Environment Monitoring Report 2019

KOPEL Bhd

Includes Monitoring & Analysis Report for

(a) Forest Restoration
(b) Wildlife Monitoring
(c) Water Quality Monitoring
(d) Salvinia Removal Monitoring
(e) Cave Restoration Project

2019

kinabatangan
KOPEL

Background & Introduction

KOPEL Bhd is a community organisation incorporated as a co-operative under the Malaysia Co-operative's Commission Act 1994. KOPEL Bhd is located in the community of Batu Puteh in the heart of the Kinabatangan Floodplain. The community of Batu Puteh consists of four villages, with the village of Batu Puteh at its centre. The entire community is surrounded by the Pin-Supu Forest Reserve, one of the largest protected forest reserves along the Lower Kinabatangan River.

KOPEL's main purpose is to support the generation of income and employment in the local community from the surrounding forests in an ecologically sustainable manner. More specifically this means operating income generating activities that support the conservation of the forest ecosystem, the aquatic ecosystem, the biodiversity of this area, and the wildlife that makes its home in these habitats.

The community of Batu Puteh has been working with the Sabah Forestry Department since 1997 to establish sustainable community-based tourism and forestry activities within the Pin-Supu Forest Reserve. In 1998 the community got involved with fighting forest fires within the reserve. This involvement lead to the first community forest restoration activities within the floodplain forests of the Lower Kinabatangan in 1999, sponsored then by Discovery Channel.

Major advancements in the forest restoration techniques were made in the following years with support and grants from Ricoh Corporation (Japan), the International School Brunei, Alexander Abraham Foundation and America Forests. LEAP, WWF, Raleigh International, Intrepid Travel, Outlook Expeditions, Camps International, World Challenge, Rakuno Gakuen University, Bring the Elephant Home, Borneo Explorer Club, and the Danau Girang Field Centre are just some of the many NGOs and companies that have supported KOPEL's restoration initiatives over the years.

In the year 2004 the conservation efforts turned to tackle the Invasive waterweed *Salvinia molesta* after this weed completely covered the Tungog Lake in 2003. Through the ingenuity and hard work of the local community, KOPEL cleared the Tungog Lake of the weed Salvinia in March 2007. The work from there on was funded by the community-based tourism (CBT) programs run by KOPEL bhd.

In the year 2009 the Sabah Forestry Department signed an agreement (MOU) with KOPEL Bhd to co-manage the Pin-Supu Forest Reserve (PSFR), there-in recognising and strengthening the community's long-running efforts to protect and restore the forest habitats of this forest reserve. The agreement is designed to ensure that the overall management of this reserve is in-line with the comprehensive 10-year Forest Management Plan for PSFR. Key partnership activities include; continuing and expanding restoration efforts, enhancing monitoring function within the reserve to strengthen feedback mechanisms, and increasing revenue collection to the Sabah Forestry Department (State Government of Sabah) via the establishment of entrance fees to PSFR.

In the year 2010 KOPEL embarked on protecting the caves in the northwest part of the Pin-Supu Forest Reserve vis a vis an agreement with the Sabah Wildlife Department. In 2012, through the support of the University Rakuno Gakuen (Japan), KOPEL Bhd began a long-term environmental monitoring program in the surrounding area. The monitoring involves collecting data on water quality, wildlife and the forest restoration activities. In the case of Pin-Supu Forest Reserve this supports monitoring and feedback mechanisms for the reserve.

This report is designed to provide an overview and summary of the monitoring outcomes of 2019 and is a key part of KOPEL's commitment towards inclusivity and transparency in Sustainable Forest Management of Pin Supu Forest Reserve and its partnership with Sabah Forestry Department and other supporting agencies.

1. Forest Restoration & Restoration Monitoring

Forest Restoration efforts in 2019 were two pronged. Firstly, KOPEL continued its forest restoration efforts through the active involvement of volunteers and ecotourists. The voluntourism and ecotourism activities still forms the backbone of KOPEL's conservation programs including the forest restoration program. The tourism program provides year-round funding streams, which likewise supports the employment of a full-time conservation team. The Conservation Team includes a conservation manager, as well as the tree propagation and nursery team, Supu Cave ranger team, and other field monitoring and reporting staff. Secondly KOPEL continued ongoing efforts partnering with the Sabah Forestry Department, via the RMK11 Restoration Project. The RMK11 project involves tree planting, maintenance of tree planting, and silviculture tending (vine liberation). Although this project came to an end in 2019, this project employs more than 74 people from the local community of Batu Puteh on a seasonal basis.

Tree planting through ecotourism activities in 2019 planted a total of **7,842 trees**. A total of 18 species of tree were planted with the bulk of the trees being Bangkal (*Nauclea sp* =2,012), Salungapid (*Mollotus muticus* = 1,210)= 1,445) and Mangkapon (*Colona serratifolia* = 1,319). Three (3) key areas were planting in 2019, as follows:

1. **Block Kaboi Stumping**, is a riparian site in Pin-Supu Forest Reserve. A total of 1,070 trees were planted in both small and large gaps within the forest at this site, namely Bongkol (*Nauclea sp.* 610 trees) and Salungapid (*Mollotus muticus*), with a mix of 3 other species (*Colona sp., Pterospermum sp. and Durio sp.)*

2. **Riparian corridor Ladang Kinabatangan**, is a riparian site providing a narrow but vital riparian corridor for wildlife on the south side of the Kinabatangan River - adjacent to Pin-Supu Forest Reserve. In 2019, a total of 4,755 trees were planted on this site, covering the remaining gaps on this site. A total of 15 species were planted on this site in 2019, the majority coming from Mangkapon (*Colona sp.* = 1,287), Bangkal (*Nauclea sp.* = 1,128), Salungapid (*Mollotus muticus* = 957), and Bayur (*Pterospermum sp*. = 817).

3. **Block G Laab (Swamp Besar)** is a permanently waterlogged swamp forest, in Pin-Supu Forest Reserve. In 2019 a total of 867 tree were planted in experimental plots to evaluate different planting techniques in this unique form of swamp forest. A total of 28 plots of size 20x20 m were established and enumerated with the support of volunteers in 2019. Four planting methods were tested in this experiment. Planting via (a) stem cuttings (otherwise known as "pole planting"). Planting with seedlings (b) at ground level and (c) on artificial mounds, and (d) using marcots from nearby Ficus sp. The tree species planted in these experimental plots were *Mytrogyna sp. Nauclea sp., Alstonia sp., Terminalia sp., Ficus sp.* (marcots).

4. **Block H Laab (Pangkalan Gajah)**, is a riparian site of mixed secondary floodplain forest within Pin-Supu Forest Reserve, directly adjacent to and southwest of Block G Laab (Swamp) referred to in previous paragraph. Similar to Block G, planting in the adjacent Block H was also experimental. The experiment on this site was designed to trial the planting of climax species within a mixed secondary forest stand. In 2019 a total of 1,150 trees were planted in this site. The planting in this site was designed to enrich the species mix and to help restore this floodplain forest to pre-logging conditions. For this effect typical climax species for Riverine Dipterocarp Forest were chosen including Seraya (*Shorea sp.*), Pengiran kesat (*Anisoptera sp.*), and Kapur (*Dryobalanops sp.*). For more information on tree planting on this site refer to page 6

The tourism restoration efforts also involved a number of related restoration activities such as seed collecting, nursery propagation, site preparation for tree planting, tree planting (mentioned above), and follow-up maintenance of planted trees.

No.	Local name	Species 2	Kaboi Stumping	Ladang K	Laab	Laab	Total
					Swamp Besar	Pangkalan Gajah	
2	Mangkapon	Colona serratifolia	32	1287			**1319**
9	Bongkol	Nauclea sp.	610	1128	274		**2012**
7	Salongapid	Mallotus muticus	368	957	120		**1445**
13	Bayur	Pterospermum sp.	50	817			**867**
11	Binuang	Octomeles sumatrana		320			**320**
8	Sepat	Mitragyna speciosa		141	125		**266**
4	Durian	Durio sp.	10	36		232	**278**
15	Payung2	Terminalia copelandii		32	127		**159**
14	Kelumpang	Sterculia sp.		14		264	**278**
12	Nyatoh	Palaquium sp.		13			**13**
5	Belian	Eusideroxylon zwager		4			**4**
1	Pulai	Alstonia sp.		3	129		**132**
6	Ficus (Marcots)	Ficus benjamina		1	92		**93**
3	Keruing	Dryobalanops sp.		1			**1**
10	Laran	Neolamarckia cadamba		1			**1**
18	Seraya	Shorea sp.				228	**228**
16	Pengiran kesat	Anisoptera sp.				227	**227**
17	Kapur paji	Dryobalanops sp.				199	**199**
		Total	**1070**	**4755**	**867**	**1150**	**7842**

Figure 1: Tree species Planted at each Planting site

Figure 2: Map Tree Planting Sites & Permanent Sample Plots PSFR 2019

Monitoring of Permanent Sample Plots (PSP) in 2019:

KOPEL has three (3) permanent sample plots in meander belt forest. Plots numbered KP01, KP03 are in the riparian corridor adjacent to Pin Supu Forest Reserve (PSFR) – on the south side of the Kinabatangan River (ref Map 3, page 26).

Plot **KP01** is the riparian corridor on the north side of the River in Pin-Supu Forest Reserve downstream of the small Kaboi River. The site KP01 is known locally as Kaboi Stumping Ground because in the early 1980s it was a large log scaling and loading depot (a.k.a. "stumping ground"). Tree planting on the Kaboi Stumping Ground started in 2006 with most of the planting occurring between 2007-2008. Three (3) tree species were planted in the plot KP01 in 2008. Enumeration of the PSP KPO1 in 2019 showed there are now nine (9) tree species, not including shrubs, vines and grasses, within the PSP. The average height of 1086 trees within this PSP was 14.8m with an average DBH of 10.5cm.

Plots **KPO2** & **KP03** are located in the riparian corridor on the southern Kinabatangan Riverbank adjacent to PSFR - known locally as the Riparian Corridor Ladang Kinabatangan. This site was planted between 2014-2015. Enumeration of the 352 trees in PSP KPO2 in 2019 shows the average height of tree on this site is now 9.3m with DBH 11.6cm. Of the 485 trees enumerated in KP03, the average height is 8.4m with average DBH at 9.1cm. Both study plots have experienced an increase in species through natural regeneration from 3 species planted to 9 species in KP02, and from 4 species planted to 8 species in KP03. Permanent Sample Plot (PSP) map and data is appended to this report.

Camera traps have only been set-up for short duration within these PSPs due to their proximity to human populations and the fear of losing the cameras to theft. Even so, tourist, guide and rangers have all observed a large variety of wildlife in KP01 including orangutan, proboscis monkey, bearded pigs, long-tail macaques, civet cats, Borneo pygmy elephants and a wide variety of hornbill species and other birds. Wildlife sightings in KP02-03 are also frequent, albeit less abundant, with sightings of long-tailed macaques, civet cats, leopard cat, hooded pitta, and a wide variety of hornbill species. Work will be expanded in 2020 to establish a more permanent wildlife monitoring presence in these permanent sample plots.

