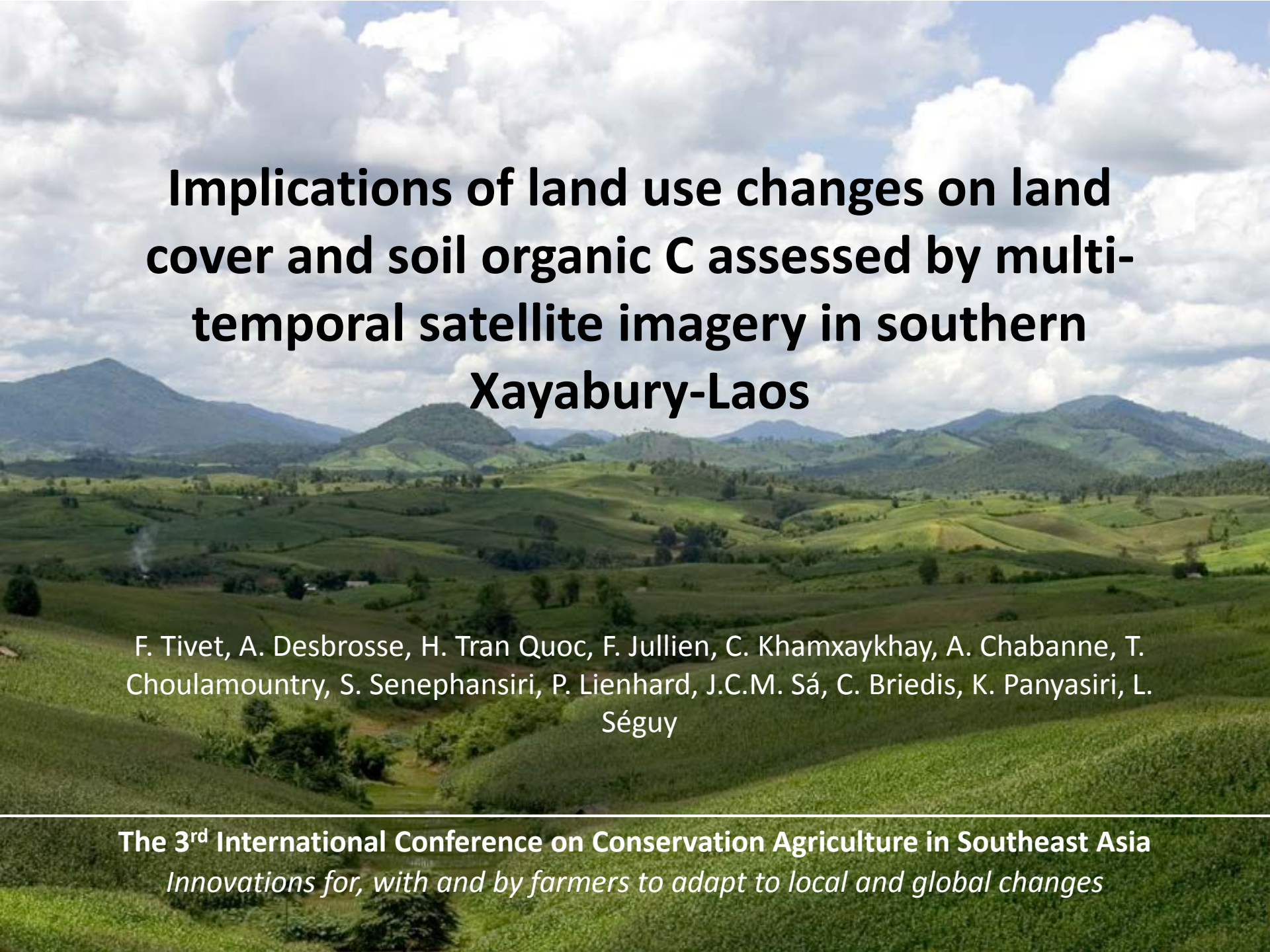


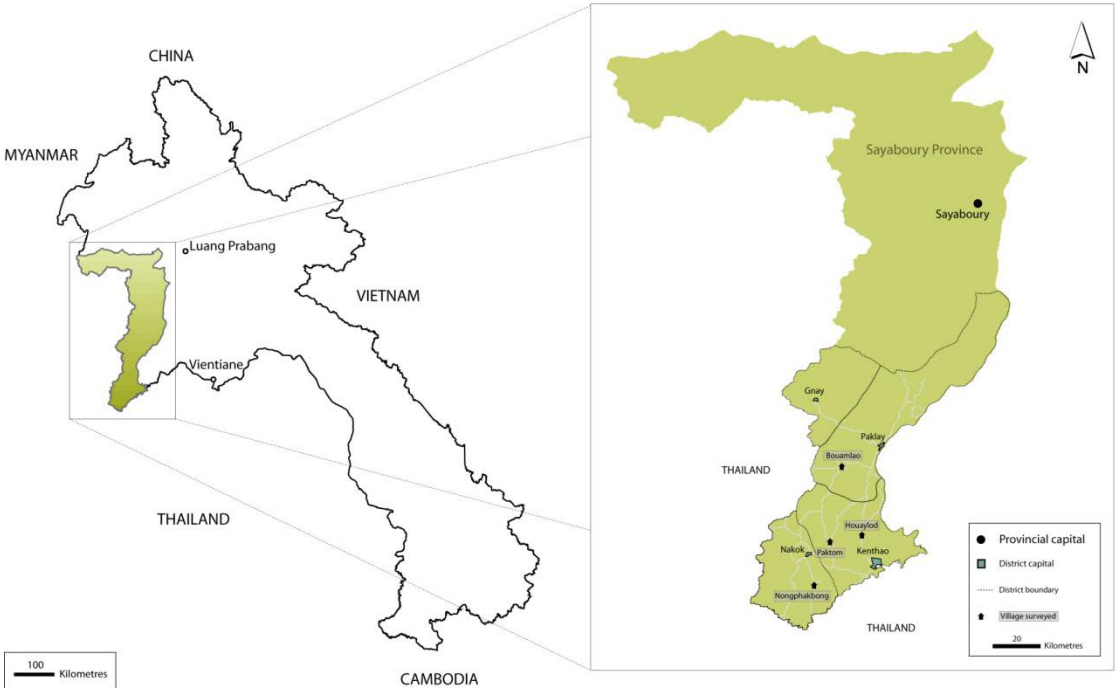
Implications of land use changes on land cover and soil organic C assessed by multi-temporal satellite imagery in southern Xayabury-Laos

F. Tivet, A. Desbrosse, H. Tran Quoc, F. Jullien, C. Khamxaykhay, A. Chabanne, T. Choulamountry, S. Senephansiri, P. Lienhard, J.C.M. Sá, C. Briedis, K. Panyasiri, L. Séguy

The 3rd International Conference on Conservation Agriculture in Southeast Asia

Innovations for, with and by farmers to adapt to local and global changes

Context and drivers of changes



- Increasing regional demand and market integration with Thailand
- Cash crops expansion and intensification, mainly maize monoculture
- Plow-based tillage, pesticides, hybrid seeds and chemical fertilizers

- High potential on basaltic and others clayeys soils
- Yields decrease drastically
- Increasing production costs and low labor profitability

