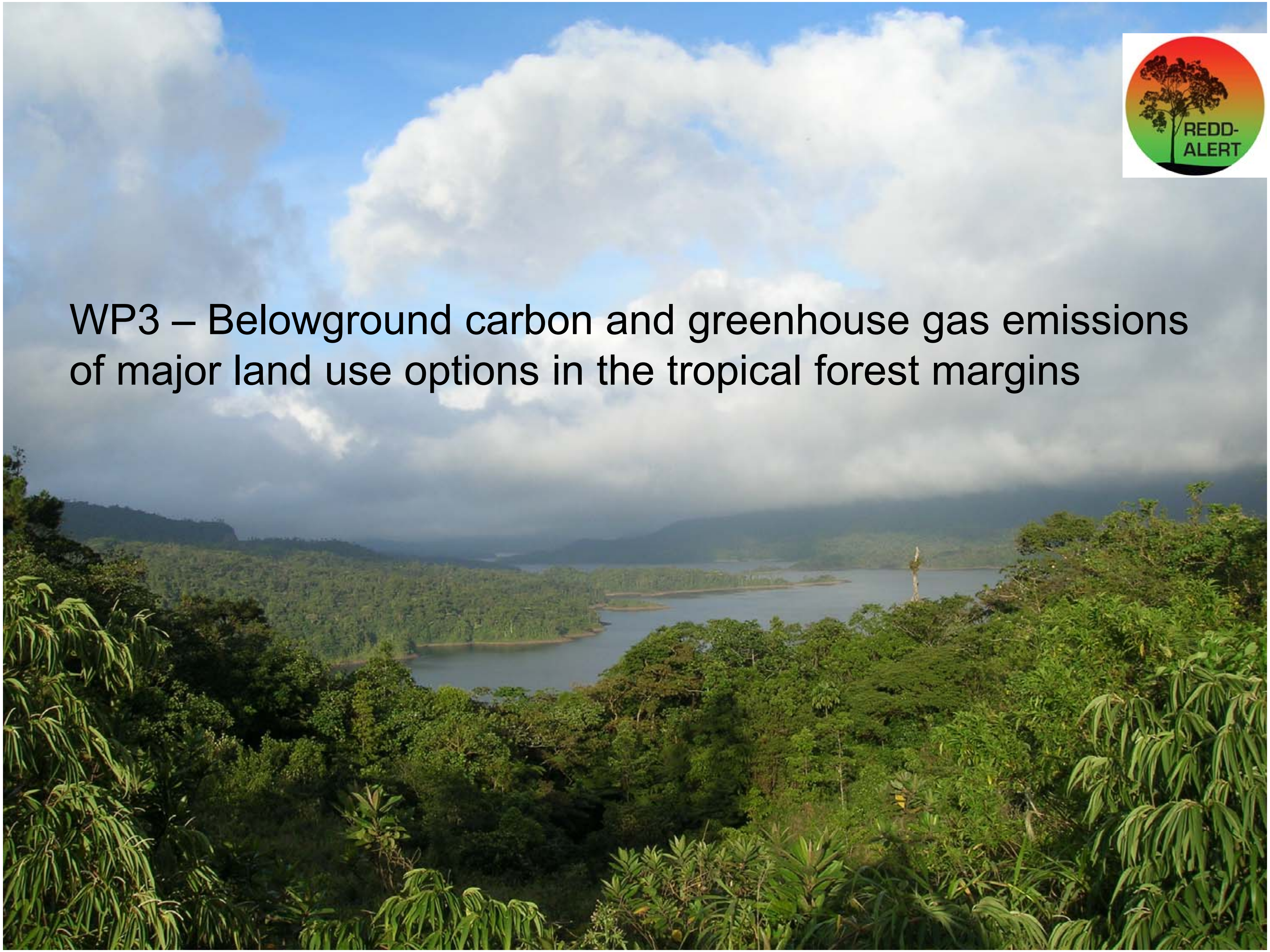


WP3 – Belowground carbon and greenhouse gas emissions of major land use options in the tropical forest margins

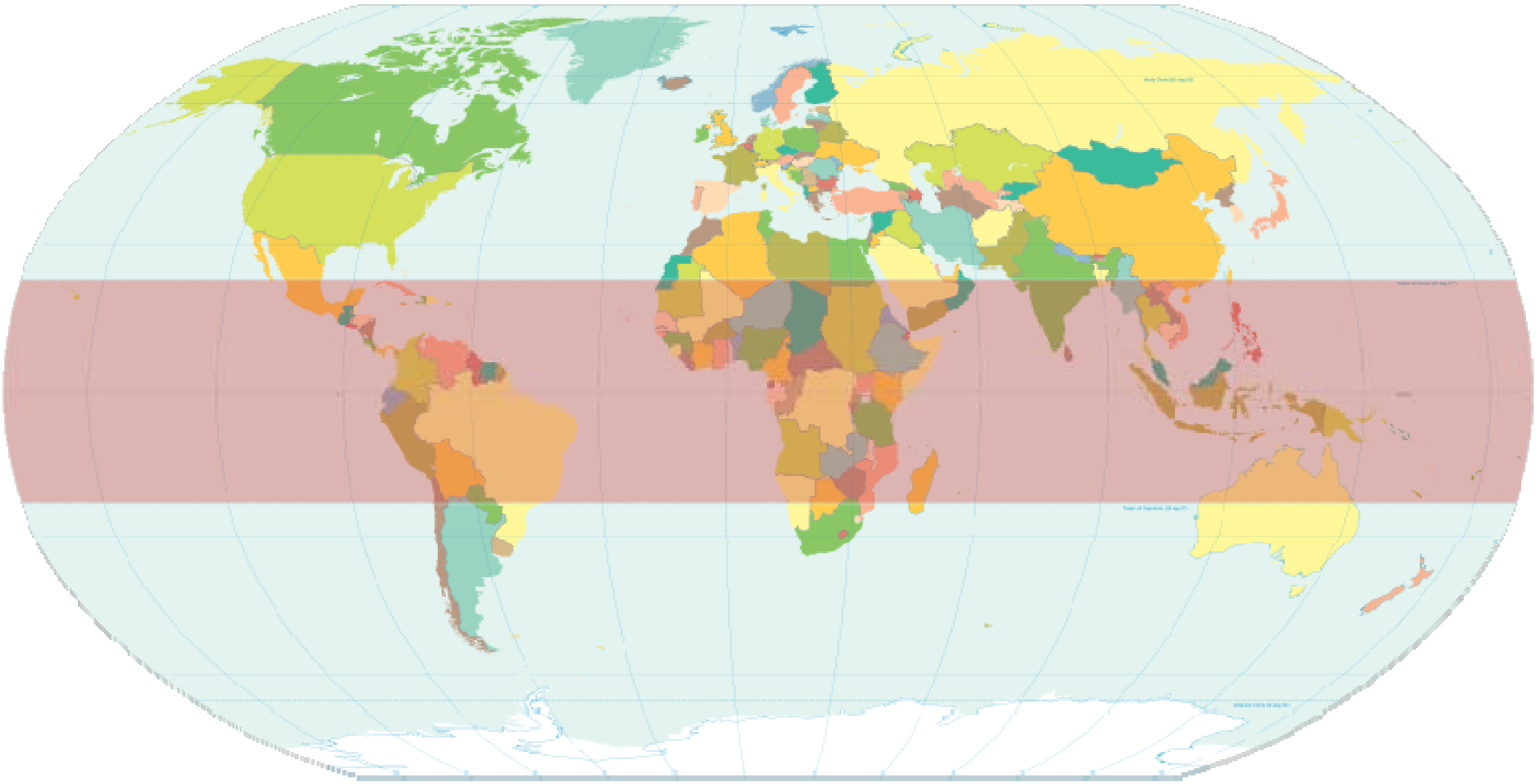
REDD-ALERT WP3, Planned activities on SOC changes:

Literature review of published case studies of land use change effects on SOC stock in the tropics

•Field studies to quantify changes in SOC stocks to 3m depth (Indonesia, Cameroon, Peru)

•Use this information to calibrate and initialize soil components of models used in WP5

A Meta-Analysis of Changes in Soil Carbon Stocks with Tropical Land-use Change



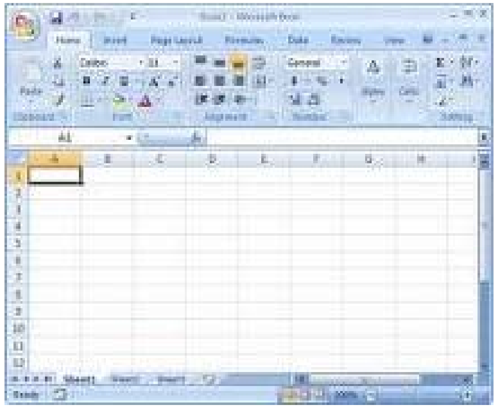
J. Powers, M. Corre, T. Twine & E. Veldkamp

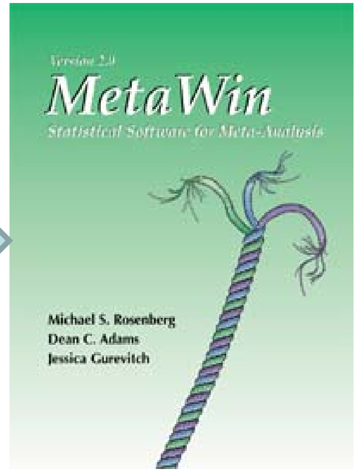
“the current knowledge remains inconclusive on both the magnitude and direction of C stock changes in mineral forest soils associated with forest type, management and other disturbances, and cannot support broad generalizations”

Aalde *et al.* 2006 *IPCC Guidelines for National Greenhouse Gas Inventories*

Questions

- How do different land-use changes affect soil C stocks?
- Do biophysical variables determine soil C dynamics following land-use change?
- Can we extrapolate field data to the global scale?





