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Log-fisher in Anap-Muput, winching a log cut down by a chain-saw to a skid trail
June 2014
(Photo by Hiromitsu Samejima)

Ground-dwelling Mammals and Birds Recorded by Camera Traps in Logged-over Forest in Anap Sustainable Development Unit, Sarawak, Malaysia

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Introduction

The tropical rainforest of Borneo is very rich in biodiversity. However, most of the remaining forests are being managed for logging by private companies. In line with the current advocacy for sustainability, the concept of sustainable forest management (SFM) can become an essential scheme to ensure that forestry practices are conducted in an acceptable manner that considers biodiversity conservation while maintaining economic sustainability. However, the performance of SFM practices and their impacts on biodiversity conservation are not well verified. From a corporate perspective, the benefits arising from SFM practices have not been well documented, and therefore, have not been utilized by companies for marketing purposes or to seek financing assistance for the additional costs incurred for the implementation of SFM.

The evaluation of the effect of SFM practices on biodiversity has not been conducted in Sarawak, a Malaysian state in Borneo. We investigated the species richness of ground-dwelling species, comprising middle- to large-sized mammals and birds, in a logging concession in central Sarawak under a management unit called the Anap Sustainable Development Unit (ASDU), to evaluate the management effect of SFM on biodiversity conservation.

Materials and methods

Study site[2]

ASDU covers an area of 1,068 km^2 and is located in the Tatau District in Bintulu Division, Sarawak, Malaysia. The entire area of ASDU was formerly known as the Anap-Muput Forest Management Unit (FMU), operating under Timber License T/4317. The northern part of FMU, known as the Muput-Lemai region and covering an area of 191 km^2, was delineated for industrial tree plantation and was planted with the fast-growing tree species *Paraserianthes falcataria* from 2006. The southern part, known as Anap-Belawit Management Area and covering an area of 43 km^2, was allocated for oil palm plantation. After the delineation, the management area of the Anap-Muput FMU was reduced to 835 km^2. The license to operate in the Anap-Muput FMU is valid up to 2024, and Zedtee Sdn. Bhd. is the contractor for extraction in and management of FMU. Logging operations started in 1977, with the second harvest conducted in 2000. Zedtee has practiced SFM in FMU since 2008 and applies Reduced Impact Logging (RIL) methods. FMU is certified by the Malaysia Timber Certification Scheme (MTCS) under the Malaysian Principle and Criteria (MC&I) 2012.

In ASDU, JH has already conducted a study using camera traps along three streams with natural salt licks from 2010 to 2011. Several mammals and birds species were recorded as visiting the areas (Hon 2011; 2013; Hon & Shibata 2013), including the elusive Borneo bay cat (*Catopuma badia*). The total sampling effort amounted to 9,270 camera-trap days.

Camera-Trapping

We conducted a camera-trap study in ASDU from May 2011 to June 2013 in eight study plots (Table 1). A plot had a radius of 500 m, and random sampling points were generated within each plot. We named each plot according to the name of the coupe. One plot, C01, is located in LPF/0039, whereas the other seven plots (C04, C06, C08, C11, C12, C16, and C24) are located in T/4317. Plots C04, C16, and C24 were harvested only once, whereas C12, C11, C08, and C06 were already harvested twice, ranging back to as recent as 0–6 years. Plot C01 in LPF/0039 was harvested more than three times. The vegetation types for all plots are lowland mixed dipterocarp forest, except plot C24, which comprises Kerangas vegetation.

In each plot, eight sampling points were randomly selected using the statistical software R 2.15[3] We placed a camera trap at each sampling point. The elevations of the sampling points ranged from 94 to 366 m a.s.l. Plot C01 has the lowest, whereas plots C06 and C16 have the highest average elevation. At each point, we placed an automatic digital camera (Bushnell Trophy Cam) with an infrared sensor. The camera was mounted on a tree at a height of 50–100 cm above the ground. The field of view of the camera was 2–7 m^2. We set the camera to record in the video mode for a duration of 10 s upon triggering. The cameras were checked every 3–5 months and the batteries and memory cards were replaced.

We analyzed all the images of the middle- and large-sized mammals and birds that were recorded by the camera traps. The number of the images of the respective species at each points was also counted; the images of the same species occurring within a 30-min period were treated as one image. Identification was based on Payne et al. (2005), Myers (2009), and Phillipps and Phillipps (2009). The sampling effort was defined by the number of camera working days at each sampling point, i.e., the end or collection date minus the starting date. If a camera malfunctioned, the last day of recording was treated as the end date.

For the abundance index, we used the mean trapping rate (MTR) of each species at each plot as a proxy. The formula

Table 1: Habitat description of the study plot where camera traps are set

Plot	No of times harvested (year last harvested)	Average elevation of sampling points (range of elevation) (m a.s.l.)	Note
C01	>3 (2008)	105.5 (94–118)	LPF/0039
C04	1 (1980s)	260.8 (186–323)	Water catchment area for the base camp.
C06	2 (2005)	280.7 (247–366)	
C08	2 (2007)	253.8 (218–291)	
C11	2 (2010)	199.1 (184–218)	
C12	2 (2011)	174.5 (149–200)	Logged a few months prior to camera trapping
C16	1 (1990s)	277.8 (241–327)	
C24	1 (1990s)	188. 3 (165–222)	Kerangas forest

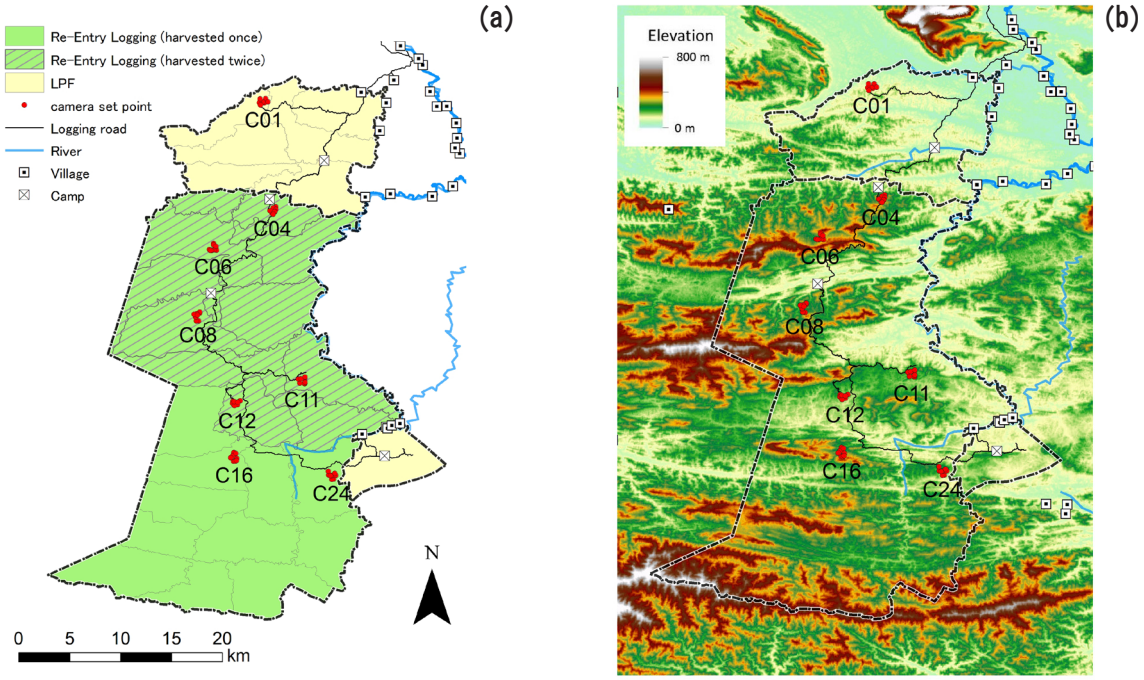

Figure 1: Distribution of the 8 plots under different management classes (a) and elevation classes of ASDU (b).

for MTR is as follows:

MTR = Total number of images / total camera-working days x 100

Results

Camera working days ranged from 4,442 to 6,190 in each plot, and the combined sampling effort for all plots totaled 41,467 working days. During this period, we recorded 30 middle- and large-sized mammals and four terrestrial bird species, with a combined total of 6,924 images (Table 2). The list includes many elusive and endangered species of Borneo, including those recorded in previous studies by Hon (2011) and Hon & Shibata (2013). The number of species recorded in each plot was 20–27 (Fig. 2). The southern pig-tailed macaque (*Macaca nemestrina*, number of images, N = 1,945) was recorded the most times, followed by the bearded pig (*Sus barbatus*, N = 892), and the common porcupine (*Hystrix brachyura*, N = 744). On the other hand, the Malay weasel (*Mustela nudipes*, N = 1), Otter civet (*Cynogale bennettii*, N = 2), Small-toothed palm civet (*Arctogalidia trivirgata*, N = 3), Sunda clouded leopard (*Neofelis diardi*, N = 2), and Crested fireback (*Lophura ignita*, N = 1) were recorded in less than five occasions. The sum of MTR ranged from 7.2 to 20.1 images, with the lowest recorded at C24 followed by C12 (Fig. 3).

