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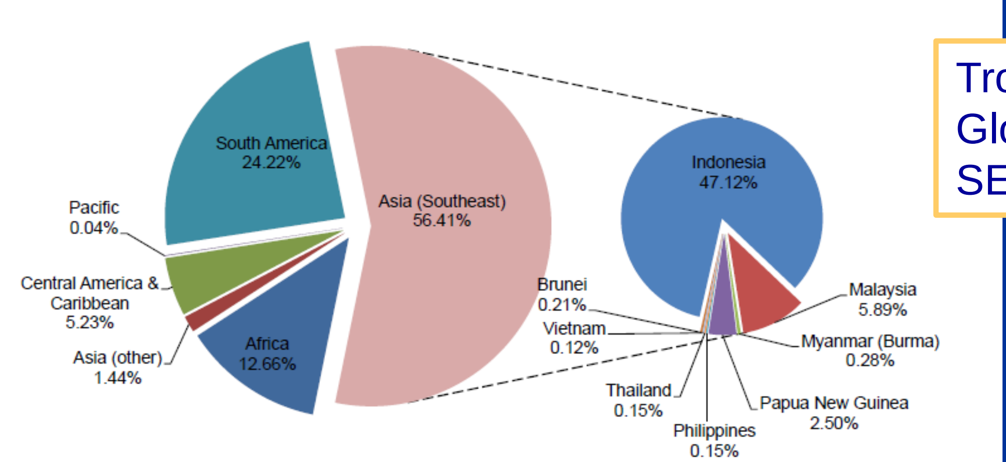
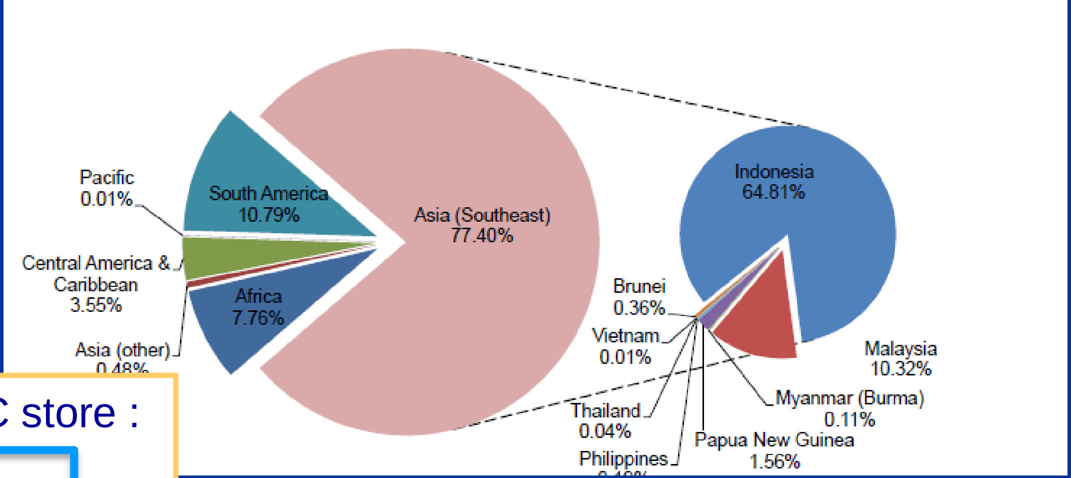
Tropical peatland research

Tropical Peatlands : Where are they?



Tropical peatland area :
Global ~ 439,000 km^2
SE Asia ~ 248,000 km^2



Tropical peatland C store :
Global ~ 89 Gt
SE Asia ~ 69 Gt

Equivalent to:
3.5% global vegetation & soil carbon pool
15-19% global peatland carbon store

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Page et al. (2011) Global Change Biology

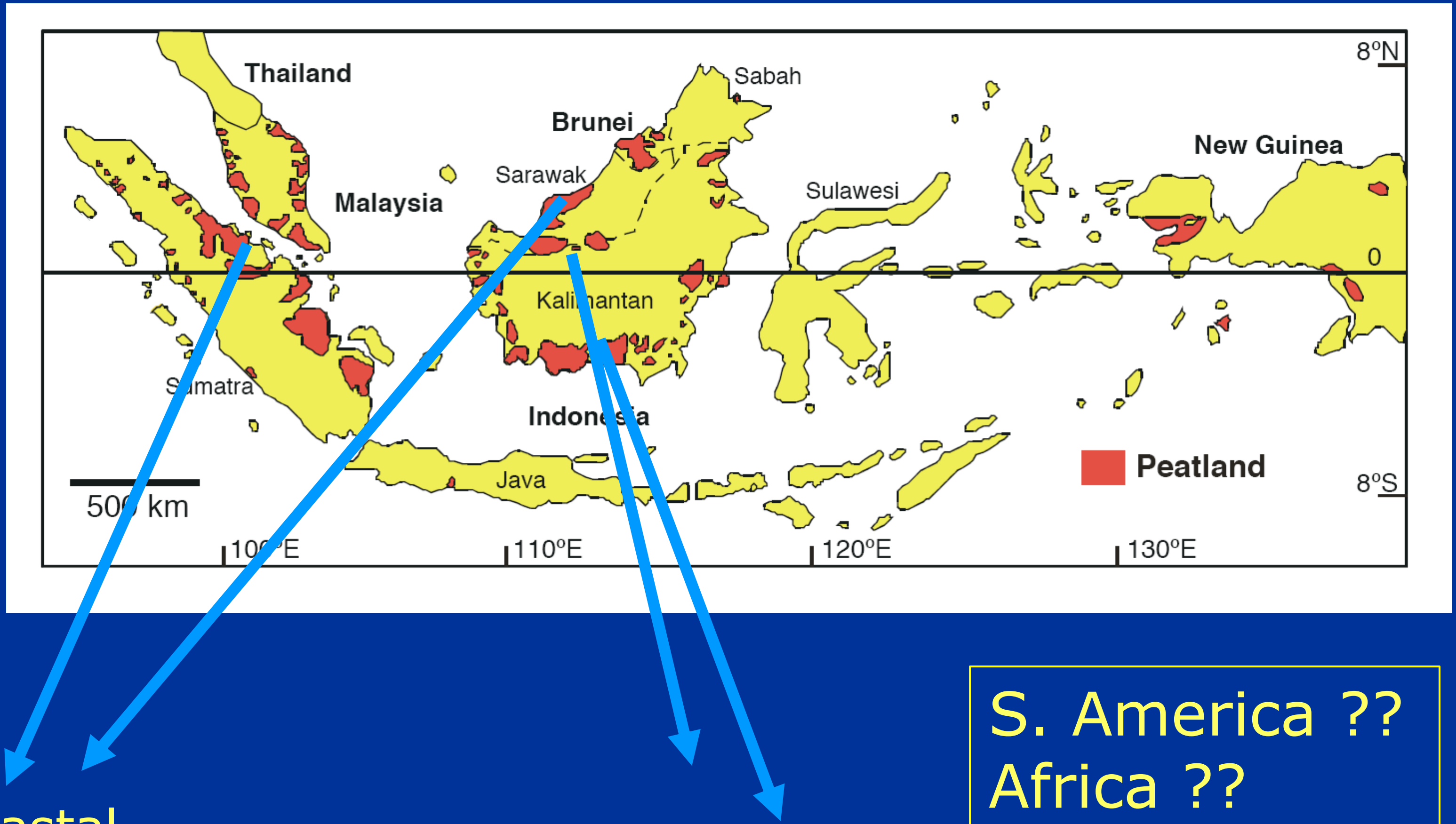
SE Asia

Tropical Peatlands

Amazonia

Africa?

Tropical peatlands & the carbon cycle: Quaternary perspective



Coastal
peatlands –

5-6,000 y BP

Interior
peatlands –

30-40,000 y BP

S. America ??
Africa ??

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Hydrology, biodiversity, livelihoods, carbon

Tropical peat swamp forests provide:

Hydrological regulation

Biodiversity support

Livelihoods for local communities

Carbon storage

Carbon sink to carbon source

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

- **Current *potential* C sequestration : ~20 Mt yr^{-1}**
  - ~25-28% of that for global peatlands
  - **Potential** rather than **actual** C storage
  - Severely impaired by recent land use changes
  - ~120,000 km^2 (45%) of SE Asian peatland currently deforested / drained
  - Many remaining forested peatlands impacted by logging / drainage

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Carbon sink to carbon source

- Forest clearance and drainage
- Plantation and agricultural enterprises
- Poor forest/land management

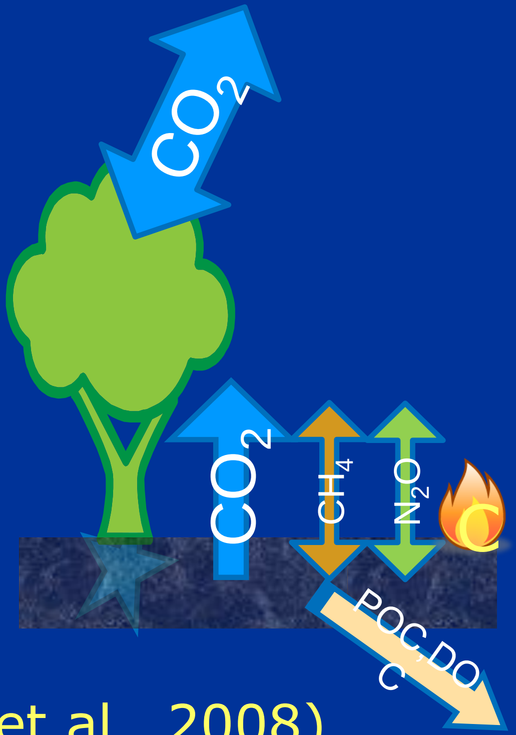
Peat oxidation !

