



Executive Summary

Source: Rapid Biological Assessments of the Nakanai Mountains and the upper Strickland Basin: surveying the biodiversity of Papua New Guinea's sublime karst environments: 16

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INTRODUCTION

The independent state of Papua New Guinea (PNG) occupies the eastern half of New Guinea, the world's largest and highest tropical island and one of the last major tropical wilderness areas on earth. Although New Guinea and nearby smaller islands remain substantially covered with tropical forest and are known to have an immensely rich and highly endemic flora and fauna, much of this biota remains undocumented, as evidenced by spectacular discoveries of both plants and animals during Conservation International's recent RAP biodiversity surveys on the island (e.g. Richards 2007).

Although information about patterns of diversity and endemism of plants and animals is largely lacking for New Guinea, these data are vital to inform and support conservation decisions in the face of increased threats to forests and their biodiversity from logging and subsistence gardening (e.g. Shearman et al. 2009), and from new challenges arising from the rapid development of resource projects including the massive Liquefied Natural Gas project. To address this lack of information CI's RAP program committed to undertake a series of biodiversity surveys in poorly-documented areas of PNG with the aims of 1) detecting and describing new and poorly-known species of plants and animals, 2) assessing threats to ecosystems upon which local communities depend, and 3) encouraging conservation through sustainable use of these ecosystems and their constituent species. These data are being made available to government agencies and non-governmental organizations (NGOs) operating within PNG to support their efforts to protect the country's unique biodiversity and ecosystems.

SCIENTIFIC PRIORITIZATION AND SITE SELECTION

To incorporate a more rigorous scientific approach to the selection of biodiversity survey sites in Papua New Guinea and to identify the largest gaps in existing biodiversity survey data, the RAP team formed a partnership with the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) to conduct a survey gap analysis using the .NET Survey Gap Analysis tool.

On 19th September 2008, a workshop at the Conservation International Asia-Pacific Field Division Headquarters in Atherton, Australia, considered the results of the survey gap analysis and selected three primary sites for RAP biodiversity surveys in Papua New Guinea to be conducted during 2009-2010. Workshop participants used the gap analysis results in conjunction with expert knowledge to identify RAP sites that might have the most positive impact on existing or proposed conservation activities in Papua New Guinea. They also considered the impacts of logistical and social issues on the likely success of RAP surveys at proposed sites. Two of these sites, the Nakanai Mountains and Muller Range, were surveyed during 2009. The 2010 survey was postponed. One additional site in the upper Strickland Basin that was surveyed during 2008 is also covered in this report.

PRIMARY OBJECTIVES

The primary objective of these RAP surveys was to document the plant, invertebrate, herpetofauna, bird and mammal diversity of poorly-known regions in need of biodiversity data in order to inform conservation and management decisions. Information gathered will be used to make recommendations about the conservation significance of, and management options for, this biodiversity. Survey sites were selected to provide the maximum elevational (and thereby habitat) diversity possible.

Specific aims of all three surveys reported here were to:

- Document the diversity and conservation significance of selected plant and animal groups at the maximum range of elevations accessible.
- Evaluate threats to biodiversity and ecosystems relevant to local communities in each region and recommend strategies for their mitigation.
- Provide on-site training in biodiversity inventory techniques for PNG scientists and for staff from DEC and local government agencies.
- Make RAP data available for decision-makers at all levels of Government, to local communities, and to NGO's and the general public.
- Promote the biodiversity values of these regions as an integral component of the ecosystems on which local people rely, and to promote the recognition of the Nakanai Mountains and Muller Range as areas worthy of World Heritage status.

BRIEF OVERVIEW OF SURVEY SITES

This report summarises the results of three RAP surveys conducted in 1) the Nakanai Mountains, 2) Kai-ingri/Wanakipa and 3) the Muller Range. The Nakanai Mountains are located on the island of New Britain, while Kai-ingri/Wanakipa and the Muller Range are located in the upper

Strickland Basin of central-western mainland PNG. The three survey sites were located partially (Kai-ingri/Wanakipa) or substantially (Nakanai Mountains and Muller Range) on limestone karst topography. Karst topography forms when limestone is dissolved by water, forming caves, underground channels and rivers, and sometimes spectacular limestone pillars on the surface. Erosion of the limestone from beneath can result in the collapse of the ground surface, forming a sinkhole (also called a doline). While the karst environments of New Guinea occur in some of the wettest regions on earth, they are also typified by a remarkable absence of surface water. Rainfall drains quickly through the limestone substrate to fuel underwater reservoirs and raging rivers in vast underground cave networks. This lack of surface water has major implications for the fauna and flora that live on the surface and some plants (and possibly animals) found in these habitats are endemic to karst environments.

Place names (and spellings) for villages and camp sites that are not included on official gazetteers and maps were obtained from local community members.

Kai-ingri and Wanakipa 2008

The 2008 RAP survey focused on two discrete sites. The first, Kai-ingri, was located in high-montane (>3,000 m) habitats on the Kaijende Highlands near Porgera in Enga Province. The general area has been described in detail in Richards (2007) and the visit to this site in 2008 aimed to collect additional data about poorly-known species in order to further support efforts to have this region gazetted as a conservation area.