Table 2: List and number of records of middle and large sized mammals and terrestrial bird captured by camera-traps in ASDU. The total sampling effort was 41,167 camera trap days. Treated status followed The IUCN Red List of Threatened Species. Version 2013.1 <http://www.iucnredlist.org>. EN; endangered, VU; vulnerable

Class	Order	Scientific name	Common name	Number of images	Threated status
Mammalia	Erinaceomorpha	*Echinosorex gymnura*	Moon Rat	25	
	Pholidota	*Manis javanica*	Sunda Pangolin	134	EN
	Primates	*Macaca fascicularis*	Long-tailed Macaque	20	
		Macaca nemestrina	Southern Pig-tailed Macaque	1945	VU
	Rodentia	*Hystrix brachyura*	Common Porcupine	744	
		Trichys fasciculata	Long-tailed Porcupine	222	
		Hystrix crassispinis	Thick-spined Porcupine	69	
	Carnivora	*Helarctos malayanus*	Sun Bear	131	VU
		Martes flavigula	Yellow-throated Marten	25	
		Mustela nudipes	Malay Weasel	1	
		Viverra tangalunga	Malay Civet	401	
		Cynogale bennettii	Otter Civet	2	EN
		Arctictis binturong	Binturong	16	VU
		Arctogalidia trivirgata	Small-toothed Palm Civet	3	
		Paguma larvata	Masked Palm Civet	58	
		Paradoxurus hermaphroditus	Common Palm Civet	7	
		Hemigalus derbyanus	Banded Civet	458	VU
		Prionodon linsang	Banded Linsang	8	
		Herpestes semitorquatus	Collared Mongoose	31	
		Herpestes brachyurus	Short-tailed Mongoose	25	
		Neofelis diardi	Sunda Clouded Leopard	2	VU
		Pardofelis marmorata	Marbled Cat	9	VU
		Prionailurus bengalensis	Leopard Cat	29	
		Catopuma badia	Borneo Bay Cat	5	EN
	Artiodactyla	*Sus barbatus*	Bearded Pig	892	
		Tragulus kanchil	Lesser Mousedeer	25	
		Tragulus napu	Greater Mousedeer	52	
		Muntiacus muntjak	Southern Red Muntjac	440	
		Muntiacus atherodes	Bornean Yellow Muntjac	652	
		Rusa unicolor	Sambar	93	VU
Aves	Galliformes	*Rollulus rouloul*	Crested Partridge	44	
		Lophura ignita	Crested Fireback	1	
		Lophura bulweri	Bulwer、s Pheasant	73	VU
		Argusianus argus	Great Argus	282	

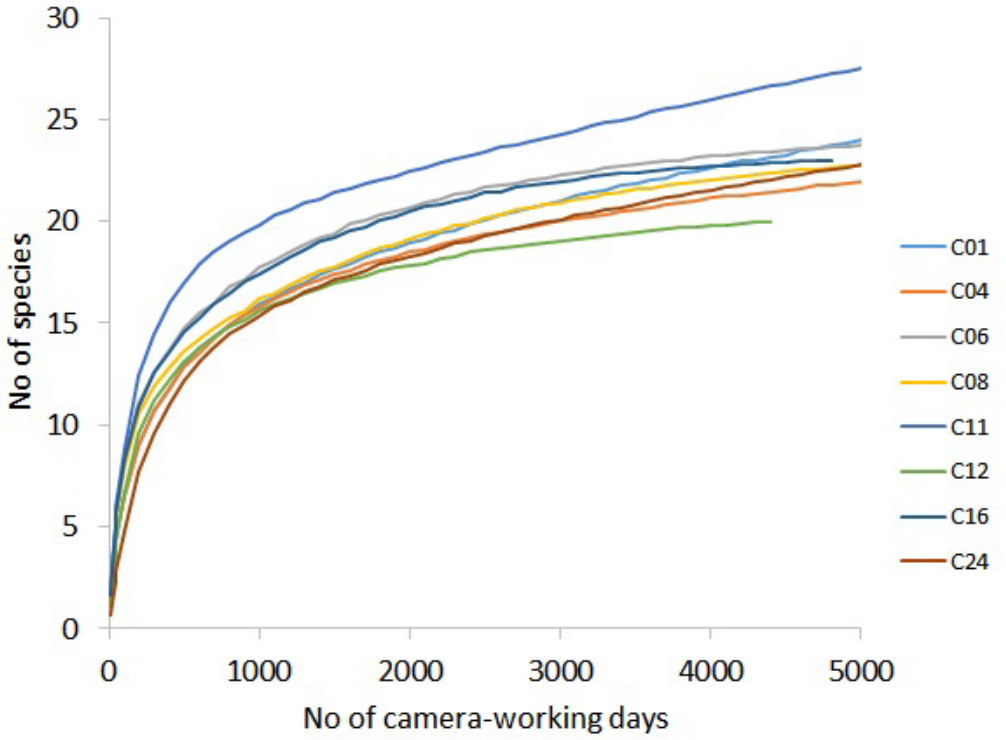

Figure 2: Species rarefaction curves with number of species plotted against sampling effort of camera trap days for all eight plots

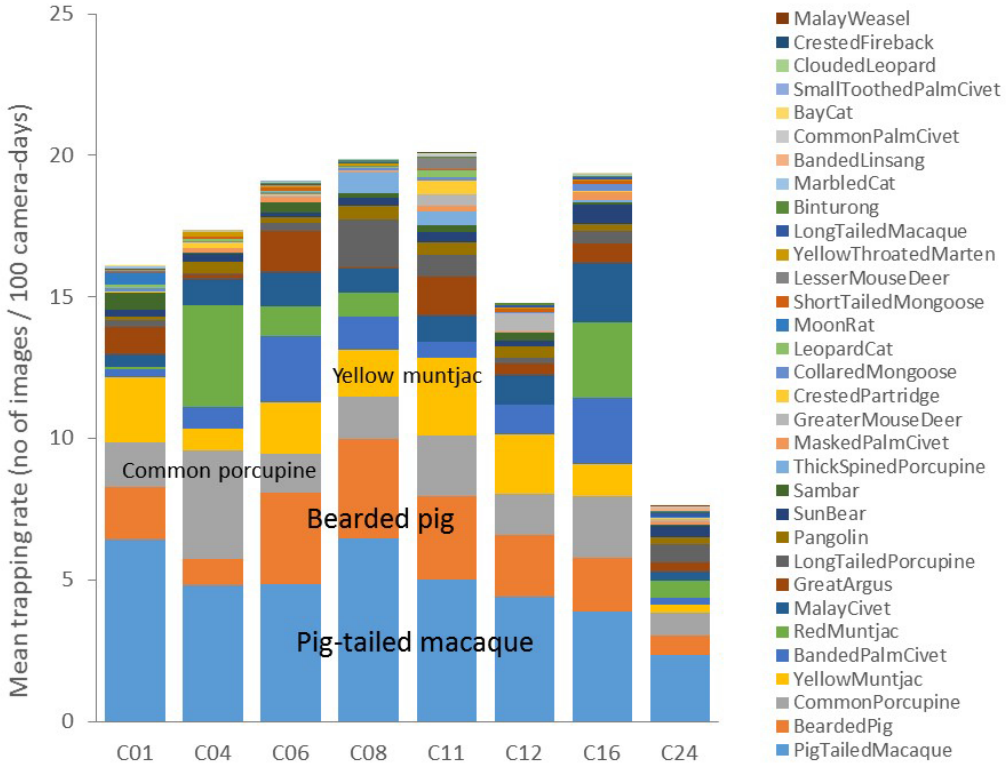

Figure 3: Sum of MTR of all species in the 8 plots

Discussion

This study documented a high species richness of middle- and large-sized mammals in ASDU. We recorded most of the ground-dwelling or semi-ground-dwelling mammal species inhabiting in Borneo. Of the 38 known species, 30 species, representing 79%, were recorded here. Of the other eight species not recorded in this study, the following six species: Bornean orangutan (*Pongo pygmaeus*); Bornean ferret badger (*Melogale everetti*); Malay badger (*Mydaus javanensis*); Borneo elephant (*Elephas maximus borneensis*); Bornean rhinoceros (*Dicerorhinus sumatrensis harrissoni*); and tembadau (*Bos javanicus*) are not known to occur in central Sarawak (Payne et al. 2005 and Giman & Jukie 2012). Hose's civet (Diplogale hosei) has been recorded only at higher elevations between 325 and 1,800 m a.s.l. (Samejima & Semiadi 2012). The flat-headed cat (*Prionailurus planiceps*) possibly occurs here but has not yet been recorded. The flat-headed cat is also very elusive in the other regions of Borneo (Samejima et al. 2012). There are 15 known terrestrial bird species in Borneo (Myers 2009 and Phillipps and Phillipps 2009), but our study recorded only four species. The lack of records for the other terrestrial bird species in our study may be because of the narrow range of most of the species.

