting by hunters	1	2	3	4
ii) subsistence gardening	1	2	3	4
iii) climate change	1	2	3	4
iv) bird watching tourism	1	2	3	4
v) human population increase	1	2	3	4
vi) chopping of trees for house/fuel	1	2	3	4

vii) others, please specify

10): How do you preserve or look after your feathers?:

11) what are the main reasons for your participation in the cultural festival?

i) Cultural pride
ii) participating for the prize money, status
iii) participating as a cultural group, association
iv) Promoting tourism v) other, please specify

12) How much of your personal funds did you spend in preparation for this cultural festival?

13) How many times a year do you participate in a cultural festival?

Note to observor(s): *particular species of interest are the Birds of Paradise (all 42 species), cassowaries, Vulturine parrot, palm cokatoos.* _____

Appendix 3.3 Birds Source Localities

	Family	Species	Common Name	Western Highlands				Jiwaka		Madang			Eastern Highlands				Chimbu			Hela	Enga		
				Baiyer	Nebilyer	Tambul	Dei Council	Jimi	Jiwaka	Simbai	Bundi	Ramu	Bena (Wasan)	Bena District	Marawaka	Lufa	Chuave	Karimui	Gembogl	Hela	Kupin, Enga	Wabag	*Total Counts per spp*
	Accipitridae	*Haliastur indus*	Brahminy Kite	1																			**1**
	Accipitridae	*Harpyopsis novaeguineae*	New Guinea Harpy-eagle				1					2											**3**
	Accipitridae	*Henicopernis longicauda*	Long-tailed Buzzard	1																			**1**
	Ardeidae	*Egretta garzetta sp?*	Little Egret						1														**1**
	Bucerotidae	*Rhyticerous plicatus*	Papuan Hornbill									5	1										**6**
	Cacatuidae	*Cacatua galerita*	Suphur crested Cockatoo									2	1		2			1					**6**
	Caprimulgidae	*Eurostopodus archboldi*	Archbold's Nightjar										1										**1**
	Casuariidae	*Casuarius sp (either bennetti or and casuarius)*	Cassowaries	2				1					2		1		1	3					**10**
	Columbidae	*Goura sheepmakerii*	Victoria's Pigeon	3			1	1					2	1									**8**
Bird of Paradise	Paradisaeidae	*Astrapia mayeri*	Ribbon Tailed Astrapia																	2			**2**
Bird of Paradise	Paradisaeidae	*Astrapia stephaniae*	Stephanie's Astapia	2			1	4	1	2			4	2		5		2	1		1		**25**
Bird of Paradise	Paradisaeidae	*Cicinnurus regius*	King Bird of Paradise											1	1								**2**
Bird of Paradise	Paradisaeidae	*Diphyllodes magnificus*	Magnificent Bird of Paradise	1	2	1																	**4**
Bird of Paradise	Paradisaeidae	*Epimachus fastuosus*	Black Sicklebill	5			4	2	2	3			1	4	1			1					**23**
Bird of Paradise	Paradisaeidae	*Lophorina superba*	Superb Bird		1	1	4	2									1	1					**10**
Bird of Paradise	Paradisaeidae	*Pteridophora alberti*	King of Saxony	1	1		3	1													1		**7**
Bird of Paradise	Paradisaeidae	*Epimachus meyeri*	Brown Sicklebill											4									**4**
Bird of Paradise	Paradisaeidae	*Paradisaea minor*	Lesser Bird	7			5	3	4	1		2											**22**
Bird of Paradise	Paradisaeidae	*Paradisaea raggiana*	Raggiana	6		3	2	2	2	1	1		2	1	2								**22**
Bird of Paradise	Paradisaeidae	*Paradisornis rudolphi*	Blue Bird of Paradise											1									**1**
Australian Parrots	Psittaculidae	*Aliterus cholopterus*	Papuan King Parrot										1		1								**2**
Australian Parrots	Psittaculidae	*Charmosyna josefinae*	Josephine's Lrikeet				3		2													1	**6**
Australian Parrots	Psittaculidae	*Charmosyna stellae*	Stella's Lorikeet							8				1									**9**
Australian Parrots	Psittaculidae	*Pseudeos fuscata*	Dusky Lorikeet					1	1			1											**3**
Australian Parrots	Psittaculidae	*Psiteuteles goldiei*	Goldie's Lorikeet					1															**1**
Australian Parrots	Psittaculidae	*Trichoglossus haematodus*	Rainbow Lorikeet	6	1	1	2	4									1	1	1				**17**
Australian Parrots	Psittaculidae	*Lorius lory*	Black-capped lory										1										**1**
	Psittrichasidae	*Psittrichas fulgidus*	Vulturine Parrot	1	1			2	3	4		1	3	1	3			4					**23**
	Strigidae	*Ninox rufa*	Rufous owl										1										**1**
	Tytonidae	*Tyto tenebricosa*	Sooty owl								1												**1**
			# species per site	**12**	**5**	**4**	**10**	**12**	**8**	**6**	**2**	**6**	**12**	**9**	**7**	**1**	**3**	**8**	**2**	**1**	**2**	**1**	**223**

Below: Source locations mapped in Chapter 3- Figure 3:2

Locality identified within Province	# of species	Proportion (#/30)
Lufa	1	0.03
Hela, Tari	1	0.03
Wabag	1	0.03
Baiyer	2	0.07
Bundi	2	0.07
Gembogl	2	0.07
Kupin	2	0.07
Chuave	3	0.10
Tambul	4	0.13
Nebilyer	5	0.17
Simbai	6	0.20
Ramu	6	0.20
Marawaka	7	0.23
Anglimp South Waghi (incl. Mina-Banz)	8	0.27
Karimui	8	0.27
Bena District	9	0.30
Dei Council	10	0.33
Jimi	12	0.40
Bena (Wasan)	12	0.40

species per site
1-3
1-3
1-3
1-3
1-3
1-3
1-3
1-3
4-6
4-6
4-6
4-6
7-9
7-9
7-9
7-9
10-12
10-12
10-12

Appendix 3.4 Traders interviewed between September 2014 - January 2016

REC#	Location	Province	Gender	Age	Trader's Prov. Of origin	Year(s) involved in trade	Species	Qty	Price range (PNG Kina); price @	Live (L) or skin (s)
M001	Kagamuga	W.H.P	M	80	CHIMBU	>20	*Paradisaea raggiana*	3	50	s
M002	Kagamuga	W.H.P	M	62	S.H.P	26	*Paradisaea minor*	1	150-200	s
							Paradisaea raggiana	1	50	s
							Trichoglossus haematodus	1	15-20	s
							Casuarius Sp		30	s
								2	30-50	s
G010	Goroka	E.H.P	F	45	CHIMBU	1	*Astrapia stephanie*	1	40	s
							Psittrichas fulgidus	1	70	s
G011	Goroka	E.H.P	M	65	E.H.P	5	*Paradisaea raggiana*	1	60	s
							Cicinnurus regius	1	50	s
							Psittrichas fulgidus	1	50	s
							Astrapia stephanie	1	50-70	s
G012	Goroka	E.H.P	F	35	E.H.P	5	*Casuarius sp. parts*	1	25	s
							sp	1	30-35	s
							Psittrichas fulgidus	1	40	s
G013	Goroka	E.H.P	M	52	E.H.P	3	*Astrapia stephanie*	1	30	s
							Epimachus fastosus	1	30	s
							Casuarius sp. parts	1	20	s
							Psittrichas fulgidus.	1	30	s
G014	Goroka	E.H.P	M	38	E.H.P	3	*Paradisaea raggiana*	1	30	s
							Psittrichas fulgidus	1	25	s
							sp.	1	20	s
G015	Goroka	E.H.P	M	38	E.H.P	3	*Lophorina superba*	1	10	s
							Aliterus cholopterus	1	15	s
							Pteridophora alberti	1	15	s
							Casuarius. sp chick	1	200-300	L
G016	Goroka	E.H.P	M	40	E.H.P	3	*Paradisaea raggiana*	1	60	s

							Casuarius bennetti (juv)	1	300	L
							Casuarius bennetti (plumes)	1	30	s
G017	Goroka	E.H.P	M	40	E.H.P	4	*Astrapia stephanie*	1	70	s
							Pteridophora alberti	1	30	s
G018	Goroka	E.H.P	M	35	E.H.P	2	*Paradisaea raggiana*	1	50	s
							Aliterus cholopterus	1	20	s
								1	30	s
G019	Goroka	E.H.P	M	43	E.H.P	3	*sp*	1	15	s
							sp	1	30	s
G003	Lae	Morobe	F	40	Morobe	first time	*Podargus papuensis (juv.)*	1	10	L
G020	Goroka	E.H.P	F	46	CHIMBU	2	*Astrapia stephanie*	1	80	s
							Psittrichas fulgidus	1	50	s
G021	Goroka	E.H.P	M	70	na	2	*Astrapia stephanie*	1	50-60	s
							Casuarius casuarius (plumes)	1	20	s
							sp (whole bird skin)	2	25-35	s
G022	Goroka	E.H.P	M	50	Jiwaka	> 30	*Paradisaea minor*	1	30	s
							Paradisaea raggiana	1	60	s
							Casuarius sp. parts	1	50	s
								1	30	s
G023	Goroka	E.H.P	M	70	E.H.P	n.a	*Casuarius sp. parts*	1	20	s
								2	100	s
							Goura sheepmakeri	1	50	s
							Aliterus cholopterus	1	50	s
G024	Goroka	E.H.P	M	70	E.H.P	> 40	*Aliterus cholopterus*	1	50	s
							Casuarius sp (headdress)	1	20	s
								2	100	s
							Eurostopodus archboldi	1	10	s
							Ninox rufa	1	10	s
								3	30	s
G025	Goroka	E.H.P	M	70	E.H.P	> 20	*Goura sheepmakeri*	6	20	s
G026	Goroka	E.H.P	M	34	E.H.P	n.a	*Astrapia stephanie*	1	30	s

G027	Goroka	E.H.P	M	60	W.H.P	39	*Paradisaea raggiana* *Pteridophora alberti* *Trichoglossus haematodus* *Pseudeos fuscata* *Psitteuteles goldiei*	1 6 2 3 1	1000	sold as a set set 20 years old
G028	Goroka	E.H.P	M	60	W.H.P	25	*Paradisaea raggiana* *Astrapia stephanie* *Epimachus fastosus* *Trichoglossus haematodus* *Casuarius sp*	1 1 1 1 1	50-100 30-100 100-300 50 50	s s s s s
G029	Goroka	E.H.P	M	75	W.H.P	n.a	*Paradisaea raggiana*	1	100-200	s
P021	Boroko Market	N.C.D	M	73	S.H.P	n.a	*Paradisaea raggiana*	2	250-300	s
P020	Boroko Market	N.C.D	M	45	S.H.P		*Paradisaea raggiana*	3	100-400	s
P019	Boroko Market	N.C.D	F	40	Gulf	13	*Casuarius sp (headdress)*	1	30	s
P018	Boroko Market	N.C.D	F	60	Madang	24	*Casuarius sp. (juv.)*	1	300	L
P017	Boroko Market	N.C.D	F	n.a	S.H.P	several years	*Casuarius sp. (woven into bag)*	1	150	s
P016	Boroko Market	N.C.D	F	40	Chimbu	4	*Casuarius sp. parts*	1	5	s
P015	Boroko Market	N.C.D	M	30	S.H.P	20	*Paradisaea raggiana*	1	200	s
P014	Holiday Inn	N.C.D	F	n.a	S.H.P		*Charmosyna josefinae*	1	200	s
P013	Boroko Market	N.C.D	M	40	Central	2	*Charmosyna josefinae*	1	30	s
P012	Boroko Market	N.C.D	F	50	S.H.P	9	*Casuarius sp.*	1	60	s
P011	Boroko Market	N.C.D	M	50	S.H.P	several years	*Paradisaea raggiana* *Lophorina superba*	2 1	50-250 100	s s
P010	Ela Beach	N.C.D	F	n.a	S.H.P	4	*Paradisaea raggiana*	2	300-500	s
P009	Holiday Inn	N.C.D	F	30	E.S.P	12	*Casuarius sp. headdress*	1	100	s
P007	Boroko Market	N.C.D	F	45	E.S.P	6	*Casuarius sp. (headdress)*	1	50	s
P006	Boroko Market	N.C.D	F	35	S.H.P	2 months	*Casuarius sp. (headdress)*	1	100	s
P005	Boroko Market	N.C.D	M	80	S.H.P	several years	*Paradisaea raggiana*	1	300	s

P004	Boroko Market	N.C.D	F	25	Madang	several years	*Casuarius sp. (headdress)*	1	2 to 5	s
P003	Ela Beach	N.C.D	F	40	E.S.P	n.a	*Paradisaea minor*	1	200	s
P002	Ela Beach	N.C.D	M	n.a	S.H.P	few months	*Paradisaea raggiana*	1	400	s
P001	Boroko Market	N.C.D	F	40	CHIMBU	13	*Casuarius sp woven into bags*	2	150	s
							Casuarius	1	5	s
P026	5 mile Sunny Bunny Pre-school	N.C.D	M	50	CENTRAL	first time	*Eclectus roratus*	2	not obtained	L
							sp	2	not obtained	L
P025	Boroko Foodworld	N.C.D	M	20	CENTRAL	n.a	*Eclectus roratus*	1	200	s
P024	Boroko Foodworld	N.C.D	M	40	CENTRAL	first time	*Paradisaea raggiana*	3	50	s
P023	Tabari Place, Boroko	N.C.D	M	70	S.H.P	n.a	*Paradisaea raggiana*	3	100	s
P022	Tabari Place, Boroko	N.C.D	M	45	S.H.P	n.a	*Paradisaea minor*	3	200	s
MP01	Lae Market	M.P	F	39	n.a	several years	*Casuarius bennetti (small bundles)*	1	7	s
MP01	Lae Market	M.P	F	39	n.a	several years	*Gallus gallus*	2	3	s
MP02	Lae Market	M.P	M	27	n.a	several times	*Casuarius bennetti (small bundles)*	1	7	s
							Cacatua galerita	1	5	s
MP03	Lae Market	M.P	F	33	n.a	12	*Casuarius bennetti (woven bag)*	1	70	s
							Gallusgallus	1	3	s
MP04	Lae Market	M.P	F	48	n.a	Often	*Gallus gallus*	1	3	s
							Casuarius sp.	1	3	s
MP05	Lae Market	M.P	M	32	n.a	many times	*Casuarius sp.*	1	60	s
							Paradisaea raggiana	3	150	s
MP06	Lae Market	M.P	F	33	n.a	n.a	*Casuarius sp. (plumes in headband)*	1	5	s
MP07	Lae, 10 Mile	M.P	n.a	31	n.a	months	*Casuarius bennetti*	1	300	L
G030	BoP Hotel Craft Market	E.H.P	M	23	E.H.P	7	*Astrapia stephanie*	4	40-50	s