<ENSO-related extended dry season>

Fire !

Greenhouse gas dynamics in tropical peatlands

- Main flux components:
  - vegetation CO_2 flux balance between sequestration in photosynthesis and emissions in plant respiration
  - CO_2 flux from decomposition
  - CH_4 fluxes in soil processes
  - N_2O fluxes in soil processes

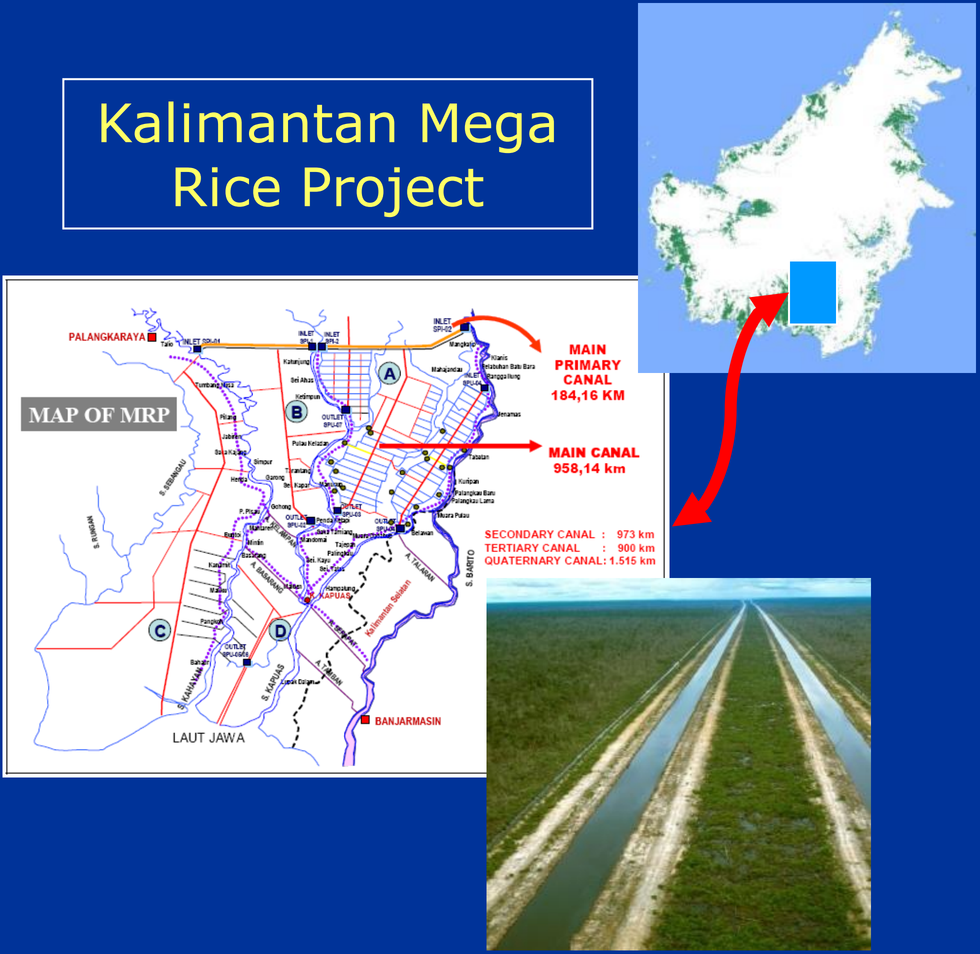


  - C-gas losses in fires (see, van der Werf et al., 2008)
  - POC and DOC export in waters (see, Moore et al., 2011)

- CH_4 and N_2O exchange typically small ($\leq$10% CO_{2e} of the concurrent soil surface CO_2 emissions)
  (e.g Jauhiainen 2005, 2008, 2011; Melling 2005a, b, 2007; Hadi et al., 2005)

Large-scale peatland agricultural and plantation projects

Kalimantan Mega Rice Project



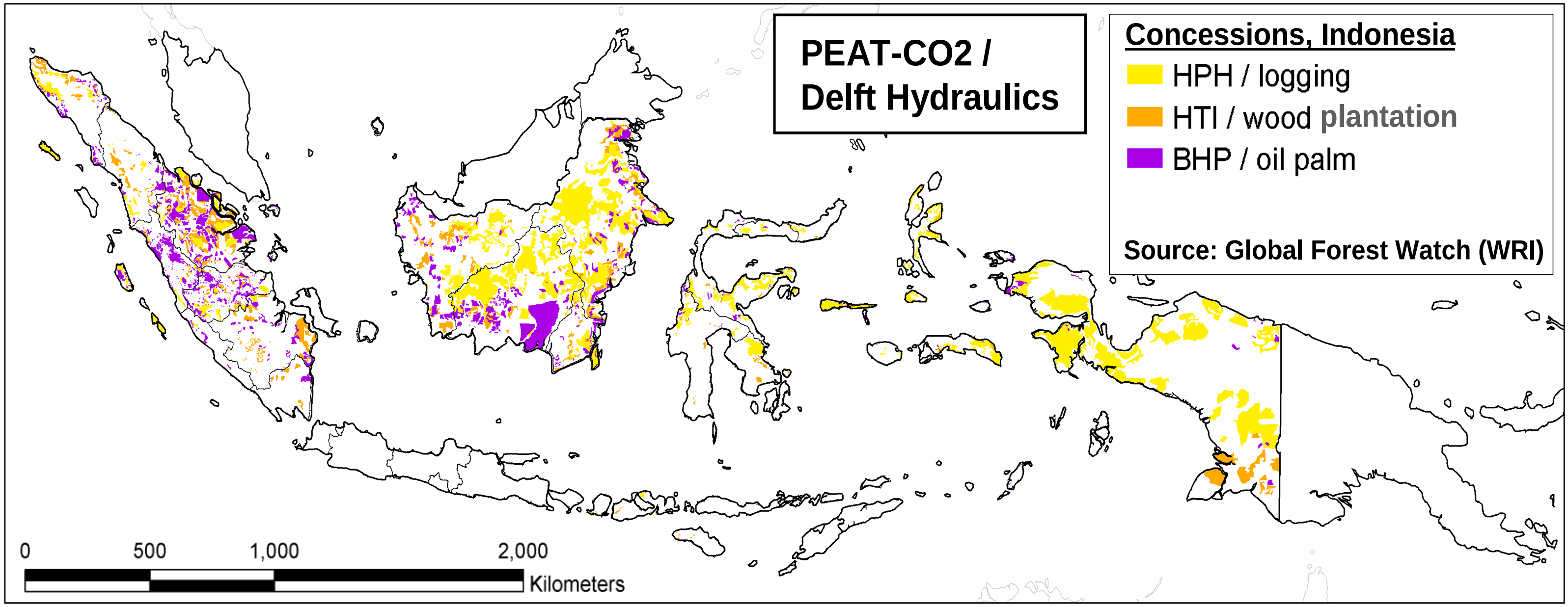
Riau pulp wood & oil palm plantations

Human disturbance

Logging

Pulpwood plantation

Oil palm



(Hooijer, Page et al. 2010, Biogeosciences) + current work is updating / improving accuracy of the extent and projected increase in plantations

Modeling carbon emissions from drainage of tropical peatlands

Near-current (2005):

