Tropical peatlands: Location & extent

- Tropical peatlands ~12% global area
- Approx. 70% (~26 M ha) occurs in SE Asia, mainly in Indonesia
- Natural vegetation: peat swamp forest

**Map**

- Sumatra 8 M ha
- Kalimantan 7 M ha
- West Papua 4 M ha
Tropical peat: Characteristics

- Tropical peat is formed from forest vegetation
- High wood content
- C content ~60%
- Peat thickness often exceeds 8 m (→ 20 m)
- Cover vast areas of coastal lowlands
Tropical peatlands & the carbon cycle

- **C storage:**
  - Above-ground: ~150 - 250 t C ha\(^{-1}\)
  - Below-ground: ~250 - >10,000 t C ha\(^{-1}\)

Current C store in tropical peatlands: 40 – 70+? Gt C
- Between ~8-13% global peatland carbon pool (528 Gt C, Gorham 1991)
- Up to 3% global soil carbon pool (2500 Gt C, Lal 2004)

Current *potential* annual C sequestration: ~35 Mt yr\(^{-1}\)**
- Equivalent to ~ 50% of that for all subarctic, boreal & temperate peatlands (66 Mt (Tg) yr\(^{-1}\), Turunen et al. 2002)
- BUT this is potential rather than actual carbon storage
- Carbon sequestration function restricted by deforestation, drainage, agricultural conversion and fire.

** Assumes current carbon accumulation rate of 85 g C m\(^{-2}\) yr\(^{-1}\) (Page et al, 2004) and peatland extent of 42 M ha
Tropical peatlands: from carbon sink to source

DRIVING FORCES

Logging (legal/illega)
Deforestation
Drainage
Plantation and agricultural enterprises
Poor forest and land management
Fire!

<<ENSO>>
Driving forces: Deforestation

Peat swamp forests: Deforestation rate 2.4% yr$^{-1}$
Driving forces: Land conversion & drainage

Large-scale agricultural and plantation projects

~ 7 million hectares of peatland: deforested and drained

Kalimantan Mega Rice Project

Riau pulp wood plantations
Driving forces: Fire


- An annual event?

Annual fire hotspot data for Borneo 1997 to 2006
*(Langner & Siegert, unpublished)*

---

*Langner & Siegert, unpublished*
Driving forces: Fire

2006 fire hotspot data superimposed on distribution of peat
(Langner & Siegert, unpublished)
C emissions from Indonesian peatland fires during 1997/98:

- Range 0.81 – 2.57 Gt C (Page et al. 2002)
  - Accounting for 55-95% of C emissions from all fires during that period in SE Asia (Schimel & Baker 2002; van der Werf et al. 2004, 2006).
- Equivalent to **18 to 57 years** of successful Kyoto implementation.

Drainage clearly increases risk of fire. In study area:

51% of drained peatland burnt compared with 19% of the undrained peatland.
Tropical peatlands and fire

- Emissions caused by fires remain a large uncertainty in projections of C emissions from tropical peatlands.

- Problems of estimating emissions from hot-spots:
  - insufficient testing of relationship between hot spots and peat fire occurrence and severity; peat fires smoulder – are they detected?
  - problems of mapping hot spots onto peatland areas;
  - different fuel loads/emission factors for peat vs non-peat fires.

- Need detailed field assessments to confirm:
  - accuracy of burnt area estimates;
  - relationship between hot spots and fire occurrence / severity;
  - relationship between drainage depth, soil moisture and burn depth;
  - accurate values for $2^0$ vegetation biomass combustion;
  - impact of post-fire conditions on fire risk / return period.
Tropical peatlands and fire: Study focus

Focus on Block C
450,000 ha

Former Mega Rice Project area
~1,000,000 ha
• Mainly peatland
• Carbon store c. 1-2 Gt
• 1995-97 attempted agricultural conversion & extensive drainage
LAND COVER CHANGE
1973-2003

Landsat MSS
Landsat TM
Landsat ETM
Aster/TERRA
DMC (Disaster Monitoring Constellation)
### Land cover change

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed peat swamp forest</td>
<td>56.5</td>
<td>48.6</td>
<td>41.1</td>
<td>40.0</td>
<td>16.0</td>
<td>12.8</td>
</tr>
<tr>
<td>Low pole peat swamp forest</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>3.1</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total peat swamp forest</strong></td>
<td>59.6</td>
<td>51.7</td>
<td>44.2</td>
<td>43.2</td>
<td>16.7</td>
<td>13.1</td>
</tr>
<tr>
<td><strong>Loss rate in relation to initial 1973</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heath forest</td>
<td>2.1</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>3.2</td>
<td>N/A</td>
</tr>
<tr>
<td>Freshwater swamp forest</td>
<td>8.7</td>
<td>8.4</td>
<td>7.9</td>
<td>7.8</td>
<td>6.0</td>
<td>N/A</td>
</tr>
<tr>
<td>Mangrove forest</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Total forest cover</strong></td>
<td>72.5</td>
<td>65.6</td>
<td>57.6</td>
<td>57.3</td>
<td>27.9</td>
<td>N/A</td>
</tr>
</tbody>
</table>
## Fire history