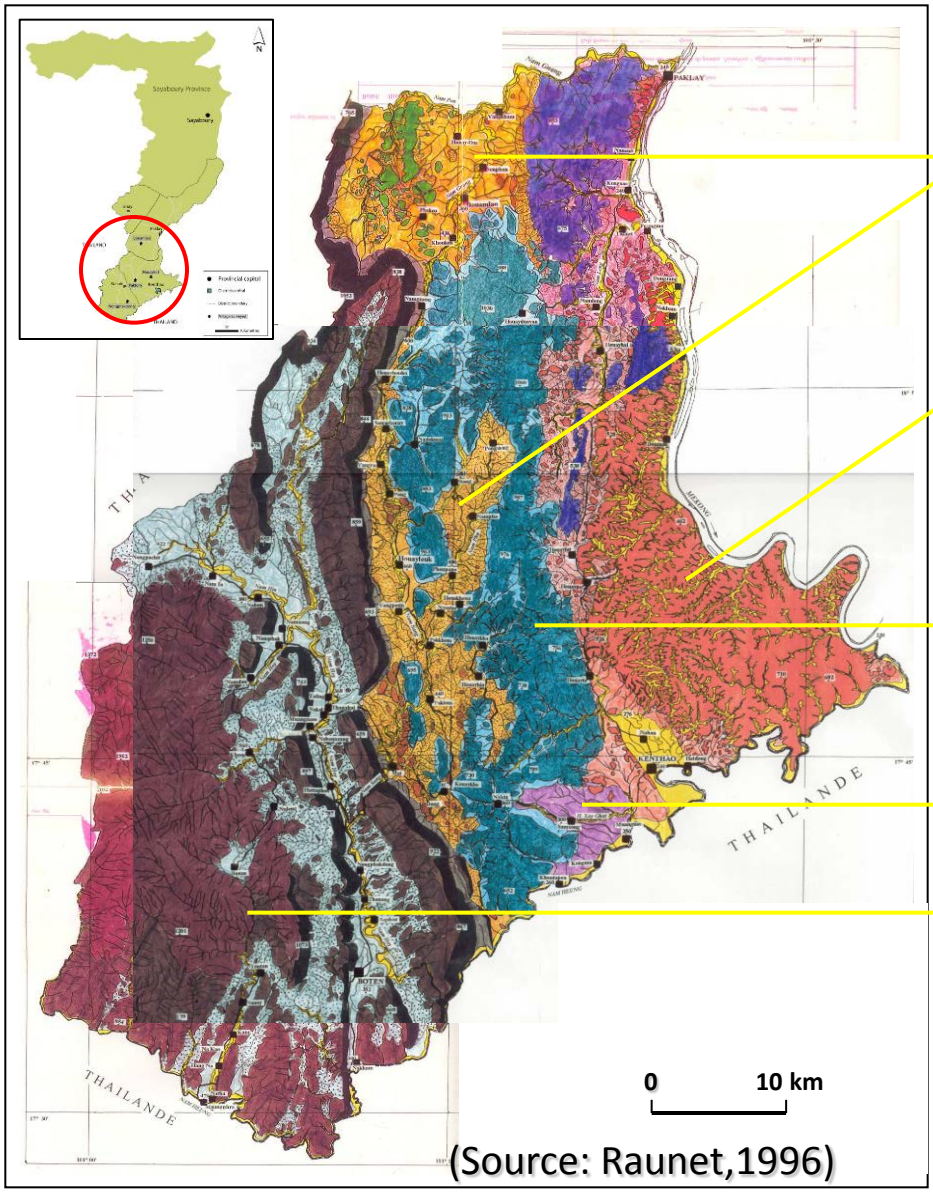
“Open fields”: disappearance of buffer and woodland zones (biological filters and corridors essential for biodiversity preservation and fauna/wildlife refuges)

Southern Xayabury

General objectives of the present study

- *Changes in land cover (1982 – 2010)*
- *Estimate changes in soil organic C after land conversion and plow-based tillage*
- *Raise awareness on the impacts of conventional tillage and restoration rate under NT cropping systems*

MORPHOPEDOLOGY & SOIL SAMPLING



(Source: Raunet,1996)

