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The Nakanai Mountain Ranges of East New Britain Papua New Guinea

E: Booklet Version 2

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Cover images
Main image: *Opening to Mageni Caves, Nakanai Mountains, East New Britain* by David Gill | 2006
Background image: Free-Photos | pixabay.com/photo-918570

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NOTES ON THE E-BOOKLET VERSION TWO

Between 2016- 2019, a multidisciplinary team of researchers[1] from Australia and Papua New Guinea worked in collaboration with local communities to document the cultural values of the Nakanai Mountains and their inextricable link to the spectacular natural landscape. This research aims to contribute to a standalone nomination to the UNESCO Tentative World Heritage List of the Nakanai Karst Area (NKA) and elevate its recognition as a cultural landscape of outstanding significance. The research team included both anthropologists and archaeologists. Further anthropological and archaeological research is likely to yield additional evidence of the richly diverse cultural values of the area.

Between July 2018 - December 2019, researchers from James Cook University (JCU) in collaboration with postgraduate researchers from the University of Papua New Guinea (UPNG) were commissioned by the United Nations Development Programme[2] in conjunction with the Conservation, Environment Protection Authority to generate awareness of protected area planning processes and to facilitate the gazettal of four Community Protected Areas around Jacquinot Bay and Central Inland Pomio. These protected area processes are ongoing.

ACKNOWLEDGEMENTS

In addition to the funding bodies and partners, the assistance of the following people who provided insight and expertise that greatly assisted our research is acknowledged with gratitude and thanks.

- We are indebted to the Pomio Community and the people of East New Britain for their hospitality, friendship, generosity, and valued support.

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- For research insights included in the E-Booklet, we thank our colleagues from James Cook University, the University of Sydney, the Australian National University, the University of Papua New Guinea, Extent Heritage, Partners with Melanesians and The PNG National Museum and Art Gallery. We especially thank the late Peter Hitchcock for his advice and expertise on World Heritage matters.

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[1] This research was supported by the Australian Research Linkage Grant LP140100536, managed by James Cook University. The project team included researchers from JCU, University of Sydney, the Australian National University (ANU), The University of Papua New Guinea and Extent Heritage.

[2] The project team for the Sustainable Livelihoods and Protected Area Planning in the Nakanai Ranges and lowland forest landscapes of Pomio, East New Britain (PNG), led by James Cook University, involved a range of researchers from the disciplines of anthropology, botany, soil science, and freshwater ecology.

THE NAKANAI MOUNTAIN RANGES OF EAST NEW BRITAIN PAPUA NEW GUINEA

Deep beneath the rain forests of New Britain, an island off the coast of Papua New Guinea, churning rapids jet through enormous passages, some of the largest, most remote river caves on the planet. To reach them, explorers must first descend into massive dolines—sinkholes where soluble rock, weakened by runoff from an estimated 18 feet of rainfall a year, has collapsed. From the air they appear like impact craters, as if a volley of meteorites had long ago pummelled the forest (Shea, 2006).

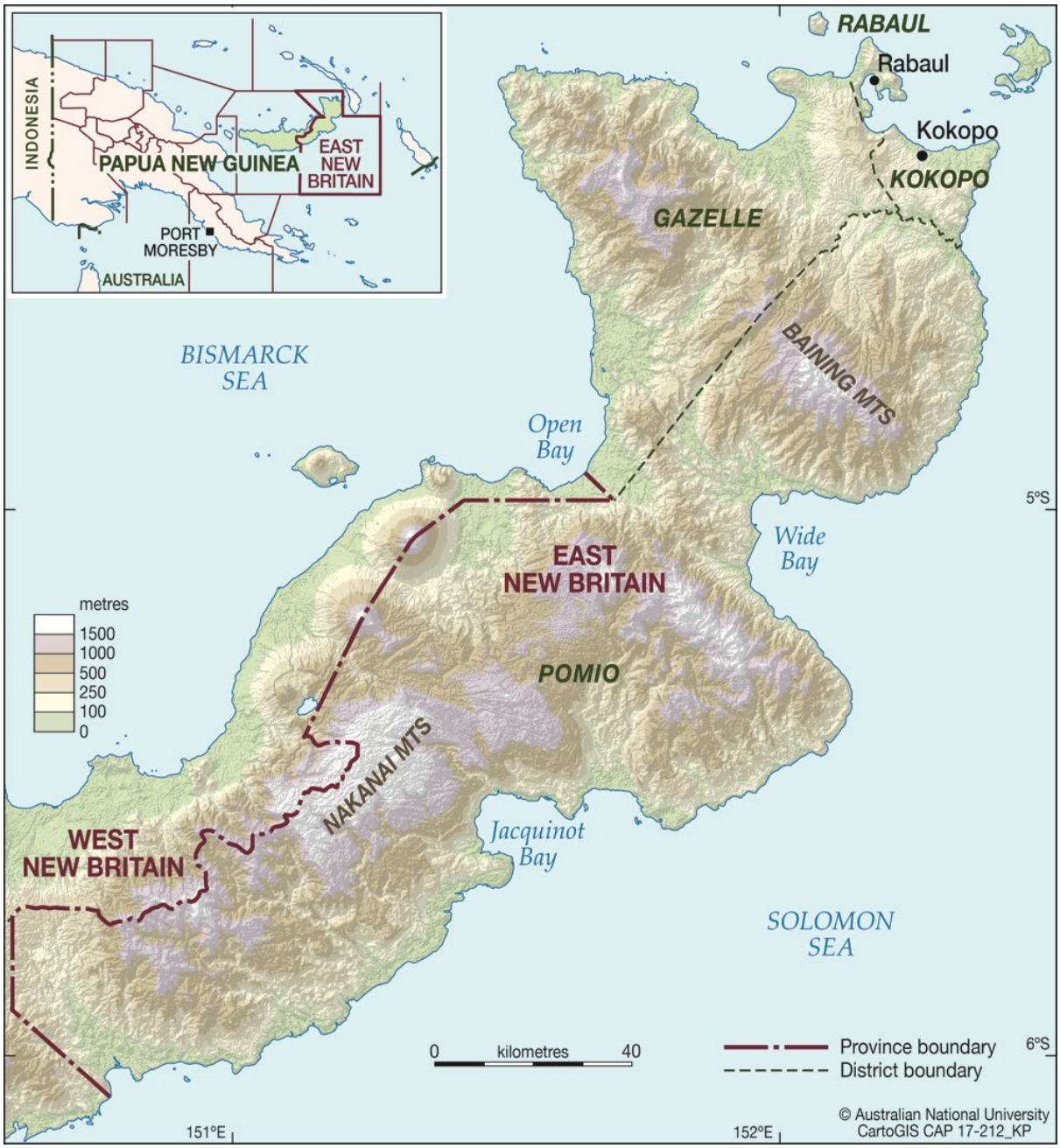

Figure 1: *Map of East New Britain Province showing Nakanai Mountains*
Map source: Australian National University, reproduced with permission.

This E-Book (Version Two) on the Nakanai Mountains of East New Britain is in four parts. The first section provides an overview of the karst and cave attributes which led to the listing of Nakanai on the Tentative World Heritage List in a Serial Site known as *The Sublime Karsts of Papua New Guinea*. The next section provides a brief history of the region involving European encounters. This is followed with a brief overview of the pre-colonial archaeology of East New Britain. The fourth section highlights some of the unique flora and fauna of the Nakanai. The final section includes the UNESCO Justification for Significance on the Tentative World Heritage List.

Nakanai Mountains, Pomio District, East New Britain Province

The Nakanai Mountain Range in East New Britain is located in Pomio District in primary rainforest with an area of over 4000 square kilometres (Gill, 2012). The limestone karst area extends from the mountain summits to the southern coastline. Within the Nakanai mountains are some of the largest caves in the Southern Hemisphere, known collectively as the Nakanai Caves. The Nakanai Mountains contains some of the world's largest river cave systems, with some of the largest and fastest flowing underground rivers in the world.

These mountains are made up of layers of limestone that are about 22.5 to 10.5 million years old, covered with fragmentary layers of fine volcanic sediments. The heavy rain creates rivers in the mountain ranges, which over time create deep valleys. Over the last 200,000 years, eight giant canyons have formed in the Nakanai Ranges with depths reaching 600 – 1,000 metres. The upper reaches of these canyons and their side ravines contain some of the most powerful springs in the world—their sources are located in giant caves deep within the limestone layer.

Large underground passages and giant sinkholes ('megadolines) have resulted partially from the erosion of soft limestone by underground streams. The deepest cave to date is called Muruk (Figure 3). At 17 kilometres in length and 1,178 metres in depth it was the deepest cave documented in the Southern Hemisphere at the time (Audra, Lauritzen & Rochette, 2011; Richards & Gamui, 2011).[3]

In 2007, the Nakanai area was nominated to the PNG Word Heritage Tentative List within the serial site known as 'The Sublime Karsts of PNG'. Four decades of exploration has increased our knowledge of the caves and brought to light the significant biodiversity value of the area. An environmental study in 2009 identified over 100 new species of animals in the Nakanai mountain range previously unknown to science. In this booklet, we outline past and current initiatives to document and protect the natural and cultural values of the Nakanai Mountains, as well as providing a brief overview of the history, archaeology and flora of the region.

[3] In 2014, Stormy Pot Cave on Mt Arthur in New Zealand, with a 10km passage, was recorded with a depth of 1200m, making it the deepest cave known to date in the southern hemisphere. http://www.stuff.co.nz/science/9675130/Southern-hemispheres-deepest-cave-found

THE CAVES OF THE NAKANAI MOUNTAINS

The Nakanai caves are part of a globally unique system of limestone caves. They are located within the Nakanai Range, amongst primary rainforest extending from the mountain summits to the southern coastline (Gill, 2012). The Nakanai region comprises a limestone mountain range with an area covering approximately 4000 square kilometres. Cavers rely on aerial images to look for deep caverns to explore. In the images, large surface sinkholes, characteristic of the rainforest-covered karst landscape, look like enormous black holes of varying sizes. Once identified, professional cavers venture into the depths of giant caves. Since 1972, major advances in understanding the Nakanai caves have been achieved through 50 years of expeditions, the first of which was undertaken by Australian cavers, followed by French and British international teams. French Speleologist Jean-Paul Sounier has participated in 13 expeditions since 1980, including 7 as leader, and Florence Guillot has taken part in 6 expeditions, 3 of which were as co-leader. The exploration, mapping, photography, and documentation of the caves explored are documented in two publications: *Nakanai 1978-1998: 20 years of exploration* (Audra et al, 2001), and *Caves of the Nakanai* (Sounier et al., 2022). By sharing their knowledge, the cavers hope to contribute to the protection of the Nakanai Karst and the cultural landscapes of the Nakanai Mountains.

The following expeditions have revealed significant information about the caves and the expansive underground cave river networks *(individual caving reports/documentaries available via hyperlinks)*.

CAVING EXPEDITION TIMELINE

- 1972/73 Pioneering Australian Expedition (Bourke 1973): Ora Cave Expedition
- 1978 First French Expedition (Sounier et al.): Reconnaissance Nare Minye Dolines
- 1979: Swiss Expedition: Kavakuna Cave
- 1980 French Expedition (Sounier et al.): Nare Doline, Kavakuna doline, Ka 2, Vuvu Expedition
- 1985 French Expedition (Sounier et al): Minye, Muruk Expedition
- 1984/1985 First British-led Expedition (Gill et al.): Nare, Pavie and Gamvo caves
- 1988 French-International Expedition (Sounier et al.) Mayang Expedition
- 1995 French-International Expedition (Sounier et al.): Muruk Cave Expedition
- 1998 French-International Expedition (Sounier et al.) Montagnes des gouffres géants
- 2000 French Expedition: (Cazes, Fulcrand et al): Reconnaissance Papou; Bairaman
- 2002 French Expedition (Guillot, Tourte et al.): Explorations sous la jungle
- 2003 French Expedition (Boureau et al.): Papou Expedition
- 2005 French Expedition (Guillot, Bence et al.): Papou 2005; Bairaman and Marana Kapate
- 2006 British (Gill et al.): Untamed Rivers Expedition
- 2007 French-International Expedition (Sounier et al.): Siphons sous la Jungle
- 2008 British: BBC Documentary (Gill et al.): Pandi River Expedition
- 2010 French-International Expedition (Sounier et al.): Vuvu Cave
- 2012 French-International Expedition (Sounier et al.): Wowo Cave
- 2014 French-International Expedition: (Bence, Guillot et al.) Iowa 2014; Wara Kalap Source
- 2015 Japanese Expedition: NHK Documentary Kavakuna Cave
- 2016 French-International Expedition (Sounier et al.): Black Hole Expedition
- 2018 French- International Expedition (Sounier et al.): Ghost Rivers Expedition
- 2019 French-Japanese: NHK Documentary (Sounier et al.)

