

Environment Monitoring Report 2018

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

2018



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 led 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 the overall management of this reserve is in-line with a more systematic and comprehensive 10-year Forest Management Plan. 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 via 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 2018 and is a key part of KOPEL's commitment towards inclusivity 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 2018 were two pronged. Firstly, KOPEL continued facilitating forest restoration efforts through the active involvement of volunteers and ecotourists. This still forms the backbone of KOPEL's forest restoration work, because this is year-round, and support funding the full-time restoration team, tree nursery team, and restoration management to facilitate all other restoration, monitoring & reporting work. Secondly KOPEL continued ongoing efforts partnering with the Sabah Forestry Department, namely via the RMK11 Restoration Project. The RMK11 project involves tree planting, maintenance of tree planting, and silviculture tending (vine liberation). This project employs more than 74 people from the local community of Batu Puteh on a seasonal basis.

Tree planting through ecotourism activities in 2018 planted a total of **12,024 trees**. A total of 15 species of tree were planted with the bulk of the trees being Bangkal (*Nauclea sp* =1,981) Sepat (*Mytrogyna sp.* = 1,885) and Salungapid (*Mollotus muticus* = 1,408). Four (4) key areas were planting in 2018.

1. **Block A Biandong**, is a seasonally flooded site in Pin-Supu Forest Reserve (Map Reference #1 in Map 3, p.26): A total of 480 trees were planted in gaps in this site, namely Bangkal (*Nauclea sp* =210) and Salungapid (*Mollotus muticus* = 270).
2. **Block Kaboi Stumping**, is a riparian site in Pin-Supu Forest Reserve (Map Reference #2 in Map 3, p.26). A total of 430 trees were planted in gaps in this site, namely Salungapid (*Mollotus muticus* = 366), with a mix of 6 other species (*Nauclea sp.*, *Pterospermum sp.*, *Octomeles sp.*, *Microcos sp.*, *Sterculia sp.*, *Dracontomelon sp.*)
3. **Block G Laab** is a permanently waterlogged swamp forest, in Pin-Supu Forest Reserve (Map Reference #3 in Map 3, p.26): A total of 4004 tree were planted via stem cuttings (otherwise known as "pole planting"). All trees planted in 2018 following this method were Sepat (*Mytrogyna sp.*)
4. **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 (Map Reference #4 in Map 3, p.26): A total of 7,110 trees where planted on this site in 2018, covering both the remaining gaps and replanting areas damaged by the drought of 2015-2016. A total of 14 species were planted on this site in 2018, the majority coming from Bangkal (*Nauclea sp* =1,756), Kalumpang (*Sterculia sp.*,=1,152), Bnuang (*Octomeles sp.* = 730), Mangkapon (*Colona sp.* = 705), Payung 3 (*Terminalia sp.* = 940), and Salungapid (*Mollotus muticus* = 270).

The tourism restoration efforts involved seed collecting, nursery propagation, site preparation for tree planting, tree planting and follow-up maintenance of planted trees.

Monitoring of Permanent Sample Plots (PSP) in 2018:

KOPEL has 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 this plot 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.

Plot KP02 & KP03 are the riparian corridor on the southern Kinabatangan Riverbank adjacent to PSFR. This site was planted between 2014-2015. Of the 352 trees on KP02, the average height is 9.3m with DBH 11.6cm. Of the 485 trees on 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.

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 2019-2020 to establish a more permanent wildlife monitoring presence in these permanent sample plots.

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.

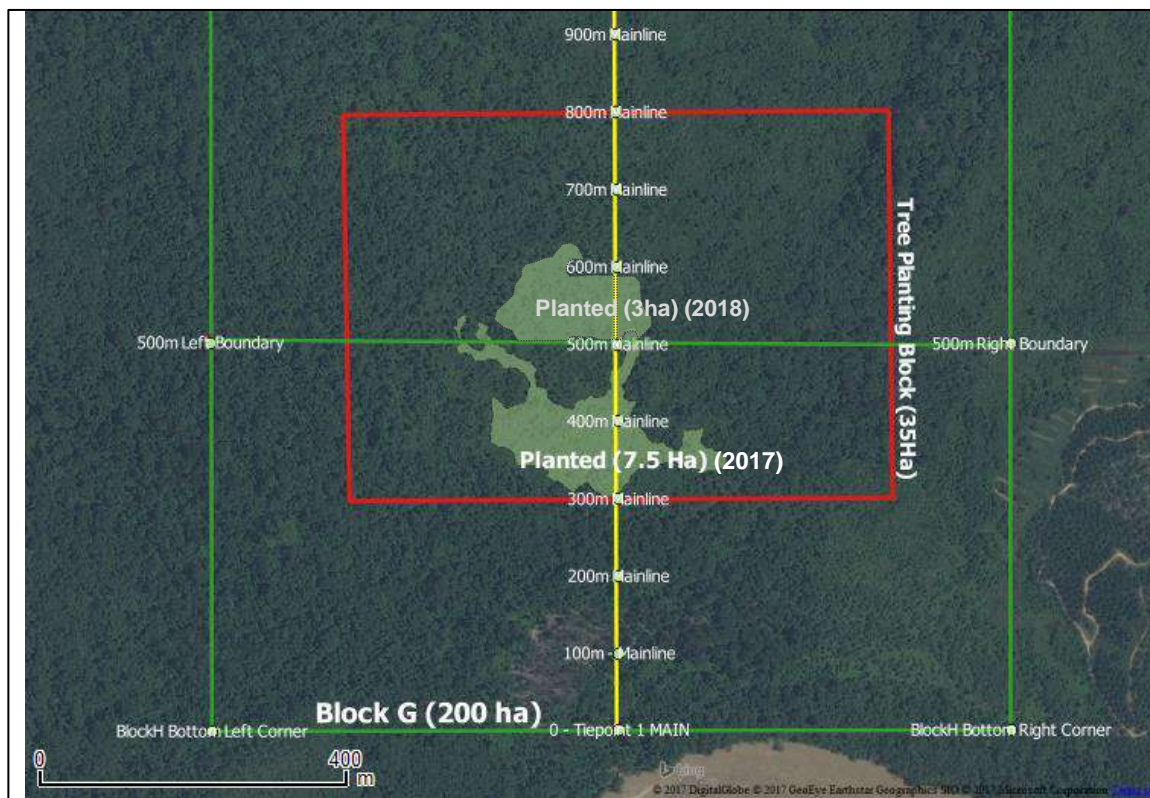
Table 1 below shows the outcomes of the experimental pole planting approach. To date the approach has provided very mixed results. A total of 7.5ha was planted in 2017, with a total of 3ha planted in 2018. Pole planting in 2017 shows approximately 50% survivorship, with similar pole planting in 2018 demonstrating very low survivorship. At this stage the reason for the high mortality in 2018 compared to 2017 is still unknown. Both efforts were carried out in July-August respectively. Planting material (pole cuttings) was procured from riverbanks in 2017, whereas planting material in 2018 was procured in nearby forest. Planting in 2017 was carried out after an extended flood in this area. The year 2017 had a dry July followed by a wetter August. The year 2018 on the other hand had a very dry July and August. Based on this experience KOPEL has requested to change the focus of tree planting in Pin Supu Forest Reserve.

