Background

- Oil palm is developing rapidly throughout the tropics, especially in Southeast Asia.
- This perennial crop (~25-30 yr rotation) is grown in extensive plantations (~130 km² per plantation).
- Plantation expansion converts mainly forested lands, including logged forests and mixed agricultural systems.
- Deforestation typically leads to increased sediment concentration and elevated stream temperature.
- Compared to intact forest to agriculture transitions, conversion of non-intact yet forested land uses (e.g., logged forests) to perennial plantations may impart distinctive outcomes on tropical freshwater stream ecosystems.

Study Sites

- In West Kalimantan, Indonesia, we assessed streams draining watersheds characterized by four land uses: logged forest, mixed agroforest, young (<3 yr) and mature (>10 yr) oil palm plantation.
- In four intensively sampled focal streams, we quantified total suspended solids (TSS, mg L⁻¹) concentration and stream temperature (°C) using high-frequency subsurface sono measurements during month-long intervals between 2009 and 2012.
- Temperature and sediment data were also collected across eight additional catchments with variable elevation, slope, area, and climatic conditions during four one-week periods in 2008 and 2009.
- Focal streams were field mapped and canopy cover was visually estimated at the stream center every ~500 m.
- Regional land use change was quantified by applying image segmentation and nearest-neighbor classification to Carnegie Landsat Analysis System-Lite (CLASlite) fractional cover data derived from a timeseries of Landsat imagery.

Methods

- Land Use | Area (ha) | Elevation (m) | Slope (°)
  - Logged Forest | 1316 | 89 (42-313) | 6.1 (0-30)
  - LOG1 | 1148 | 138 (12-441) | 8.6 (0-31)
  - LOG2 | 1336 | 70 (17-271) | 5.1 (0-32)
  - LOG3 | 1465 | 68 (36-227) | 4.7 (0-28)
  - Agroforest | 2074 | 133 (22-642) | 8.0 (0-33)
  - AgF1 | 2272 | 105 (19-519) | 7.0 (0-31)
  - AgF2 | 2454 | 220 (27-909) | 13 (0-40)
  - AgF3 | 1471 | 77 (19-497) | 5.5 (0-26)
  - Young Oil Palm | 3496 | 54 (21-217) | 3.7 (0-20)
  - YOP1 | 2621 | 103 (19-839) | 2.0 (0-10)
  - YOP2 | 495 | 62 (30-109) | 4.8 (0-16)
  - YOP3 | 7372 | 58 (15-450) | 4.1 (0-34)
  - Mature Oil Palm | 522 | 27 (10-62) | 3.9 (0-14)
  - MOP1 | 1383 | 87 (32-104) | 3.0 (0-15)
  - MOP2 | 561 | 47 (25-95) | 4.8 (0-15)
  - MOP3 | n/a | n/a | n/a

Table 1. Characteristics of 12 sample watersheds, with bold rows indicating means for each land use treatment, and asterisks denoting focal watersheds. Oil palm streams were characterized by lower elevation and slope compared to logged and agroforest streams. OPM3 watershed parameters are unavailable because the area was too flat for characterizing using ArcGIS hydrology tools.

Conclusions

- Temperature in focal oil palm streams was significantly greater (~1°C to >3°C) than in agroforest and logged forest streams.
- Young and mature oil palm streams had the lowest canopy cover (12% and 45%, respectively) compared with 81% cover in the logged forest stream.
- Focal logged forest and agroforest streams had significantly lower TSS concentration than the young oil palm stream.
- Across 12 regional streams, young and mature oil palm land uses generated 2- to 6-fold greater mean TSS concentration than logged forests and agroforest.
- Watersheds with similar area, slope, and elevation to those studied here occupy approximately 23% of Kalimantan’s land area.
- Thus, our findings inform potential hydrologic outcomes of continued expansion of oil palm plantations in Kalimantan.