The total MTR in one of the plots, C24, was markedly lower than MTRs in other plots. C24 is situated inside the Kerangas forest type, which is known for its poor soil nutrients. The conditions of soil may limit the productivity of the plants, resulting in the lower densities of faunal species that occur here.

The impact of logging on mammals and birds is not obviously severe in the Anap-Muput FMU. Although the total MTR and number of species were initially low in plot C12, which was harvested just a few months ago, the total MTRs and number of species of plots C11 and C08, which were harvested one and four years ago, differed little from those of C04 and C16, which were harvested 20–30 years ago. We speculate that the MTR of plot C12 would increase to those of C11 or C08 in a few years. However, continuous monitoring is necessary to confirm the population recovery.

We took note of the SFM practices employed inside the Anap-Muput FMU and various conservation measures that have been put in place. Among others, the FMU practices strict security by having manned gates at the access to FMU and closing all branch roads just after harvesting, which may have eliminated unnecessary and illegal hunting activities. The scale of hunting by the local communities is quite low because there is no clear demand for wild meat by outsiders and most residents hunt for subsistence only.

Many lowland forests in Borneo are at a high risk of being converted for other uses such as oil palm and industrial tree plantations. The role of the Anap-Muput FMU in particular, and ASDU in general for undertaking the important role of helping maintain regional biodiversity, is commendable. As the only certified natural forest in Sarawak, it provides a positive sign that certification and sound management practices preserve a balance between logging and wildlife conservation, and therefore, should be promoted.

Acknowledgment

This study was carried out with the support of Zedtee Sdn Bhd for granting us the permission to carry research in ASDU. In particular, we would like to thank Wong Ing Yung and the staff in Anap-Muput FMU for their kind assistance during field work.

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Notes

[1] Formerly Graduate School of Global Environmental Studies, Kyoto University. Current employment is WWF Malaysia.

[2] These information of ASDU is mostly based on the homepage of Anap-Muput FMU,
http://www.anapmuputfmu.com/introduction.php

[3] R is a free software, can be downloaded from
http://www.r-project.org/.

Above Ground Biomass and Tree Species Diversity in Anap Sustainable Development Unit, with the Focus on the High Conservation Value Forest (HCVF)

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Introduction

Maintenance of biomass or carbon stock and biodiversity are among the targets of sustainable forest management (SFM) and establishing a high conservation value forest (HCVF) is one of the measures of SFM to achieve these targets. However, the performance of HCVF management has not been well studied.

Inside the Anap Sustainable Development Unit (ASDU), Sarawak, Malaysia, four HCVFs and three water catchment areas (WCs) have been established. WCs in ASDU were originally listed as a part of HCVFs in the *Forest Management Plan for Anap-Muput Year 2006–2025*, and accordingly can be considered part of HCVFs in ASDU.

In ASDU, we established 70 vegetation plots to evaluate the aboveground biomass (AGB) and tree species diversity in the management area. Using these data, we evaluated the contribution of HCVFs in sustaining the high biomass and rich biodiversity of ASDU.

Materials and methods

Study site

ASDU is located in Tatau District, Bintulu Division, Sarawak, Malaysia. It is managed by a private company, Zedtee Sdn Bhd. ASDU covers an area of 106,820 ha, and its forests can be classified into three types: lowland/hill mixed dipterocarp forest (MDF), Kerangas forest, and riparian forest. MDF is the major forest type in lowland Borneo and ASDU. Kerangas forest is a heath forest on sandy nutrient-poor soil, distributed in the southeast part of ASDU. Riparian forest is a type of MDF distributed along rivers but generally more degraded and with lower densities of large trees than normal MDF on the slopes and ridges, probably because the riparian area is more vulnerable to logging disturbance.

The management system of ASDU is divided into three parts: Anap-Muput Forest Management Unit (FMU: T/4317), which forms the main part; an area with License for Planted Forest (LPF/0039) in the northern part; and Anap-Belawit state land in the south (Fig. 1). The Anap-Muput FMU is divided into coupes and managed in a 25-year cutting cycle for sustainable timber production of indigenous tree species such as meranti (*Shorea* spp.) and kapur (*Dryobalanops* spp.). Logging activity in ASDU started in 1977, all the coupes have been harvested at least once, and coupes 1–12 have been harvested again in the last 12 years. LPF is allocated for intensive planting of fast-growing species, and the original vegetation has been repeatedly harvested, but most of the area has not been planted to date.

In ASDU, H. Samejima and J. Hon established eight plots to conduct camera-trapping surveys for ground-dwelling, middle, and large-sized mammals from 2011 to 2013 (Samejima & Hon 2014). One plot is a circle with 1-km diameter and eight cameras are set inside at randomly selected points. Hon also established a 2-km line transect along each of the three rivers where natural salt licks were present and conducted a camera trap survey from 2010 to 2011 (Hon 2011; 2013; Hon & Shibata 2013).

In ASDU, Zedtee established four HCVFs, HCVF1–4. Demies and Sang (2008) established six quadrats in HCVF1, three in HCVF2, nine in HCVF3, and five in HCVF4 in 2008. Each quadrat was of 50 × 50 m. They recorded all trees belonging to three genera of Dipterocarpaceae, *Dipterocarpus*, *Dryobalanops*, and *Shorea* with diameter at breast height (DBH) of ≥10 cm.

Vegetation plots

From 2011 to 2013, H. Samejima and M. Demies established 61 circle plots with radius 20 m (0.126 ha) and M. Koizumi established 9 circle plots with radius 15 m (0.071 ha) distributed in 19 areas (Table 1, Fig. 1, Koizumi 2012). The distances between the neighboring plots within an area were approximately 100 m. A total of 18 plots were positioned in three HCVFs and two WCs. HCVF3 and WC_Ayam are covered by primary forests, and the

other two HCVFs and one WC are covered by old-growth forest that was harvested during the 1980's. Four plots in HCVF1 and two plots in HCVF3 overlap the quadrates established by Demies and Sang (2008). 11 areas were set up the eight plots and along the three transects for the camera trap study. The other four areas were selected to include the other vegetation types. C06b is a swampy area where trees were harvested 7 years ago, and C06c is mostly primary forest remaining along a steep ridge in coupe 6.

Inside each plot, we measured DBH and heights of all trees with DBH (at 130 cm above ground) of ≥10 cm. We painted a red line at the height where DBH was measured (Figs. 2, 3) and attached a metal number plate (Fig. 4) for future re-census. All trees were identified by staffs of Botanical Research Center, Sarawak Forestry Corporation and Koizumi, referring to the herbarium of Sarawak Forest Research Center, Kuching (Fig. 5). The classification followed the Angiosperm Phylogeny Group III system.

There are three formulas for estimating AGB of tropical moist forest (FAO 1997, Chave et al. 2005):

$$1)\ AGB = \exp\left(-2.977 + \ln(\rho D^2 H)\right)$$

$$2)\ AGB = \rho \times \exp\left(-1.499 + 2.148\ln(D) + 0.207(\ln(D))^2 - 0.0281(\ln(D))^3\right)$$

$$3)\ AGB = \exp\left(-2.134 + 2.53\ln(D)\right)$$

ρ: Wood specific gravity D: Diameter at breast height H: Total tree height

Following these formulas, we obtained three estimates, AGB1, AGB2, and AGB3, of the AGBs of all trees. Wood specific gravity data were based on Lemmens et al. (1995), Oey (1951), Soerianegara and Lemmens (1993), and Sosef et al. (1998) following Imai et al. (2012). In case wood specific gravity of a genus was unknown, we used AGB3 as a substitute for AGB1 and AGB2 for the tree. As Koizumi did not measure the tree heights, we calculated only AGB2 and AGB3 for her data.

Table 1: List of plots. Numbers in parentheses show numbers of plots established by Koizumi.