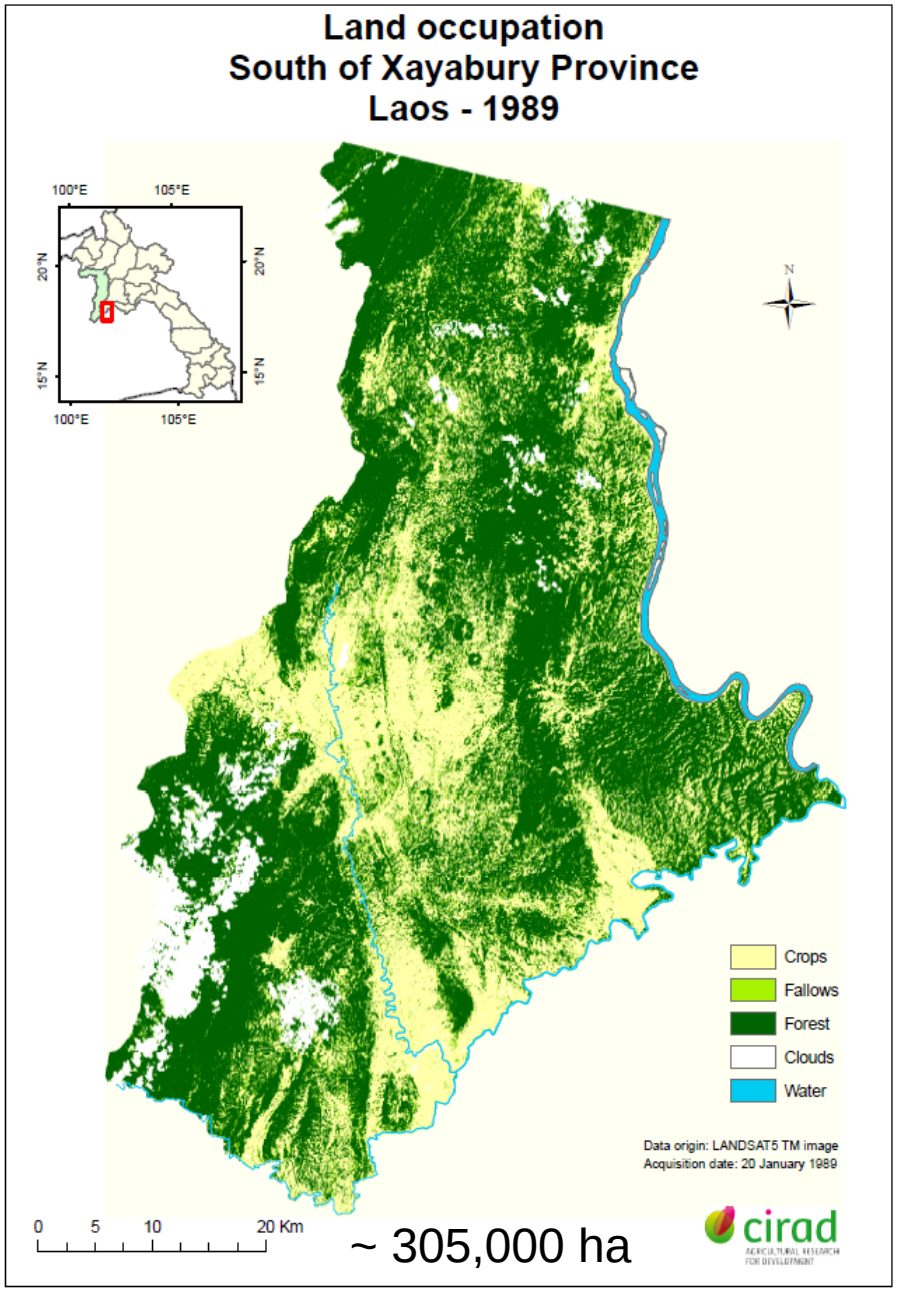
Clayey schale (illite) + igneous rocks

Clayey schale (kaolinite)

Igneous rocks (basic and intrusive: gabbro, dolerite)

Granite

Unfolded sandstones and claystones (Acrisol)



LandSat imagery 1982, 1989, 2000, 2005, and 2010

All images were orthorectified, geodetic reference system WGS-84

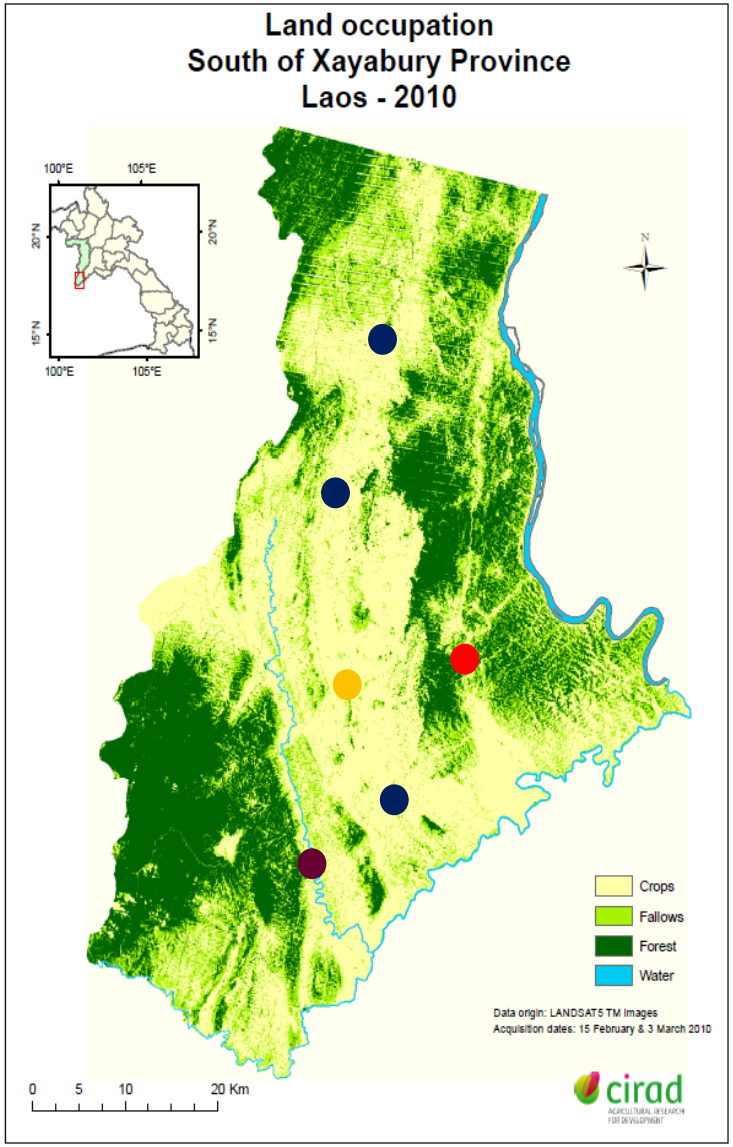
Of the 10 spectral profiles, three types have been aggregated