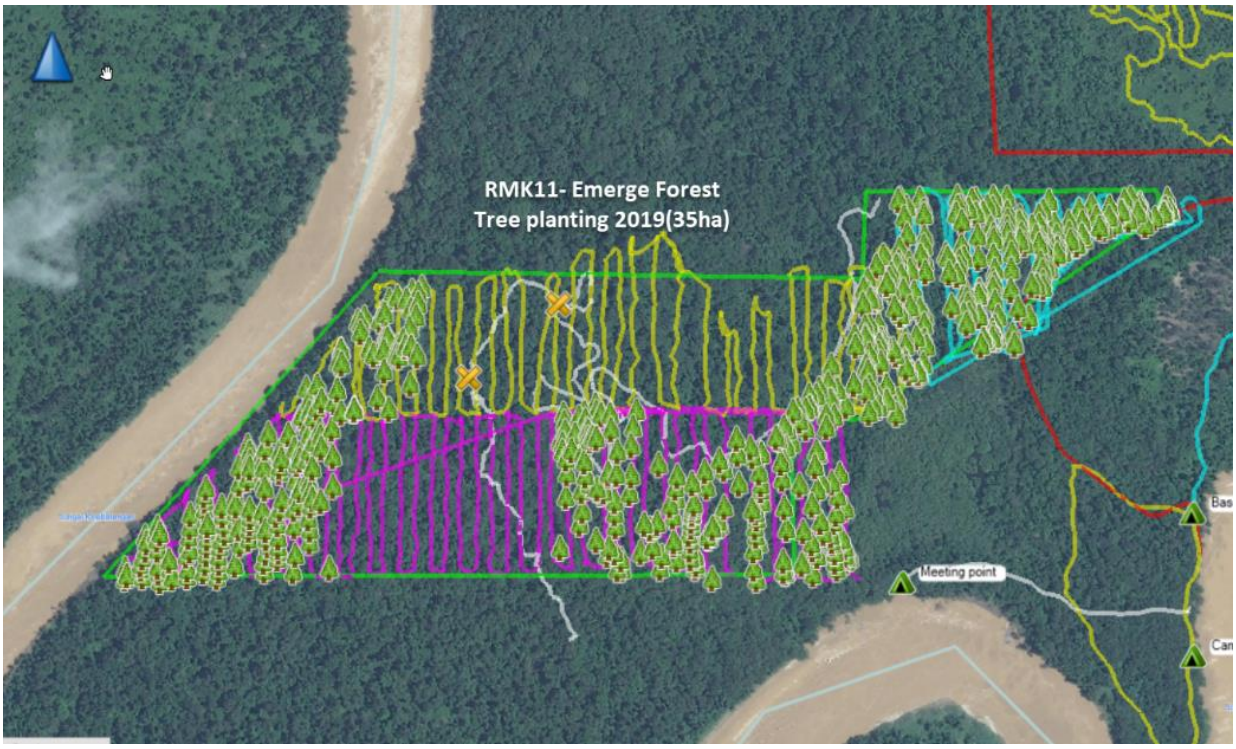

Figure 3: Map RMK11 Tree planting Project (35ha) 2019

RMK11 Forest Restoration Project PSFR:

The RMK11 Project is focused primarily on the Pin Supu Forest Reserve (PSFR) and includes tree planting, silviculture treatment and maintenance work on trees previously planted.

Tree Planting: Tree planting efforts have targeted the most severely degraded sites outlined in the PSFR Management Plan. The most severely degraded sites within PSFR are currently all within seasonally flooded and permanently waterlogged sites (refer to Figure 1 next page). KOPEL has taken a precautionary approach to tree planting work on these sites due to the high potential of failure due to flooding and subsequent potential to waste RMK11 funds.

Tree planting by KOPEL in these flooded and waterlogged sites was decided to be experimental at first, following the method of "pole planting" based-on the success of this methodology, by KOPEL, in similar waterlogged sites in LKWS Lot 7. The tree species chosen for the pole planting technique are *Nauclea spp*. (Bangkal/Rubiaceae) and *Mytrogyna speciosa* (Sepat/Rubiaceae) based on previous experience and their tolerance to flooded and waterlogged environments. The Laab site was chosen for this experimental tree planting because of its relative proximity to Batu Puteh compared to other sites for its accessibility - being set-back only 300m from access points on the Kinabatangan River.

Tree Maintenance: The removal of grasses, weeds and climbers from around the newly planted trees was carried out twice in 2019. This maintenance work was carried out on the total 10.5ha of tree planting sites. This maintenance was designed to remove the chocking grasses and vines that smother the newly planted trees. It is understood that without this maintenance work, these sites would experience a much higher mortality. Maintenance work is carried out by staff of KOPEL Bhd from the surrounding community of Batu Puteh. The method includes grass cutting, grass folding (to further impede grass regrowth) and vine cutting.

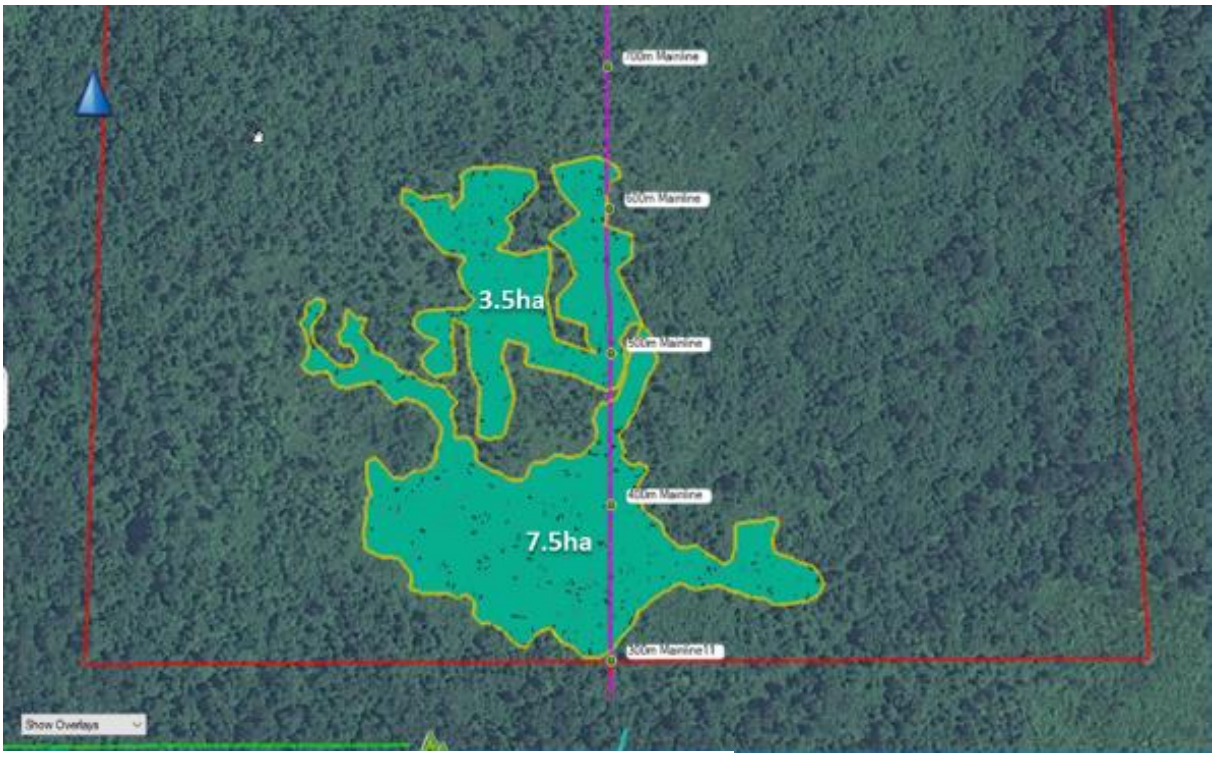

Figure 4: Location Map RMK11 Tree Maintenance(10.5ha) 2019

Silviculture Treatment: Within Pin Supu Forest Reserve silviculture treatment involved vine cutting to liberate trees threatened by thick and chocking vine cover – also known as "vine liberation treatment". The removal of the vine cover is designed to support and speed up the regeneration of tree species within the forest, especially in target sites where trees are threatened and damaged by thick vine cover. The vine liberation treatment is designed to enhance the regeneration of climax species and enhance the diversity and structure of the forest (See Figure 6, next page).

Silviculture treatment under the RMK11 project in 2019 was carried out on 255ha of forest in both Pin Supu Forest Reserve Block A & Block B (See Figure 5). The largest of the silviculture sites was upstream from the KOPEL base, in the area known as Kawasan Batu Supu. A total of 544ha was treated in the Supu site. The remainder of the Silviculture sites were downstream from the KOPEL base. A total of 11ha was restored in PSFR Block A.

Silviculture response: KOPEL is in the process of establishing a long-term-study to quantify the benefits of silviculture liberation treatment on forest health and wildlife habitat within Pin-Supu Forest Reserve. Based on the feedback from guides, forest rangers and tourists, there has been an increase in sightings of wildlife in areas treated by vine liberation. Even so, the long-term improvement to forest structure and tree species diversity has yet to be established. It is expected that improvement to forest structure will only be visible via detailed sampling through a long-term monitoring program.

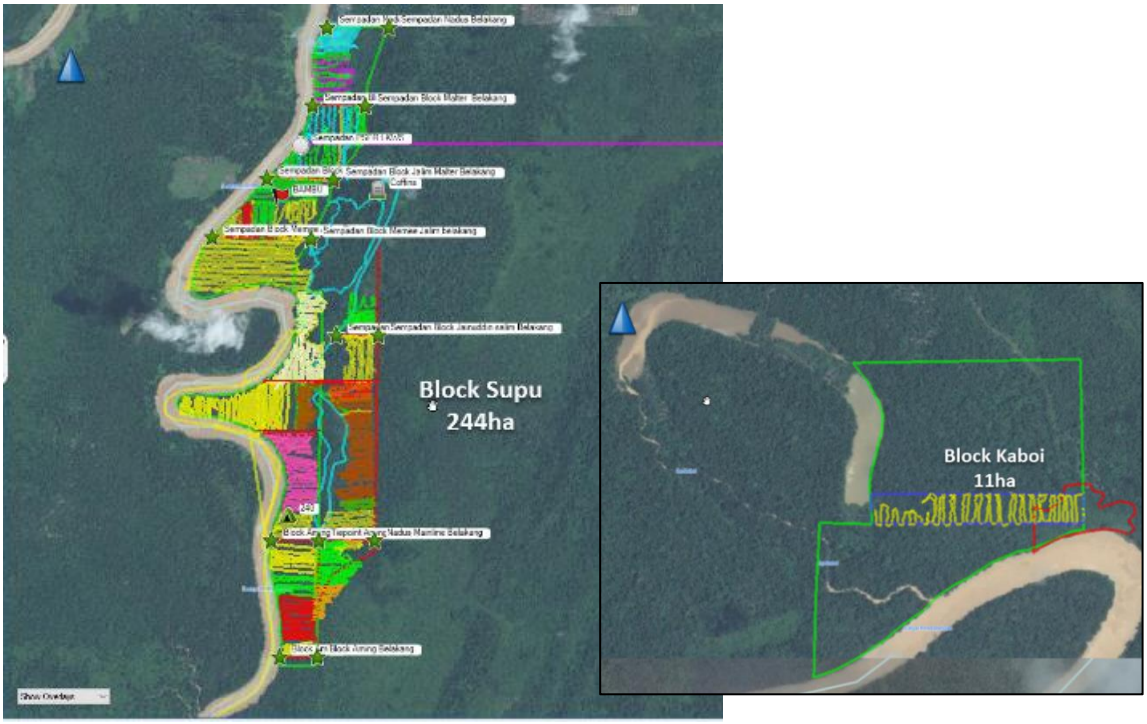

Figure 7: Location Map of RMK11 Silviculture Vine Liberation Treatment 2019

Restoration Monitoring Outcomes & Feedback into Management

1. Current data shows positive outcomes for restoration work on all riverine and riparian sites, which are mostly dry and well drained. In all other areas which are seasonally flooded or permanently waterlogged outcomes are mixed and some site extremely poor outcomes.
2. Further experimentation is advised in these waterlogged and seasonally flooded sites. The current experimental plots are designed to provide further data and it is hoped that work can be expanded and trials enhanced with additional equipment for monitoring hydrology and soil chemistry alongside additional trials on alternative or innovative restoration techniques.

