



Climate and Landscape Change in Borneo's Rainforest

2012 FIELD REPORT

Background Information

Lead PI: Dr Glen Reynolds

Report completed by: Dr Glen Reynolds - assisted by Kogila Vani Annammala, Dzaeman Dzulkifli and Yeong Kok Loong (Benny)

Period Covered by this report: January 2012-December 2012

Date report completed: 2013-01-25 00:02:32

Protected area status: Partially, yes. The forests surrounding Danum Valley have recently been re-gazetted as Class I (Protection) Forest Reserves.



Dear Earthwatch Volunteer,

2012 was another productive year for the project - the final full year of data collection - and one in which the contribution you made was vital. As you have learned while you were with us, most of the research on the project is being done by three young Malaysian students - Vani Annammala, Dzaeman Dzulkifli and Benny Yeong. Vani and Dzaeman were most actively involved with the teams and their work, (on forest/plantation hydrology/soil erosion and forest restoration respectively) progressed well, very much according to plan and were assisted greatly by the support the volunteer teams provided during the year.

Vani's work in particular, which has involved re-measuring numerous (several hundred in total) erosion bridge sites is especially labour-intensive and would simply not have been possible without your support. Vani is now carrying out sophisticated analyses on the soil and sediment samples she has collected with the aim of understanding the effects of land-use change at a landscape level. Dzaeman, who is registered for a PhD at the University of Zurich, continued to re-measure the plots in which his main experimental treatment, climber cutting, had earlier been applied. With the assistance of volunteers, he is attempting to assess the effects of climber cutting by monitoring arthropod populations and the key ecosystem process of decomposition. Dzaeman also spent a significant period in Zurich during 2012 to begin the process of analyzing his data.

Benny, whose work is based largely in forest fragments within oil palm plantations, continued to measure the several thousand seedlings planted, during his first year, in the primary forest at Danum, at Malua (most of the teams this year helped with this) and in several small patches of forest within oil palm plantations. Benny continues to monitor these seedlings for survival, growth and insect herbivory with the aim of assessing the 'resilience' and likely restoration requirements of small areas of forest embedded within oil palm plantations. Benny spent the first months of 2012 at the University of York to begin the analyses of his data and attend a number of courses.

2012 represents the third and final full year of data collection on the project, and with Vani, Dzaeman and Benny all now analyzing previously collected data, there will be a regular flow of results and findings – so please keep an eye on the Royal Society SEARRP website (www.searrp.org) and its linked Facebook and Blog sites. Your contribution to this critical work, which will be some of the most comprehensive and detailed research done in SE Asia on the impacts of forest disturbance and conversion to plantation, has been important and greatly appreciated by all concerned with this project. Vani, Dzaeman and Benny - as well as Philip, Remy, Udin and our team of dedicated Research Assistants at Malua (and our wonderful cooks!) - join with me in thanking you for your time, effort and support.

Kindest Regards,

A handwritten signature in blue ink, appearing to read 'Glen Reynolds', with a stylized flourish at the end.

Dr. Glen Reynolds

Director - Royal Society SEARRP and Earthwatch Lead Scientist

SECTION ONE: Scientific research achievements

Reporting against research objectives

(Vani's Section)

Objective 1: To examine erosion rates in various types of terrain in the tropical rainforest zone.

Erosion rates were assessed across the landscape gradient from continuous forest to plantation. A total of 300 erosion bridge sites were established in i) primary forest, ii) logged forest (including rehabilitated logged forest), iii) forest fragments and iv) within oil palm plantations) covering a representative range of slopes of between zero and 50 degrees. Erosion rate varied from 0.07mm a-1 to 42.69 mm a-1 (note: a-1 is a soil classification used to describe attributes such as grain size, cohesiveness, and constituent minerals) in managed environments such as within oil palm plantation and logged forest, whereas primary forest had a mean deposition rate of 1.52 mm a-1. Erosion rates ranged from 1.48 to 8.55 mm a-1 (in logged forest) to 1.22 mm a-1 with deposition of up to 1.43 mm a-1 in forest treated by enrichment planting.