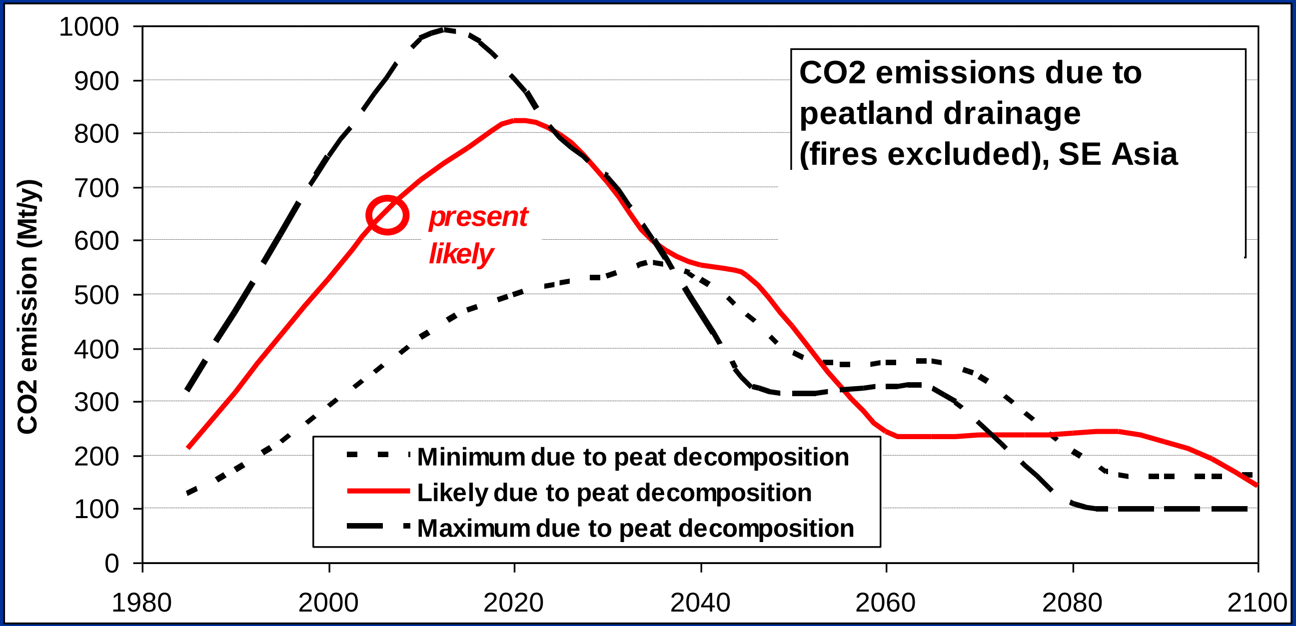
355-874 Mt CO_2 yr^{-1}

(**100–240 Mt C yr^{-1}**)

Projected (2015-2035):

557-981 Mt CO_2 yr^{-1}

(**150-270 Mt C yr^{-1}**)



Current tropical peat <u>drainage</u> emissions equivalent to 1.4 – 3.5 % of global emissions from fossil fuels (25,000 Mt CO_2 yr^{-1}) (excluding initial biomass loss & fire)

[based on 91 t ha^{-1} y^{-1} CO2 at 1 m & 46 t ha^{-1} y^{-1} at 0.5 m drainage]

(Hooijer, Page et al. 2010, Biogeosciences)

Most (limited !!) data derived from

Chamber measurements

- Usefulness of data is often limited by;
  - low data amount in individual study
  - CO_2 emissions from decomposition processes and root respiration cannot be separated
  - poor method description and data collection procedures
- There is a need for data which
  - enable quantification of CO_2 emissions from identified sources (instead of total)
  - are spatially and temporally sufficiently large for describing the phenomenon

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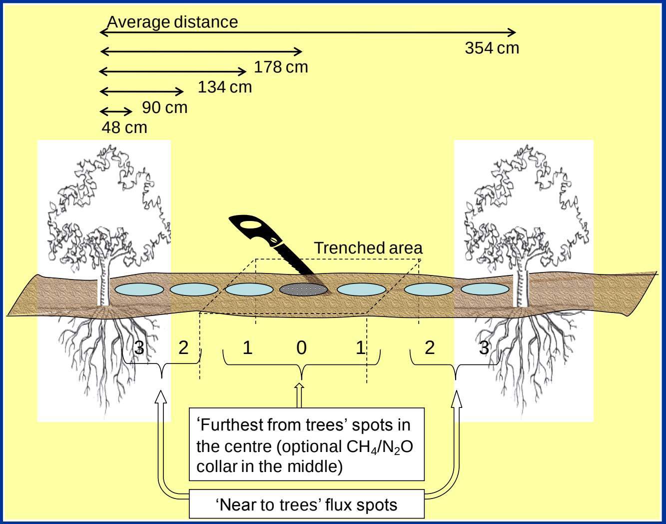
Study on CO_2 emissions from acacia plantation on peatland in Sumatra, Indonesia

(led by Jyrki Jauhiainen, Univ. Helsinki)



- Peat not affected by fire
- Acacia crop growth cycle stages from unplanted to harvest (60 months)
- Water table controlled

- To separate autotrophic from heterotrophic respiration, monitoring included
  - locations within and beyond the tree rooting zone
  - peat (and possible plant roots) were cut using a saw around a number of monitoring locations
  - CO_2 emissions were measured in both planted and harvested areas

(Jauhiainen, Hooijer & Page, Biogeosciences Discussions (2011, in review))

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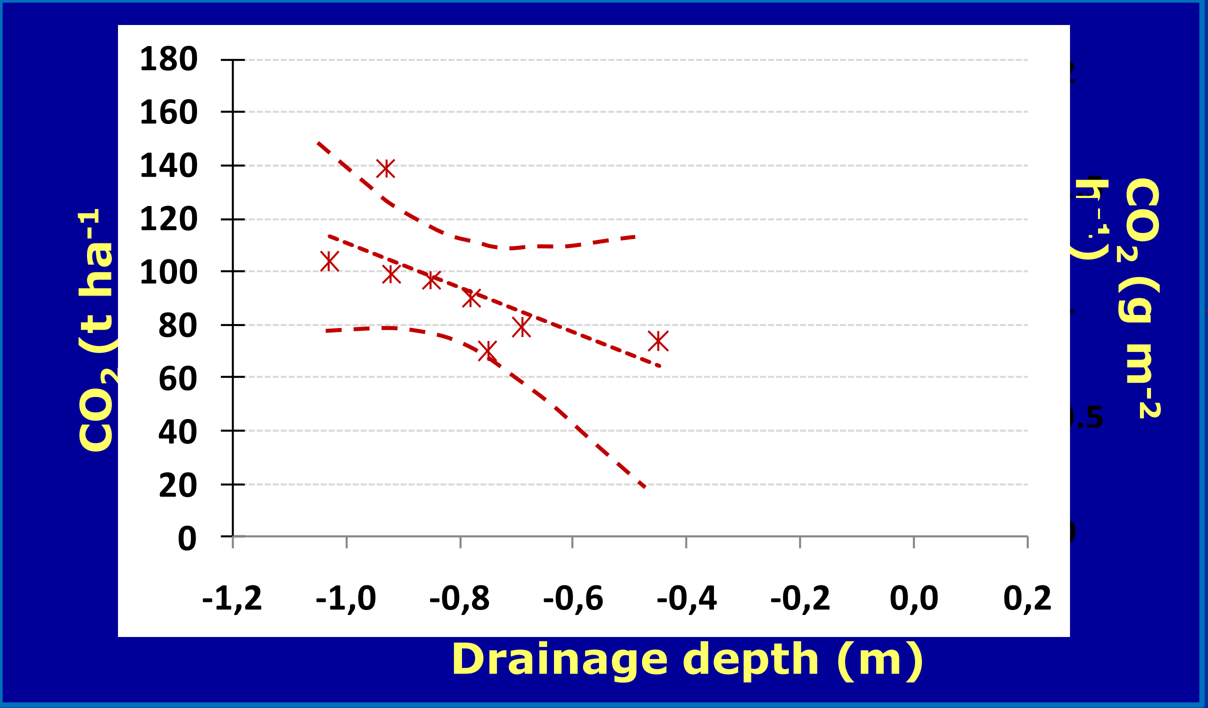


Jauhiainen et al. (2011) BGD

* Peat decomposition (based on average CO$_2$ flux data at typical water table depths)