2. Wildlife Monitoring

Wildlife Monitoring within Pin-Supu Forest Reserve is carried out by the community cooperative KOPEL Bhd using camera trapping methodology. The monitoring of wildlife via camera trapping has been ongoing since 2012 and has compiled a large bank of data on the wildlife within Pin Supu Forest Reserve as well as the surrounding area. In 2019 a total of 8 camera traps were deployed semi-permanently within Pin Supu Forest, some for multiple or single short duration monitoring periods and some for single longer duration monitoring periods.

The wildlife monitoring is designed primarily to determine wildlife species diversity within Pin Supu Forest Reserve. Species diversity per se is important to understand when considering basic management objectives such as the significance of this forest unit for forest protection. Species diversity is also as an important component of HCVF assessment as it is an important determinant of conservation value. This is because a list or inventory of species can highlight the presence of vulnerable, threatened, or endangered species within the forest unit.

In addition to the simple inventorying of wildlife within the reserve, the wildlife monitoring is now being used to determine trends or changes in the presence of certain species and their long-term abundance. This is only made possible when the study is long-term in nature, which is an important consideration for management and community involvement as in the case of Pin-Supu Forest Reserve. The long-term nature of the study by KOPEL Bhd is vital to determine temporal use of the reserve as habitat for wildlife. In this way the study can be also used as a determinant of impacts within the reserve, both positive or negative.

It should be highlighted that understanding the temporal changes within the reserve cannot happen overnight, and it is expected that only through the implementation of a consistent and long-term study (e.g. for a period of more than 5 years) will sufficient data be present to analyse and interpret temporal changes (such as trends) and the potential positive or negative impacts of a certain activity (to any reasonable degree of scientific accuracy). It is possible that impact of other key environmental factors (variables) such as cyclical and changing climatic conditions (such as droughts or floods) may prolong the study conclusions, and for example 5 years may still not be enough to determine temporal utilisation and changes.

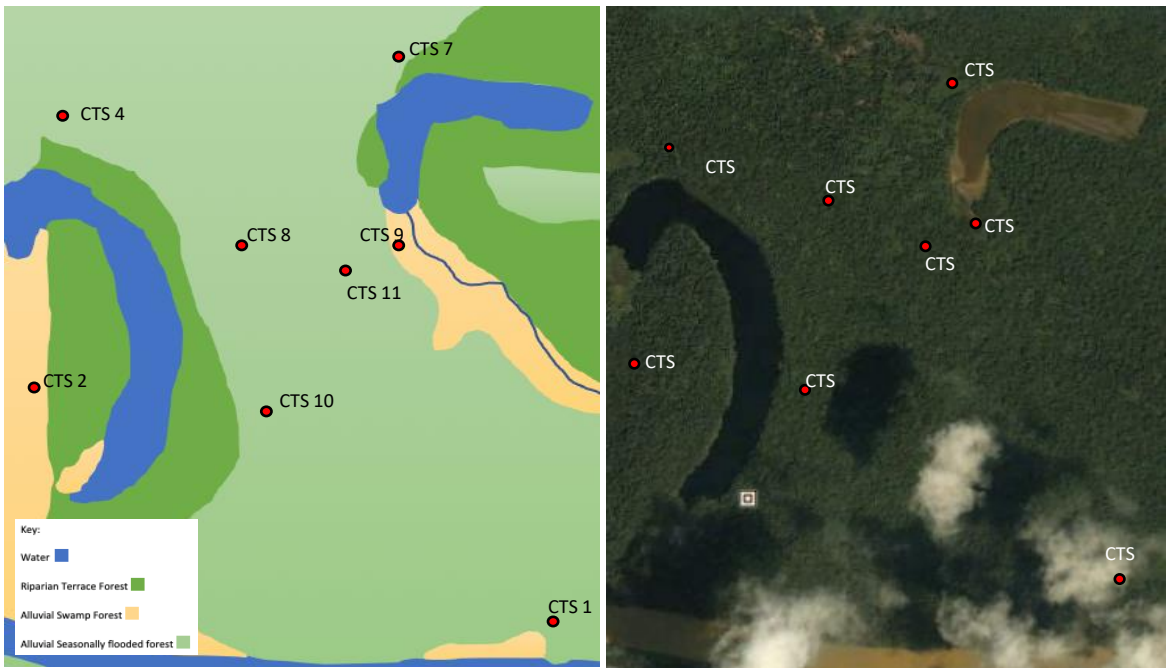

Figure 8: Camera Trap Stations (2019)

IN LIGHT OF THIS it is extremely important for the management of Pin Supu Forest Reserve that any planning of activities within the reserve should proceed based on a "precautionary approach" and activities should only be carried out with the strictest sensitivity to wildlife alongside a strong management regime of "zero footprint" and at best minimising any potential negative impacts. This clearly indicates against the development of any mass tourism development within this critical habitat.

Ongoing camera trapping by KOPEL to date, has already determined the presence of several critically endangered, vulnerable and threatened species of wildlife within this forest unit (see Table 2, below). Based on the preliminary results, forest management planning has already taken into consideration the sensitivity of this forest management unit in the establishment of species conservation targets, the establishment HCVF values, and the establishment and institutionalisation of monitoring mechanisms.

Moving forward the monitoring methodology itself (primarily using camera traps) needs to continuously be refined, improved and expanded to meet the basic monitoring requirements for forest managers of PSFR. This report is a short summary of analysis and findings for 2019. This report also concludes, with a list of implications for management, designed to feed-back into annual revisions of PSFR FMP.

Monitoring stations used in 2019 were located in the Southern part of the BLOCK A section of the Pin Supu forest reserve; all in Meander Belt Riverine Dipterocarp Forest or Seasonally Flooded Alluvial Swamp Forest . Other notable features of this area are the north bank of the Kinabatangan River, the Tungog Lake, and multiple Oxbow lakes. The data gathered is analysed with (a) Relative Analysis Index (RAI) to record the species abundance, and (b) the Shannon and Simpson index for species diversity.

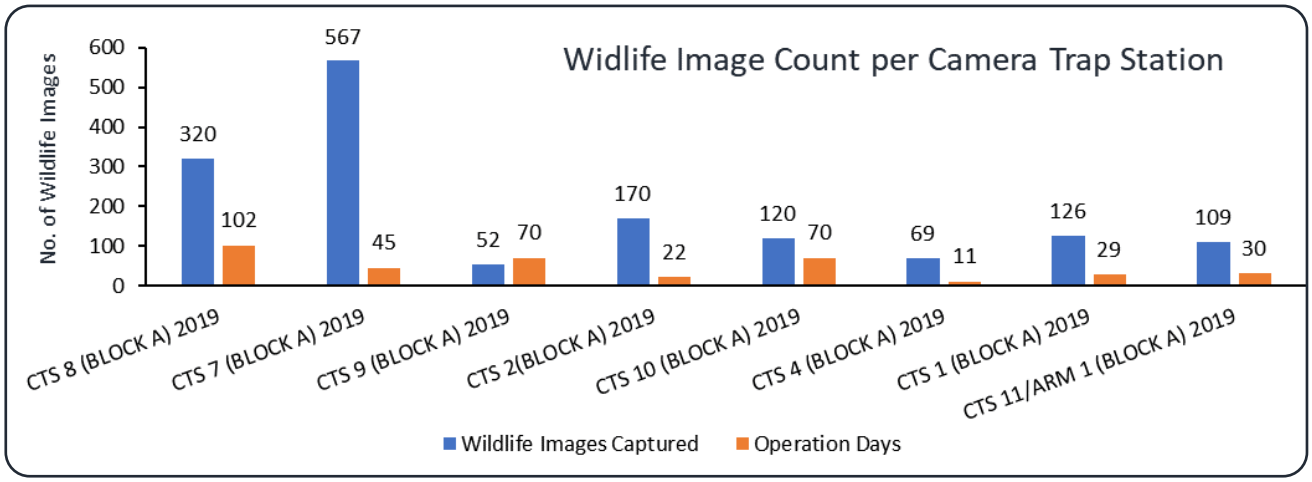

Figure 9: Number of wildlife pictures and Operation Days at 8 separate stations.

Analysis of Data 2019

I. Some previously seen species such as clouded leopard *Neofelis nebulosi*, sun bear *Helarctos malayanus* and Bearcat (*Arctictis binturong*) were not captured in 2019 (although the camera locations were in a different section of the reserve). Other notable species were captured however, including the Critically Endangered Orang utan *Pongo pygmaeus* and the endangered Proboscis monkey *Nasalis larvatus* (the latter not captured by any camera traps in the previous year 2018)

II. There was no statistically significant difference between 2018 and 2019 species diversity and abundance (based on independent samples t-tests, df=11, t=-1.738, P>0.05 and df=7.945, t=-

1.838, P>0.05) indicating that there has not been a decrease in wildlife diversity or abundance within the Pin Supu forest reserve.

III. Camera Traps 2, 4 and 1 have the highest diversity (Simpsons and Shannon's indexes) and are situated in Meander belt Forest (a form of Riverine Dipterocarp forest). The low diversity in some other stations is possibly due to the prevalence of Bearded Pigs reducing the diversity value, despite high variety of species captured.

IV. Bearded Pigs *Sus barbatus* are the most abundant sightings in the RAI analysis (relative abundance). Seven of the eight stations captured notable numbers of images of this species, indicating that there is a prominent population in this area (BLOCK A). Further research into this population may be needed in future.

