Vulnerability of carbon pools in tropical peatlands

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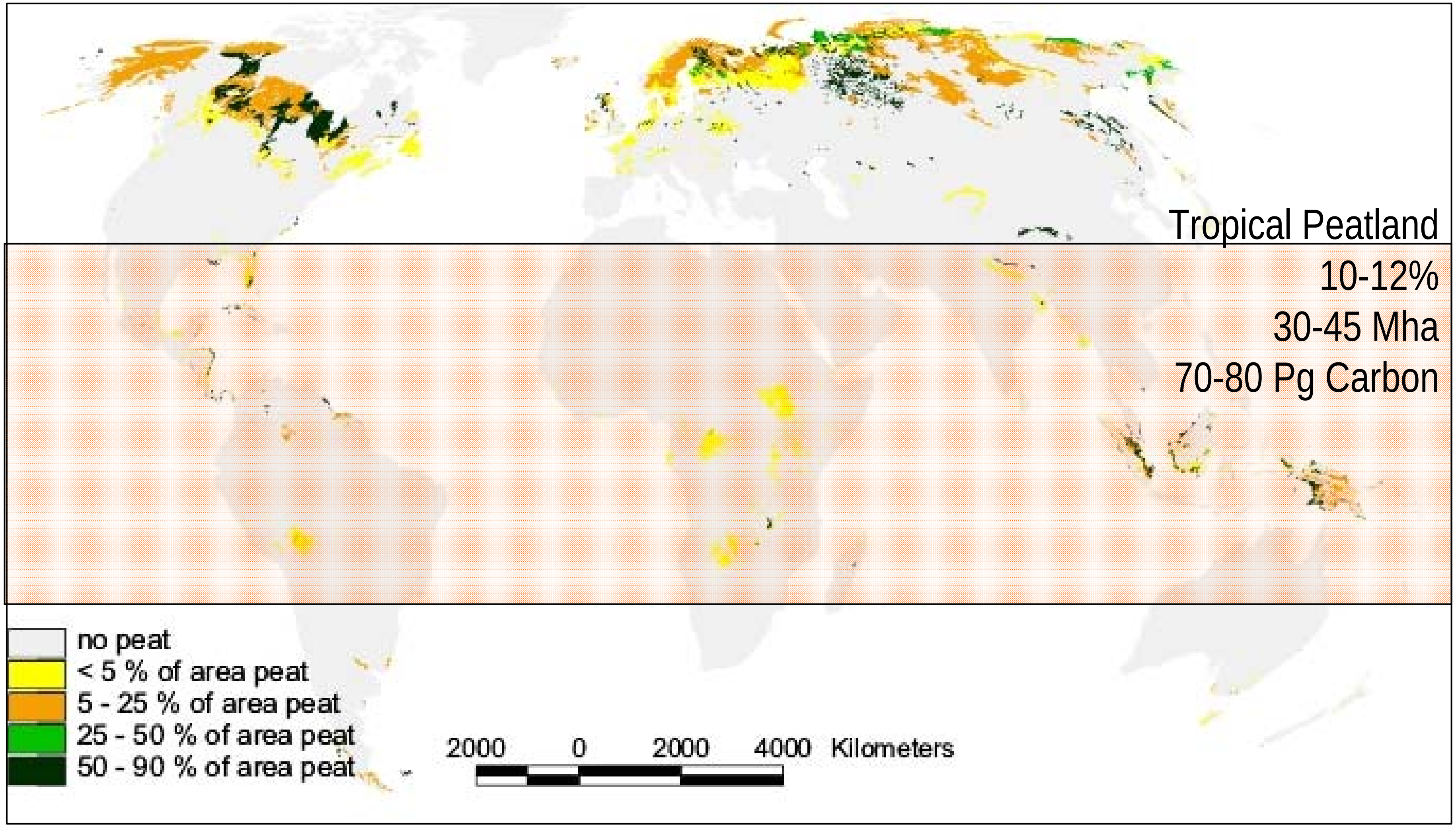
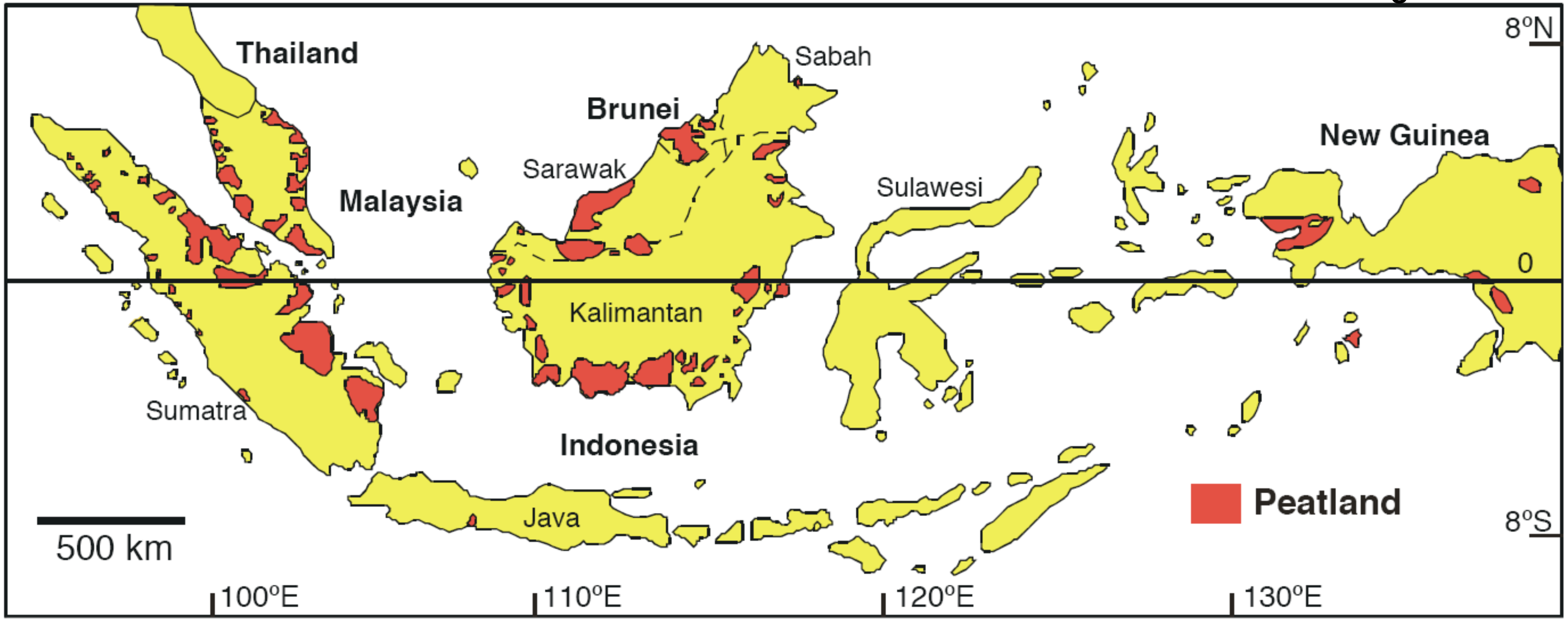
Photos: Kim Serensen