Tree Maintenance: The removal of grasses, weeds and climbers from around the newly planted trees was carried out twice in 2018. This maintenance work was carried out on the total 10.5ha of tree planting sites. This maintenance was designed to remove the choking 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.

Table 1: Tree Planting Outcome 2017-2018 = 10,816 trees = 10.5ha

| Local Name | Family | Name | Total Trees | Survivorship | Year |
|------------|-----------|---------------------------|-------------------|-------------------|------|
| Bongkol | Rubiaceae | <i>Nauclea sp.</i> | 6130 trees | 70% | 2017 |
| Sepat | Rubiaceae | <i>Mytrogyna speciosa</i> | 682 trees | 20% | 2017 |
| | | TOTAL 2017 | 6812 trees | 4427 trees | |
| Bongkol | Rubiaceae | <i>Nauclea sp.</i> | 0 trees | | 2018 |
| Sepat | Rubiaceae | <i>Mytrogyna speciosa</i> | 4004 trees | 5% | 2018 |
| | | TOTAL 2018 | 4004 trees | 202 Trees | |

Figure 1: RMK11 Tree Planting Sites Pin Supu Forest Reserve 2017-2018



Silviculture Treatment: Within Pin Supu Forest Reserve silviculture treatment involved vine cutting to liberate trees threatened by thick and choking 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 3, next page).

Silviculture treatment under the RMK11 project in 2018 was carried out on 277ha of forest in both Pin Supu Forest Reserve Block A & Block B (See Figure 2, next page). The largest of the silviculture sites was upstream from the KOPEL base, in the area known to local people as Laab - named after the previous Laab Village in the vicinity. A total of 176ha was treated in the Laab site. The remainder of the Silviculture sites were downstream from the KOPEL base. A total of 98ha was restored in PSFR Block A (Biandong 30ha, Hilir Tungog 38ha, Hilir Kuala Kaboi 30ha).

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 2: Location Map of RMK11 Silviculture Vine Liberation Treatment 2018



Figure 3: Impact of RMK11 Silviculture Vine Liberation Treatment 2018

Long-term Forest Restoration Impacts

KOPEL is in the process of compiling a full detailed report on the impact of restoration over the last 20 years in Pin-Supu Forest Reserve. The detailed report is targeted to be finished before the end of 2019. Prior to the completion of this report, it should be noted that over the last 20 years KOPEL has planted more than 330ha of forest and in the process planted more than 380,000 trees. All this planting has been in severely degraded forest, both in seasonally flooded and meander belt forests.

The observation of a diverse array of birds & wildlife species in the newly restored forest is already evidence that the restoration efforts are providing a positive impact to the wider habitat and food availability for wildlife in this part of the Kinabatangan. The restoration efforts have also targeted riparian corridors critical to linking forest fragments along the Kinabatangan. Further work is underway to provide scientific data to concur with local community and tourist observations.

The restoration work is providing much needed employment opportunities in the surrounding community, both in a full-time and seasonal basis. **In 2018 total of 85 staff were involved** in the forest restoration program in 2018. Of this, KOPEL employed three (3) full time staff on restoration projects. An additional eleven (11) staff participated from the core KOPEL team in 2018. The restoration projects provided an addition seventy-four (74) people with part-time employment from the surrounding community in 2018.

Some of the key lessons learnt through this process is that

- (a) Tree Planting per se is NOT the sole answer to the restoration of degraded forests. Tree planting without adequate site preparation and follow-up tending (maintenance) continues to result in high mortality of the trees planted.
- (b) A proper understanding of the site conditions and existing vegetation (scrub, vine & grass cover), soils and hydrology in the each separate degraded site respectively is key to success, alongside;
- (c) A lot of extremely hard work on the ground clearing the thick and choking vines & grasses that inhibit the natural regeneration of tree species in these sites.

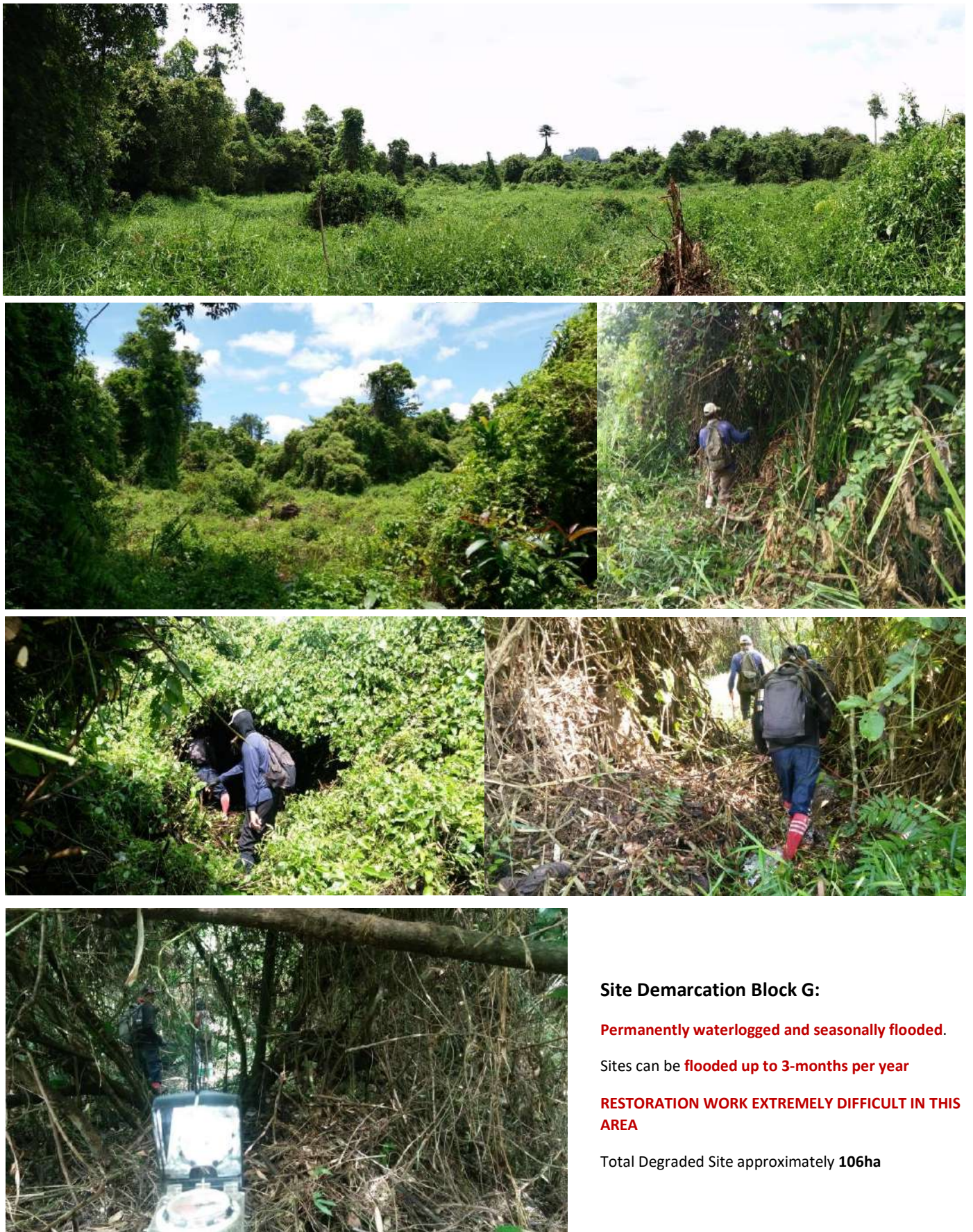
In parallel with the above-lesson learned, key recommendations include:

- (d) The cost of restoring the degraded forests is much higher than anticipated or widely understood. Based on KOPEL's experience over the last 20 years, neither Government or environmental NGO's are willing to pay the full costs required (including protection of workers, minimum wages, and providing basic good working conditions) to restore degraded forests, and initiatives such as KOPEL continue to be under resourced and misunderstood – this needs to change.
- (e) It is highly recommended to change the approach to restoration of seasonally flooded or permanently waterlogged areas. In this case a precautionary and experimental approach should be carried out before contracting out large-scale restoration efforts.
- (f) Restoration efforts should be revised, improved and expanded to include the enrichment of climax species such as dipterocarps and other key conservation target species to ensure species conservation targets are met alongside improvements to ecosystem and forest function.



Figure 4: Waterlogged tree planting site after site preparation

Site Conditions **Block G** 2017-2018



Site Demarcation Block G:

Permanently waterlogged and seasonally flooded.

Sites can be **flooded up to 3-months per year**

RESTORATION WORK EXTREMELY DIFFICULT IN THIS AREA

Total Degraded Site approximately **106ha**

Figure 5: Waterlogged tree planting site before site preparation

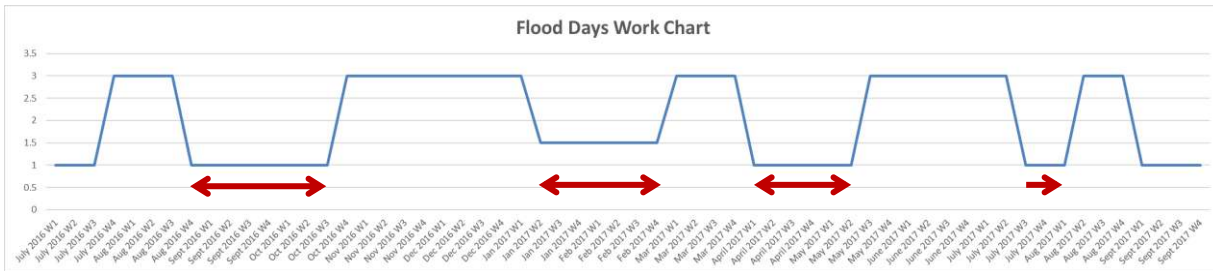
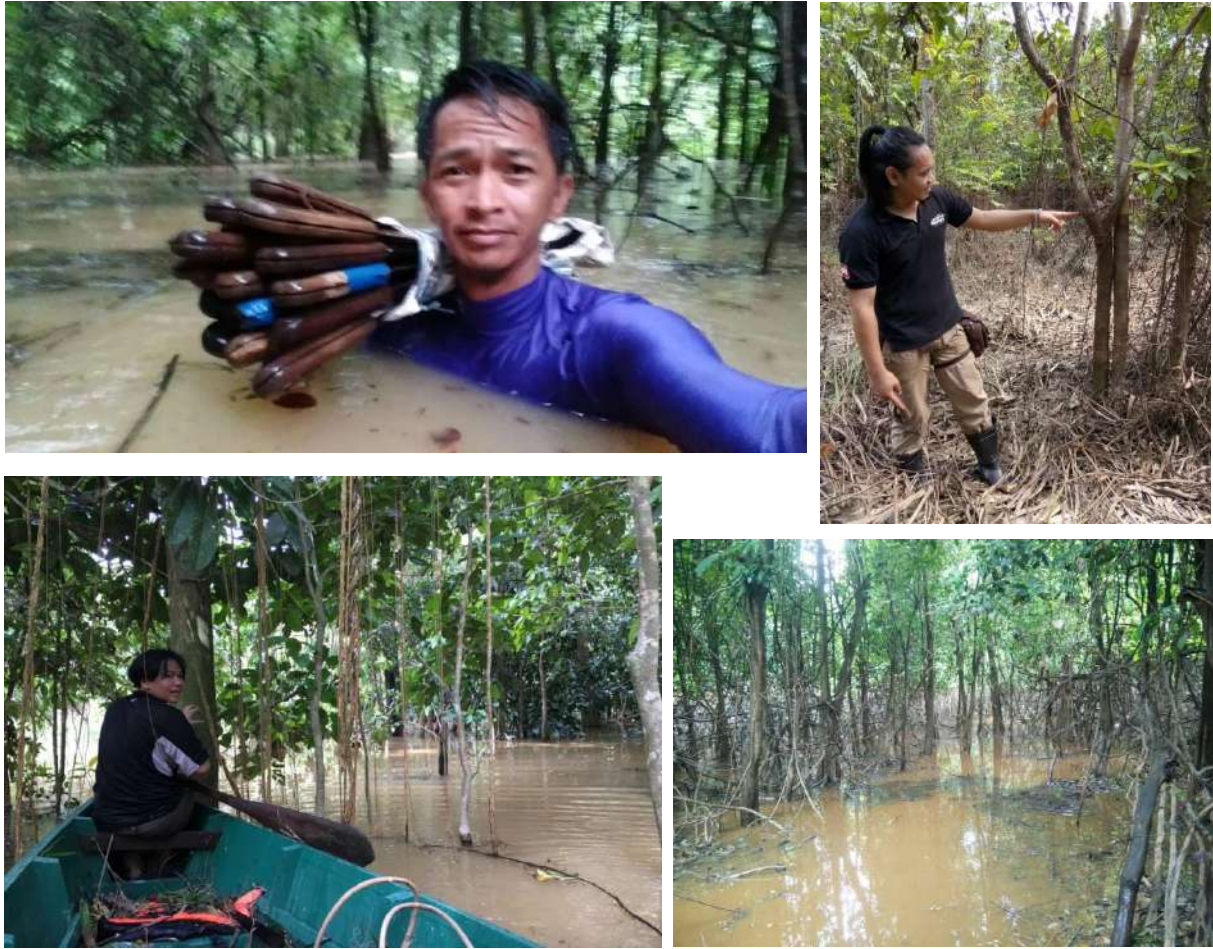
Tree Planting **Block G** 2017-2018