G031	Goroka Show Ground	E.H.P	M	61	E.H.P	c.40	*Paradisaea raggiana*	1	150	s
							Tyto tenebricosa		25	s
G032	Goroka Show Ground	E.H.P	M	62	E.H.P	> 20 years	*Paradisaea raggiana*	3	40-200	s
							Paradisaea minor	1	40	s
							Haliastur indus	1	15	s
							Henicopernis longicauda	1	20	s
G033	BoP Hotel Craft Market	E.H.P	M	51	E.H.P	Once	*Astrapia stephanie*	2	20-30	s
							Epimachus meyeri	3	70-100	s
G034	BoP Hotel Craft Market	E.H.P	M	80	E.H.P	many times	*Astrapia stephanie*	3	100	
							Epimachus fastosus	1	80	s
							Paradisornis rudolphi	1	100	s
G035	BoP Hotel Craft Market	E.H.P	M	62	E.H.P	2 months	*Astrapia stephanie*	1	100	s
							Epimachus fastosus	3	50-100	s
							Charmosyna stellae	1	70	s
							Accipter sp (Goshawk)	1	15	s
P027	5 mile - Sunny Bunny Pre-school	N.C.D	M	20	Central	n.a	*Trichoglossus haematodus*		100	s
P028	Museum Craft Market	N.C.D	F	28	S.H.P	n.a	*Paradisaea raggiana*	2	200	s
P029	Museum Craft Market	N.C.D	F	33	Oro	n.a	*Paradisaea minor*	5	300-500	s
P030	Takarara	N.C.D	M	40	NA	n.a	*Haliastur spenurus*	2	15	L
P039	Boroko Foodworld Gordons	N.C.D	M			n.a	*Eclectus roratus*		50-80	L
							Circus aproximans spilothorax (pied)	3	80-100	L
P040	Boroko Foodworld Gordons	N.C.D	M	40		n.a	*Eclectus roratus*	2	100	L
G036	Wataraise	E.H.P	M	35	E.H.P	n.a	*Epimachus meyeri*	1	200	L

G037	Goroka Show Ground	E.H.P	M	35	W.H.P	n.a	*Pitohui dichrous*	1	10	L
G038	Goroka Show Ground	E.H.P	M	62	S.H.P	n.a	*Paradisaea minor*	2	200-300	s
SJ039	Kalam Festival	Simbai	M	28	Madang	n.a	*Paradisaea minor*	2	150-200	L

Appendix 3.5 Members Representing Cultural Groups Interviewed (2014 -2015)

ID	Annual Cultural Show	Group Name	Province	Village/Town	Lives in:	Total members #	Male #	Female #	Chil d.	Gender	Occupation
M1	Mt. Hagen	Palimb Culture	W.H.P	Palimb, Hagen Central	Palimb	15	0	15	0	F	home maker
M2	Mt. Hagen	Polka Culture	Jiwaka	Anglimp,Poka	Anglimp, Jiwaka	15	15	0	0	M	works at the culture centre/sub.farmer
M3	Mt. Hagen	Kunai Brothers Culture	W.H.P	Nebilyer, W.H.P	Nebilyer, W.H.P	21	21	0	0	M	sub.farmer
M4	Mt. Hagen	Marowe Welda	W.H.P	Nebilyer, W.H.P	Nebilyer, W.H.P	15	0	15	0	F	sub.farmer
M5	Mt. Hagen	Poipin Women's culture	W.H.P	Nebilyer, W.H.P	Nebilyer, W.H.P	16	0	16	0	F	sub.farmer
M6	Mt. Hagen	Sili Muli Boys	Enga	Kondemapun, Kupin	Kupin, Enga	42	22	20	0	M	sub.farmer
M7	Mt. Hagen	Mala one	W.H.P	Nunga, Dei Council	Dei Council, W.H.P	15	2	13	0	F	sub.farmer
M8	Mt. Hagen	Pikal Singsing	Jiwaka	Mt. Hagen	Mt.Hagen	16	0	16	0	F	sub.farmer
M9	Mt. Hagen	Korowas	W.H.P	na	na	12	1	11	0	F	n.a
M10	Mt. Hagen	Mindima Womens Culture	Chimbu	Mindima	Mindima, Chimbu	18	0	18	0	F	sub.farmer
M11	Mt. Hagen	North Wind	Jiwaka	Nondukgl	Nondukgl	17	6	11	0	F	n.a
M12	Mt. Hagen	North Wind	Jiwaka	Nondukgl	Nondukgl	17	6	11	0	M	sub.farmer
M13	Mt. Hagen	Malo 1	W.H.P	Kitip, Dei Council	Nunga, Kitip/Dei Council	15	2	13	0	F	sub.farmer
M14	Mt. Hagen	Mala 1	W.H.P	Mala, Dei Council	Dei Council, W.H.P	15	2	13	0	F	unemployed
M15	Mt. Hagen	Malida	W.H.P	Mayokona, Tambul	Mayokona, Tambul, W.H.P	15	0	15	0	F	sub.farmer
M16	Mt. Hagen	Not record	Chimbu	Mindima	Mindima, Chimbu	25	0	25	0	F	sub.farmer
M17	Mt. Hagen	Upper Culture	W.H.P	Dei Council	W.H.P	36	18	18	0	M	sub.farmer
M18	Mt. Hagen	Polka Culture	W.H.P	Kiminiga, Mul-Baiyer	Kimininga, W.H.P	n.a	n.a	n.a	n.a	F	Betel nut seller
M19	Mt. Hagen	Solo Ark	W.H.P	Moke	W.H.P	15	0	15	0	F	n.a
M20	Mt. Hagen	Kui's Women's	W.H.P	Kagamuga	Kagamuga, W.H.P	15	0	15	0	F	sub.farmer
M21	Mt. Hagen	Tokua Women's	Jiwaka	Eka	Eka, Jiwaka	13	0	13	0	F	sub.farmer

G22	Goroka	Kosaiufa	E.H.P	Goroka	Goroka, E.H.P	25	10	10	5	M	sub.farmer
G23	Goroka	Asaroyufa (Bena)	E.H.P	Asaroyufa Village 1	Asaroyufa village	27	2	22	3	F	volunteer with an N.G.O
G24	Goroka	Arango 1 Chuave	Chimbu	Kimo	Siane	15	5	9	1	M	villager, sub.farmer
G25	Goroka	Koropa Singsing	Hela	Koropa	Koropa	45	40	0	5	M	villager, sub.farmer
G26	Goroka	Mindima Culture 2	Chimbu	Mindima	Mindima, Chimbu	20	0	20	0	F	home maker and sub.farmer
G27	Goroka	Mindima Womens Culture	Chimbu	Mindima	Mindima, Chimbu	20	0	20	0	F	elementry school teacher
G28	Goroka	Wup Pogia Wia Culture	W.H.P	Gumas	Mt Hagen	16	1	14	1	M	student
G29	Goroka	Asaroyufa	E.H.P	Bena	Bena High School	25	2	23	0	F	sub.farmer
G30	Goroka	Kiane Culture	Chimbu	Wara Chimbu, Sinesine	Kamkumu	30	0	30	0	F	housewife
G31	Goroka	Yongawo	Chimbu	Mindima	Mindima, Chimbu	25	0	25	0	F	sub.farmer
G32	Goroka	Hela Wigman	Hela	Egele	Tari	45	43	0	2 (f)	M	sub.farmer
G33	Goroka	Wup Pogia Wia Culture	W.H.P	Rabiamul	Rabiamul, W.H.P	15	1	14	0	F	sub.farmer
G34	Goroka	Arango 1	Chimbu	Chuave, Siane	Goroka/E.H.P	14	5	9	0	F	home maker
G35	Goroka	Mindima Culture	Chimbu	Mindima	Mindima, Chimbu	20	0	20	0	F	involved in tourism culture in her village
G36	Goroka	Yasowara Tunuia	E.H.P	Wandakia, Marawaka	Goroka	22	12	8	2	M	security guard
G37	Goroka	Mengunagu	E.H.P	Goroka	Upper Bena	37	20	7	10	M	teacher
G38	Goroka	Megunagu	E.H.P	Megunangu	Kafana, E.H.P	10	7	3	0	M	sub. farmer
G39	Goroka	Yasonara Funiufa	E.H.P	E.H.P	Sipiga, E.H.P	20	11	6	3	M	sub.farmer
G40	Goroka	Sabiri	E.H.P	Upper Bena	Sabiri	n.a	n.a	n.a	n.a	M	sub.farmer
G41	Goroka	Yasowara Tunia	E.H.P	Marawaka, Obura Wonenara	Wandatia	20	14	6	0	M	n.a
G42	Goroka	Kosaufa	E.H.P	Goroka	Asaro	26	10	15	1	M	sub. farmer
G43	Goroka	Mara Boys1	W.H.P	Mt. Hagen	Sigirap, Dei Council	32	32	0	0	M	sub. farmer
G44	Goroka	Mara boys2	W.H.P	Mul-Baiyer	Kela	20	20	0	0	M	sub. farmer
G45	Goroka	Mara boys3	W.H.P	Mt. Hagen	Kela	36	15	11	10	M	sub.farmer
G46	Goroka	Kasaufa	E.H.P	Kasaufa	Kasaufa, Asaro	15	9	16	0	M	n.a

G47	Goroka	Kei Women's	W.H.P	Kaiwe, Hagen Central		15	0	15	0	F	sub. farmer and owner of headdress sets (x6); hires out on cultural shows
G48	Goroka	Kei Women	W.H.P	Kaiwe Hagen Central	Kaiwe, W.H.P	16	0	15	1	F	sub. farmer
M.P 49	Morobe	Nasville Burumme	Morobe	Nasuapum	Nasville	n.a	n.a	n.a	n.a	F	secretary for a women's group
M.P 50	Morobe	Kindeng Women's	Jiwaka	Kinding (Awi)	Kinding, Jiwaka	18	0	18	0	F	home maker
M.P 51	Morobe	Kiane Culture	Chimbu	Kiane Culture Group	Lae	n.a	n.a	n.a	n.a	F	Janitor with a company
M.P 52	Morobe	Numuru Siasi	Morobe	Lae	Tuam	31	28	3	0	F	n.a
M.P 53	Morobe	Chimbu	Chimbu	na	Kundiawa / Kamkumu	female group	n.a	n.a	n.a	F	n.a
M.P 54	Morobe	Garaina	Morobe	na	Bulolo	male group	n.a	n.a	n.a	M	road constructio n
M.P 55	Morobe	Sinasina	Chimbu	Kundiawa	Kamkumu, Lae Morobe province	female group	n.a	n.a	n.a	F	homemaker
M.P 55	Morobe	Sinasina	Chimbu	Kundiawa	Kamkumu, Lae Morobe province	female group	n.a	n.a	n.a	F	homemaker
M.P 56	Morobe	Kasaufa	M.P	Yamumet	Bumayong	male group	n.a	n.a	n.a	M	n.a
M.P 58	Morobe	Gatika	M.P	Menyama	Unigate, Lae M.P	25	9	14	2	M	n.a
M.P 59	Morobe	Kobabo	M.P	Bulolo Wau	Markham	27	15	9	3	M	brick layer
M.P 60	Morobe	Kiane Culture	Chimbu	Sinesine	Lae	23	0	23	0	F	n.a
SJ61	Simbai	Bartnasa Culture	Madang	Nungut-Simbai	Nungut	40	40	0	n.a	M	sub.farmer
SJ62	Simbai	Bartnasa Culture	Madang	Nungut-Simbai	Nungut	male group	40	0	0	M	sub.farmer
SJ63	Simbai	Bartnasa Culture	Madang	Nungut-Simbai	Nungut	male group	40	0	0	M	sub. farmer, church catechist and founder of Bartnasa Culture Group
SJ64	Simbai	Asima = "widow struggle"	Madang	Nungut-Simbai	Nungut	female group	n.a	7	n.a	F	sub.farmer
SJ65	Simbai		Madang	Simbai	Simbai	male group	n.a	n.a	n.a	M	sub.farmer

SJ66	Simbai		Madang	Simbai	Simbai	male group	33	n.a	n.a	M	student/ sub.farmer
SJ67	Simbai		Madang	Simbai	Simbai	male group	n.a	n.a	n.a	M	student/ sub.farmer
SJ68	Simbai		Madang	Simbai	Simbai	male group	n.a	n.a	n.a	M	sub.farmer
SJ69	Simbai		Madang	Simbai	Simbai	male group	n.a	n.a	n.a	M	sub.farmer
SJ70	Simbai		Madang	Simbai	Simbai	male group	n.a	n.a	n.a	M	n.a
SJ71	Simbai	Asima = "widow struggle"	Madang	Simbai	Simbai	female group	n.a	n.a	n.a	F	sub.farmer
SJ73	Simbai	Asima = "widow struggle"	Madang	Simbai	Simbai	female group	n.a	n.a	n.a	F	sub.farmer
SJ74	Goroka	Ase	E.H.P	Karume, Unnagi	Karume village, Unggai	12	7	5	n.a	M	sub.farmer
SJ75	Goroka	Wiula Kinging Culture	W.H.P	Rabiamul	Rabiamul, W.H.P	40		20	20	F	n.a
SJ76	Goroka	Sipiga Lahani	E.H.P	Sipiga	Sipiga, E.H.P	18	10	8	2	M	industry
SJ77	Goroka	Sitani	E.H.P	Komiufa, E.H.P	Komiufa	17	6	7	4	M	sub.farmer

Appendix 4.1 Hunter Data Survey Questions

Date: _____

Interviewer: _____

Location: _____Clan Name: _____ ID:_____ Gender: M/ F
Age:_____(if known or approximate)

C. Hunter

20. How often did you go hunting in the last 12 months?

v) Weekly or more often
vi) Fortnightly
vii) Once a month
viii) Less often or on holidays

21. How many days in total did you go hunting in the last 12 months? ____
22. How many years have you been hunting? _____
23. Compared to other activities you do (gardening, build house, sports, etc), would you say hunting is;

vi) Your most important activity
vii) Second most important activity
viii) Third most important activity
ix) One of the many activities

24. What is your preferred method of hunting or plume harvesting?
    i) Snare
    ii) Bow and arrow
    iii) Sling shot
    iv) Gun
    v) Other, please specify_____
25. What have you killed (list animals, species) in the last 12 months using the hunting method(s) above?

26. What did you do with the plumes of birds you last hunted?
    i) Kept for personal use
    ii) Gave to a family member in the village/ town
    iii) Gift to someone else
    iv) Sold
    v) Other_____please specify_____
27. If you sold, how much was the plume(s) bought for?_____Was the buyer a local person?_____(elaborate)

D. Current hunting locations

28. Collect GPS point location(s) or mark on the map your current hunting location(s). This refers to the area you frequent or where you usually hunt
29. For each of the location you marked;

i) How often do you hunt there?
ii) What species do you target or catch there?
iii) Are there any particular reasons why you like to hunt there?