History of Caving in the Nakanai Mountains

The Nakanai Mountains are up to 2,185 metres high in the central-eastern part of the island. They are bounded on the east by the Kol Mountains and to the west the Kapiura-Ania Divide which separates the Nakanai Range from the Whiteman Range. Vast limestone outcrops span over 550,000 hectares North, South and West. The topography, which is known as 'cockpit karst' is covered in dense tropical forest. An early report on the caves of New Britain noted that 'stories of great river effluxes and cave entrances are common for the area inland from Pomio' (Bourke, 1973, p. 15). An abundance of insects, and multiple species of bats and flying foxes could be found in a single cave in large numbers.

The first very preliminary exploration to the Nakanai Mountains was undertaken in 1968 by Chris Borough and Kevin Reid of the Port Moresby Speleological Society. The team sought to explore the Minye dolines near Tuke Village. C. J. Borough, writing in the *Niugini Caver* (1973), of his experience locating what he called the 'BIG HOLE' in 1968, described the Nakanai karst landscape as consisting of endless sinks with almost vertical sides near the outer edge of each and clothed in dense forest. Borough wrote:

> It can only be described as impossible country and I never succeeding in pursuing more than a km into it from one edge. Army maps show two remarkable features on one of the limestone plateaux North of Pomio in Eastern New Britain. They are a large hole about 1.5 km long and 460 m deep and a smaller hole, 0.5 km wide and 380 m deep. For the average caver, this is too much and I drooled at the prospect of seeing these immense holes (Borough, cited in Bourke, 1973, p. 25).

C. J. Borough and his caving colleague, Kevin Reid, arrived in Tuke Village by helicopter. To locate the 'BIG HOLE', local people were recruited as guides, but would not accompany Borough and Reid all the way to the sinkhole, as it was regarded as a place of foreboding, where devils and ravenous crocodiles may lay in wait at the bottom. Upon descending around 60 metres into the hole, the realisation that a full descent to the 300 metres would require specialist equipment saw Borough and Reid return to the village.

The first official caving expedition to the Nakanai Mountains was undertaken by an Australian team in 1972 when Michael Bourke led an expedition (4 men and 2 women) from the University of Queensland Speleological Society to the Ora dolines. Bourke had previously conducted an 8-day trip to the Oro dolines in April 1972, entering the northern doline but not reaching the bottom. During the 1972-73 expedition, the team explored the northern doline, following a river at the bottom to a cave chamber 15-27 metres wide and about 27 metres high. They charted 168 metres of passage before progress was halted by a waterfall that occupied the entire cave floor (Figure 2). The Australian team noted that it should be possible to explore further by traversing above the waterfall.

Moving upstream from the bottom of the doline they entered a large cave chamber 600 metres long and 67 metres deep, with huge stalagmites hanging from the roof. By moving through the chamber in a southerly direction they emerged out in the bottom of the twin doline. Walls as high as 100 metres rose up from the bottom. Re-entering the cave from the southern doline, the cavers followed an old stream passage back to the river. Downstream was a spectacular waterfall, and upstream they moved through a beautiful section along the river to a lake: "Calcite curtains, candle wax stalagmites, flowstone and stalactites, lavishly decorate this area" (Bourke, 1973, p. 30).

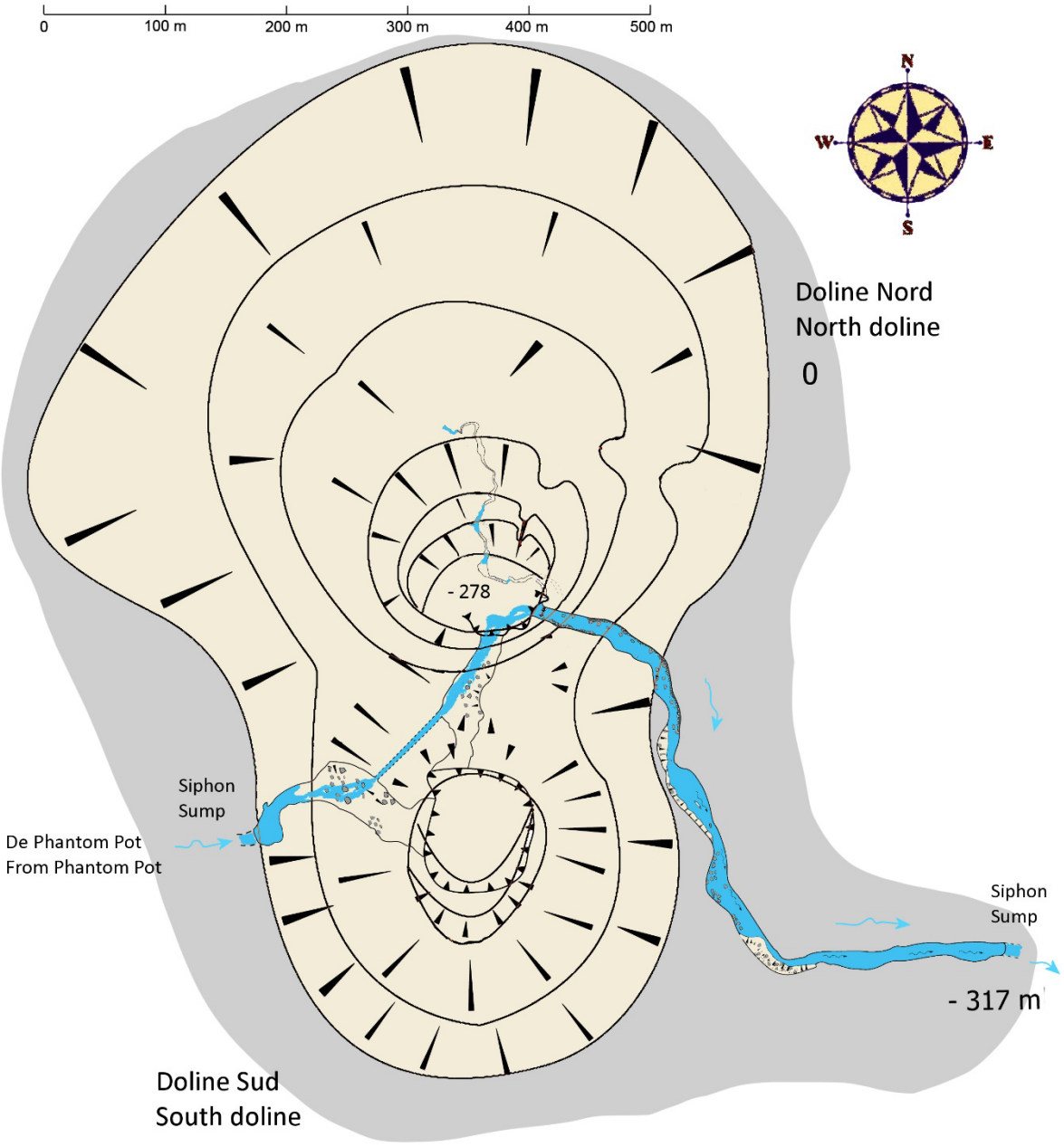

Figure 2: *Ora River Caves schematic by Dave Clucas, redraw by J-P Sounier, 2022.*

Following the Australian expedition, a French caving expedition continued the research in 1978. Numerous expeditions came later (refer 'Timeline', p.6). Tragically, during the 1979 Swiss expedition to Kavakuna Cave and descent to 320 metres one of the cavers drowned in a caving mishap, and then the rescue helicopter, en-route to Rabaul, had engine failure and crashed into the river (Maleckar 1982, p.89-95). In 1980, a French team led by Jean-François Pernette explored five caves which form the Matali system: Kavakuna mégadoline, Ka2, Ka6, Ka 5 caves and the Matali resurgence.

In 1984 and 1985 the British caving team completed the exploration of Nare Cave, the Pavie River Cave and the Gamvo Cave system. Towards the end of the expedition a reconnaissance trip looked at the Ora dolines. The British team felt that the cave warranted a further visit, but it was to be over twenty years before they returned (Gill, 2012).

The 1985 expedition to Nakanai, undertaken by the French team, explored Minye Cave, and Muruk Cave. A decade later during the 1995 expedition, the French team dived the final sump (a passage in a cave that is submerged under water) and enabled Muruk to become the first 1,000-metre-deep cave documented in the Southern Hemisphere (Audra et al., 2011).

In 1988, during a helicopter reconnaissance flight over the area between Galowe Gorge to the east, and the huge Wunung Gorge to the west, French caving expedition leader Jean-Paul Sounier was surprised to see that, unlike Galowe Gorge, no rivers poured into this 1,000-meter-deep Wunung Gorge canyon. This begged the question: where was the water flowing into the mouth of the coastal Wunung River coming from? The mysterious ghost rivers of the Wunung Gorge became the subject of additional French expeditions in 2016 and 2018.

The British cavers returned in 2006 with a team of twelve from the U.K., France, and the United States. The U.K. expedition, led by David Gill, involved a two-month expedition to complete the Untamed Rivers Expedition, first commenced in 1984. The primary purpose was to complete the exploration and mapping of the Ora River cave and to search for other caves in the area. The secondary objective was to gather data with the aim of establishing a Nakanai Conservation Area which would be proposed for World Heritage status to protect the cave area from destruction by logging. Funding was obtained from the National Geographic Society, the Royal Geographic Society and the Ghar Parau Foundation. The National Geographic Society sent along a photographic team and published an article about the River Caves of East New Britain (Shea, 2006).

Ora River Cave was explored down-stream to a siphon (a passage in a cave that is submerged under water). The total length of the Ora River Cave system was recorded as 1,220 metres with a depth of 317 metres from the lowest point of the doline rim. To the north-west a cave entrance was discovered named Phantom Pot. A steeply descending passage was explored to a large river. Downstream reached a siphon only a few hundred meters from the upstream siphon of Ora River Cave. Upstream led to a large lake 67-metre-long, 58-metre-wide which was named Lake Myo. The river emerged from a 10 metres high waterfall named Myo Falls. Phantom Pot at 1,045 metres altitude was mapped for 3.9 kilometres with a depth of 191 metres. During the British expedition, over twelve kilometres of river caves were explored and mapped (Gill, 2012, p. 14).

On a helicopter flight into Ora Village a large cave entrance was seen emerging from high up on the cliff face to the south of the village. Entry into the cave required a fifty-metre abseil descent and a climb along the cliff to the 80-metre waterfall named Mageni by the local people. Beyond the waterfall

were more than five kilometres of cave tunnels—but the team only explored the main tunnel. The Mageni cave system[4], mapped to a total length of 9.4 kilometres, lies parallel to the underground Ora River cave system. Another cave located they called Triosaurus Cave—a small cave 61 metres long and 43 metres deep.

To promote conservation of the caves, meetings were held with the Department of Environment and Conservation, the National Research Institute, the Provincial Government of East New Britain, the Governor of East New Britain, the Tourism Authority, the Local Level Government Pomio District and non-government conservation organisations, as well as with local villagers and logging company management. A presentation was given to the World Heritage Department in Port Moresby. The expedition eventually led to the area gaining Tentative World Heritage listing status (Gill, 2012).

In 2007, the 'Siphon beneath the jungle' expedition led by Jean-Paul Sounier documented many underwater passages in different caves which form the 'Wallaby system' at 515 m deep, 10,416 m long. In 2010, a French-Swiss caving team led by Jean Paul Sounier returned to the Nakanai Mountains and found the junction of two big caves, which form the Wowo cave system. The expedition in 2012 by the French-Swiss team went back to the Wowo cave system; and with more than 20 kilometres of charted galleries it is now the most extensive cave system known in New Britain Island. The team also discovered and explored a 423-metre-deep cave known as Khou.