Plot area	No. of plots	Forest type	Year after harvest	Camera trapping
WC_Ayam	3	Mixed Dipterocarp Forest	Primary forest	
HCVF2	4			
HCVF1	4		About 30 years	
WC_Sekawie	5			○
C14	1		24 years	
C16	4		22 years	○
C06b	2		7 years	
C06c	2		Primary forest/7 years	
C06	5		7 years	○
C08	4		5 years	○
C11	5		2 years	○
C12	4		1 years	○
C01	4		Multiple times	○
C02	4			
HCVF3	2	Kerangas Forest	About 30 years?	
C24	4		14 years	○
Apan Sebedie	4 (2)	Riparian Forest	Multiple times	○
Apan Malat	5 (5)		9 years	○
Apan C11	4 (2)		2 years	○

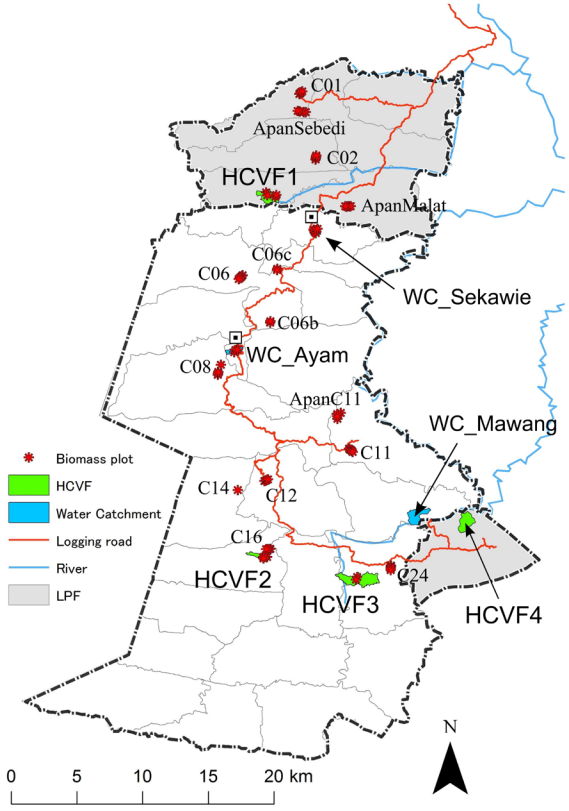

Figure 1: Locations of plot areas

Figure 2 (Above) : Measuring DBH and marking

Figure 3 (Right Top) : For a tree with high buttress, DBH was measured at above the buttress.

Figure 4 (Right Middle) : Metal number tag, attached on all trees.

Figure 5 (Right Bottom) : SFC staff collected the tree specimens for identification in Kuching.

Table 2: The number of trees and species, and amount of above ground biomass (ton / hector) in each plot.

Names of researchers	Vegetaion	Year after harvest	Area	Plot	No. of trees	No. of species	AGB1 (ton/ha)	AGB2 (ton/ha)	AGB3 (ton/ha)
Samejima & Malocm	Mixed Dipterocarp Forest	Primary forest	WCAyam	WCAyamP1	109	53	429.7	473.1	446.1
(Plot 20 m in diameter -> radius)				WCAyamP2	99	52	643.0	718.2	627.1
				WCAyamP3	82	44	712.3	733.7	624.4
			HCVF(2)	HCVF(2)P1	87	52	721.8	777.8	740.0
				HCVF(2)P2	96	54	512.1	672.4	687.2
				HCVF(2)P3	129	57	643.0	754.1	732.0
				HCVF(2)P4	119	58	446.9	643.4	622.4
		About 30 years	HCVF(1)	HCVF(1)P2	100	57	438.1	565.8	503.1
				HCVF(1)P3	104	49	777.7	753.0	828.3
				HCVF(1)P4	117	43	473.9	523.4	442.0
				HCVF(1)P5	119	38	287.5	355.2	338.5
			C04	C04V1	84	61	366.4	426.3	414.7
				C04V2	139	45	453.1	545.1	505.7
				C04V3	99	50	361.5	420.6	381.1
				C04V6	142	62	370.1	397.7	336.7
				C04V7	120	59	387.7	450.5	387.2
		24	C14	C14V1	70	34	184.3	211.2	224.6
		22	C16	C16V1	109	48	112.7	136.6	147.6
				C16V2	139	51	367.1	455.9	460.8
				C16V3	143	67	247.6	290.7	317.9
				C16V4	97	62	182.7	237.4	228.6
	Swampy	7	C06b	C06bV1	80	21	204.7	227.2	221.0
				C06bV2	78	39	266.6	272.9	251.9
	Mixed Dipterocarp Forest	Primary / 7	C06c	C06cV1	114	56	917.6	1018.7	914.1
				C06cV2	117	65	413.7	454.0	423.5
		7	C06	C06V1	104	39	340.9	446.4	469.6
				C06V2	53	27	48.5	63.0	77.0
				C06V3	74	40	295.2	400.1	408.8
				C06V4	97	56	255.3	275.9	260.1
				C06V5	86	46	338.9	392.1	384.2
		5	C08	C08V1	118	66	407.7	523.3	505.5
				C08V2	85	47	249.5	295.4	279.4
				C08V3	51	33	220.4	251.2	248.6
				C08V6	92	31	218.9	255.6	263.5
		2	C11	C11V1	82	56	179.6	231.0	222.8
				C11V2	82	44	224.3	281.4	239.5
				C11V3	150	50	336.4	379.2	331.6
				C11V4	88	52	302.9	339.3	326.4
				C11V5	60	44	128.8	142.4	123.1
		1	C12	C12V2	94	46	253.9	266.8	256.3
				C12V3	95	49	177.7	203.9	188.7
				C12V4	98	54	169.0	198.5	192.2
				C12V5	112	56	169.9	241.8	214.2
		Multiple times	C01	C01V1	62	37	105.9	144.2	123.6
				C01V2	64	34	150.4	233.3	238.5
				C01V3	67	29	63.7	93.1	91.2
				C01V4	101	44	205.9	229.1	223.7
		Multiple times	C02	C02V1	114	41	196.5	219.3	214.0
				C02V2	83	51	163.1	177.0	157.3
				C02V3	113	61	258.4	292.0	277.4
				C02V4	60	37	166.0	198.4	176.7
	Kerangas forest	About 30 years?	HCVF(3)	HCVF(3)P3	147	73	389.7	407.1	377.1
				HCVF(3)P8	136	56	326.7	358.1	340.1
		14	C24	C24V1b	117	57	206.6	259.1	229.7
				C24V2	53	43	167.1	199.8	207.0
				C24V3	99	47	287.2	318.2	271.7
				C24V4	130	57	486.5	497.3	432.4
	Riparian forest	Multiple times	ApanSebedi	Sebedi2	61	37	135.0	158.4	124.9
				Sebedi3	91	43	203.9	248.5	215.1
		2	ApanC11	ApanC11_2	50	23	159.1	199.0	178.9
				ApanC11_3	53	30	115.7	149.9	139.3
Koizumi	Riparian forest	Multiple times	ApanSebedi	08ApanSebedi	35	29		271.3	268.5
(Plot 15 m in diameter -> radius)				09ApanSebedi	52	33		201.3	210.8
		9	ApanMalat	01ApanMalat	44	28		151.3	154.2
				02ApanMalat	40	20		334.5	284.4
				03ApanMalat	45	32		171.4	186.0
				04ApanMalat	48	12		59.1	78.8
				05ApanMalat	60	12		59.7	89.7
		2	ApanC11	06ApanC11	38	21		257.8	226.6
				07ApanC11	36	26		122.4	101.1

Table 3: The number of genera, species and trees in each family recorded in the 70 plots in ASDU.

Family	No. of genera	No. of species	No. of trees
Achariaceae	4	17	179
Actinidiaceae	1	2	125
Actinidiaceae	1	1	5
Anacardiaceae	10	27	140
Anisophylleaceae	1	2	8
Annonaceae	6	22	61
Apocynaceae	4	4	28
Aquifoliaceae	1	1	1
Araucariaceae	1	1	4
Arecaceae	2	3	39
Asteraceae	1	1	1
Bignoniaceae	1	1	3
Burseraceae	3	32	158
Calophyllaceae	1	16	34
Celastraceae	4	9	61
Chrysobalanaceae	3	3	4
Clusiaceae	5	24	91
Combretaceae	1	2	4
Cornaceae	2	5	7
Crypteroniaceae	1	2	11
Ctenolophonaceae	1	2	7
Dilleniaceae	1	6	9
Dipterocarpaceae	9	131	1989
Ebenaceae	2	28	115
Elaeocarpaceae	2	19	44
Escalloniaceae	1	3	3
Euphorbiaceae	21	57	757
Fabaceae	13	26	118
Fagaceae	4	36	132
Irvingiaceae	1	2	3
Ixonanthaceae	2	2	11
Lamiaceae	4	15	108
Lauraceae	12	49	164
Lecythidaceae	1	5	21
Loganiaceae	2	4	5
Lythraceae	1	1	2
Magnoliaceae	2	6	13
Malvaceae	11	30	151
Melastomataceae	2	5	49
Meliaceae	5	25	54
Memecylaceae	1	5	10
Moraceae	3	23	109
Moringaceae	1	1	1
Myristicaceae	5	51	302
Myrsinaceae	1	4	8
Myrtaceae	3	48	335
Ochnaceae	1	1	1
Olacaceae	4	5	21
Oleaceae	1	4	15
Oxalidaceae	1	3	17
Pentaphylacaceae	3	5	14
Phyllanthaceae	6	56	154
Polygalaceae	1	16	94
Proteaceae	1	1	1
Rhizophoraceae	2	3	7
Rhmnacae	1	1	1
Rosaceae	1	1	7
Rubiaceae	11	21	158
Rutaceae	2	3	29
Sabiaceae	1	1	4
Salicaceae	4	7	55
Sapindaceae	4	17	37
Sapotaceae	5	40	141
Simaroubaceae	1	1	2
Sonneratiaceae	1	1	4
Stemonuraceae	3	5	7
Symplocaceae	1	4	7
Tetrameristaceae	1	1	2
Thymelaeaceae	2	10	24
Ulmaceae	1	2	16
Total	223	968	6302

Results

In total, we recorded 6,302 trees in the 70 plots (Table 2), including 968 species of 223 genera and 70 families (Table 3). Dipterocarpaceae was the most dominant family, representing 31.6 % of all trees (1,989 trees and 131 species). HCVFs and WCs had a large stock of AGB (Fig. 6). The mean and standard deviation of AGB2 of all plots were 338.8 ± 197.1 t/ha, whereas those of plots inside HCVFs and WCs were 595.0 ± 157.1.