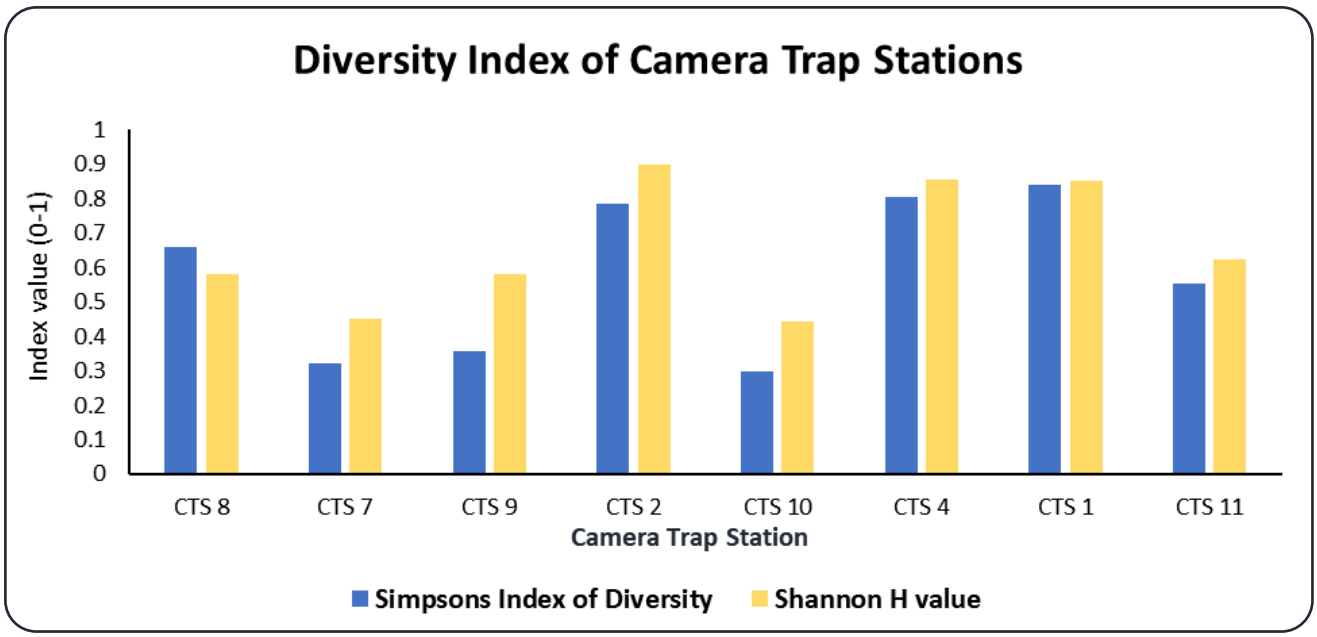

Figure 10: Diversity (Simpsons Index of Diversity or Shannon's diversity index) by camera trap station 2019

Conclusions & Management Implications

I. The results of camera trap wildlife monitoring in 2019 were consistent with previous years. The results for both Diversity Index and RAI analysis, concurs that the forest ecosystem within Pin Supu continues to be healthy with high diversity and abundant food sources for a wide range of wildlife species, including Vulnerable, Endangered and Critical species (IUCN).

II. The current methodology of camera trapping is still the most appropriate mechanism for monitoring wildlife populations within PSFR. This is because the method poses no threat to wildlife and very minimal impact on the wildlife directly and forest ecosystem more generally.

III. Based on analysis of measurable effectiveness indicators for the camera trapping methodology the following recommendations should be noted within revised FMP action plans:

   a. The camera trapping needs to be expanded and implemented more consistently over a wider range and broader diversity of forest ecosystems within the PSFR.
   b. Refined camera trapping methods or alternative methods should be developed to monitor the impacts of the main road (Sandakan Lahad Datu Highway) which divides and fragments the Kinabatangan Forest Corridor.
   c. The camera trapping needs to be upgraded, revised and improved to stay abreast of technology, and to avoid theft of the cameras (unfortunate incidents, which has occurred repeatedly within the PSFR). Minimizing detection of camera traps, a red filter

over the infrared flash to reduce visible glow of infrared flashes or utilising cables and padlocks have been successful in other studies and may be potential methods to consider.

d. In the past KOPEL has consistently moved camera traps after a few months. This practice needs to be changed, so that longer-term (permanent) stations are established to ensure the camera traps can continue functioning more consistently for a longer period at each station (location) to ensure adequate data is collected over the long-term to determine temporal changes and trends. Consistent monitoring of the same locations for multiple years enables more detailed analysis (and greater accuracy when analysing trends and patterns).

e. Technique for avoiding floodwaters is critical and should be developed to protect camera traps from being flooded. Examples could also include the installation of hydrological monitoring stations, which can be used to both protect equipment from flooding and provide corelating data.

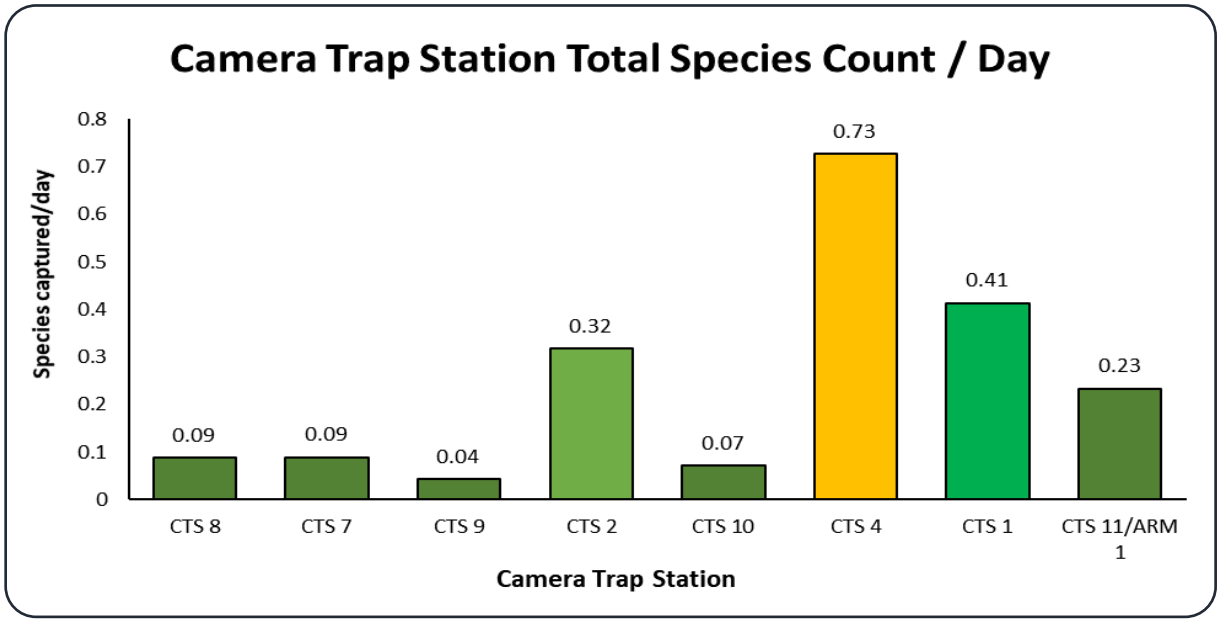

Figure 11: Total species captured per camera trap station/time period

IV. Based on the analysis of camera trap data and consistent with the Shannon and Simpson (diversity) index values, a diverse list of high conservation value species have been recorded for PSFR, hence it is highly recommended to expand the conservation species targets for Pin-Supu Forest Reserve.

V. Based on consistent findings over the last 4 years, namely absence of large groups of Borneo Pygmy Elephants for much of the monitoring period. It is suggested that Borneo Pygmy Elephant be removed as one of the conservation targets for PSFR.

VI. Based on consistent findings over the last 4 years, namely the absence of large groups of Proboscis monkeys in camera trap data for much of the monitoring period. It is suggested that a different methodology be developed to monitor this primate within PSFR. Monitoring using river surveys or arboreal camera traps may be feasible options for future consideration.

Species	IUCN Conservation Status	Total Images
Bearded Pig *(Sus barbatus)*	VU	888
Long-tailed Macaque (*Macaca fascicularis)*	LC	238
Sambar Deer *(Rusa unicolor)*	VU	92
Moon Rat *(Echinosorex gymnura)*	LC	78
Lesser Mouse Deer *(Tragulus javanicus)*	DD	61
Common Palm Civet *(Paradoxurus hermaphroditus)*	LC	34
Banded Palm Civet *(Hemigalus derbyanus)*	NT	30
Greater Mouse Deer *(Tragulus napu)*	LC	24
Pig-tailed Macaque *(Macaca nemestrina)*	VU	22
Crested Fireback Pheasant *(Lophura ignita)*	NT	20
Orang utan *(Pongo pygmaeus)*	CR	14
Common Porcupine *(Hystrix brachyura)*	LC	10
Malay Civet *(Viverra tangalunga)*	LC	10
Short tailed Mongoose (*Herpestes brachyurus*)	-	6
Proboscis Monkey *(Nasalis larvatus)*	EN	5
Malay Badger *(Mydaus javanensis)*	LC	4
Unknown Fowl	-	4
Crested Serpent Eagle *(Spilornis cheela)*	LC	3
Four-striped Ground Squirrel *(Lariscus hosei)*	LC	3
Unknown Rat	-	1
Unknown Flying Squirrel	-	1
Taxonomic Class		
Mammal		1521
Bird		27
Reptile		0

Figure 12: Number of images captured per species 2019 (Pin Supu BLOCK A)

VII. More broadly there is insufficient data to concur that restoration efforts or tourism activities are having a positive or negative impact on wildlife. It suggested that the monitoring be modified to include comparison sites and control sites to compare the current data sets. This will need to be implemented consistently over several years to establish temporal changes.

VIII. It is recommended that the data be share more broadly with students, select scientific experts, or select technical people within the conservation community, to provide a broader analysis of the data. This is likewise envisaged to encourage local capacity building through the sharing of technical expertise, and likewise encourage further collaboration in the wildlife management aspects of PSFR.

IX. It is recommended that some changes are made to the database structure and data logging process to ensure accurate analysis and reduce confounding effects. One such example is adding a standardised 'sighting' variable to reduce confounding effects of the same sighting of an individual being recorded multiple times in the database.

X. In summary ongoing monitoring work has been effective and continues to have consistent outcomes, no other major changes are suggested apart from what has already been outlined in this document. It is important that this work continues into the long-term hence ensuring reliable and consistent income into this program is paramount to its success. Income

generation mechanisms are hoped to be expanded to benefit expanded monitoring activities in the future.