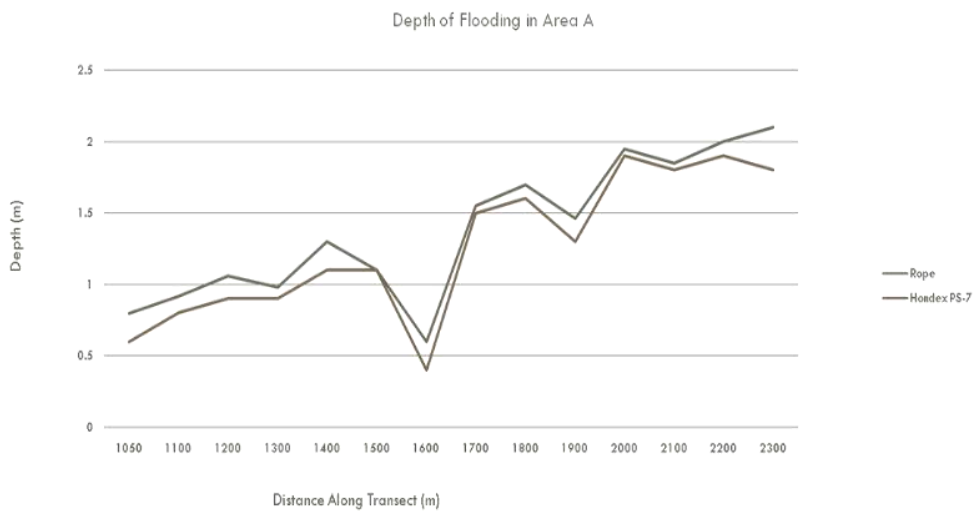
Figure 6: Pole planting at Laab site before during & after planting

Site Flooding Block G 2017-2018

Figure 7: Flooding Inside the Biandong & Laab Restoration Sites (Block A & G) 2017-2018



Total Work Time 2017 Due to Flooding on Site = 17 weeks = 4.25 months



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 2018 a total of 8 camera traps were deployed permanently within Pin Supu Forest Reserve with another 4 traps deployed for short term duration.

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 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. 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.

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 2018. This report also concludes, with a list of implications for management, designed to feed-back into the upcoming revision of PSFR FMP.

The key monitoring points in the Supu complex on the west side of Pin- Supu Forest Reserve. **Reference Figure 13.** Camera traps has been deployed on the ridges (station 1 and 2), swamp (station 3, 4 and 5). 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.

Analysis of Data 2018

- I. Camera trap data shows binturong (*Arctictis binturong*), also known as bearcat, and banded linsang (*Prionodon linsang*) were recorded. This is the first camera trap records for these two species within Pin-Supu Forest Reserve.
- II. Other rare species which consistently appear in camera trap records are the clouded leopard (*Neofelis nebulosa*), sun bear (*Helarctos malayanus*) and orang-utan (*Pongo*). These species were also recorded in 2018, which is continuing “good news” for forest conservation and ongoing protection mechanisms around and within the reserve.
- III. The swamp forest at the base of Supu Hill, followed by Supu ridge has the highest number of species number recorded and likewise the highest Shannon and Simpson (diversity) index value. Even so, there are unique groups of species recorded for both forest types (see supporting documents).
- IV. Small mammals such as rodents are the most abundant sightings in the RAI analysis (abundance). All five camera traps have a high RAI for rodents.

Conclusions & Management Implications

- I. Although not unexpected, the results in 2018 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 source for a wide range of wildlife species.
- 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).
 - 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.
- e. Technique for avoiding floodwaters is critical and should to be developed to protect camera traps from being flooded. Examples should include the installation of hydrological monitoring stations, which can be used to both protect equipment from flooding and provide correlating data.
- 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 3 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 3 years, namely 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.
 - 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.

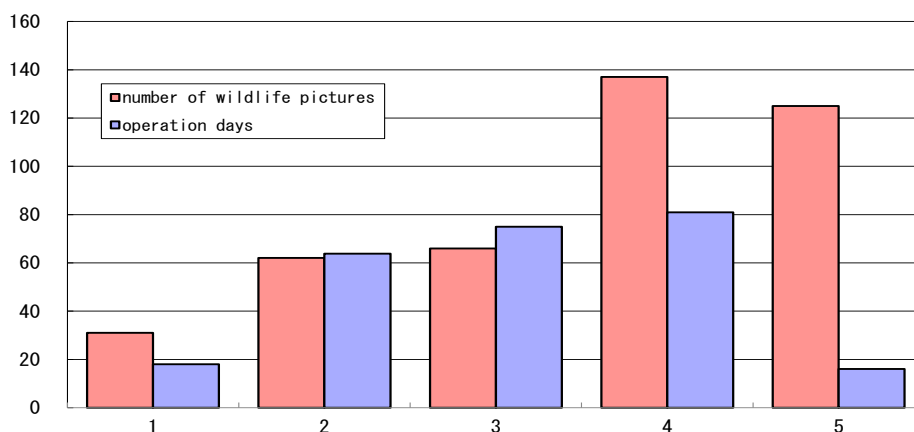


Figure 8: Number of wildlife pictures and operation days at 5 separate stations.

Figure 9: Species and number of captures compiled from 5 stations (Supu B)

| Species | Count |
|---|-------|
| Badger (<i>Meles meles</i>) | 30 |
| Banded linsang (<i>Prionodon linsang</i>) | 5 |
| Banded palm civet (<i>Hemigalus derbyanus</i>) | 6 |
| Bearded pig (<i>Sus barbatus</i>) | 4 |
| Binturong (<i>Arctictis binturong</i>) | 1 |
| Clouded leopard (<i>Neofelis nebulosa</i>) | 19 |
| Common palm civet (<i>Paradoxurus hermaphroditus</i>) | 2 |
| Crested fireback (<i>Lophura ignita</i>) | 3 |
| Emerald dove (<i>Chalcophaps indica</i>) | 7 |
| Great argus (<i>Argusianus argus</i>) | 7 |
| Ground bird spp. | 2 |
| Long tailed macaque (<i>Macaca fascicularis</i>) | 3 |
| Malay civet (<i>Viverra zangalunga</i>) | 10 |
| Mouse deer (<i>Tragulidae</i>) | 1 |
| Orang utan (<i>Pongo</i>) | 4 |
| Owl spp. | 5 |
| Porcupine spp. | 28 |
| Rodents spp. | 151 |
| Sambar deer (<i>Rusa unicolor</i>) | 1 |
| Snake spp. | 2 |
| Squirrel spp. | 18 |
| Sun bear (<i>Helarctos malayanus</i>) | 2 |
| Unknown birds | 42 |
| Unknown mammals | 31 |
| Water monitor (<i>Varanus salvator</i>) | 23 |

| Species | Total Count |
|----------|-------------|
| Birds | 6 |
| Mammals | 19 |
| Reptiles | 2 |

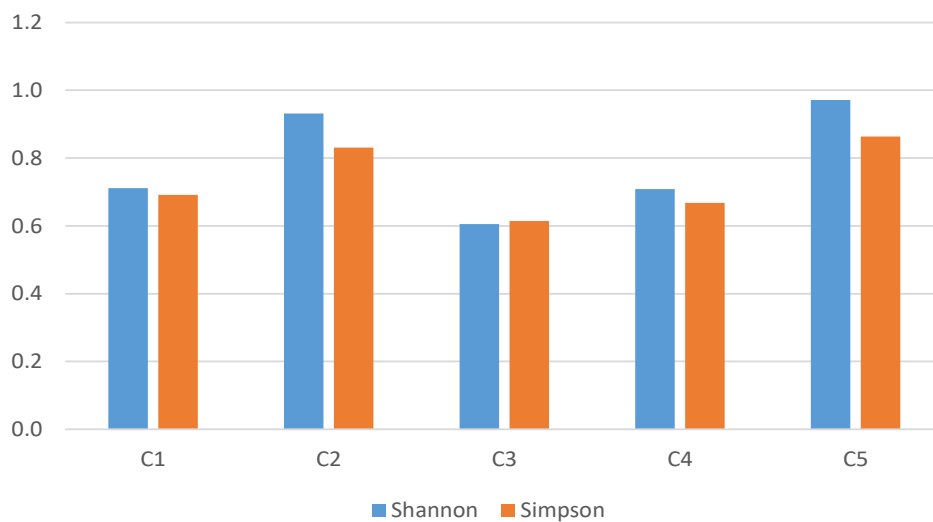


Figure 10: RAI using Shannon and Simpson index trend from each monitoring location.