Soil conservation techniques introduced in oil palm plantations including terracing, mulching using palm fronds and empty fruit bunches and allowing the growth of herbaceous ground cover plants, were found to reduce soil erosion. Erosion rates at these sites ranged from 0.31-5.31 mm a-1 (with deposition rates of up to 3.39 mm a-1 in some sites) compared to 6.38-43.72 mm a-1 erosion rates sites without soil conservation measures. In logged forest, we hypothesise that increased erosion rates are linked to enhanced splash detachment in large canopy gaps, often associated with abandoned logging tracks and skid trails. We also noted particularly elevated erosion rates on slopes greater than 25 degrees in plantations - though these are reduced when soil conservation measures are applied.



Image 1: Teams sort freshly collected soil samples

Objective 2: To assess the current situation and changes through time as regards the relative importance of sediment contributions to the Segama River following timber harvesting and/or conversion to plantation.

Soil samples (725 in total) were collected from the various forest and plantations sites at 4 depths: 0-5cm, 5-10 cm, 10-15cm and 15-20cm. The samples were assessed for bulk density, soil moisture (using Theta-probe and gravimetric methods to cross check with Theta probe reading) and particle size. Soil Bulk Density (BD), a measure of compaction, varied according to depth and slope angle. In primary forest sites (at Danum), BD at surface ranged from 0.69- 1.08 g cm⁻³, 0.50- 1.23 g cm⁻³ in subsurface layers and 0.53-0.87 g cm⁻³ at 20 cm depth. Under forest cover, average BD increased with depth in top 20cm of soil. BD values were higher in logged forest compared to primary forest - which is likely due to the use of heavy machinery during logging operations, causing considerable soil disturbance and compaction. Logged forest BD values ranged from 0.63 – 1.82 g cm³, in logged forest with enrichment planting, BD valued from 0.83-1.78 g cm³. Sites on or near skid trails and enrichment planting lines showed high BD reading, suggesting that even a decade after

logging, soil remained compacted. Surprisingly, we recorded lower BD values within fragmented forest ($0.58 - 1.67 \text{ g cm}^3$) and within oil palm plantation sites ($0.50 - 0.85 \text{ g cm}^3$). This could be accounted for by differences in soil type and cultivation practices, including the addition of large quantities of organic matter. Further investigation is required.

Sediment fingerprinting techniques were used to determine long-term trends in soil erosion/deposition. This technique involves relating downstream geochemical properties of river sediment to determine (a) differences in properties between different upstream sub-catchments and/or (b) differences in properties between surface/near-surface soil and deeper material. Changes in geochemistry down a river sediment core can therefore be used to indicate changes through time in the proportions of sediment coming from different parts of the catchment and/or the proportions coming from landslides (associated with logging or land use change) compared with the surface erosion and soil pipe erosion of primary or regenerating forest.

X-ray fluorescence offers a powerful means of making these assessments since it provides data for a large number of geochemical properties simultaneously and hence a composite signature (or fingerprint) of each sub-catchment. The procedure involves (1) obtaining and analysing a downstream core and identifying down-profile changes in its geochemistry, (2) obtaining and analysing the bed-sediment characteristics of upstream sub-catchments (all of known logging and land-use history), (3) applying an unmixing model to calculate changes in the relative contributions of each sub-catchment to the downstream sediment.

Early findings from the Segama River Catchment indicate that more sediment is, as predicted, being washed from recently altered environment. Sediment samples were collected at 2.5cm interval in a 1.6 m core at down stream of the Segama Catchment. Fine sediment fractions ($<63\mu\text{m}$) were analysed using portable Niton XRF. Findings were based on the hypothesis that recent enrichment of the downstream sediment with alkali and alkaline earth elements, which are considered mobile elements during weathering and are more susceptible to retention by absorption at the top of the core, may be linked to increased inputs from sections of the catchment that have been recently converted to oil palm and other non-forest land uses.

Objective 3: To use radionuclide fallout of Lead-210 and Caesium-137 as indicators to study the sediment history of the Segama River catchment.

