

Ecological Study Along the Highlands Highway in Papua New Guinea

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Abstract— This ecological survey carried out along the Highlands Highway (71 locations-bridges) between Erap Bridge in Morobe Province to Whagi Bridge, Western Highlands Province. Data and information collection involved physical site observations and informant interviews. The survey used the capture-release method for insects, invertebrates, fish, and plankton; flyover counts were used for birds and informant interviews for mammals and other animals of interest. Terrestrial ecosystem: Common fauna included invertebrates such as *Eurema hecabe*, *Danaus plexippus*, *Plutella xylostella*, and other types of butterflies, Anisoptera, *Apis cerena*, and black ants (*Fomicidae*). Vertebrates such as sparrows (*Passeridae*), willy wagtail (*Rhipidura leucophrys*), eagle (*Hieraaetus weiskei*), kingfisher (*Alcedinidae*), mountain cuscus (*Phalanger carmelitae*), tree kangaroo (*Dendrolagus goodfellowii*) and Princess Stephanie's *Astrapia* (*Astrapia. Stephaniae*). Flora across the highlands province commonly appeared bamboo, casuarina oligodon (she-oak), *Ficus dammaropsis*, coffee, elephant grass (*Pennisetum purpureum*), cow grass (*Axonopus compressus*), rain tree (*Samanea saman*), *Piper adancum* and banana. In contrast, common and significant flora along plain region included casuarina, pine, leucaena, bamboo, and other anthropogenic grasses, *Piper adancum*, sunflower (*Helianthus annuus*), *Northofagus grandis*, and *Ficus*. Aquatic ecosystem: Aquatic fauna along the highlands region included carp (*Cyprinidae*), tilapia (*Oreochromis mossambica*), juvenile fish, freshwater prawns (*Palaemonidae*), trout (*Oncorhynchus mykiss*), and catfish (*Arius spp*) while aquatic fauna of coastal province comprised of invertebrates like pond skaters, water beetle and tadpoles and invertebrates such as rainbow trout and tilapia. Aquatic flora was limited to green algae at a few locations in the highlands provinces where the water was stagnant or had human impacts, but it was primarily green and brown algae in the plain area. We also found *Dendrolagus goodfellowii* as an endangered species, while *Phalanger carmelitae*, *Astrapia stephaniae*, and *Northofagus grandis* are endemic but classified as the least concern. The findings indicated modification of habitats throughout the Highlands Highway. The absence of native and endemic species was also noted in most of the locations. Only six sites revealed some primary and secondary forests and vegetation.

Keywords— Environmental impact, Highlands Highway, Papua New Guinea.

I. BACKGROUND

The Highlands Highway in Papua New Guinea passes through the coastal province of Morobe to the mountainous Highlands Provinces of Eastern Highlands, Western Highlands, Southern Highlands, Enga, Jiwaka, Hela, and Simbu, which is a densely populated region with a population of over 2.9 million (Census, 2011). The area is spread in its ecology as it ranges from the highest peak

at Mt Wilhelm in the Simbu province at 4,509m above sea level to the lowlands of Kutubu Lake area in the Southern Highlands Province. The provinces of Eastern Highlands, Simbu, Jiwaka, and Western Highlands, where the Highlands Highway passes through, fall into the two ecoregions (Morrison, 2000).

The region is part of the Central Cordillera that outlines two ecoregions of interest, namely the Central Range

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flyover count involved close observation of the bird that flew near or around the location. It enabled the observers to take note of the details of the bird, including its color, size, and type. Birdcalls were also used to identify the bird type. Information about other animals that were not sighted at the time of the survey was gathered through informant interviews. A total of 62 informant interviews were conducted out of the 71 locations surveyed.

Flora. At each site, there was a physical observation of the surrounding vegetation. A physical count of common trees and plant species was carried out to determine their availability. Photographs of plant and tree species were also captured, and a field guide on the Flora of Papua New Guinea was also used to identify common species.

