Institution: Swansea University
Unit of Assessment: 17 - Geography, Environmental Studies and Archaeology
Title of case study: Improved land management and rainforest conservation in South East Asia

1. Summary of the impact

Between 1996 and 2011, Swansea staff published a series of papers into effects of logging practices, land-use change and recent climatic change on rainforest erosion, hydrology and ecology in Sabah (Malaysian Borneo). This research has led to improved logging practices and land management policy and enhanced the spatial extent, design and security of rainforest conservation in the region – for example, in 2012-13, the Sabah Government more than doubled the area of legally protected rainforest to form an east–west (E–W) contiguous 5000 km^2 rainforest area in eastern Sabah. This zone will be more robust in its responses to climatic change and less prone to wildfires than if the forest had been fragmented. This is of global conservational significance because the zone contains the largest remaining area of primary lowland rainforest (and orang-utan habitat) in SE Asia. The impact of our research was achieved through direct, long-term links between Swansea staff and local forest management and governmental bodies.

2. Underpinning research

The long-term research carried out by the team from **Swansea** in Sabah has chiefly involved Rory **Walsh** (Swansea throughout; Professor since 2000) and Glen **Reynolds** (Swansea-based post-doc since 2000), together with more recent contributions by Swansea's dendroclimatology team (Neil **Loader** (Swansea since 2002, NERC Fellow 2005-10, Reader 2012-), Mary **Gagen** (Swansea since 2003, RCUK Fellow 2006-11, Lecturer/Ass. Prof. 2011-) and Iain **Robertson** (Swansea throughout; Reader 2013)). Research foci were (1) the long-term consequences of selective logging and climatic change for erosion, forest ecosystems and forest regeneration in Sabah, and (2) ways of reducing the negative effects involved. The research was carried out as Swansea-led component projects of the multidisciplinary Royal Society South East Asia Rainforest Research Programme (SEARRP), which has been based at Danum Valley in Sabah since 1985 and is a collaborative venture with the Sabah Government. **Walsh** has carried out hydrological and climatic change research since 1990 and has led the SEARRP hydrology team since 2002; **Reynolds**, as resident Royal Society Senior Scientist (later SEARRP Director) since 2000, has not only carried out forest management and rehabilitation research, but has also had a key role in translating research into policy through dissemination to Government departments, and through his involvement with forest and land-management policy bodies in Malaysia and regionally in SE Asia.

The underpinning research had two foci. The first was the long-term hydrological and erosional effects of selective logging, and ways of reducing these effects. This research included a >20-year monitoring record of slope and stream erosion in a small catchment that was selectively logged in 1989 [R1, R2, R3]. This research revealed for the first time that 5-8 years after primary rainforest is logged a second peak in erosion can occur [R1]. This second peak was linked to poorly-aligned mid-slope logging roads and the biological decay and collapse of logs in culverts and bridges along them, leading to blockages to water flow and landslides during major rainfall events. Since the second peak, landslide scars have acted as foci of gully erosion [R2] and fresh road-linked landslip activity has occurred [R3]. These findings highlighted the need for improved logging-road alignment. We also used sediment fingerprinting and dating techniques to analyse downstream sediment cores and: (a) quantify changes in sources of sediment; and (b) relate the history of sedimentation to variations in logging intensity and practices [R3]. We demonstrated that downstream sedimentation rates and inferred erosion rates in the same steep terrain areas were six times higher with large-scale logging involving road construction in 1999-2001 than in the early 1980s prior to the arrival of roads when logs were floated down the river and logging intensities were light.

A second research focus was on recent climatic change and its impacts on rainforest dynamics and erosion. Archival climatic records were used to assess variations in extreme climatic events (droughts and heavy rainfall) over the past 100–150 years in Borneo and elsewhere in SE Asia. This demonstrated: (i) a sharp increase in drought magnitude and frequency since 1967 that was

linked to El Niño events; (ii) an E–W gradient in drought proneness across Sabah and Borneo that was reflected in contrasts in rainforest age-size distribution and species composition; and (iii) a natural resilience of primary forest to occasional drought, contrasting with logged and fragmented forest that is prone to fire (and biodiversity loss and change) under the same conditions [R4, R5]. A model was presented in R4 of contrasting forest responses to drought with and without fire across a climatic gradient (E-W in Borneo) of drought magnitude and frequency. Pioneer research showing a progressive increase in water-use efficiency indicated by changes in carbon isotopes of wood in cross-sections of 210-700 year-old rainforest trees demonstrates their resilience so far in responding to increased atmospheric carbon dioxide [R6].