Global Peatland Distribution



Peatland Distribution in Southeast Asia

16-27 Mha in Indonesia
55 Pg Carbon

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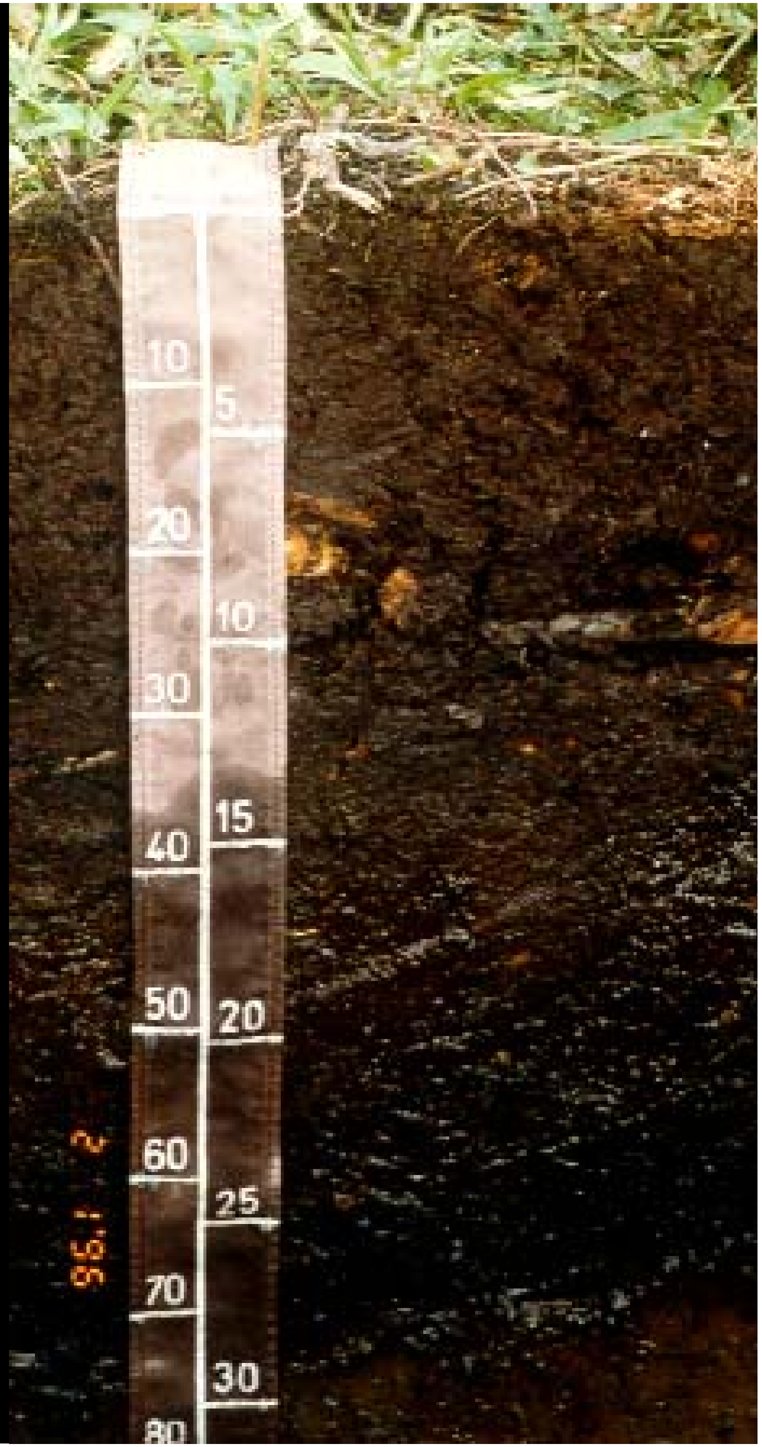


Vulnerability of Tropical Peatlands

Climate System X **Human System**

Climate Variability-El Nino
Climate Change

Land Use Change:
Deforestation, Drainage

(+) (+)

Vulnerable
C Pools

(+)

C
Emissions

(+)

Impacts

Global
(climate change)

Regional
(haze: health, tourism, aviation)

Local
(industry: peat subsidence
local comm.: subsistence)

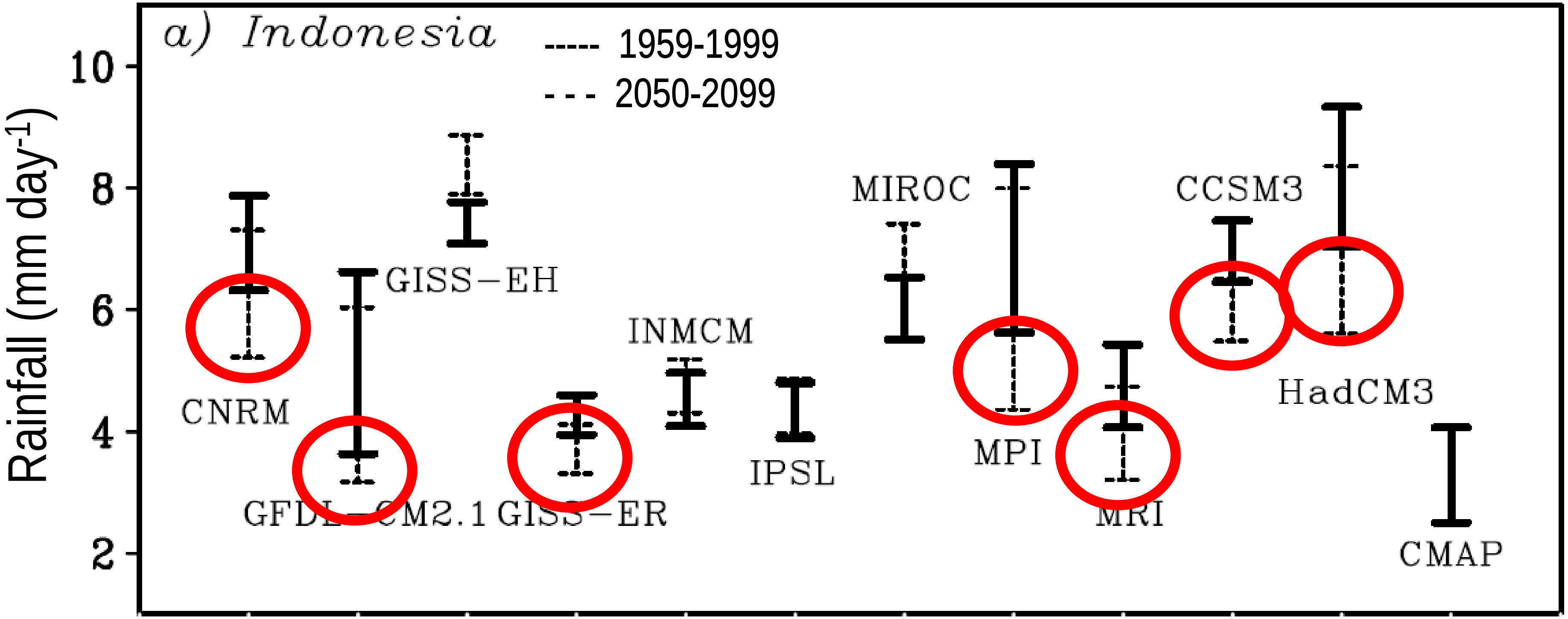
Drivers of Vulnerability

Land Use Change

- Need land for:
  - Growing population and Transmigrasi programs
  - Expansion of oil palm plantations (food, biodiessel)
  - Expansion of pulp for paper industry
- Forest degradation:
  - Unsustainable selective logging
  - Illegal logging
- Depletion of lowland land on mineral soils

Drivers of Vulnerability: Climate Change

Dry Season (JAS) (0°-10°S)



Li et al. 2007

Characteristics of Vulnerability

- Drainage of peat
  - Extensive of large canals
  - Dense network of small canals (eg. illegal logging)
- Extensive use of fire to clear
- Strong interaction between fire x droughts (particularly El Niño, but also Indian Ocean Dipole)