Species richness was not very different between HCVFs and WCs and normal logging areas. The average numbers of species were 137–170 in four plots (approximately 0.5 ha) of HCVFs and WCs and 159–176 in C16, C12, and C11 (Fig. 7).

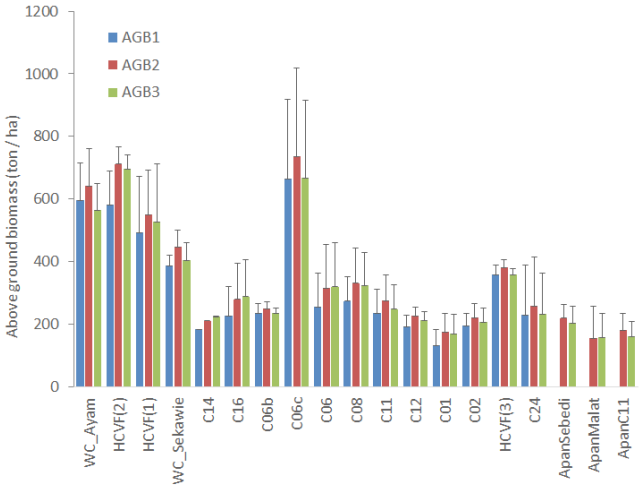

Figure 6: Estimated above ground biomass of 19 areas.

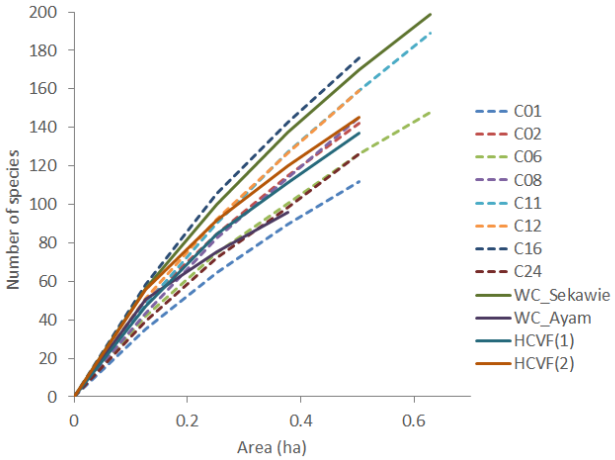

Figure 7: Species rarefaction curve with number of species against total area (hectare) of plots for 12 areas where more than three 20-m radius vegetation plots wereestablished. The number of species are average number of number of species in 1000 times randomly selected plots in each area.

Discussion

HCVFs and WCs had higher biomass or carbon stock than normal areas that were subjected to logging operations. AGB remained low even 22 or 24 years after the last logging (C16 and C14). Whereas AGB2 in C12, just after harvest, was 227.8 ± 28.0 t/ha, only 280.2 ± 115.6 and 221.2 in C16 and C14, respectively. Although one of the reason of the low biomass stocks in C16 and C14 may be due to the slow speed of biomass recovery under the specific environmental conditions in the two areas (e.g., soil), our results indicated that the biomass of logged-over forests does not recover to the state of unlogged forests during the standard logging cycle of 25 years in ASDU. Thus, HCVFs and WC areas are valuable for showing the original and potential status of standing volume or carbon stock in ASDU.

However, the species richness in HCVFs and WCs was not obviously higher than that in normal logging areas. Even areas harvested recently, for example C12 and C11, had many species as HCVFs and WCs. The current logging system is considered not too harmful in reducing the species richness of the original forest.

In this study, metal number tags were attached to all enumerated trees. As these metal tags can remain intact for a long time, future surveys such as measuring DBH can be performed and will allow the determination the growth rate of these trees. Among potential uses of such information is the calculation of annual growing speed, which in turn can be used to revise the annual allowable cutting volume for sustainable timber production.

The presence of the primary forests in HCVFs and WCs inside ASDU is of high advantage for the management of FMU, given that few existing FMUs in Sarawak retain such original habitats to show the original forest conditions inside FMU.

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Notes

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A Report on Longhouse Communities in the Anap River Basin: Based on Household Surveys

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Introduction

This is a report on surveys of villages in the Anap River Basin of Sarawak, Malaysia. The aim of the surveys was to collect basic information and to figure outline of the longhouse communities in Anap River Basin. This report documents our itinerary and presents excerpts from the interviews carried out by Masahiro Ichikawa, Hiromitsu Samejima, and Yumi Kato on August 23–25, 2011. We conducted interviews in Rh. Mawang and Rh. Entri in the Upper Anap Basin; Rh. Gerina, Rh. Banda, and Rh. Jatun in the middle Anap Basin; and Rh. Jalong in the lower Tatau Basin (Figure 1). The Ibans constitute the majority in the Rh. Mawang, Rh. Entri, and Rh. Gerina longhouses. The Bekatans constitute the majority in the Rh. Banda and Rh. Jatun longhouses. Both the Tataus and Ibans are mixed in the Rh. Jalong longhouse.

The interview questions included the reasons for migration; the history of the forestry product trade; and the current situation of the villages economy, subsistence activities, and intermarriage. We also asked about hunting and wildlife around the longhouses. We present below an overall picture of each longhouse.

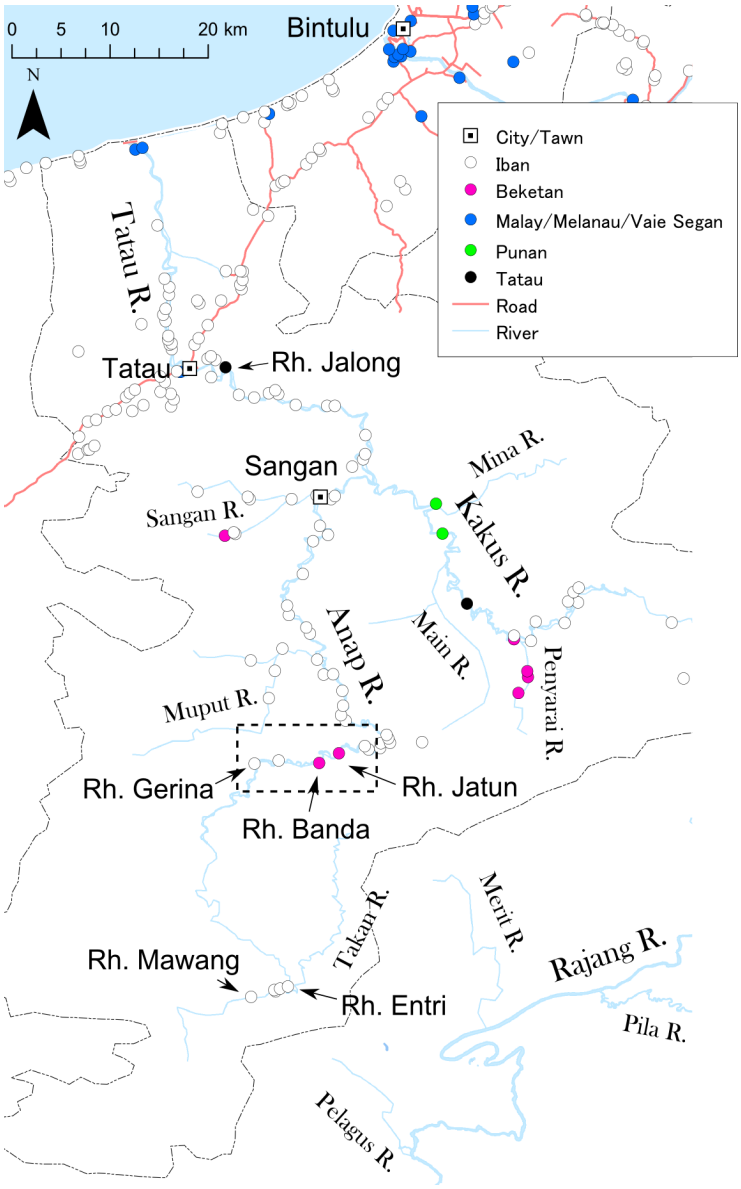

Figure 1: Fieldwork sites

Rh. Mawang (Nanga Takan)

In Rh. Mawang, Ichikawa and Kato carried out interviews about migration history and the forestry product trade. Samejima conducted interviews about hunting and wildlife.