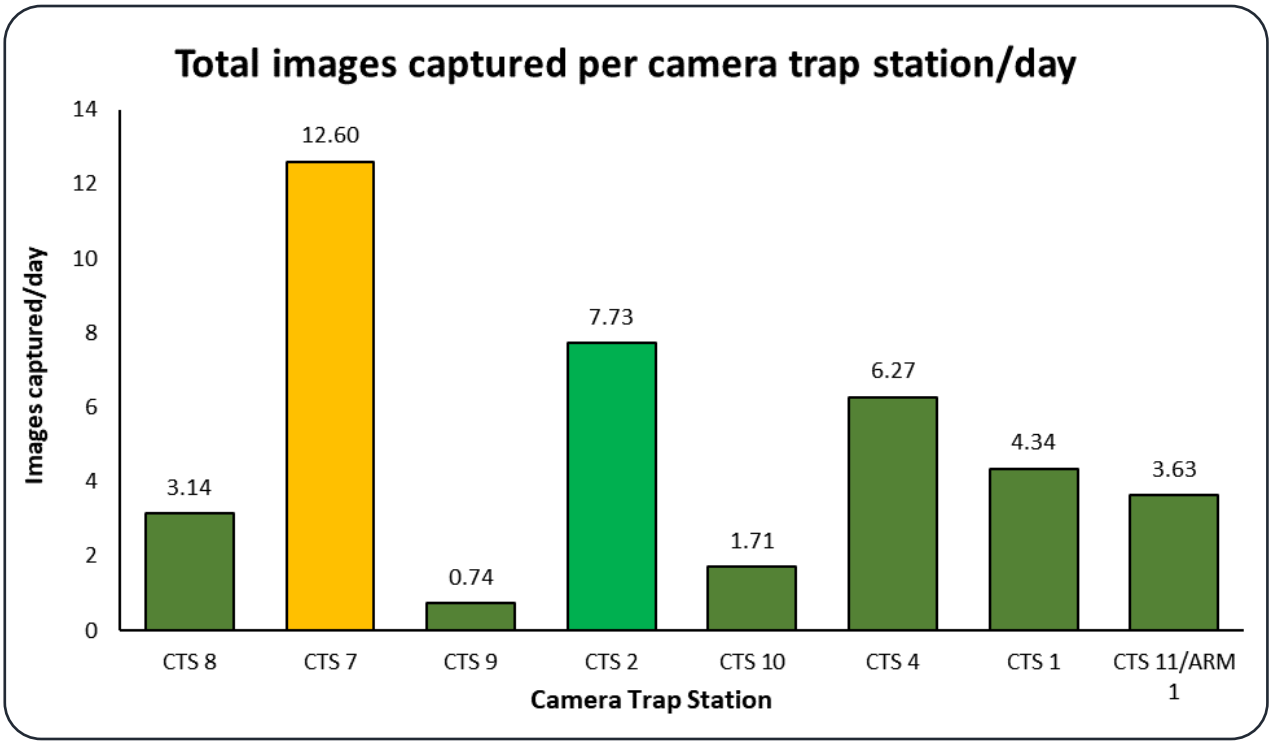

Figure 13: Total images captured per camera trap station/time period

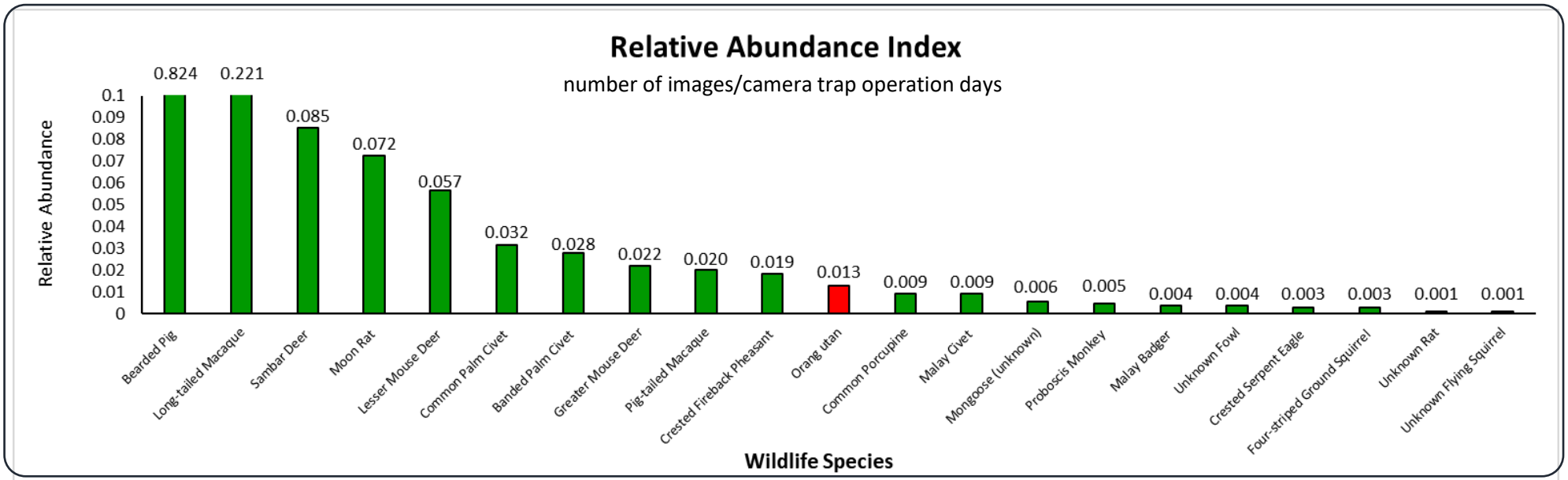

Figure 14: Relative Abundance Rate (RAI) (number of images/camera trap operation days)

Figure 15: Image captured of Short tail Mongoose, *Herpestes brachyurus*, (near threatened (IUCN) a small predatory mammal active by day (CTS 7 20/4/2019)

Figure 16: Male Proboscis Monkey, *Nasalis larvatus* an Endangered species (IUCN) endemic to Borneo (CTS 1 27/9/2019)

Figure 17: Orang Utan, *Pongo pygmaeus* a characteristic primate species, classed as Critically Endangered by the IUCN. (CTS 11 19/10/2019)

Figure 18: Image captured of Borneo Bearded Pig, *Sus barbatus*, endemic to Borneo, most common mammal in camera trap data by KOPEL Bhd (CTS 7 20/4/2019)

Figure 19: Borneo pygmy elephant, *Elephas maximus borneensis* an Endangered species (IUCN) endemic to Borneo (CTS 1 27/9/2019)

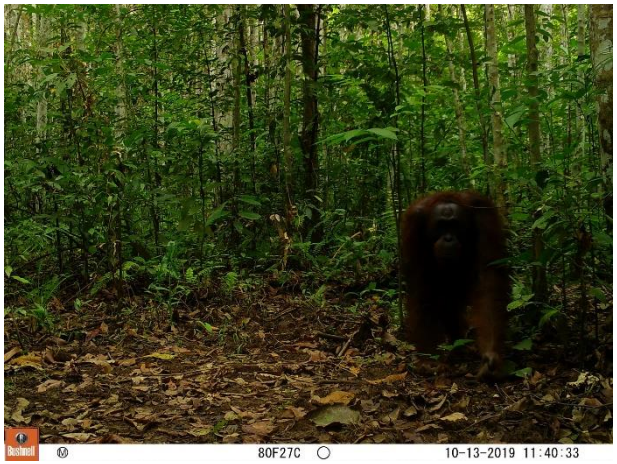

Figure 20: Orang Utan, *Pongo pygmaeus* a characteristic primate species, classed as Critically Endangered by the IUCN. (CTS 11 19/10/2019)

Figure 21: Image captured of Common porcupine, *Hystrix brachyura*, uncommon nocturnal rodent within PSFR listed as Least Concern (IUCN) (CTS 7 20/4/2019)

Figure 22: Banded palm civit, *Hemigalus derbyanus* an Near threatened species (IUCN) is a nocturnal predator feeds on small rodents, frogs & snakes (CTS 1 27/9/2019)

Figure 23: Crested fireback, *Lophura ignita* a not uncommon forest pheasant in PSFR, classed as Near Threatended by the IUCN. (CTS 11 19/10/2019)

3. Water Quality Monitoring

Pin-Supu Forest Reserve water quality monitoring is conducted by community cooperative KOPEL Bhd. This work has been ongoing since 2012 and compiles water quality parameter data from a total of 5 sample points. These include a point of discharge from the Kg Mengaris, Tungog Lake, and the others at the confluence of the Kaboi River, the Takala River, and the Pin River, with the Kinabatangan River **– refer to figure 12** (Sample Location Map)**.**

Data collected is compared with the National Water Quality Standards for Malaysia to determine the status of water quality in the sampled area **– refer to figure 10** (National Water Quality Standard).

Analysis of Data 2019

I. pH values are stable amongst all sample points, SK1 (Sg. Kinabatangan/Sg. Pin), SK2 (Sg. Kinabatangan/Jetty KOPEL), SK3 (Sg. Kinabatangan/Sg. Takala), KB1 (Kuala Kaboi) and TREC (Tungog Lake). Neutral values ranging from 6.1 -7.5 **–refer to figure 1** lie within class I, class IIA and class IIB - **refer to figure 2**, indicating no detrimental effects of the quality of both the River and the Lake. Sample site TREC occupies the lower values, although the values are still neutral, neither acidic nor alkaline, therefore show no area of concern in regard to pH. Factors such as, but not limited to, photosynthesis, respiration, fossil fuel emissions, and agricultural runoff can influence the minor fluctuations seen monthly and site wide.

II. Dissolved oxygen levels for sample points SK1, SK2 , and SK3 all remain relatively stable occupying class IIA in the national water quality standards**–refer to figure 4**. While this does mean aquatic species are sensitive, sample points KB1 and TREC are substantially lower. KB1 station values range from 2.9mg/L to 5.5mg/L **–refer to figure 3,** mostly occupying class III, because of stream, and or peat swamp area influences within Pin Supu Forest Reserve. Dissolved oxygen levels decrease even further at TREC, all but one sample (5.5mg/L) range from 0.6mg/L – 2.5mg/L **–refer to figure 3**, occupying class V**–refer to figure 4**. This data exhibits a similar pattern to 2018 due to the vast amount of *Salvinia molesta* that still exists, covering around 90% of the Lakes surface. Dissolved oxygen at this level is extremely low and not suitable for aquatic life. Although some fish are still present in Tungog lake, these levels of dissolved oxygen continue to pose a huge threat to the biodiversity and aquatic species.

III. Chemical oxygen demand data ranges predominantly between 10mg/L-30mg/L **– refer to figure 5, fluctuating** within class I, class IIA and class IIB –**refer to figure 6,** amongst all sample sites throughout the entirety of the year. With an exception of the 4 samples which remain ever so slightly outside of class IIA and class IIB. The reason for the small spike in July is unclear; however, these values are not high enough to be considered in class III and show no area of concern. Chemical oxygen demand levels can typically fluctuate both seasonally and over a 24-hour period as seen in the minor variations monthly. Chemical oxygen demand levels can also be affected by aeration of water resulting in higher values at a sampling site with slower water, as observed at sample site TREC.

IV. Electrical conductivity data across all stations in 2019-**refer to figure 7** are unable to be compared with the National Water Quality Standards Malaysia-**refer to figure 8.** This is due to scientific error as the data has been taken in different units; µs/cm/m and Ωm. The issue is that Ωm is a unit of electrical resistivity and is the opposite of conductivity therefore this data set cannot be analysed at the moment and should be considered as inaccurate.

V. NH4 (ammonium), NO2 (nitrogen dioxide) and NO3(nitrate) concentrations all show completely stable, bar one value, across all 5 stations for the entirety of the year **–refer to**

figure 9. NH4 at 0.2mg/L, NO2 at 0.02mg/L and NO3 at 1mg/L, these values however don't fall within a class for the national water quality standards for Malaysia **– refer to figure 10.**

Conclusions and Management implications

I. Based on the current evidence from water quality monitoring in 2019 there is insufficient evidence to suggest major pollution occurrence at the sampling points, or the need for immediate corrective action in any of the immediate surrounding areas upstream or adjacent to Pin- Supu Forest Reserve (i.e. in the headwaters of Pin- Supu Forest Reserve).

II. Tungog Lake continues to be a site with critical condition in terms of Dissolved Oxygen. This is attributed to the invasive weed, *Salvinia molesta.* This aquatic fern shades out any submerged plant life and blocks oxygen exchanged to suitable animals and fish. The aquatic life is threatened by the low oxygen conditions and imbalance in the ecology of the lake. A long-term integrated pest management approach involving the Salvinia weevil (*Cyrtobagous salviniae*) alongside physical removal is currently being used to try tackle the problem.

III. The water quality monitoring program involves 100% the local community and supports (a) local awareness-raising, (b) employment benefits to the local community, and (c) inclusivity of local community in the co-management of Pin Supu Forest Reserve. For these reasons it is highly recommended that that the water quality monitoring should continue to be used for outreach programs and environmental educations programs moving forward.

IV. Even so, based on the outcomes of measurable effectiveness indicators it is highly recommended that the water quality monitoring be revised, improved and expanded to provide a more effective feedback for management of PSFR. Improvements suggested include (a) the prevention of scientific error when sampling sites, i.e. electrical conductivity. (b) the establishment of a laboratory at KOPEL, (c) upgrading of sampling equipment, (d) installing auto logging monitoring stations, (e) installing hydrological station and automatic weather station to corelate results, and the expansion of these efforts to include other closely related monitoring such as hydrology monitoring.