Criteria: -C stocks reported or calculated
-Clear reference land use
-included data on climate and soils

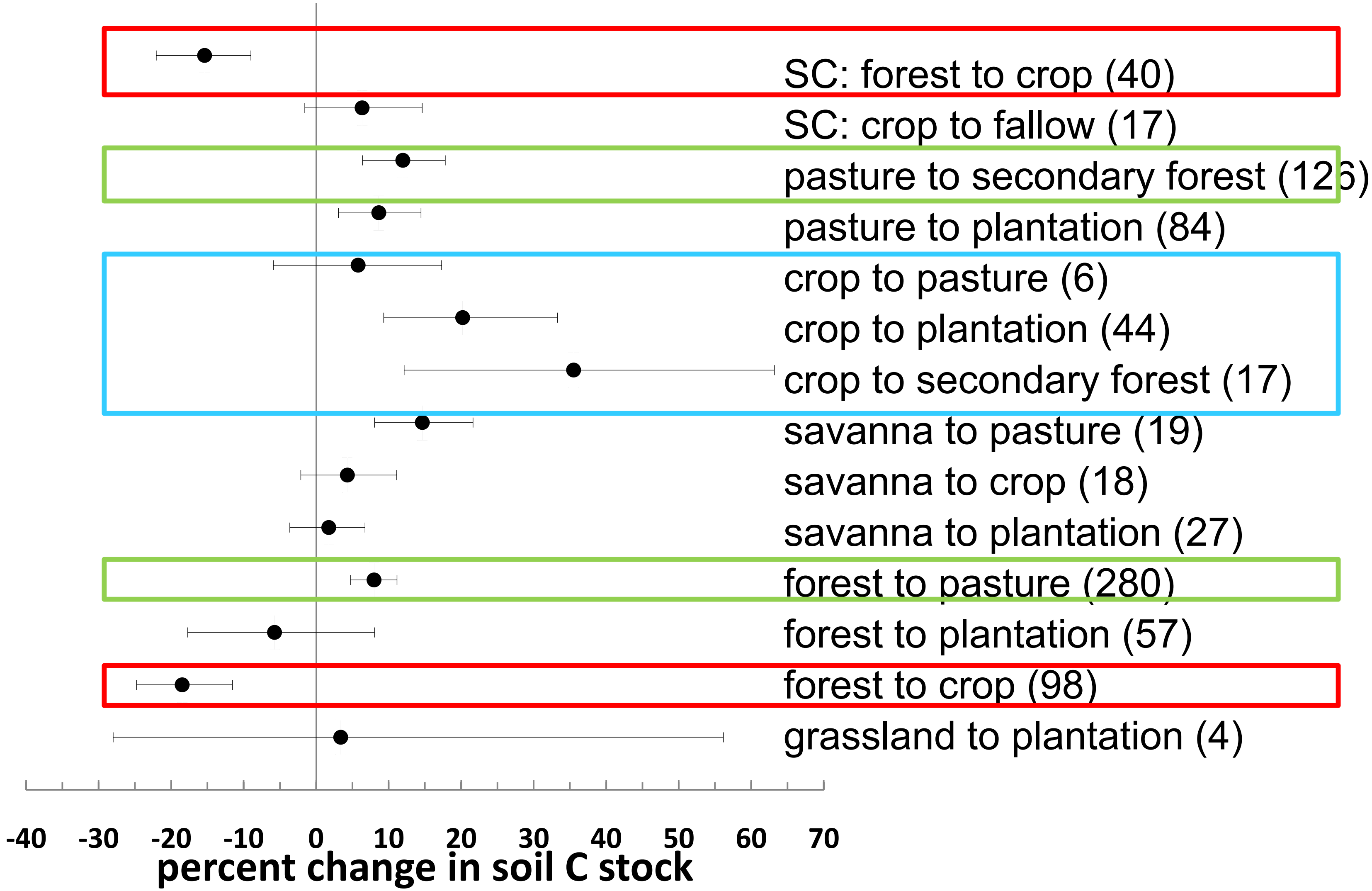
Response metric → percent change in soil C stock

$$\% \text{ change} = ((Xc-Xr)/Xr)*100$$

Xc = soil C stock current land use

Xr = soil C stock reference land use

How do different land-use changes affect soil C stocks?



Questions

- How do different land-use changes affect soil C stocks? **IT DEPENDS**

- Do biophysical variables determine soil C dynamics following land-use change?

- Can we extrapolate field data to the global scale?

Do biophysical variables determine soil C dynamics following land-use change?

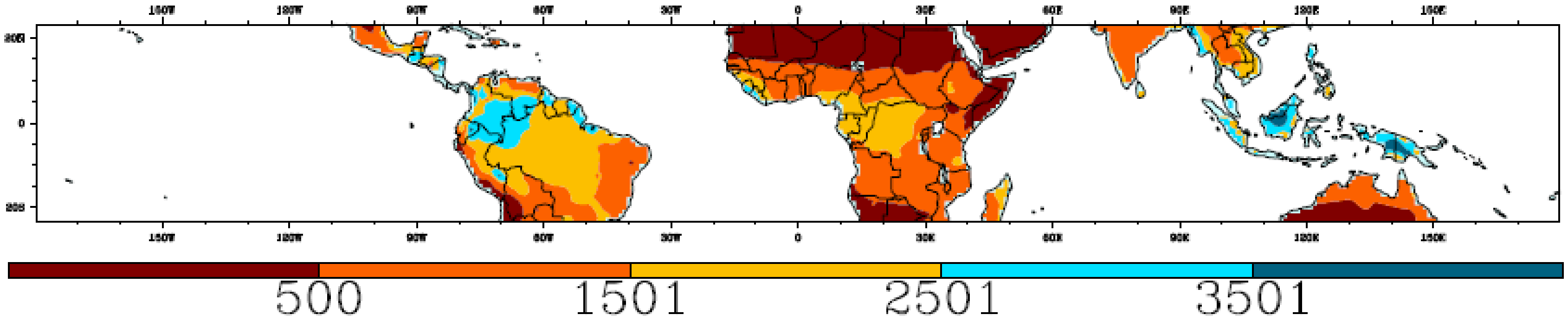
Soil clay mineralogy

allophane & non-crystalline clays

low activity clays (more weathered), e.g. kaolinite

high activity clays (less weathered), e.g. smectite

Precipitation regime



annual rainfall (mm)

Map courtesy of Tracy Twine

Forest to pasture conversion (0-30 cm)

Clay mineralogy class	Annual precipitation class	Mean Percent Change (Lower and Upper CI)		N
		forest to pasture conversion		
Allophane	1501 to 2500	7.3	(-33.82, 55.2)	3
	2501 to 3500	-2.7	(-16.3, 14.1)	7
	>3501	**-15.8**	**(-24.4, -7.3)**	5
High activity	<1500	16.4	(-1.8, 37.7)	6
	1501 to 2500	**-10.2**	**(-21.4, -0.5)**	7
Low activity	1501 to 2500	**26.4**	**(20.8, 32.2)**	79
	2501 to 3500	1.1	(-14.4, 18.1)	9
	>3501	14.1	(-0.7, 29.7)	12

loss

gain

Powers et al, in prep

Pasture to secondary forest conversion (0-30 cm)