Changes in the rates, processes and spatial patterns of sources of erosion in relation to the history of upstream logging and conversion to oil palm in the Segama catchment are being investigated by dating of downstream river sediment cores. Dating the core and establishing changes in rates of sedimentation (and inferred erosion) is accomplished by analysing changes in Lead-210 and Cs-137 down the sediment core.

Lead-210 (which has a known half-life) lands on depositing particles at a known rate during deposition while exposed to the air. The slower the deposition rate, the longer the time of exposure and hence the greater the density of Pb-210. High Pb-210 implies a low sedimentation rate and low Pb-210 implies a high sedimentation rate. Worldwide deposition of Caesium-137 occurs as a result of nuclear bomb testing and nuclear accidents. A marked peak occurred in 1963 immediately prior to the Nuclear Testing Ban Treaty. The depth that this peak occurs at marks 1963 and allows the Pb-210 curve to be calibrated and turned into a rate of sedimentation record.

A 2-metre sediment core of a lateral bench of the Lower Segama core has been analysed for changes in geochemistry. The core has been analysed for Pb-210 and Cs-137. Bed sediment has now been obtained and analysed from all the sub-catchments of the Segama. Full analysis of the results is still being carried out.

(Benny's section)

Objective 1: Impacts of forest fragmentation on Dipterocarp seedling abundance.

Fieldwork addressing this objective has been completed. The abundance of Dipterocarp seedlings increased with increasing forest fragment size and was positively correlated with increasing forest quality. Forest fragmentation reduced Dipterocarp seedling abundance by up to 90% in the smallest fragment (3 ha) in comparison to both primary and logged forest.

Objective 2: Growth and survival of Dipterocarp seedlings in forest fragments and continuous forests

Fieldwork addressing this objective has also been completed. Dipterocarp seedlings (3 species - *Parashorea malaanonan*, *Dryobalanops lanceolata* and *Hopea nervosa*) were re-measured in 12 sites: 8 forest fragments ranging in size from 3 ha to 3290 hectares and 2 sites each in continuous logged and primary forest. Data analysis for this objective is in progress.

Objective 3: Assessing herbivory of Dipterocarp seedlings in relation to fragment size.

Fieldwork addressing this objective has been completed. Several thousand planted Dipterocarp seedlings were re-measured for herbivory damage (leaf area loss and number of leaves lost). Leaf area losses were assessed by using eye estimation (output as percentage). Data analysis for this objective is in progress.

Objective 4: Leaf litter decomposition of Dipterocarp species.

Fieldwork addressing this objective has been completed. Decomposition (a critically important ecosystem process) increased with increasing fragment size and correlated positively with increasing forest quality. Data analyses for Objectives 1 and 4 is completed and manuscript writing is ongoing.



Image 2: Teams collect soil samples.

(Dzaeman's section)

Objective 1: The effects of forest management practices on dipterocarp seedling growth and mortality.

A total of 2,380 seedlings were planted as part of a field-based experiment which aims to test management practices used in the assisted regeneration of lowland dipterocarp forest. Seedlings of 16 different dipterocarp species were planted, under 3 treatment

regimes. 1146 trees were planted using standard line planting methods (as used on several other reforestation programs across Sabah). 691 seedlings were planted using the same method, but 12 months after planting the forest matrix had climber cutting treatments imposed. A total of 543 seedlings were planted as a control treatment into forest with no planting lines or climber cutting treatments.

Since planting, a series of six measurements (to date) have been made on all seedlings on an average of six-monthly intervals including seedling stem diameter, height and leaf count. At each measurement interval canopy openness was assessed at each planting point by hemispherical densiometer. Three measurements were carried out prior to the climber cutting treatment being imposed and, to date, two post-treatment measures have been carried out. Continued measurements and analyses of these data are ongoing.

Objective 2: The effects of enrichment line planting and climber cutting on litter fall.

A total of 56 x 1-meter square litter traps were placed in the experimental sites in order to quantify the deposition of leaf litter following climber cutting. Litter traps were emptied every two weeks and data collection continues to date. We found that climber cutting in the short term (two months) increases overall litter fall by 130.13% and annually this treatment had caused 17.48% higher litter production volume than standard line planting methods. The bulk of litter production was accounted for by leaves and stems of climbing bamboo (*Dinochola* spp.) - the dominant climber in the degraded forests of the Malua Forest Reserve. The climber cutting method had increased overhead light conditions by of 46.74%.