The second site was centred on the village of Wanakipa in Southern Highlands Province. There the RAP team worked with the Hewa people who are involved with the Papuan Forest Stewards initiative, a program they developed in collaboration with William Thomas of Montclair State University to assist the Hewa to preserve their bio-cultural heritage. The team's aim was not only to document the biodiversity of this poorly-known area, but also to learn more about the local plants and animals by accessing the Hewa's extensive traditional ecological knowledge. Details of the 2008 RAP sites and schedules are presented in Tables 1 and 2.

Table 1. Survey schedule and major sites for upper Strickland Basin 2008-2009 RAP surveys.

Camp	Coordinates	altitude (m)	Province	Dates
Kai-ingri Camp	05°34.442S, 143°02.896E	3,315	Enga	5-10 July 2008
Tualapa Camp	05°17.003S, 142°29.849E	1,115	Southern Highlands	11-26 July 2008
Umge (Fly Camp)	05°18.245S, 142°30.704E	1,438	Southern Highlands	11-26 July 2008
Gugusu (Camp 1)	05°43.751S, 142°15.797E	515	Western	4-10 Sept 2009
Sawetau (Camp 2)	05°39.397S, 142°18.277E	1,587*	Western	11-17 Sept 2009
Apalu Reke (Camp 3)	05°29.174S, 142°18.117E	2,875	Southern Highlands	18-25 Sept 2009

*Elevations accessed from Sawetau ranged from 1,300-2,000 m asl.

Nakanai Mountains 2009

New Britain's Nakanai Mountains form a rugged, rainforest-covered spine along the central-eastern interior of the island. Extending from sea level to 2185 m at the highest point, the mountains are a predominantly karst landscape of exceptional natural beauty and geological interest. Some of the world's largest underground rivers flow through massive cave systems here, many emerging from caves as beautiful waterfalls that fuel torrential white water rivers in spectacular gorges, and in some places plunging directly into the ocean.

Despite a long history of cave exploration in the Nakanai Mountains (Gill 1988, Audra et al. 2001) the biodiversity of these remote and inaccessible rainforest-covered mountains remains poorly documented. Coninck (2001) presented a useful summary of hypogean (cave-dwelling) fauna known from New Britain but these results likely only scratch the surface of the true diversity of cave-dwelling fauna on the island. For surface-dwelling fauna the most significant recent biological expedition to the region was a biodiversity survey organized by the University of Wisconsin in 1999 that ascended to about 1,600 m elevation on the northern slopes of the range in West New Britain Province (Anthony et al. 2001). That expedition discovered a number of new animal species, providing a tantalizing hint of the undiscovered biodiversity of the region.

The spectacular cave systems and natural beauty of the Nakanai Mountains also prompted Papua New Guinea's Department of Environment and Conservation and other interested parties to prepare a nomination of the Nakanai Mountains for inclusion on the World Heritage Tentative List. Since 2006 this spectacular range has been on the Tentative List, along with the Muller Range and the Hindenburg Wall, in a submission titled 'The Sublime Karsts of Papua

New Guinea.' The World Heritage nomination process continues today and we hope that our documentation of a treasure-trove of previously unknown and unique biological diversity in the Nakanai Mountains will provide impetus to this important initiative.

The 2009 Nakanai RAP survey conducted surveys at 3 major sites: Lamas (200 m), Vouvou (859 m) and Tompoi near the top of the Galowe Plateau (1,500-1,700 m). Details of the Nakanai Mountains RAP sites and schedule are presented in Table 3. Because botanical collections were not made during the 2009 Nakanai Mountains expedition, a brief overview of vegetation formations at the three RAP sites is presented here based on identifications kindly provided by Dr W. Takeuchi (see Takeuchi, Chapter 9, this volume for explanation of forest types) from photographs taken in the field.

Vegetation formations at three sites in the Nakanai Mountains

Lamas Camp (Camp 1; 200 m). Forest type Hm in part

Lamas Camp was in a lowland mosaic of alluvial and hill communities. The drainage channels are primarily *Pometia*-dominant, with or without successional taxa such as *Cerbera*, *Endospermum*, *Macaranga*, *Mallotus*, *Osmoxylon*, *Parasponia*, and urticates (*Dendrocnide*, *Leucosyke*, *Pipturus*). On well-drained slopes with mature growth, the woody flora is mainly represented by *Archidendron*, *Calophyllum*, *Chisocheton ceramicus*, *Dysoxylum*, *Ficus* (numerous spp.), *Gmelina*, *Horsfieldia*, *Neuburgia corynocarpa*, *Paraserianthes*, *Semecarpus*, and *Sterculia*. Taxonomic compositions are intergrading with the Hm forest above 500 m (Vouvou Camp), with most taxa being shared between the sites but at differing frequencies. Understories were depauperate, with scattered aroids, *Bolbitis*, *Pteris*, *Sphaerostephanos*, and thelypterids.