Unsupervised classification of these images (NDVI), improving the accuracy of the classification

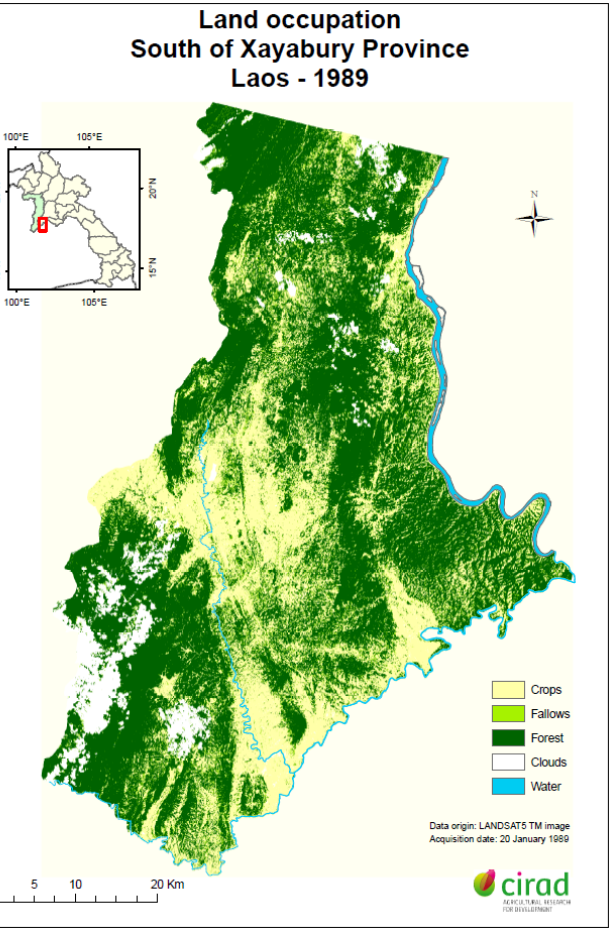
Field survey to validate the classification