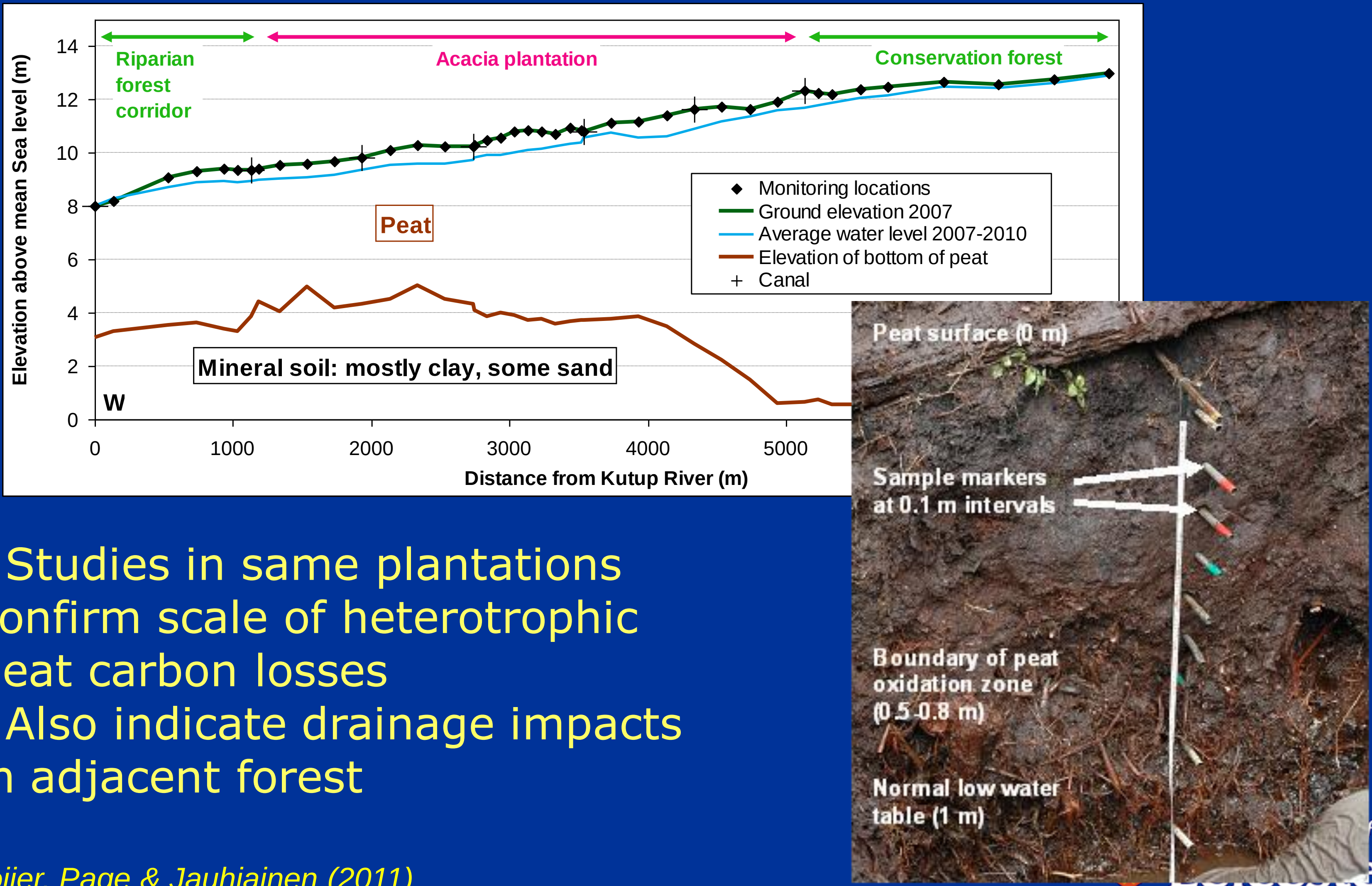
--- 95% confidence limits

<u>Main observations</u>

- Data for long-term means indicate that CO$_2$ emissions increase under deeper drainage conditions.
- Mean heterotrophic CO$_2$ emission (±SE) was 1053±88 mg m^{-2} h^{-1} at 0.78 m average water table depth = **92 t ha^{-1} y^{-1}**
- After correction for diurnal temp fluctuation → **~80 t ha^{-1} y^{-1}**

Subsidence studies to reduce uncertainties in peat soil carbon loss

Sites in SE Asia



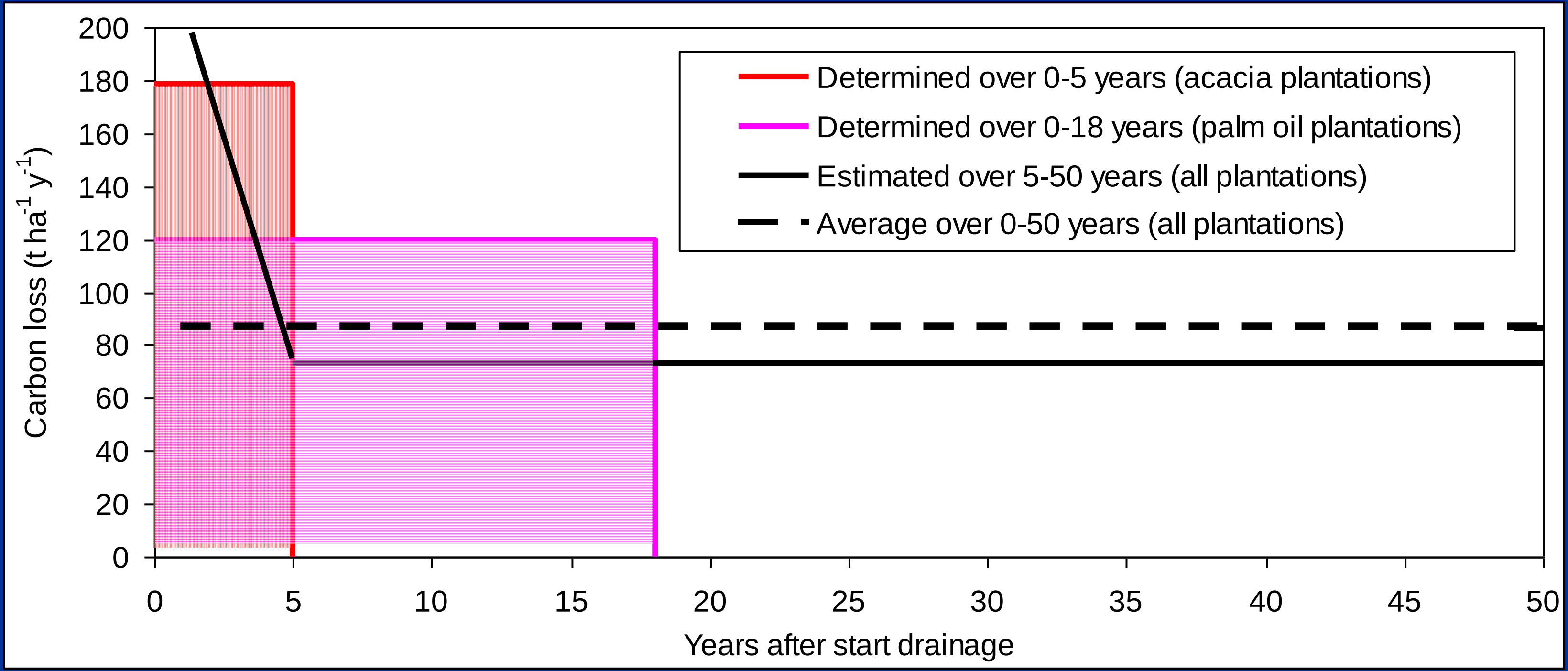
- Studies in same plantations confirm scale of heterotrophic peat carbon losses
- Also indicate drainage impacts in adjacent forest

Hooijer, Page & Jauhiainen (2011) Biogeosciences Discussions

Key conclusions

Changes in oxidation and carbon loss over time have so far been overlooked:

- **Relative oxidation contribution to subsidence increases over time, from <50% to nearly 100% (92% over 0-18 years).**
- **Carbon loss decreases over time, stabilizing at ≥70 t/ha/y CO_2 equivalent.**



Hooijer et al (2011) BGD

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Controls

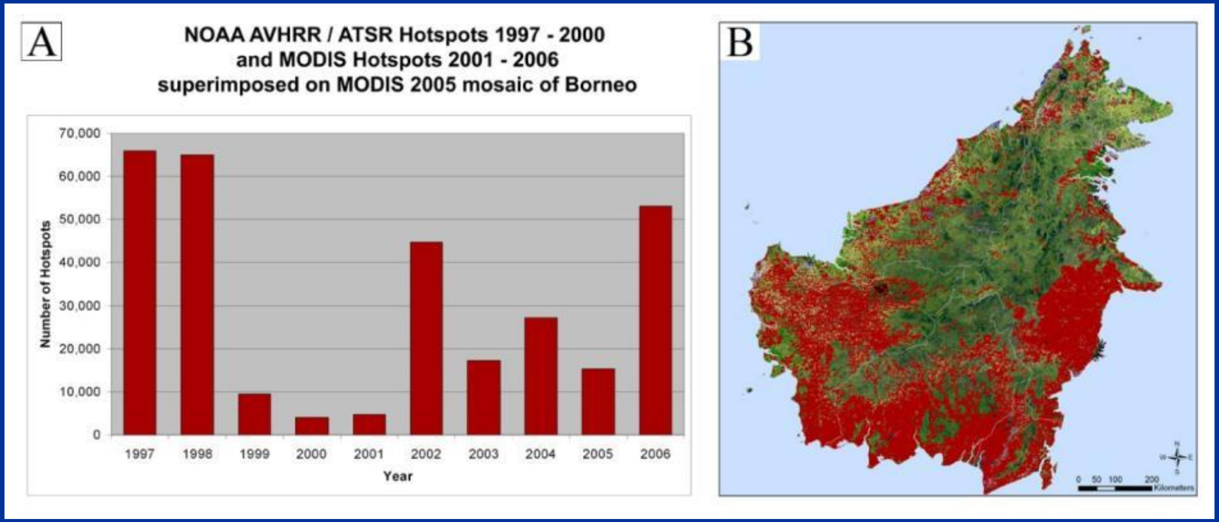
Water depth is often seen as the main control, but is <u>not the only control</u>.

Peat oxidation much enhanced by:

- **High temperature due to limited vegetation cover**
- **Fertilization**

Peatland Fires

- Regular fires over last decade – **1997/98!**, **2002!**, 2003, 2004, 2005, **2006!**, **2009!**
- A near annual event?