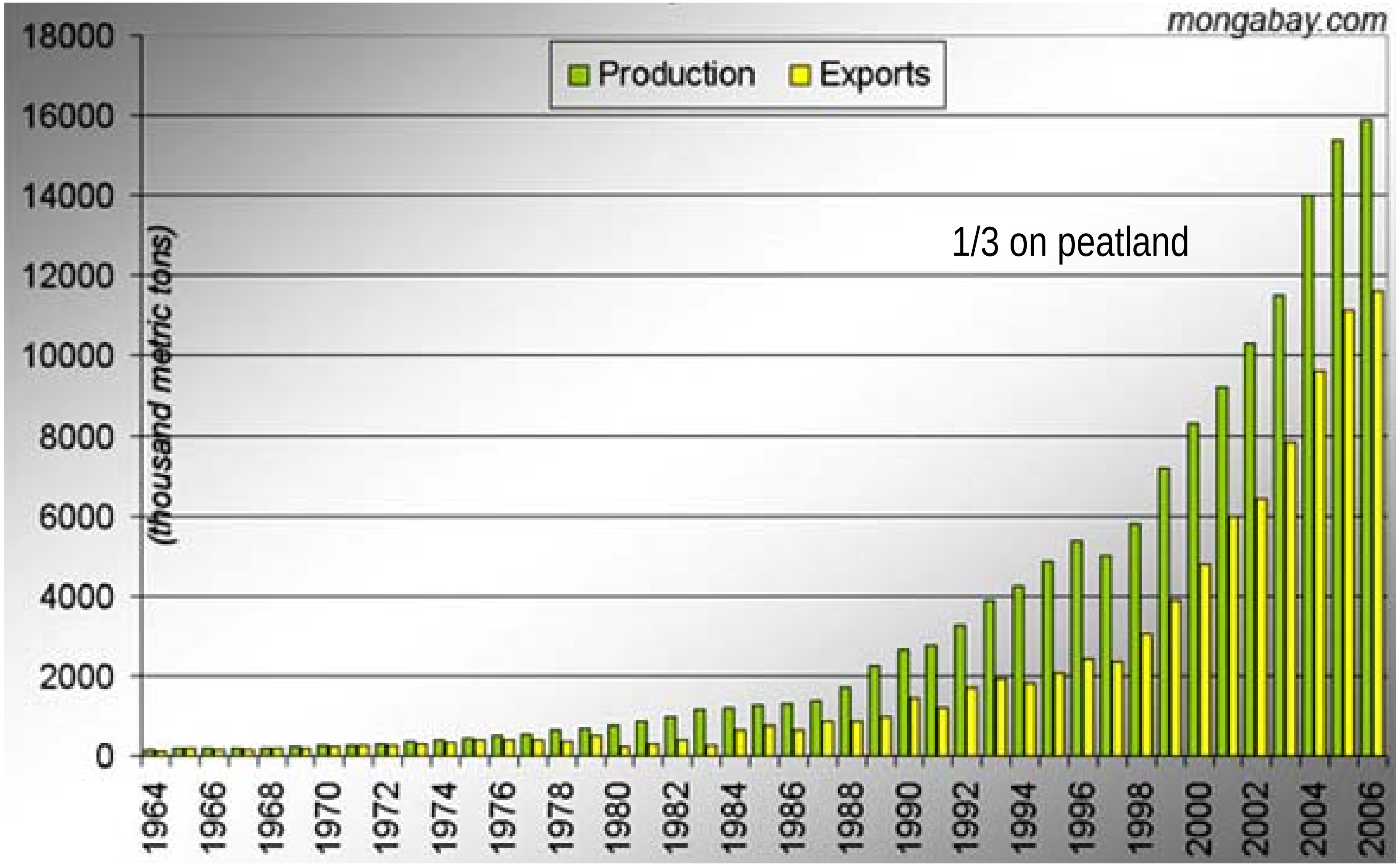
7 Mha drained peat in SE Asia

Illegal logging

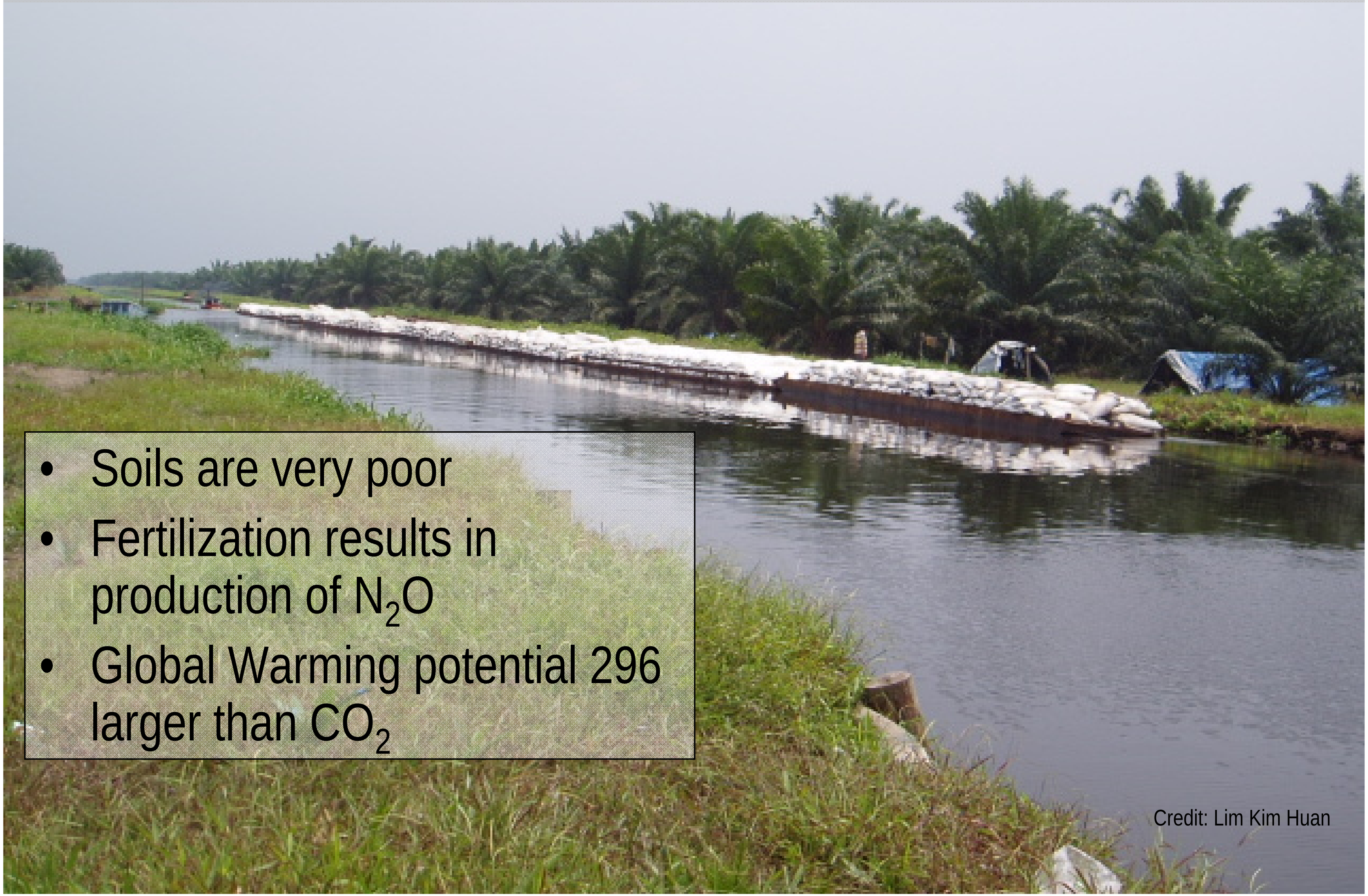
Small farming - Transmigrasi

Oil palm for foods and biodiesel

Palm Oil Production and Exports in Indonesia



Oil palm for foods and biodiesel



- Soils are very poor
- Fertilization results in production of N_2O
- Global Warming potential 296 larger than CO_2