E. Previous hunting areas

30. Are there any previous hunting locations you used to go to but now can't?
31. For each location/area:
    i) How often did you used to hunt there?
    ii) What species did you used to catch/target there?
    iii) Is there any particular reason why you like to hunt there?
32. For the locations you **do not go to** anymore:
    i) Have you replaced those areas with new areas for hunting? If 'yes' where are the new areas (mark on the map)
    ii) With the change in hunting area, has this caused a change in target or catch different species? If 'yes' which ones?
    iii) Are there any ways, you have compensated or adjusted for the loss of these hunting areas?
33. Has the protected area (or *taboo* site) affected your hunting activity?

F. Attitude about protected areas (traditional *taboo*/ Govt designated Protected Area)

34. Do you have any *taboo* sites within your clan boundary? Collect GPS point location(s) or mark on the map the *taboo* sites known to you.

35. Do you think the traditional protected areas are a;
    i) Very good idea
    ii) Good idea
    iii) Neither
    iv) Bad idea
    v) Very bad idea

Do you think the Government Gazetted protected areas is; (Alternately)

    vi) Very good idea
    vii) Good idea
    viii) Neither
    ix) Bad idea
    x) Very bad idea

15. What is your level of approval of the number of taboo sites/protected areas in your traditional land?

a) Strongly approve
b) Approve
c) Neither approve nor disapprove
d) Disapprove
e) Strongly disapprove

15b. in what way do you approve/disapprove of the number of protected (and/or taboo sites)
_____

16. What is your level of approval of the size of protected area in the area where you hunt?

a. Strongly approve
b. Approve
c. Neither approve nor disapprove
d. Disapprove
e. Strongly disapprove

16b. In what way do you approve/disapprove of the size of the protected and or taboo area?

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17. What is your level of approval of the location of protected area (or taboo sites) in the areas you hunt?

a. Strongly approve
b. Approve
c. Neither approve nor disapprove
d. Disapprove
e. Strongly disapprove

17b. In what way do you approve/disapprove of the size of the protected and or taboo area?

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18. Do you have any suggestions as to how concerns of protected area could be better improved?

19. The taboo site in your area are;

a) Still maintained by strict traditional beliefs

b) Protection not very strict

c) No, not anymore

d) I'm not aware

G. Changes in the Hunting Activity

20. Over the past years, has the level of hunting activity increased, decreased or stayed the same?

H. Perceptions of Birds of Paradise, the environment, and Governance

21. Do you think the general trend of the number of Birds of Paradise species in your area has;

a) Decreased a lot

b) Decreased

c) Stayed the same

d) Increased

e) Increased a lot

What are your reasons for the increase or decrease?

22. In this present time, how important are each of the bird species to your culture?

23. In what way do you think the forest size under you (clan ownership) has changed in the following way in the last 30 years;

a) Decreased a lot

b) Decreased

c) Stayed the same

d) Increased

e) Increased a lot

What are your reasons for the increase or decrease?

---

24. Do you know what time of the year is the best or preferred to go hunting?

_____(Y/N) if yes, when is it_____

25. Is the access to forest restricted to clan/family members only today? _____(Y/N) and why? _____

_____

26. Do you know what plants the Birds of Paradise in your area feed on? Y/N. If yes, please name or identify at least 4 plants _____

_____

27. If it is plant(s), what time of year does this species usually fruit/flower?

_____

28. Are you familiar with the language names of the Birds of Paradise that occur in your area?

29. Do you currently have any plumes for traditional festivity with you in your household? Y/N,

If yes, name the species or alternately show the plumes for identification

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30. Do you think any of the birds you hunt are currently protected by the PNG Government law? Y/ N

If yes, name the species: _____

31. Please tell us how much of a threat you believe each of the following is to the health of the numbers of Birds of Paradise;

	No threat	Minor threat	Major threat	Don't know
a) over hunting by hunters	1	2	3	4
b) subsistence gardening	1	2	3	4
c) climate change	1	2	3	4
d) bird watching tourism	1	2	3	4
e) human population increase in members of the clan/village	1	2	3	4
f) chopping of trees for house/fuel	1	2	3	4

Appendix 4.2 Hunter Data Sheet for Goroka, Lufa, and Gembogl

	Hunter Details						Species Record				GPS Location of species killed			
No.	HunterID	Hunter's age	Clan Name	Village Name	District	Province	Est. date killed	Weapon used	Tokpeles name	Species name	South	East	Elevation (m)	GPS date

Appendix 4.3 Wildlife Hunted from Study Sites, Central Highlands.

No.	Hunter ID	Clan Name	Site	Distict	Yr_last Hunt	Month	Season	Weapon	Taxa	Species	Common Name
1	G01	Ganakoiha	Gahavisuka	Goroka	2014	Jan	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
2	G01	Ganakoiha	Gahavisuka	Goroka	2014	Jan	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
3	G01	Ganakoiha	Gahavisuka	Goroka	2014	Feb	Wet	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
4	G01	Ganakoiha	Gahavisuka	Goroka	2014	Mar	Wet	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
5	G01	Ganakoiha	Gahavisuka	Goroka	2014	Mar	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
6	G01	Ganakoiha	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
7	G01	Ganakoiha	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
8	G01	Ganakoiha	Gahavisuka	Goroka	2014	Jun	Dry	Bow and arrow	M		Tree mouse
9	G01	Ganakoiha	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
10	G01	Ganakoiha	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
11	G01	Ganakoiha	Gahavisuka	Goroka	2014	Aug	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
12	G01	Ganakoiha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
13	G01	Ganakoiha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
14	G01	Ganakoiha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
15	G01	Ganakoiha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
16	G01	Ganakoiha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M		Tree mouse
17	G02	Gopamozuha	Gahavisuka	Goroka	2014	Jan	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
18	G02	Gopamozuha	Gahavisuka	Goroka	2014	Feb	Wet	Bow and arrow	M	*Phalanger sericeus*	Silky cuscus
19	G02	Gopamozuha	Gahavisuka	Goroka	2014	Mar	Wet	Bow and arrow	M		Tree mouse
20	G02	Gopamozuha	Gahavisuka	Goroka	2014	Mar	Wet	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
21	G02	Gopamozuha	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
22	G02	Gopamozuha	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
23	G02	Gopamozuha	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky cuscus
24	G02	Gopamozuha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M		Tree mouse

25	G02	Gopamozuha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
26	G03	Gopamozuha	Gahavisuka	Goroka	2014	Feb	Wet	Bow and arrow	M	*Phalanger gymnotis*	Silky Cuscus
27	G03	Gopamozuha	Gahavisuka	Goroka	2014	Mar	Wet	Bow and arrow	M		Tree mouse
28	G03	Gopamozuha	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
29	G03	Gopamozuha	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
30	G03	Gopamozuha	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M		Tree mouse
31	G03	Gopamozuha	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
32	G03	Gopamozuha	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
33	G03	Gopamozuha	Gahavisuka	Goroka	2014	Aug	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
34	G03	Gopamozuha	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
35	G04	Gamekave	Gahavisuka	Goroka	2014	Feb	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
36	G04	Gamekave	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
37	G04	Gamekave	Gahavisuka	Goroka	2014	Jun	Dry	Bow and arrow	M		Tree mouse
38	G04	Gopamozuha	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
39	G04	Gamekave	Gahavisuka	Goroka	2014	Aug	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
40	G04	Gamekave	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
41	G04	Gamekave	Gahavisuka	Goroka	2014	Oct	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
42	G05	Gamekave	Gahavisuka	Goroka	2014	Mar	Wet	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
43	G05	Gamekave	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
44	G05	Gamekave	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
45	G05	Gamekave	Gahavisuka	Goroka	2014	Jun	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
46	G05	Gamekave	Gahavisuka	Goroka	2014	Jun	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
47	G05	Gamekave	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M		Tree mouse
48	G05	Gamekave	Gahavisuka	Goroka	2014	Aug	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
49	G05	Gamekave	Gahavisuka	Goroka	2014	Aug	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
50	G05	Gamekave	Gahavisuka	Goroka	2014	Oct	Dry	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus

51	G06	Gamekave	Gahavisuka	Goroka	2014	Jan	Wet	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
52	G06	Gamekave	Gahavisuka	Goroka	2014	Feb	Wet	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
53	G06	Gamekave	Gahavisuka	Goroka	2014	Feb	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
54	G06	Gamekave	Gahavisuka	Goroka	2014	Mar	Wet	Bow and arrow	M	*Phalanger gymnotis*	Silky Cuscus
55	G06	Gamekave	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
56	G06	Gamekave	Gahavisuka	Goroka	2014	Apr	Wet	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
57	G06	Gamekave	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M		Tree mouse
58	G06	Gamekave	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M	*Phalanger gymnotis*	Silky Cuscus
59	G06	Gamekave	Gahavisuka	Goroka	2014	May	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
60	G06	Gamekave	Gahavisuka	Goroka	2014	Jun	Dry	Bow and arrow	M	*Phalanger gymnotis*	Silky Cuscus
61	G06	Gamekave	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M		Tree mouse
62	G06	Gamekave	Gahavisuka	Goroka	2014	Jul	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
63	G06	Gamekave	Gahavisuka	Goroka	2014	Aug	Dry	Bow and arrow	M	*Phalanger gymnotis*	Silky Cuscus
64	G06	Gamekave	Gahavisuka	Goroka	2014	Aug	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
65	G06	Gamekave	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
66	G06	Gamekave	Gahavisuka	Goroka	2014	Sept	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
67	G06	Gamekave	Gahavisuka	Goroka	2014	Oct	Dry	Bow and arrow	M	*Phalanger sericeus*	Silky Cuscus
68	G06	Gamekave	Gahavisuka	Goroka	2014	Oct	Dry	Bow and arrow	M	*Pseudochirulus forbesi*	Painted Ringtail
69	K1	Kurube-Osobiri	Karimui	Karimui	2013	Sept	Dry	Bird blind + Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
70	K1	Kurube-Osobiri	Karimui	Karimui	2013	Sept	Dry	Bird blind + Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
71	K10	Sololaisibi	Karimui	Karimui	2014	Aug	Dry	Bow and arrow + Dog	B	*Casuarius bennetti*	Dwarf cassowary
72	K10	Sololaisibi	Karimui	Karimui	2014	Aug	Dry	Slingshot	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
73	K10	Sololaisibi	Karimui	Karimui	2014	Aug	Dry	Bow and arrow + dog	M	*Sus scorfa*	Feral Pig
74	K11	Sololaisibi	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	B	*Rhyticeros plicatus*	Hornbill

75	K11	Sololaisibi	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bird hide	B	*Cacatua galerita*	Suphur-crested Cockatoo
76	K11	Sololaisibi	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bird hide	B	*Eclectus roratus*	Eclectus parrot
77	K11	Sololaisibi	Karimui	Karimui	2014	N/A	N/A	Bow and arrow + bird hide	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
78	K12	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + Dog	B	*Casuarius bennetti*	Dwarf Cassowary
79	K12	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + special tree bark	M	*Dorcopsulus macleayi*	Wallaby
80	K12	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + special tree bark	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
81	K12	Kesipe	Karimui	Karimui	2014	Sept	Dry	Dog	M	*Echymipera kalubu*	Bandicoot
82	K12	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + special tree bark	M	*Sus scorfa*	Feral Pig
83	K13	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	B	*Casuarius casuarius*	Southern Cassowary
84	K13	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	M	*Dendrolagus goodfellowi*	Goodfellows Tree kangaroo
85	K13	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	M	*Dorcopsulus macleayi*	Wallaby
86	K13	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
87	K13	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	M	*Phalanger gymnotis*	Ground cuscus
88	K13	Kesipe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	M	*Sus scorfa*	Feral Pig
89	K14	Olai	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + Dog	B	*Casuarius casuarius*	Southern Cassowary
90	K14	Olai	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	B	*Ducula chalconota*	Rufiscent Imperial Pigeon
91	K14	Olai	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	B	*Ptilinopus superbus*	Superb Fruit Dove
92	K14	Olai	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + dog	M	*Phalanger gymnotis*	Ground Cuscus
93	K15	Solita	Karimui	Karimui	2014	Sept	Dry	Snare	B	*Casuarius bennetti*	Dwarf Cassowary
94	K15	Solita	Karimui	Karimui	2014	Sept	Dry	Dog	B	*Megapode sp*	Megapode
95	K15	Solita	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + dog	M	*Echymipera kalubu*	Bandicoot

96	K15	Solita	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + dog	M	*Spilocuscus maculatus*	Spotted Cuscus
97	K16	Begasibi	Karimui	Karimui	2014	Sept	Dry	Slingshot	B	*Megapode sp*	Megapodes
98	K16	Begasibi	Karimui	Karimui	2014	Sept	Dry	Slingshot	M	*Phalanger gymnotis*	Ground Cuscus
99	K16	Begasibi	Karimui	Karimui	2014	Sept	Dry	Slingshot	M	*Spilocuscus maculatus*	Spotted Cuscus
100	K17	Dobe	Karimui	Karimui	2014	Jul	Dry	Bow and arrow	M	*Dendrolagus dorianus*	Doria's Tree Kangaroo
101	K17	Dobe	Karimui	Karimui	2014	Jul	Dry	Bow and arrow	M	*Dendrolagus goodfellowi*	Goodfellow i's Tree Kangaroo
102	K17	Dobe	Karimui	Karimui	2014	Jul	Dry	Bow and arrow	M	*Dorcopsulus sp*	Forest Wallaby
103	K17	Dobe	Karimui	Karimui	2014	Jul	Dry	Bow and arrow	B	*Megapode sp eggs*	Megapode
104	K17	Dobe	Karimui	Karimui	2014	Jul	Dry	Bow and arrow	B	*Eclectus roratus*	Juvenile Eclectus parrot
105	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bush knife + axe	B	*Casuarius bennetti*	Dwarf Cassowary
106	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bush knife + axe	B	*Casuarius casuarius*	Southern Cassowary
107	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bush knife + axe	B	*Casuarius casuarius*	Southern Cassowary
108	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bush knife + axe	B	*Ptilinopus superbus*	Superb Fruit Dove
109	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bush knife + axe	B	*Erythrura trichroa*	Blue- faced Parrot Finch
110	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bush knife + axe	M	*Dendrolagus spadix*	Spadix Tree kangaroo
111	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	M	*Dorcopsulus sp*	Forest wallaby
112	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Harvest eggs from mounds	B	*Megapode sp eggs*	Megapode
113	K19	Dobe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow + bush knife + axe	M	*Zaglossus bruijnii*	Long-beaked Echidna
114	K2	Noria	Karimui	Karimui	2014	N/A	N/A	Snare	B	*Casuarius bennetti*	Dwarf Cassowary
115	K2	Noria	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia

116	K2	Noria	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	M	*Spilocuscus maculatus*	Spotted Cuscus
117	K2	Noria	Karimui	Karimui	2014	N/A	N/A	Dog	M	*Sus scorfa*	Feral Pig
118	K20	Yalisibe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	B	*Cacatua galerita*	Suphur-crested Cockatoo
119	K20	Yalisibe	Karimui	Karimui	2014	Sept	Dry	Bow and arrow	B	*Otidiphaps nobilis*	Pheasant Pigeon
120	K20	Yalisibe	Karimui	Karimui	2014	Sept	Dry	Harvest eggs from mounds	B	*Megapode sp eggs*	Megapode
121	K21	Wegisibi	Karimui	Karimui	2014	Sept	Dry	Gun + Dog	M	*Echymipera kalubu*	Numerous Bandicoots
122	K3	Kurupe	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	B	*Otidiphaps nobilis*	Pheasant Pigeon
123	K3	Kurupe	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	M	*Dendrolagus goodfellowi*	Goodfellow's Tree Kangaroo
124	K3	Kurupe	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	B	*Astrapia stephaniae*	Princess Stephanies Astrapia Bird of Paradise
125	K3	Kurupe	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	B	*Cicinnurus regius*	King Bird of Paradise
126	K3	Kurupe	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
127	K3	Kurupe	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
128	K3	Kurupe	Karimui	Karimui	2014	N/A	N/A	Captured from hollow	B	*Psittichas fulgidus*	Vulturine Parrot
129	K36	Naiyo	Karimui	Karimui	2015	Sept	Dry	Bow and arrow + bird hide	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
130	K38	Yuro	Karimui	Karimui	2015	Aug	Dry	Bow and arrow	B	*Paradisornis rudolphi*	Blue Bird of Paradise
131	K38	Yuro	Karimui	Karimui	2015	Aug	Dry	Bow and arrow	B	*Paradisornis rudolphi*	Blue Bird of Paradise
132	K39	Yawio	Karimui	Karimui	2015	Oct	Dry	Bow and arrow	B	*Ephimachus fastosus*	Black Sickelbill
133	K5	Yawiyo	Karimui	Karimui	2014	N/A	N/A	Dog and trap	B	*Casuarius bennetti*	Dwarf Cassowary
134	K5	Yawiyo	Karimui	Karimui	2014	N/A	N/A	Harvest eggs from mounds	B	*Megapode sp eggs*	Megapode
135	K5	Yawiyo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	M	*Phalanger gymnotis*	Ground Cuscus
136	K5	Yawiyo	Karimui	Karimui	2014	N/A	N/A	Trap	M	*Sus scorfa*	Feral Pig
137	K6	Naiyo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	B	*Casuarius casuarius*	Southern Cassowary
138	K6	Naiyo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	B	*Amblyornis sp*	Bowerbird
139	K6	Naiyo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow	M	*Sus scorfa*	Feral Pig
140	K8	Palayo	Karimui	Karimui	2014	N/A	N/A	Harvest eggs from mounds	B	*Megapode sp eggs*	Megapode

141	K8	Palayo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow + Dog	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
142	K8	Palayo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow + dog	M	*Phalanger gymnotis*	Ground Cuscus
143	K8	Palayo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow + dog	B	*Ailuroedus melanotis*	Black-eared Cat bird
144	K8	Palayo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow + dog	B	*Mino dumontii*	Yellow-Faced Myna
145	K8	Palayo	Karimui	Karimui	2014	N/A	N/A	Bow and arrow + dog	M	*Sus scorfa*	Feral Pig
146	M01	Komkane	Toromambuno	Gembogl	2002	Oct	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
147	M01	Komkane	Toromambuno	Gembogl	2002	Nov	Dry	Slingshot	B	*Ducula chalconota*	Rufescent Imperiel Pigeon
148	M01	Komkane	Toromambuno	Gembogl	2002	Nov	Dry	Slingshot	B	*Charmosyna stellae*	Stella's Lorikeet
149	M01	Komkane	Toromambuno	Gembogl	2006	N/A	N/A	Slingshot	B	*Aegotheles albertisii*	Mountain Owlet-nightjar
150	M01	Komkane	Toromambuno	Gembogl	2005	N/A	N/A	Slingshot	B	*Macropygia amboinensis*	Brown Cucko Dove
151	M01	Komkane	Toromambuno	Gembogl	2003	N/A	N/A	Slingshot	B	*Macropygia amboinensis*	Brown Cucko Dove
152	M01	Komkane	Toromambuno	Gembogl	2003	N/A	N/A	Slingshot	B	*Ptilinopus ornatus*	Ornate Fruit-Dove
153	M01	Komkane	Toromambuno	Gembogl	2006	N/A	N/A	Slingshot	B	*Melidectes belfordi*	Belford's Melidectes
154	M01	Komkane	Toromambuno	Gembogl	2005	N/A	N/A	Slingshot	B	*Melionyx fuscus*	Sooty Honeyeater
155	M01	Komkane	Toromambuno	Gembogl	2006	N/A	N/A	Slingshot	B	*Melionyx princeps*	Long-bearded Honeyeater
156	M01	Komkane	Toromambuno	Gembogl	2006	N/A	N/A	Slingshot	B	*Ptiloprora perstriata*	Grey - steaked Honeyeater
157	M01	Komkane	Toromambuno	Gembogl	2004	N/A	N/A	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
158	M01	Komkane	Toromambuno	Gembogl	2006	N/A	N/A	Slingshot	B	*Pteridophora alberti*	King of Saxony Bird of Paradise
159	M01	Komkane	Toromambuno	Gembogl	2005	N/A	N/A	Slingshot	B	*Paramythia montium*	Eastern Crested Berrypecker
160	M01	Komkane	Toromambuno	Gembogl	2004	N/A	N/A	Slingshot	B	*Neopsittacus musschenbroekii*	Yellow-billed lorikeet
161	M01	Komkane	Toromambuno	Gembogl	2004	N/A	N/A	Slingshot	B	*Psittacella brehmii*	Brehm's Tiger Parrot
162	M02	Komkane	Toromambuno	Gembogl	2007	Jan	Wet	Slingshot	B	*Aegotheles albertisii*	Mountain Owlet-nightjar
163	M02	Komkane	Toromambuno	Gembogl	2007	Jan	Wet	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
164	M02	Komkane	Toromambuno	Gembogl	2008	Oct	Dry	Slingshot	B	*Zosterops novaeguineae*	New Guinea White eye
165	M02	Komkane	Toromambuno	Gembogl	2008	Nov	Dry	Slingshot	B	*Ducula chalconota*	Rufescent Imperiel Pigeon
166	M02	Komkane	Toromambuno	Gembogl	2008	Nov	Dry	Slingshot	B	*Macropygia amboinensis*	Brown Cucko Dove

167	M02	Komkane	Toromambuno	Gembogl	2008	Nov	Dry	Slingshot	B	*Ptilinopus ornatus*	Ornate Fruit-Dove
168	M02	Komkane	Toromambuno	Gembogl	2009	Nov	Dry	Slingshot	B	*Pachycephala Schlegelli*	Regent Whistler
169	M02	Komkane	Toromambuno	Gembogl	2009	Nov	Dry	Slingshot	B	*Charmosyna stellae*	Stella's Lorikeet
170	M02	Komkane	Toromambuno	Gembogl	2009	Nov	Dry	Slingshot	B	*Neopsittacus pullicauda*	Orange-billed Lorikeet
171	M02	Komkane	Toromambuno	Gembogl	2009	Nov	Dry	Slingshot	B	*Neopsittacus musschenbroekii*	Yellow-billed Lorikeet
172	M02	Komkane	Toromambuno	Gembogl	2008	Nov	Dry	Slingshot	B	*Psittacella brehmii*	Brehm's Tiger Parrot
173	M02	Komkane	Toromambuno	Gembogl	2009	Nov	Dry	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
174	M02	Komkane	Toromambuno	Gembogl	2007	Dec	Dry	Slingshot	B	*Eurostopodus archboldi*	Archbold's Nightjar
175	M02	Komkane	Toromambuno	Gembogl	2007	Dec	Dry	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
176	M03	Komkane	Toromambuno	Gembogl	2009	Oct	Dry	Trap	B	*Melidectes belfordi*	Belford's Melidectes
177	M03	Komkane	Toromambuno	Gembogl	2009	Oct	Dry	Slingshot	B	*Aleadryas rufinucha*	Rufous-naped Bellbird
178	M03	Komkane	Toromambuno	Gembogl	2009	Oct	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
179	M03	Komkane	Toromambuno	Gembogl	2009	Oct	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
180	M03	Komkane	Toromambuno	Gembogl	2009	Oct	Dry	Bow and arrow	B	*Zosterops novaeguineae*	New Guinea White eye
181	M03	Komkane	Toromambuno	Gembogl	2009	Oct	Dry	Slingshot	B	*Zosterops novaeguineae*	New Guinea White eye
182	M04	Siako	Toromambuno	Gembogl	2005	Feb	Wet	Slingshot	B	*Melidectes belfordi*	Belford's Melidectes
183	M04	Siako	Toromambuno	Gembogl	2005	Feb	Wet	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
184	M04	Siako	Toromambuno	Gembogl	2005	Feb	Wet	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
185	M04	Siako	Toromambuno	Gembogl	2005	Feb	Wet	Slingshot	B	*Paramythia montium*	Eastern Crested Berrypecker
186	M04	Siako	Toromambuno	Gembogl	2005	Feb	Wet	Slingshot	B	*Zosterops novaeguineae*	New Guinea White eye
187	M04	Siako	Toromambuno	Gembogl	2004	Oct	Dry	Slingshot	B	*Zosterops novaeguineae*	New Guinea White eye
188	M05	Siako	Toromambuno	Gembogl	2004	Jan	Wet	Slingshot	B	*Ptilinopus ornatus*	Ornate Fruit-Dove
189	M05	Siako	Toromambuno	Gembogl	2004	Jan	Wet	Slingshot	B	*Ptiloprora perstriata*	Grey - steaked Honeyeater
190	M05	Siako	Toromambuno	Gembogl	2007	Jun	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
191	M05	Siako	Toromambuno	Gembogl	2006	Sept	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
192	M05	Siako	Toromambuno	Gembogl	2007	Nov	Wet	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
193	M05	Siako	Toromambuno	Gembogl	2007	Dec	Wet	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
194	M06	Wandike	Toromambuno	Gembogl	2010	May	Dry	Slingshot	B	*Melidectes belfordi*	Belford's melidectes
195	M06	Wandike	Toromambuno	Gembogl	2010	May	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
196	M06	Wandike	Toromambuno	Gembogl	2010	May	Dry	Slingshot	B	*Paramythia montium*	Eastern crested berrypecker
197	M06	Wandike	Toromambuno	Gembogl	2010	May	Dry	Slingshot	B	*Psittacella brehmii*	Brehm's Tiger parrot
198	M06	Wandike	Toromambuno	Gembogl	2010	May	Dry	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail

199	M06	Wandike	Toromambuno	Gembogl	2010	May	Dry	Slingshot	B	*Zosterops novaeguineae*	New Guinea White eye
200	M07	Denglagu	Toromambuno	Gembogl	2015	Jul	Dry	Slingshot	B	*Ducula chalconota*	Rufescent Imperiel Pigeon
201	M07	Denglagu	Toromambuno	Gembogl	2015	Oct	Dry	Slingshot	B	*Macropygia amboinensis*	Brown Cucko Dove
202	M08	Denglagu	Toromambuno	Gembogl	2006	Feb	Wet	Slingshot	B	*Melidectes belfordi*	Belford's Melidectes
203	M08	Denglagu	Toromambuno	Gembogl	2015	Sept	Dry	Slingshot	B	*Ducula chalconota*	Rufescent Imperiel Pigeon
204	M08	Denglagu	Toromambuno	Gembogl	2015	Sept	Dry	Slingshot	B	*Macropygia amboinensis*	Brown Cucko Dove
205	M08	Denglagu	Toromambuno	Gembogl	2015	Sept	Dry	Slingshot	B	*Melidectes belfordi*	Belford's Melidectes
206	M08	Denglagu	Toromambuno	Gembogl	2014	N/A	N/A	Slingshot	B	*Haliastur indus*	Braminy's Kite
207	M08	Denglagu	Toromambuno	Gembogl	2015	N/A	N/A	Slingshot	B	*Ptiloprora perstriata*	Grey - steaked Honeyeater
208	M08	Denglagu	Toromambuno	Gembogl	2015	N/A	N/A	Slingshot	B	*Aleadryas rufinucha*	Rufous-naped Bellbird
209	M08	Denglagu	Toromambuno	Gembogl	2014	N/A	N/A	Slingshot	B	*Phylloscopus poliocephalus*	Island Leaf-Warbler
210	M08	Denglagu	Toromambuno	Gembogl	2014	N/A	N/A	Slingshot	B	*Neopsittacus pullicauda*	Orange-billed Lorikeet
211	M08	Denglagu	Toromambuno	Gembogl	2015	N/A	N/A	Slingshot	B	*Charmosyna stellae*	Stella's Lorikeet
212	ML1	Auta	Mane-Agotu	Lufa	2015	Jul	Dry	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
213	ML10	Kusili	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
214	ML10	Kusili	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Parotia lawesii*	Lawes Parotia
215	ML10	Kusili	Mane-Agotu	Lufa	2014	Aug	Dry	Slingshot	B	*Pteridophora alberti*	King of Saxony Bird of Paradise
216	ML11	Luka	Mane-Agotu	Lufa	2014	Apr	Wet	Bow and arrow	B	*Parotia lawesii*	Lawes Parotia
217	ML12	Kusili	Mane-Agotu	Lufa	2014	Sept	Dry	Bow and arrow	B	*Paradisornis rudolphi*	Blue Bird of Paradise
218	ML13	Kusili	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise
219	ML2	Auta	Mane-Agotu	Lufa	2014	Feb	Wet	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
220	ML3	Halavi	Mane-Agotu	Lufa	2014	Nov	Dry	Slingshot	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
221	ML4	Luka	Mane-Agotu	Lufa	2014	Feb	Wet	Bow and arrow	B	*Ephimachus fastosus*	Black Sickelbill
222	ML4	Luka	Mane-Agotu	Lufa	2014	Mar	Wet	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
223	ML4	Luka	Mane-Agotu	Lufa	2014	May	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
224	ML4	Luka	Mane-Agotu	Lufa	2014	May	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
225	ML4	Luka	Mane-Agotu	Lufa	2014	May	Dry	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise

226	ML4	Luka	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
227	ML5	Luka	Mane-Agotu	Lufa	2015	Apr	Wet	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
228	ML5	Luka	Mane-Agotu	Lufa	2014	Jul	Dry	Bow and arrow	B	*Paradisaea raggiana*	Raggiana Bird of Paradise
229	ML6	Luka	Mane-Agotu	Lufa	2015	Feb	Wet	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise
230	ML6	Luka	Mane-Agotu	Lufa	2015	Feb	Wet	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise
231	ML6	Luka	Mane-Agotu	Lufa	2015	May	Dry	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise
232	ML6	Luka	Mane-Agotu	Lufa	2015	May	Dry	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise
233	ML6	Luka	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
234	ML6	Luka	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
235	ML6	Luka	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
236	ML6	Luka	Mane-Agotu	Lufa	2014	Aug	Dry	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise
237	ML6	Luka	Mane-Agotu	Lufa	2014	Nov	Dry	Bow and arrow	B	*Lophorina superba*	Superb Bird of Paradise
238	ML6	Luka	Mane-Agotu	Lufa	2015	Nov	Dry	Bow and arrow	B	*Pteridophora alberti*	King of Saxony Bird of Paradise
239	ML7	Kusili	Mane-Agotu	Lufa	2014	Jun	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
240	ML7	Kusili	Mane-Agotu	Lufa	2014	Jun	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
241	ML8	Kaiawa	Mane-Agotu	Lufa	2015	Mar	Wet	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
242	ML8	Kaiawa	Mane-Agotu	Lufa	2015	Mar	Wet	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
243	ML8	Kaiawa	Mane-Agotu	Lufa	2015	Mar	Wet	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
244	ML8	Kaiawa	Mane-Agotu	Lufa	2014	Jun	Dry	Bow and arrow	B	*Ephimachus fastosus*	Black Sickelbill
245	ML9	Kaiawa	Mane-Agotu	Lufa	2015	Jul	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
246	ML9	Kaiawa	Mane-Agotu	Lufa	2015	Jul	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
247	ML9	Kaiawa	Mane-Agotu	Lufa	2015	Jul	Dry	Bow and arrow	B	*Ephimachus fastosus*	Black Sickelbill
248	ML9	Kaiawa	Mane-Agotu	Lufa	2015	Aug	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
249	ML9	Kaiawa	Mane-Agotu	Lufa	2015	Aug	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
250	ML9	Kaiawa	Mane-Agotu	Lufa	2015	Aug	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
251	ML9	Kaiawa	Mane-Agotu	Lufa	2014	Oct	Dry	Bow and arrow	B	*Pteridophora alberti*	King of Saxony

											Bird of Paradise
252	ML9	Kaiawa	Mane-Agotu	Lufa	2014	Oct	Dry	Bow and arrow	B	*Pteridophora alberti*	King of Saxony Bird of Paradise
253	ML9	Kaiawa	Mane-Agotu	Lufa	2014	Oct	Dry	Bow and arrow	B	*Pteridophora alberti*	King of Saxony Bird of Paradise
254	ML9	Kaiawa	Mane-Agotu	Lufa	2014	Oct	Dry	Bow and arrow	B	*Pteridophora alberti*	King of Saxony Bird of Paradise
255	N01	A.zua	Nupaha	Goroka	2014	Jun	Dry	Trap	B	*Casuarius bennetti*	Dwarf Cassowary
256	N01	A.zua	Nupaha	Goroka	2014	Jun	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
257	N01	A.zua	Nupaha	Goroka	2014	Jun	Dry	Bow and arrow	B	*Peneothello sigillata*	White-winged Robin
258	N02	Uhetox	Nupaha	Goroka	2013	Nov	Dry	Bow and arrow	M	*Dendrolagus goodfellowi*	Goodfellow's Tree Kangaroo
259	N02	Uhetox	Nupaha	Goroka	2013	Nov	Dry	Bow and arrow	B	*Talegalla jobiensis*	Red-legged Brushturkey
260	N02	Uhetox	Nupaha	Goroka	2013	Nov	Dry	Bow and arrow	M	*Spilocuscus maculatus*	Spotted Cuscus
261	N02	Uhetox	Nupaha	Goroka	2013	Nov	Dry	Bow and arrow	M		Cuscus
262	N03	A.zua	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit-dove
263	N03	A.zua	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
264	N04	G.zua	Nupaha	Goroka	2013	Dec	Wet	Trap	B	*Casuarius bennetti*	Dwarf cassowary
265	N04	G.zua	Nupaha	Goroka	2013	Dec	Wet	Bow and arrow	B	*Ptilinopus bellus*	Mountain Fruit Dove
266	N04	G.zua	Nupaha	Goroka	2013	Dec	Wet	Bow and arrow	B	*Ptilinopus bellus*	Mountain Fruit-dove
267	N05	Uhetox	Nupaha	Goroka	2016	Jan	Wet	Slingshot	B	*Gymnophaps albertisii*	Papuan-Mountain Pigeon
268	N05	Uhetox	Nupaha	Goroka	2016	Jan	Wet	Slingshot	B	*Devioeca papuana*	Papuan Flycatcher
269	N06	Geza	Nupaha	Goroka	2013	Sept	Dry	Bow and arrow	B	*Ptilinopus bellus*	Mountain Fruit Dove
270	N06	Geza	Nupaha	Goroka	2013	Sept	Dry	Bow and arrow	B	*Ptilinopus bellus*	Mountain Fruit-dove
271	N06	Geza	Nupaha	Goroka	2013	Sept	Dry	Bow and arrow	M	*Dendrolagus goodfellowi*	Goodfellow's Tree Kangaroo
272	N06	Geza	Nupaha	Goroka	2013	Sept	Dry	Bow and arrow	B	*Melilestes megarhynchus*	Long-billed Honey eater
273	N06	Geza	Nupaha	Goroka	2013	Sept	Dry	Slingshot	M	*Spilocuscus maculatus*	Spotted Cuscus
274	N07	H.op	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Gerygone ruficollis*	Brown-breasted Gerygone
275	N07	H.Op	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Ptilinopus sp*	Fruit-dove
276	N07	H.op	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Ptilinopus sp*	Fruit-dove
277	N07	H.Op	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
278	N07	H.op	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
279	N07	H.op	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Calidris acminata*	Sharp tailed Sandpiper

280	N08	Notox	Nupaha	Goroka	2015	Mar	Wet	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
281	N08	Notox	Nupaha	Goroka	2015	Mar	Wet	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
282	N08	Notox	Nupaha	Goroka	2015	Mar	Wet	Slingshot	B	*Rhiphidura atra*	Black Fantail
283	N08	Notox	Nupaha	Goroka	2015	Mar	Wet	Slingshot	B	*Calidris acminata*	Sharp tailed Sandpiper
284	N09	Uhetox	Nupaha	Goroka	2015	Mar	Wet	Slingshot	B	*Calidris acminata*	Sharp-tailed Sandpiper
285	N09	Uhetox	Nupaha	Goroka	2015	Jul	Dry	Slingshot	B	*Gerygone ruficollis*	Brown-breasted Gerygone
286	N09	Uhetox	Nupaha	Goroka	2015	Jul	Dry	Slingshot	B	*Columba vitiensis*	White-throated Pigeon
287	N09	Uhetox	Nupaha	Goroka	2015	Jul	Dry	Slingshot	B	*Gymnophaps albertisii*	Papuan-Mountain Pigeon
288	N09	Uhetox	Nupaha	Goroka	2015	Jul	Dry	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit-dove
289	N09	Uhetox	Nupaha	Goroka	2015	Jul	Dry	Slingshot	B	*Devioeca papuana*	Papuan Flycatcher
290	N09	Uhetox	Nupaha	Goroka	2015	Jul	Dry	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
291	N10	Uhetox	Nupaha	Goroka	2014	Jun	Dry	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit-dove
292	N10	Uhetox	Nupaha	Goroka	2014	Jun	Dry	Slingshot	B	*Pteridophora alberti*	King of Saxony Bird of Paradise
293	N10	Uhetox	Nupaha	Goroka	2014	Jun	Dry	Slingshot	B	*Rallicula forbesi*	Forbes's Forest Rail
294	N10	Uhetox	Nupaha	Goroka	2014	Jun	Dry	Slingshot	B	*Rhiphidura atra*	Black Fantail
295	N11	Uhetox	Nupaha	Goroka	2015	Apr	Wet	Slingshot	B	*Artamus maximus*	Great Woodswallow
296	N12	Notox	Nupaha	Goroka	2014	Jul	Dry	Slingshot	B	*Artamus maximus*	Great Woodswallow
297	N13	Notox	Nupaha	Goroka	2015	Oct	Dry	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit Dove
298	N13	Notox	Nupaha	Goroka	2015	Oct	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
299	N14	Geza	Nupaha	Goroka	2014	Aug	Dry	Slingshot	B	*Astrapia stephaniae*	Stephanie's Astrapia
300	N14	Geza	Nupaha	Goroka	2014	Sept	Dry	Slingshot	B	*Gerygone ruficollis*	Brown-breasted Gerygone
301	N14	Geza	Nupaha	Goroka	2014	Sept	Dry	Slingshot	B	*Melidectes belfordi*	Belford's Melidectes
302	N14	Geza	Nupaha	Goroka	2014	Sept	Dry	Slingshot	B	*Devioeca papuana*	Papuan Flycatcher
303	N14	Geza	Nupaha	Goroka	2014	Sept	Dry	Slingshot	B	*Peneothello sigillata*	White-winged robin
304	N15	Geza	Nupaha	Goroka	2015	Jan	Wet	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit Dove
305	N16	Uhetox	Nupaha	Goroka	2014	Jul	Dry	Bow and arrow	B	*Ptilinopus bellus*	Mountain Fruit-dove
306	N17	Uhetox	Nupaha	Goroka	2015	Apr	Wet	Slingshot	B	*Gerygone ruficollis*	Brown-breasted Gerygone
307	N17	Uhetox	Nupaha	Goroka	2014	Oct	Dry	Bow and arrow	B	*Ptilinopus bellus*	Mountain Fruit-dove
308	N18	Uhetox	Nupaha	Goroka	2015	Sept	Dry	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit-dove
309	N19	Uhetox	Nupaha	Goroka	2015	Sept	Dry	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit-dove
310	N20	Geza	Nupaha	Goroka	2013	May	Dry	Bow and arrow	B	*Ptilinopus bellus*	Mountain Fruit Dove
311	N21	Uhetox	Nupaha	Goroka	2013	May	Dry	Bow and arrow	B	*Ptilinopus sp*	Fruit Dove

312	N21	Uhetox	Nupaha	Goroka	2013	May	Dry	Bow and arrow	B	*Ptilinopus sp*	Fruit Dove
313	N21	Uhetox	Nupaha	Goroka	2013	May	Dry	Bow and arrow	B	*Melidectes belfordi*	Belford's Melidectes
314	N21	Uhetox	Nupaha	Goroka	2013	May	Dry	Bow and arrow	B	*Astrapia stephaniae*	Stephanie's Astrapia
315	N22	Notox	Nupaha	Goroka	2015	Sept	Dry	Slingshot	B	*Gerygone ruficollis*	Brown-breasted Gerygone
316	N22	Notox	Nupaha	Goroka	2015	Sept	Dry	Slingshot	B	*Melipotes fumigatus*	Common Smokey honey eater
317	N22	Notox	Nupaha	Goroka	2015	Sept	Dry	Slingshot	B	*Devioeca papuana*	Papuan Flycatcher
318	N23	Geza	Nupaha	Goroka	2014	Dec	Dry	Slingshot	B	*Ptilinopus sp*	Fruit-dove
319	N23	Geza	Nupaha	Goroka	2014	Dec	Dry	Slingshot	B	*Ptilinopus sp*	Fruit-dove
320	N23	Geza	Nupaha	Goroka	2014	Dec	Dry	Slingshot	B	*Ptilinopus sp*	Fruit-dove
321	N23	Geza	Nupaha	Goroka	2014	Dec	Dry	Slingshot	B	*Ptilinopus sp*	Fruit-dove
322	N24	Notox	Nupaha	Goroka	2014	Feb	Wet	Slingshot	B	*Melidectes torquatus*	Ornate Melidectes
323	N24	Notox	Nupaha	Goroka	2014	Feb	Wet	Slingshot	B	*Melidectes belfordi*	Belford's Melidectes
324	N25	Notox	Nupaha	Goroka	2015	Feb	Wet	Slingshot	B	*Phonymaaus keraudrenii*	Trumpet Manucode
325	N26	Notox	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Ptilinopus bellus*	Mountain Fruit-dove
326	N26	Notox	Nupaha	Goroka	2014	May	Dry	Slingshot	B	*Rhiphidura atra*	Black Fantail

Appendix 4.4 Species Traded by Hunters from Karimui and Lufa

Hunter ID	Clan	Site	Taxa	Qty	Common Name	Elevation (m.a.s.l)	Sold (Kina)	To?
K10	Sololaisibi	Karimui	B	1	Dwarf Cassowary [ba+d]	914	80	Kelau, Salt/Nomane, Chimbu
K15	Sa', Solita village	Karimui	B	3	Cassowary (adult and 2 chicks) [s]	1603		Chicks given to family in Baimuru (Gulf Province)
K22	Hait	Karimui	B	1	Southern Cassowary [ba+d]			intend to sell
K24	Waiyo	Karimui	B	1	Southern Cassowary [ba]		15	Karimui, Chimbu
K29	Naseyame	Karimui	B	1	Southern Cassowary [ba]			traded for live pig at Bomai, Chimbu
K4	Omo	Karimui	B	1	Dwarf Cassowary [s+ba]		5 to 6	plumes per bundle - sold at Karimui
K35	Naiyo 2	Karimui	B	1	Dwarf Cassowary [s]		n.a	Yuro, Karimui, Chimbu
K13	Kesipe	Karimui	M	4	Goodfellows Tree kangaroo [ba]	1079	20	Salt-Nomane (Kelau), Chimbu
K3	Kurupe	Karimui	B	1	Stephanie's Astrapia [ba]	1434	120	Mingende, Chimbu
K3	Kurupe	Karimui	B	1	King Bird of Paradise [ba]	2022	120	Mingende, Chimbu
K12	Kesipe	Karimui	B	1	Raggiana Bird of Paradise [ba+tb]	1052	15	Karimui, Chimbu
K1	Kurube-Osobiri	Karimui	B	2	Raggiana Bird of Paradise [bb+ba]	994-996	100	each sold for K100 to Salt-Nomane (Kelau), Chimbu
K10	Sololaisibi	Karimui	B	1	Raggiana Bird of Paradise [sl]	1206	n.a	Enga resident at Karimui
K13	Kesipe	Karimui	B	3	Raggiana Bird of Paradise [ba]	1005	45	Kundiawa, Chimbu
K29	Naseyame	Karimui	B	1	Raggiana Bird of Paradise [ba]			traded for live pig at Bomai, Chimbu
K3	Kurupe	Karimui	B	1	Raggiana Bird of Paradise [ba]	1067	120	Mingend, Chimbu
K30	Beiyer	Karimui	B	1	Raggiana Bird of Paradise [ba]		60	
K8	Palayo	Karimui	B	1	Raggiana Bird of Paradise [ba+d]	1501		Gembogl, Chimbu
K38	Yuro	Karimui	B	2	Blue Bird of Paradise [ba]		15	Each sold for K15. Fresh skins ~3 weeks old
K24	Waiyo	Karimui	M	1	Ground Cuscus [ba]		30	Salt-Nomane (Kelau), Chimbu
K11	Sololaisibi	Karimui	B	1	Eclectus Parrot [bb+ba]	967	10	Kerowagi, Chimbu
K30	Beiyer	Karimui	B	1	Parrot sp [ba]			
K29	Naseyame	Karimui	B	1	Vulturine Parrot [ba]			traded for live pig at Bomai, Chimbu
K3	Kurupe	Karimui	B	1	Vulturine Parrot [th]	1067	120	Mingend, Chimbu
K30	Beiyer	Karimui	B	1	Vulturine Parrot [ba]			traded for live pig at Bomai, Chimbu