Clay mineralogy class	Annual precipitation class	Mean Percent Change (Lower and Upper CI)		N
		pasture to secondary forest conversion		
Allophane	2501 to 3500	4.0	(-5.5, 17.8)	9
High activity	<1500	**16.5**	**(8.3, 24.1)**	4
	1501 to 2500	10.8	(-0.6, 21.9)	15
	2501 to 3500	-5.0	(-18.3, 6.9)	8
Low activity	1501 to 2500	**19.0**	**(1.3, 34.9)**	11
	2501 to 3500	**23.6**	**(4.8, 43.4)**	6
	>3501	**32.6**	**(25.9, 39.2)**	4

loss

gain

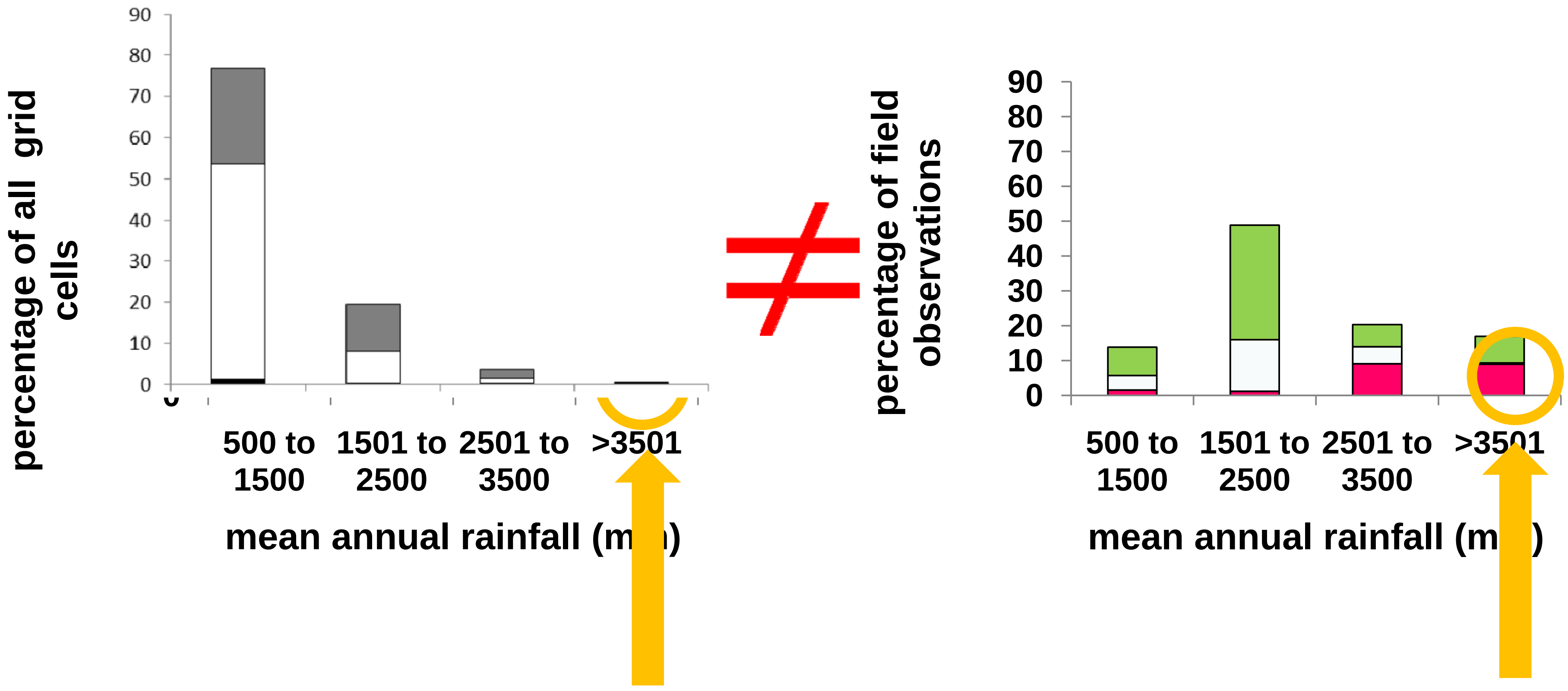
Questions

- How do different land-use changes affect soil C stocks? **IT DEPENDS**
- Do biophysical variables determine soil C dynamics following land-use change? **YES**
- Can we extrapolate field data to the global scale?

Can we extrapolate field data to the global scale?

Only if the field data correspond to the biophysical conditions in the tropics

Grid cells (N= 2857) | Field observations (N=837)



0%

Chi ^{2} = 11,789

9%

Caveats

- Limited data for many transitions
- Recent land-cover transitions (e.g. peat land cleari
  are not represented
- Few data < 30 cm depth
- Data assume rapid equilibration following conversi
- Ignores species effects, management effects, etc

Research in the tropics is geographically biased…

BIOTROPICA
THE JOURNAL OF TROPICAL BIOLOGY AND CONSERVATION

BIOTROPICA 40(4): 397–404 2008 10.1111/j.1744-7429.2007.00393.x

The Geographical and Institutional Distribution of Ecological Research in the Tropics

Gabriela Stocks[1,5], Lisa Seales[2], Franklin Paniagua[2], Erin Maehr[3], and Emilio M. Bruna[4]

Geographic bias in the soil C database precludes spatial extrapolation….

Conclusions

- biophysical factors determine carbon dynamics after land-use change

- field observations are biased towards unrepresentative conditions

- presently, extrapolations from meta-analyses to coarser spatial scales are not warranted

Questions

- How do different land-use changes affect soil C stocks? **IT DEPENDS**
- Do biophysical variables determine soil C dynamics following land-use change? **YES**
- Can we extrapolate field data to the global scale? **NO**

REDD-ALERT WP3, Planned activities on SOC changes:

Literature review of published case studies of land use change effects on SOC stock in the tropics

- Field studies to quantify changes in SOC stocks to 3m depth (Indonesia, Cameroon, Peru)

- Use this information to calibrate and initialize soil components of models used in WP5

Landuse trajectories

1. to rubber

(Deforestation)