2.2.2. Methods for Aquatic ecosystem

Fauna. The data and information on fish and other aquatic invertebrates were gathered through three main methods - physical sighting of organisms, capture release, and informant interviews. Physical sighting and capture release were used for juvenile fish, prawns, pond skaters, mollusks, and water beetles. These were caught with a net, observed, and released back into the water. For zooplankton, water samples were collected, and a hand lens was used to look at this sample. This was then poured back into the water. Due to the timing of the surveys, informant interviews were also carried out to establish other kinds of fish and aquatic fauna present in each location. Again, a total of 62 interviews were conducted.

Flora. Data for aquatic flora was gathered through physical sightings of water in each location. A water sample was also collected at each site and checked using a hand lens to identify any signs of phytoplankton.

Water, air, and ground temperatures were also recorded to observe any effect on the availability of organisms at different times of the day.

III. RESULT AND DISCUSSION

3.1. Results

The survey found that most of the habitats along the Highlands Highway have had some human impact that modifies the environment and its vegetation. Human settlements in or near the road have changed the ecosystems through clearing for gardening, house construction, washing, and other daily activities. Of these, the environments at two locations - Clean Water River Bridge Km77+800 (B#4) and GorambamPam River Bridge Km113+000 (B#6) - were found to have little or no human impact, thus, appearing to be more natural. Feonoku River Km335+450 (B#51) has a high montane type of vegetation with very short shrubs and trees with a

lesser human impact on the environment. Nurape River Km342+850 (B#52), Kenangi River Km345+200 (B#53), and Baikabai River Km348+400 (B#54) - still have some primary and secondary forests near the mountains close to the bridges. All four locations are located within Watabung in the Daulo District of Eastern Highlands Province, where steep mountains rise from the side of the road with the Highway running through these narrow passages. Villages also appear on the roadsides along the Highway.

Four (4) locations - Zumin River Km133+00 (B#10), Yafatz River Km137+100 (B#1), Bintia River Km151+000 (B#13) and Utwini River Km157+150 (B#15) - all located in the Markham Plains in Morobe Province had little or no data for the aquatic ecosystem. The riverbanks were dried up during the survey due to the dry season. The Markham Plains experiences fluctuating weather conditions that bring long periods of wet or dry spells. These seasons are also influential on the conditions of the Highway. Along the Highway, aquatic flora is primarily green and brown algae observed in rivers where human activities like swimming, laundry, and waste disposal were high.

In addition, nine (9) locations along this section have evidence of quarry activities on or near the bridge - Bena Bena River Km 280+650 (B#42), Kanalipi River Km 288+100 (B#44), Mapemo River 3 Km 10+900 (B#48), Simbu River Km 376+700 (B#55), Garniger River Km401+500 B#58), Miunde River Km 404+500 (B#59), Ahl River Km 414+150 (B#60), Tumam River Km 449+500 (B#68) and Komun River Km 462+100 (B#70). These locations are spread within all four provinces of Eastern Highlands, Simbu, Jiwaka, and Western Highlands. The quarry activities have modified the riverbeds and the surrounding environments where the natural vegetation has been cleared.

Due to modifications by human activities, the vegetation of these locations is also comprised of introduced and exotic species as well as a few local or native species. Common flora across all locations included elephant grass (*Pennisetum purpureum*), cow grass (*Axonopus compressus*), rain tree (*Samanea saman*), *Piper aduncum* and food trees like banana. On locations B#1 to B#19, which are on the coastal side of the Highlands Highway, common flora included betel nut tree (*Areca catechu*), coconut, cogon grass (*Imperata cylindrica*), sensitive grass (*Mimosa pudica*) and food trees such as mango. Also, on locations B#1 and B#6, giant nut grass (*Cypriss rotundas*) was recorded. On locations Undono Creek Km 178+000 (B#20) to Baikabai River Km 348+400 (B#54), which are on the Eastern Highlands side of the Highlands Highway, commonly occurring flora included bamboo, *Casuarina*