The first attempt to understand the underground river network known as the Wara Kalap resurgence was made by a French team of 15 cavers led by Phil Bence and Florence Guillot in 2014. The Wara Kalap (or 'leaping waterfall') cascades onto the beach on the western side of Jacquinot Bay at around 5 cubic metres per second[5] from an opening, roughly 1 metre wide by 1.8 to 2 metres high. It is one of three waterfalls along the coastal beach, whose source lies deep inside the forested Nakanai Mountains. In 2014, the Iowa Expedition was concerned with exploring caves above the source of the Wara Kalap waterfall. The team set up three camps at different elevations (400 m, 650 m, 1,000 m), with the highest camp about 6 to 7 hours trek from the ocean through almost impenetrable primary rainforest. After three weeks exploring blocked cave entrances, the team found a collection basin with fast-flowing underground rivers, charting 6 kilometres of networks with two major cavities more than 500 metres deep. The biggest of these cavities, at around 580 metres deep and the fourth deepest cave in Papua New Guinea, was named Phillipe Pato Cave (to pay homage to a former porter).

At the beginning of 2016, a team of speleologists led by Jean-Paul Sounier decided to explore the karst wedged between the Wunung and Lolotu gorges. The international team explored a gigantic black sinkhole spotted in aerial images. On a plateau along the left bank of Wunung Gorge, a black and white mark indicated a surface sinkhole with a black hole almost 100 meters wide and 100-150 metres deep. During the 'Black Hole' Expedition in 2016, the team, spent four weeks surveying and mapping caves and galleries. One cave was named Wild Dog Cave after a long howl similar to that of a wolf, pierced the previous night. In the sinkhole they initially named Dooble, the ceiling is magnificently decorated with white stalactites and streams, waterfalls, and underground lakes flow through the galleries. The discovery of a 714-metre-deep cave with four entrances was named Christian Rigaldie system to honour a caver who was part of the first French expedition to the Nakanai Mountains in 1980.

[4] The Mageni cave featured in the BBC documentary '*The Lost Land of the Volcano*', April 2008.
[5] There are several areas where the water flow is around 20m^3/second.

Although he never returned to Nakanai, Christian Rigaldie contributed to the funding of several expeditions and died of illness in 2015. At 714 metres deep, the Christian Rigaldie cave now ranks as the second deepest cave in Papua New Guinea, after the Cassowary (Muruk) system (Sounier, 2017)[6].

In 2018, the French-led team returned to explore the area north of the Christian Rigaldie Cave network. It is assumed that the drainage of this area flows beneath the Wunung Gorge. This expedition was named “Ghost Rivers” and discovered 19 more caves in the Wunung area.

Figure 3. *Muruk underground river*
Image credit: J-P. Sounier.

Mega-dolines of the Nakanai Mountains

Four exceptionally large dolines (‘megadolines’) are known from the north of Pomio. One is only a few kilometres north-west of Pomio (Bourke, 1973, p. 28). A doline or sinkhole is a collapsed cave system that provides entrances to the underground world. Huge limestone cliffs on the plateau are formed where rivers cut through the limestone. Cliffs as tall as 300 metres high are common, with some reaching up to 900 metres high (Bourke, 1973, p. 28).

Giant sinkholes (‘megadolines’) of the Nakanai Mountains have been surveyed and found to be among the largest and most impressive in the world. Nare, Kururu, Poipun, and Bikbik Vuvu are just a few of the cavernous dolines explored by international teams of cavers. The massive Ora dolines are known

[6] The deepest caves in the Nakanai are:

1. Cassowary system (Muruk): - 1178 m
2. Christian Rigaldie system: - 714 m
3. Wowo system: - 662 m
4. Philip Pato cave: - 567 m
5. Wallaby system: - 515 m

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as a 'double doline' or *uvala,* with a bridge across the centre. From above, the Ora dolines look like giant holes in the dense green jungle, visible even in comparatively blurry satellite images. They are situated in thick limestone, around 1,130 metres above sea level. The Ora dolines are the largest in the limestone plateau. Ora's twin dolines have been surveyed to be 1,400 metres in length, 750 metres across and 200 metres in depth (Gill, 2012, p. 9).

The Minye doline lies on a plateau at an elevation of 1,000 metres, close to the village of Tuke, located near the Namure resurgence where the Minye River comes out. The area of the Minye sinkhole (Figure 4) is around 75,000 square metres, and water volume is up to 26 million cubic metres. The doline is 350 metres in diameter with a depth of 400 – 510 metres. Because Minye is located on a slope (Figure 5), the upper rim is 100 metres higher than the lower rim. The floor of the sinkhole is crossed by a powerful river—from the upper rim it may look like a narrow stream, but the volume of the stream is 15-25 cubic metres per second, increasing significantly after torrential rain. The cave passages in the Minye system have been explored to a length of 5,421-metres, but this may be just a small part of the system. Powerful subterranean rivers require large passages—and the ones in Minye are giants. Tuke chamber is one of the largest cave chambers in the world. It is estimated at 240 metres long, 160 metres wide and 180 metres high. The floor area of this chamber is around 48,000 square metres, with total water volume estimated at 6.24 million cubic metres.

The Nare doline (Figure 6 & 7) is around 150 metres in length and 120 metres wide. The depth is between 240 to 310 metres, with water volume estimated around 4.7 million cubic metres. The walls of the sinkhole are vertical and not covered with jungle. All of the limestone, which earlier filled the present hole, has been washed down the ranges by the subterranean river, named Nare River (the huge downstream passage has been named the 'Flying Dutchman gallery'), flowing across the bottom of sinkhole. The volume of this river flows around 15-20 cubic metres per second, and after heavy rain, the discharge can be up to 50 times higher. The mighty subterranean river in Nare Cave is extremely loud and earplugs are required to endure exploration. French cavers descended into this doline in 1978 and 1980, exploring cave passages up to four kilometres in length. British cavers continued exploration in 1985.

Figure 4. *Minye underground river. Image credit: J-P. Sounier in Audra et al., 2001.*

Figure 5. *Minye Doline from above*
Image credit: J-P. Sounier (1985) in Audra et al., 2001.

Figure 6. *Nare Doline*
Image credit: D. Gill, 2006.

Figure 7. *Nare Doline on the Nakanai Plateau*
Image credit: J-P. Sounier (1985) in Audra et al., 2001.

HISTORY OF THE REGION: EARLY EUROPEAN ENCOUNTERS

The first European references to the southern shore of the island of New Britain come from the voyage of William Dampier when he passed by the island in the late 17th Century. In 1699 he sailed in the *Roebuck* past the north coast of New Guinea. In February 1700, he visited the large island to the east of New Guinea and determined that it is separate from New Guinea. He then sailed along its southern coast and named it Nova-Britannia (New Britain). He sighted and named Cape Orford, after his patron and Admiral of the Fleet, Edward Russell but passed by the study area of Jacquinot Bay with no mention in the ship's log of any features along this part of the south coast because of poor visibility due to bad weather (Dampier, 1906, pp. 533, 543; 1939, pp. 208-210).

In July 1827, Dumont D'Urville's French ship *Astrolabe* also sighted the south coast of New Britain (D'urville, 1830, p. 522ff). During the course of this voyage, D'Urville mapped part of the southern coast of New Britain and it was at this time that Jacquinot Bay is named after the 2nd in command of the exploration fleet, Charles-Hector Jacquinot (1796-1879).

Early Commercial and Missionary Activity

Missionary efforts in Oceania had commenced in late 18th Century in Polynesia and had moved to Micronesia by the early 19th Century. Melanesia was the last area in Oceania to be Christianised (Ernst & Anisi, 2016). The Catholic Church established the Apostolic Vicariate of Melanesia in 1844 with the first Marist missionaries to Melanesia arriving in the following year. They first set up in the Solomon's and later on Woodlark Island. This initial effort failed and successful missionary efforts had to wait until the end of the 19th Century. In the 1870s the Rev George Brown established a mission at Port Hunter, Duke of York Island, organised by the Australasian Wesleyan Methodist Mission. During his stay on the island he travelled to both New Britain and New Ireland and reported on his observations of the land and its inhabitants (Brown, 1881, 1877).

In 1882, Pope Leo XIII appointed the Missionaries of the Sacred Heart (MSC), a French order, to evangelise the vacant vicariates of Melanesia and Micronesia. Fr. Couppé (MSC), from France, arrived at Yule Island, British New Guinea in 1886 and three years later was appointed Vicar Apostolic of Melanesia Christianised (Ernst & Anisi, 2016)[7]. The establishment of European missions in New Britain, the latter part of the 19th Century, was largely focused on the Gazelle peninsula. Missionary activity outside this area was scant but Bishop Couppé visited Jacquinot Bay in late November 1899 in the company of Fr. Rascher and the Imperial Administrator Heinrich Schnee (Schneider, 1954). It was probably during the 1899 visit to Jacquinot Bay that the land for the future Mal Mal mission was purchased or the site chosen.[8] However no development of this mission was to take place until the next century.

The New Guinea Compagnie (NGC), a mercantile venture that would be closely associated with the development of the German possessions in New Guinea, was a speculative enterprise, set up in 1884. It had originally been established to colonise and exploit the resources of the new colony. The exploitation of the colony was to be primarily undertaken through the establishment of plantations directed by European colonists directing local labour.

World War I

In 1912 the NGC purchased land at Jacquinot Bay that was to become the plantation of Palmalmal. However, WWI intervened, and Australia occupied the German possessions including New Britain. As a result of the determinations at Versailles, the German colonies in the south Pacific were stripped from Germany and the former colony of New Guinea was mandated to Australia. Land formerly owned by German companies and individuals was expropriated by the Australian Government and auctioned off to former Australian Imperial Force (AIF) soldiers. The land holding at Palmalmal was expropriated by the Australian Government auctioned in 1926 to J. Chapman. Chapman had purchased a number of other plantations in New Britain at the same time and it would appear he was in fact "dummying" or acting for a larger company in the purchase. That company was W.R. Carpenter and Co Ltd a large

[7] Couppé was to remain Vicar Apostolic until 1923 when he resigned. He died in 1926 in Douglas Park, NSW and was reburied at Vunapope the following year.

[8] Couppé was reportedly refused many areas of land he had chosen for his missions by the Governor. He claimed to have interviewed officers at the German Foreign Office during a trip there and "talked them over" into meeting his land requirements without them realising there had been an official refusal; see MacKellar, 1912, p. 77.

trading firm based in Sydney, Port Moresby and later Solomon Islands. By the 1930s the plantation was managed by Paul 'Kar Kar' Schmidt an experienced plantation manager.

The NGC also purchased land on the north coast of Jacquinot Bay that was to eventually become Cutarp Plantation. The original indigenous name for the locality was Malavapun. The Custodian of Expropriated Property submitted the site for auction as lot 145, offered as the third group of expropriated properties, in February 1927. Two Australian ex-soldiers; Frank Oakley Cutler and Victor A. Pratt bought the 1,000 hectares of 'virgin land' on the central coast of Jacquinot Bay for £831. Cutler was to eventually acquire Pratt's interest in Cutarp and run the plantation until the beginning of WW2.

The 1930s was a period of change in the Bay. On May 12, 1931, the Mission motor launch Teresa, accompanied by the cutter *Toriu*, set out from Vunapope carrying the first missionary (Fr. William Culhane M.S.C) to the Mengen village Malmal in Jacquinot Bay. The initial construction at the Malmal mission, on land already owned by the Church, consisted of a church 60 feet by 21 feet which the locals had built out of bush materials on their own initiative ("South Sea cannibals", 1932, p. 21). Due to poor siting of this church, it did not remain in use for very long and was replaced by the present church, presbytery and some ancillary buildings, and a small motorboat, all built from wood sawn at the sawmill at Ulamona. The presbytery was situated on a small hill 200 yards from the water ("South Sea cannibals", 1932, p. 21). Fr. Culhane's initial presbytery consisted of a small dwelling and a detached 'prayer house', both made of bush materials (Fr. Clarence Paru – Mal Mal Mission, personal communication). Father Edward (Ted) Harris arrived in Rabaul in 1940 and by April 1941 he had replaced Fr. Culhane (who moved to Gasmata) as the missionary at Mal Mal Mission at Jacquinot Bay (Dawes, 1959, p. 45).

During the 1930s, Wunung plantation was also established. In the 1920s and 30s a sawmill, run by Cecil "Charlie" Bowles, operated on the land that would later become Wunung plantation (Gwarpoon, 1945; Waldersee, 1995, p. 560). In 1937 the sawmill, was moved to Waterfall Bay and was still operated by the Bowles family[9] (Mackenzie, 1942, p. 5). This report indicates that it was not until this time that Wunung Plantation itself was established (Gwarpoon, 1945, p. 3).