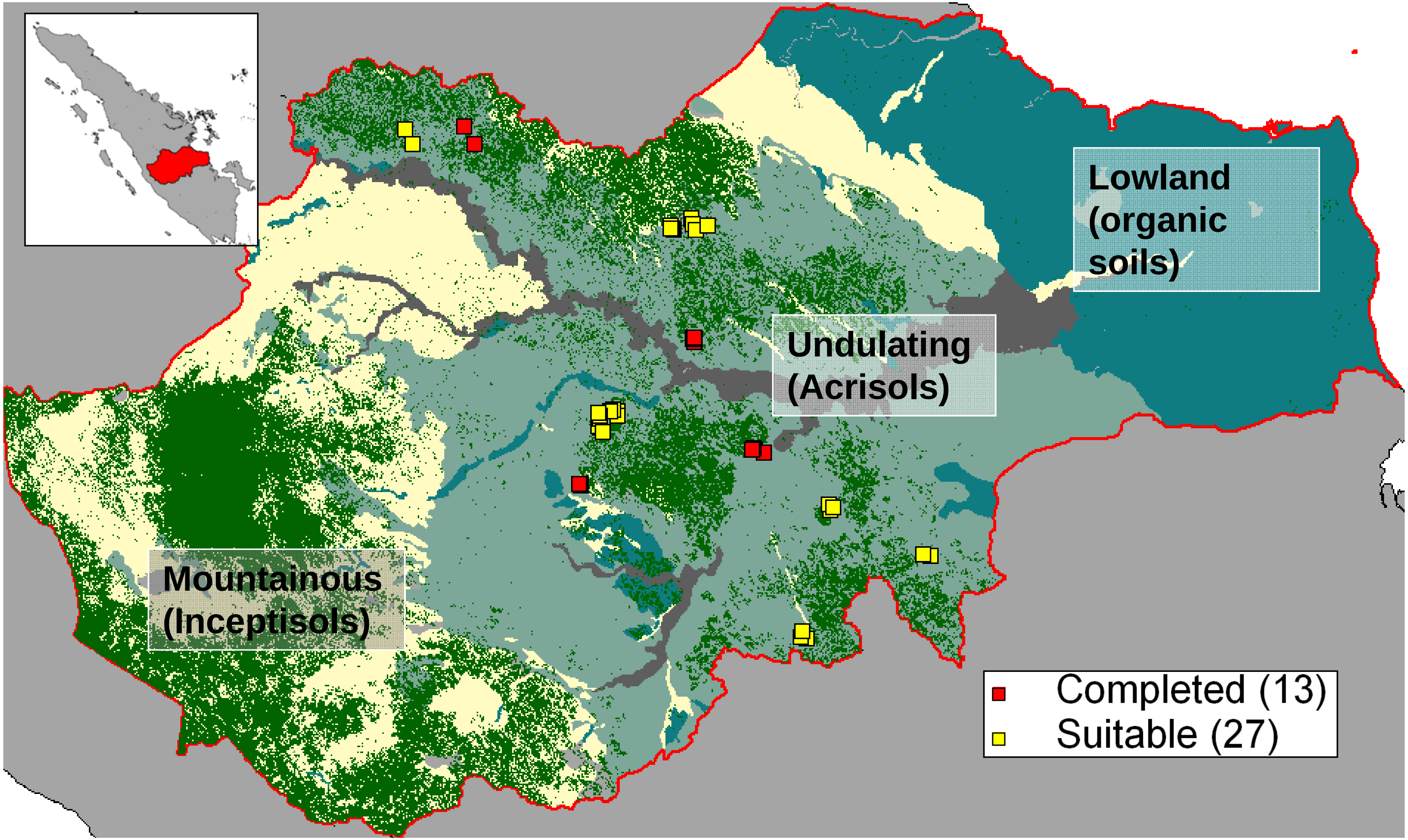
2. to oil palm

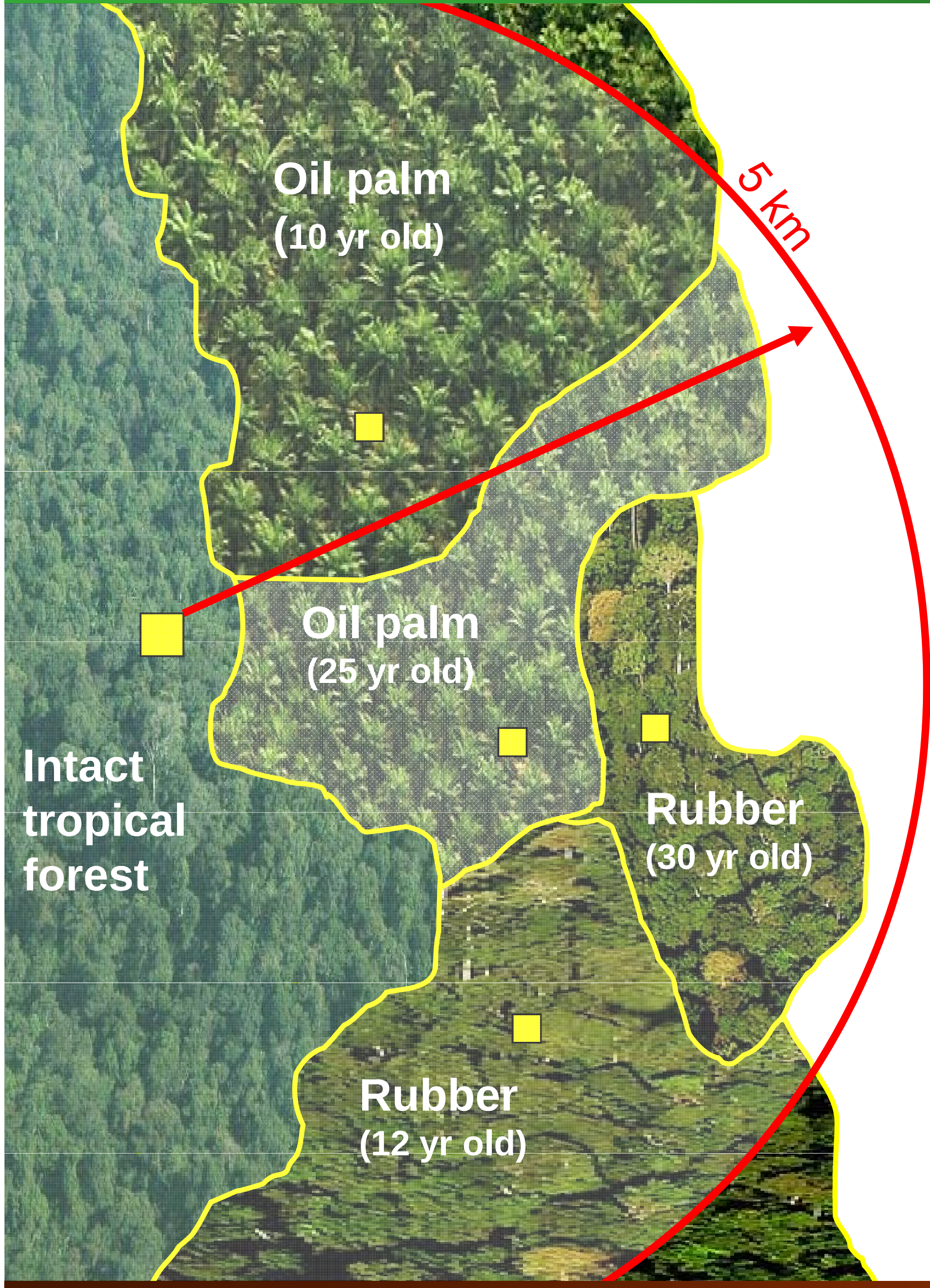
(Deforestation)

3. to oil palm

(landscape intensification)

Sampling sites in Jambi





Sampling design

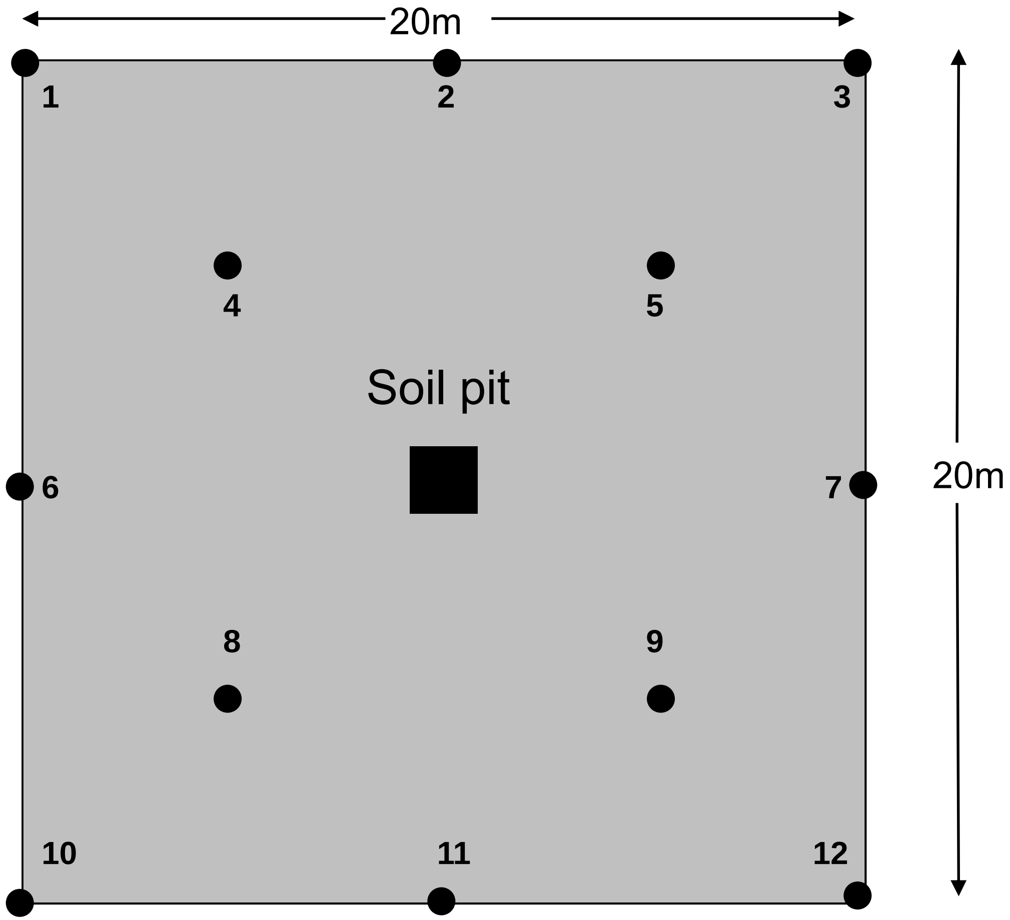
- Clustered design
- One reference site
- Compared with converted landuse
  - Mature oil palm or rubber (different ages >10 yrs)
- Site selection criteria:
  - Landscape position
  - Texture
  - Close proximity (max. distance 5km)

Soil pit samples:

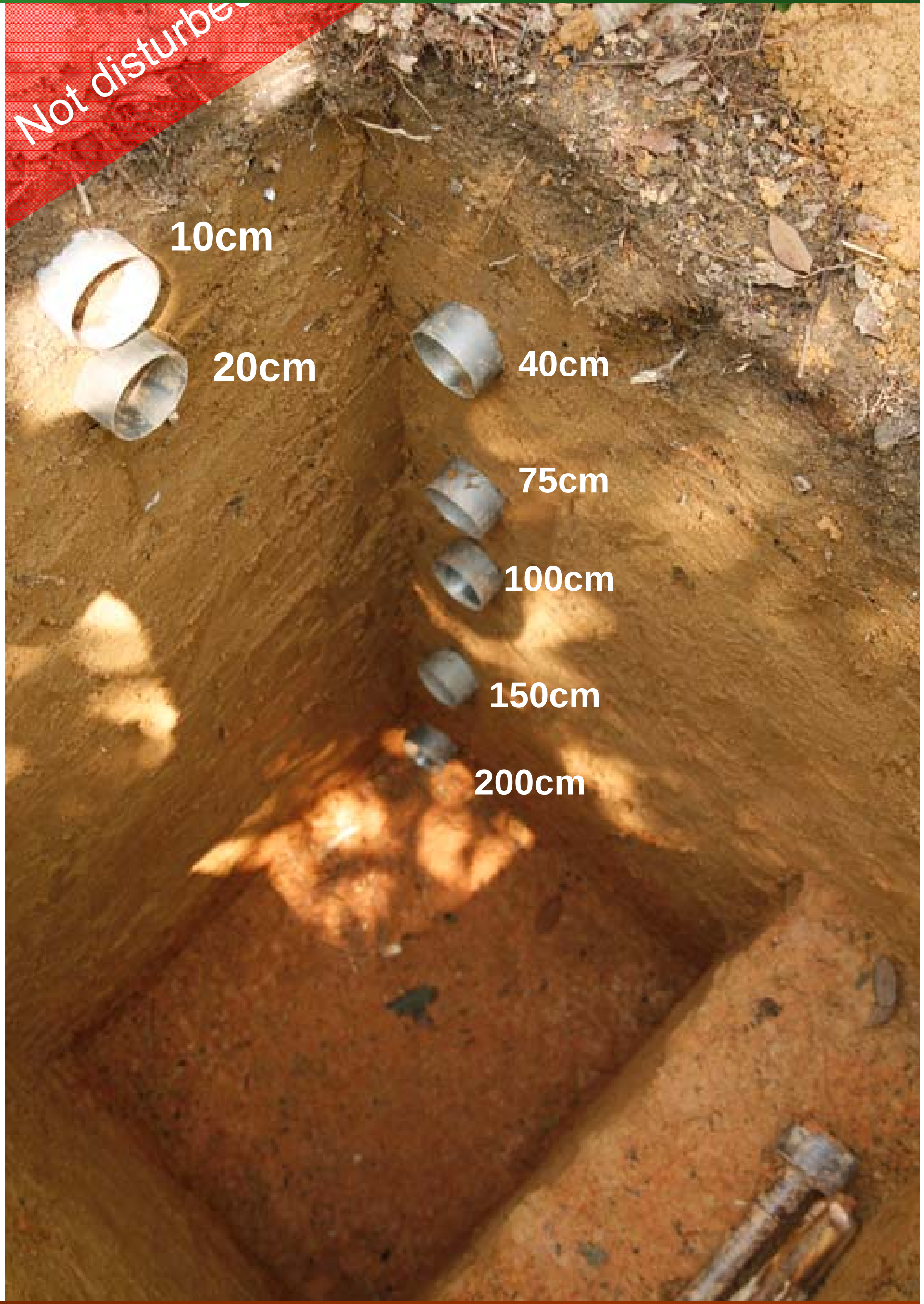
- 2 m depth
- Auger to 2-3 m
- Analysis:
  - C, N, CEC, pH
  - Texture
- Lab analysis planned to be done in Göttingen

Composite sample

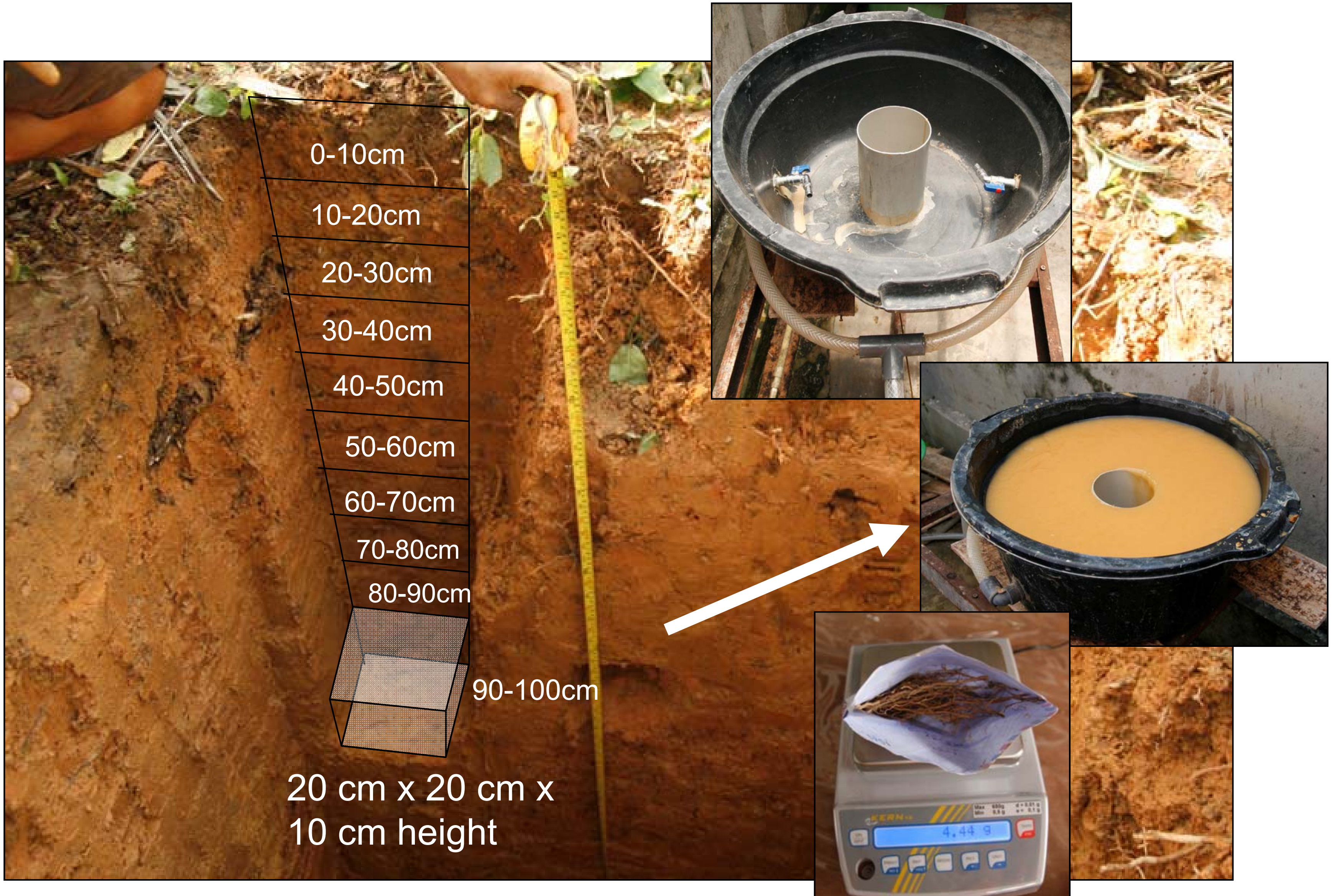
- 12 x composite soil samples (0-10, 10-30, 30-50cm)



Bulk density



Fine and coarse root biomass estimation



History of converted landuse

- Questionaire:
  - Age of current landuse?
  - What was the previous landuse? Age of previous landuse
  - Management of plantation (fertilization, cutting brush, burning etc.)



Outlook

	2010	2011				2012				2013	
	4th Qrtr	1st Qrtr	2nd Qrtr	3rd Qrtr	4th Qrtr	1st Qrtr	2nd Qrtr	3rd Qrtr	4th Qrtr	1st Qrtr	1st Qrtr
Indonesia	**Fieldwork**		**Lab analysis**		**Data analysis & write up**						
Cameroon			**Fieldwork**		**Lab analysis**		**Data analysis & write up**				
Peru					**Fieldwork**		**Lab analysis**		**Data analysis & write up**		

ISRI Activities:

1. Carbon stock and properties of peat under several land use types in Jambi Province, Indonesia

2. Interactive effects of water table depth and ameliorant on CO_2 flux

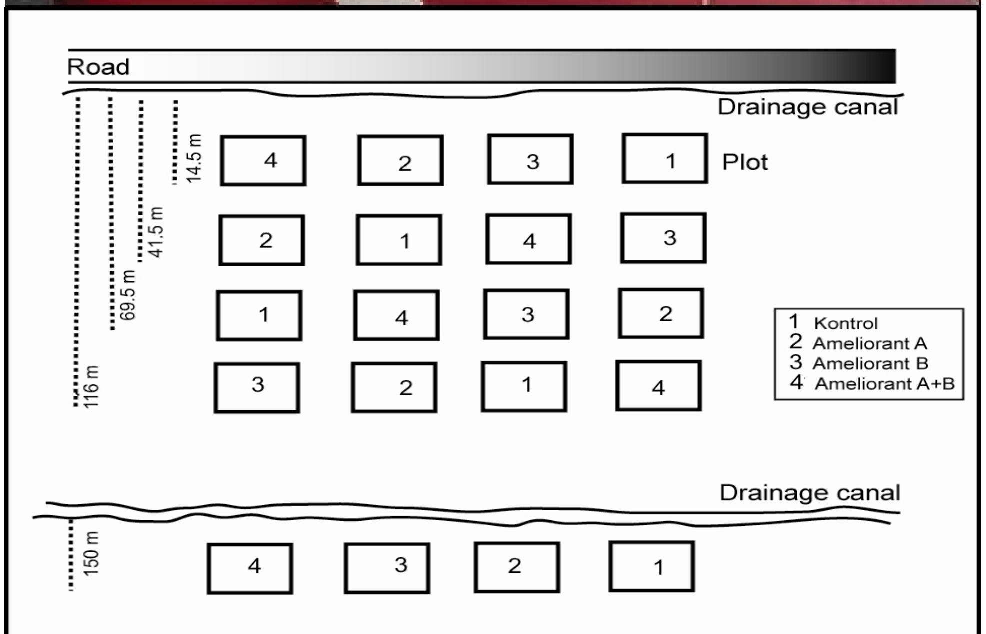
3. Microbial Activities as Affected by Peat Maturity, Peat Dryness and Ameliorants