ML10	Kusili	Lufa	B	1	Stephanie's Astrapia [ba]	2308		kept by hunter
ML4	Luka	Lufa	B	2	Stephanie's Astrapia [ba]	2308		kept by hunter
ML6	Luka	Lufa	B	3	Stephanie's Astrapia [ba]	2344	n.a	Two kept by hunter, one traded
ML7	Kusili	Lufa	B	2	Stephanie's Astrapia [ba]	~ 2324	n.a	sold one, kept another
ML8	Kaiawa	Lufa	B	3	Stephanie's Astrapia [ba]	2262	n.a	sold
ML9	Kaiawa	Lufa	B	5	Stephanie's Astrapia [ba]	2118	n.a	sold
M4	Kusiri	Lufa	B	6	Stephanie's Astrapia [ba]		20	Sold one to clan member and others given as gifts to relatives in village and Goroka (E.H.P).
ML4	Luka	Lufa	B	1	Black Sickelbill [ba]	2308	n.a	
ML8	Kaiawa	Lufa	B	1	Black Sickelbill [ba]	2262	n.a	sold
ML9	Kaiawa	Lufa	B	1	Black Sickelbill [ba]	~2260	n.a	sold
ML13	Kusili	Lufa	B	1	Superb Bird of Paradise [ba]	2032		kept by hunter
ML4	Luka	Lufa	B	1	Superb Bird of Paradise [ba]	2308	n.a	
ML6	Luka	Lufa	B	6	Superb Bird of Paradise [ba]	1751 - 2344		kept by hunter
M2	Alulaisa	Lufa	B	2	Superb Bird of Paradise [ba]		20	Mane, local person
ML1	Auta	Lufa	B	1	Raggiana Bird of Paradise [ba]	1454		kept by hunter
ML2	Auta	Lufa	B	1	Raggiana Bird of Paradise [ba]	~1478		kept by hunter
ML3	Halavi	Lufa	B	1	Raggiana Bird of Paradise [sl]	~1478		kept by hunter
ML4	Luka	Lufa	B	2	Raggiana Bird of Paradise [ba]	1502 - 1543	n.a	
ML5	Luka	Lufa	B	2	Raggiana Bird of Paradise [ba]	1543		kept by hunter
M1	Alulaisa	Lufa	B	1	Raggiana Bird of Paradise [ba]		35	Sold to relatives in Goroka
ML12	Kusili	Lufa	B	1	Blue Bird of Paradise [ba]	2115		kept by hunter
ML10	Kusili	Lufa	B	1	Lawes Parotia [ba]	1977		kept by hunter
ML11	Luka	Lufa	B	1	Lawes Parotia [ba]	1977		kept by hunter
ML10	Kusili	Lufa	B	1	King of Saxony Bird of Paradise [s]	2308		kept by hunter
ML6	Luka	Lufa	B	1	King of Saxony Bird of Paradise [ba]	2308		kept by hunter
ML9	Kaiawa	Lufa	B	4	King of Saxony Bird of Paradise [ba]	~ 2260	n.a	sold
M2	Alulaisa	Lufa	B	3	King of Saxony Bird of Paradise [ba]		15	Mane-Lufa, local person

Key -superscripts above common name of species indicates weapon used by hunter	Bird blind = bb, Bow and arrow = ba, Snare = s, Slingshot =sl, Dog = d, captured from tree hallow = th, special tree bark = tb, and = + plus sign

Appendix 5.1 Priority Species Assessment

#	Order	Family	Species	Common Name	Total importance score (max 3)	Risk group
1	COLUMBIFORMES	Columbidae	*Goura victoria*	Victoria Crowned Pigeon	2.321	1
2	PASSERIFORMES	Paradisaeidae	*Epimachus fastuosus*	Black Sicklebill	2.115	1
3	GALLIFORMES	Megapodiidae	*Talegalla jobiensis*	Red-legged Brush-Turkey	2.093	1
4	ACCIPITRIFORMES	Accipitridae	*Harpyopsis novaeguineae*	New Guinea Harpy Eagle (Papuan Eagle)	2.053	1
5	BUCEROTIFORMES	Bucerotidae	*Rhyticeros plicatus*	Blyth's Hornbill (Papuan Hornbill)	2.026	1
6	PASSERIFORMES	Paradisaeidae	*Paradisaea raggiana*	Raggiana Bird of Paradise	1.826	1
7	PASSERIFORMES	Paradisaeidae	*Lophorina superba*	Superb Bird of Paradise	1.788	1
8	PSITTACIFORMES	Psittrichasidae	*Psittrichas fulgidus*	Vulturine Parrot (Pesquet's Parrot)	1.777	1
9	PSITTACIFORMES	Cacatuidae	*Probosciger aterimus*	Palm Cockatoo	1.758	1
10	GALLIFORMES	Megapodiidae	*Aepypodius arfakianus*	Wattled brush-turkey	1.699	1
11	PASSERIFORMES	Paradisaeidae	*Parotia carolae*	Carola's Parotia	1.646	1
12	PASSERIFORMES	Paradisaeidae	*Paradisornis rudolphi*	Blue Bird of Paradise	1.637	1
13	COLUMBIFORMES	Columbidae	*Ducula chalconota*	Rufescent Imperial Pigeon	1.543	2
14	PASSERIFORMES	Paradisaeidae	*Astrapia stephaniae*	Stephanie's Astrapia	1.527	1
15	ANSERIFORMES	Anatidae	*Salvadorina waigiuensis*	Salvadori's teal	1.522	2
16	PASSERIFORMES	Paradisaeidae	*Pteridophora alberti*	King of Saxony Bird of Paradise	1.498	1
17	PASSERIFORMES	Paradisaeidae	*Paradisaea minor*	Lesser Bird of Paradise	1.450	1
18	PASSERIFORMES	Paradisaeidae	*Epimachus meyeri*	Brown Sicklebill	1.397	1
19	STRIGIFORMES	Strigidae	*Ninox rufa*	Rufous Owl	1.386	1
20	PSITTACIFORMES	Psittaculidae	*Charmosyna stellae*	Stella's Lorikeet	1.361	1
21	PSITTACIFORMES	Psittaculidae	*Eclectus roratus*	Eclectus Parrot	1.307	1
22	COLUMBIFORMES	Columbidae	*Otidiphaps nobilis*	Pheasant Pigeon	1.254	2
23	COLUMBIFORMES	Columbidae	*Ptilinopus ornatus*	Ornate Fruit-Dove	1.247	2
24	PASSERIFORMES	Paradisaeidae	*Astrapia mayeri*	Ribbon-tailed Astrapia	1.234	2
25	PSITTACIFORMES	Psittaculidae	*Psittaculirostris salvadorii*	Salvadori's Fig-parrot	1.228	2
26	COLUMBIFORMES	Columbidae	*Alopecoenas beccarii*	Bronz Ground-Dove	1.195	2
27	PASSERIFORMES	Paradisaeidae	*Drepanornis albertisi*	Black-billed Sicklebill	1.189	2
28	PASSERIFORMES	Pachycephalidae	*Pachycephala schlegelii*	Regent Whistler	1.188	2
29	GRUIFORMES	Rallidae	*Rallicula forbesi*	Forbe's Forest-Rail	1.181	2
30	PASSERIFORMES	Cnemophilidae	*Loboparadisea sericea*	Yellow-breasted Bird of Paradise	1.1701	2
31	CAPRIMULGIFORMES	Caprimulgidae	*Eurostopodus archboldi*	Archbold's Nightjar	1.156	2
32	PASSERIFORMES	Meliphagidae	*Caligavis obscura*	Obscure Honeyeater	1.155	2
33	COLUMBIFORMES	Columbidae	*Goura scheepmakeri*	Southern Crowned Pigeon	1.149	2
34	COLUMBIFORMES	Columbidae	*Ducula zoeae*	Zoe Imperial Pigeon	1.148	2
35	STRIGIFORMES	Tytonidae	*Tyto tenebricosa*	Sooty Owl	1.132	2

36	PASSERIFORMES	Paradisaeidae	*Parotia lawesii*	Lawes's Parotia	1.102	2
37	PSITTACIFORMES	Psittaculidae	*Psittacella brehmii*	Brehm's Tiger-Parrot	1.081	2
38	PASSERIFORMES	Ptilonorhynchidae	*Amblyornis macgregoriae*	Macgregor's Bowerbird	1.075	2
39	PASSERIFORMES	Cnemophilidae	*Cnemophilus loriae*	Loria's Bird-of-paradise	1.071	2
40	COLUMBIFORMES	Columbidae	*Ducula rufigaster*	Purple-tailed Imperial Pigeon	1.071	2
41	PASSERIFORMES	Meliphagidae	*Melidectes belfordi*	Belford's melidectes	1.059	2
42	PASSERIFORMES	Meliphagidae	*Melipotes fumigatus*	Common Smokey Honeyeater	1.057	2
43	PSITTACIFORMES	Psittaculidae	*Neopsittacus muschenbroekii*	Yellow-billed Lorikeet	1.057	2
44	PASSERIFORMES	Paramythiidae	*Paramythia montium*	Eastern Crested Berrypecker	1.056	2
45	PASSERIFORMES	Meliphagidae	*Caligavis subfrenata*	Black-throated Honeyeater	1.050	2
46	PSITTACIFORMES	Psittaculidae	*Neopsittacus pullicauda*	Orange-billed Lorikeet	1.049	2
47	PASSERIFORMES	Meliphagidae	*Ptiloprora guisei*	Rufous-Backed Honeyeater	1.045	2
48	PSITTACIFORMES	Psittaculidae	*Oreopsittacus arfaki*	Plum-faced lorikeet	1.045	2
49	PASSERIFORMES	Paradisaeidae	*Paradisaea guilielmi*	Emperor Bird of Paradise	1.001	2
50	ACCIPITRIFORMES	Accipitridae	*Accipiter melanochlamys*	Black-mantled Goshawk	0.990	2
51	PASSERIFORMES	Paradisaeidae	*Manucodia chalybatus*	Crinkle-collared Manucode	0.977	2
52	PASSERIFORMES	Sturnidae	*Mino anais*	Golden Myna	0.972	2
53	PASSERIFORMES	Paradisaeidae	*Diphyllodes magnificus*	Magnificent Bird of Paradise	0.964	2
54	ACCIPITRIFORMES	Accipitridae	*Circus approximans spilothorax (pied)*	Swamp Harrier	0.951	2
55	PASSERIFORMES	Paradisaeidae	*Cicinnurus regius*	King Bird of Paradise	0.950	2
56	COLUMBIFORMES	Columbidae	*Columba vitiensis*	White-throated Pigeon	0.949	2
57	PSITTACIFORMES	Psittaculidae	*Pseudeos fuscata*	Dusky Lory	0.947	1
58	PSITTACIFORMES	Psittaculidae	*Charmosyna pulchella*	Fairy Lorikeet	0.943	2
59	PASSERIFORMES	Petroicidae	*Devioeca papuana*	Papuan flycatcher	0.935	2
60	STRIGIFORMES	Tytonidae	*Tyto delicatula*	Australian Barn Owl	0.933	2
61	PASSERIFORMES	Cnemophilidae	*Cnemophilus macgregorii*	Crested Bird-of-paradise	0.933	2
62	PASSERIFORMES	Cinclosomatidae	*Ptilorrhoa castanonotus*	Chestnut-backed Jewel-Babbler	0.924	2
63	COLUMBIFORMES	Columbidae	*Ptilinopus rivoli*	White-Bibbed Fruit-Dove	0.920	2
64	PASSERIFORMES	Meliphagidae	*Melidectes rufocrissalis*	Yellow-browed Melidectes	0.916	2
65	PASSERIFORMES	Meliphagidae	*Melionyx princeps*	Long-bearded honeyeater	0.910	2
66	PASSERIFORMES	Oreoicidae	*Aleadryas rufinucha*	Rufous-naped Bellbird	0.910	2
67	CORACIIFORMES	Halcyonidae	*Syma megarhyncha*	Mountain Kingfisher	0.910	2
68	PSITTACIFORMES	Psittaculidae	*Psittacella madaraszi*	Madarasz's Tiger-Parrot	0.909	2
69	CAPRIMULGIFORMES	Aegothelidae	*Aegotheles albertisii*	Mountain Owlet-nightjar	0.909	2
70	PASSERIFORMES	Petroicidae	*Pachycephalopsis poliosoma*	White-Eyed Robin	0.908	2
71	PASSERIFORMES	Meliphagidae	*Melionyx fuscus*	Sooty Honeyeater	0.907	2
72	COLUMBIFORMES	Columbidae	*Reinwardtoena reinwardtii*	Great Cuckoo-Dove	0.906	2
73	PASSERIFORMES	Ifritidae	*Ifrita kowaldi*	Blue capped Ifrita	0.906	2
74	PASSERIFORMES	Cracticidae	*Peltops montanus*	Mountain peltops	0.906	2
75	ACCIPITRIFORMES	Accipitridae	*Henicopernis longicauda*	Long-tailed Buzzard	0.904	2