We used a second assembled archive of century-long daily rainfall records at 3 stations in Sabah (unique for equatorial areas) to demonstrate an upsurge in heavy rainstorm frequency to unprecedented levels since 1998, suggesting that Intergovernmental Panel on Climate Change (IPCC) 2007 predictions of increases in extreme rainfall events may already be occurring in Sabah [R3]. Consequences of the upsurge for Increased river flows, sediment transport and slope erosion were demonstrated and the likelihood of a major landslide phase and downstream flooding if steep terrain is logged or converted to oil palm was highlighted [R3]. This has been strengthened by the unit's research into land-use change, forest management and rehabilitation [e.g. R7].

3. References to the research

Swansea authors in bold font (with PhD students/research assistants in italics); Number of citations and journal impact factor (IF) from Thomson Reuters Web of Knowledge (Oct 2013)

[R1] Douglas I., Bidin K., Balamurugam G., Chappell N.A., **Walsh R.P.D.,** Greer T. & Sinun W. (1999) The role of extreme events in the impacts of selective tropical forestry on erosion during harvesting and recovery phases at Danum Valley, Sabah. *Phil. Trans. R. Soc. B* 354, 1749-1761. (cited: 50; IF: 6.40)

[R2] ***Clarke M.A.*** & **Walsh R.P.D.** (2006) Long-term erosion and surface roughness change of rain-forest terrain following selective logging, Danum Valley, Sabah, Malaysia. *Catena* 68, 109–23. (cited:13; IF: 1.89)

[R3**]** **Walsh R.P.D.,** Bidin K., Blake W.H., Chappell N.A., ***Clarke M.A*.,** Douglas I., ***Ghazali R*.,** ***Sayer A.M.,*** Suhaimi J., Tych W. & ***Annammala K.V*.** (2011) Long-term responses of rainforest erosional systems at different spatial scales to selective logging and climatic change. *Phil. Trans. R. Soc. B* 366, 3340-3353. (cited: 3; IF: 6.40)

[R4**]** **Walsh R.P.D.** (1996) Drought frequency changes in Sabah and adjacent parts of northern Borneo since the late nineteenth century and possible implications for tropical rain forest dynamics. *J. Trop. Ecol.* 12, 385–407. (cited: 71; IF: 1.40)

[R5**]** **Walsh R.P.D**. & Newbery D.M. (1999) The ecoclimatology of Danum, Sabah, within the context of the world's rain-forest regions, with particular reference to dry periods and their impact. *Phil. Trans. R. Soc. B* 354, 1869–1883. (cited: 77; IF: 6.40)

[R6**]** **Loader N.J., Walsh R.P.D., Robertson I.**, Bidin K., Ong R., **Reynolds G., McCarroll D., Gagen M.** & ***Young G.H.F***. (2011) Recent trends in the intrinsic water-use efficiency of ringless rainforest trees in Borneo. *Phil. Trans. R. Soc. B* 366, 3330-3339. (cited: 8; IF: 6.40)

[R7] **Reynolds G**., Payne J., Sinun W., Mosigil G. & **Walsh R.P.D.** (2011) Changes in forest land-use and management in Sabah, Malaysian Borneo, 1990-2010, with a focus on the Danum Valley region. *Phil. Trans. R. Soc. B* 366, 3168-76. (cited: 11; IF: 6.40)

Main sources of funding:

(G1) European Economic Community (1997–2001) 596,000 Ecus [**Walsh** with Prof. I. Douglas (Manchester), Prof. G. Foody (Salford), Freiburg & five SE Asian institutions] 'Ground and remote sensing indicators of post-logging erosion and forest status in SE Asia'.

(G2) Earthwatch (2010–2013) £600,000 [Lead PI = **Reynolds** (Swansea); co-PIs = **Walsh** (Swansea), Prof J. Hill (York) & Prof A. Hector (Zurich)].