Study site description and sampling

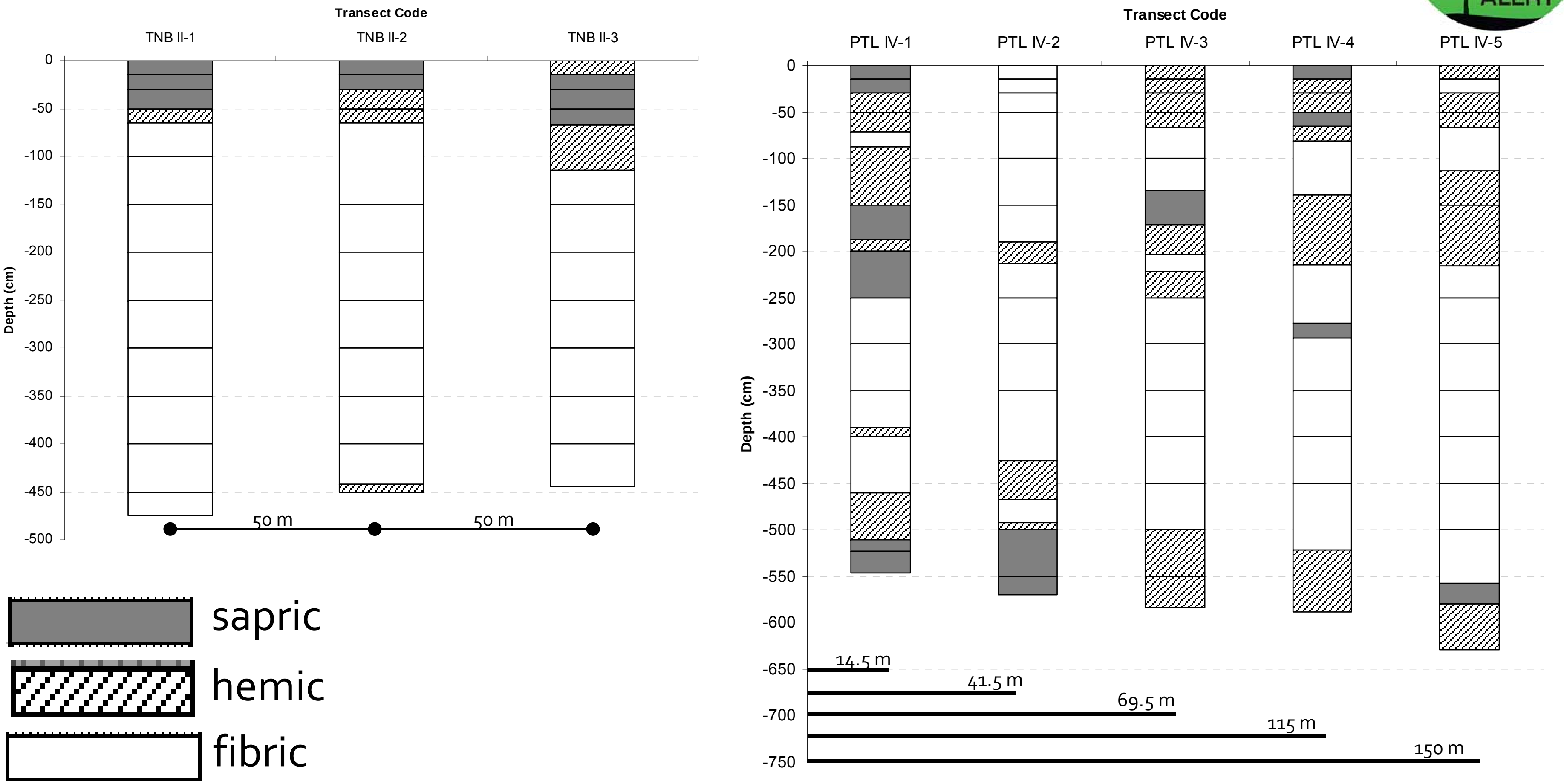
No	Coordinates	Land use	Peat depth	Location	
1	1° 52’ 53.5” S 103° 43’ 0.6” E	Oil Palm Plantation (13 years old)	Deep (>400 cm)	Ds. Sumberagung, Kec. Sungai Gelam, Kab. Muaro Jambi	PTL
2	1° 01’ 48.0” S 103° 19’ 52.1 ” E	Oil Palm Plantation (4 years old)	Shallow (<200 cm)	Ds. Sri Menanti, Kec. Betara, Kab. Tanjung Jabung Barat	SWT
3	1° 01’ 27.8” S 103° 19’ 42.9” E	Bumt forest, (young oil palm <1 yrs old)	Shallow (<200 cm)	Ds. Sri Menanti, Kec. Betara, Kab. Tanjung Jabung Barat	HTB
4	1° 01’ 26.3” S 103° 19’ 33.1” E	Logged Forest	Shallow (<200 cm)	Hutan Lindung Gambut (HLG) Bram Hitam	HLG
5	1° 27’ 48.1 ” S 104° 21’ 30.7” E	Primary forest	Deep (>400 cm)	Berbak National Park, Kab. Tanjung Jabung Timur	TNB

- Peat samples were taken from 0-15, 15-30, 30-50, and 50 cm using Eijkelkamp peat augers (for C and bulk density analyses)
- Composite peat samples were taken from the above sites for chemical analyses, C and N with C&N auto analyzer
- Samples are being processed for laboratory analyses


LI-820

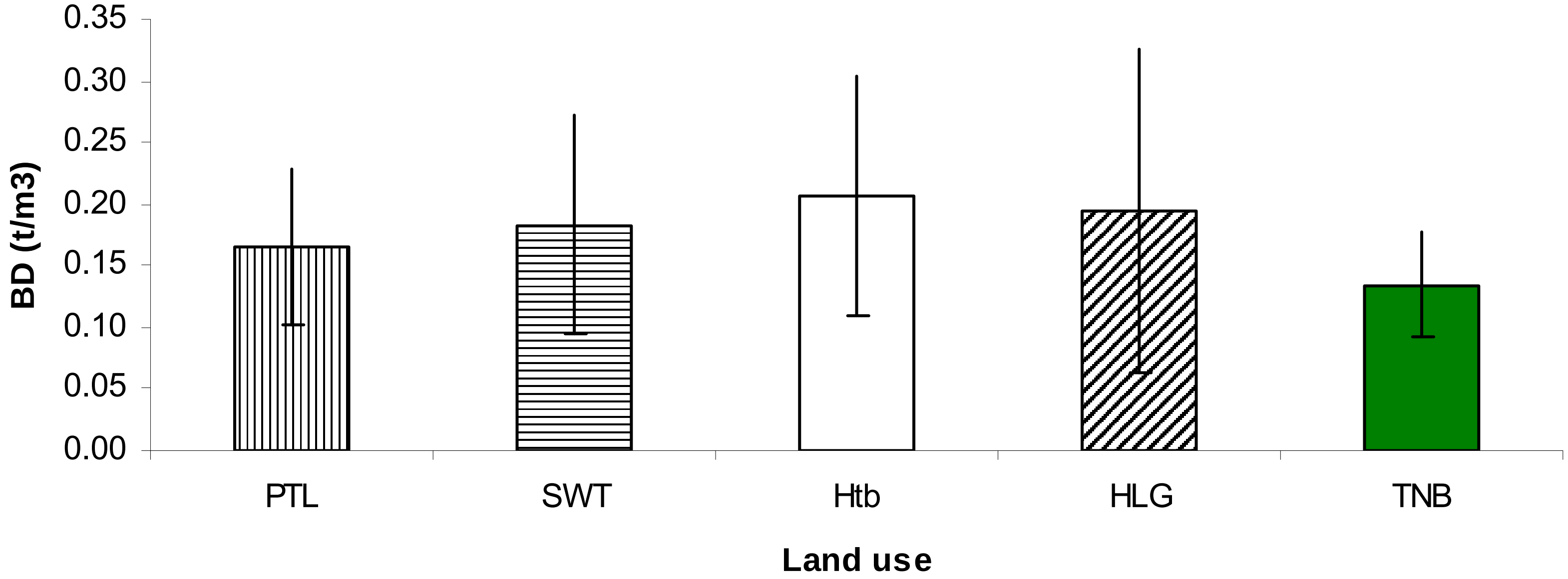

Road
Drainage canal
14.5 m
41.5 m
69.5 m
116 m
4
2
3
1
Plot
2
1
4
3
1
4
3
2
3
2
1
4
1 Kontrol
2 Ameliorant A
3 Ameliorant B
4 Ameliorant A+B
Drainage canal
150 m
4
3
2
1

Peat maturity in the study sites



- Peat maturity under 13 yr oil palm plantation (PLT) is more variable than that of primary forest (TNB)

Average Bulk Density of sites studied



PTL: 13 yr oil palm; SWT: 4 yr oil palm; HTB: Burnt forest; HLG: Logged forest; TNB: Primary forest

Correlation matrix of Distance, CO_2 flux, Soil & Air Temperatures and Soil Water Level

