Variations in suspended sediment dynamics of catchments of differing land-use history in the upper Brantian and Kalabakan catchments of the SAFE Project, Sabah (North Borneo)

Anand Nainar (Universiti Malaysia Sabah)
Kawi Bidin (Universiti Malaysia Sabah)
Rory Walsh (Swansea University)
Introduction

• The SAFE Project hydrology component aims to understand the effects different land use as well as different treatment of catchments on suspended sediment load, solutes and water quality in tropical streams

• Today’s focus: Different land use history
Background

- Stream water quality is inextricably linked to land use of the catchment
- The export of suspended sediment (terrestrial or aquatic) has important impacts on water quality – aquatic ecosystems, health and economic activity
Background

Adverse effects of high suspended sediment

- Limit penetration of sunlight – limiting aquatic plants
- Killing of aquatic animals – clogging of gills
- Prevent spawning of aquatic animals
- Unfit for human consumption
- Economic activity – industrial or commercial
- Limit of less than 1 NTU for drinking water (WHO, 2011)
Aim

- To compare

(i) peak suspended sediment concentration

(ii) duration of high suspended sediment concentration

between streams of repeatedly logged forest (5 m), logged forest (LFE), virgin jungle reserve (VJR) and the oil palm (OP).
Experimental Design

- 4 catchments of differing land use history
  - 5 m (repeatedly logged)
  - LFE (Logged Forest Experiment – logged)
  - VJR (Virgin Jungle Reserve – Old Growth)
  - OP (Oil Palm)

- Catchment area of 2.6 km² and gradient of 16°.

- Data collected via depth sensor, turbidity sensor, conductivity sensor and a tipping bucket raingauge all connected to solar-powered datalogger in each catchment
Experimental Design

- Two sizes of storms from each stream – one for small storm (< 100 L/s) and one large (~ 400 L/s)
## Results

Suspended sediment concentration at baseflow and peak flow

<table>
<thead>
<tr>
<th>Stream</th>
<th>Baseline Discharge (L/s)</th>
<th>Peak Discharge (L/s)</th>
<th>Baseline SSC (mg/L)</th>
<th>Peak SSC (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 m (repeatedly logged)</td>
<td>15 - 35</td>
<td>1250</td>
<td>0 - 70</td>
<td>32107</td>
</tr>
<tr>
<td>LFE (logged; regenerating)</td>
<td>100 - 250</td>
<td>2005</td>
<td>0 - 189</td>
<td>35402</td>
</tr>
<tr>
<td>VJR (virgin jungle reserve)</td>
<td>3 - 10</td>
<td>440</td>
<td>0 - 101</td>
<td>25856</td>
</tr>
<tr>
<td>OP (oil palm)</td>
<td>3 - 10</td>
<td>443</td>
<td>86 - 414</td>
<td>30926</td>
</tr>
</tbody>
</table>
Duration of high suspended sediment concentration (discharge increment < 100 L/s)

SSC vs Time for Storm 22 of the 5 m Stream
- Time: 0 - 1250 mins
- SSC: 0 - 1200 mg/L
- Peak SSC: 1067 mg/L

SSC vs Time for Storm 29 of the LFE Stream
- Time: 0 - 1240 mins
- SSC: 0 - 300 mg/L
- Peak SSC: 275 mg/L

SSC vs Time for Storm 6 of the VJR Stream
- Time: 0 - 960 mins
- SSC: 0 - 5000 mg/L
- Peak SSC: 4644 mg/L

SSC vs Time for Storm 58 of the OP Stream
- Time: 0 - 200 mins
- SSC: 0 - 25000 mg/L
- Peak SSC: 21432 mg/L
Duration of high suspended sediment concentration (discharge increment ~ 400 L/s).

SSC vs Time for Storm 63 of the 5 m Stream:
- 2588 mg/L
- 520 mins
- 1000 mins

SSC vs Time for Storm 1 of the LFE Stream:
- 4498 mg/L
- 280 mins
- 750 mins

SSC vs Time for Storm 82 of the VJR Stream:
- 5020 mg/L
- 220 mins
- 600 mins

SSC vs Time for Storm 60 of the OP Stream:
- 23075 mg/L
- 15831 mg/L
- 29408 mg/L
- 23665 mg/L
- 4737 mg/L
- 600 mins
Duration of high suspended sediment concentration (discharge increment ~ 900 L/s)

SSC vs Time for Storm 32 of the 5 m Stream

12557 mg/L

SSC vs Time for Storm 51c of the LFE Stream

10986 mg/L

300 mins

250 mins
Hysteresis Loops (discharge increment < 100 L/s)

SSC vs Discharge for Storm 22 of the 5 m Stream

**Sediment export** = 1.93 t
0.0074 t ha\(^{-1}\)

SSC vs Discharge for Storm 29 of the LFE Stream

**Sediment export** = 1.77 t
0.0067 t ha\(^{-1}\)

SSC vs Discharge for Storm 6 of the VJR Stream

**Sediment export** = 0.85 t
0.0033 t ha\(^{-1}\)

SSC vs Discharge for Storm 58 of the OP Stream

**Sediment export** = 5.27 t
0.0207 t ha\(^{-1}\)
Hysteresis Loops (discharge increment ~ 400 L/s)

SSC vs Discharge for Storm 63 of the 5 m Stream
Sediment export = 4.03 t
0.0155 t ha\(^{-1}\)

SSC vs Discharge for Storm 1 of the LFE Stream
Sediment export = 17.03 t
0.0655 t ha\(^{-1}\)

SSC vs Discharge for Storm 82 of the VJR Stream
Sediment export = 5.59 t
0.0215 t ha\(^{-1}\)

SSC vs Discharge for Storm 60 of the OP Stream
Sediment export = 37.64 t
0.1448 t ha\(^{-1}\)
Hysteresis Loops (discharge increment > 900 L/s)

**SSC vs Discharge for Storm 32 of the 5 m Stream**

- Sediment export = 30.45 t
- 0.1171 t ha\(^{-1}\)

**SSC vs Discharge for Storm 51c of the LFE Stream**

- Sediment export = 46.46 t
- 0.1787 t ha\(^{-1}\)
Early Conclusions

• In the largest storms, peak SSC recorded is similar for the 5 m, LFE and OP streams (30000 – 35000 mg/L). The VJR stream has lower peak SSC (25000 mg/L)

• For the OP stream, SSC is never as low as other streams even at baseflow.
Early Conclusions

- SSC declines much faster in the LFE stream compared to the 5 m stream
- The VJR has higher peak SSC, but SSC recovery time is shorter than the 5m and LFE
- The oil palm has much higher SSC. SSC declines rapidly to about 1000 mg/L, but recovery time from then is the longest. Baseline is never as low as other streams
- For extreme events, the LFE stream has lower peak SSC than the 5 m stream; and takes less time to return to baseline levels.
Early Conclusions

- Sediment export is highest for the OP stream for small and large storms.
- Sediment export is lowest for the VJR stream for small storms, but equals to that of logged streams for larger storms.
Funded by

Sime Darby Foundation


Dinamik Berjiwa Rakyat
Komited Prihatin

The Royal Society

SEARRP South East Asia Rainforest Research Programme

Imperial College London
Thank you
Variations in suspended sediment and solute dynamics of catchments of differing land-use history in the upper Brantian and Kalabakan catchments of the SAFE Project, Sabah (North Borneo)

Anand Nainar (Universiti Malaysia Sabah)
Kawi Bidin (Universiti Malaysia Sabah)
Rory Walsh (Swansea University)