World War II

On January 22nd, 1942, Japanese Military forces, known as the *Nankai Shitai* (South Seas Detachment) landed at Rabaul to establish a major base to be served by Simpson Harbour (formerly known as Simsonhafen under German administration). The defenders were known as 'Lark Force', and consisted of the 2/22nd AIF Battalion, the local New Guinea Volunteer Rifles, artillery and anti-aircraft units and support services (Wigmore, 1957). The defeat and dispersion of Lark Force at Rabaul saw their retreat through the jungles towards the west. The remnants moved away from Rabaul, along both the north and south coasts where movement on foot was easiest. Some of those moving to the south were victims of a massacre, by Japanese Forces, at Tol Plantation. Those able to avoid Japanese forces moved further west and gradually coalesced at Palmalmal, Wunung and Drina Plantations. The exhausted and demoralised troops were assisted by the occupants of the plantations and most notably by Fr. Harris at Mal Mal mission.

[9] see Mackenzie's reference to Mrs Bowles sawmill at Waterfall Bay, 1945, p. 5.

After several weeks of recuperation at the missions the survivors were picked up by HMAS Laurabada, on April 10, 1942, who took 156 back to relative safety at Port Moresby. This included many from the plantations who had assisted the Australian troops. However, despite many entreaties, Fr. Harris refused to leave his parishioners. He was subsequently murdered by the Japanese and his body has never been found. Many of the locals left, after they had seen the treatment of Fr. Harris, or were forced from their homes by the Japanese. Some lived in caves nearby for the duration of the war. However, some also stayed as collaborators (Korba of Tokai) while others resisted and were able assist the Allied Forces during the period 1942-44 (Golpak, Luluai at Sali). Many no doubt largely continued with the lives they led prior to the war hoping to maintain a level of normalcy in their lives.

The Japanese occupied the area of Jacquinot Bay and there is evidence of an early warning radio position at Cape Cunningham, and anti-aircraft position and headquarters building at Palmalmal, along with use of existing buildings at Palmalmal, Mal Mal, and Cutarp for storage and accommodation. The Japanese also constructed sections of road around the bay and bridges crossing major water courses but many of these had become derelict and unusable by 1944.

Allied activity between 1942 and 1944 that impinged on the locals around the bay was focussed on airstrikes at the facilities at Palmalmal, Mal Mal, Cutarp and the small anchorage at Kalmalgaman, near Cape Jacquinot. Some structures were badly damaged while others such as St Patrick's church at Mal Mal survived the war. Friendly locals aided the airmen shot down in these raids as well as supporting the Coastwatchers and guerrilla forces that gradually took control of the area—so that by mid-1944 Japanese control of Jacquinot Bay was very fragile. In April 1944 the Japanese garrison at Palmalmal was attacked by Australian led local guerrillas (Long, 1963). At the time, this garrison reportedly consisted of 17 Japanese naval personnel, 14 of whom were killed during the attack and three taken prisoner.

In October, units of the Australian Army and Navy landed at Palmalmal and Mal Mal to establish a base for a push on to the major Japanese garrison at Rabaul. Large areas of plantation at Palmalmal and Wunung were cleared to establish store areas and encampments of the 5th Australian Division. Units of this division quickly pushed out north to contest the approaches to Rabaul while the area around Jacquinot Bay continued to be built up with military stores, troops and facilities. This included the establishment of the airfield at Jacquinot Bay which remains today as the airfield for the region.

When a big military offensive on Rabaul was decided against the base at Jacquinot Bay gradually wound down and by the end of the war many units had left. Civil administration was quickly reinstated and people's lives gradually returned to normal. Those that had fled the coast returned, gardens were re-established, and compensation paid for war damage to villages and gardens. Many of the locals took the opportunity to utilise discarded equipment and materials in their new homes and some villages took on the aspect of 'shanty-towns' to the chagrin of the area's patrol officers.

Post War

The activities at Mal Mal mission were also resumed quickly with new priests having arrived at Jacquinot Bay by late 1945. Fr. John Askew was installed as the first post-war priest—to replace Fr. Harris. The church and presbytery had survived with some superficial damage from Allied air attacks. The plantations had suffered more damage, the substantial plantation house at Palmalmal was completely destroyed as were the copra drying and bagging huts and worker accommodations.

Similarly, Cutarp and Wunung plantations took some time to recommence operations but Frank Cutler's association with Cutarp appears to have ended; perhaps a combination of his age and the work resulting from war damage compelled him to sell the concern to the firm of Colyer Watson Ltd. Watsons installed a series of managers at Cutarp through the 1950s and 60s.

Figure 8. *View of Palmalmal plantation house on the small rise showing the house in relation to the plantation. Image credit: Quentin Anthony Coll.*

Figure 9. *Members of a company HQ Patrol of the 14/32nd Infantry Battalion leaving the Mal Mal Mission church. Note the damage to façade of the church, probably from RAAF strikes. These remain as patched sections in the current façade. Image credit: Australian War Memorial 076664.* *https://www.awm.gov.au/collection/C77133*

Figure 10. *Remains of the plantation homestead at Cutarp Plantation, Jacquinot Bay, 15-December 1944. Image credit: Australian War Memorial 084323 https://www.awm.gov.au/collection/C82889*

Figure 11. *An old copra drying shed on Palmalmal Plantation which had been used as a Japanese kitchen during the occupation, 21st November 1944. Image credit: Australian War Memorial 077159 https://www.awm.gov.au/collection/C20333*

ARCHAEOLOGY OF THE PRE-COLONIAL PERIOD IN THE NAKANAI MOUNTAINS REGION

The Nakanai Mountains largely lie within the East New Britain Province of PNG. Unlike the West New Britain Province, the ENBP has seen little archaeological activity other than in the islands of Watom and the Duke of York group lying off the Gazelle Peninsula where sites of the Lapita pottery period have been the main focus of attention (Figure 12). The lack of field research and excavations on the mainland of ENB severely restrict what we can say about the pre-colonial period of the province, though some general observations are possible.

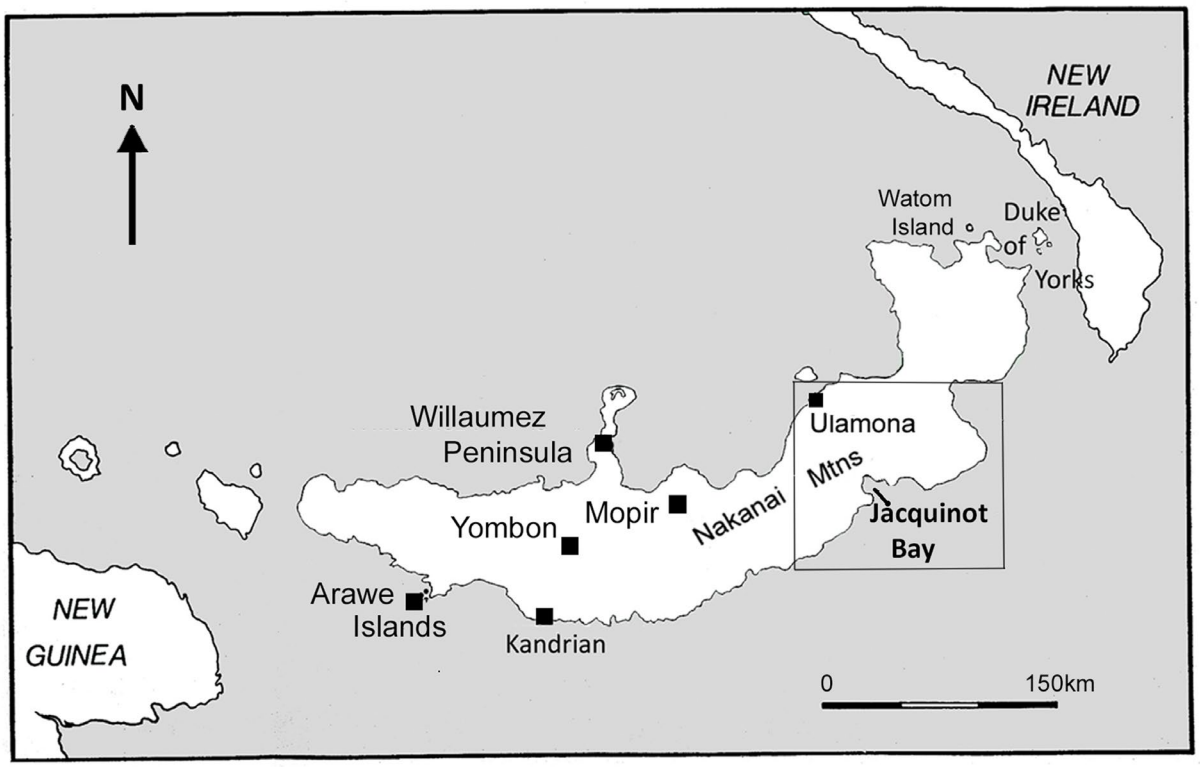

Figure 12: *Map of New Britain in relationship to New Guinea and New Ireland, showing study area. Image credit, J. Specht, 2022.*

People probably first reached the island of New Britain before 40,000 years ago, arriving from the New Guinea mainland by sea because even at times of lower sea-levels, New Britain has never been joined to New Guinea. By 38,000-40,000 years ago they had expanded throughout New Britain, reaching Kupona na Dari on the north coast (Torrence et al. 2004) and the Passismanua area of the Whiteman Range inland from the south coast (Pavlides 2004). Kupona na Dari lies between two major sources of obsidian, a natural black volcanic glass, in the Talasea area on Willaumez Peninsula and at Mopir to the south of Cape Hoskins in the east. Obsidian from both areas was used from the start of human settlement at the Kupona na Dari. In contrast, the early locations in the Passismanua area are in a limestone area with high quality chert that probably attracted visitors to this remote area (Pavlides 2004, 2006). Whether they just visited the area to obtain chert from their residences on the coast or whether they were actually living in the area permanently remains unknown.

At this stage, we have no evidence for people being in the Nakanai Mountains at this early date, though they are likely to have spread rapidly through New Britain because people were in the nearby island of New Ireland around the same time as Kupona na Dari and the Passismanua area were occupied (Leavesley and Chappell 2004; Specht 2005a). The oldest evidence from the Nakanai Mountains region is much later and comes from three chance finds within the karst area. The first is an obsidian stemmed tool from Pakia village inland to the north of Jacquinot Bay (Specht 2005b) and a similar one is reported from near Bago village on the north side of the Nakanai Mountains (J. Gabriel, personal communication) (Figure 13). The third item is a broken chert stemmed tool recovered from the bottom of a 25 m entrance pitch in the cave named "Puits de la Hâche" by the French speleologists (Guillot, 2014). This cave is several hours' walk inland from Malakur village on the western side of the Bay (Figure 14). Although none of these items came from a controlled excavation, they can be assigned to an approximate date range by comparing them to similar items found in dated contexts on Willaumez Peninsula and in the Passismanua area, where they were made from about 9,000-6,000 years ago to about 3,300 years ago (Pavlides, 2006; Torrence et al., 2009).

Figure 13: *Obsidian stemmed tool found near Bago reported by J. Gabriel & M. Wood. Image credit: J. Gabriel, 2016.*

Figure 14: *Broken stemmed chert tool found in the "Puits de la Hâche" cave near Poipuna by the French speleological team. The stem has broken off and would have been at the base of the tool. This item remains in the possession of Bruno Ngalungkena of Malakur village. Image credit: J. Specht, 2015.*

The function of these tools is unclear, but the skill and care needed to produce such perfect forms probably indicate that they were used in special ceremonial situations to mark wealth, status, or an important life-stage. This would apply especially to the group of unusually shaped obsidian tools found at Barema on Hargy Oil Palm Plantation in a volcanic area to the north of the Nakanai Mountains that resembles a phallic form and is identical to another such tool from the Kandrian area on the south coast (Torrence, White and Kononenko, 2013).

Since neither obsidian nor chert occur naturally around Jacquinot Bay or in any part of the Nakanai Mountains, these tools must have been imported. Geochemical analysis of the Pakia find confirms that it came from the Kutau-Bao obsidian source on Willaumez Peninsula (Torrence, Kelloway and White. 2013: table 1, item 26; the Bago find is now in the National Museum and Art Gallery, Port Moresby but has not yet been analysed). The chert tool has not been traced to a source region but is

most likely to have come from the Passismanua area inland from Kandrian. In each case the tools were transported over 250 km from the source areas. The people of the Nakanai Mountains are unlikely to have travelled directly to the sources to obtain the tools, but probably received them as they passed from one community to another through sets of trading and kinship connections (cf. Panoff 1969, p. 15).