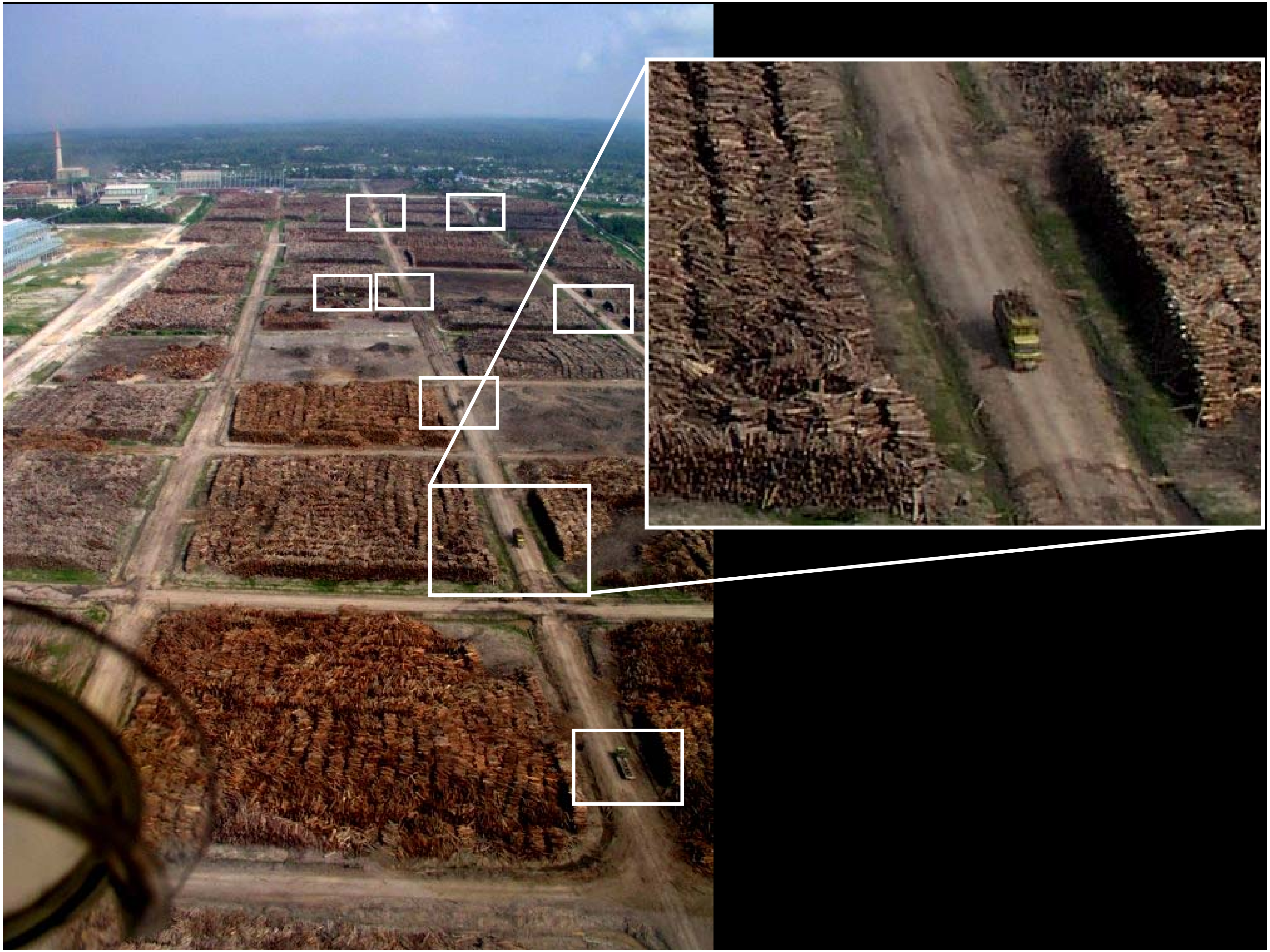
Credit: Lim Kim Huan

Over-logged forest

Credit: Lim Kim Huan

Acacia plantations for pulp wood

Photo: Worm



Net Carbon Balance: Components

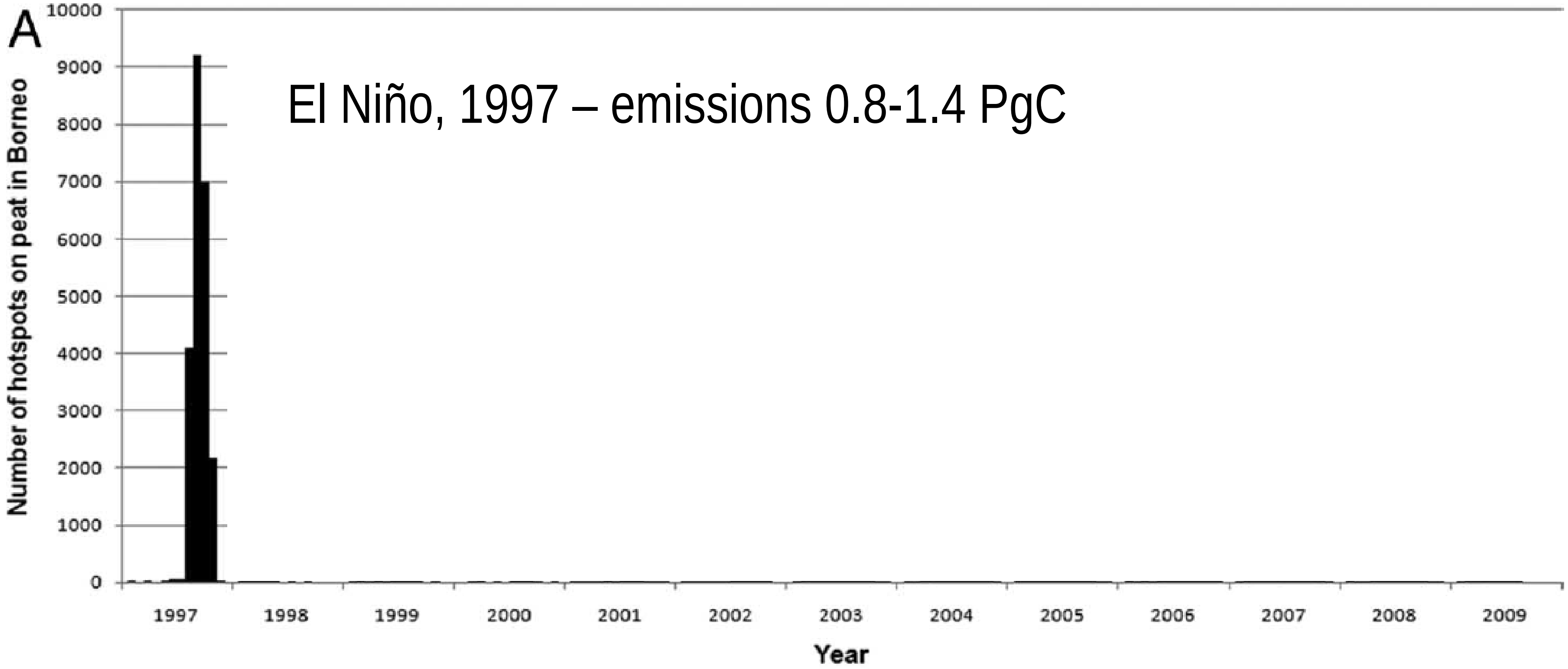
- Sources:
  - Combustion (fire)
    - Biomass loss
    - Peat loss
    - Emissions (eg, emission factors for peat)
  - Oxidation (decomposition, heterotrophic respiration)
    - Emissions due to drainage
  - Lateral removal
    - Losses into canals and rivers
- Sinks:
  - Plant uptake
    - Regrowth or uptake by mature forests

Methodological Approach

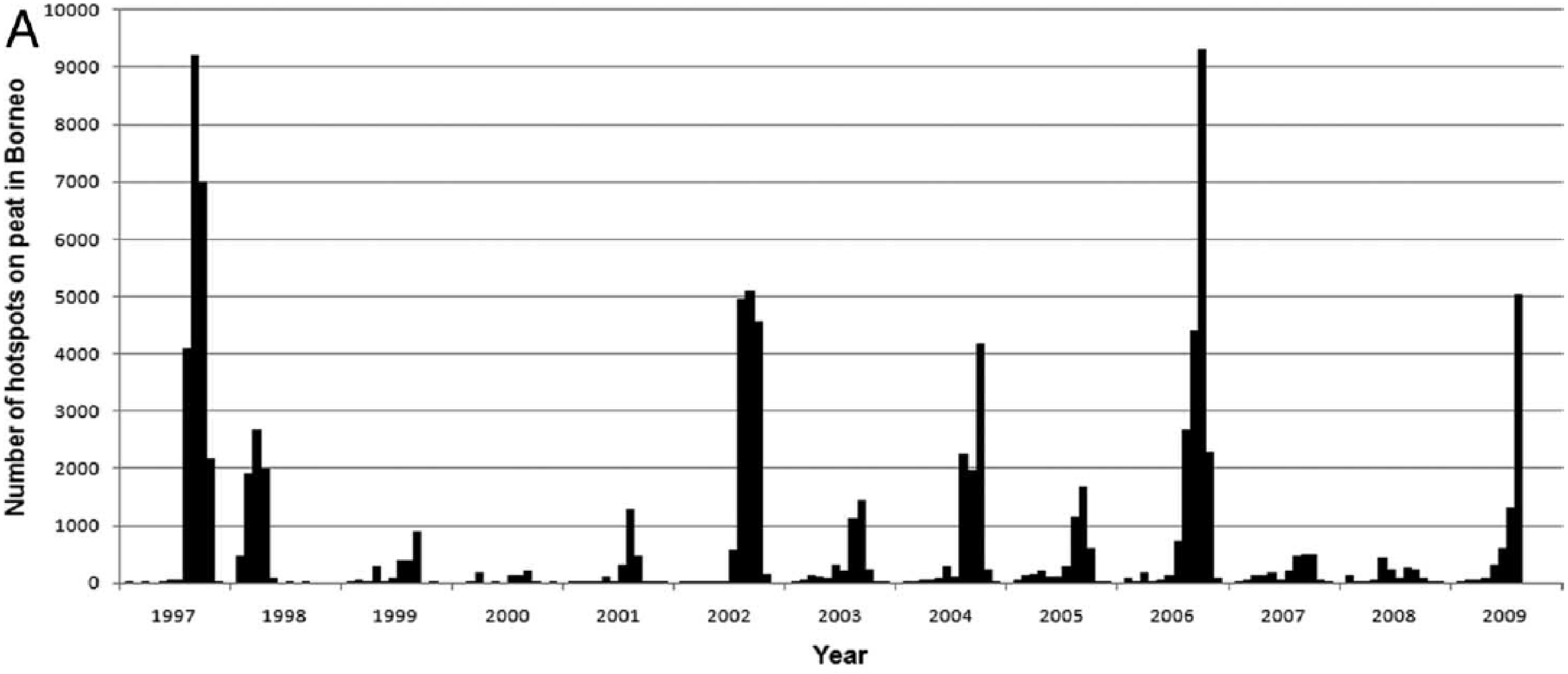
- Emissions from Combustion (fire):
  - Ground monitoring of peat loss (bottom-up) and atmospheric/modeling estimates (top-down).
- Emissions from Oxidation (heter. resp.):
  - To measure peat subsidence and decompose the contributions from compaction versus decomposition