(G3) Royal Society (2000–2014): three 5-year grants totalling £786,000 for SEARRP rainforest research at Danum Valley, Sabah, Borneo; as Research Co-ordinator, **Walsh** led these bids.

4. Details of the impact

Context regarding dissemination and impact of the research

A key SEARRP aim has been to provide sound, unbiased science to test and underpin existing and alternative improved land-management techniques and strategies for decision-making bodies in Malaysia. Dissemination of its research and translation into policy in Sabah has been greatly facilitated by the unusually direct two-way links that SEARRP has with Yayasan Sabah (YS - a Government-run foundation that manages a 10,000-km^2 forested section of the State), its Environment and Conservation Division, and the Sabah Forestry Department. The direct links are enabled by requirements for all SEARRP research projects to be approved at State and Federal levels, to involve local research collaborators (often from YS or Government ministries), and for copies of all papers and reports to be provided to YS and the Sabah/Malaysian Governments. The roles of **Walsh** and **Reynolds** as Research Co-ordinator and the Sabah-based Director of SEARRP respectively since 2000 have also aided dissemination of research and its translation into policy through invited membership of committees and advisory panels [e.g. C1].

Direct impact in Sabah and Malaysia

Research findings from the Swansea team **underpinned key land management and forest conservation decisions and policies adopted by the Sabah Government in 2008-13**. On the hydrological side, of particular importance has been the science demonstrating and quantifying the benefits of keeping steep (>25°) slopes unlogged or at least under forest, and of carefully aligning logging roads [R3]. The Group Manager of the Environment and Conservation Division of Yayasan Sabah wrote that "the research findings of the hydrological group led by Walsh demonstrating the influence of logging roads and their alignment on landslides and sediment transport have provided the underpinning science behind Reduced Impact Logging protocols used within Sabah and recent adoption of helicopter logging in higher slope terrain" [C2].

The climatic change and forest response research [R4-R6] was accompanied by specific recommendations by Walsh at a Sabah Government-organized conference on the need to retain a large contiguous E–W unit of forest in eastern Sabah with buffer areas around primary forest conservation areas to (1) reduce fire risk and (2) increase the ability of forest ecosystems to adapt to climatic change, thereby maximizing the security and value of biodiversity conservation strategies [C3]. The research underpinned a series of forest conservation initiatives by the Sabah Government in 2008–2013 [e.g. C4, C5]. These included: (1) rehabilitation of large areas of overlogged forest, starting with the Malua Forest Reserve in 2008; (2) designation in 2009 of a third primary forest conservation area (Imbak Valley; 30,000 ha), with 15% of Sabah now protected primary forest; (3) a decision in 2010 to apply for World Heritage Status for the three Sabah conservation areas, with **Reynolds** appointed to the panel to take this forward; and (4) decisions in May–September 2012 [C4] and in June 2013 [C5] to commit irrevocably to the principle of contiguity of forest cover E–W across eastern Sabah. The final initiative was accomplished by giving legal protection to forest corridors of regenerating forest linking the three primary forest conservation areas, and to large additional buffer areas – an additional 285,000 ha of protected forest [C5]. Thus, the Director of Forestry in Sabah in June 2013 confirmed the extension of legal protection to create "*the single largest contiguous area to be placed under protection anywhere in the country….an unbroken stretch from Maliau Basin to Imbak Canyon to Danum Valley….of nearly 500,000 hectares*" [C5].

These dramatic policy changes acknowledging the importance of forest retention in supporting environmental and socioeconomic sustainability and mitigating climatic change followed talks by Walsh and Reynolds at Government-organised workshops and conferences in Malaysia, supported often by Climate Change Initiative funds of the UK Foreign Office. Thus the 2012-13 decisions directly followed invited participation of Walsh and Reynolds (who gave presentations on policy implications of their research) in the Government-organised workshop in September 2011 to develop Sabah's REDD+ policy. REDD+ is the second phase of the United Nations REDD Reducing Emissions from Deforestation and forest Degradation) collaborating initiative aimed at promoting forest cover in developing countries and combating global warming. The Sabah Director of Forestry thanked **Walsh** 'for making the Conference a world-class event' and stated the

research "…*has given us an insight on how to realise REDD-plus in Sabah, in tandem with the Heart of Borneo Initiative*" [C6]. The Chief Minister also twice acknowledged the key role SEARRP science has played in aiding Government policy [C7]. The decisions represent a step-change in Government attitude and policy and have their origins in letters to the Sabah Government in the early 2000s from the Royal Society (drafted in part by **Walsh** as SEARRP Research Co-ordinator) expressing concern about the environmental consequences of headwaters logging and proposed land-use change that would have broken the contiguity of remaining forest [C2].