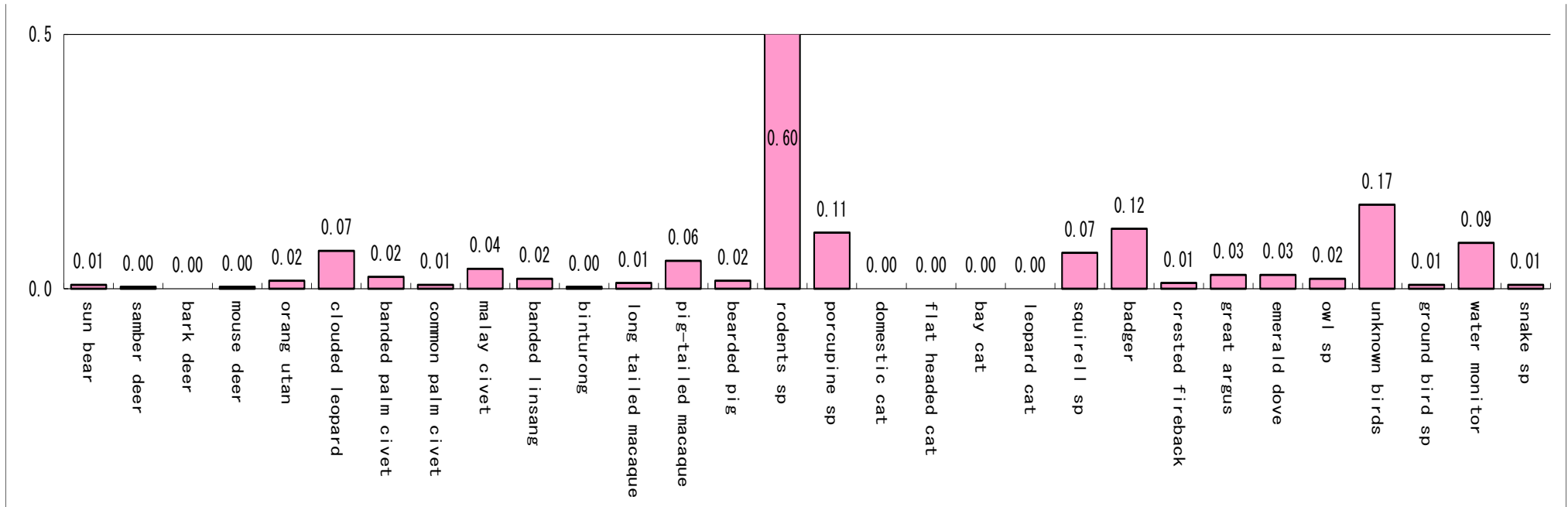


Figure 11: Relative Abundance Rate (RAI) using Shannon and Simpson index, on 24 hours (number or pictures / species / 24 hours).



Figure 12: Storm Stork (*Ciconia stormi*) considered as the rarest of all storks and listed under the IUCN Red List.



Figure 13: Sun bear (*Helarctos malayanus*) a rare civet cat - listed as vulnerable under the IUCN red list.



Figure 14: Binturong (*Arctictis binturong*) a rare civet cat - listed as vulnerable under the IUCN red list.



Figure 15: Two cubs of Clouded Leopard (*Neofelis diardi*). The first sighting of cubs on the Supu Hill ridge.

3. Water Quality Monitoring

The Water Quality Monitoring in the vicinity of Pin- Supu Forest Reserve is conducted by community cooperative KOPEL Bhd. This work is ongoing since 2012 and has compiled data from a total of 5 collection points, including one at a point of discharge from the Kg Mengaris, a second at Tungog Lake, with the others at the confluence of the Kaboi River, the Takala River, and the Pin River, with the Kinabatangan River – refer to figure 18.

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 16.

Analysis of Data 2018

- I. Sampling points, SK1 (Sg. Kinabatangan/Sg. Pin), SK2 (Sg. Kinabatangan/Jetty KOPEL), and SK3 (Sg. Kinabatangan/Sg. Takala) have remained stable at a Class IIA and IIB and Class I. Except KB1 (Kuala Kaboi), which fluctuates between Class III and Class IV due to discharge from peat swamp forests within Pin Supu Forest Reserve. – See figure 18.
- II. TREC (Tungog Rainforest Eco Camp) has the lowest levels of dissolved oxygen (DO) at a Class V. This is contributed to the large amount of *Salvinia molesta* covering the surface. This is a major threat to the aquatic species, biodiversity, and the aesthetics of this site to visitors to Lake Tungog. Dissolved Oxygen at this level is not suitable for aquatic life, although some fish are still present and adapted to these conditions.
- III. Data for the chemical oxygen demand was also collected. The Chemical Oxygen Demand (COD) has been constant at all sampling points throughout the year. SK1 (Sg. Kinabatangan/Sg. Pin) and SK2 (Sg. Kinabatangan/Jetty KOPEL), and KB1 are stable at a Class I and enter Class IIA and Class IIB during the June month. However, COD at Tungog Lake (TREC) remained relatively high in comparison to the other tributaries. This is contributed to the presence of the *Salvinia molesta*. - See figure 21.
- IV. Electrical Conductivity (EC) is stable in sampling areas SK2 (Sg. Kinabatangan/Jetty KOPEL) and SK3 (Sg. Kinabatangan/Sg. Takala), at a Class II. These levels of higher ions may be contributed runoff from a nearby palm oil plantation and use of chemicals, and/or a nearby peat swamp forest. SK1 (Sg. Kinabatangan/Sg. Pin) enters below a Class II in May and returns to a stable state as the other sampling points. EC at KB 1 (Kuala Kaboi) fluctuates dramatically below a Class I and above Class IIA and Class IIB but does not enter a Class III. Based on the other parameters at present this is not of critical concern. EC at Tungog Lake (TREC) is below Class III and is not suitable for the survival of aquatic life species. - See figure 23.

Conclusions & Management Implications

- I. Based on the current evidence from water quality monitoring in 2018 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. 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 establishment of a laboratory at KOPEL, (b) upgrading of sampling equipment, (c) establishing auto logging monitoring stations, and the expansion of these efforts to include other related monitoring such as hydrology monitoring.
- III. Tungog Lake continues to be a site with critical condition in terms of Dissolved Oxygen and COD. This is attributed to the invasive weed, *Salvinia (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 should be used to tackle the problem.
- IV. 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.

| 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 16: Water classes and uses

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

Figure 17: Collection Areas on the Kinabatangan River for Water Quality Analysis.