Vouvou Camp (Camp 2; 859 m). Forest type Hm.

The forest at Camp 2 is a typical Hm forest, the most widespread vegetation class in New Guinea and also presumably the most species-rich. The medium-crown canopies at this site were primarily composed of the families Burseraceae (*Canarium*), Elaeocarpaceae (*Elaeocarpus*, *Sloanea*), Lauraceae (*Cinnamomum*, *Cryptocarya*, *Litsea*), Meliaceae (*Aglaia*,

Table 3. Survey schedule and major sites for 2009 Nakanai Mountains RAP surveys. All sites are in East New Britain Province.

Camp	Coordinates	Altitude (m)	Dates
Palmal	05°38.244S, 151°30.180E	0	2, 25-26 April 2009
Lamas (Camp 1)	05°36.853S, 151°24.483E	200	3-8 April 2009
Vouvou (Camp 2)	05°26.740S, 151°27.842E	859	10-18 April 2009
Tompoi (Camp 3)	05°20.623S, 151°18.875E	1,590	19-25 April 2009

Table 2. Minor sites mentioned in the text that were visited briefly by some team members during the 2008 RAP survey.

Camp	Province*	Coordinates	Altitude (m)
Suyan Village, Paiam Forest	Enga	05°29.496S, 143°08.288E	2,270
Mountain Lodge, Porgera Town	Enga	05°28.947S, 143°08.488E	2,185
Wanakipa Village (Lagaip River)	SHP	05°15.425S, 142°31.297E	807
Ate Weti	SHP	05°17.080S, 142°29.756E	1,075
Ate Pukhali	SHP	05°16.402S, 142°30.352E	845
Ate Tautwa	SHP	05°17.284S, 142°30.047E	1,135
Ate Kokopa	SHP	05°18.342S, 142°30.654E	1,422
Umge Fly Camp	SHP	05°18.245S, 142°30.704E	1,438

*SHP = Southern Highlands Province

Chisocheton, *Dysoxylum*), Myristicaceae (*Horsfieldia*, *Myristica*), Myrtaceae (*Syzygium*), Rosaceae (*Prunus*), Sapotaceae (*Pouteria*), and Ulmaceae (*Celtis*). *Elmerrillia tsiampaca*, *Platea excelsa*, *Galbulimima belgraveana*, *Gordonia amboinensis*, and *Weinmannia fraxinea*, can be locally dominant. Understories were represented mainly by terrestrial *Bambusa*, *Cyathea*, *Tectaria*, and thelypterid ferns and epiphytically by *Asplenium*, *Lindsaea*, and polypodies. Tree diversity was probably highest at or near the elevation of Vouvou Camp (850–900 m), but declines progressively above this.

Tompoi Camp (Camp 3; 1,500–1,700 m). Forest type L

The montane forest at Camp 3 is an L-class formation whose normal structure has probably been disrupted by recent El Niño events. Bryophyte, fern, and epiphytic loads are less than normal for this type of vegetation, presumably due to the past disturbances. Dense tangles of *Nastus productus* are especially common on higher ridges.

In mature-growth stands the taller trees include *Ascarina*, *Astronidium*, *Caldcluvia celebica*, *Daphniphyllum gracile*, *Metrosideros salomonensis*, *Nothofagus*, *Sphenostemon papuanus*, *Weinmannia fraxinea*, and *Xanthomyrtus*. The substage is mostly *Elaeocarpus culminicola*, *Eurya*, *Trimenia weinmannifolia*, and *Zygogynum*. Understory diversity is generally low.

Muller Range 2009

Straddling Western and Southern Highlands Provinces of central-western mainland PNG, the Muller Range is a largely uninhabited, forest-covered massif that extends from near sea-level to over 3,500 m in the upper Strickland catchment. Like the Nakanai Mountains, the karst cave systems of the Muller Range have been the subject of intensive speleological exploration (James and Dyson 1980); efforts that have far outstripped biological exploration. Indeed the Muller Range was identified by the CSIRO/CI gap modeling process as a high priority for exploration to fill a major gap in biological knowledge for Papua New Guinea.

The Muller Range is included in the same World Heritage nomination process as the Nakanai Mountains ('The Sublime Karsts of Papua New Guinea'), and has been on the World Heritage Tentative List since 2006. The aim of the 2009 Muller Range RAP expedition was to collect information about the biodiversity of this spectacular mountainous region to support its declaration as a World Heritage Area. The team conducted surveys at three sites: Gugusu (515 m), Sawetau (1,300–2,000 m) and Apalu Reke (2,875 m). Details of the Muller Range RAP sites and schedule are presented in Table 1.