The next datable record of people in the Jacquinot Bay area comes from chance finds in the Liton River mouth near Baien village (Figure 15), where local people discovered sherds of decorated pottery of the Lapita pottery tradition (Leavesley and Sarar, 2013). This pottery had with its origins in island southeast Asia (Green, 2003) and is distributed from New Guinea and its neighbouring islands southwards and eastwards to New Caledonia and Samoa.

Figure 15: *Lapita sherd found at the Liton River mouth, Jacquinot Bay. This site was first reported by Mr Patrick Sarar with assistance from his son Andrew. Image credit: Leavesley & Sarar, 2013.*

Figure 16: *Pottery spout from the Liton River in possession of Patrick Sarar of Baien. Image credit: J. Specht, 2015.*

Little is known about the Liton River site (Figure 17). It is likely that the finds eroded from the riverbank into the river, where they were found on the riverbed at 2 m below the surface. The lack of evidence for the site in the riverbank above the water level suggests that the site probably lies within a water-logged situation that will make excavation difficult. Stylistically, the pottery can be assigned to a late stage of Lapita pottery, probably around 2900-2750 years ago, and this is supported by the presence of a piece of Mopir obsidian (Specht et al., 2018: table 3 sample SFI, LIT_1), a source that only became popular at Lapita pottery sites after about 3000 years ago (Summerhayes, 2003).

Figure 17: *The Liton River Lapita find area, general view. Image credit: J. Specht, 2015.*

A later date may be possible for an unusual 'spout-like form (Figure 16) that appears to be unique among Lapita pottery sites, where double-spouts of different form are present, especially in the Arawe Islands about 300 km west of Jacquinot Bay but at a later date around 2,100-2,000 years ago in Manus Province to the north of New Britain (Kennedy, 1982: fig. 2; Wu 2016, pp. 357-363). The Liton River 'spout' could be the top of a stand to support a flat-bottomed bowl (S. Bedford, personal communication), though this seems unlikely in view of the narrow diameter of the rim (about 30 mm), but another possibility is that the unusual relief decoration imitates a metal technique. This is a speculative suggestion that is open to debate, but it raises the possibility of connection to island Southeast Asia, where poorly dated double-spouted vessels are known at the Niah cave complex in Sarawak on Borneo (Harrisson, 1971; Wu, 2016, pp. 365-366). This possible pottery link back to metal-age societies in island Southeast Asia is intriguing in light of a small bronze item found in Manus Province and dated to about 2,000-2,100 years ago, which most likely came from island Southeast Asia (Ambrose 1988). We know that obsidian and pottery from Manus Province were reaching Lapita pottery sites in New Britain (Summerhayes, 2003, 2009; Dickinson, 2000), presumably continuing earlier links across the Bismarck Sea between artisans working at the New Britain obsidian sources and those of the Manus area before the appearance of Lapita pottery (Torrence et al., 2009). This speculation remains to be tested.

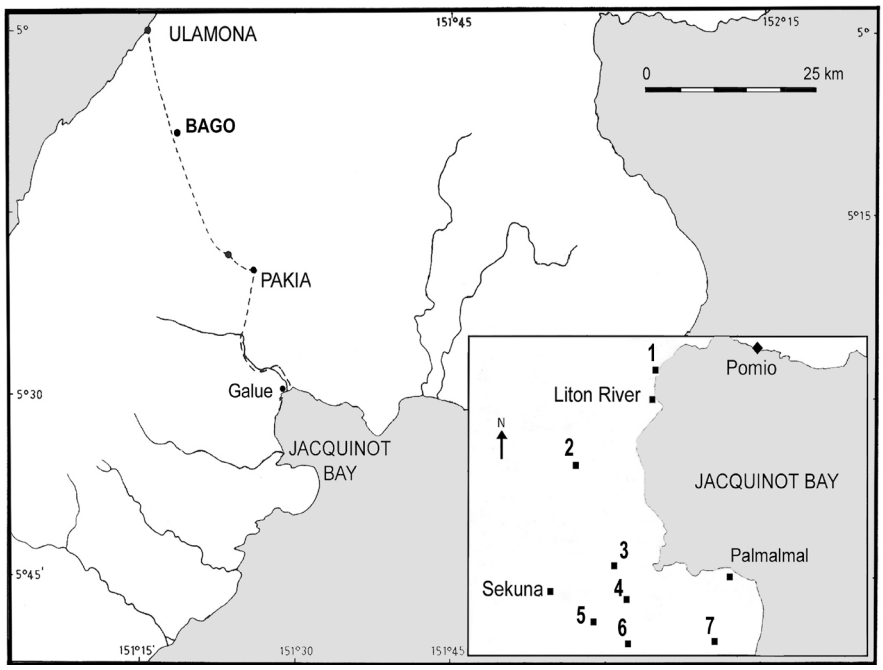

Figure 18: *Map of the field study area showing approximate locations of the Liton River (Baien village) Lapita site and the rock art sites. Image credit: J. Specht, 2022.*

The most striking evidence of the past occupation of the Jacquinot Bay area comes from rock art sites (Figure 19). Between 2015 and 2019 we recorded six sites known to local people, including one previously reported by a French speleological team (Guillot, 2005a, 2005b). All six sites are engravings or carvings on limestone; no painted sites have yet been reported. The site known as Mata Pilo (stands at beach level between Baien and Galuwe villages and consists of a unique high-relief figure carved on flowstone formed on the vertical cliff face. It appears to be a human-like figure with fish, snake and other engravings on various parts of the body. Several metres further along the beach from this figure is what may be the heavily weathered remains of another one.

Figure 19: *Nakanai Rock Art sites*

A *Image credit: J. Specht, 2015.*

B *Image credit: J. Specht, 2015.*

C *Image credit: J. Specht, 2015.*

D *Image credit: J. Specht, 2015.*

E *Image credit: J. Specht, 2017*

F *Image credit: J. Specht, 2019*

A: Marana Kapate entrance area with various 'face' or 'mask' motifs and geometrics.
B: Nutu Lilia main panel, with traditional guardian Gabriel Lualiu of Puapal village.
C: Mata Pilo showing the main well-preserved figure (left) and the heavily weathered figure (right).
D: Pinasi site on the oil palm plantation, showing recent finger-tracing over the engravings of a fish (bottom right) and indeterminate forms, including a possible 'foot' or 'hand' obscured by the finger-tracing.
E: Pelaunga site on the oil palm plantation showing fish, circles and a crescent, and indeterminate forms, all with finger-tracing over them.
F: Kapelo 'walk through' cave, with cupule marks on part of the wall leading to a cavity associated with a local myth.

Two sites currently within a Gilford Oil Palm Plantation have series of fish forms, oval to round elements and others of uncertain form. A third site just outside the boundary of the plantation appears to represent several schematic faces and other elements. (Figure 19, D). All three sites are in old, soft limestone that has allowed local people to re-trace some of the designs.

The fifth site, Marana Kapate, is a cave about 1.5 km inland from the south coast. One side of the entrance is covered with high stylised faces and other elements, including vertical lines of short straight lines, various geometric forms including concentric arcs and a possible turtle shape (Guillot 2005a, b). They extend for over 20 m into the back of the cave where they are in total darkness (Figure 19, A). Some motifs are covered with a thin layer of flowstone, suggesting that they are reasonably old.

The final site variously recorded as Kapelo, Kaipo and Kapol, is a 'walk-through' passage through the limestone, several kilometres inland where people took refuge during the Pacific War of 1941-1945. There are several areas of engravings that form irregular geometric composition, and a large area of 'cupules', small circular holes made into the limestone surface. Such cupules are very common in the Witu Islands (Byrne 2013) and Garua Island of New Britain (R. Torrence, personal communication; Wilson, 2002, plate 7); their meaning, function and age are unknown, though Wilson (2002, p. 209) places them around 3,000 years ago at the beginning of her Vanuatu rock art sequence.

An additional site in the Jacquinot Bay area is known to local peoples but has yet to be recorded. Further rock art sites in the Uvol area to the west of Jacquinot Bay, located on the edge of the Nakanai karst, are listed on the National Register of Ancestral and Archaeological sites at the National Museum of Papua New Guinea but nothing is known about their motifs.

None of the rock art sites is dated, except for the obviously recent engravings. Meredith Wilson (2002, 2004) proposed a chronology that sees the start of rock art in Vanuatu at about 3,300 years ago with cupules, more or less contemporary with the appearance of Lapita pottery. There is no reason to assume that the New Britain rock art is older than this, given the similarities between the motifs in each area, but neither on the other hand should we assume that all sites are of the same age. What is remarkable about them is that they occur in three completely different physical contexts: on a beach, in a cave and on vertical rock surface in open air. It is tempting to speculate that these locations were deliberately chosen for separate kinds of activities; whatever they may have been, we can only speculate.

Finally, throughout the Nakanai Mountains region there are many stray finds of stone items such as axe and adze blades, rounded objects often described by archaeologists as 'pestles' though interpreted by local people as belonging to rituals for growing taro (Figure 20). A most unusual carved object from the Bago area (Figure 23) appears to be part of a larger object, though what that object was remains uncertain.

Figure 20: *Find spot of stone pestle; New Britain, Jacquinot Bay. Image credit: Felix Speiser, 1930 © (F)Vb 68; Museum der Kulturen Basel.*

Figure 21: *Possible grindstone from Malakur Village. Image credit: J. Specht, 1984.*

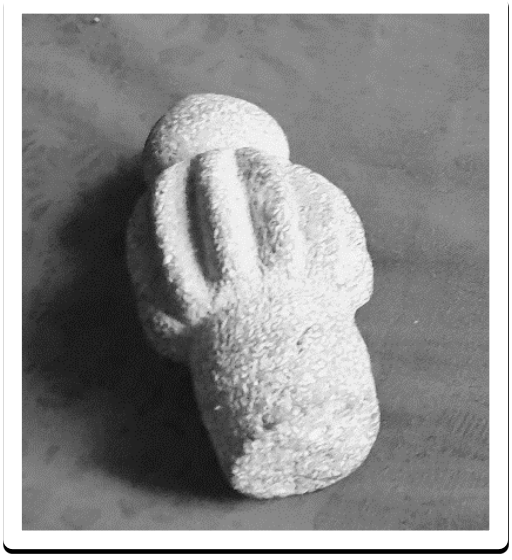

Figure 22: *Carved stone from Bago area reported by J. Gabriel & M. Wood. Image credit: J. Gabriel, 2016.*

An unexpected item seen in Malakur village in 1984 is a volcanic rock with a smooth surface like a grindstone (Figure 21). This would have been suitable for grinding axe and adze blades perhaps for repairing them rather than for making them from scratch. 'Pestles', on the other hand, were made from a much softer stone and were probably formed by scraping and rubbing with rough materials such as sand, shark skin and certain leaves. As with obsidian and chert, the rock types from which the axe and adze blades and the grindstone items were made are foreign to the Jacquinot Bay – karst areas and are further evidence of the extensive trading links enjoyed by the people of the region.

The archaeological evidence currently available for the pre-colonial period in the Nakanai Mountains region, and the Jacquinot Bay area in particular is sparse, and allows little more than speculation. There is no evidence to indicate that the region was occupied as early as Kupona na Daro or the Passismanua area, though this is a possibility. We have no information about the lifeways of the inhabitants through time, though we can deduce their participation in extensive social networks extending throughout New Britain and further afield through the movement of stone items across many millennia.

It is likely that throughout history people have preferred to live close to the coasts and did not live permanently in the rugged interior of the Nakanai karst country where there are few surface water sources, though no doubt they would have entered it for hunting or to obtain bush products, or when following cross-island trade routes. These intermittent forays may be witnessed by the discovery of the chert tool and human bones in two caves, one at seven hours walk inland at nearly 1000 m above sea level and the other at a somewhat lower altitude closer to the coast (Guillot 2014: 15). The distance inland of these finds makes it unlikely that the bodies were taken there for disposal from a coastal settlement; perhaps the bones are the remains of victims of unfortunate accidents in this dangerous karst country.