Emissions from Peat Fires

Fire Hotspots on Peat in Borneo

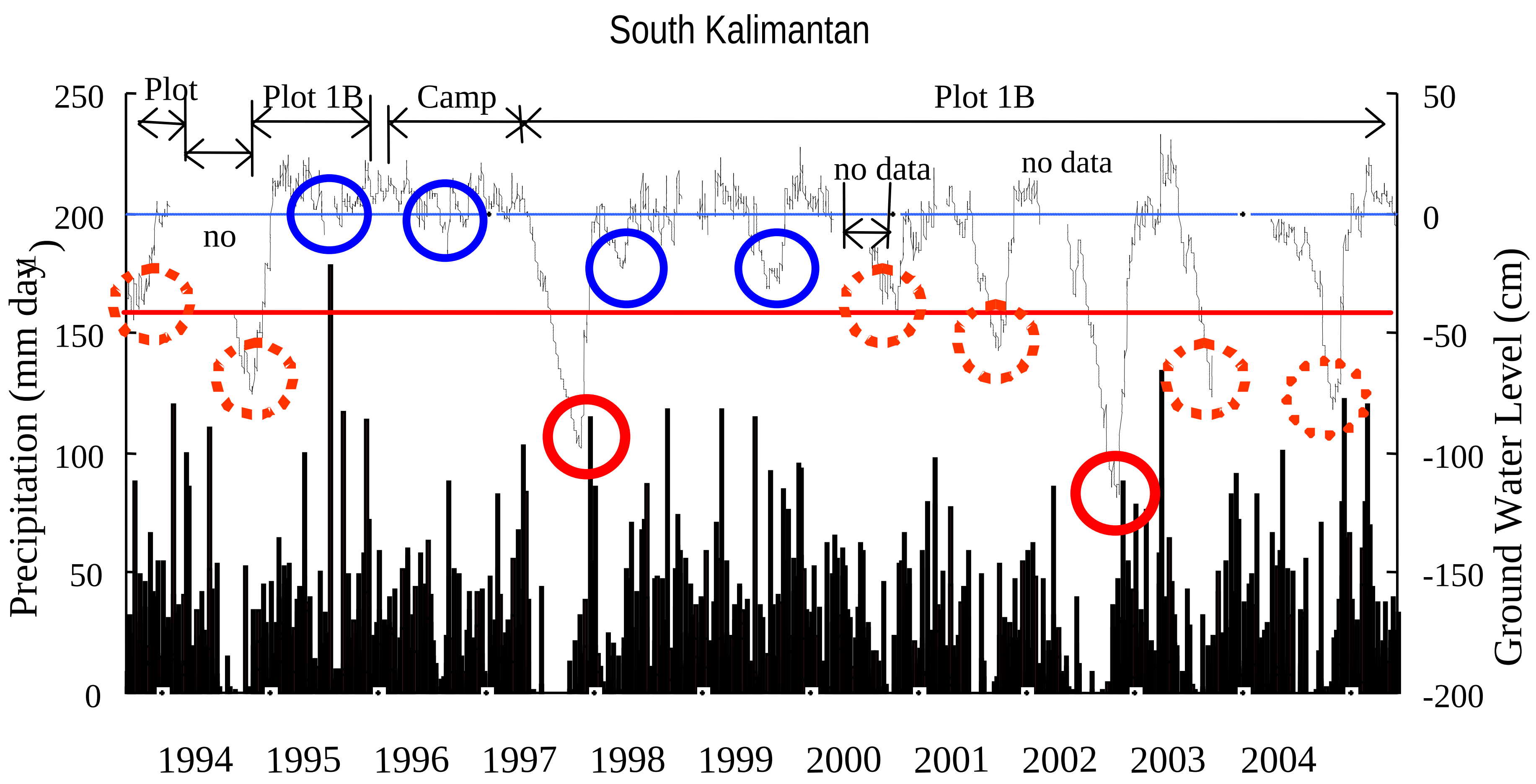


Fire Hotspots on Peat in Borneo



Ballhorn et al. 2009, PNAS, in press

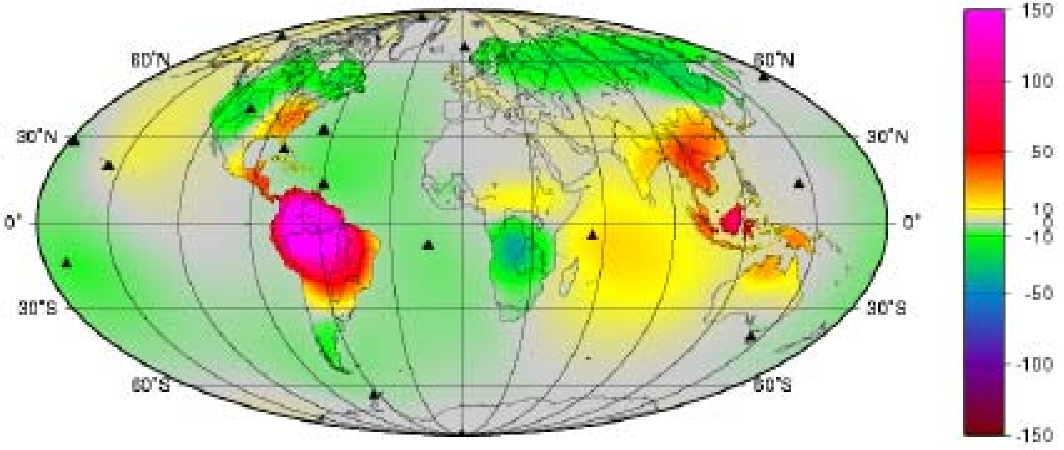
Ground water level modulates the intensity and spread of fires in the tropical peat swamp forest



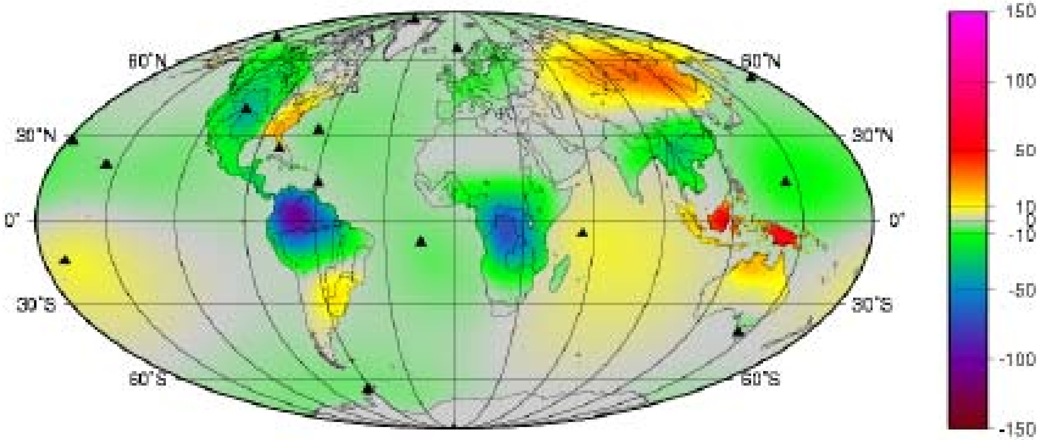
Takahashi, unpublished

Spatial Distribution of the CO_2 Growth Perturbations

Flux Anomalies El Nino (June 1997-May 1998 [gC/m2/yr])



Flux Anomalies La Nina (Oct 1998-Sept 1999 [gC/m2/yr])