The villagers mainly made their living by rice cultivation. They only grew hill paddy but had sufficient harvest every year. Additionally, this longhouse was in the operational area of a logging company, Zedtee, and many had worked at Zedtee since 1992. At the time of the interviews, roughly 75 percent of the households have some members working at Zedtee. In addition, a few villagers were working at other logging companies such as Rimbunan Hijau, Shin Yang, and Samling. Only a small number were working in cities, and a large number of households stayed in the village.

As for hunting, the villagers caught roughly forty wild boars a year and between twenty and forty sambar deers. They caught about twenty muntjacs (barking deer) a year. The villagers recognized four types of wild boars, four types of muntjacs, three types of sambars, and two types of mouse deer. The names of those types are shown in Table 1.

Table 1: The types of wild boar and deer recognized by the villagers of Rh. Mawang

Local names	Characteristics
Wild boar (Only one species is known biologically)	
Babi Nibong	Small in size and black. Short hair. Seen occasionally.
Babi Kanbam	Not many. Large in size and with a strong smell. Large nose and high cheek bones. Seen once in five to ten years. Seen three times in thirty-six years.
Babi Bulan	Most numerous. White body. Seen during mass fruiting period. Eat rice, maize, and cassava.
Babi Lengkae	Common wild boars.
Muntjac / Barking deer (Two species are known biologically)	
Kijang Ngenuling	Most numerous. Red.
Kijang Keranggas	Second most numerous. Yellow.
Kijang Balut	Found in Baram and Belaga.
Kijang Bela'	The smallest. Live in the mountains. Mixture of red and white.
Sambar deer (One species is known biologically)	
Rusa Ubi	Most numerous. With antlers.
Rusa Lalang	Second most numerous. Small in size. With antlers.
Rusa Balut	Antlers are too short to see. Between four and five individuals are captured in a year.
Mouse-deer (Two species are known biologically)	
Pelandok Kemayang Panas	
Pelandok Tu(a)mping	

The migration history of Ibans in the Upper Anap River region

The five villages in the Upper Anap River Basin (Rh. Mawang, Rh. Entri, Rh. Belong, Rh. Sayong, and Rh. Gasah) migrated from Julau in the upper Kanowit River, a branch of the Rajang River (Figure 2). They moved in 1940s. When they were migrating, they asked for and were granted permission from the government administrator in Sibu. The pre-migration longhouse was a roughly fifteen-minute ride on the boat (15 horsepower) from Nanga Julau and had fifteen households. The villagers made their livings by collecting rubber latex in Julau, but the price was too low, not proportionate to the hard work. Additionally, all of the areas surrounded the village became *temuda* (secondary forests). Thus, the villagers moved to the new location to seek uncultivated forests where they could hunt wild boars and fish.

The current village chief himself moved in 1964, when he was not yet married. When he migrated with other villagers, they went down the Kanowit River to reach the Rajang River. They went up the Rajang River to Kapit, where he spent a night in the boat. On the following day, they went farther up the Rajang River to reach the Pelagus River. They spent a night at Rh. Massam along the Iran River, an upper stream of the Pelagus River. After that, they walked six hours, carrying their luggage, from the Dapu River, farther upstream of the Iran River; after going over the hill, he reached the Kilong River, a small distance downstream of the current longhouse along the Anap River. The Bekatans, who inhabited there previously, already left to lower Anap. A total of twenty households moved from Julau, and they were gradually joined by two or three households from Sarikei, four or five households from Saratok, four or five households from Skrang, and seven households from Assan (a small distance upstream of Sibu); all of these groups were Ibans (see Figure 2). Other Iban groups also immigrated into this Upper Anap, but because they migrated without permission, these groups were let to relocate again to the Pila River and Julau River.

In the 1960s, their longhouse was at the Rengas River (on the other side of the mouth of the Kilong River) and thatched with palm leaves. At that time, they cultivated hill paddy and made their living by selling rattan and illipe-nut (*Shorea* spp.) in Kapit bazaar.

Between 1973 and 1974, government let them to join a group resettlement along the Sekuau River, in the middle reaches of the Oya River to empty the Upper

Anap and to isolate communists group from the villagers, because of the government's anti-communist policies. People who were resettled along the Sekuau River were not only from the Upper Anap River Basin but also from various places, including Kapit, Bintangor, and Biduk. In 1974, the administrator of Sri Aman issued licenses to the Chinese communists as contractors for logging and school building and the Ibans came back to the Upper Anap River Basin in 1975.

The villagers have made their living by gathering rattan and illipe-nut and selling both in Kapit bazaar. During the 1970s, the Chinese from Tatau sometimes visited the village to buy illipe-nut. Recently, illipe-nut tree flowered in August 2009. The nuts became available in March and April 2010, and all households in the village collected it, but the price was very low.

On the right-hand side when traveling down Nanga Dakat from Rh. Mawang, there is a graveyard for the Bekatans who lived Upper Anap from 1920 to 1930 or so, but we missed it. There is also a place called "Pemali Bukit Tugong" near Rh. Enteri. This is the graveyard for eighteen to twenty Kenyah from Baram who lost their lives in the fight with the Ibans in the mid-nineteenth century (before the rule by Brooke's government). Bukit Tugong was a warpath used by the Kenyah in the past. The path led to various places such as Merit, Kanowit, Belaga, and Pelagus along the Rajang River. When people pass the Bukit Tugong now, they place a piece of woods to console the souls.

Photograph 1: Children playing in the clear Anap River in front of Rh. Mawang in the evening

Photograph 2: With the village chief of Rh. Mawang and other interviewees

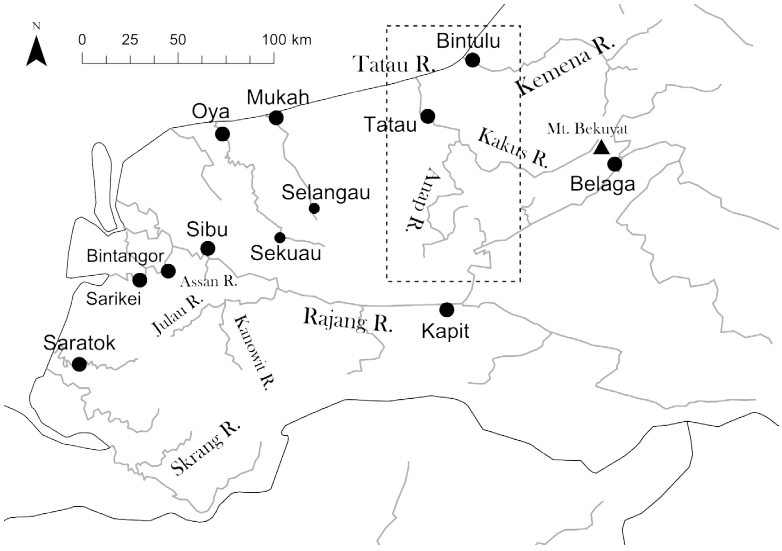

Figure 2: Rivers around the Tatau River

Rh. Enteri (Nanga Takan)

Ichikawa and Kato conducted a household survey. The ancestors of the villagers lived in Rh. Assan along the Julau River, and it was the same village with Rh. Mawang reported above. After migration to the Anap River, their longhouse was still called as Rh. Assan.

There was pepper-processing equipment in the longhouse. In 2004, as part of a government agriculture project, all households planted more than 1,000 pepper trees and sold approximately 1,500 kg. However, the trees died of disease in the third year. Rice cultivation was not as widely practiced as in Rh. Mawang. Not many people were working at Zedtee and many were working in the cities. They previously collected illipe-nuts. Recently, the illipe-nut trees bore nuts in 2010, and the oil was stocked for home consumption.

In the upper Anap River Basin, many children attend a primary school in Pelagus and a junior high school in Kapit. The primary school in Pelagus was built in 1975. The villagers wanted to have a primary school in the upper Anap River.

Some people from Rh. Enteri lived in Kapit. There were also a small number of people moving to Tatau. In general, the communities in upper Anap River region were closely connected with Kapit than with Tatau.

The Ibans' migration from the Rajang River region to the upper Anap River Basin continued until recently. The last migration from Pila River, a branch of Rajang River occurred in 1983.

Among five villages in the upper Anap River Basin, Rh. Mawang, Rh. Entri and Rh. Bilong were longhouses where relatively large and many households stayed in the villages. On the other hand, both Rh. Sayong and Rh. Gasah had smaller populations, and the numbers of households staying in the village were small.