Annual fire hotspot data for Borneo 1997 to 2006
[Langner et al. 2007]

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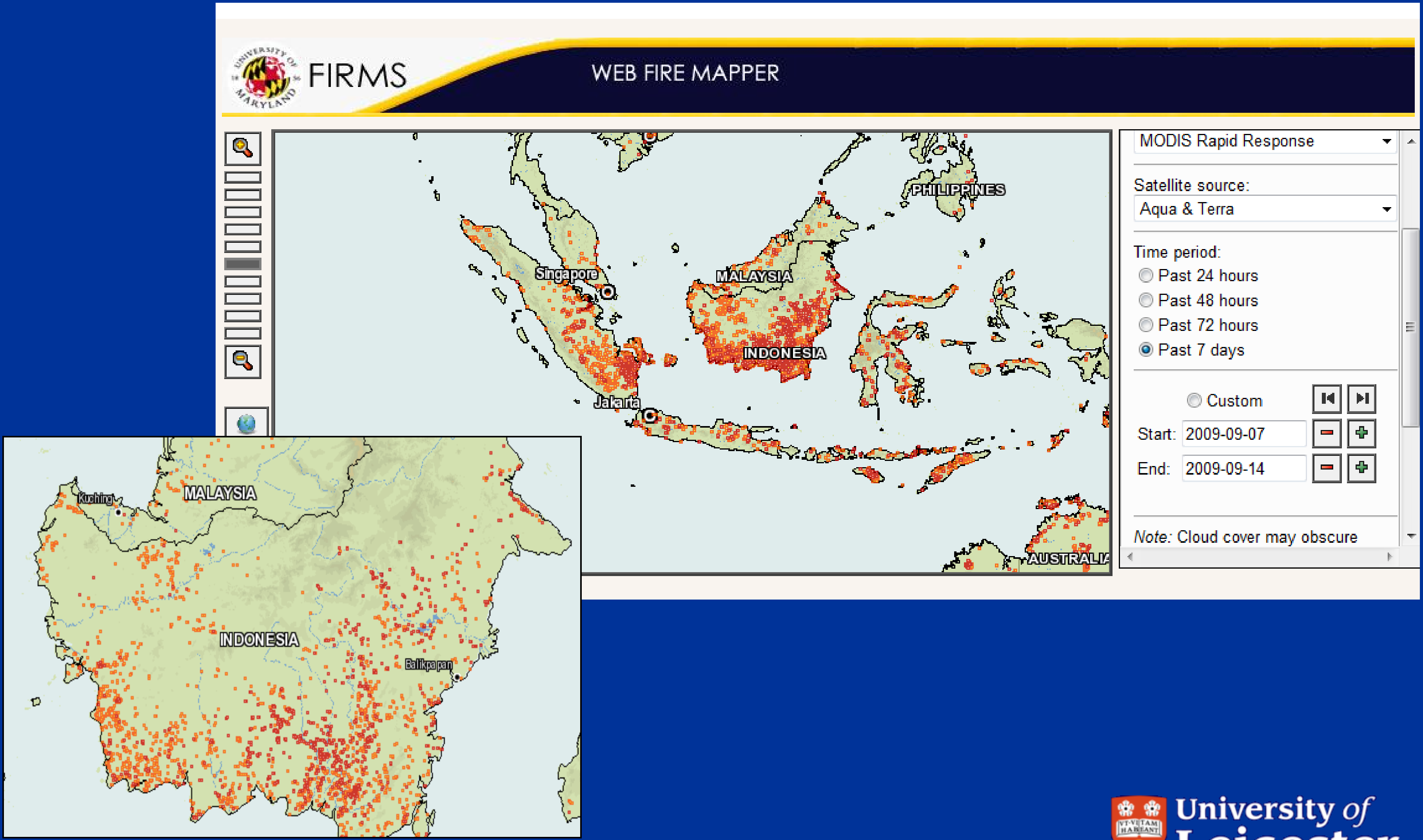
Fire hotspots : 7-14 Sept 2009



MODIS Rapid Response

Satellite source:
Aqua & Terra

Time period:
○ Past 24 hours
○ Past 48 hours
○ Past 72 hours
● Past 7 days

○ Custom
Start: 2009-09-07
End: 2009-09-14

Note: Cloud cover may obscure

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Scale of fire-related emissions

◆ 1997-1998: 0.81 – 0.95 Gt C / 0.87 Gt C

(Indonesia; Page et al. 2002; van der Werf et al. 2008)

◆ 2002: 0.74 Gt C

(equatorial SE Asia; Langner & Siegert unpub. data)

◆ 2006: 0.30 ± 0.12 Gt C

(equatorial SE Asia; van der Werf et al. 2008)

◆ 1997-2006: likely total fire emission 2–3+ Gt C

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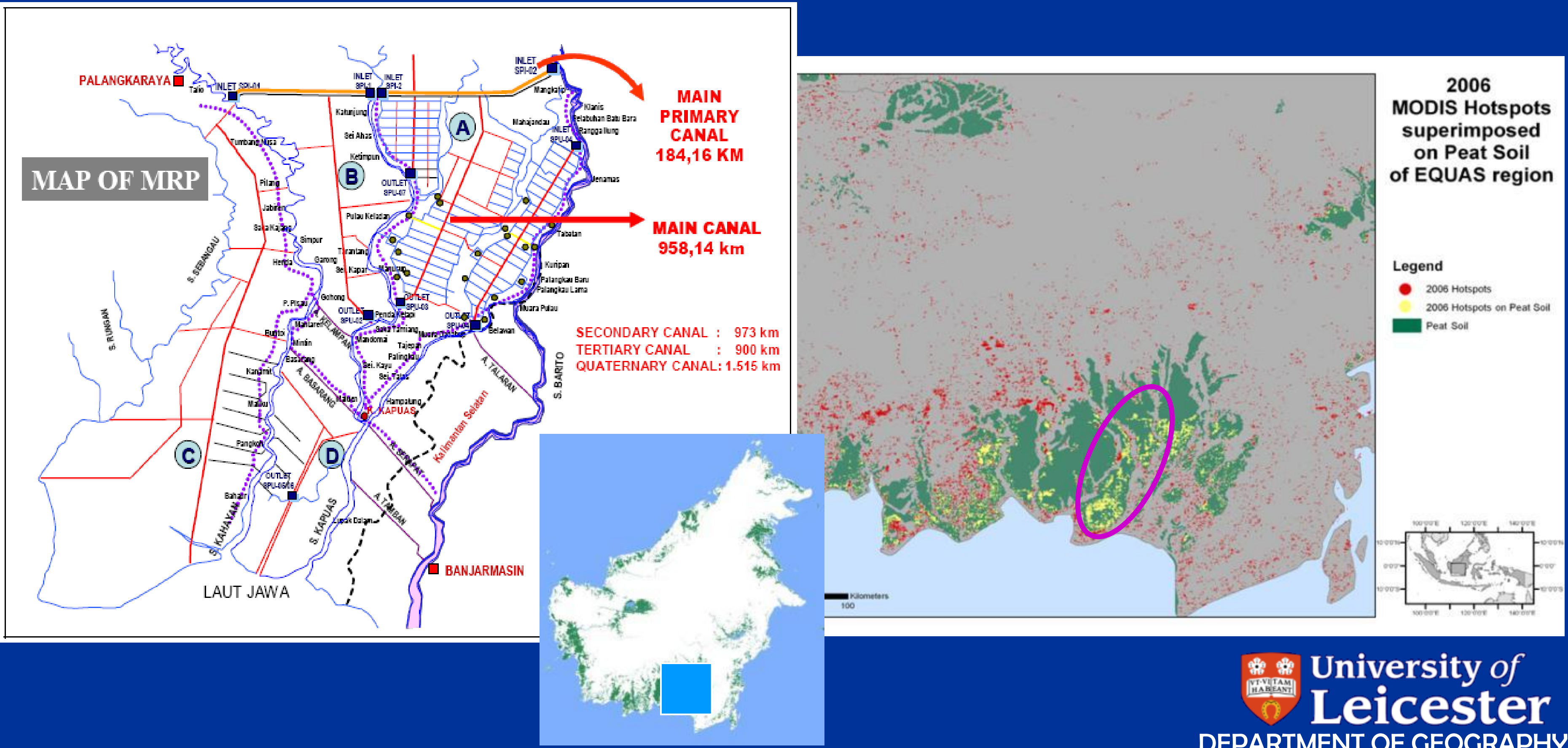
Tropical peatlands and fire: Study focus