<table>
<thead>
<tr>
<th>Time period</th>
<th>El Niño events</th>
<th>Area of fire scars (ha)</th>
<th>% of block</th>
</tr>
</thead>
<tbody>
<tr>
<td>before 1973</td>
<td>1972/73</td>
<td>31,109</td>
<td>6.9</td>
</tr>
<tr>
<td>1974-1990</td>
<td>1982/83</td>
<td>35,605</td>
<td>7.9</td>
</tr>
<tr>
<td>1991/92</td>
<td>1991/92</td>
<td>33,586</td>
<td>7.5</td>
</tr>
<tr>
<td>1994-1996</td>
<td></td>
<td>4,629</td>
<td>1.0</td>
</tr>
<tr>
<td>1997</td>
<td>1997/98</td>
<td>150,486</td>
<td>33.5</td>
</tr>
<tr>
<td>2002</td>
<td>2002/03</td>
<td>106,481</td>
<td>23.7</td>
</tr>
<tr>
<td>2003/04</td>
<td></td>
<td>64,180</td>
<td>14.3</td>
</tr>
<tr>
<td>2005</td>
<td></td>
<td>55,768</td>
<td>12.4</td>
</tr>
<tr>
<td>2006</td>
<td>2006</td>
<td>?</td>
<td>?</td>
</tr>
</tbody>
</table>

**TPSF** | **non-forest**
---|---
84.4 | 5.2
68.3 | 31.7

**Dry season 2006**

http://maps.geog.umd.edu/maps.asp
Repeat fires promote growth of secondary vegetation dominated by ferns → dry fuel load and increased risk of fire.
Hydrology and fire risk

Annual variation in ground water levels
(Wosten, Clymans, Page in press)

Wet year
(1999) 2%
< -40 cm

Average year
(2003) 18%

Dry year (1997)
40%

Groundwater level < -40 cm ⇒ high risk of fire

Block C
Estimating C losses from peatland fires:
Block C MRP : 1973-2005
(450,000 ha)

<table>
<thead>
<tr>
<th>Year</th>
<th>Area burnt peatland (ha)</th>
<th>C loss (Mt)**</th>
<th>Cumulative C loss (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>before 1973</td>
<td>31,109</td>
<td>7.09</td>
<td>7.09</td>
</tr>
<tr>
<td>1974-1990</td>
<td>35,605</td>
<td>8.12</td>
<td>15.21</td>
</tr>
<tr>
<td>1991-96</td>
<td>38,215</td>
<td>8.71</td>
<td>23.92</td>
</tr>
<tr>
<td>1997</td>
<td>150,486</td>
<td>34.31</td>
<td>58.23</td>
</tr>
<tr>
<td>2002</td>
<td>106,481</td>
<td>24.28</td>
<td>82.51</td>
</tr>
<tr>
<td>2003-04</td>
<td>64,180</td>
<td>14.63</td>
<td>97.14</td>
</tr>
<tr>
<td>2005</td>
<td>55,768</td>
<td>12.72</td>
<td>110</td>
</tr>
<tr>
<td>2006</td>
<td>??</td>
<td>20 ??</td>
<td>130 ??</td>
</tr>
</tbody>
</table>

** based on combustion of 0.40 m peat, with bulk density 0.1 g cm\(^{-3}\) & C content 57% (excludes C lost in combustion of above-ground biomass)
Conclusions

- Peatland fires will likely increase as more damaged, less fire-resistant vegetation covers the landscape & peatland drainage continues.
- Some fires are the unintended consequence of current land-use practices (….. although many are intended so can be controlled?).
- Peatland fires are currently main source of biomass combustion emissions in SE Asia.
- Peat fire emissions currently exceed those from slower peat decomposition.
- BUT this does not mean the problem can be solved by “fire fighting”.
- Peatland fires are promoted by deforestation and forest degradation linked to peatland drainage.
- They can only be stopped if these root causes are dealt with.
- **Stopping peat fires but not peatland drainage merely means it will take a longer time for the carbon to be released to the atmosphere !!**
- Longer term consequences for & of climate change ???
Dr. Sue Page: Department of Geography

She is a carbon loss fighter...

Thank you!
Thank you!
Tropical peatlands & the carbon cycle: from sink to source

Current (2005):
355-874 Mt CO₂ yr⁻¹
(100–240 Mt C yr⁻¹)

Projected (2015-2035):
557-981 Mt CO₂ yr⁻¹
(150–270 Mt C yr⁻¹)

Modelling C emissions from tropical peatland drainage – fire emissions NOT included
Current global emissions from fossil fuels ~ 25,000 Mt CO₂ yr⁻¹
(in comparison, tropical peat drainage emissions equivalent to 1.4-3.5% of fossil fuel emissions)
Estimating C emissions from tropical peatland fires: landscape-scale approach

- Block C peat fire emissions: 9.6 Mt C yr\(^{-1}\) (average annual emission 1997-2005)

- Block C peat drainage emissions (based on 0.25 t C ha\(^{-1}\) yr\(^{-1}\) emission per cm drainage depth (Hooijer et al. 2006; peatland area 337,632 ha)):
  - Drainage depth 0.50 m: 4.22 Mt C yr\(^{-1}\)
  - Drainage depth 1.00 m: 8.44 Mt C yr\(^{-1}\)

- Total emissions for Block C 1997-2005:
  - Fires: 86 Mt + Drainage: 38-76 Mt = 124-162 Mt C