Rh Gerina (Nanga Malat)

This was an old longhouse with many people. We interviewed the village chief about their subsistence activities, the history of the longhouse, and hunting. Kato also interviewed about the saltlick.

The villagers had migrated from the Selangau River, a branch of the Mukah River (see Figure 2). The first move from Mukah took place in 1941 and the second one in 1959. There were thirty households in Mukah at that time. Because it was difficult to cultivate rice and hunt wild boars in Mukah, they moved to the Anap River. They took a ship from Mukah to Tatau, and from Tatau they used paddling boats. When they migrated here, the Bekatans had already split into two villages in the middle Anap River region. In the 1940s and 1950s, the villagers cultivated rice and visited Tatau by paddleboat to sell *dammar*, *jelutong* (both natural latex), rattan, wild boars, and fish. It took four days to reach Tatau and five days to get back to the village. In the 1980s, many villagers left the village to join Rh. Nyalo (thirty households) in Kuala Tatau. Only six households stayed in the village at that time. However, three years later, five households returned. At the time of our interviews, there were twenty-three households and every household stayed in the longhouse.

The longhouse was actively engaged with rice cultivation and hunting. All households cultivated hill paddy. They had never cultivated swamp paddy. The rice harvest was sometimes sufficient but sometimes not. As for hunting, roughly, thirty wild boars and thirty sambars a year were caught, but few common muntjacs were caught. A few villagers worked at Zedtee and at a plantation company.

Photograph 3: The approach to Rh. Garina
A very long pier stretching from the river

Rh. Banda (Kerangan Paji)

Ichikawa and Kato conducted interviews on subsistence activities and Samejima carried out interviews on local animal names. We also asked about the Bekatans' history of migration and split along the Anap River and about the forestry product trade. Processing and crafting rattan were active and found everywhere in the longhouse. In addition to those engaged with rice cultivation, there were many who worked for logging companies or in the cities. Besides, many villagers follow the Ibans' traditional belief, not Christianity.

The history of the Bekatans' migration in the middle Anap River region

The Bekatans' history goes back to the Kapuas River, West Kalimantan. From the Kapuas River, they migrated to Sarawak and lived for many years in Kanowit. From Kanowit, some of them migrated farther, to Selangau. Although one group stayed in Kanowit, the other group reached Takan in the upper Anap River region via Pelagus[1]. They lived in Takan for a long while, however during the reign of James Brooke, the government ordered them to move downstream and they moved to the mouth of the Malat River, in the middle reaches of the Anap River. This was when Tuan Ot and Taun Inyi[2] ruled in this area. After that, the government ordered them to move again, and they moved to the lower Paum River (Figure 3).

The Bekatans' migration history in the middle Anap River region was as follows. In the late nineteenth century, Meraing led the group, and roughly, fifteen households lived at the mouth of the Paum River. After that, when Asai was the leader, they moved to the Palung River. Asai was a leader for ten years when Abang Cai[3] ruled the area, and he died in 1944. He was succeeded by Beruang Gawan in 1944, and the villagers lived in a longhouse comprising of eighteen households made of ironwood (*Eusideroxylon zwageri*). They then split into two villages. A group led by Beruang Gawan was ten households and stayed at Nanga Pelawan. The other group led by Lantai Jaban was eight households, syaed at Kerangan Paji. These villages became today's Rh. Jatun and Rh. Banda, respectively.

Former sites of longhouses are called tevawei in Bekatan. The list of tevawei at the time of the interviews is shown in Table 2.

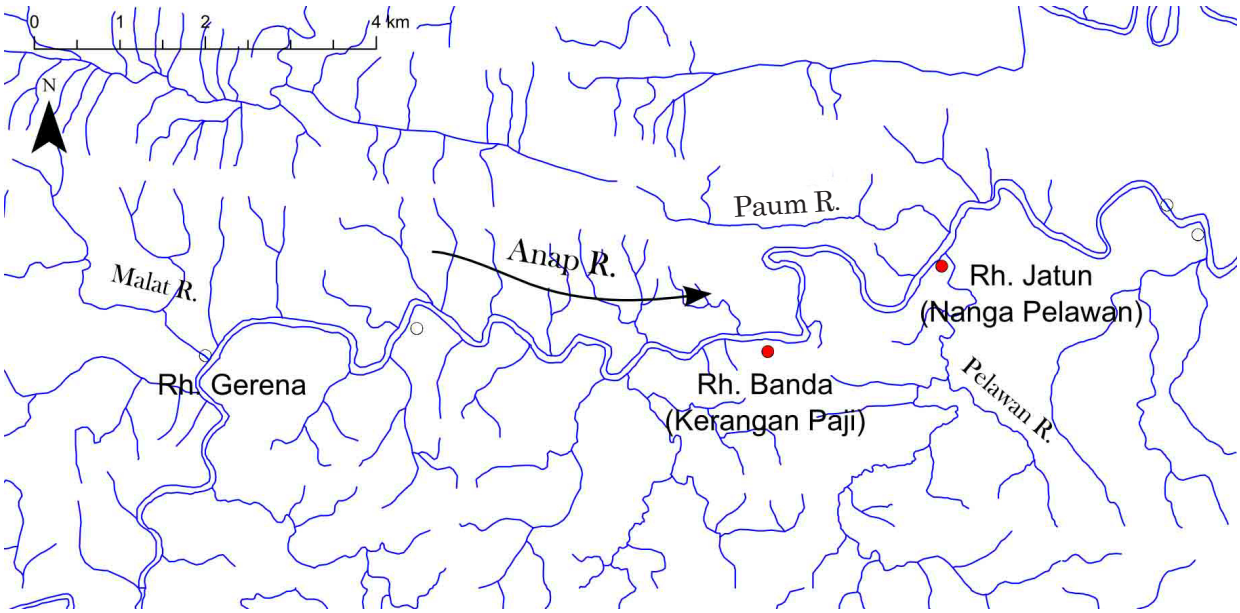

Figure 3: Map of the middle Anap River region

Table 2: The locations of the Bekatans' tevawei in the middle Anap River

Name of the tevawei	Location of the tevawei	Village Chief	Notes
Tevawei Laput[4] Paum	The left bank of the mouth of the Paum River		At the end of the nineteenth century. Not yet split into two village. Fifteen households.
Tevawei Tenuan	Somewhat upstream of Tevawei Laput Paum	Meraing	
Tevawei Lirung[5] Manang	Somewhat upstream of Tevawei Tenuan	Meraing	
Tevawei Majen	Somewhat upstream of Tevawei Lirung Manag	Asai	
Tevawei Palung	The right bank, upstream of Tevawei Majen	Asai	
Tevawei Palung	The left bank of the above.	Beruang Gawan	Approx. 1944. Eighteen households. The longhouse made of ironwood.
Nanga Pelawan	The mouth of the Pelawan River	Beruang Gawan	The village split into two in this period. The predecessor of Rh. Jatun. Ten households.
Tevawei Paji	On the hill, slightly upstream from the present location	Lantai Jaban	The village split into two in this period. The predecessor of Rh. Banda. Eight households.
Tevawei Belangir	Somewhat downstream from the present location	Selangong Senuni	Eighteen households. Migrated from Tevawei Paji.

Photograph 4: An interview conducted at Rh. Banda

Photograph 5: With the interviewees

During the time, that Asai was the chief (around 1940), the villagers gathered rattan, dammar, and illipe-nut and sold them to the Chinese in Tatau. They cultivated rice, but the yield was small, so they often ate sago. In the past, all households made mats with rattan.

After the logging companies started to operate, the number of animals decreased. At the time of our interviews, the villagers could catch at most one wild boar a year, and the same applied to sambar deer. They rarely caught muntjacs. In the past, they had used spear for hunting but use rifles and traps nowadays.

Rh. Jatun (Nanga Pelawan)

Because the village chief was away at Tatau, we conducted interviews with the longhouse residents. We interviewed about cash crop cultivation and the relationships with logging companies. Ichikawa and Kato carried out a household survey and conducted interviews on marriage with other ethnic groups.

There were many who worked at the logging companies or in the cities, in addition to rice cultivation, in this longhouse. They cultivated only hill paddy, and the yield was always sufficient. Just as in Rh. Banda, rattan craft was very active in Rh. Jatun. Rattan was collected from the hill behind the longhouse. When hunting, no dogs were used and the hunters traveled on foot in the forest. There were still many secondary forests behind the village, and they hunted there. In the previous week, they had caught four wild boars.