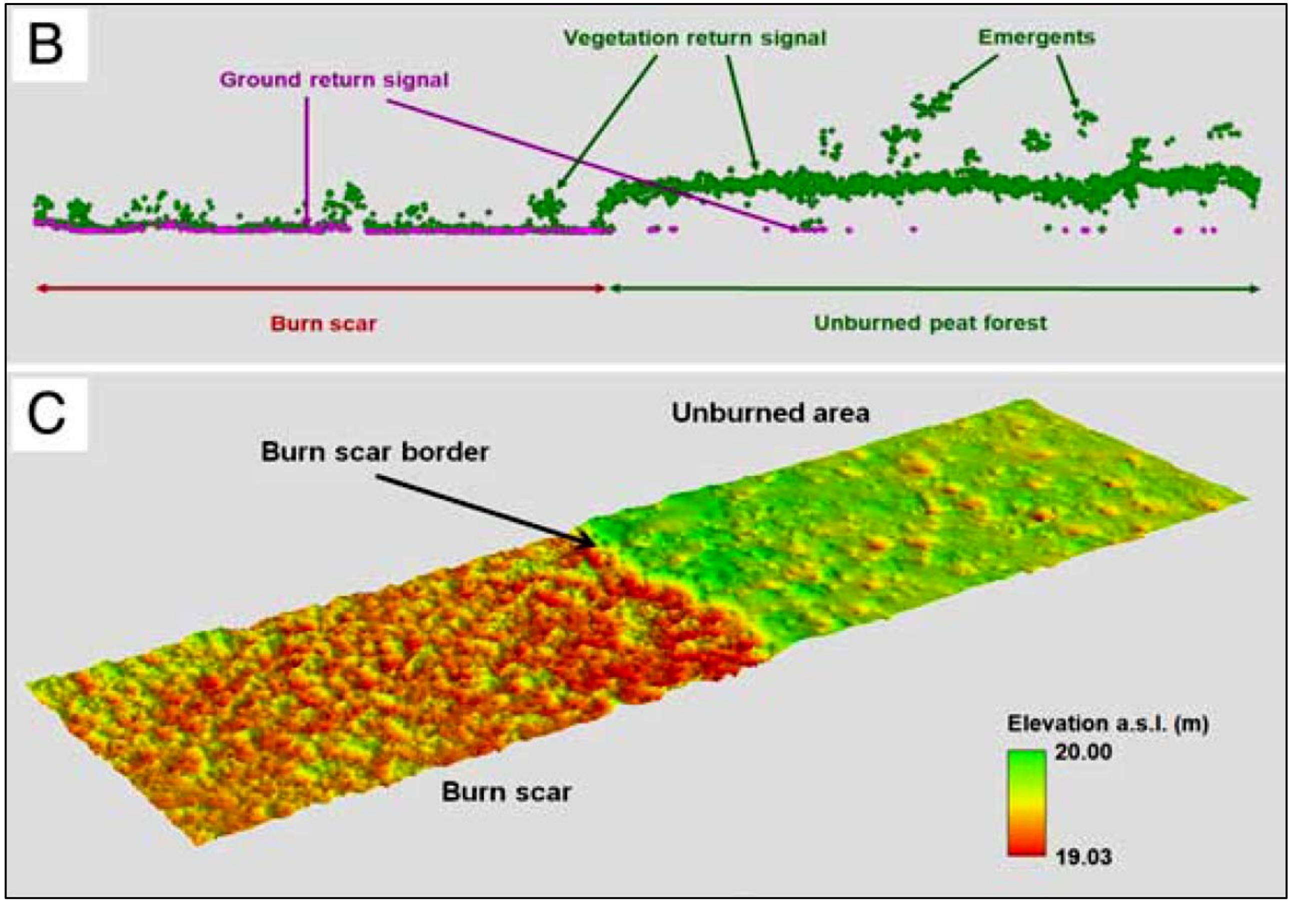
Global Carbon Project

Rodenbeck et al. 2003

Earth System Science Partnership

Loss of peat by fire

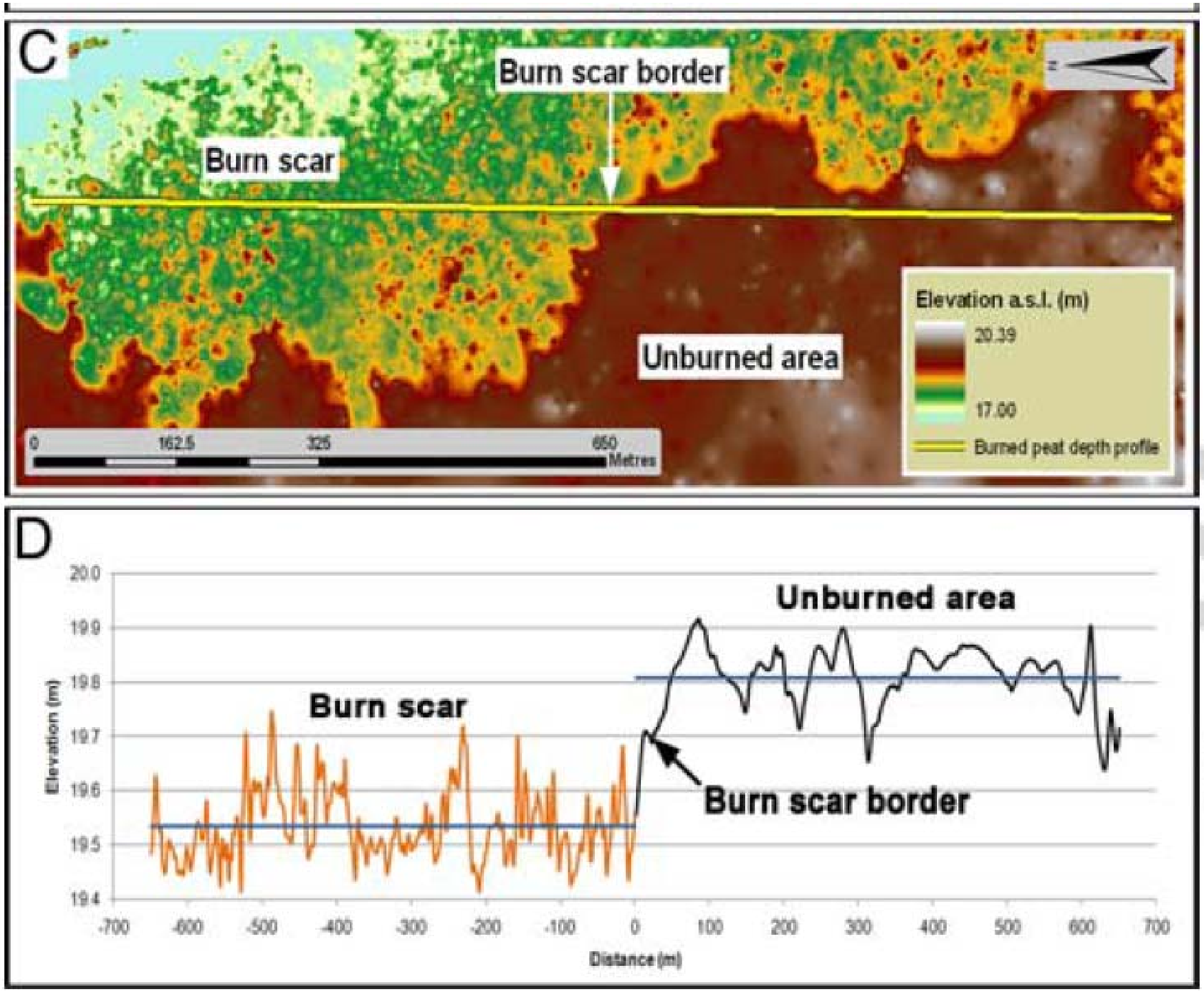
LIDAR: Light Detection and Ranging (laser pulses from aircraft)



- High estimate resolution:
  2-3 cm
- 112 returns in unburned per ha
- 1200 returns in burned areas per ha

Ballhorn et al. 2009, PNAS, in press

Loss of peat after fire



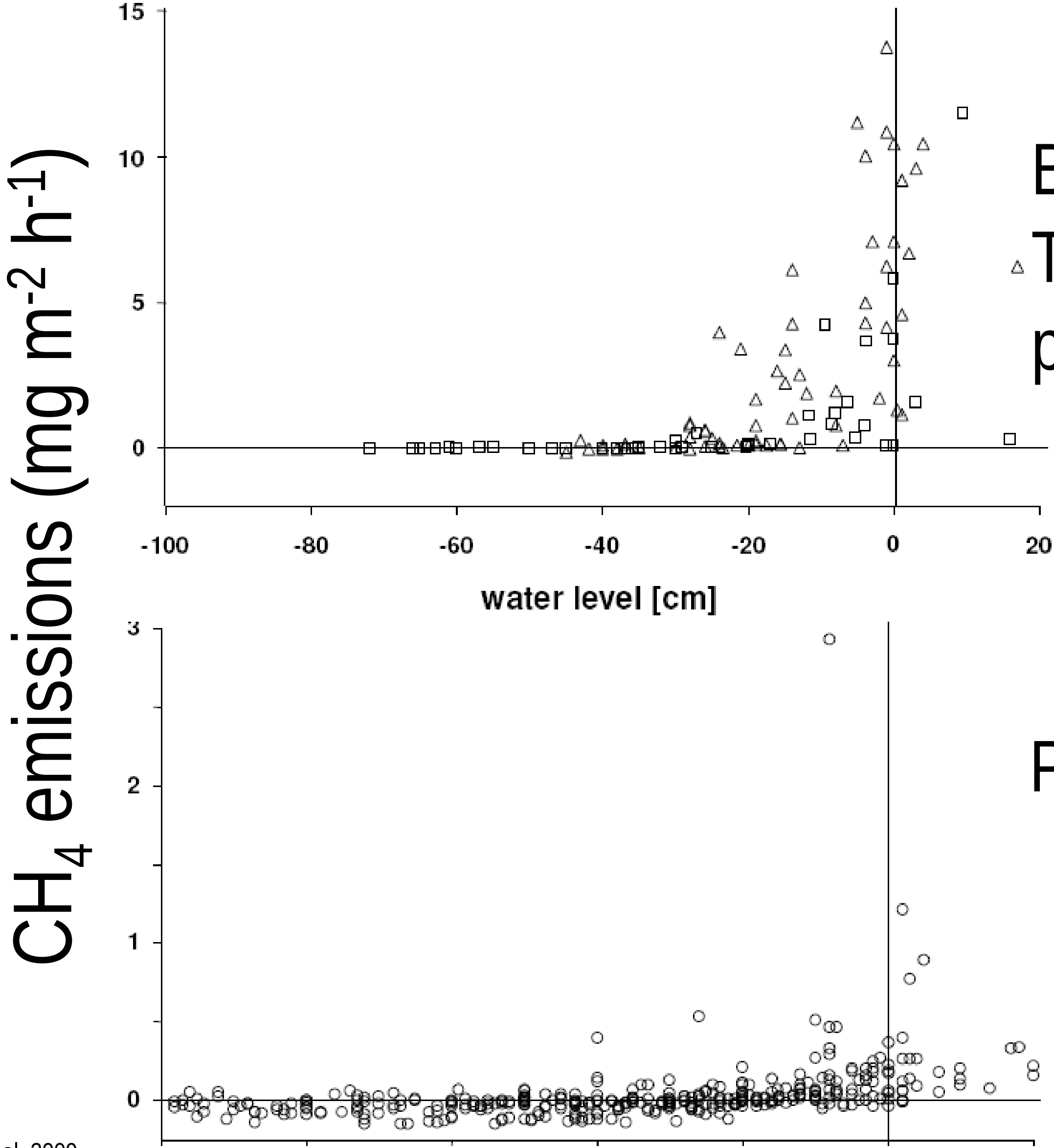
- 256,273 ha burned in 2006
- > 2,000 ha of transects
- Average fire scar depth: 33 cm
- Burned area x 0.33 m x bulk density x 58% carbon = carbon lost (49±25MtC)