oligodon (she-oak), *Ficus dammaropsis* and coffee. These have mostly been planted by local people. Anthropogenic grasses (elephant grass, kunai, pitpit, etc.) are quite common, where human activities have gone on for some time. *Piper aduncum* was also common in modified vegetation. The only location with some native species such as *Nothofagus grandis* and *Ficus* species that can still be seen include Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River Km 348+400 (B#54). Most of these species are located on the sides of the mountains beside the Highway. Aquatic flora is mostly green and brown algae. These were observed in rivers where human activities like swimming, laundry, and waste disposal were high.

Apart from these, a couple of locations had some floral species of interest. At Erap Bridge (B#1), we found the leucaena tree (*Leucaena leucocephala*), which is listed as low risk. Clean water bridge (B#4) has rattan palm (*Korthalsia zippelii*) whose status is unknown. At Ngaraburam River (B#7), we recorded an Erima Tree (*Octomeles sumatrana*), which IUCN lists as the least concern. The tree may have been introduced at this location through other means. At Utwini Bridge (B#15), one *Elaeocarpus* tree was recorded, which could also have been planted or introduced through other means. At Tapiruna (B#21), Luwin (B#23), Orompanka (B#27), and Kingkio Bridges (B#32), *Pandanus julianetti* was recorded, indicating that people may have planted these. Only Ofiga River (B#30) and Umbaka River (B#31) recorded the presence of *Ficus dammaropsis* at the observation location. Ofiga River (B#30) also recorded *Nothofagus grandis*.

Terrestrial fauna besides the Highway was limited to insects and other invertebrates such as butterflies and dragonflies, although the black and white Willy wagtail was commonly sighted near rivers. The most common butterfly sighted in most of the locations in the plain area was the small yellow butterfly (*Eurema hecabe*). Other butterflies such as *Danaus plexippus* and moths such as *Plutella xylostella* also appeared in most of these locations. In contrast, at the locations of the Highlands region, only Kenangi River Km 345+200 (B#53) recorded sightings of four different types of butterflies.

In addition, sparrows (*Passeridae*) were the most common birds in most of the locations, followed by kingfisher (*Alcedinidae*), hawk (*Accipitridae*), and Willy wagtail (*Rhipidura leucophrys*). Mammals, reptiles, and frogs were not sighted during the survey. However, the results of informant interviews indicated that the presence of mammals such as mountain cuscus, tree kangaroos, and Princess Stephanie's astrapia bird of paradise (*A. stephaniae*) was recorded at Feonoku River Km 355+450

(B#51), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53), and Baikabai River Km 348+400 (B#54).

Aquatic flora mostly comprised green algae at all sites except B#4, B#5, B#7, B#10, B#15, and B#43.

Aquatic fauna that commonly appeared in most of the locations (B#1 to B#44) included carp (*Cyprinidae*), tilapia (*Oreochromis mossambica*), juvenile fish, and freshwater prawns (*Palaemonidae*). Trout was recorded in B#32, B#33, B#39, B#41, and B#43, while the freshwater turtle was reported only in Ramu River (B#3). Other species of fish such as catfish (*Arius spp*) were only recorded in B#1, B#2, B#3, and B#4 while golden carp and black carp were reported in B#26, B#27, B#28, B#29 and B#30.

3.2. Discussion

The results indicated that all locations from Erap River Bridge (B#1) to Kanalipi River Bridge (B#44) had some human impact which modified most of the environment and ecosystems within them. Only six locations Clean Water River Bridge Km77+800 (B#4), GorambamPam River Bridge Km113+000 (B#6), Feonoku River Km 335+450 (B#51), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River Km 348+400 (B#54) were recorded as having a more natural environment or ecosystem due to none or minimal human impact and appeared to have remnants of primary and secondary montane forests existing on the sides or near the Highway. These sites were also noted to have a variety of terrestrial fauna and native or local species. For example, over 24 species were recorded, rattan palm (*Korthalsia zippelii*) was only recorded in Clean Water River Km77+800 (B#4).