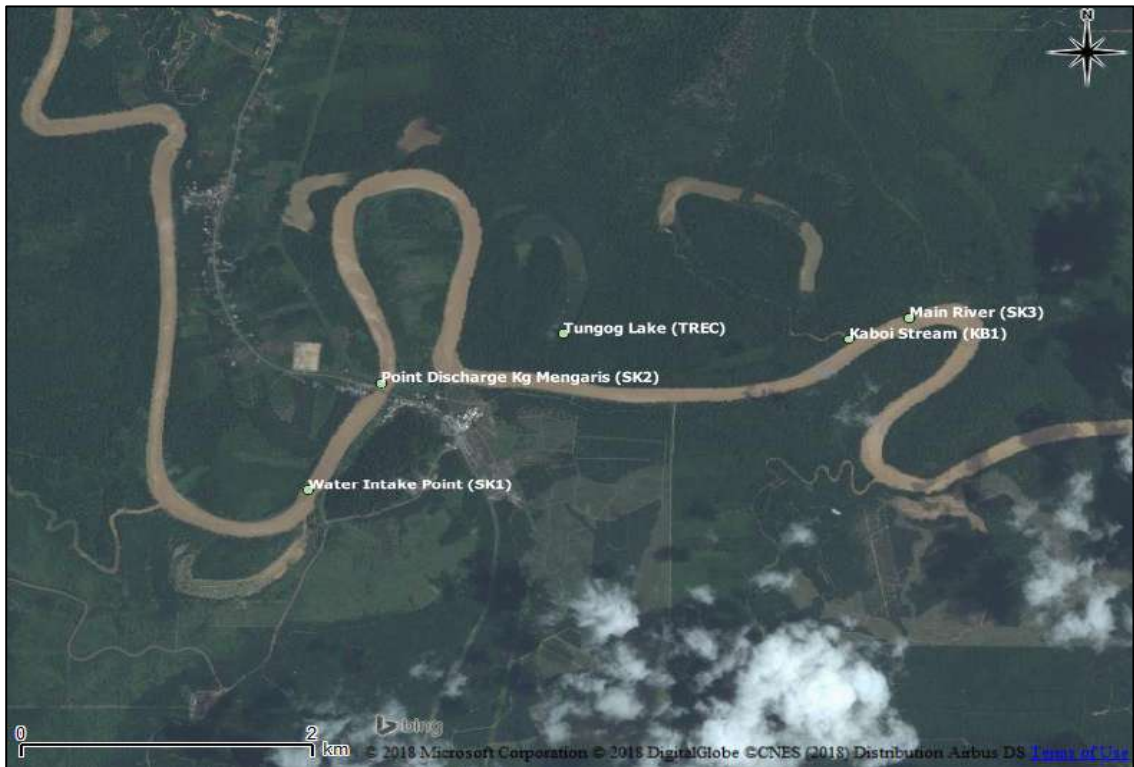


Figure 18: Sampling point is chosen by water intake point, discharge point, streams confluence or lake.

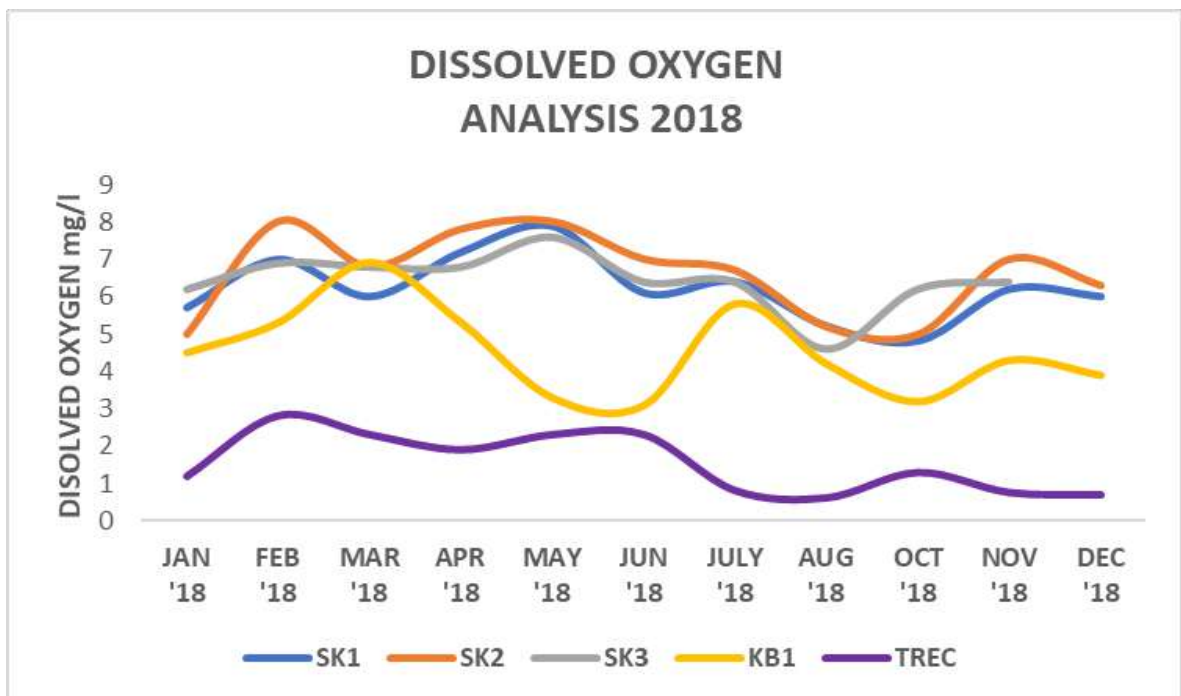


Figure 19: Dissolved Oxygen Monthly Analysis, 2018.

| CLASS I | CLASS IIA | CLASS IIB | CLASS III | CLASS IV | CLASS V |
|---------|-----------|-----------|-----------|----------|---------|
| 7 mg/l | 5-7 mg/l | 5-7 mg/l | 3-5 mg/l | <3 mg/l | <1 mg/l |

Figure 20: National Water Quality Classes Standards from Malaysia for Dissolved Oxygen.