SUMMARY OF RAP RESULTS BY TAXONOMIC GROUP

(not all taxa were sampled on all surveys)

Vegetation

Upper Strickland Basin 2008–2009

Seven vegetation formations were identified and characterized in the upper Strickland Basin (Kai-ingri, Wanakipa and Muller Range combined) from seven sampling sites over an elevational range from 515–3,315 m. A taxonomic inventory of the flora (based on 901 collections and 276 additional sightings) documented the presence of species-rich habitats of exceptional floristic value. The checklist of species includes 757 species of tracheophytic plants (141 ferns and lycophytes, 11 gymnosperms, 72 monocots, and 533 dicots) from a total of 149 families and 427 genera. At least 15 species and one genus are new to science. The two Strickland surveys also yielded 29 other botanical records of major taxonomic and/or phytogeographic interest. The stewardship opportunities inherent in isolated environments provide numerous avenues for future conservation action.

Ants

Nakanai Mountains 2009

Leaf-litter sifting and hand-collecting produced 140 species of ants, of which approximately 40 appear to be undescribed; nine of these have so far been confirmed as new to science. Species richness was similar at low and mid elevations, with 93 and 92 species respectively. Species richness at high elevation was considerably lower with 22 species documented, of which ten were unique to the high-elevation site. Based on the high numbers of probably undescribed ant species encountered on this survey and the threats facing forest communities on Pacific Islands, steps should be taken to conserve the remaining intact tracts of rainforest at low, mid and high elevations in the Nakanai Mountains.

Muller Range 2009

A survey of ants at three sites in the Muller Range documented 237 species of ants belonging to 56 genera. At least 31 of these species (13%) are new to science. At the lowland site (500 m) 177 species were collected, of which 19 (11%) are undescribed species; at mid-elevation (1,600 m) 79 species were found, 16 (20%) of which are undescribed; at high elevation (2,875 m) two ant species were found, one of which is undescribed. Of the 237 species of ants encountered, only 21 (9%) were found at more than one site and hence local patchiness may be an important driver of diversity across these sites. In addition to discoveries of species new to science, collections from this survey extended the known elevational limit of ants in New Guinea from 2,600 m to 2,875 m. The close association of many ant species with ant-plant hosts, and apparent lack of any introduced ant species to this region contribute to a unique and diverse ant fauna in this largely intact rainforest

habitat, which we strongly recommend be prioritized for conservation.

Katydid

Nakanai Mountains 2009

Thirty-five species of katydids were collected during the RAP survey of the Nakanai Mountains, representing an increase of more than 130% in the known katydid fauna of New Britain island. An additional nine species of katydids were recorded at the Mt. Gahavisuka Regional Park (Eastern Highlands Province). At least 12 species recorded during the survey are new to science, and one represents a new genus. Although no specific conservation issues are known to affect the katydid fauna, habitat loss on New Britain is the primary threat to the biota of the island.

Muller Range 2009

Ninety species of katydids were collected at three different elevations in the Muller Range. At least 56, or 62% of species recorded during the survey, represent species new to science. The current survey confirms that the katydid fauna of Papua New Guinea is exceptionally rich, yet still virtually unknown. Although no specific conservation issues affecting the katydid fauna were identified during the survey, habitat loss on Papua New Guinea is the primary threat to the biota of New Guinea.

Odonates (Dragonflies and Damselflies)

Nakanai Mountains 2009

Thirty-two species of Odonata were collected at three different elevations between 200-1,700 m in the Nakanai Mountains and, to a minor extent, on the coastal fringe of Jacquinot Bay. Ten species are recorded from New Britain island for the first time. An undescribed species of *Pseudagrion* and a species or subspecies of *Tetrathemis* Brauer new to science were found. The *Pseudagrion* was known previously from New Britain and is currently being described. Eleven odonate taxa appear to be endemic to the island and some species were only found at particular elevations suggesting that more odonate species await discovery on the island. Due to the karst topography of the Nakanai Mountains, surface water that is essential for the development of odonate larvae is very scarce in the region. Natural forest cover is crucial for the survival of forest-dwelling habitat specialists, particularly those occupying the limited above-ground aquatic habitats that do exist.

Upper Strickland Basin 2008-2009

Thirty-six species of odonates were documented at three sites between 515 m and 2,875 m elevation in the Muller Range, of which 31 were found only at the lowland site (Gugusu; ~515 m). Diversity at this site was similar to that documented from the limited number of other sites studied in the central mountain range, and the dragonfly community conformed with a number of patterns previously observed at low elevations in the central ranges: (1) Higher level taxonomic

diversity (number of families) is high in proportion to the number of species; (2) the majority of species are dependent on running water; (3) most of the species associated with running water are endemic to New Guinea while most species occupying standing water habitats are more widespread and often also occur outside New Guinea. At least six species found at Gugusu were new to science reinforcing the view that many species of dragonflies still await discovery in New Guinea. The discovery of the presumed larvae of *Papuagrion* at Camp 3 constitutes the first record of larvae of this genus and its life-style (aboreal and semi-terrestrial) is unique among dragonflies and warrants more research.

Eighteen species were also documented around Tualapa Camp during the 2008 RAP survey near Wanakipa Village in the upper Strickland River Basin at elevations between 845-1,422 m. These included one species new to science and one species classified as Data Deficient by the IUCN (*Hylaeargia magnifica*).