Indonesia wide (2006) - peat lost to fire: 0.4 PgC y^{-1}

Ballhorn et al. 2009, PNAS, in press

Emissions from Peat Decomposition

CH_4 Emissions and water water levels

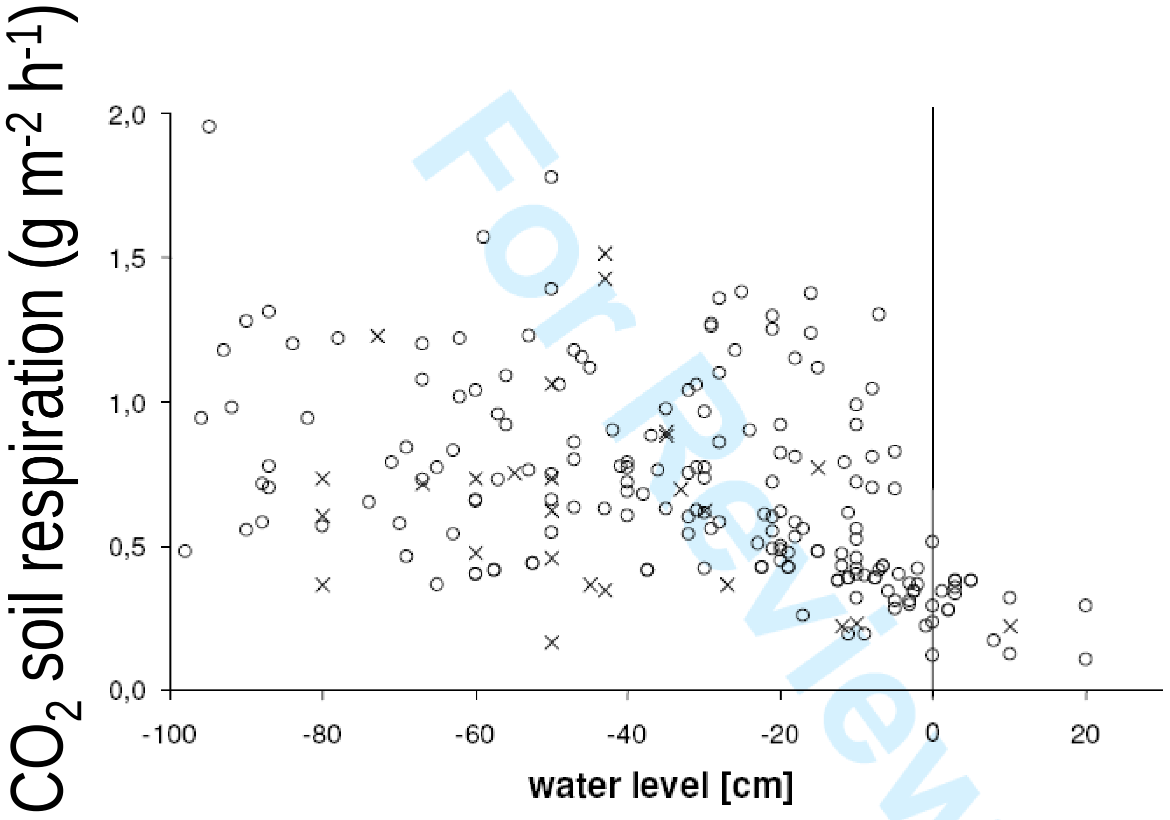


Boreal and Temperate peat

Peat swamp

Cowenberg et al. 2009

CO_2 Soil Respiration and water table level



Cowenberg et al. 2009, in press

Subsidence and GHG emissions

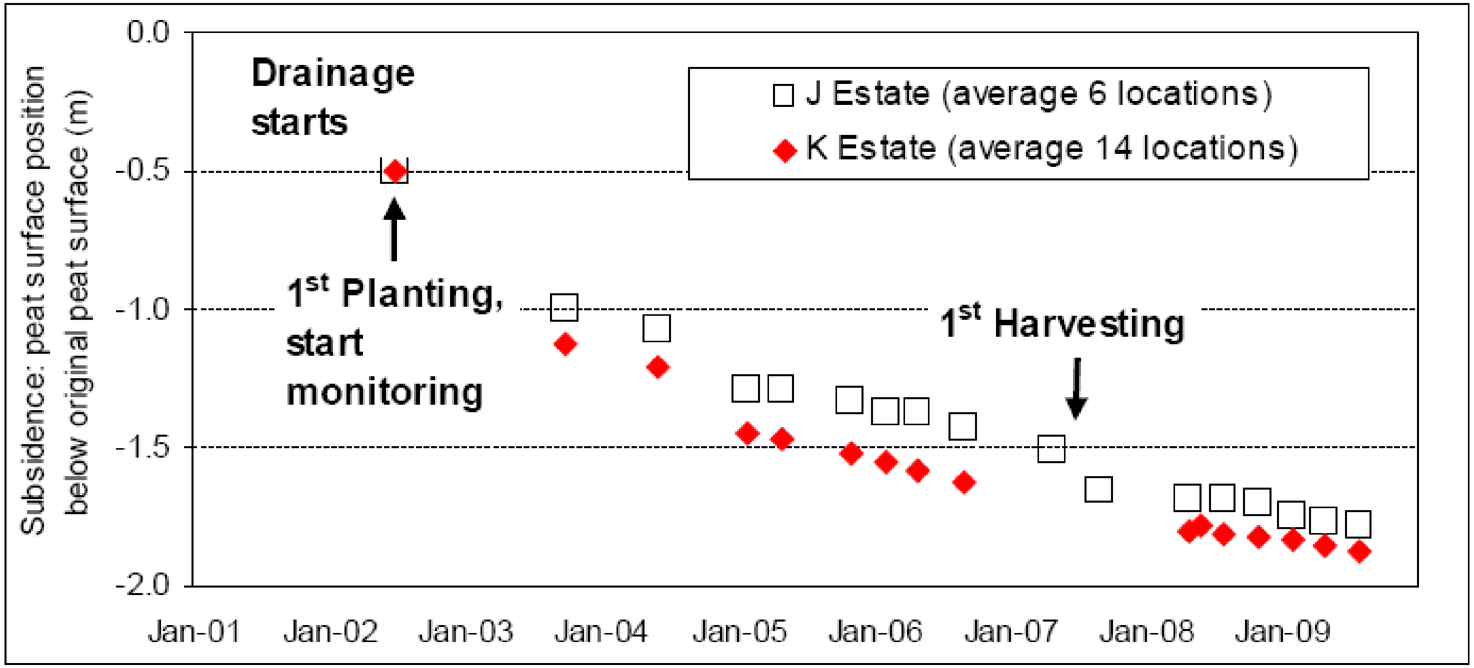
Photo: Jyrki J, Johor Bahru, Malaysia

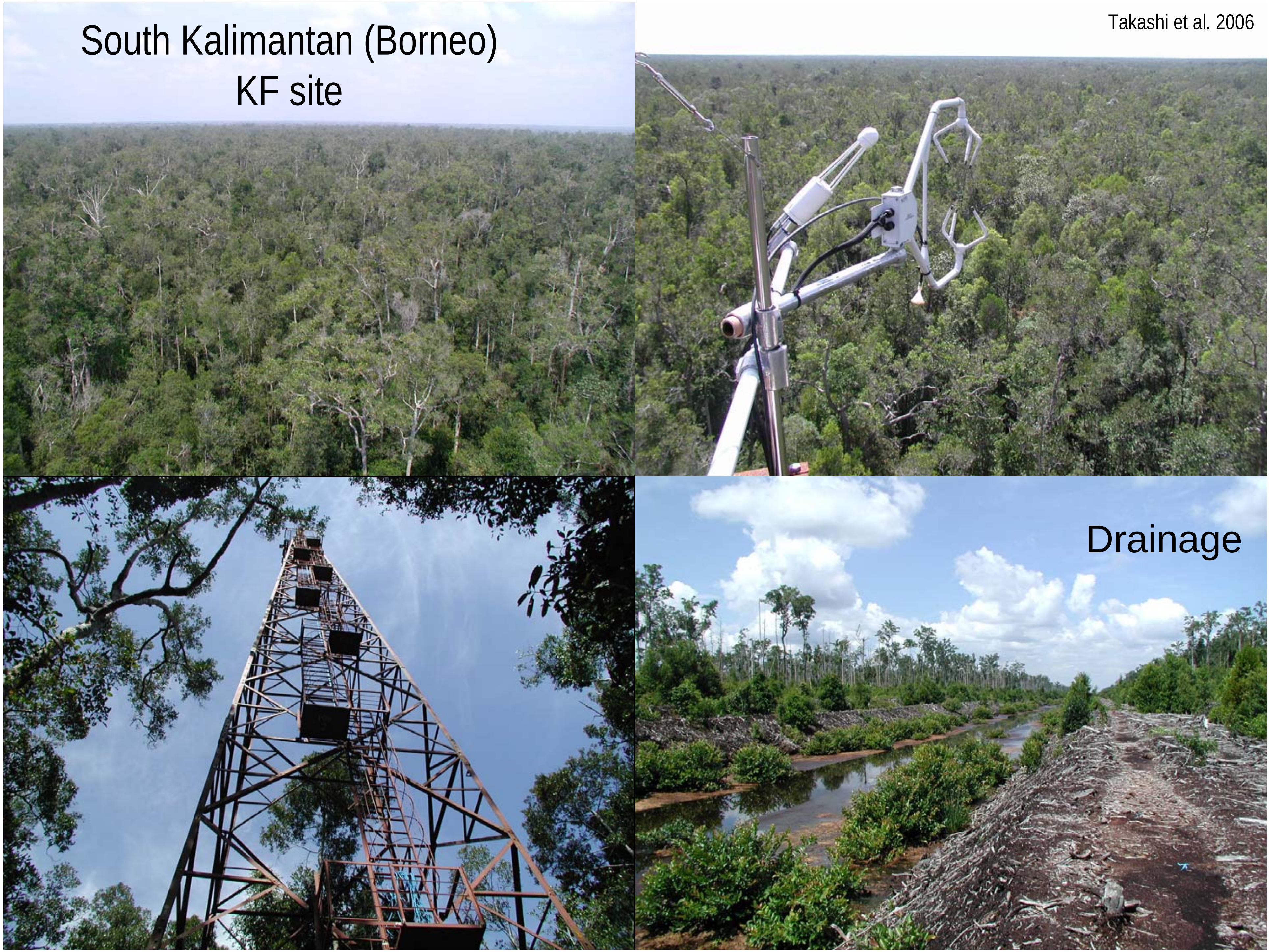
Subsidence as a surrogate for GHG emissions

- **Consolidation**: the compression of saturated peat (compaction1).
- **Shrinkage**: volume reduction due to lost of water from pores (compaction2).
- **Oxidation**: gradual volume reduction due to decomposition of organic matter.
- **Fire**: fast or rare lost of organic matter by burning.

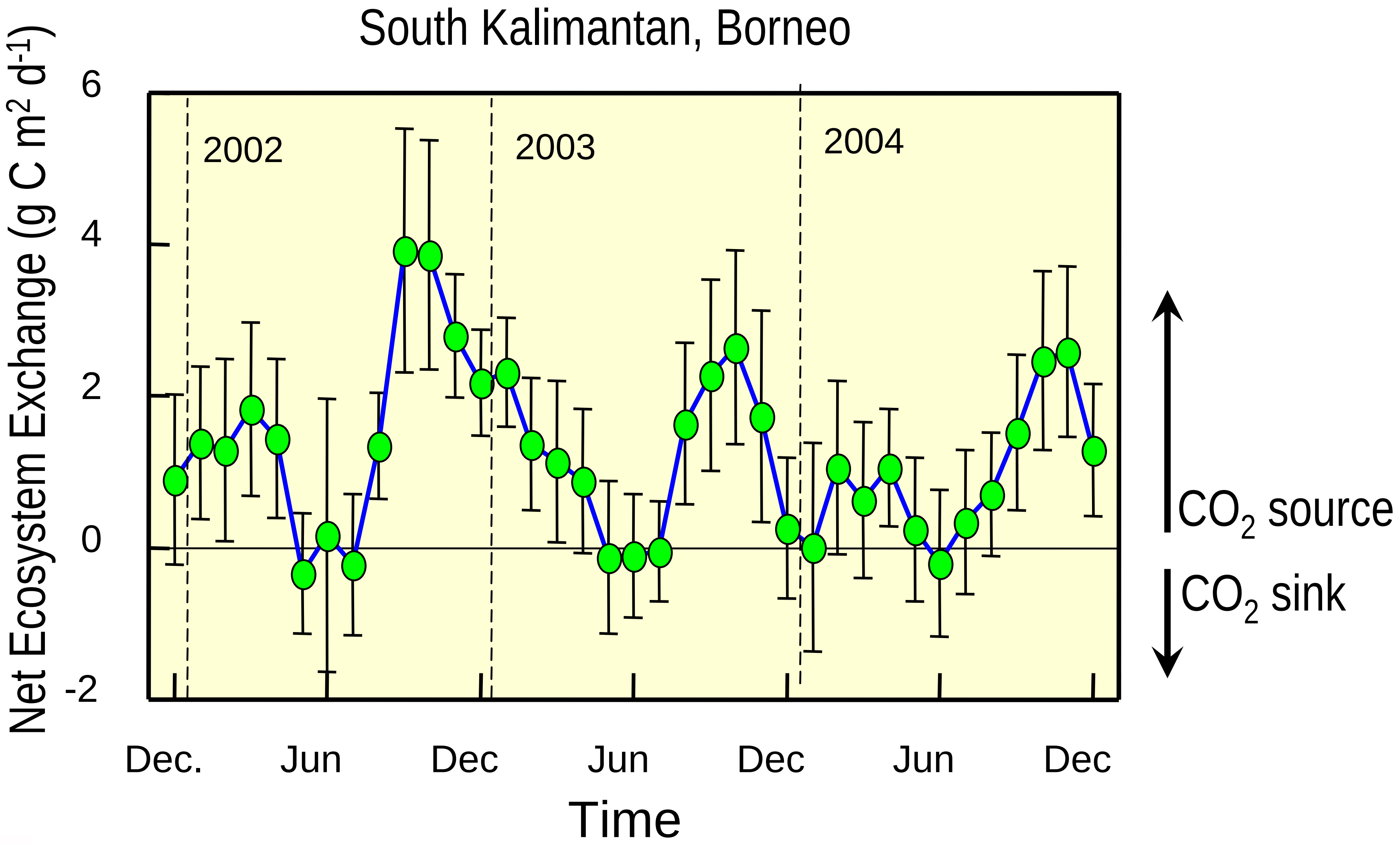
Compaction versus Respiration

60% compaction 40% respiration (average multi-decade)




South Kalimantan (Borneo)
KF site
Takashi et al. 2006
Drainage

Drained swamped forest: Net Carbon Balance



Takashi et al. 2006

Global Carbon Project

Earth System Science Partnership