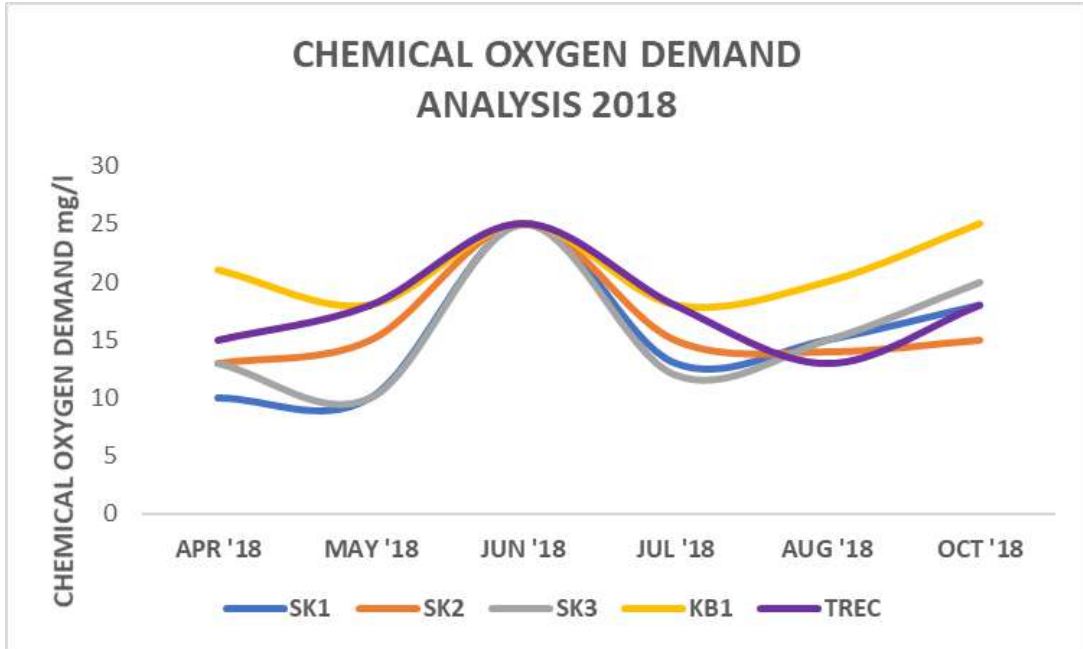


Figure 21: Chemical Oxygen Demand (COD) Analysis, 2018

| CLASS I | CLASS IIA | CLASS IIB | CLASS III | CLASS IV | CLASS V |
|---------|-----------|-----------|-----------|----------|-----------|
| 10 mg/l | 25 mg/l | 25 mg/l | 50 mg/l | 100 mg/l | >100 mg/l |

Figure 22: National Water Quality Classes Standards from Malaysia for Chemical Oxygen Demand (COD).

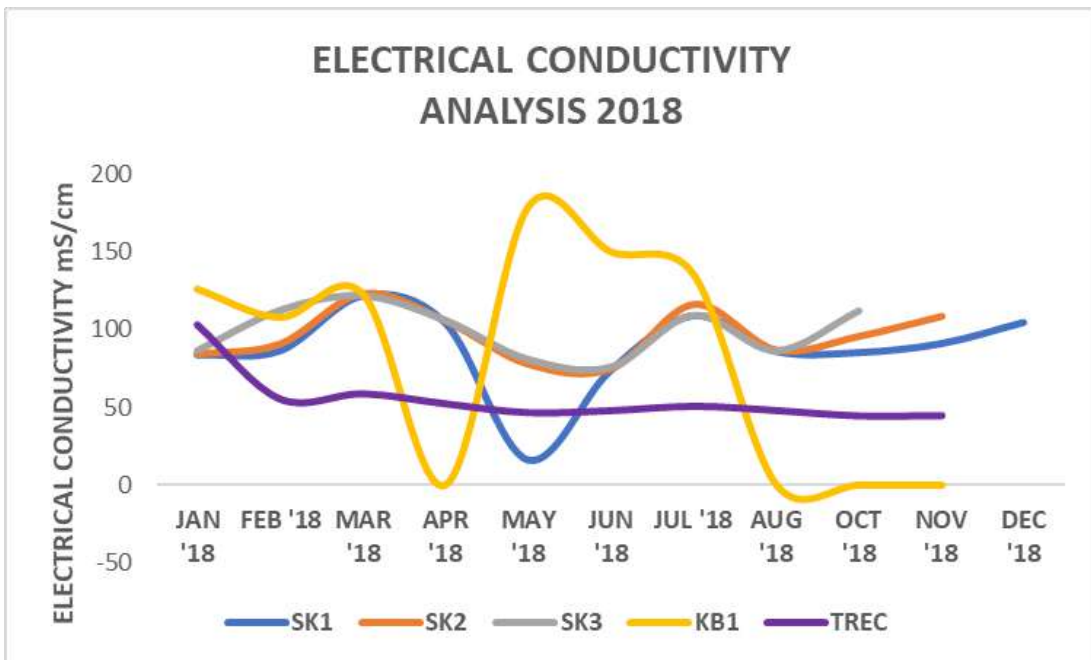


Figure 23: Electrical Conductivity (EC) Monthly Analysis 2018.

| CLASS I | CLASS IIA | CLASS IIB | CLASS III | CLASS IV | CLASS V |
|---------|-----------|-----------|-----------|----------|---------|
| 1 mS/cm | 1 mS/cm | - | - | 6 mS/cm | - |

Figure 24: National Water Quality Classes Standards from Malaysia for Electrical Conductivity (EC) in mS/cm.

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 the Tungog Lake case 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 within Tungog Lake.

Maintenance work ceased in 2013 for five months due to the closing of KOPEL operations during the Tando 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.



Figure 25: Grass Suds growing on Salvinia at the North End of Tungog Lake.



Figure 26: Open water being maintained manually at the Southern End of Tungog Lake.

In addition to the 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 introduce a biological control agent - the *Salvinia* beetle (*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 the weevil release impacts is ongoing and provides additional input into the Tungog Lake Monitoring program. This monitoring follows the release and monitoring protocols established by the Sabah Agriculture Department. At the end of 2018, there has still only been one single release of the weevil, with the first quarterly monitoring due in January 2019.

Monitoring the Tungog Lake ecosystem is ongoing and is continuing in parallel with the weevil monitoring program. Assisting this, the Tropical Restoration Ecology Field Course conducted by the University San Francisco (USF) has collected data on Tungog Lake in June 2016, June 2017 & June 2018. 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.

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 approximately 25 metres apart along the transects, at different depths, to measure temperature, dissolved oxygen, pH, clarity, depth, ammonium and nitrate. Comparisons were conducted and recorded along each. A fish survey was also conducted using three types of nets at each of the sampling points along the transect. A drip net for surface fish, casting net for pelagic species, and a trap for bottom dwelling species.

Analysis of results from USF Study shows the dissolved oxygen levels along both transects is extremely low. Fish required 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 expectation of biodiversity and abundance of Tungog Lake are low but, 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.

Management Implication

- I. The *Salvinia* covering Tungog Lake is immediate threat to Tungog Lake and 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, addressing the spread of the invasive species *Salvinia* is imperative and should be of utmost importance in management approaches moving forward.
- II. Monitoring the impacts of the biological control agent (*Cyrtobagous salviniae*) is the next important step in controlling the *Salvinia* on Tungog Lake. It is still uncertain how successful the *Salvinia* weevil will be, hence monitoring the release is critical in the next 1-2 years to understand the broader implications of this control method.
- 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 27: Lake Profile Sampling at Tungog Lake 2018



Rasbora sumatrana Adult
Common name: Sumatran rasbora
Local name: Rarapit



Labiobarbus sabanus juvenile
Local name Ikan matulang

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 license 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:

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.