Spiders

Kai-ingri/Wanakipa 2008

Jumping spiders (family Salticidae) were sampled from four areas in Papua New Guinea, most intensely at Wanakipa (600-1,400 m elevation, Southern Highlands Province), but also near Porgera (2,300-3,300 m, Enga Province), Mt. Gahavisuka (2,200-2,500 m, Eastern Highlands Province), and Varirata National Park (750 m, Central Province) to assess their diversity and endemism. A conservative estimate of the total number of species found is 128, including perhaps as many as 50 undescribed species and 12 new genera. One particular salticid group, *Cocalodes*, was a special target of the 2008 PNG RAP survey, because it is endemic to the New Guinea region and may occupy a key position in the evolutionary tree of salticids - like the "platypus of salticids." The expedition succeeded in collecting *Cocalodes* (and its close relative *Allococalodes*), and using this fresh material will be able to determine precisely its position in the evolutionary tree. However most surprising was the discovery of three new genera related to *Cocalodes*, each strikingly different from the others in their body form and ecology. Significantly, these genera and species were not merely new; they are evolutionarily quite distinct from previously known species.

Nakanai Mountains 2009

Spider diversity was documented at three sites (Lamas: 200 m, Vouvou: ~900 m and Tompoi: 1,600 m) in the Nakanai Mountains. Sampling techniques included beating vegetation to dislodge spiders and nocturnal visual searches, and together they produced over 100 species. Lamas was the richest site with over 80 species, and Vouvou had over 50 species. Tompoi had the lowest diversity but was sampled less intensively than the other two sites so data from there are not comparable. Given the current knowledge of New Britain's spider fauna and known levels of endemism, over 50% of the spider species are likely to be new to science, i.e. 50+ species. This high diversity and the large number

of species new to science, some of which are likely to be endemic to the Nakanai Mountains, confirm the significance of World Heritage nomination for this area as an important step in the conservation of New Britain's rich but poorly-known fauna.

Muller Range 2009

A survey of spider fauna conducted at two elevations (~500 m and 1,600 m) in the Muller Range documented well over 100 species. More than 70 species were documented at the 500 m site, while somewhat over 30 species were found at the 1,600 m site. Overlap between sites was less than 10%. The genus *Styposis* was recorded (at Gugusu; 515 m) for the first time in Asia/Australasia, and a putatively new genus of the subfamily Hadrotarsinae was found. A species of the subsocial genus *Anelosimus* that is new to science was found in Porgera township, Enga Province – the first time a subsocial *Anelosimus* species has been documented in Australasia. Given current knowledge of the Papuan spider fauna and levels of endemism, over 50% of the spider species are likely to be new to science, i.e. 50+ species. The large number of taxonomic novelties and the likelihood of local endemism, argues for conservation efforts to protect the poorly-known biota of the Muller Range. Declaration of this region as a World Heritage Area will help to protect this unique biodiversity.

Herpetofauna

Upper Strickland Basin 2008-2009

A short survey in the Wanakipa area of the Strickland River Basin in 2008 documented 21 species of herpetofauna including 17 species of frogs, three of which appear to be new to science, and four lizards. In 2009 a total of 61 species of herpetofauna (49 frogs and 12 reptiles) were documented across a 2,300 m altitudinal gradient in the Muller Range of Western and Southern Highlands Provinces. At least 25 species of frogs (51%) are undescribed and 14 of these were discovered for the first time during this survey. Herpetofaunal diversity decreased with increasing elevation, with 32 species at the lowland site (500 m), 23 species at the mid-elevation site (1,600–2,000 m), and only six species at the montane site (2,875 m). However the proportion of new frog species at each elevation was remarkably consistent, with approximately half of the species collected at each site being undescribed. The poorly-known treefrog *Litoria dorsivena* (DD; IUCN) was found during both surveys and these new records indicate that the species' IUCN Red-list status should be adjusted to Least Concern.

Nakanai Mountains

A total of 39 species (23 frogs and 16 reptiles) were documented across a 1,500 m altitudinal gradient. Four species of frogs are new to science and of the 16 described frog species assessed by IUCN eight (50%) are classified as Data Deficient, and a further two (12.5%) are listed as Vulnerable on the basis of their small or fragmented distributions

and threats from habitat conversion. The highest elevation site (Tompoi; 1,500–1,700 m) had the largest proportion of undescribed frog species of all sites, with three of the eight species (37.5%) found there being new to science. The Nakanai Mountains represent a significant refuge for a large number of new, poorly known and vulnerable frog species. Their recognition as a World Heritage Area would be a critical first step in ensuring the long-term survival of this unique frog assemblage.

Birds

Kai-ingri 2008

We compared records of birds surveyed from a high elevation camp in the Kaijende Highlands in 2008 with a similar dataset collected in 2005. In both surveys most species had been recorded within four days of effort, but apparently local patchiness of species distribution led to single-site surveys missing common species. In order to fully survey the impoverished avifauna at 3,200 meters elevation it may be more productive to move camp after four days of effort and work at no fewer than three separate camps, which would give access to the entire avifauna. Earlier field work underestimated the high-elevation fauna, which we now estimate to be 60 resident species at 3,200 m. This higher count may, in part, be a product of upslope retreat of montane species in the face of ongoing climate change. We document seven species on the Kaijende Plateau that are substantially above their known elevational limits elsewhere.