Overall, the treatment didn't cause any long term changes in the litter cycle, however; treatment annually reduced fruit and flower production by 81.41%. The climber cutting treatments indicate that the primary aims of increasing light conditions can be achieved in a short period of time, however, disruption to fruit and flower production can cause negative impacts on the faunal community.

Objective 3: Arthropod diversity and abundance changes with different forest management regime.

To date, a series of 4 insect/arthropod fogging collections have now been made in order to assess the effects of climber cutting on arthropod species composition and abundance. Preliminary sorting of the samples has been completed and identification continues.

SECTION TWO: Impacts

Partnerships

Universiti Malaysia Sabah, Yayasan Sabah, Danum Valley Management Committee, Sabah Forestry Department, Sabah Biodiversity Centre, University of York, Swansea University, University of Zurich, The Round Table on Sustainable Palm Oil (RSPO), The Wilmar Group/PPB Oil Palms Sdn Bhd.

Contributions to conventions, agendas, policies, management plans

- **International**

(Oral Presentation) Blake, W.H., Walsh, R.P.D., Bidin, K., Annammala, K.V, 2012. Contextualizing impacts of logging and tropical rainforest catchment sediment dynamics and source processes using the stratigraphic records of an in-channel bench deposit. Geographical Research Abstracts 14. EGU General Assembly (EGU 2012-7190), Vienna. April 2012. H. Hazebroek, W. Sinun, Z. Adlin (with G. Reynolds & W.K. Meng). 2012. Danum Valley: The Rainforest. Natural History Publications.

- **National or regional**

(Oral Presentation) K.V. Annammala¹, R.P. D. Walsh, K. Bidin, A. Nainar; 2012. High Rates Of Soil Loss To Streams In Oil Palm Areas In Eastern Sabah Detected Using A Modified Soil Erosion Bridge Technique – And Reductions With Soil Conservation Practices. Asia Oceania Geosciences Society (AOGS) Conference-European Geosciences Union (EGU) Joint Assembly, Singapore, 13-17 August 2012. (BG06-A009)

(Oral Presentation) R.P.D. Walsh, R. Williams, K.V. Annammala, T. Coombs, K. Bidin, A. Nainar, 2012. Potential, Problems and Challenges in Using Sediment Fingerprinting at Different Spatial Scales within the Segama Catchment, Sabah, Malaysian Borneo. Asia Oceania Geosciences Society (AOGS) Conference-European Geosciences Union (EGU) Joint Assembly, Singapore, 13-17 August 2012. (BG06-A007)

(Oral Presentation + Full Paper) K.V. Annammala¹, R.P. D. Walsh, K. Bidin, A. Nainar; 2012. Higher Erosion Rate and Enhanced Sedimentation from disturbed landforms in Eastern Sabah, Borneo. 2nd International conferences on Water Resources in Conjunction with 20th UNESCO-IHP regional Steering Committee Meeting for Southeast Asia and the Pacific. Langkawi, Malaysia, 5-9th November, 2012

Dr. Glen Reynolds, Yeong Kok Loong and Dzaeman Dzulkifli attended and presented at a International Conference on HEART OF BORNEO +5 and Beyond “Shaping and Nurturing Sabah’s Future Together” held at the The Magellan Sutera, Sutera Harbour Resort, Kota Kinabalu, Sabah.

Developing Environmental Leaders

Of particular significance has been the development of the 3 students - Vani, Benny and Daeman - both academically and in terms of the management and leadership skills. Extremely encouraging.

Conservation of Taxa

Marginal benefits re. a series of red list (IUCN) Dipterocarp species were planted as part of the Sabah Biodiversity Experiment: *Shorea johorensis* - Critically endangered, *Shorea gibbosa* - Critically endangered, *Shorea argentifolia* – Endangered, *Shorea faguetiana* – Endangered, *Shorea leprosula* – Endangered, *Shorea macrophylla* – Vulnerable, *Parashorea malaanonan* - Critically endangered, *Hopea sangal* - Critically endangered, *Hopea ferruginea* - Critically endangered, *Dryobalanops lanceolata* – Endangered.