Wider reach and significance of the impact

The forest involved includes the largest remaining area of primary lowland rainforest in SE Asia, and is key habitat for orang-utans – and many other endangered species of global importance. It represents an oasis of conservation in a region in which rates of loss of forest habitat remain high. Furthermore, since 2009, the nested forest conservation area concept of Danum has been widened to include Indonesia, through the development of a 'Heart of Borneo Concept', with a crescent of conservation areas spanning north-east Kalimantan, eastern Sabah and Brunei [C6]. Also, both **Walsh** and **Reynolds** are involved in advising the Round Table on Sustainable Palm Oil (RSPO) on their attempts to rehabilitate and extend riparian forest and forest fragments. The findings detailed in R3 are also being used by the Australia-based Forest Practices Authority in drawing up new Guidelines for Logging in Papua New Guinea [C8]. Acknowledgment of the scale and significance of the research and its impact is also provided by the Honours bestowed on **Reynolds** by both the British and Malaysian Governments in 2011 and 2012, respectively [C9].

5. Sources to corroborate the impact *(documents available on request)*

C1. Anon (2008) Forest Management Plan for the Ulu Segama-Malua Forest Reserve. Sandakan: Sabah Forestry Department. Reynolds was involved in formulating this.

C2. Testimonial from the Group Manager, Environment and Conservation Division, Yayasan Sabah, confirming the influence of research by **Walsh** and **Reynolds** on logging practice and conservational policies in Sabah.

C3. Conference presentation by Walsh - Extended abstract published in: Proceedings of the International Conference on In-Situ and Ex-Situ Biodiversity Conservation in the New Millennium 20-22 June 2000, Kota Kinabalu, Sabah, pp.137-144. ISBN 983-808-152-3

C4. September 2012: Press statement from the Sabah Forestry Department announcing gazetting of 183,000 ha of lowland forest into Class I Protection Status to form an E–W corridor linking the three primary forest conservation areas.

C5. Lead front-page article in the (Sabah) *Daily Express* 27 June 2013 reporting a speech by the Sabah Director of Forestry on enactment of an unbroken 500,000-ha E–W stretch of protected contiguous forest (the largest in Malaysia).

C6. November 2010: Letter of thanks from Director of Forestry for invited presentation by Walsh at the 'Sabah International Conference on Forest and Climate Change – Decoding and Realising REDD-Plus in the Heart of Borneo (HoB), with Specific Focus on Sabah'.

C7. Lead front-page articles in the *New Sabah Times* reporting speeches by the Chief Minister of Sabah: on 28 July 2010 on the conservational role of long-term research by scientists of the Royal Society SE Asia Rainforest Research Programme www.newsabahtimes.com.my/ nstweb/archives (accessed 27.10.2013) and on 5 March 2010 acknowledging conservational and socioeconomic significance to Sabah of Danum Valley rainforest research.

C8. E-mail of 6 March 2013 from Senior Scientist, Forest Practices Authority, Hobart, Tasmania, on usefulness of R3 in revising Papua New Guinea Logging Guidelines.

C9. Award of an MBE to **Reynolds** in the 2011 Queen's Birthday Honours and the title of 'Datuk' (equivalent of 'Sir' in the Malaysian Honours System) in October 2012, in each case for his role in rainforest science and conservation in Malaysia.

Individual users/beneficiaries able to corroborate claims include: (C10) Director of Forestry, Sabah Forestry Department, Sandakan, Sabah; (C11) Head of Environment and Conservation, Yayasan Sabah, Sabah; and (C12) The British High Commissioner to Malaysia 2009–2012.