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



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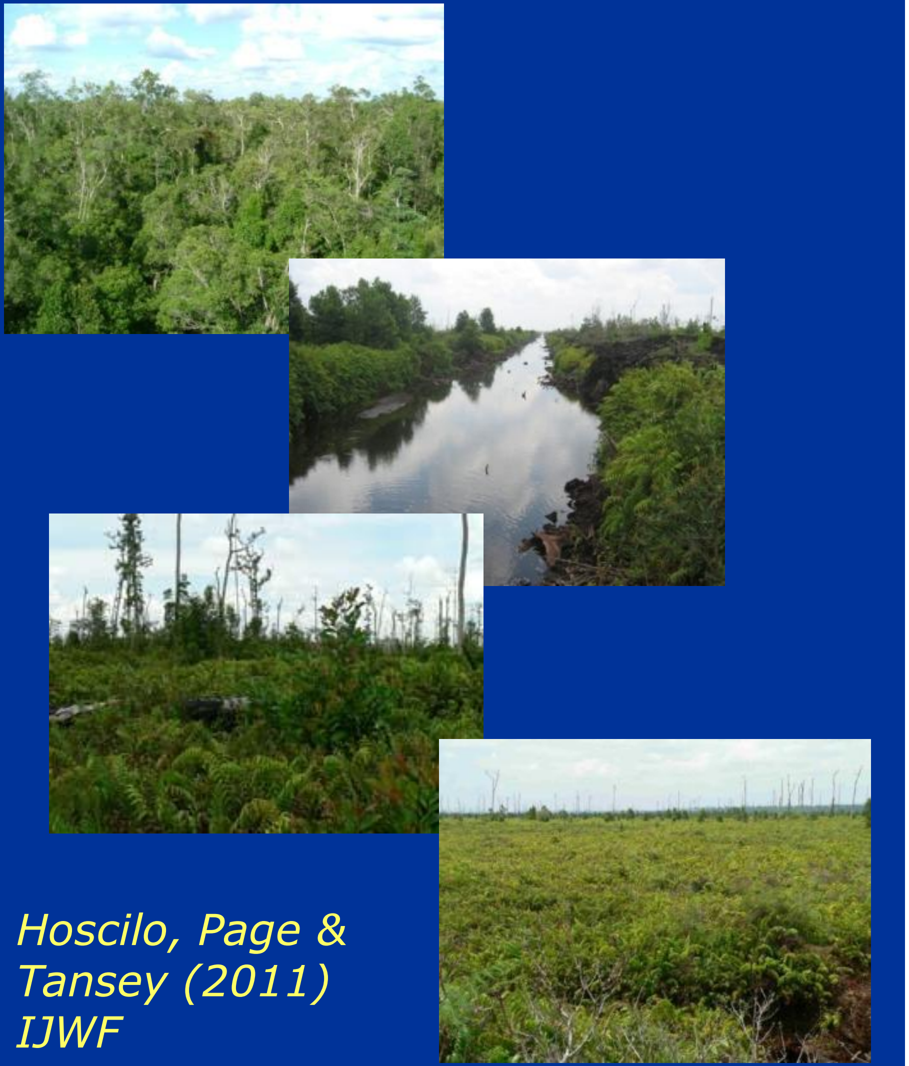
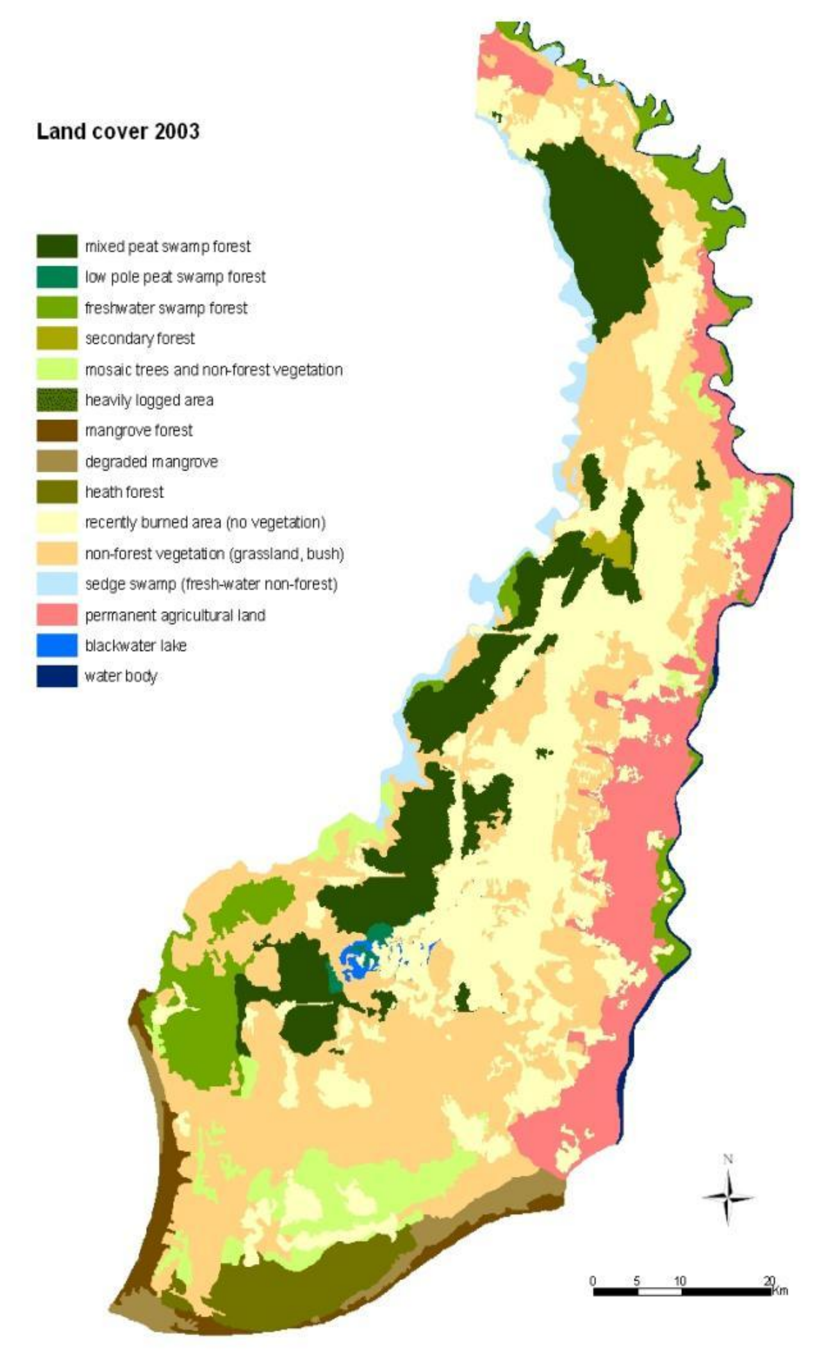
LAND COVER CHANGE