Parameters	Distance (m)	CO_2 flux (t/ha/y)	Soil T (^{0}C)	Air T (^{0}C)	SWL (cm)
Distance (m)	1.000	-0.535**	0.161	0.062	0.403**
CO_2 flux (t/ha/y)		1.000	-0.085	0.272*	-0.328**
Soil T (^{0}C)			1.000	-0.074	0.004
Air T (^{0}C)				1.000	0.015
SWL (cm)					1.000

SWL (Soil Water Level)

* 5% level of significance
**1% level of significance

REDD-ALERT WP3, Planned activities on N_2O, CH_4 fluxes:

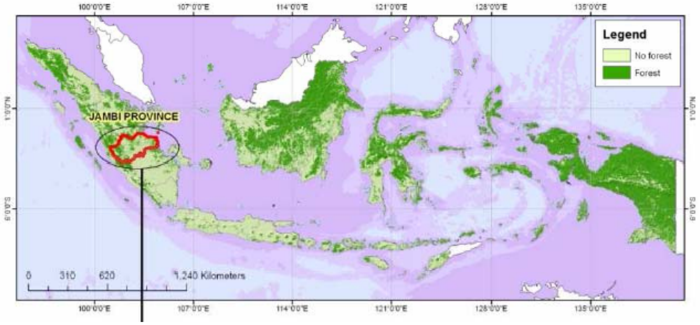
•Literature review of published case studies of land use change effects on N_2O emissions in tropical agriculture; meta-analysis

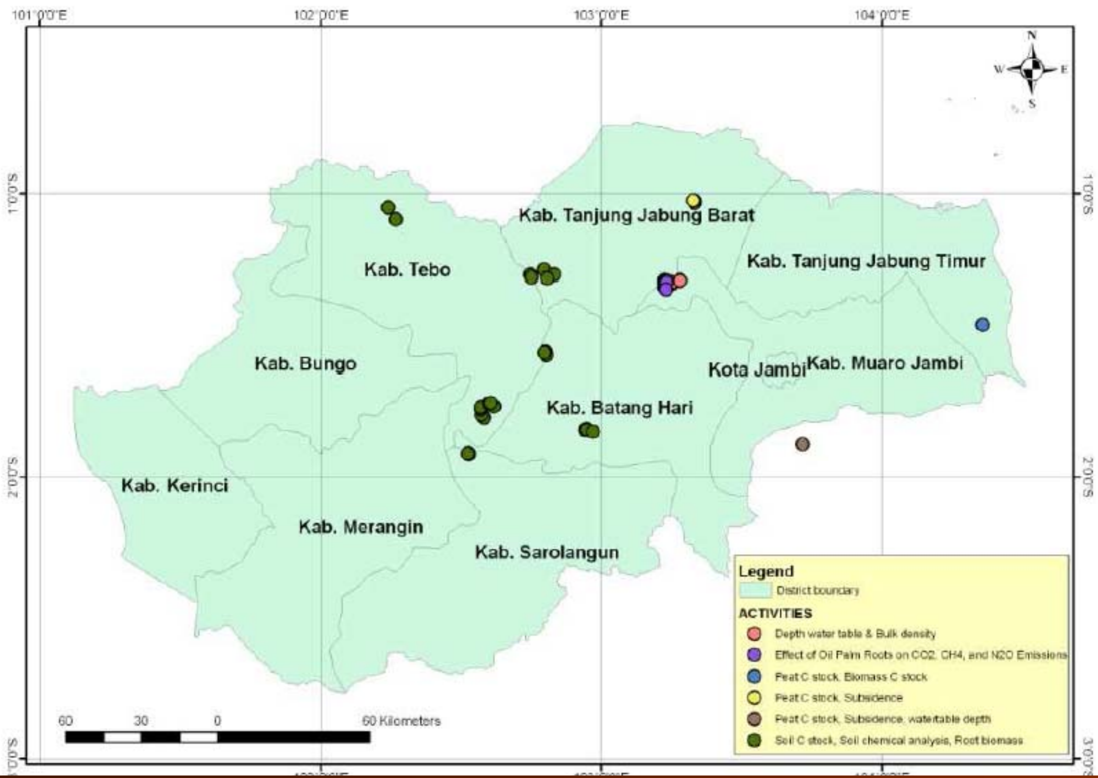
•Field studies in hot-spot area (Indonesia, Jambi) to quantify N_2O fluxes from intensive agriculture following forest clearing

•Special focus on tropical peat forests and intensive land use on cleared peat areas

•Develop simple relations between biophysical parameters and net GHG emissions as basis for extrapolation: focus on proxies of soil aeration status

Greenhouse gases flux changes associated with land use change in Indonesia





- **Mineral** soils

Pasir Mayang

Desa Harjran

Desa Bukit Suban

- **Peat** soils

Tajung Jabung Barat (shallow peat < 2 m)

Petaling & Berbak national park (deep peat up to 10 m)

Research in sites on mineral soils

Forest conversion to oil palm and rubber plantations

1) Changes in soil CO_2, CH_4 and N_2O fluxes

   Rainfall, air temperature, soil temperature & moisture, litterfall, mineralization & nitrification potentials, termite population

2) Soil carbon stock change, modeling approach

   Soil type characterization, bulk density, total carbon & nitrogen content, C^{13} & N^{15}

   Kristell Hergoualc'h

Research in sites on peat soils
Forest conversion to oil palm plantations

1) Peat and aboveground carbon stocks

Peat physical and chemical properties, water table level, C stocks in peat and aboveground vegetation (trees, understorey, necromass), peat subsidence

2) Root C stocks

Coarse root biomass, biomass C content, tree species inventory

Research in sites on peat soils
Forest conversion to oil palm plantations

1) Effect of water table depth & N fertilization on soil CO_2, CH_4 and N_2O fluxes in oil palm plantations

Rainfall, air temperature, soil temperature & moisture, water table depth.

Partitioning of **soil respiration** into **autotrophic** and **heterotrophic** components (~ trenching method)

2) Modeling of carbon loss from land use change

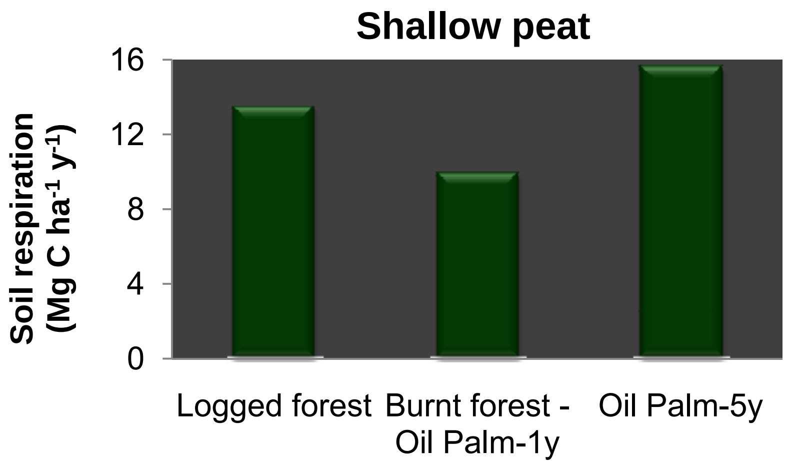
Rainfall, air temperature, soil temperature, water table depth, litterfall.
Partitioning of **soil respiration** into **autotrophic** and **heterotrophic** components (isotopic method)

Preliminary results on peat soils

1) Soil respiration

LF → BF-OP1y: ↘ due to ↘ root respiration

BF-OP1y → OP5y: ↗ due to ↗ both root respiration and peat decomposition (vicinity to drainage canal)