Photograph 6: Gathering rattan and rattan craft are very active in Rh. Jatun

Photograph 7: In front of a waterfall in the middle Anap River region

There were roughly thirty villagers working at the logging companies. Many worked at Shin Yang, and no one worked at Zedtee. Three worked at an oil palm plantation and one at an acacia plantation. Ten or so young women worked in the city as waitresses. Even though the villagers wanted to plant oil palm by themselves, they could not start because the seeds were not available

Different from the upstream villages, intermarriage with other ethnic groups were not rare in Rh. Jatun. There were more people married with Kayans than Ibans. In addition, in the Bekatan villages, there are marriage relationships with Bekatans in other regions.

Rh. Jalong (Nanga Buan)

From Tatau town, Ichikawa left for the airport while Samejima and Kato again took a boat to visit Rh. Jalong. This was the longhouse of the Tataus people. Interviews were conducted about an old tale of Tatau's population decline, the relationship between the Tataus and the Lugats, the history in the Tatau River region, and marriage to other ethnic groups. We also asked some families about their lineage.

The longhouse residents had moved to the current location 11 years ago (in 2000 or so). Before that, they had built and lived in a longhouse consisting of eighteen households upstream of the current location. There were only two households left in the former location at the time of our interviews. The village chief at the time had assumed his position in 1987 and had served as the village chief for twenty-four years. Before that, Li anak Sare was the village chief, and there were seven households. Before that, in 1947 or so, Dimang anak Jarap (married to an Iban) was the village chief, and there were seven households. Before that, Beyang was the village chief. There has been only one longhouse here.

The villagers were engaged with various occupations. They cultivated both hill and swamp paddy, but more households cultivated swamp paddy. Many of the seventeen households had recently started to cultivate rubber. Only one household cultivated oil palm. This was because it was difficult to grow the sapling. Other households were also planning to cultivate rubber when the road was constructed. Some residents of the longhouse worked in cities in Sarawak and some others worked even in Peninsula Malaysia and overseas. They caught wild boars mostly with snares in the nearby forest, they also hunted in the acacia plantation. Wild boards do not go near the acacia forest when the trees are young. However, when acacia start to bear fruits, wild boars come to the forest to eat the fruits.

According to the Tataus, Tatau dialect is close to Lugat and Melanau, but not close to Sekapan, Kejaman, and Lahanan. Intermarriage with other ethnic groups was very common in this longhouse. Many were married to Ibans, and others were married to Bekatans, Chinese, Punans, Kenyahs, Melayus, Segans, and Lugats. According to

the village chief, because every members of the village were relative in the past, marriage among the villagers was taboo. Because of this, they would look for marriage partners in other ethnic groups such as the Ibans and Punans, and by inviting the partners to live in the Tatau village, Tataus increased the population.

The history of the Tataus in the Tatau River Basin

When the Penans were still living in the forest, the Tataus started to settle down. The Tataus previously lived on sago and did not eat rice. In Tatau language, former places of residence are called *ugan*. There were *ugan* in various places along the Tatau river, both in the forest and by the river.

The Tataus once lived along the Takan River, at the uppermost reaches of the Anap River, and the Kakus River. There still remained durians planted by the Tataus along the Takan River. The Bekatans immigrated to Takan long after the Tataus lived there. When the Bekatans lived in Takan, the Tataus lived along the Penyarai River (see Figure 2). The pillars of the Tataus longhouse are still remained in the Penyarai River. They were huge pillars of ironwood. The Bekatans were sometimes engaged in headhunting and immigrated from the Rajang River. The Punans migrated from the Balui River before the Bekatan and the Ibans migrated after the Beketan. The Ibans were fearful headhunters in the past. Because the Ibans practiced headhunting, the Tataus used to hide in the forest in the upper river region.

In the past, the population of Tataus was more than current population and widely distributed. Even now, there are Tataus' bones in Bukit Bukuyat in the Main River. They often visited there by boat in the past. The bones were large and long. However, because of many supernatural disasters that happened in the Penyarai River and lower Basin of Tatau River, their population became very small. This supernatural disaster was called *puru*. In the past, people hesitated even to use the word *puru*. Even now, this word was not used very often.

Keliring and *salong*, the Tataus' burial poles, were found everywhere by the Tatau River. There were five *kelirings* and two *salongs* in Rantau Belak, roughly a fifteen-minute boat ride away. There had been a *keliring* on the path along the Kampung Melayu Tatau, but it was inundated and destroyed by a flood. In addition, there was a *keliring* near Rh. Roni (Iban), another one in Rh. Saban (Iban) There were also *kelirings* along the Penyarai River, at Kuala Tengiliri and Kuala Miskin, but these were inundated. These episodes suggest that the Tataus once lived widely across the Tatau River Basin. It was very interesting to hear that the Tatau population began to decline after they shot a large snake. Because of space constraints, we will discuss this story further on a different occasion.

Concluding Remarks

This report's aim was to describe the overall picture of longhouse communities in the Anap River Basin. We captured the outline of the migration history, the history of the forestry product trade, and the basic economic activities in each longhouse. We also gathered basic information about the development around villages and about marriage relationship with other ethnic groups. However, the situation of each longhouse varied greatly, and it is impossible to consider the situations of the six longhouses we visited as a general condition of the all villages in Anap River Basin.

The findings from the household surveys carried out on this interview will be compared with the findings from the household surveys carried out in the Kemena River region. The history of the forestry product trade will be published separately.

Notes

[1] According to preceding studies, it is Merit.

[2] It is not clear what kind of position Tuan Ot and Taun Inyi held.

[3] We did not get the details of what kind of position Abang cai occupied.

[4] *Laput* in Bekatan means the mouth of the river.

[5] *Lirung* in Bekatan means a stagnated or deep river.

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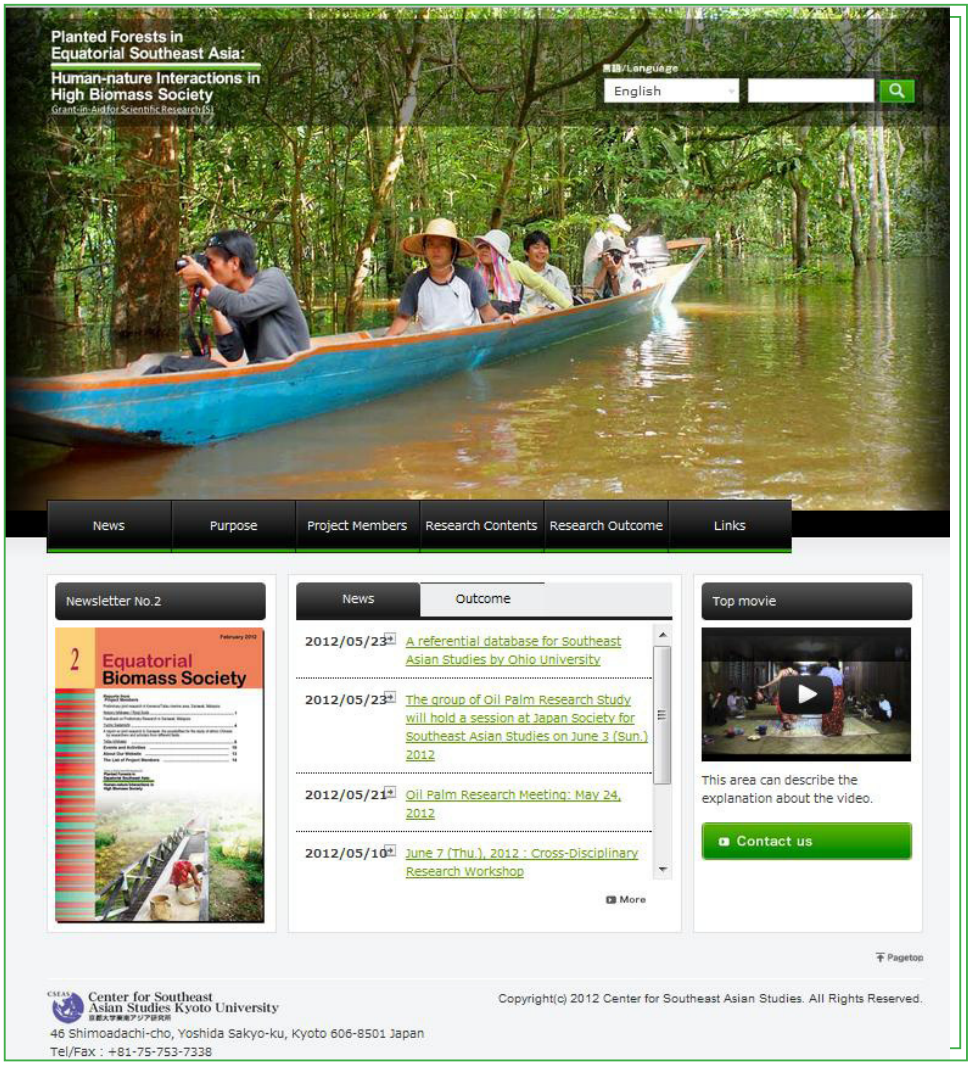

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Measuring tree diameters in Anap-Muput
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(Photo by Hiromitsu Samejima)