A summary of the discussions about the species and their presence or absence are discussed below.

3.2.1 Terrestrial ecosystem

Fauna

Common terrestrial fauna identified included invertebrates such as *Eurema hecabe*, *Anisoptera*, *Apis cerena*, *Fomicidae*, *Plutella xylostella*, and other butterflies of various colours and sizes such as Monarch butterfly (*Daanaus plexippus*). Presence of these invertebrates may be attributed to their preference of water in their ecology. Birds that were commonly sighted included sparrows (*Passeridae*), hawk (*Accipitridae*), eagle (*Hieraetus weiskei*), kingfisher (*Alcedinidae*), and Willy wagtail (*Rhipidura leucophrys*). These birds are also identified as common in open grasslands and rivers.

Generally, no mammals, frogs, and reptiles were observed in all these locations except the ones reported by the informant interviewees. Informant interviews indicated

that mountain cuscus (*Phalanger carmelitae*¹), exists in the mountains near Feonoku River Km 355+450 (B#51). These mountains are higher up and not very close to the Highway. This is because the *P. carmelitae* needs trees to move on and with lesser tall trees at the bottom of the mountains near Feonoku River, they will not be easily harmed. Moreover, Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River Km 348+400 (B#54) were all reported by informant interviews as having some local mammal and bird species such as mountain cuscus (*Phalanger carmelitae*), tree kangaroo (*Dendrolagus goodfellowi*²) and Princess Stephanie's Astrapia (*Astrapia. stephaniae*³) in the mountains near the Highway. While *P. carmelitae* and *A. stephaniae* are listed by IUCN as of least concern, *D. goodfellowi* is listed as endangered due to overhunting.

Flora

Common terrestrial flora from B#1 to B#44 included elephant grass (*Pennisetum purpureum*), cow grass (*Axonopus compressus*), rain tree (*Samanea saman*), Piper adancum, and banana. Coastal locations on B#1 to B#19 also recorded typical coastal flora such as betel nut tree (*Areca catechu*), coconut, cogon grass (*Imperata cylindrica*), sensitive grass (*Mimosa pudica*), and mango. On locations from B#20 to B#44, commonly existing highland flora included bamboo, *Casuarina oligodon* (she-oak), *Ficus dammaropsis*, and coffee, while *Casuarina oligodon* (she-oak), klinki pine trees, bamboos, Piper adancum, and anthropogenic grasses were quite common in all locations B#45 to B#71

Rare occurrences of the flora of interest, such as *Leucaena leucocephala* in B#1, *Korthalsia zippelii* in B#6, *Octomeles sumatrana* in B#7 and *Elaeocarpus* in B#15, imply that they could have been distributed via another medium as they are not common grassland flora. According to IUCN, *Korthalsia zippelii* is unknown, although it is commonly distributed in the lowlands of continental Asia and Malesian region (Barfod, Banka & Dowe, 2001). Similarly, *Leucaena leucocephala* and *Octomeles sumatrana* are the least concern.

On the highlands side, the occurrence of *Pandanus julianetti* in B#21, B#23, B#27, and B#32 and *Ficus dammaropsis* in B#30 and B#31 imply that they were introduced by people. In addition, near Ofiga River Bridge Km 223+900 (B#30), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53) and Baikabai River

Km 348+400 (B#54) found *Nothofagus grandis*⁴ and a couple of *Ficus* species also implicate a human origin. Of these, *N. grandis* has been recorded as the least concern on the IUCN Red list.