Nakanai Mountains 2009

The 2009 Nakanai Mountains RAP survey was conducted at three sites along an elevational gradient between 200 m and 1,590 m. Sixty-four species of birds representing 27 families were documented. Seven are species endemic to New Britain. Species richness declined monotonically with elevation. Notable records include *Accipiter luteoschistaceus*, *Henicophas foersteri*, *Todirhamphus albonotatus*, and *Megalurulus rubiginosus*.

Muller Range 2009

One hundred and thirty-three species were recorded at three camps between 500 m and 2,900 m elevation in the Muller Range. A total of 303 individual birds were mist-netted. Interesting distributional records for the Muller Range include Archbold's Robin (*Eurostopodus archboldi*), Green-backed Robin (*Pachycephalopsis hattamensis*), Crested Satinbird, Yellow-breasted Satinbird, and Ribbon-tailed Astrapia (*Astrapia mayeri*). Notable for not being recorded in the Muller Range is the Blue Bird of Paradise, which reaches its western range boundary somewhere between the Muller Range and Tari Valley. This substantial upland area will merit additional ornithological field study in order to search for species such as Papuan Whipbird (*Androphobus viridis*), Greater Ground-Robin (*Amalocichla sclateriana*), and Sooty Whistler (*Pachycephala tenebrosa*).

Mammals

Kai-ingri 2008

Renewed mammal survey efforts in high elevation forests and subalpine habitats in the Kaijende Highlands, undertaken in July 2008, recorded 17 species of mammals (9 marsupials, 7 rodents, 1 bat) primarily on the basis of small mammal trapping, mistnetting, and examination of bones and teeth recovered from caves. At least two of these species, a bandicoot (*Microperoryctes*) and a pygmy possum (*Cercartetus*), are unnamed species, although these do not occur exclusively in the Kaijende Highlands, being known also from other mountain areas of New Guinea. Two species, the insectivorous bat *Nyctophilus microdon* and the moss mouse *Pseudohydromys fuscus*, represent new records for Enga Province, and the giant rat *Mallomys rothschildi* is newly recorded from the Kaijende Highlands. The capture of two individuals of *Nyctophilus microdon* in forest at 3,315 m extends the recorded elevational distribution of this bat by more than 1,000 m. This survey provided sufficient new information to re-examine the IUCN conservation status classification of two poorly known mammal species (*Nyctophilus microdon* and *Rattus giluwensis*, both previously listed as “Data Deficient”, now recommended as species to be classified as “Least Concern”), an important result for conservation prioritization and planning. The presence of the amphibious rat *Crossomys moncktoni*, previously recorded from the Kaijende Highlands only on the basis of informant interviews, is confirmed by a mandible from a cave deposit, probably accumulated via predation by the Sooty Owl, *Tyto tenebriosa*. Close inspection of mammal remains from a single cave accumulation revealed that at least 12 species of mammals, mostly nocturnal taxa weighing less than 500 grams, make up the diet of owls in the area, with the Pygmy ringtail *Pseudochirulus mayeri* being the most important prey species. This survey brings the total number of native mammal species known to occur in the Kaijende Highlands above 2,000 meters to 38, and in Enga Province to at least 41.

Wanakipa 2008

Specimens collected during a survey of mammal diversity and indigenous knowledge of mammals in Hewa country around Wanakipa Village documented the occurrence of 22 mammal species in the immediate area, including one monotreme, 6 marsupials, 7 rodents, and 8 bats. Two species of conservation concern, the Eastern Long-Beaked Echidna *Zaglossus bartoni* (IUCN Critically Endangered) and Goodfellow's Tree Kangaroo *Dendrolagus goodfellowi* (IUCN Endangered) were documented by trophy skulls and bones kept by Hewa hunters. Three mammals are apparently reported from Southern Highlands Province for the first time: the bent-wing bat *Miniopterus macrocneme*, the long-eared bat *Nyctophilus microtis*, and a rodent species in the *Rattus rattus* species complex. The presence of this last species, an invasive rodent trapped distant from an immediate village commensal context, provides an indication

of recent environmental change in the highlands of Papua New Guinea. Hewa informants convincingly communicated their familiarity with more than 20 additional mammal species, including those restricted to higher elevations than we visited during our survey, including one of special conservation concern, the tree kangaroo *Dendrolagus [dorianus] notatus* (IUCN Endangered). Hewa folk taxonomy suggests that three tree kangaroo species may occur in the region, one of which may be the Lowland Tree Kangaroo (*Dendrolagus spadix*) or even a currently undocumented population or unrecognized species. The mammal fauna of Wanakipa is similar in composition to better surveyed areas of similar elevation situated along the southern margin of the central cordillera in Southern Highlands Province, such as Mt. Sisa and Mt. Bosavi.