Conservation of Habitats

The project has direct relevance to the conservation, restoration and sustainable management of lowland (mixed Dipterocarp) tropical rainforest. Findings will have wide application to all areas (across SE Asia) which support this forest type.

Ecosystem Services

Research on forest fragments within oil palm plantations directly relates to the provisions of ecosystem services within agricultural landscapes, most particularly: possible pest and disease control by beneficial species, soil conservation, nutrient availability, etc.

Impacting Local Livelihoods

Work on soil erosion has indirect relevance - particularly to communities dwelling near to or using rivers.

Dissemination of research results

Scientific peer-reviewed publications

Grey literature and other dissemination

- R.P.D Walsh & K.V.Annammala, was invited to give a talk to the executive staff of Wilmar Groups,Sabah in Sandakan on 9th August,2012. Talk on hydrology in relation to frequent floods on major rivers of Sabah and massive de-silting of the rivers which resulted to frequent floods on the major rivers located in east coast of Sabah'.
- K.V.Annammala and Y.K. Loong gave a brief explanation about the project to the Duke and Duchess of Cambridge,during their visit to Danum Valley, Borneo on 15th September,2012.

SECTION THREE: Anything else

Is there anything else you would like to tell us?

Early project findings and experimental techniques have directly contributed to the development of the SEnSOR Project (in collaboration with the RSPO). See: www.searrrp.org/sensor/ Pasted from above "highlights" section:

(Vani's Section) Enhanced sediment transport, sedimentation, channel change and downstream flooding in large tropical catchments often result from upstream land-use change and land management policies. Using multi-proxy sediment fingerprinting method to access the changes in geochemical variables within downstream floodplain (lateral bench core) and relating them to differences in geochemical character of upstream tributary sediment inputs of the Segama catchment. Early finding on sediment fingerprinting approach in Segama river catchment reveals that more sediments are being washed from recently altered environment. Sediment samples were collected at 2.5cm interval in a 1.6 m core at down stream of the Segama Catchment. Fine sediment fraction (<63µm) were analysed using portable Niton XRF elemental analyser to obtain the elemental composition. It is tentatively hypothesized that recent enrichment of the downstream sediment with alkali and alkaline earth elements which are all considered mobile elements during weathering and are more susceptible to retention by sorption at top of the core may be linked to increased inputs from sections of the catchment that have been recently converted to oil palm.

(Benny's section) Forest fragmentation decreased Dipterocarp abundance and rate of decomposition. We found that the abundance of Dipterocarp seedlings in forest fragments was reduced up to 90% compared to logged and undisturbed continuous forests. The rate of decomposition was reduced up to 20% in smallest fragment i.e. 3 ha in comparison to logged and undisturbed continuous forests. Dipterocarp seedlings and decomposition - a key ecosystem process decreased significantly with decreasing fragment size and forest quality.

(Dzaeman's Section) We found that climber cutting in the short term (two months) increases overall litter fall by 130.13% and annually this treatment had caused 17.48% higher litter production volume than standard line planting methods. The climber cutting method had increased overhead light conditions by 46.74%. Overall the treatment didn't

cause any long term changes in the litter cycle, however annually reduced fruit and flower production by 81.41%. The climber cutting treatment shown from our findings suggest that the primary aims of increasing light conditions can be achieved in a short period of time however disruption to fruit and flower production can cause negative impact on the fauna community. Early results show that only after one and a half year after treatment liana and bamboo return. With some species capable of sending runners which reach heights above 10 meters. Early growth results show that the climber cutting treatment had positively increased growth for the rehabilitated dipterocarp seedlings, however mortality due excessive heat stress will be explored over the next few months.

Acknowledgements

Local collaborating organisations, as listed above.

Appendices



Image 3: Talk on Hydrology to Executive Staff of WILMAR group, Sabah



Image 4: Meeting with the Royals in Danum



Image 5: Soil sample preparation for sieving.