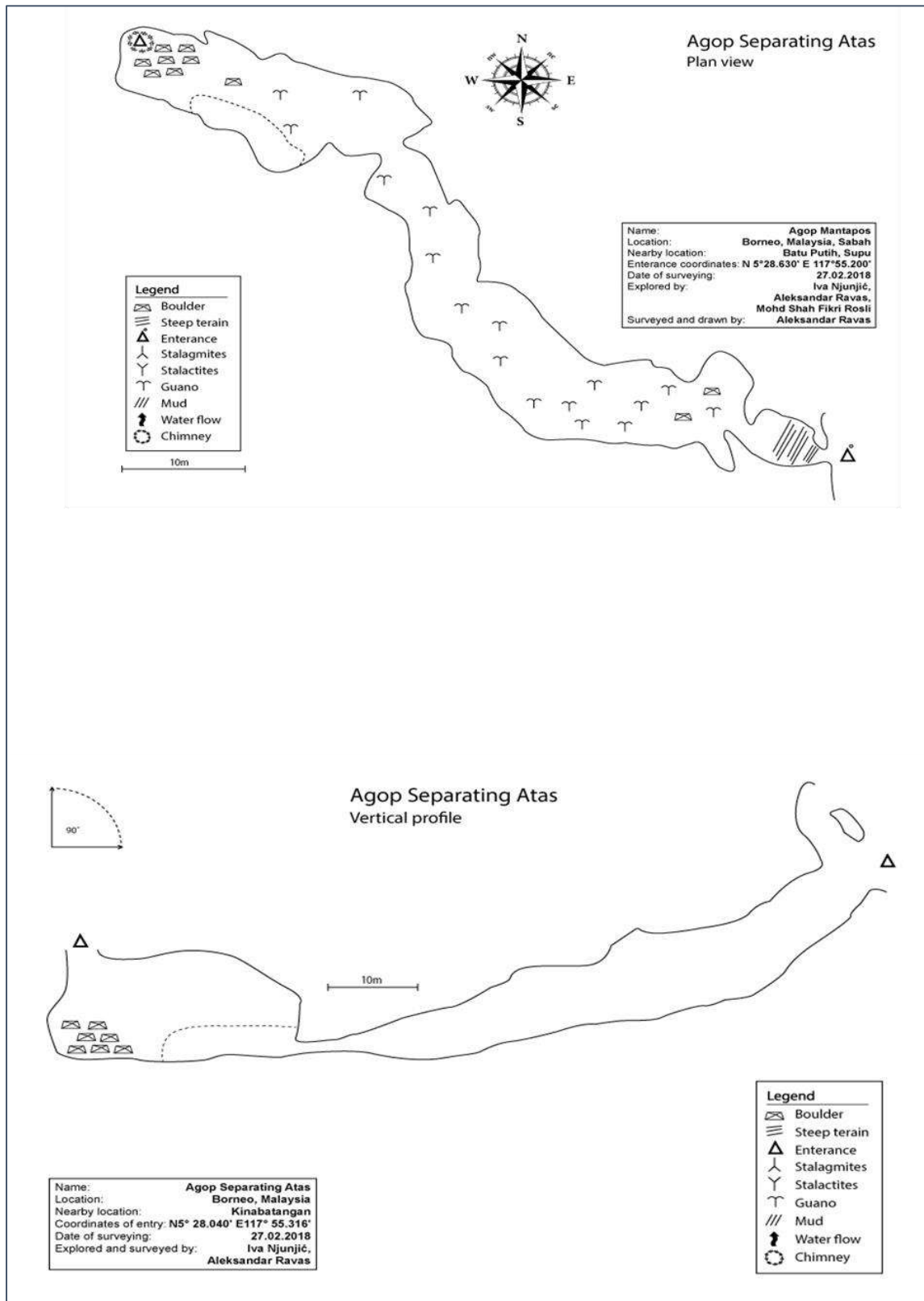


Figure 28: Cave mapping plan from The Rufford Foundation Study (Plan View: Top, Vertical View: Bottom)

Swiftlet Nest counts were not conducted from 2013 – 2019. Nest counts were conducted in March 2019. The results below (figure 29, below) are a summary of the nest counting work. One of the outcomes of the nest count work is

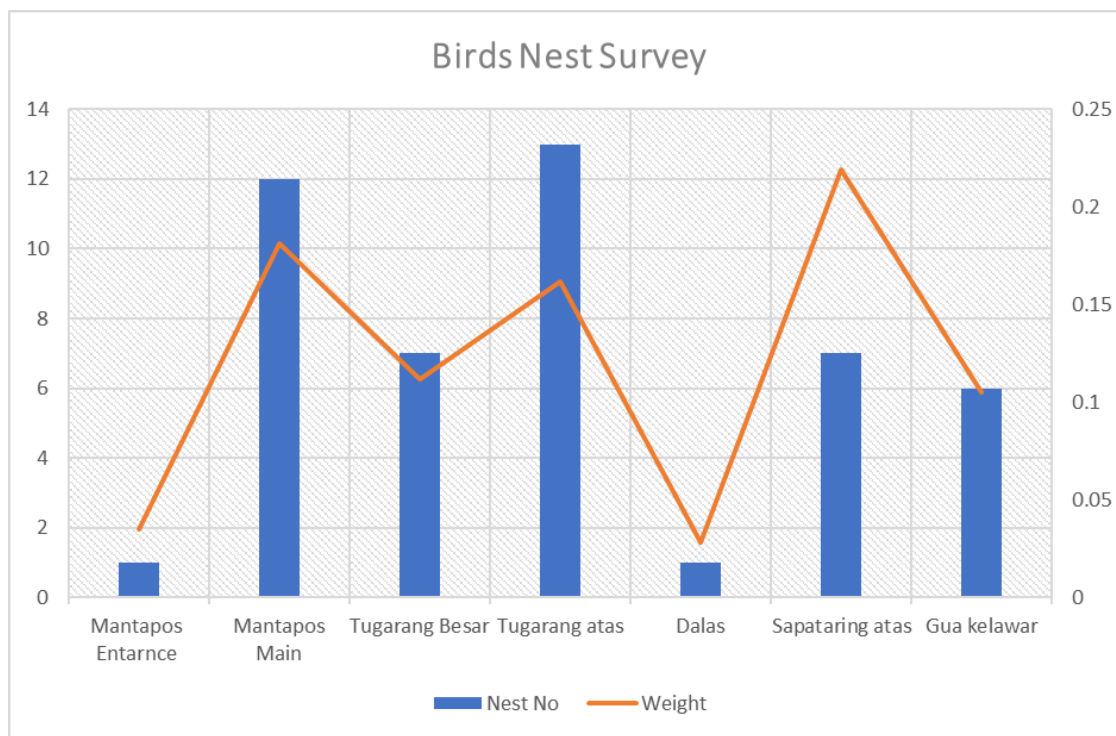


Figure 29: Swiftlets Nest Survey.

Management Implication

- I. 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.
- II. 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.
- III. Based on the 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.
- IV. 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.

Closing Remarks:

KOPEL Bhd continues to work closely with numerous of partners both in the preparation and analysis of data collected for the monitoring in 2018. 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 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.



Figure 30: Map Tree Planting Sites & Permanent Sample Plots PSFR 2018