One aspect that has yet to be addressed is the landscape history of the region. At several locations around the bay, such as Baien village and the islands just off Palmalmal Station, there are accounts of land being lost within living memory, though whether by erosion, subsidence or both is not always clear. This may further complicate the discovery or excavation of archaeological sites such as the Liton River Lapita pottery site. It is worth remembering, however, that Lapita pottery sites usually occur in clusters of up to six or eight, frequently within sight of each other, and so other Lapita pottery sites are very likely to be located around the Bay (cf. Specht and Torrence, 2007; Specht et al., 2016).

Around the southwest margin of the Bay from Cape Cunningham westwards, there is clear evidence for the uplift of coral terraces over the last 10,000 years (Riker-Coleman et al., 2006), on which early occupational evidence may be preserved, though sites predating 10,000 years ago are now likely to be some way inland. Locating them will be a challenge.

UNIQUE FAUNA AND FLORA OF THE REGION

The Nakanai region is an extremely bio-diverse ecosystem, harbouring large numbers of endemic species of plants and animals.

Rapid Biological Assessment (2009)

In April 2009, a team of scientists from Conservation International and the Papua New Guinea Institute of Biological Research joined with local landowners to survey the biodiversity of East New Britain's rainforest covered Nakanai Mountains. The 2009 Rapid Assessment (RAP) Survey was conducted at three sites along an elevational gradient between 200 metres and 1,590 metres. Exceptional results were obtained. A report entitled *Rapid Biological Assessments of the Nakanai Mountains and the upper Strickland Basin: Surveying the biodiversity of Papua New Guinea's sublime karst environments* outlines the findings (Richards & Gamui, 2011). The survey documented more than sixty-four species of birds in the Nakanai Mountains, seven of which are endemic to the Island. The most significant of these was a very rare sighting of the slatey-backed goshawk (*Accipiter luteoschistaceus*), an uncommon species endemic to New Britain and nearby Umboi Island.

More than 100 species of spiders were documented, of which at least 50 appear to be undescribed. 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-plus 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 (Richards & Gamui 2011, pp. 20-21).

Figure 23: *Previously undescribed species of montane mouse. Image credit: Richards & Gamui, 2011, p. 44.*

The survey of mammals around three sites in the Nakanai Mountains – Lamas, Vouvou, and Tompoi identified 26 species, including 10 species of terrestrial mammals. It appears that three species of mammals from the high elevation site are undescribed, including two rats and a white-tailed mouse (Figure 23) that represents a previously unknown genus. The long-tailed mouse was located at the high elevation site (1590m above sea level) in the Nakanai Mountains. Although it resembles the prehensile-tailed tree mice of PNG, this remarkable new species has no close relatives and represents an entirely new genus

The newly documented mouse has narrow feet and forward-directed incisors that may be used for digging and carrying soil, suggesting that it might be a burrower that lives most of its life at or near the forest floor. Its long, pure white tail tip distinguishes it from all other mice in the area. The results of the mammal survey confirmed that the island has its own endemic species of mammals.

A total of 23 frog and 16 reptile species were documented in the Nakanai Mountains. Four species of frogs are new to science, with the highest proportion of previously undescribed frog species located

at the site with the highest elevation (1,500-1,700 metres) (Figure 25). Amongst the newly discovered frogs is a striking, yellow-spotted species of the genus *Platymantis* (*Platymantis sp. nov.*). This unique frog (Figure 27) was found only at the highest elevations surveyed in the Nakanai Mountains (Richards & Gamui, 2011). Thirty-two species of dragonflies and damselfies (*Odonata*) were collected in the Nakanai Mountains at three different elevations between 200-1,700 metres and, to a minor extent, on the coastal fringe of Jacquinot Bay. Ten species were recorded from New Britain Island for the first time

Figure 24: *The colourful dragonfly, Agrionoptera insignis similis, was common near small streams in disturbed forest around Palmalmal Village. Image credit: Richards & Gamui, 2011, p. 41.*

Figure 25: *The Platymantis species is new to science and known only from the cold, wet forests atop the Galowe Plateau in the Nakanai Mountains. Image credit: Richards & Gamui, 2011, p. 42.*

Figure 26: *Rhytidoponera sp., an ant collected during the Nakanai RAP expedition. Image credit: Richards & Gamui, 2011, p. 38.*

Figure 27: *A shrub dwelling Platymantis is new to science and known only from the highest elevations accessed during the 2009 survey. Image credit: Richards & Gamui, 2011, p.42.*

Preliminary botanical survey (2019)

Figure 28: *Jacquinot Bay, Pomio. Image credit: F. Venter & D. Crayn 2019.*

The Pomio - Pakia area has been neglected in the past by botanists with only a few collections made by A.N. Millar (October 1968) and M. Panoff (January 1968 & November 1969). The vegetation is disturbed to various degrees near the coast and at Pakia with the rest of the area relatively undisturbed. To our knowledge, no detailed vegetation survey has been conducted on New Britain to date. In 2019, Professor Darryn Crayn and Dr Fanie Venter from the Australian Herbarium at James Cook University (Cairns, Australia) conducted a preliminary botanical survey in Pomio. The vegetation survey describes the flora along the three survey routes and cannot be regarded as representative of the whole Pomio - Pakia area.

The timed meander survey method was used where the selected area was covered in a random manner so as to maximise the coverage of the habitat (Goff *et al*. 1982). Sample tracks were chosen based on differences in plant communities, elevation, and topography. Three areas were surveyed near Pomio (Figures 29, 30 & 31).

1) Road from Pomio to Pakia (50–1050 m elevation). The 30+ km long unpaved road runs through medium crowned forest at lower elevations (50–700 m) to small, crowned forest with *Nothofagus* (950–1050 m) to mixed small, crowned forest at Pakia.

2. Footpath from Pomio Primary School to Olaipuna Village (30–210 m elevation). The footpath leading from Pomio to Olaipuna Village is just over 1 km long and runs through medium crowned forest.

3) Beach area from Galuwe along the beach for 1.5 km (10–60 m elevation). The survey area stretched from the high tide mark to the road that runs parallel to the beach. The vegetation consists of Littoral Forest with Mangrove Forest along the creek.

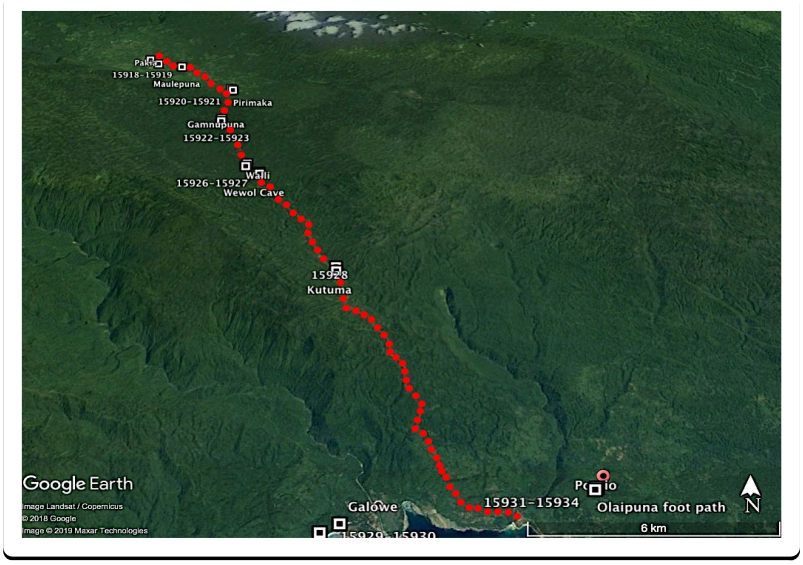

Figure 29*: Survey route along road from Pomio to Pakia. Numbers are the Venter & Crayn collector numbers.*

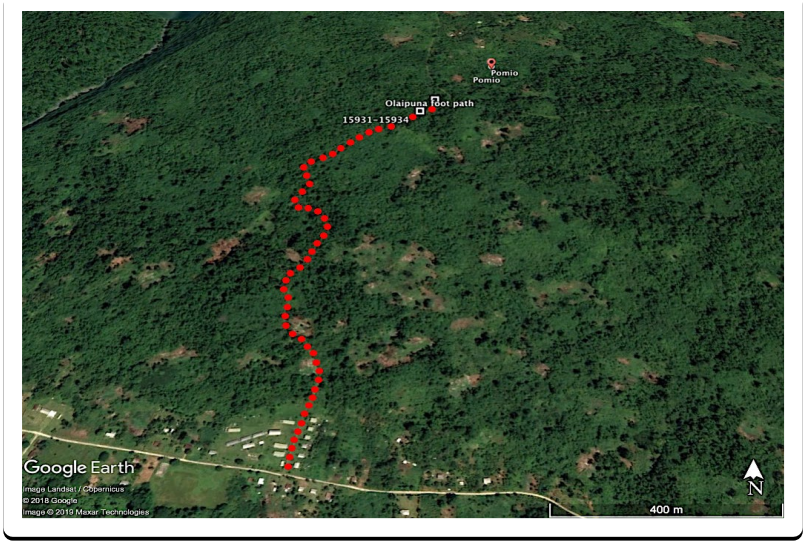

Figure 30: *Survey route along footpath from Pomio to Olaipuna Village. Numbers are the Venter & Crayn collector numbers.*

Figure 31: *Survey route at Galuwe. Numbers are the Venter & Crayn collector numbers.*

Herbarium specimens of selected plant taxa were collected for the purpose of confirming the identification at the PNG National Herbarium, Forest Research Institute (FRI) in Lae. Collecting was done with the permission from local landowners in Pakia, and the FRI. These specimens are housed in the plant collection of the National Herbarium in Lae with a duplicate set of specimens transferred to the Australian Tropical Herbarium at James Cook University, Cairns, Australia, with permission granted by the FRI to export this material.

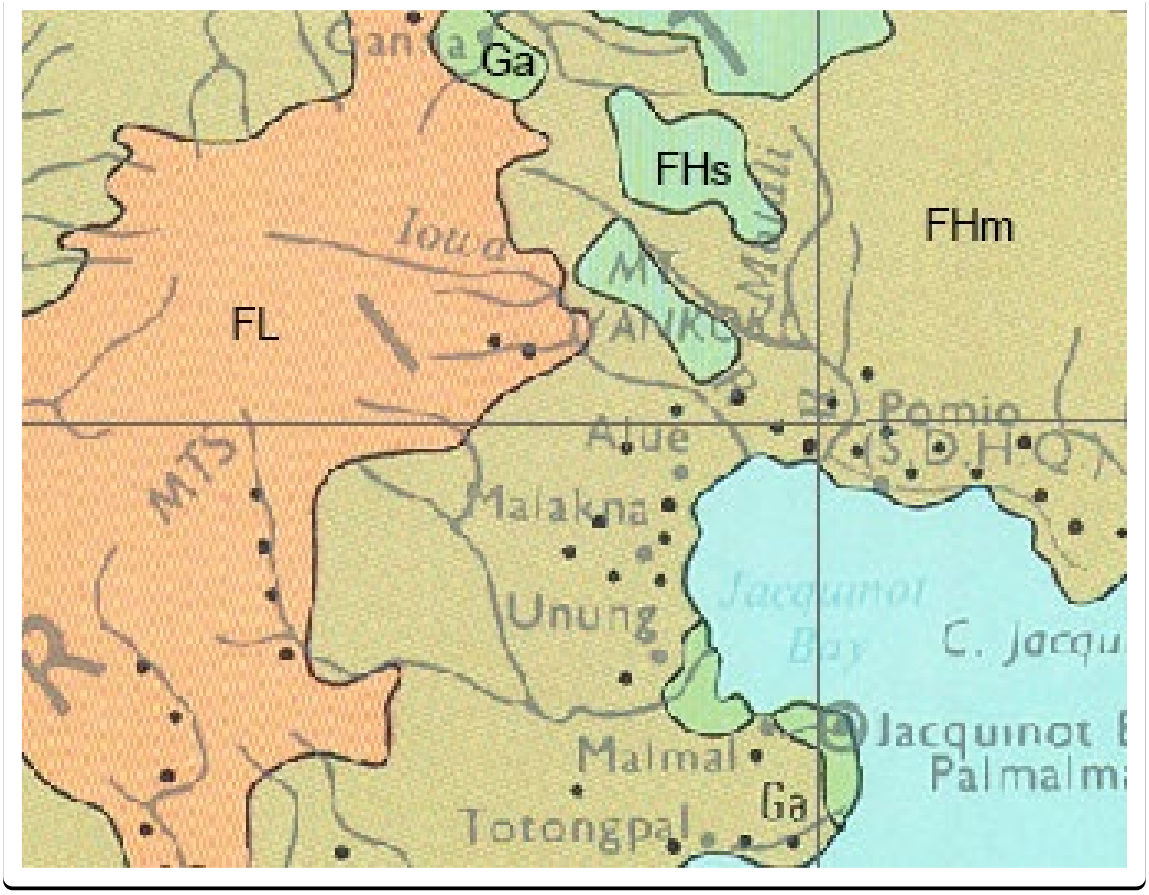

Figure 32: *FIMS Vegetation map of Survey Area*
Ga = Grassland, human disturbance, FHm = Low altitude medium crowned forest on uplands below 1000 m, FHs = Low altitude small crowned lower montane forest on uplands below 1000 m and FL = lower montane small, crowned forest above 1000 m.