GLOBAL CHANGE
IHDP
WCRP

Emissions from Combustion + Oxidation

- Peat fires: 0.25±0.14 PgC

  (Indonesia 2006, Ballhorn et al. 2009, PNAS)

- Peat+Biomass fires: 0.3 Pg C

  SE Asia, year average for 1997-2008; (0.8-2.5 Pg C, 1997)

  van der Werf et al. 2006, updated)

- Peat decomposition: 0.17±0.8PgC

  (2006 SE Asia, Hooijer et al. 2009, Biogeosciences)

Emissions from Peat Combustion + Oxidation

- Peat Combustion + Oxidation emissions
  - El Niño-year: 0.4 PgC y^{-1}
  - Long-term average: 0.2-0.3 PgC y^{-1}

- Global LUC emissions
  - 1990-2005: 1.5±0.7 Pg C y^{-1}
  - 2008: 1.2±0.6 Pg C y^{-1}

Vulnerability of Tropical Peatlands

Climate System x **Human System**

Climate Variability-El Nino
Climate Change

Land Use Change:
Deforestation, Drainage

(+) (+) (-)

Vulnerable C Pools

(+) (-)

C Emissions

(+) (-)

Impacts

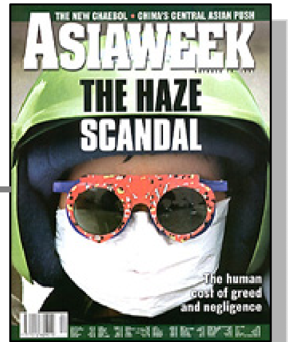
Global
(climate change)

Regional
(haze: health, tourism, aviation)

Local
(industry: peat subsidence
local comm.: subsistence)

Regional Sustainable Development

Mitigation
Adaptation
(REDD)



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