Home - News - Sabah - William and Kate visit Danum Valley

William and Kate visit Danum Valley

by Sandra Sokial. Posted on September 16, 2012, Sunday



REYNOLDS (third left) briefing William and Kate on their research during the Royal Highnesses visit to the Danum Valley Field Centre Laboratory, yesterday.

LAHAD DATU: Britain's Prince William and his wife Catherine Middleton, or fondly known as Kate, did not mind the sun, at all.

In fact, the Duke and Duchess of Cambridge refused transportation and chose to walk a distance of 500 metres from the Danum Valley Terrace House to meet 25 researchers and Oxford University undergraduates at the Field Centre Laboratory.

William was heard advising one of the researchers, Kogila Vani Annammala who focuses her research on soils within the conservation area, to "keep up the good work and keep digging."

The nature-loving royal couple decided to walk through Danum Valley, Malaysia's well-reserved rainforest, here, to end their visit to Malaysia.

Spending about three hours touring the Danum Valley Conservation Area, they also sat on tree branches to be briefed on ants and the other living creatures on trees within the 43,800 hectares conservation area.

They came in by Sabah Air's eight-seater helicopter at 10.15am, where the Royal Highnesses were ushered in for a briefing on the conservation works jointly carried out by Yayasan Sabah and the Royal Society's South East Asia Rainforest Research Programme (SEARRP), by Yayasan Sabah Conservation and Environmental Management Division group manager Dr Waidi Sinun, SEARRP's director Dr Glen Reynolds, Sabah Tourism Board chairman Datuk Tengku D Z Adlin and Sabah Forestry Department director Datuk Sam Mannan, to mention some.

William became a Royal Fellow of the Royal Society during the Royal Society's 350th anniversary celebrations in 2010.

The couple showed their strong interest in the progress of conservation works in the area, and asked details on other issues such as the impact on the wildlife, such as the Orang Utan and the Proboscis monkeys.

After the half-an-hour briefing, the Royal couple, who were spotted with matching jungle-themed outfit, trekked into the rainforest to experience the area's remarkable biodiversity for themselves.

William and Kate walked through the rainforest to reach the Danum Valley Research Center, which is located deep inside the rainforest and is run by the Royal Society.

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Their visit to the forest was planned because of William's longstanding interest in conservation, and offered the royal couple an opportunity to experience the ecological wealth of Sabah's forests and the importance of supporting the efforts of the scientists working to understand and conserve them.

Dr Kalsum Yusah, who is doing her research on ants in Danum Valley, was all excited when told that she would be briefing the royal couple at one of her research spots.

"They were pulled up to a branch, 50 metres above the ground, which is equivalent to seven-storey high building, to listen to my findings on ants and its impact to the environment. They were very nice and looked very interested in nature as a whole," she said.

Waidi, meanwhile, described the royal couple's visit as "successful and beneficial".

"The Duke of Cambridge did say that his father (Prince Charles) has a soft spot for the rainforest.

"To me, the visit was both successful and beneficial as it will now lift the Danum Valley Conservation Area to a higher level. It is truly a recognition to the joint effort by Yayasan Sabah and the Royal Society, especially to our conservation works.

"We believe what has and being done here is important and is globally significant ... and I believe that was what attracted the royal couple to come to this part of the world," he said.

After spending about three hours at the Danum Valley Conservation Area, the Royal couple took off for the Borneo Rainforest Lodge's 300 metres canopy walk, before adjourning to a private lunch at the lodge.

He said the Royal Society is approaching its third decade collaboration with Yayasan Sabah to help develop effective conservation, management and restoration strategies for these vital ecosystems and environmental research and management capacity in the scientific community of Malaysia.

The Duke and Duchess then took the commercial aircraft to Kota Kinabalu.

Malaysia is the royal couple's second destination after Singapore on their nine-day tour of the Far East as representatives of Her Majesty Queen Elizabeth II in conjunction with the celebration to mark the 60th reign of the Queen of England.

They are scheduled to visit the Solomon Islands and Tuvalu next.



THE Royal Highnesses walking on the suspension bridge after trekking the Danum Valley rainforest, yesterday.

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