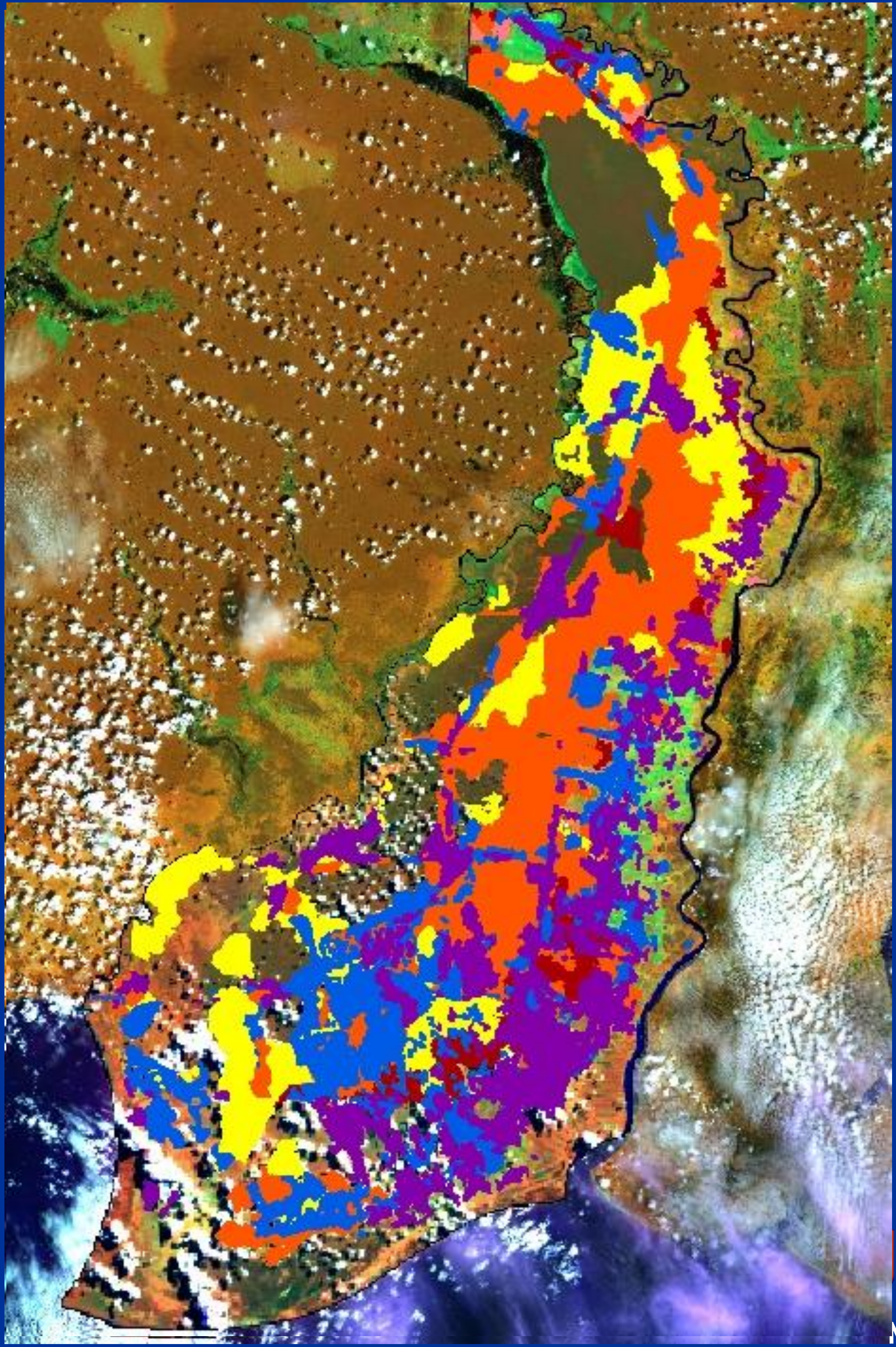
1973-2003





Hoscilo, Page & Tansey (2011) IJWF

Fire history



Hoscilo, Page et al. (2011)
Int. J. Of Wildland Fire

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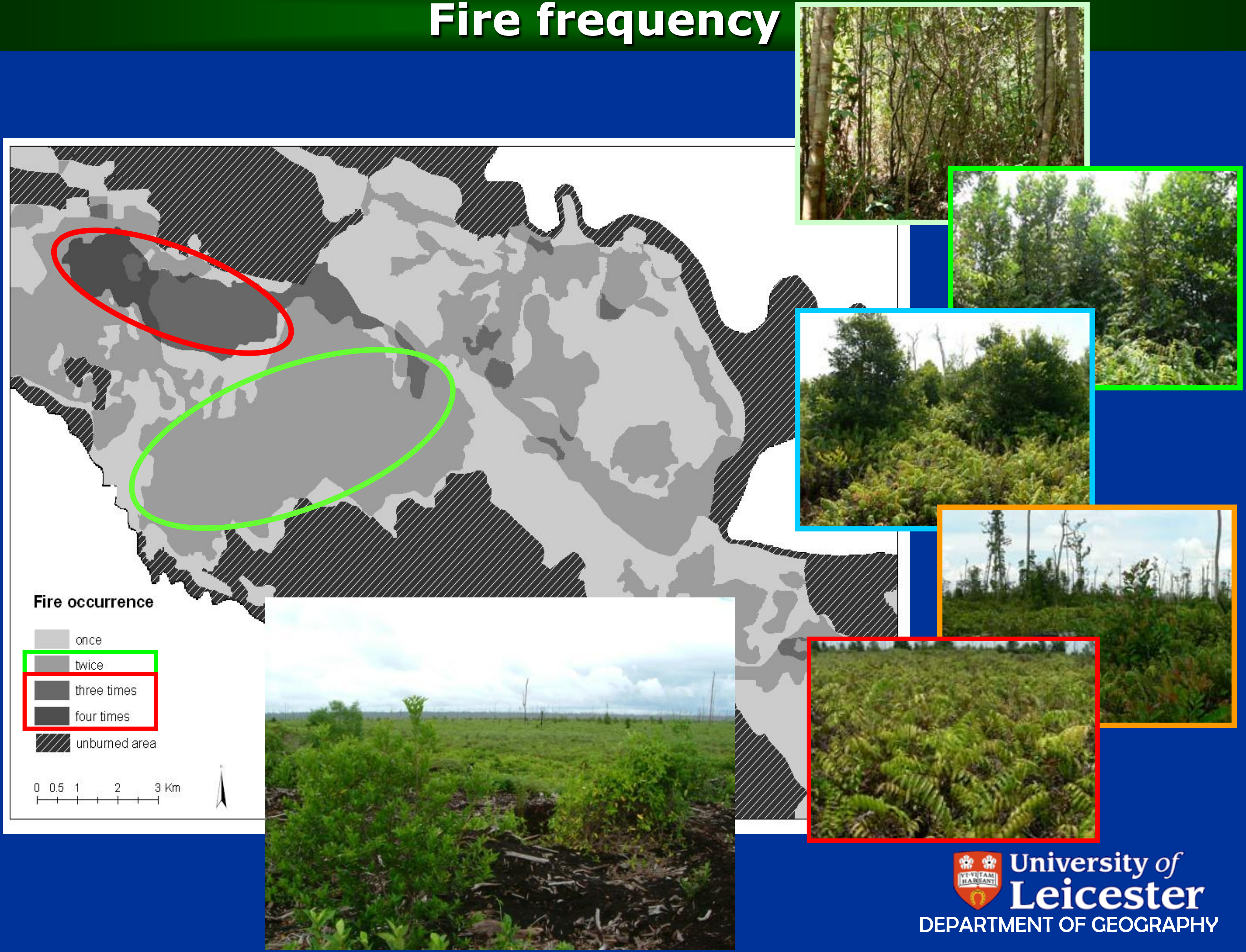
Fire frequency



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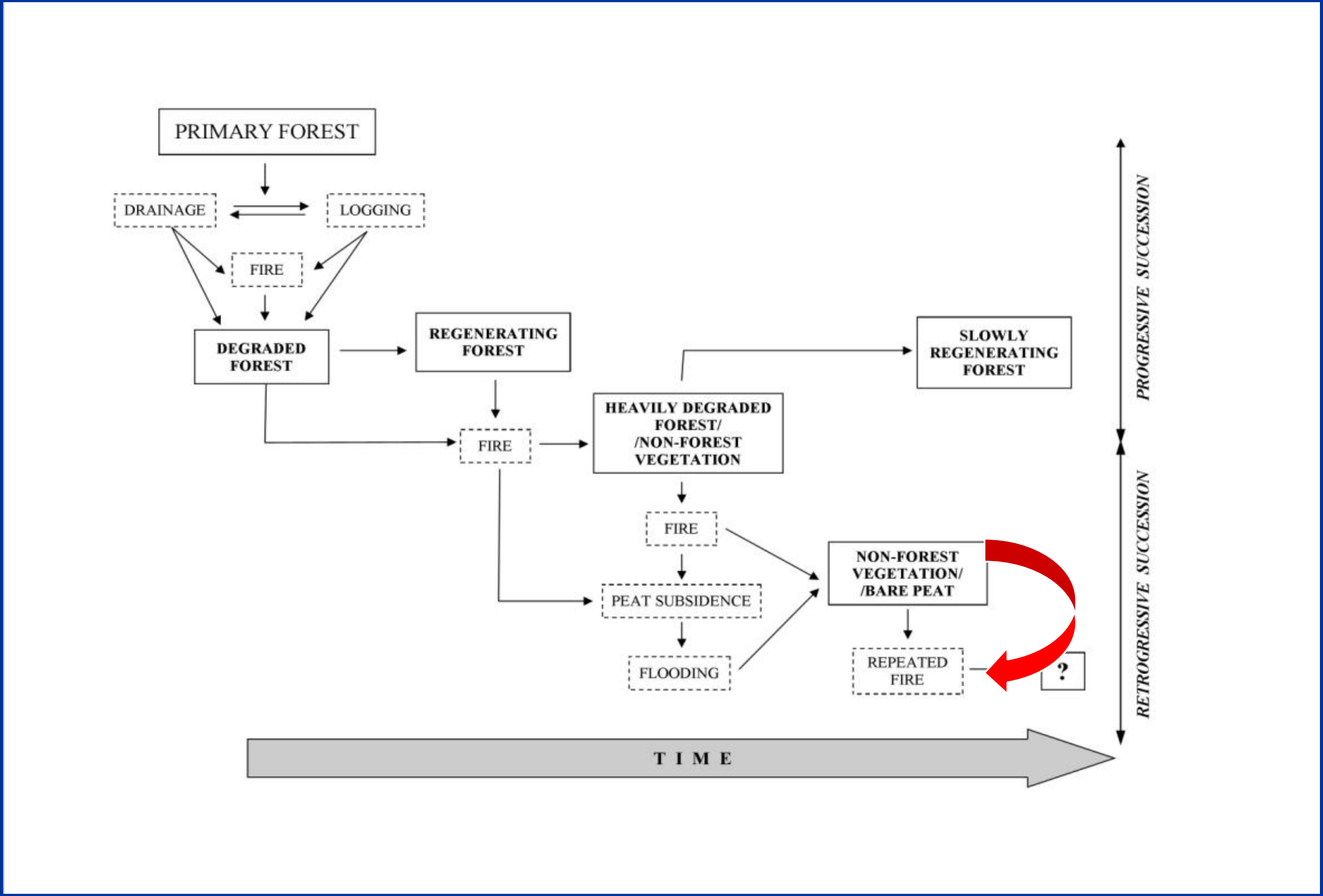
Downward spiral of change



(Page et al. (2009) Ecosystems)