Results are shown in Fig 24 – 28 below

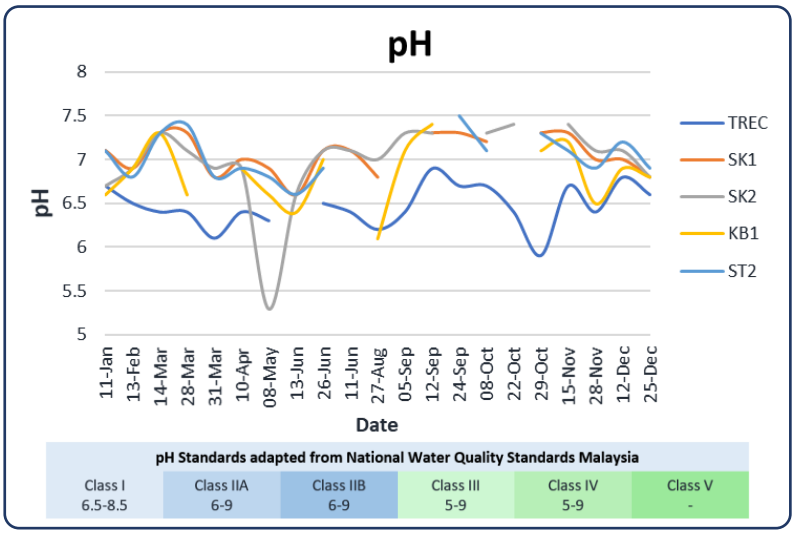

Figure 24: pH bimonthly analysis, 2019.

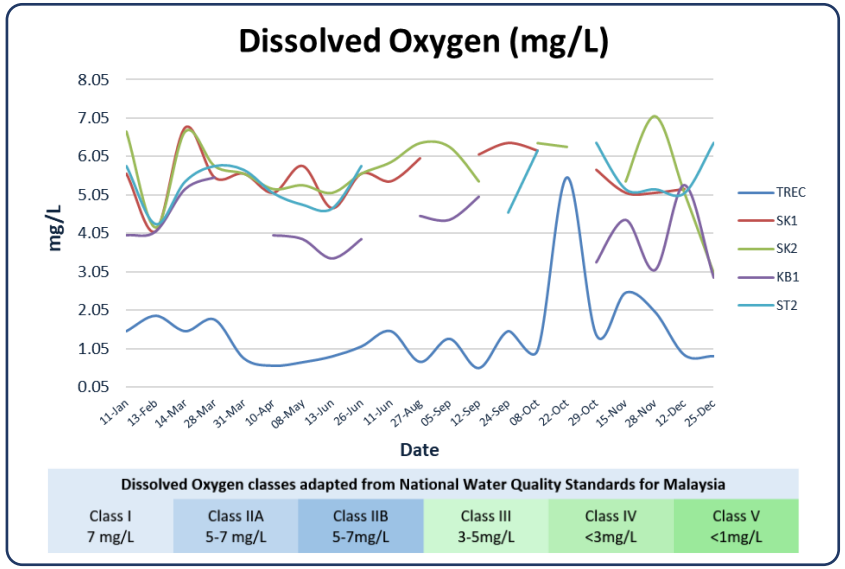

Figure 25: Dissolved oxygen bimonthly analysis, 2019

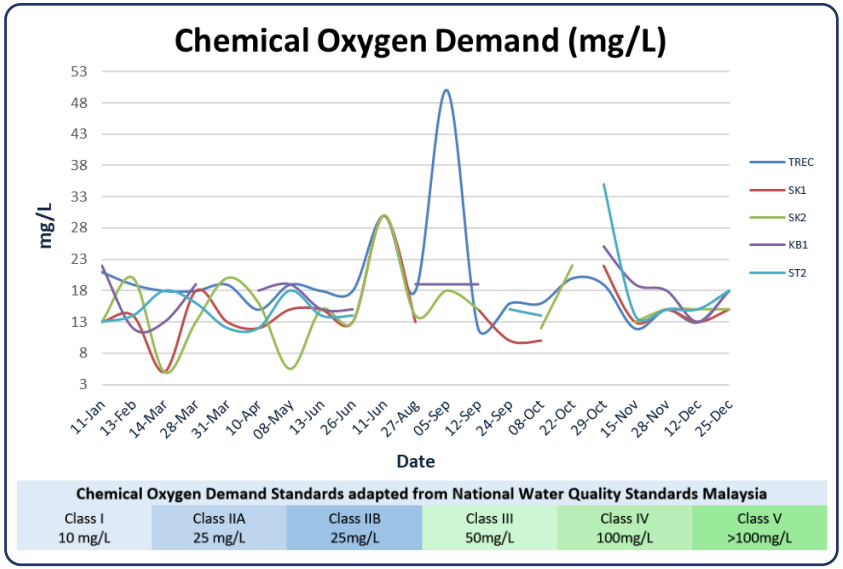

Figure 26: Chemical oxygen demand bimonthly analysis, 2019

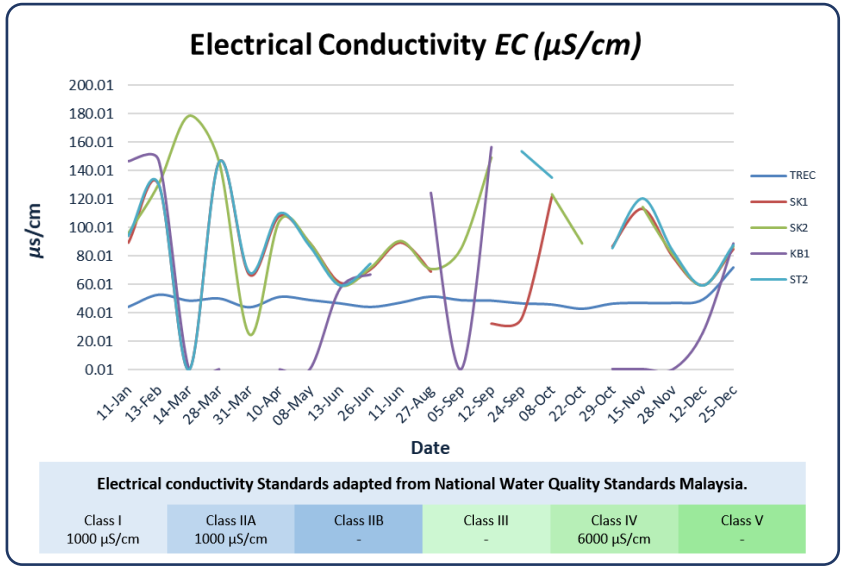

Figure 27: Electrical conductivity bimonthly analysis, 2019

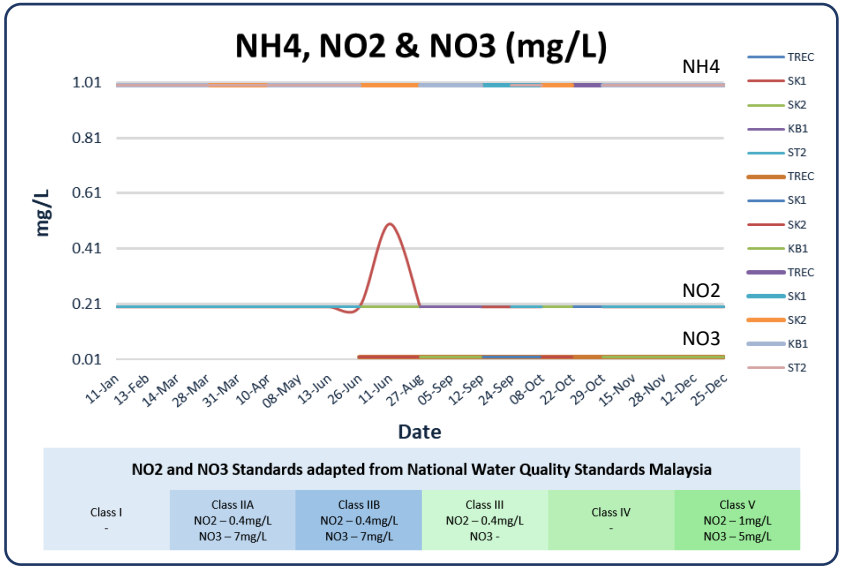

Figure 28: NH4, NO2 and NO3 bimonthly analysis, 2019.

CLASS	USES
Class I	Conservation of natural environment. Water Supply I - Practically no treatment necessary. Fishery I - Very sensitive aquatic species.
Class IIA	Water Supply II - Conventional treatment.
Class IIB	Fishery II - Sensitive aquatic species. Recreational use body contact.
Class III	Water Supply III - Extensive treatment required. Fishery III - Common, of economic value and tolerant species; livestock drinking.
Class IV	Irrigation.
Class V	None of the above.

Figure 29: Water classes and uses adapted from National Water Quality Standards for Malaysia.

Figure 30: Garmin base map of sample points, 2019.

TREC	Tungog Rainforest Eco Camp (Tungog Lake)
SK1	Sg. Kinabatangan confluence to Sg. Pin
SK2	Sg. Kinabatangan confluence to Jetty KOPEL
SK3	Sg. Kinabatangan confluence to Sg. Takala
KB1	Sg. Kinabatangan confluence to Kuala Kaboi

Figure 31: Sample points on the Kinabatangan River for Water Quality Analysis.

4. Lake Tungog Salvinia Removal Project

Salvinia (*Salvinia molesta*) is an invasive aquatic fern that originates from South America. In the Sabah context this plant is a noxious aquatic weed that has spread rapidly over the last 10-15 years across the freshwater lakes of the Lower Kinabatangan and other areas of Sabah. Salvinia weed infested the Tungog Lake between 2001-2002 during a major flood event. In Tungog Lake there is no permanent river entering the lake and hence there is no natural annual flushing of the lake making this an enclosed aquatic ecosystem. Given the right conditions Salvinia grows extremely rapidly forming dense mats covering the the surface of the lake. At present Tungog Lake is 90% covered by the Salvinia weed.

The presence of Salvinia covering the Tungog Lake has had a major impact on the overall water quality, species abundance, and aesthetics of the Lake. Salvinia has direct negative effects on water quality such as dissolved oxygen, chemical oxygen demand, pH, clarity, and electrical conductivity, which in-tern has a major implications on the aquatic ecosystem such as fisheries and food abundance for many wildlife species. Monitoring of the Tungog Lake water quality has been ongoing since 2012 through KOPEL's water quality monitoring program (Refer to page 16 in this document). The outcomes of the monitoring demonstrates the toxic impacts of the Salvinia weed on this lake ecosystem.

Efforts to remove the Salvinia has been ongoing since 2005. In 2007 KOPEL completely cleared the lake of the Salvinia weed and had an active monthly maintenance program until 2013. During this period the lake was completely open and clear of Salvinia, whereby many of the native wildlife species such as Otter (*Lutrogale perspicillata,* and *Aonyx cinereus*), Oriental Darter (*Anhinga melanogaster*), and Buffy Fish Owl (*Ketupa ketupu*) returned and were present at Tungog Lake.

Maintenance work ceased in 2013 for five months due to the closing of KOPEL operations during the Tanduo Crisis. During these five months the Salvinia weed rapidly spread covering approximately 25% of the lake. Since then the weed has rapidly spread outpacing KOPEL's monthly manual removal programs. The impacts of the Salvinia weed on Tungog Lake are multiple, with immediate decrease in aquatic dependent wildlife such as Otters and other water birds. Based on current observations, assessment and analysis of monitoring data (see page 16 above), the Tungog Lake is in a critical state of decline at present.