3.2.2 Aquatic ecosystem

Fauna

Common aquatic fauna along plain region included carp (*Cyprinidae*), tilapia (*Oreochromis mossambica*), juvenile fish and freshwater prawns (*Palaemonidae*). Trout (*Oncorhynchus mykiss*) was recorded in B#32, B#33, B#39, B#41 and B#43 while catfish (*Arius spp*) was only recorded in B#1, B#2, B#3 and B#4. Golden carp and black carp were also reported in B#26, B#27, B#28, B#29 and B#30. The findings imply that most of these species are common and were introduced into the locations.

The aquatic fauna identified in highlands locations were also generally common and included organisms such as small brown mollusk, water beetle, pond skaters, rainbow trout (*Oncorhynchus mykiss*), and tilapia (*Oreochromis mossambica*). *O. mykiss* and *O. mossambica* are both introduced species and hence are common.

Washing and domestic waste disposal also affected the water quality resulting in the growth of both brown and green algae in the water that affected the existence of aquatic fauna which were not easily visible at the time of the survey.

Flora

There was no unique or threatened aquatic flora recorded in all locations. The most common was brown and green algae, which also depended on the quality of the river. That is the higher river water usage, the more availability of algae.

In addition, locations with aggravated human impact, such as quarries, clearly showed high modification of the vegetation and the surrounding environment that also affected the type of organisms and flora present in the area. Other activities, such as washing and domestic waste disposal, also affected the water quality resulting in the growth of brown and green algae in the water.

The survey along the Highway showed that human impacts affected the changes in the environment and the terrestrial and aquatic ecosystems. No new species have been identified in all locations. However, some local and endemic species were identified in Feonoku River Km 335+450 (B#51), Nurape River Km 342+850 (B#52), Kenangi River Km 345+200 (B#53), and Baikabai River Km 348+400 (B#54) where remnants of primary and

¹ *Phalanger carmelitae* is classified by IUCN as of least concern.

² *Dendrolagus goodfellowi* is classified by IUCN as endangered.

³ *A. stephaniae* is listed by IUCN as least concern and is an endemic species.

⁴ *Nothofagus grandis* is listed on the IUCN Red list as least concern.

secondary forests and vegetation are evident, while Clean Water River Bridge Km 77+800 (B#4) and GorambamPam River Bridge Km 113+000 (B#6) are more natural than other locations.

IV. CONCLUSION AND RECOMMENDATION

This survey indicates that while there is generally evidence of human impact on all locations that have modified the environments in many ways, some are more detrimental than others. There is one location (B#51) located at the bottom of a high montane sub-alpine vegetation was reported to have one endemic mammal (Phalanger carmelitae that is considered of the least concern (IUCN). Three specific locations (B#52, B#53, and B#54) that still have remnants of montane forests beside or near the Highway were reported to have two endemic mammals (Phalanger carmelitae and Dendrolagus goodfellowi) and one bird (Astrapia stephaniae). In addition, locations B#52, B#53, and B#54 also have sightings of Nothofagus grandis, an endemic species of Beech tree. According to the IUCN Red list, Dendrolagus goodfellowi is considered endangered, while the other two species are listed as of the least concern. Korthalsia zippelii recorded in B#4, is widely spread in the tropical lowlands and is not threatened. Octomeles sumatrana, a commercially important tree species located at B#7, is not a common grassland flora. Humans may introduce its presence at this location. Similarly, Nothofagus grandis located in B#30, is of least concern according to IUCN. Its appearance at this location may be through humans.

No unique or threatened aquatic fauna were noted. All species were either introduced or commonly available. Similarly, the only aquatic flora recorded is green algae.

The general absence of terrestrial mammals, reptiles, and frogs may be attributed to the timing of the survey, the weather, and climatic conditions. For instance, Markham Plains was experiencing a dry season at the time of the survey, which may have caused the terrestrial fauna to go into hiding. A similar condition also existed on the Eastern Highlands side of the Highlands Highway, where the absence of other terrestrial fauna was also noted. On the other hand, the aquatic fauna was consistently recorded except where the river or creeks were dried up.

The existence of quarries also affects the vegetation and the general environment of the locations, thus modifying them.

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