Results

Plant communities in PNG have been broadly mapped (Fig. 4) using aerial photography and GIS-based algorithms (Saunders 1993, Hammermaster & Saunders 1995). From a total of 63 FIMS typing codes, three (FHm, FHs, FL) were present in the survey areas. The PNG mapping protocols serves as a basis for standardization of forest descriptions across Papua New Guinea.

A total of 101 families, 258 genera and 338 species of plants were recorded during the field survey (Table 1).

Table 1: Taxonomic counts by vascular plant category

Group	Pteridophytes	Gymnosperms	Monocots	Dicots	TOTAL
Families	18	1	15	67	101
Genera	33	1	51	173	258
Species	32	1	62	243	338

Coastal Communities

The plant communities along the Galuwe beach (Figure 33) are moderately intact despite the adjoining old logging camp. No hardwood tree species occur in this vegetation community and because of this, the logging company did not target it.

Dominant tree species of this vegetation community are *Milletia pinnata*, *Intsia bijuga*, *Syzygium aqueum*, *Calophyllum inophyllum* and *Terminalia catappa*. Dominant shrub species are *Polyscias pacifica*, *P. prolifera* and *Scaevola taccada* with *Nephrolepis lauterbachii*, *Myrmecodia tuberosa*, *Drynaria sparsisora*, *Asplenium nidus*, *Hoya* spp., *and Dischidia* spp. as the dominant epiphyte species.

Figure 33: *Littoral Forest at Galuwe beach. Image credit: F. Venter and D. Crayn, 2019.*

Road from Pomio to Pakia

The vegetation along the road for the first 10 km from Pomio is medium crowned forest with *Cerbera floribunda*, *Terminalia complanata*, *Aglaia sapindina*, *Ficus pungens* and *Pometia pinnata* the dominant tree species with *Saurauia conferta* and *Neolitsea brassii* the dominant shrub species. At 800 m elevation the forest is dominated by *Nothofagus resinosa* and *Nothofagus starkenborghiorum* with the latter species dominant. The understory in this forest type is low and consists mainly of fern and palm species with various Urticaceae forb species. Plants of the palm *Hydriastele costata* are emergent in the *Nothofagus* forest (Figure 34).

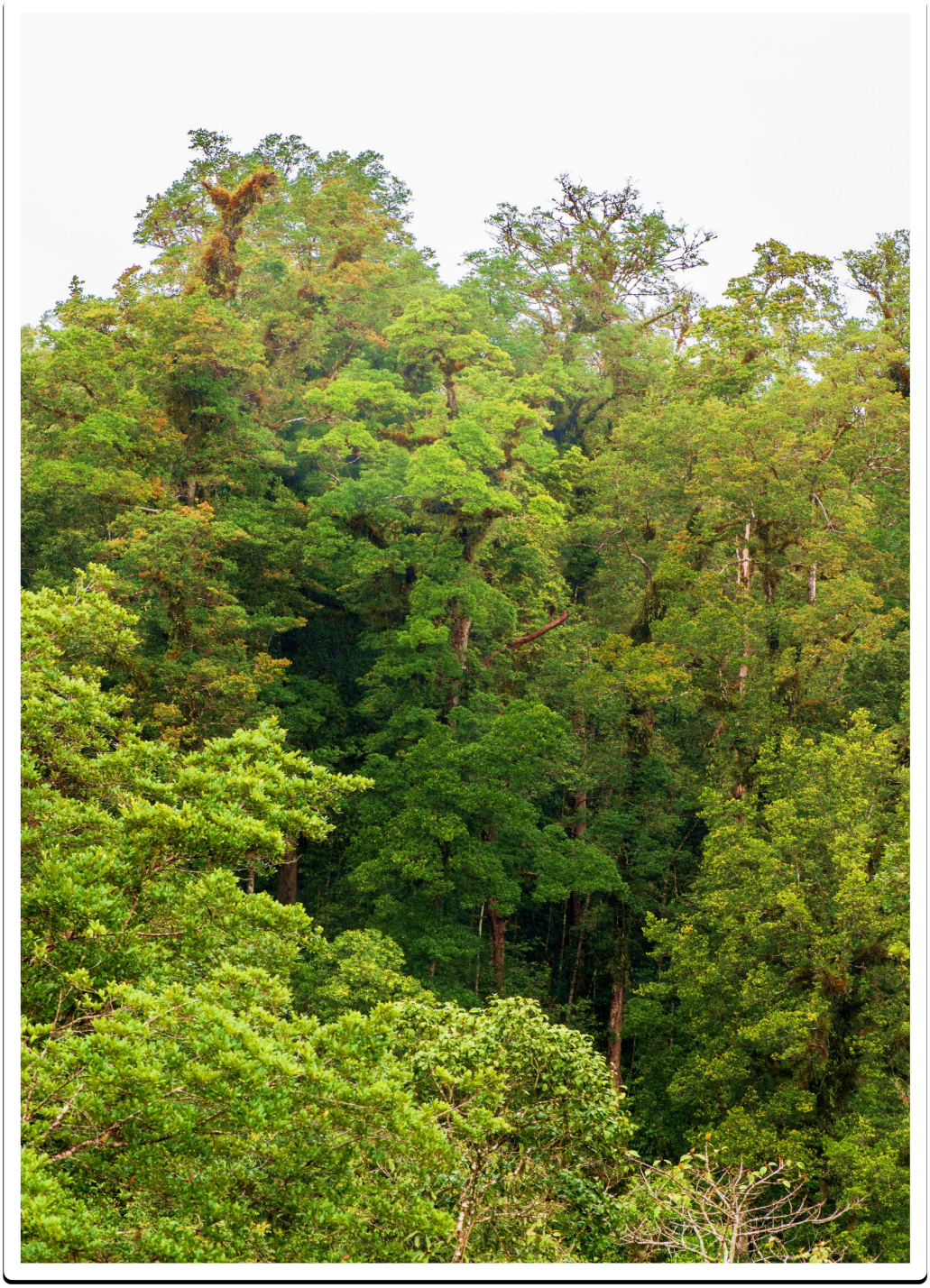

Figure 34: *Nothofagus forest near Pirimaka. Image credit: F. Venter & D. Crayn, 2019.*

The vegetation from Pirimaka to Pakia consists of small crowned forest (Figure 35). *Nothofagus* is less dominant in these forests but still occurs in isolated communities. Dominant tree species of the small crowned forest are *Rhus taitensis*, *Celtis philippensis*, *Dillenia schlechteri*, *Papuacedrus papuana*, *Ficus* spp., *Syzygium* spp., *Pometia pinnata* and *Terminalia sepicana* with *Myristica subalulata*, *Myrsine leucantha* and *Symplocos cochinchinensis* subsp. *leptophylla* as the dominant shrub species.

Figure 35: *Small crowned forest understory. Image credit: F. Venter & D. Crayn, 2019.*

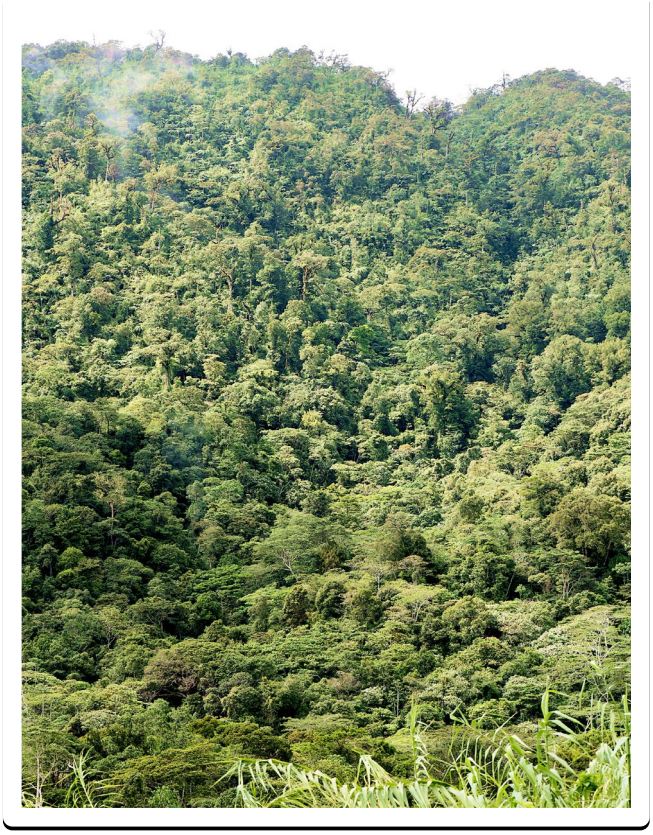

Figure 36*: Small crowned forest at Pakia. Image credit: F. Venter & D. Crayn, 2019.*

Pomio Primary School to Olaipuna Village

The vegetation along the entire footpath consists of medium crowned forest (Figure 37) with *Cerbera floribunda*, *Terminalia complanata*, *Aglaia sapindina*, *Ficus pungens* and *Pometia pinnata* the dominant tree species, and *Saurauia conferta*, *Neolitsea brassii*, *Alpinia oceanicum*, *Hornstedtia scottiana* and *Pleuranthodium racemigerum* the dominant shrub species. Various species of Araceae and Urticaceae are common in ground layer. The medium crowned forest is much richer in species than the small, crowned forest or the *Nothofagus* forest.

Figure 37: *Medium crowned forest along the footpath to Olaipuna Village. Image credit: F. Venter & D. Crayn, 2019.*

IUCN Red List species

***Intsia bijuga* (Fabaceae) – NT (Near Threatened)**

Listed as Near Threatened (NT) in the IUCN Red List of Threatened Species. It occurs occasionally in the Littoral forest at Galuwe. The population is stable with a number of plants in each life history cohort. At least one adult tree appeared to have been felled and cut into planks by local people.

***Terminalia brassii* (Combretaceae) – NT (Near Threatened)**

Listed as Near Threatened (NT) in the IUCN Red List of Threatened Species. Three mature specimens were recorded near the top of the footpath to Olaipuna Village.

Language Names for Terrestrial and Marine Fauna and Flora

In 2015, during a short fieldwork trip by James Cook University Researchers Assoc. Professor Simon Foale and Sopa Caleb, Mengen language names were obtained for a total of 95 plant species from *Medicinal plants of Papua New Guinea*. (Holdsworth, 1977). Uses, including food, medicine, building materials, magic, fishing equipment, and more were recorded against each Mengen plant name. Mengen names for taro were also recorded, and it was noted that people are always bringing new taro (*Colocasia esculenta*) cultivars home whenever they travel to other villages or provinces, and while these are given names to identify their provenance, sometimes they are not easy to distinguish physically from local cultivars.[10]

Mengen language names for fish were solicited by asking local informants, both individually and as a group, to go through a set of illustrations of fish. The illustrations were contained in two books – one on reef fish (Allen, 2009) and one on reef associated fauna more broadly (Allen & Steene, 2002) – as well as illustrated resources on pelagic fish, seabird, turtle and marine mammal species, mainly provided by the Secretariat of the Pacific Community (SPC) and the Food and Agriculture Organisation (FAO). Interviews took place primarily at Palmalmal, Malop Village and Pomio Station. A small number of slight differences in pronunciation of Mengen names among the different informants were recorded, but overall, there was a high level of agreement.