Data was collected on Tungog Lake in June 2016, June 2017 & June 2018 by The Tropical Restoration Ecology Field Course conducted by the University San Francisco (USF). These short term studies were conducted to describe the fish species, plankton, water invertebrates and wildlife on this lake, alongside establishing a profile of water quality across the lake. The objective of this work is to act as a baseline survey of the lake condition before the release of the biological control and to support ongoing monitoring of the weevil release.

Figure 32: Grass Suds growing on Salvinia at the North End of Tungog Lake.

The USF study involves the establishment of transects across the lake and taking water samples along the transects at specific depths. One transect runs across open water and a second over Salvinia-infested water. Water is sampled at three sites approximently 25 metres apart along the transects, at different depths, to measure temperature, dissolved oxygen, pH, clairty, depth, ammonium and nitrate. Comparisons were conducted and recorded along each. A fish survey was also conducted using three types at nets at each of the sampling points along te transect. A drip net for surface fish, casting net for pelagic speices, and a trap for bottom dwelling speices.

Figure 33: Open water being maintained manually at the Southern End of Tungog Lake, 2019.

Analysis of results from the USF Study shows the dissolved oxygen levels along both transects to be extremely low. Fish require between 4-15mg/l for survival, although some species are found to be tolerant of much lower levels of oxygen. Due to the low levels of dissolved oxygen the expectation of biodiversity and abundance of Tungog Lake are low, however results do show the lake is ecologically diverse with species at high trophic levels. These results and the amount of *Salvinia molesta* present indicate the conditions of the lake could experience further degradation.

In addition to the USF study and ongoing manual removal of Salvinia by KOPEL staff and volunteers, KOPEL started a more integrated approach in 2015 working with the Sabah Agriculture Department to introduced a biological control agent - the Salvinia weevil *(Cyrtobagous salviniae*). After more than three years of preparatory work, quarantine, breeding, and the establishment of release protocols, the weevil was finally released on October 27th 2018. Monitoring of Tungog Lake ecosystem is continuing in parallel with the weevil monitoring programme. This monitoring follows the release and monitoring protocols established by the Sabah Agriculture Department.

Twelve (12) sample sites**-refer to figure 4,** were established around the lake to monitor the progress of the weevil since its release. The sampling involved collecting 1kg samples of Salvinia weed and determining the presence or absence of the weevil within the Salvinia sample as well as the current weevil population. The Salvinia samples were also assessed for plant damage as a result of weevil establishment. Damaged buds are one indicator of weevil activity due to a direct relationship between the amount of bud damage and adults present.

The results of the monitoring activities confirm the weevil is present around the very first release site and have spread north, east, south and west from this site (sample sites 1, 2, 3, 4, 5, 6, 7, and 8 **– refer to figure 3**). Release site 2 and 3 (site 11/12) and the surrounding sites (9/10) did not show the evidence of the Beetle within the sample taken. Despite this result the samples obtained from release site 3 did have 12% bud damage, indicating beetle activity regardless of beetle absence.

It should be noted that sample sites 9, 10, 11 and 12 on the most north end all inhibit vast amounts of grass on top of the Salvinia mat covering Tungog Lake, it is currently uncear how this is affecting the

weevil but sampling will continue to take place in 2020 to ensure a better understanding of the weevils presence and numbers. It is considered vital for the health of the Lake that the weevil continues to spread and Salvinia damage is ongoing, hence ongoing monitoring is required to understand the biocontrol dynamic and to assess the needs for future follow-up beetle release on Tungog Lake.

Management Implications

I. The Salvinia covering Tungog Lake remains an immediate threat to Tungog Lake and the freshwater aquatic ecosystem. Tungog Lake is already identified as HCV 3.0 and is of critical importance at the site specific, ecosystem and landscape levels. Therefore, continuing to monitor the impacts of the biological control agent (Cyrtobagous salviniae) is of the upmost importance in management approaches in controlling the Salvinia on tungog lake.

II. The Salvinia weevil has been successful at most sample sites thus far, ensuring these sites continue to thrive is absolutely necessary, whilst the unsuccessful sites and implications of the grass are addressed and possibly revised. Continuing to detect the spread and potentially modifying control methods is critical in this upcoming year in order to move forward.

III. Based on the outcomes of measurable effectiveness indicators it is highly recommended that the monitoring efforts on Tungog Lake be revised, improved and expanded to provide more effective feedback for management of PSFR. Improvements suggested include (a) establishing a detailed and in-depth study of Tungog Lake to provide comprehensive base-line information on this unique aquatic ecosystem, (b) expanding the collaboration and partnerships to local universities and research partners to support building local capacity to continue monitoring of Tungog Lake, and (c) expanding the collaboration and partnerships with volunteer organisations to support the manual removal of the Salvinia water weed.

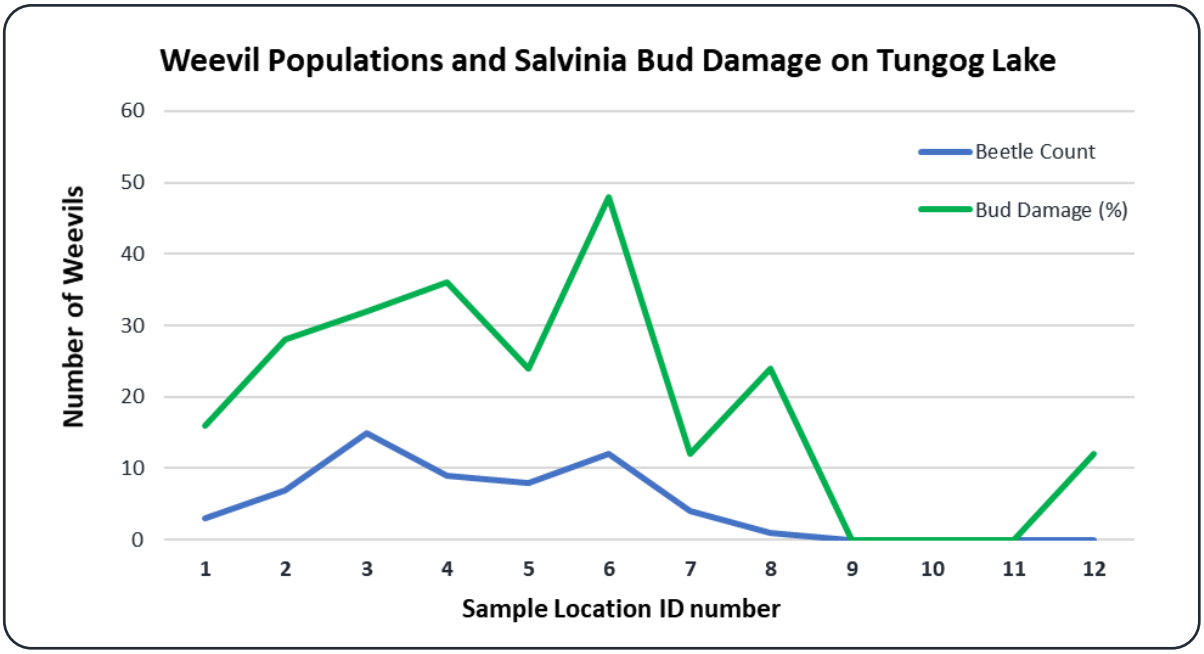

Figure 34: Weevil beetle count and percentage of salvinia bud damage per sample site

Figure 35: Location map of sampling points

5. Cave Restoration & Monitoring

There are more than 11 recorded limestone caves within the Pin-Supu Forest Reserve (PSFR). Many of these caves in the Supu Complex have unique cave formations, ancient artefacts, and specialised cave fauna, all of which are significant and specialized features of HCV 3.0 for PSFR.

KOPEL began active conservation and restoration efforts in the Supu Limestone Caves in 2010 after receiving support from Sabah Wildlife Department to manage and restore the swiftlet population within the caves.

Since the year 2010 KOPEL has appointed four forest rangers full time, to monitor and protect the caves in the Supu Limestone Complex. The rangers are based at Supu Camp, to maintain a permanent presence at the caves and impede encroachment into the caves, whilst maintaining the facilities and trails. Prior to KOPEL's work in this site, there was no scientific monitoring of the caves. In 2018 KOPEL formed a short-term partnership with The Rufford Foundation to make scientific cave exploration under the project of, *Cave biodiversity conservation in Lower Kinabatangan, Sabah, and Malaysian Borneo*. The study detail is described below:

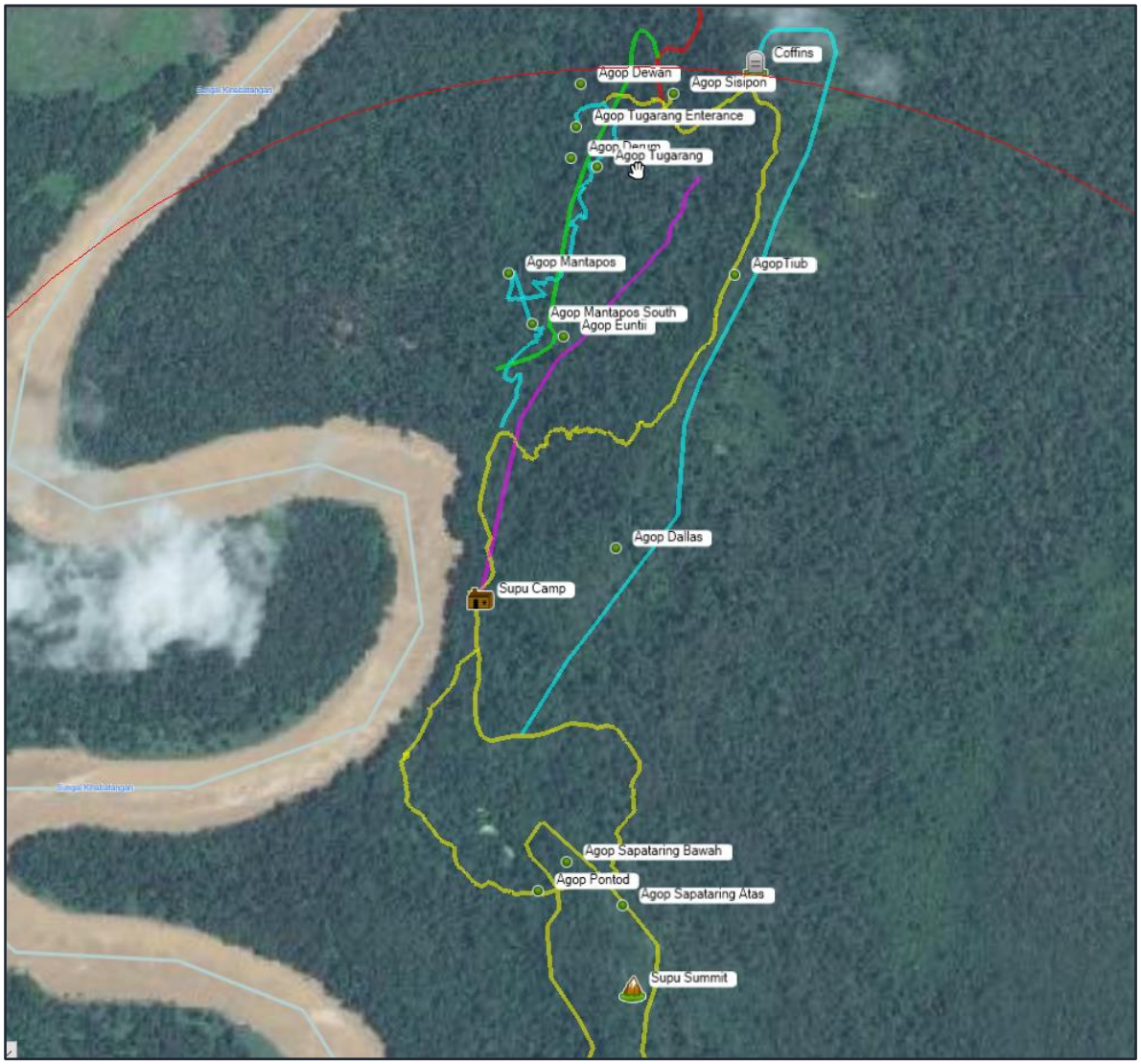

Figure 36: Location Limestone chamber in supu cave

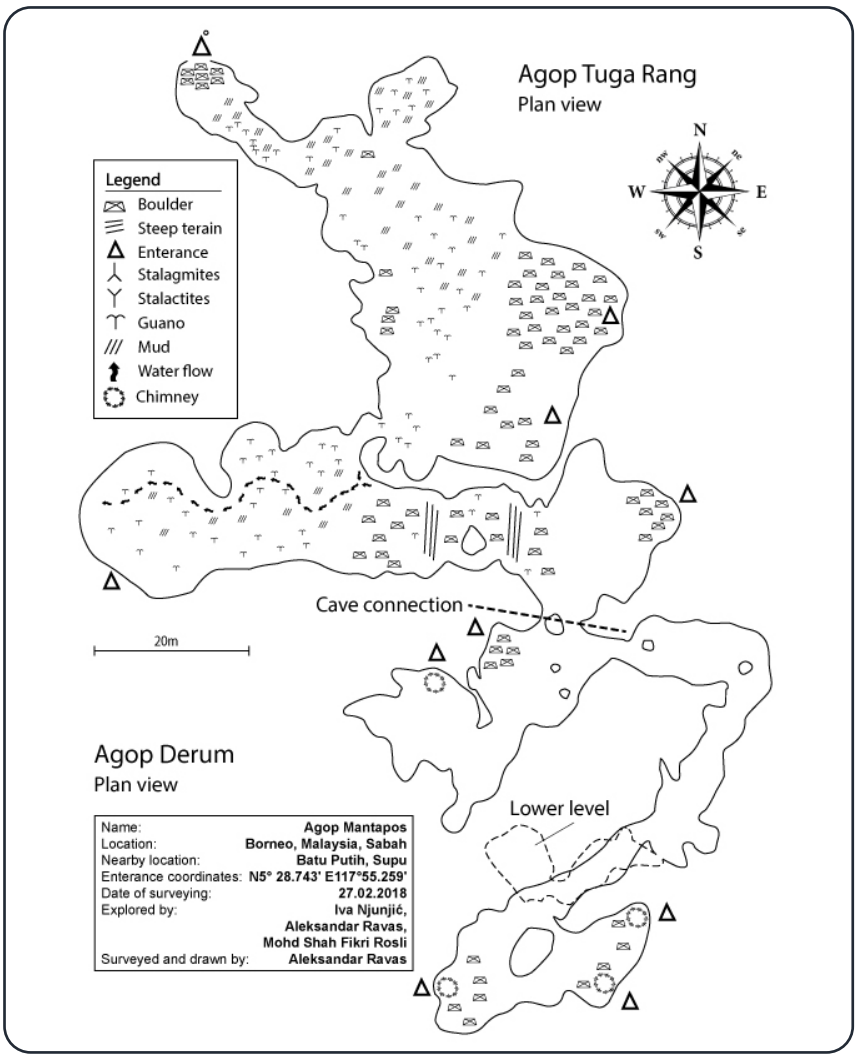

Figure 37: Cave mapping plan from The Rufford Foundation Study (Plan View)

Cave and Karst fauna conservation in Pin Supu Forest Reserve

I. The first phase of the project involved the training local conservation staff regarding basic cave survey techniques, including cave mapping & sampling of cave fauna. Phase 1 involved, exploring Supu limestone hills, mapping a selection of caves and compiling information on the history of cave-use via interviews with local people. This field work also involved specimen collection to establish baseline data on species richness and endemism of cave-adapted beetles and Micromollusks in the area.

II. The second phase of the project was the identification of the material and data collected and the analysis of the data collected during the first phase of the project. Combining the data collected in the field with existing materials at University Malaysia Sabah will support the development of organized inventories for each cave, alongside measure species richness, and create maps of cave endemism. The work in this phase involved local collaborators wherever possible. The purpose of this involvement was to disseminate information and build local skills in analysis techniques alongside the creation of promotional materials to be used for educational activities and public presentations.

III. The last phase of the project focused on education and raising environmental awareness. Two sessions were organised to share information on the process and findings about cave life were delivered to local primary school students from Batu Puteh. Also, an excursion was organised to the caves for local school students to explore hands on involvement of young school students in bio

speleological investigations. The purpose being to provoke an interest in disciplines associated with cave explorations. Towards the end of the project, findings were presented to staff and students at KOPEL, Danau Girang Field Centre, and University Malaysia Sabah. Other invitees were conservation officers from the Sabah Wildlife Department, Sabah Forestry Department, and the Minerals & Geosciences Department at UMS.

Important caves access trails were mapped out to prepare for the scientific exploration in Supu Cave. Cave mapping within selected caves used specially modified laser rangefinder combined with and connected to mobile phone apps, the chambers of three cave were mapped out in this exploratory phase. Example cave map is shown in Fig XX above.

Swiftlet Nest Monitoring

Swiftlet Nest surveys were not conducted from 2013 – 2018. Nest counts were started again in March 2019. The results below (figure 29, below) are a summary of the nest counting work. The methodology of the nest surveys involves (a) counting all nest within the caves, (b) counting nest with eggs or young swiftlet (these are left undisturbed and untouched), and (c) collection of abandoned nests. The outcomes of the nest counting survey is shown in figure 38 below. The Caves Agop Tugarang, Agop Sisipon and Agop Dalas have the highest nest counts – approximately 20 nest per cave.

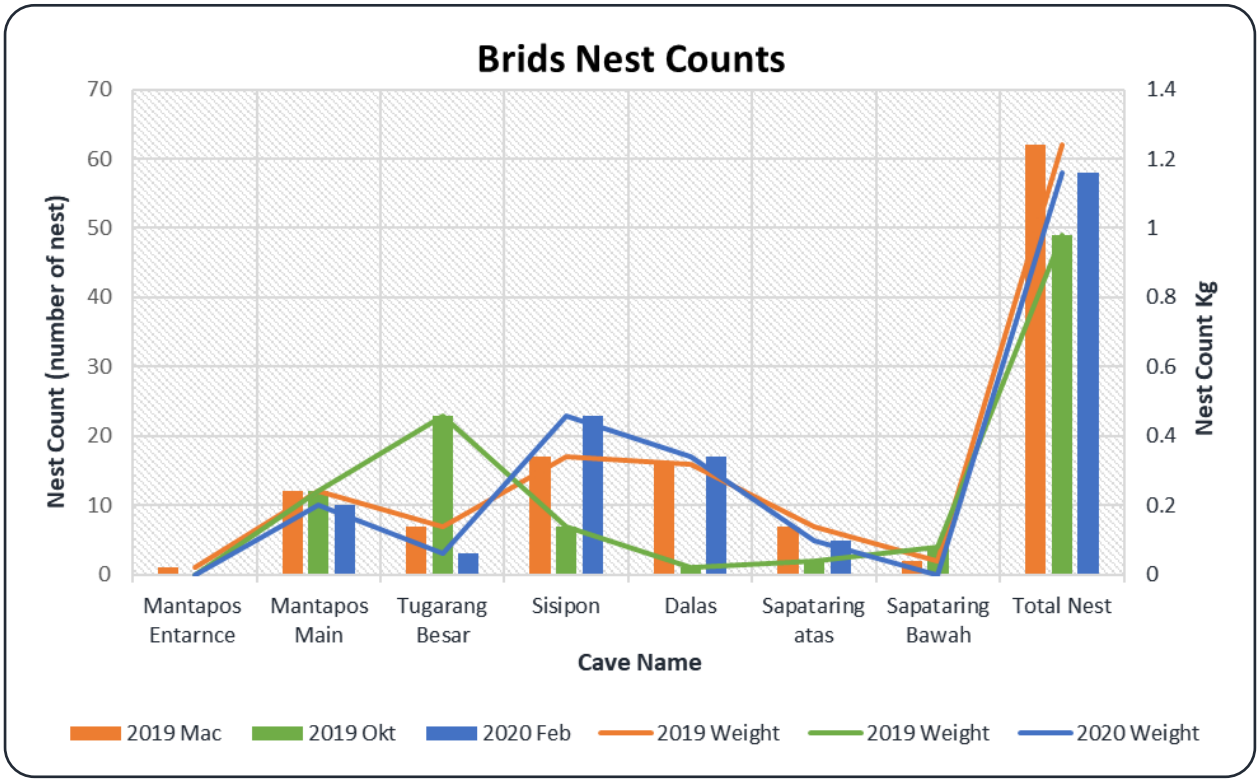

Figure 38: Birds nest counts from 3x Survey 2019-2020

Management Implication

I. Based on the overall outcomes of the preliminary cave fauna survey, it is understood there is considerable lack of knowledge and research into unique habitats such as the limestone caves, hence it is recommended that the monitoring be expanded to cover all aspects of cave fauna and cave conservation in the future. The data and results can be used to improve the practice in management and monitoring the caves into future.

II. Results of nest count monitoring shows a notable increase in the population of nesting swiftlets in the caves of the Supu Limestone Complex. This is considered a positive indicator for conservation efforts within Pin Supu Forest Reserve.

III. From a management perspective the increase in nest count is also a positive indicator of the health of the forest ecosystem within PSFR and is likewise considered a positive indicator of forest protection efforts across the reserve.

IV. The monitoring and subsequent fluctuation of nest counts across the year demonstrated illegal intrusions were being carried out in the caves. The intrusions were reported to Sabah Forestry Department; however, lack of evidence is thwarting further action or prosecution of the offenders. Additional security interventions have been established to prevent intrusions from recurring.

V. The cave monitoring program involves 100% the local community hence supports (a) local awareness-raising, (b) employment benefits to the local community, and (c) inclusivity of local community in the co-management of Pin Supu Forest Reserve. This is already providing opportunity for environmental education of local school students in 2018. It is recommended that the cave environments and monitoring program be an ongoing part of environmental education programs in the future.

Figure 39: Birds nest survey

Closing Remarks:

In summary ongoing monitoring work has been effective and continues to have consistent outcomes, no other major changes are suggested apart from what has already been outlined in this document. It is important that this work continues into the long-term hence ensuring reliable and consistent income into this program is paramount to its success. Income generation mechanisms are hoped to be expanded to benefit expanded monitoring activities in the future.

KOPEL Bhd continues to work closely with numerous of partners both in the preparation and analysis of data collected for the monitoring in 2019. KOPEL Bhd acknowledges and is extremely grateful for the efforts of students, volunteers, KOPEL staff, and the staff of Sabah Forestry Department and Sabah Agriculture Department. It is hoped that future partnerships can be established with Sabah Wildlife Department and other research institutions (such as UMS and Danau Girang Field Centre) to further build local capacity within KOPEL Bhd to strengthen monitoring and protection activities.

It is also hoped that the monitoring work can be expanded and improved to support better management of the forests and ecosystems around the Community of Batu Puteh and in the process further the knowledge and skills transfer to the community, the education of students, and economic benefits to the community, alongside improved conservation of the HCVF values into the future.