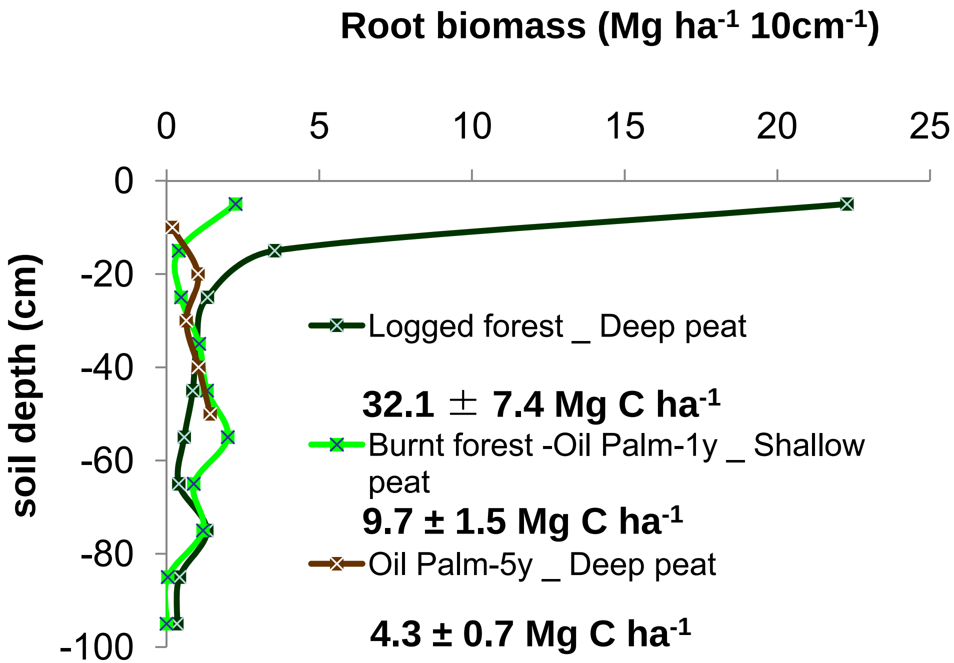


2) Coarse root biomass

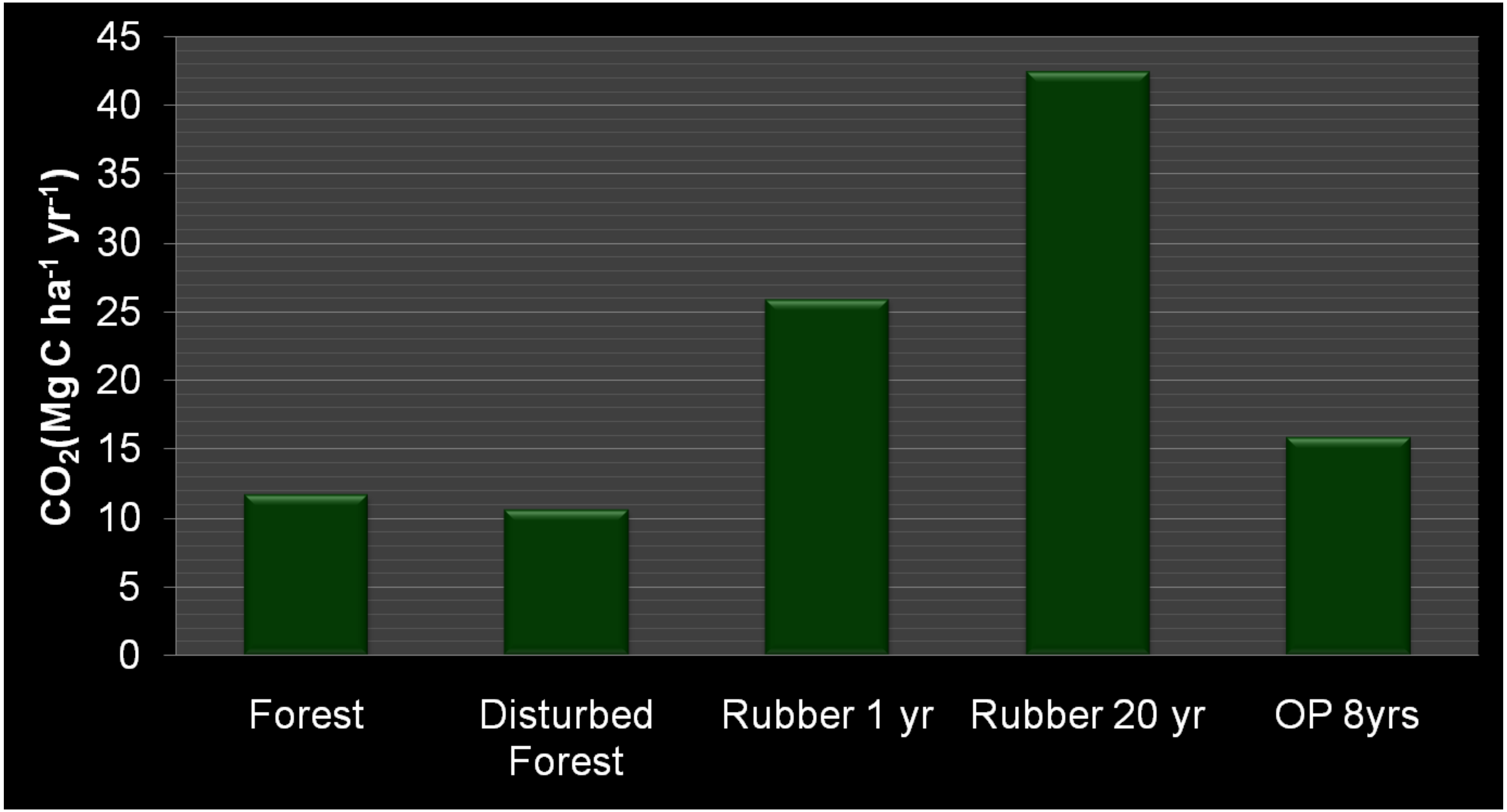
Logged forest: high root biomass

Burnt forest: still many roots from previous forest

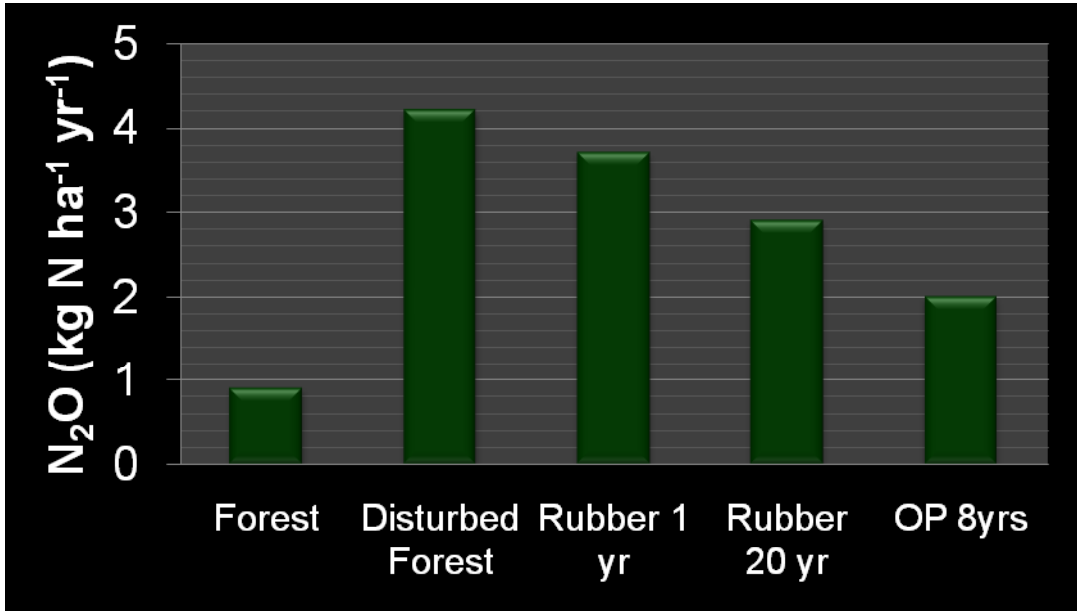
Conversion logged forest-oil palm: loss of 28 +/- 7 Mg C ha-1 from roots

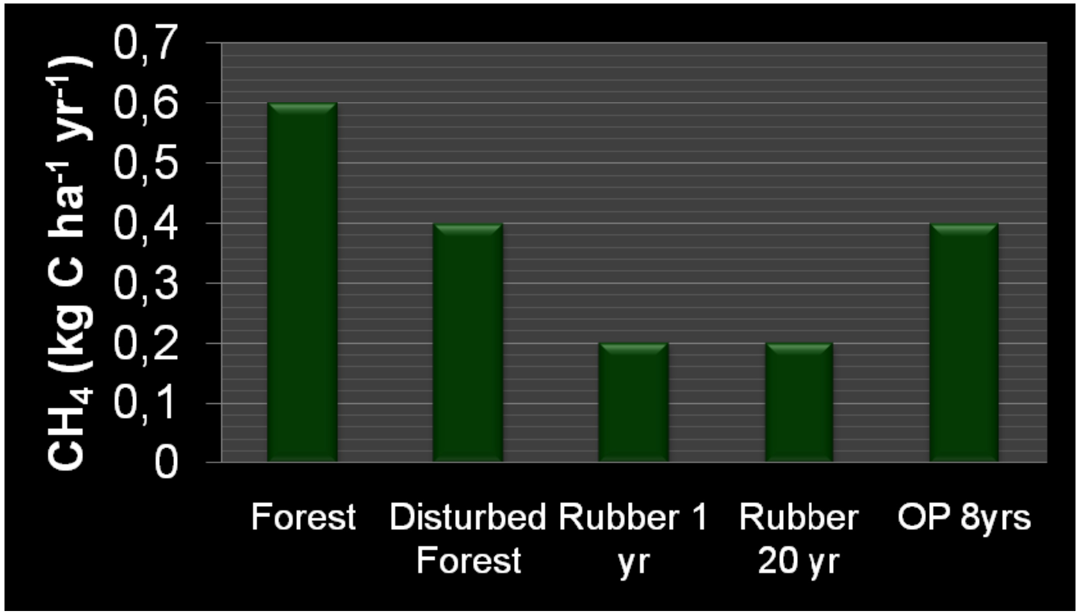


Preliminary results on mineral soils



Preliminary results on mineral soils





Thank you!