For marine fauna, more than 350 unique Mengen names were recorded, with the greatest level of taxonomic elaboration occurring in fish and invertebrate families or orders with higher salience, primarily due to food value. Species-rich fish families with relatively low local salience, such as Chaetodontidae (butterflyfishes), Pomacentridae (Damselfishes) Gobiidae (Gobies) and Blenniidae (Blennies), had relatively few corresponding species-level Mengen names and tended to be grouped under generic terms. The same applied to corals, for which a generic term was obtained (*Valvali*) but no specific Mengen terms at all.

Families of larger fish that are typically harvested for food, such as Lutjanidae (snappers), Lethrinidae (emperors), Epinephelidae (groupers) and Acanthuridae (surgeonfishes) tended to have a higher proportion of species-level Mengen names. This pattern of 'lumping' of scientific taxa of comparatively low salience is found across the Pacific (Cohen et al., 2014; Foale, 1998; Foale et al., 2016; Ross et al., 2011). While sea cucumbers (Mengen generic: *Popooghe*) are harvested and processed for the beche-de-mer trade in Jacquinot Bay area of Pomio, people traditionally did not eat them for subsistence.

In the course of recording the names, some interesting stories about fish were also recorded, including the assertion by two informants that 1) Lizardfish (*Synodus* spp.; *Kukulevoro*) (Figure 38) and 2) flying fish (Fam: Exocetidae; Siisi), respectively, are known to fly into gardens at night in order to eat ripe bananas.

[10] In the 1970s, anthropologist Francoise Panoff recorded more than 100 names for taro cultivars.

Figure 38: *Lizardfish (Synodus spp.; Kukulevoro). Image Credit: Simon Foale.*

People know the spawning cycles of Palolo worms (*Palola viridis*) (Mengen: *Matmata*) in Jacquinot Bay and harvest them when they emerge. It appears that Mengen people are also familiar with the timing of seasonal schools of amphidromous gobies entering rivers to migrate upstream, and traditionally harvest them at this time. More information on this may be possible with further fieldwork. Further research is also needed to explore the etymologies of most of the Mengen names collected, many of which are likely to embody substantial local knowledge of behaviour and ecology of corresponding species (Foale, 1998). An example from the Mengen data includes: *Kuruvo* (Stonefish: *Synancea verrucosa*): *Kuru* = 'reef'; *vo* = 'inflicts injury'.

The language names for plant data obtained during the fieldwork shows a generally high level of species-level correspondence. This, and the fact that a large number of named taro cultivars was collected in a short field trip suggests that 'cultural continuity' in the Nakanai Ranges is very strong. While the marine fauna data is of a somewhat different nature, it also supports this conclusion.

UNESCO WORLD HERITAGE TENTATIVE LIST: THE SUBLIME KARSTS OF PAPUA NEW GUINEA

In 2001 at the World Heritage Conference held at the Gunung Mulu National Park in Sarawak (Malaysia), the Nakanai Caves and the karst areas of Papua New Guinea were first touted as potential World Heritage sites (Audra, Gill, Hamilton-Smith, Sounier & Salas, 2005). The three Natural Heritage Properties that were identified, and now comprise the listing 'The Sublime Karsts of PNG' on the tentative world heritage list include Nakanai, Muller Plateau and Hindenburg Wall.

A proposal document entitled *Conserving the Sublime Karst of Papua New Guinea* was prepared under the Task Force on Cave and Karst Protection (Audra et al., 2005). The document outlined plans for the long-term goal of World Heritage status for the Nakanai Caves and other major karst areas in Papua New Guinea. The international working group included Maureen Ewai, representing Conservation International, and Florence Paisarea, then East New Britain Provincial Environment Officer. Supporting the long-term objective of creating the 'Nakanai Mountains Conservation Area', and eventually to propose the area for World Heritage Status, Professor Elery Hamilton Smith from Australia joined the group for meetings in Rabaul with Provincial Government officials (Gill, 2012).

In 2006, the Government of Papua New Guinea nominated seven areas to the World Heritage Tentative List, including The Sublime Karsts of Papua New Guinea. Places on the Tentative List are not necessarily already protected, but instead send a signal to the international community that Papua New Guinea possesses areas of outstanding universal value (World Heritage) and is committed to protecting these areas.

Justification for Outstanding Universal Value

The following text is a reprinted in its entirety (unedited) from the report entitled *Untamed Rivers of East New Britain* (Gill, 2012, p. 27-33). While the *Sublime Karsts of Papua New Guinea* include Nakanai Range, Muller Range and Hindenberg Range, only the justification criteria for Nakanai Range are included below.

Nakanai Range

(v) An outstanding example of a traditional human settlement, land use and sea-use which is representative of a culture (or cultures) and human interaction with the environment when it has become vulnerable under the impact of irreversible change (Gill, 2012, p. 29).

The cultural significance of the indigenous clans is a vital and integral part of the Nakanai Mountains. Their traditions and beliefs are as important as the biodiversity and caves of this unique part of the world. As in many parts of Papua New Guinea, traditional culture and lifestyle remains relatively intact, in spite of persistent modernism. The bond to traditional lands provides a remarkably stable basis for both community and personal sense of identity. It offers a stable cultural basis from which the people have been able to adapt to and function well within the culture of modernism without abandoning their traditional culture. In the Nakanai, this means that the various villages generally remain true to their cultural traditions, pursuing a hunter-gather lifestyle integrated with simple agriculture.

> (vii) Contains superlative natural phenomena and areas of exceptional natural beauty and aesthetic importance (Gill, 2012, p. 30).

The geological history covers a period of 43 million years and the mountains exhibit rapid uplifting, some of the highest recorded. The majority of the mountain range lies within the Yalam limestone and is a karst limestone up to 1.5 kilometres in thickness, deposited over a period of 17 million years. The limestone regions contain numerous white-water rivers situated in spectacular one kilometre deep gorges. Large rivers can be seen issuing from caves as beautiful waterfalls from high above the river level. There are many massive sinkholes with collapsed dolines up to 400 metres deep and 500 metres in diameter. At the base of the dolines some of the world's largest and most turbulent underground rivers flow, some of them at over 20 tons of water a second in caves of outstanding natural beauty and immense proportions.

The caves are of international importance and are unique as they are considered to be among the most active river caves in the world and are certainly some of the most technically difficult caves in the world to explore. Muruk Cave is 17 kilometres long and 1178 kilometres deep, the second deepest cave in the Southern hemisphere and one of the most beautiful 1000 metre deep caves in the world. The entrance pitch of Nare is one of the most impressive known being 250 metres deep with a massive river flowing along the base into one of the largest river passages in the world. Minye cave possesses one of the biggest pitch entrances at 410 metres in depth. At the bottom a river, carrying 15 cubic metres of water per second, roars into the immense cave.

Kavakuna is also a giant doline with its 392 metre deep entrance pitch. One side is not vertical so this cave is suitable for adventure eco-tourism. The coastal regions are also of exceptional natural beauty and exhibit raised coral reefs and terraces up to 200 metres above sea level with numerous pure white coral sand beaches fringed with palms.

> (viii) An outstanding example representing major stages of earth's history, including the record of life, significant ongoing geological processes in the development of landforms, and significant geomorphic physio-geographic features (Gill, 2012, p. 29).

Although the very real problems of access have constrained research at this stage, and the region is still far from being fully understood, the geomorphology of the karst certainly has a multitude of distinctive features which result from its turbulent history of tectonic movement, volcanism, heavy rainfall, limestone deposition and intense karstification.

> (ix) Outstanding examples representing significant ongoing ecological and biological processes in the evolution and development of terrestrial, freshwater, coastal and marine ecosystems and communities of plants and animals (Gill, 2012, p. 29).

As with so many of the isolated areas of Papua New Guinea, the Nakanai is unique in its geological evolution and its biodiversity. In particular, it demonstrates high levels of localisation and endemism, with various adaptions to the remarkable karst environment. Over 20 new species of troglobitic or stygiobitic fauna have been collected from the caves, although few of these have yet been named and described.

The mountains range in altitude from sea level to 2,185 metres and are predominantly covered by primary tropical rain forest of lowland and montane types but with relatively few large trees. Although the vegetation has not yet been adequately studied, it is particularly rich in epiphytic species and is considered of high biological importance. Many species are endemic to New Britain and are found

nowhere else on earth. This is only a small proportion of the estimated total and no doubt there will be thousands more species identified with further research. There are also a number of ecologically important mangrove swamp forests. Estuarine crocodiles and Leather Back Turtles inhabit the coastal waters along with a vast variety of marine species. The pristine and biologically important reefs lie close to shore with a huge diversity of coral forms and marine life.

> (x) The most important and significance natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation (Gill, 2012, p, 30).

Although faunal and floral inventories are only at an early stage, there are at least eight species of endemic or near endemic mammals, and at least four of these are recognised as endangered. Similarly, there are 22 endemic or near endemic species of birds, including eight that are recognised as threatened.

Update: In 2015, based upon the known values, it has been recommended in a formal review of PNGs Tentative World Heritage Sites that the PNG World Heritage Secretariat/Committee create a separate Tentative Listed area for the Nakanai Mountains (Hitchcock & Gabriel, 2015).

National Conservation Priority

A Land-Sea Conservation Assessment for Papua New Guinea (Adams et al 2017) has identified Nakanai (No. 49, Figure 39) as a Priority Area of National interest.

> Areas of Interest (AOIs) are a subset of the conservation assessment priorities that have been identified as areas critical for immediate conservation attention. Areas of Interest (AOIs) were identified through expert workshops in November 2016 and further vetted in March 2017 to identify National priorities (A) that should receive immediate investment and Provincial priorities (A1). (GPNG 2017, p. 3).

The size of the proposed conservation area for the Nakanai Conservation Area (CA) is identified in the National Biodiversity Strategic Action Plan (2019-2024) as 454,522.6 ha (GPNG 2019, p. 16).

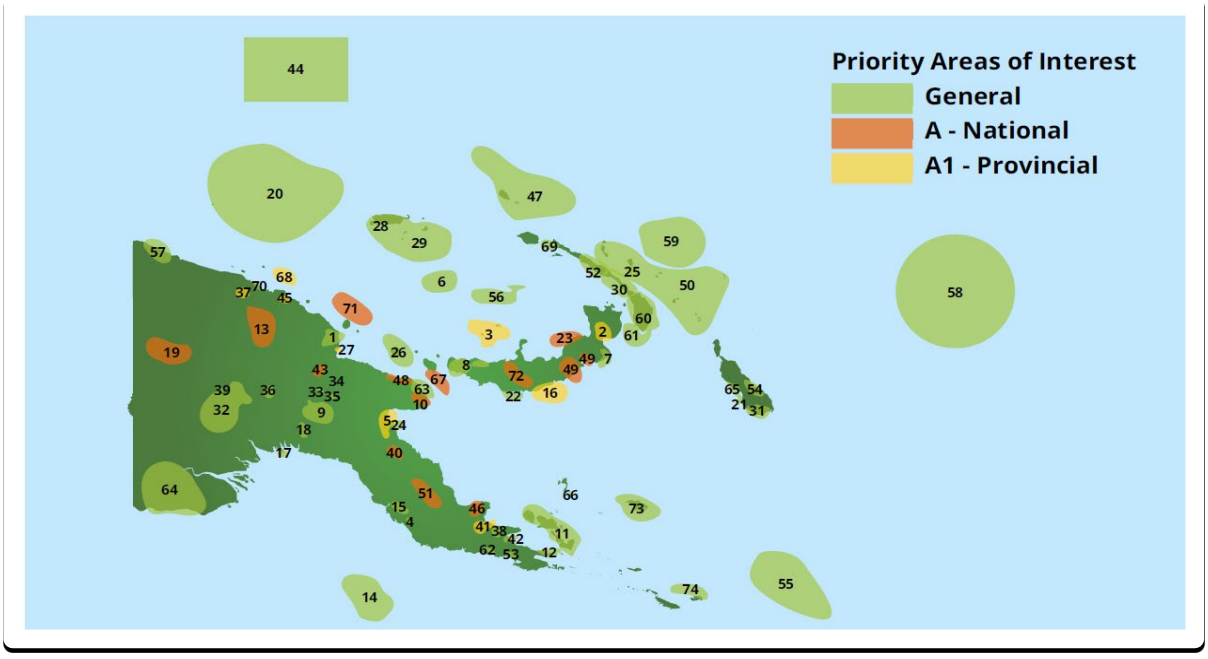

***Figure 39**: National Priority Areas (CEPA, 2017, p.3)*

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