Nakanai Mountains 2009

The survey of mammals around three sites in the Nakanai Mountains of East New Britain produced records of 26 species, including ten species of terrestrial mammals (three marsupials and seven rodents), six pteropodid bats, and ten insectivorous bats. At least three (possibly four) of the rodents are undescribed species, two of them representing new genera, and at least one (possibly two) of these species is an entirely new discovery, with no previous record. One of the captured bats is probably an undescribed species related to *Nyctimene albiventer*. Further study of the bats may reveal additional species of special interest, especially in the genus *Miniopterus*. The results of the Nakanai RAP survey fundamentally alter our perception of the mammal fauna of New Britain. Rather than having a depauperate subset of the New Guinean mammal fauna, New Britain has its own deeply endemic mammal fauna that includes at least two endemic genera of murine rodents as well as endemic species of at least four other murine genera. In addition, it also supports numerous distinctive species or subspecies of bats, many of them shared with New Ireland and/or the northern Solomon Islands. The mammal fauna of New Britain thus contains many mammalian taxa of global significance. Effective protection of the large tracts of pristine forests that exist in the Nakanai Mountains is of fundamental importance to the long-term conservation of these taxa.

Muller Range 2009 – Non-flying mammals

A survey of non-flying mammals around three sites in the biologically unexplored Muller Range of Western and Southern Highlands Provinces resulted in confirmed records of one monotreme, nine marsupials, 12 murid rodents, and the feral New Guinea Singing Dog. With the possible exception of an unusual Long-footed Tree-mouse (*Lorentzimys* sp.), all of the non-flying mammal species recorded are previously known taxa. However, several of the recorded species are currently undescribed and may be restricted to a relatively small area in the headwaters of the Strickland and Kikori Rivers. Sightings and other evidence of tree kangaroo and a long-beaked echidna in the montane forests of the Muller Range

testify to very low hunting pressure, even along walking tracks that traverse the range. Human disturbance appears to be limited to annual visits to the subalpine zone to harvest fruit of a wild *Pandanus*, an activity which has only localised and short-term impacts on wildlife. The Muller Range thus preserves an essentially pristine altitudinal transect that spans hill forests, lower and upper montane forests, and diverse subalpine habitats. Although most of the mammals that inhabit these forests are probably quite widely distributed in the extensive catchments of the Strickland and Kikori Rivers, the intact nature of the forest ecosystems across such a broad elevational gradient is almost without parallel in the wider region. Long-term preservation of this spectacular series of interconnected ecosystems represents a conservation priority of the highest international importance.

Muller Range 2009 – Bats

A survey of the bat fauna at three altitudinally separated sites (c. 500, 1,600, 2,900 m) was undertaken in the remote Muller Range, which contains a largely undocumented and intact mammal fauna. Capture rates were relatively low, producing a total of 37 individuals of five species in two families. Most captures were of small Pteropodidae, with one capture of a hipposiderid bat. At least two of the captured pteropodid species are currently unnamed (in the genera *Nyctimene*, *Syconycteris*), though each is known from other localities in PNG. Genetic analysis was used to confirm the identity of the pteropodid *Paranyctimene raptor*. Recordings of bat echolocation calls using an AnaBat recorder documented 16 different call types, representing at least 12 species of insectivorous bats. Of these, four could be allocated a species name based on available information. Most bat call sequences were recorded at the edge of artificial clearings (helicopter pads) rather than on natural corridors along watercourses. The greatest diversity of insectivorous bats (13 call types, possibly nine species) was recorded at an elevation of 1,600 m, with seven call types/species at 500 m, and four call types from at least three species at 2,900 m. The richness at 2,900 m is a notable observation, since only two insectivorous bats have been captured at similarly high elevations elsewhere in New Guinea. The results highlight the general need for further collecting to help with taxonomic and distributional studies, and the particular need to acquire reference echolocation calls so that bats can be surveyed with greater confidence using acoustic recordings.

OVERALL SUMMARY AND GENERAL CONSERVATION RECOMMENDATIONS

The three surveys reported here have documented a remarkable diversity of plants and animals, including more than 300 species new to science and a large number of genera new to science. Many of these species that are new to science are likely to be endemic to the regions of their discovery and the

conservation implications of these results differ somewhat among sites.

At Kai-ingri the data collected provide further evidence for the conservation significance of these spectacular montane habitats and indicate that the area may be an excellent site for monitoring the long-term effects of climate change. Formalising a conservation area on the Kaijende Highlands remains critical if this unique environment is to be protected in the long term. Conservation International, the Porgera Joint Venture (PJV) and local communities are working together to achieve this goal.

At Wanakipa the Hewa people are actively involved in the Papuan Forest Stewards initiative. We anticipate that the 2008 RAP survey at Wanakipa will be the first of a series of similar surveys and hope that it will encourage the local Hewa people to continue their conservation activities, retain their traditional knowledge, and use that knowledge to educate more scientists and their own descendants about the biodiversity on their lands.