76	PASSERIFORMES	Petroicidae	*Peneothello bimaculatus*	White-Rumped Robin	0.903	2
77	PASSERIFORMES	Petroicidae	*Peneothello sigillata*	White-winged Robin	0.902	2
78	PASSERIFORMES	Meliphagidae	*Meliphaga orientalis*	Mountain Meliphaga	0.902	2
79	PASSERIFORMES	Paramythiidae	*Oreocharis arfaki*	Tit Berrypecker	0.901	2
80	PASSERIFORMES	Acanthizidae	*Pachycare flavogriseum*	Goldenface	0.900	2
81	PASSERIFORMES	Petroicidae	*Tregellasia leucops*	White-faced Robin	0.900	2
82	PASSERIFORMES	Acanthizidae	*Crateroscelis murina*	Rusty Mouse-Warbler	0.899	2
83	COLUMBIFORMES	Columbidae	*Gymnophaps albertisii*	Papuan Mountain-Pigeon	0.899	2
84	PASSERIFORMES	Monarchidae	*Symposiachrus axillaris*	Fantailed Monarch (Black Monarch)	0.899	2
85	PASSERIFORMES	Acanthizidae	*Sericornis perspicillatus*	Buff-faced Scrubwren	0.899	2
86	PASSERIFORMES	Melanocharitidae	*Melanocharis longicauda*	Mid-Mountain Berrypecker	0.899	2
87	PASSERIFORMES	Monarchidae	*Myiagra cyanoleuca*	Satin Flycatcher	0.899	2
88	PASSERIFORMES	Acanthizidae	*Sericornis papuensis*	Papuan Scrubwren	0.898	2
89	PASSERIFORMES	Rhiphiduridae	*Rhipidura brachyrhyncha*	Dimorphic fantail	0.898	2
90	PASSERIFORMES	Zosteropidae	*Zosterops novaeguineae*	New Guinea White-eye	0.897	2
91	PASSERIFORMES	Machaerirhynchidae	*Machaerirhynchus nigripectus*	Black-breasted Boatbill	0.897	2
92	PASSERIFORMES	Acanthizidae	*Sericornis arfakianus*	Grey-Green Scrubwren	0.897	2
93	PASSERIFORMES	Machaerirhynchidae	*Machaerirhynchus flaviventer*	Yellow-breasted Boatbill	0.896	2
94	PSITTACIFORMES	Psittaculidae	*Alisterus chloropterus*	Papuan King-Parrot	0.890	1
95	FALCONIFORMES	Falconidae	*Falco berigora*	Brown Falcon	0.889	2
96	ACCIPITRIFORMES	Accipitridae	*Haliastur indus*	Brahminy Kite	0.886	2
97	PASSERIFORMES	Sturnidae	*Mino dumontii*	Yellow-faced Myna	0.876	2
98	PSITTACIFORMES	Psittaculidae	*Trichoglossus haematodus*	Rainbow Lorikeet (or Coconut Lorikeet)	0.875	1
99	PASSERIFORMES	Cracticidae	*Cracticus quoyi*	Black Butcherbird	0.855	2
100	PSITTACIFORMES	Cacatuidae	*Cacatua galerita*	Sulphur-crested Cockatoo	0.850	2
101	ANSERIFORMES	Anatidae	*Anas superciliosa*	Pacific Black Duck	0.820	2
102	PASSERIFORMES	Pachycephalidae	*Pitohui dichrous*	Hooded Pitohui	0.813	2
103	PASSERIFORMES	Cinclosomatidae	*Ptilorrhoa caerulescens*	Blue Jewel-Babbler	0.809	2
104	PASSERIFORMES	Meliphagidae	*Melidectes torquatus*	Ornate Melidectes	0.806	2
105	ACCIPITRIFORMES	Accipitridae	*Accipiter hiogaster*	Variable Goshawk	0.806	2
106	PASSERIFORMES	Meliphagidae	*Ptiloprora perstriata*	Grey-Streaked Honeyeater	0.796	2
107	PASSERIFORMES	Meliphagidae	*Xanthotis polygrammus*	Spotted Honeyeater	0.794	2
108	CAPRIMULGIFORMES	Podargidae	*Podargus papuensis*	Papuan Frogmouth	0.794	2
109	PASSERIFORMES	Rhiphiduridae	*Rhipidura atra*	Black Fantail	0.791	2
110	CUCULIFORMES	Cuculidae	*Caliechthrus leucolophus*	White-crowned cuckoo	0.789	2
111	CORACIIFORMES	Halcyonidae	*Clytoceyx rex*	Shovel-billed kookaburra	0.762	2
112	COLUMBIFORMES	Columbidae	*Ptilinopus superbus*	Superb Fruit-Dove	0.730	2
113	PASSERIFORMES	Paradisaeidae	*Manucodia atra*	Glossy Mantled Manucode	0.727	2
114	PASSERIFORMES	Paradisaeidae	*Seleucidis melanoleuca*	Twelve-wired Bird of Paradise	0.722	2
115	PSITTACIFORMES	Psittaculidae	*Lorius hypoinochrous*	Purple-bellied lory	0.722	2

116	PASSERIFORMES	Paradisaeidae	*Phonygammus keraudrenii*	Trumpet Manucode	0.720	2
117	PSITTACIFORMES	Psittaculidae	*Geoffroyus geoffroyi*	Red-cheeked Parrot	0.711	2
118	COLUMBIFORMES	Columbidae	*Ptilinopus bellus*	Mountain Fruit Dove	0.705	2
119	COLUMBIFORMES	Columbidae	*Macropygia amboinensis*	Brown Cuckoo-Dove	0.703	2
120	COLUMBIFORMES	Columbidae	*Ptilinopus perlatus*	Pink-Spotted Fruit-Dove	0.701	2
121	CORACIIFORMES	Coraciidae	*Eurystomus orientalis*	Oriental Dollarbird	0.701	2
122	PASSERIFORMES	Paradisaeidae	*Astrapia splendidissima*	Splendid Astrapia	0.697	2
123	ACCIPITRIFORMES	Accipitridae	*Haliastur spenurus*	Whistling Kite	0.693	2
124	PSITTACIFORMES	Psittaculidae	*Charmosyna placentis*	Red-flanked Lorikeet	0.693	2
125	PSITTACIFORMES	Psittaculidae	*Psitteuteles goldiei*	Goldie's lorikeet	0.691	2
126	COLUMBIFORMES	Columbidae	*Macropygia nigrirostris*	Black-billed Cuckoo-Dove	0.679	2
127	PASSERIFORMES	Pittidae	*Pitta erythrogaster*	Red-bellied pitta	0.671	2
128	PASSERIFORMES	Artamidae	*Artamus maximus*	Great Woodswallow	0.668	2
129	CUCULIFORMES	Cuculidae	*Microdynamis parva*	Dwarf Koel	0.665	2
130	PASSERIFORMES	Oriolidae	*Oriolus szalayi*	Brown Oriole	0.663	2
131	PASSERIFORMES	Monarchidae	*Grallina bruijnii*	Torrent-lark*	0.659	2
132	PASSERIFORMES	Melampittidae	*Melampitta lugubris*	Lesser Melampitta	0.657	2
133	PASSERIFORMES	Meliphagidae	*Meliphaga mimikae*	Mottled Meliphaga	0.654	2
134	PASSERIFORMES	Meliphagidae	*Meliphaga albonotata*	Scrub Meliphaga	0.654	2
135	PASSERIFORMES	Petroicidae	*Peneothello cyanus*	Blue-Grey Robin	0.653	2
136	PASSERIFORMES	Meliphagidae	*Meliphaga montana*	White-eared Meliphaga	0.653	2
137	PSITTACIFORMES	Psittaculidae	*Charmosyna josefinae*	Josephine's Lorikeet	0.653	2
138	PASSERIFORMES	Pachycephalidae	*Pachycephala monacha*	Black-Headed Whistler	0.652	2
139	PASSERIFORMES	Meliphagidae	*Meliphaga gracilis*	Graceful Meliphaga	0.651	2
140	PASSERIFORMES	Melanocharitidae	*Melanocharis nigra*	Black Berrypecker	0.649	2
141	PASSERIFORMES	Meliphagidae	*Myzomela rosenbergii*	Red-collared myzomella	0.646	2
142	PSITTACIFORMES	Psittaculidae	*Lorius lory*	Black-capped Lory	0.624	2
143	PASSERIFORMES	Ptilonorhynchidae	*Ailuroedus melanotis*	Black-eared Catbird (or Spotted Catbird)	0.624	2
144	ACCIPITRIFORMES	Accipitridae	*Accipiter fasciatus*	Brown/Australian Goshawk	0.600	2
145	COLUMBIFORMES	Columbidae	*Ducula spilorrhoa*	Torresian Imperiel Pigeon	0.576	2
146	PASSERIFORMES	Meliphagidae	*Melilestes megarhynchus*	Long-billed Honeyeater	0.554	2
147	CORACIIFORMES	Halcyonidae	*Dacelo leachii*	Blue-winged kookaburra	0.523	2
148	CUCULIFORMES	Centropodidae	*Centropus phasianinus*	Pheasant Coucal	0.499	2
149	GRUIFORMES	Rallidae	*Gallirallus philippensis*	Buff banded rail	0.475	2
150	COLUMBIFORMES	Columbidae	*Ptilinopus magnificus*	Wompoo Fruit-Dove	0.454	2
151	CORACIIFORMES	Halcyonidae	*Dacelo gaudichaud*	Rufous-bellied kookaburra	0.450	2
152	PASSERIFORMES	Meliphagidae	*Philemon buceroides*	Helmeted Friarbird	0.448	2
153	COLUMBIFORMES	Columbidae	*Gallicolumba rufigula*	Cinnamon Ground-dove	0.447	2
154	CORACIIFORMES	Halcyonide	*Melidora macrorrhina*	Hook-billed Kingfisher	0.434	2
155	COLUMBIFORMES	Columbidae	*Ptilinopus pulchellus*	Beautiful Fruit-Dove	0.420	2

156	PASSERIFORMES	Pachycephalidae	*Pitohui kirhocephalus*	Variable Pitohui	0.420	2
157	CORACIIFORMES	Halcyonidae	*Tanysiptera galatea*	Common Paradise-Kingfisher	0.418	2
158	PASSERIFORMES	Meliphagidae	*Xanthotis flaviventer*	Tawny-Breasted Honeyeater	0.411	2
159	PASSERIFORMES	Pachycephalidae	*Colluricincla megarhyncha*	Little Shrike Thrush	0.408	2
160	PASSERIFORMES	Meliphagidae	*Meliphaga aruensis*	Puff-Backed Meliphaga	0.405	2
161	PASSERIFORMES	Meliphagidae	*Meliphaga analoga*	Mimic Meliphaga	0.403	2
162	PASSERIFORMES	Estrildidae	*Erythrura trichroa*	Blue-Faced Parrotfinch	0.401	2
163	PASSERIFORMES	Rhiphiduridae	*Rhipidura hyperythra*	White-bellied Thicket-Fantail	0.399	2
164	PSITTACIFORMES	Psittaculidae	*Micropsitta pusio*	Buff-faced Pygmy-parrot	0.398	2
165	PASSERIFORMES	Rhiphiduridae	*Rhipidura hyperythra*	Chestnut-Bellied fantail	0.397	2
166	PASSERIFORMES	Phylloscopidae	*Phylloscopus poliocephalus*	Island Leaf-Warbler	0.397	2

Appendix 6.1 Point Count Data Sheet for Birds Observed along Transects

Point Count Field Data Sheet

Province	Locality	Station/Transect	Date (dd/mm/yy)	Visit

First Name	Last Name	Initials used in data entry	Temp (°C)*	Cloud Cover (%)*

Point		Time				Species		Location				B	O

BO - Bird Observation Codes

FE-Feeding
PE-Perching
FL-Flying
CA-Calling
FL-Fledgings
PR-Preening
BW-Bill Wiping

*Please either measure or estimate temperature and cloud Cover

Species codes

BB-Blue BoP
BBR - Buff banded rail
BCD - Brown Cuckoo Dove
BK-Brahminy kite
BlK-Black Kite
BlS - Black Sickelbill BoP
BM - Belford's Melidectes
BrS - Brown Sickelbill BoP
CB-Crested Berrypecker
CSH- Common Smokey Honeyeater
DC - Dwarf Cassowary
DL - Dusky Lory
FF - Friendly Fantail
GF- Grey Wagtail
GG - Grey gerygone
GS- Glossy Swift
KB - King BoP
KS - King of Saxony BoP
MB-McGregor's Bowerbird
MMW- Mountain-mouse warbler
MTP-Madarasz's Tiger-parrot
OM - Ornate Melidectes
PF - Papuan Flower pecker
PL-Papuan Lorikeet
PP-Pheasant Pigeon
RM-Red-collard Myzomela
RW-Rufous-naped whistler

SA - Stephanie's Astrapia

SB-Superb BoP

SMF - Snow mountain Robin

TB - Tit Berrypecker

WSF - White shouldered Fairywren

OT- Other (please ID if you can)

WW - Willy Wagtail

Appendix 6.2 Species List of Point Count Surveys

Family	Species	Common Name	Mt Gahaviska	Hogave	Karimui	Gembogl	Range
Acanthizidae	*Acanthiza cinerea*	Grey gerygone (aka Grey thornbill)	2178-2658	2191-2224	1502-1520		1502-2658
Acanthizidae	*Crateroscelis nigrorufa*	Bicoloured mouse warbler		2102	1502-1533		1502-2102
Acanthizidae	*Crateroscelis robusta*	Mountain mouse warbler	2636-2723	2189			2189-2723
Acanthizidae	*Gerygone magnirostris*	Large-billed Gerygone			1520		1502
Acanthizidae	*Gerygone ruficollis*	Brown breasted Gerygone	2183-2206	2191			2183-2206
Acanthizidae	*Sericornis nouhuysi*	Large Scrubwren	2189		1511-1538		1511-2189
Acanthizidae	*Sericornis papuensis*	Papuan Sericornis (or Papaun Scrubwren)	2474-2636	2053-2224		2910	2053-2910
Acanthizidae	*Sericornis perspicillatus*	Buff-faced Scrubwren	2658	1859-2149			1859-2658
Acciptiridae	*Harpyopsis novaeguineae*	New Guinea ddHarpy Eagle		2224			2224
Anatidae	*Anas sp.*	Wildfowl	2636				2636
Apodidae	*Aerodramus hirundinacea*	Mountain Swiftlets	2485-2723				2485-2723
Apodidae	*Collocalia esculenta*	Glossy Swiftlet	2203-2723			2895	2203-2895
Campephagidae	*Coracina longicauda*	Hooded Cuckoo Shrike	2647-2682				2647-2682
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-shrike	2636				2636
Campephagidae	*Edolisoma montanum*	Black-bellied Cicadabird (previously known as black-bellied cuckoo-shrike)	2390-2485	1864-2107			1864-2485
Casuaridae	*Casuarius bennetti*	Dwarf Cassowary	2551				2551
Cinclosomatidae	*Ptilorrhoa castanonota*	Chestnut-Backed Jewel-Babbler			1522-1538		1522-1538
Cinclosomatidae	*Ptilorrhoa leucostica*	Spotted Jewel Babbler		2107			2107

Columbidae	*Ducula chalconota*	Rufescent Imperial Pigeon			1502		1502
Columbidae	*Ducula pinon*	Pinon's Imperial Pigeon			1502-1533		1502-1533
Columbidae	*Gymnophaps albertisii*	Papuan Mountain-Pigeon		1856-2110	1511-1522		1511-2110
Columbidae	*Macropygia amboinensis*	Brown cuckoo dove	2189-2658	2067	1502-1511		1502-2658
Columbidae	*Macropygia nigrirostris*	Black-billed Cuckoo-Dove		1856-2224	1522		1522-2224
Columbidae	*Otidiphaps nobilis*	Pheasant Pigeon/Magnif icent Ground Pigeon			1502-1538		1502-1538
Columbidae	*Ptilinopus bellus*	Mountain Fruit Dove (also known as white breasted fruit dove)	2203-2455	2102-2131	1538		1538-2455
Columbidae	*Ptilinopus coronulatus*	Coroneted fruit dove		1884			1884
Columbidae	*Ptillnopus pulchellus*	Beautiful Fruit Dove (also known as rose-fronted pigeon or crimson-capped fruit dove			1502-1538		1502-1538
Columbidae	*Reinwardtoena reinwardti*	Great Cuckoo-Dove		2189-2235			2189-2235
Cracticidae	*Peltops montanus*	Mountain Peltops	2390-2445				2390-2445
Cuculidae	*Cacomantis flabelliformis*	Fan-tailed Cuckoo	2160-2455		1533		1533-2455
Cuculidae	*Heteroscenes pallidus*	Pallid Cuckoo/Cacomantis/Cuculus pallids			1511-1533		1511-1533
Estrildidae	*Erythrura trichroa*	Blue-faced parrot finch	2189-2507	2107	1511		1511-2507
Falconidae	*Falco berigora*	Brown Falcon		1855-1884			1855-1884
Machaerirhynchidae	*Machaerirhynchus flaviventer*	Yellow-breasted boatbill			1533		1533
Machaerirhynchidae	*Machaerirhynchus nigripectus*	Black breasted Boatbill		2189			2189
Maluridae	*Malurus aboscapulatus*	White Shouldered fairywren	2160	1859-2131			1859-2160