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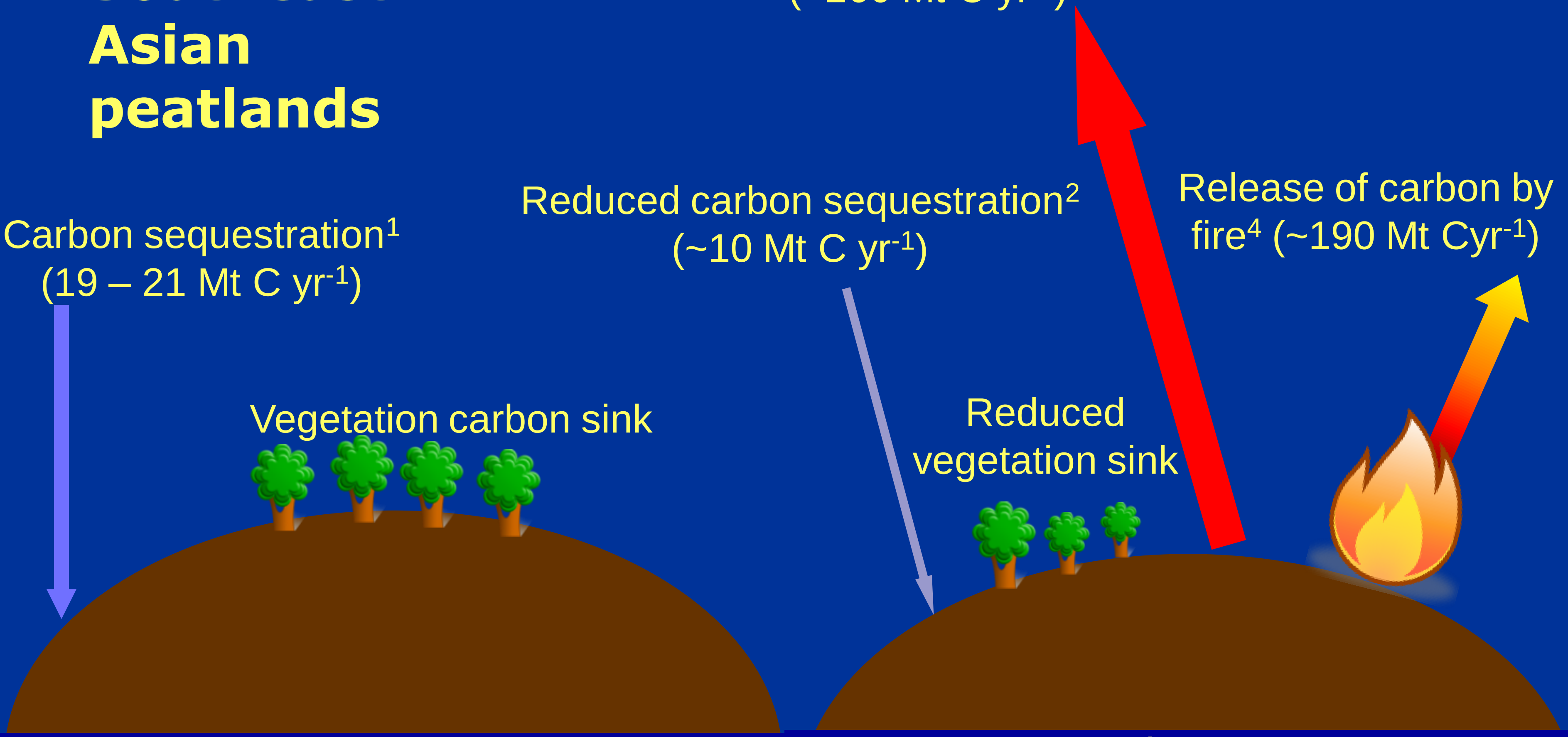
Southeast Asian peatlands



Carbon sequestration[1] (19 – 21 Mt C yr^{-1})

Vegetation carbon sink

Reduced carbon sequestration[2] (~10 Mt C yr^{-1})

Loss of carbon through peat oxidation[3] (~260 Mt C yr^{-1})

Release of carbon by fire[4] (~190 Mt Cyr^{-1})

Reduced vegetation sink

Pool: 69 Gt (& increasing?)

Natural overall carbon sequestration

Pool: < 69 Gt

(& decreasing by 460 Mt C yr^{-1})

Current situation overall carbon source

Notes:

[1] based on area of 252,229 km^2 and carbon accumulation rate of 80 g C m^2 yr^{-1} (Neuzil, 1997; Page et al., 2004)

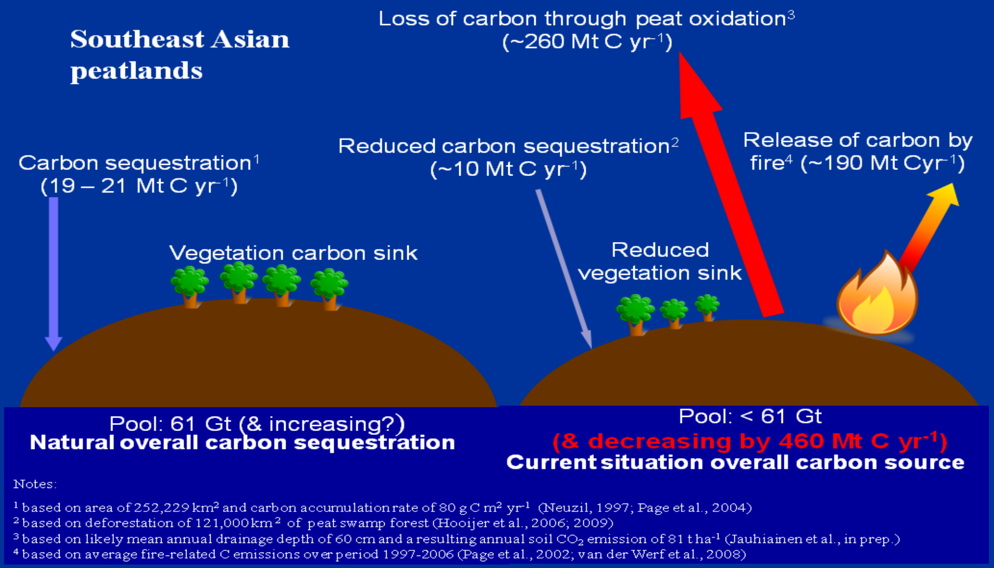
[2] based on deforestation of 121,000 km ^{2} of peat swamp forest (Hooijer et al., 2006; 2009)

[3] based on likely mean annual drainage depth of 60 cm and a resulting annual soil CO_2 emission of 81 t ha^{-1} (Jauhiainen et al., in prep.)

[4] based on average fire-related C emissions over period 1997-2006 (Page et al., 2002; van der Werf et al., 2008)

Southeast Asian peatlands - from carbon sink to carbon source

- Estimated current annual loss ~460 Mt C
  - England's total peat store is ~300 Mt C !!
  - 1700 Mt $CO_2e\ yr^{-1}$ $\cong$ 5.6% global fossil fuel emissions !!
  - Indonesian peat losses alone ~245 – 270 Mt C yr^{-1}



Southeast Asian peatlands

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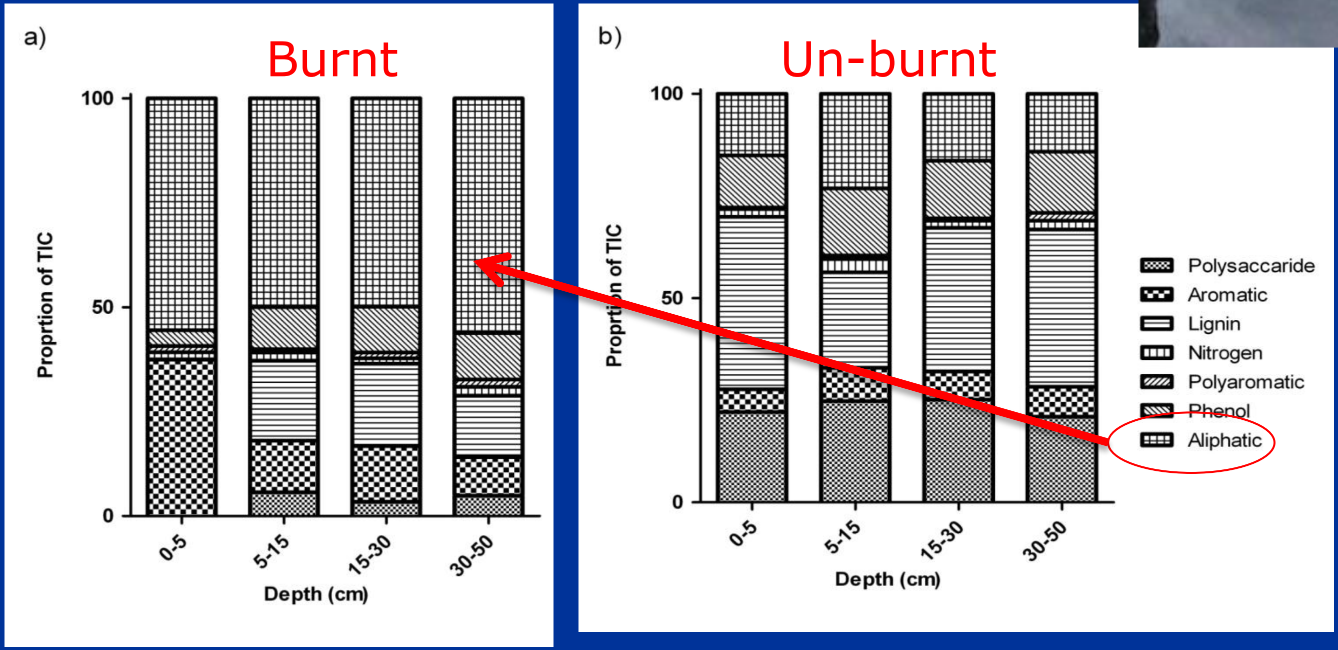
Other fire effects

- Change in peat soil nutrient status & nutrient cycling
- Change in organic geochemistry
- Change in surface water-repellency
- Increased fluvial C losses (esp. DOC)
- Change in land albedo
- Surface subsidence → flooding



(Milner et al. in prep.)

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Terima kasih

Thank you

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