In the Nakanai Mountains and Muller Range the RAP team found an incredible diversity of plants and animals including hundreds of species new to science, and dozens of species classified as either Data Deficient or threatened by the IUCN. The team consistently recommended that these two areas be recognised as World Heritage Areas as the first step to ensuring the long-term survival of this unique biodiversity and the ecosystems upon which it and the local communities depend. We hope that these results will also be used to generate awareness and interest in the existing Klampun Wildlife Management Area in the Nakanai Mountains and in ongoing efforts to establish a broader protected area over upland forests of the Nakanai.

Management plans for the Nakanai Mountains and Muller Range should be formulated in close consultation with local communities. To be successful in the long term these plans need to build on traditional systems of environmental management, and recognise local communities' aspirations for development and wealth generation. Local communities must also ultimately take ownership of the long term management of these high-priority conservation areas.

A number of species-specific conservation recommendations pertinent to development of management plans for these two areas are presented in individual chapters, and the most broadly relevant of these are presented in the 'Report at a Glance' chapter. Several further general considerations that are relevant to the long-term conservation of PNG's sublime karst environments, taken (and modified) from Chapters 7 and 18, are reiterated below. However these recommendations, and all of those presented in this report, must be considered in the context of traditional custodianship systems that underlie existing environmental management practices, and in the knowledge that conservation efforts will fail unless appropriate community livelihood programs are an integral component of the management plan.

Nakanai Mountains

Conservation of the currently remote and largely un-utilized landscapes of the Nakanai Mountains of East New Britain has to date been at least partially influenced by the remoteness and isolation of these habitats. Any inroads into this area to establish gardens, or for targeted extraction of forestry or mineral resources, will almost certainly result in greater secondary utilization of areas along roads and paths. In combination these impacts will result in changes to forest (including wildlife) community structure, with increasing prevalence of disturbance-loving species, including transfer of invasive plants and animals into natural habitats. Gardens also bring hunters, and consequently populations of cuscus, wallabies, and other species targeted for food, may decline. Local changes will soon add up to regional scale changes, which on an island of endemics like New Britain, translates to global scale changes.

In a place as important for global conservation as the Nakanai Mountains an effective management plan will require great skill in the design of food production and resource utilization systems that ensure that the livelihoods of local communities can be maintained and improved while at the same time limiting impacts to the ecosystems on which they and the region's highly endemic biodiversity depend.

Muller Range

Long-term preservation of this spectacular series of interconnected ecosystems represents a conservation priority of the highest international importance. The pristine elevational gradient along the southern slopes of the Muller Range provides a rare opportunity for conservation on a landscape scale such that a regional biota can respond and adapt to future climatic changes and regimes in a fully natural way, without the added complexity that is introduced through human activities and the presence of exotic organisms. There are few places in the world, and even fewer places in the Old World tropics, where such a dream could become reality through relatively simple measures.

The extremely high conservation values of the Muller Range are a product of its current remoteness from major human populations and from resource development projects. The Muller Range is one of the few places on Earth where the pressures of the modern age have yet to arrive. From the standpoint of conservation, it would be best if they never did. However, a more likely future will involve some degree of incursion of the modern world into this pristine paradise, and it can only be hoped that this occurs with a genuine commitment to conservation from all partners. Knowledge of the ecosystems will be fundamental to achieving the best possible outcome – knowledge of the biodiversity and how it is distributed within the landscape; knowledge of how the organisms work together to form balanced ecosystems; and knowledge of how human-induced changes might impact on the environment at all levels, from individual species through to entire ecosystems. The scientific results of the

Muller Range RAP are a small first step toward acquisition of the necessary knowledge.

REFERENCES

- Anthony N., D. Byrnes, J. Foufopoulos and M. Putnam. 2001. Biological Survey of New Britain Island, Papua New Guinea. Falcon Art Media. Madison, Wisconsin.
- Audra, P., P. Coninck and J-P. Sounier (eds.). 2001. Nakanai 1978-1998: 20 years of exploration. Association Hémisphère Sud. Antibes.
- Coninck, P. 2001. Faune cavernicole et épigée de Nouvelle-Bretagne. *In*: Audra, P., P. Coninck and J-P. Sounier (eds.). 2001. Nakanai 1978-1998: 20 years of exploration. Association Hémisphère Sud. Antibes. Pp. 108-114.
- Gill, D. W. (ed.). 1988. The untamed river expedition: Nakanai Mountains, East New Britain, Papua New Guinea. The Untamed River Expedition. Chinley, Stockport.
- James J. M., and H. J. Dyson (Eds.). 1980. Caves and Karst of the Muller Range. Atea 78. Newtown.
- Richards, S. J. (ed.). 2007. A rapid biodiversity assessment of the Kaijende Highlands, Enga Province, Papua New Guinea. RAP Bulletin of Biological Assessment 45. Arlington, Virginia. Conservation International.
- Shearman, P. L., J. Ash, B. Mackey, J. E. Bryan and B. Lokes. 2009. Forest conversion and degradation in Papua New Guinea 1972-2002. *Biotropica*. 41: 379-390.