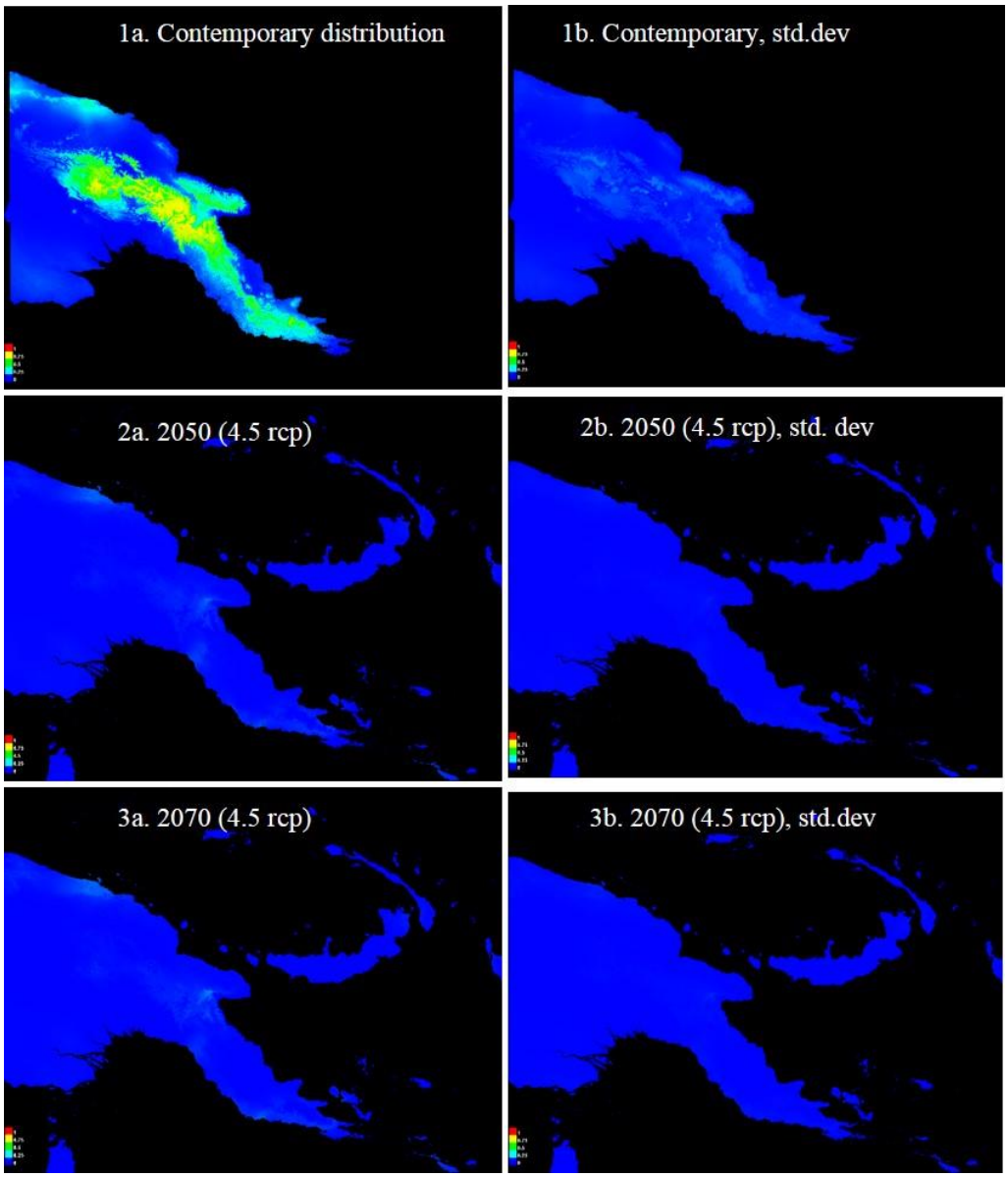
Megapodidae	*Aepypodius arfakianus*	Wattled Brush turkey	2459				2459
Melanochariti dae	*Melanochar is ongicauda*	Mid-mountain berrypecker	2206	1855-2117			1855-2206
Melanochariti dae	*Melanochar is versteri*	Fan-tailed Berrypecker	2230				2230
Melanochariti dae	*Toxorhamph us poliopterus*	Slaty-headed Longbill/Slaty-chinned Longbill	2647-2682	2149-2224			2149-2682
Meliphagidae	*Glycichaera fallax*	Green-backed Honeyeater(?)		1856			1856
Meliphagidae	*Melidectes torquatus*	Ornate Melidectes	2160-2189	1864-2163			1864-2189
Meliphagidae	*Melidectes belfordi*	Belford's Melidectes	2160-2641	1864-2235			1864-2641
Meliphagidae	*Meliphaga orientalis*	Mountain Meliphaga		2224			2224
Meliphagidae	*Melipotes fumigatus*	Common Smokey honey eater	2160-2682	2089-2235	1522	2895-2909	1522-2909
Meliphagidae	*Myzomela cruentata*	Red myzomella		1856-1884			1856-1884
Meliphagidae	*Myzomela nigrita*	Papuan black Myzomela	2474				2474
Meliphagidae	*Myzomela rosenbergii*	Red collared myzomela	2183-2485	2149-2210		2859-2895	2149-2895
Meliphagidae	*Ptiloprora guisei*	Rufous - backed Honeyeater		2107-2210		2859-2909	2107-2909
Meliphagidae	*Ptiloprora perstriata*	Grey-streaked Honeyeater or Black-backed Honeyeater	2682				2682
Meliphagidae	*Pycnopygius cinereus*	Marbled Honeyeater	2445-2474				2445-2474
Meliphagidae	*Xanthotis flaviventer*	Tawny-breasted Honeyeater		1855-2163			1855-2163
Motacillidae	*Motacilla cinerea*	Grey Wagtail	2178		1522		1522-2178
Nectariniidae	*Dicaeum geelvinkianu m*	Red-capped Flowerpecker		1855-2210			1855-2210
Oreoicidae	*Alreadryas rufinucha*	Rufous naped Bellbird (formerly rufous naped whistler)	2474-2507				2474-2507
Pachycephalid ae	*Colluricincl a megarhynch a*	Little Shrike Thrush	2203-2485				2203-2485

Pachycephalidae	*Pachycephala monacha*	Black-headed whistler	2203	2117			2117-2203
Pachycephalidae	*Pachycephala schlegelii*	Regent Whistler	2183-2682				2183-2682
Pachycephalidae	*Pachycephala hyperythra*	Rusty Whistler		1884-1859	1511-1520		1511-1859
Pachycephalidae	*Pitohui dichrous*	Hooded Pitohui		1884-2163			1884-2163
Paradisaeidae	*Astrapia stephaniae*	Stephanie's Astrapia		2178-2723		2859-3031	2178-3031
Paradisaeidae	*Epimachus fastosus*	Black Sicklebill	2474-2723	2503		2819	2503-2819
Paradisaeidae	*Epimachus meyeri*	Brown Sicklebill	2647-2723	2189		2923	2189-2923
Paradisaeidae	*Lophorina superba*	Superb Bird of paradise	2178-2390	1884-2235	1453-1538		1453-2390
Paradisaeidae	*Paradisea raggiana*	Raggiana Bird of Paradise			1194-1416		1194-1416
Paradisaeidae	*Paradisornis rudolphi*	Blue Bird of Paradise		1855-2163	1505-1533		1505-2163
Paradisaeidae	*Parotia lawesii*	Lawes parotia		2138	1522		1522-2138
Paradisaeidae	*Pteridophora alberti*	King of Saxony Bird of Paradise	2390-2507	2110			2110-2507
Paramythiidae	*Oreocharis arfaki*	Tit Berrypecker		1856-2117			1856-2117
Petroicidae	*Amalocichla sclateriana*	Lesser Ground-Robin			2053-2149		2053-2149
Petroicidae	*Devioeca papuana*	Papuan Flycatcher (Canary flycatcher)	2445				2445
Petroicidae	*Heteromyias armiti*	Black-capped Robin		2235			2235
Petroicidae	*Peneothello cyanus*	Blue-grey Robin	2390-2682	2053-2189		2909	2053-2909
Petroicidae	*Tregellasia leucops*	White-faced Robin	2507				2507
Phylloscopidae	*Phylloscopus poliocephalus*	Island Leaf warbler	2203-2206	2089	1522		1522-2206
Psittacidae	*Charmosyna pulchella*	Fairy Lorikeet (a.k.a little red Lorikeet)	2183				2183
Psittacidae	*Charmosyna stellae*	Stella's Lorikeet	2189-2682				2189-2682
Psittacidae	*Micropsitta bruijnii*	Red breasted pygmy parrot	2183				2183

Psittacidae	*Neopsittacus musschenbroekii*	Yellow-billed Lorikeet	2445-2636	2053-2235			2053-2636
Psittacidae	*Neopsittacus pullicauda pullicauda*	Orange-billed Lorikeet		2189-2210			2189-2210
Psittacidae	*Psittacella madaraszi*	Madarasz's Tiger-Parrot	2455				2455
Psittacidae	*Trichoglossus haematodus*	Rainbow lorikeet		1855-1884	1502		1502-1884
Psittaculidae	*Alisterus chloropterus*	Papuan King Parrot			1502-1533		1502-1533
Psittaculidae	*Charmosyna papou*	Papuan (flowered) Lorikeet					
Psittaculidae	*Charmosyna stellae*	Stella's Lorikeet/Papuan Lorikeet/Fairy Lory			1511-1538		1511-1538
Psittaculidae	*Geoffroyus simplex*	Blue-collared Parrot/Lilac-collared Parrot					
Psittaculidae	*Lorius lory*	Black-capped Lory/tricolored lory			1538		1538
Psittaculidae	*Neopsittacus pullicauda*	Orange-billed Lorikeet/Emerald Lorikeet				2839	2839
Psittaculidae	*Pseudeos fuscata*	Dusky Lory			1520-1538		1520-1538
Psittarichaslidae	*Psittrichas fulgidus*	New Guinea Vulturine Parrot/ Vulturine Parrot/Pesquet's			1476-1520		1476-1520
Ptilonorhynchidae	*Ailuroedus buccoides*	Black-eared Catbird			1502		1502
Ptilonorhynchidae	*Ailuroedus melanotis*	Black-eared Catbird/Spotted or Green Catbird			1511-1538		1511-1538
Ptilonorhynchidae	*Amblyornis macgregoriae*	Macgregor's Bowerbird			2053		2053
Rhagologidae	*Ragologus leucostigma*	Mottled Berryhunter			1859-2110		1859-2110
Rhiphiduridae	*Rhiphidura abolimbata*	Friendly Fantail	2390-2647	2067-2224	1502		1502-2647
Rhiphiduridae	*Rhiphidura atra*	Black fantail	2203-2682	1855-2110			1855-2682
Rhiphiduridae	*Rhiphidura leucothorax*	White-bellied Thicket-Fantail			1511-1538		1511-1538

Rhipiduridae	*Rhiphidura brachyrhyncha*	Dimorphic fantail					
Sturnidae	*Aplonis mystacea*	Yellow-eyed Starling					
Zosteropidae	*Zosterops atrifrons*	Black-fronted White-eye/Z.minor		1855-2163		2859	1855-2859

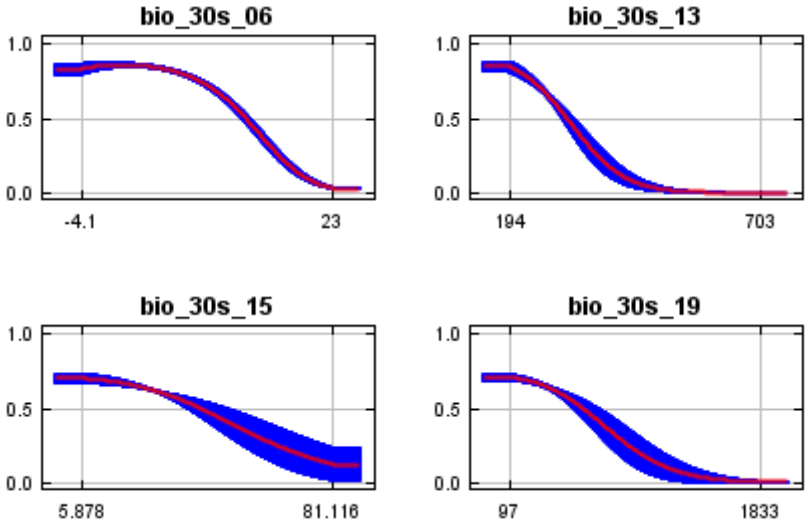
Appendix 6.3 (a) Contemporary and projected scenarios for 2050 and 2070



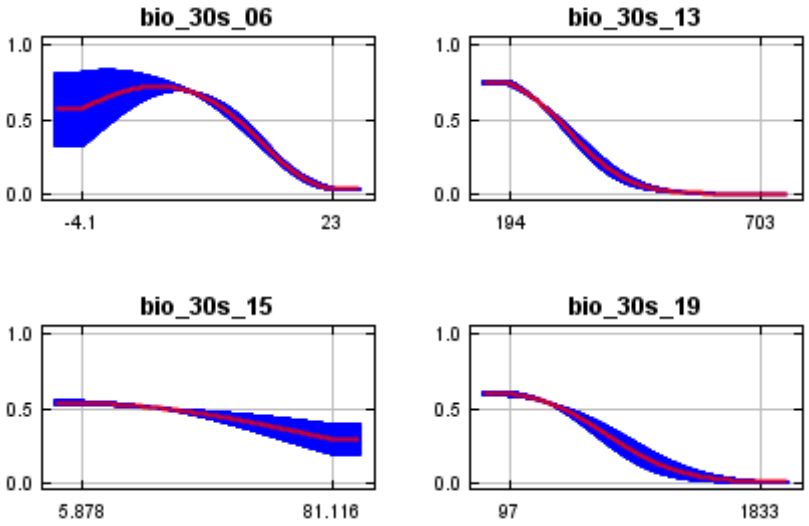
The red and orange bar on the bottom left corner indicates suitable habitats for the Blue Bird of Paradise. By 2050 habitat suitability areas for the Blue Bird of Paradise will have reduced by 100 percent.

6.3 (b) Response curves

Maxent predictions are determined by each of the environmental variables. The curves depict the mean responses of the 16 replicate Maxent runs (red) and the mean +/- one standard deviation (blue, two shades for categorical variables)



The curves below represent a model using only the corresponding variable. The plots show a predicted suitability from the selected variable and on variable dependencies as a result of correlations between the selected variable and others.



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