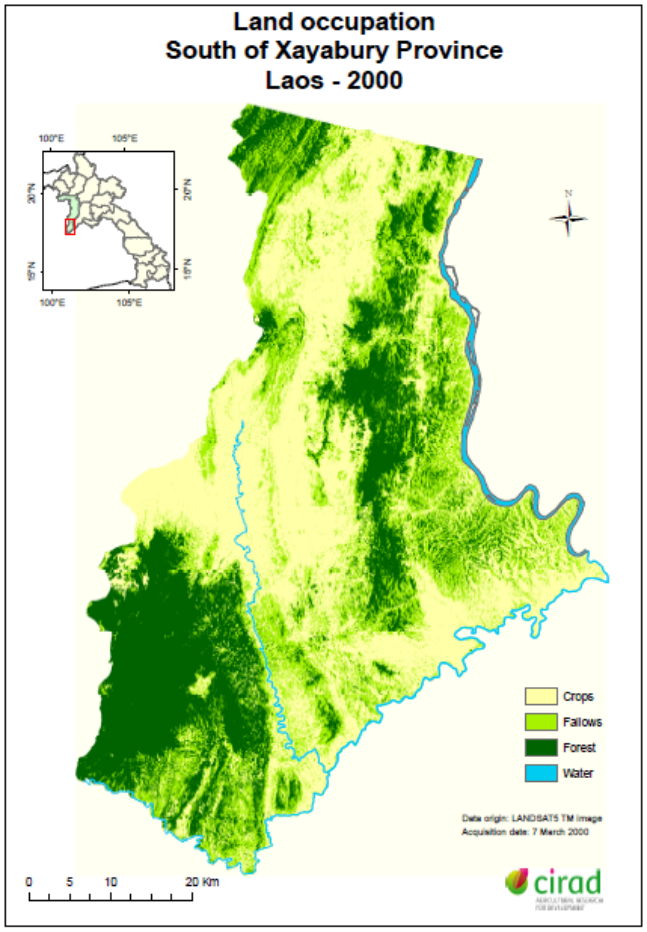
SOIL SAMPLING AND SOC

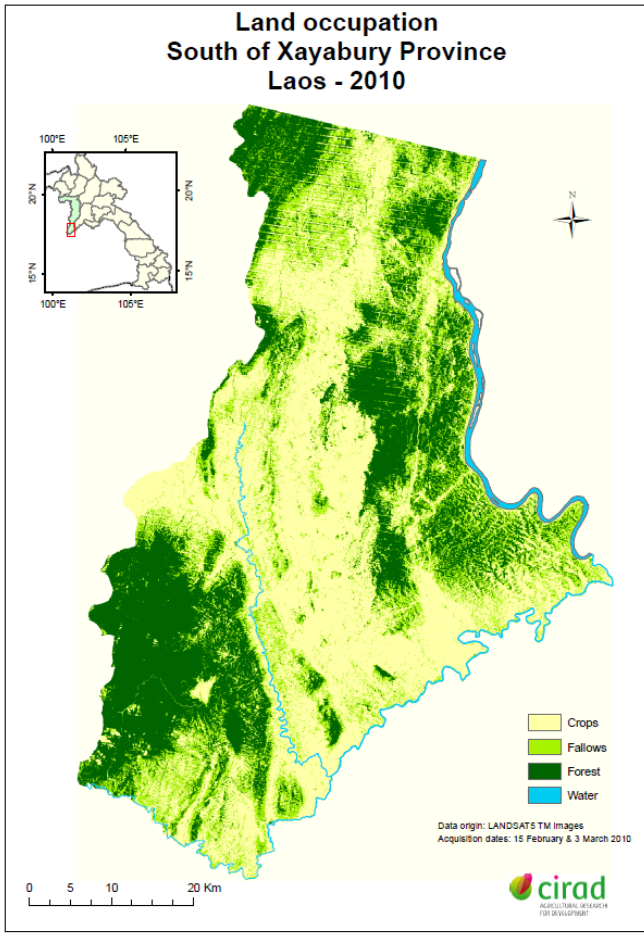
- Soil samples were collected in June and July 2009
- Six zones representing the main morphopedological units were selected
- Toposequence were identified and soil under native vegetation and conventional tillage were sampled: 24 points × 3 replicates
- Three depth: 0-10, 10-20, and 20-30 cm depths

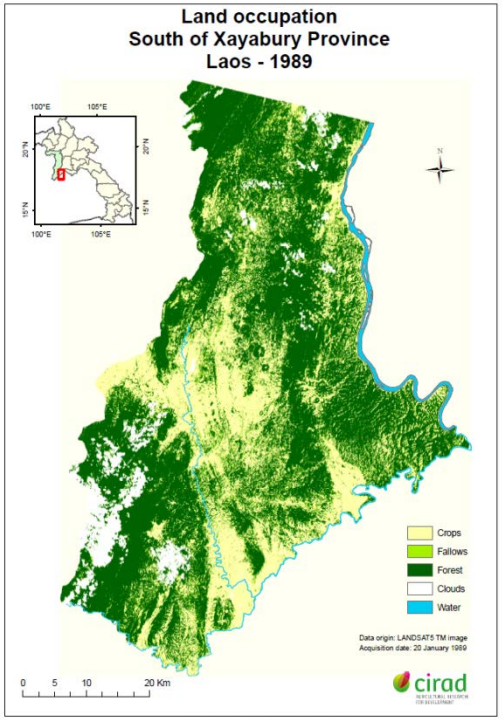


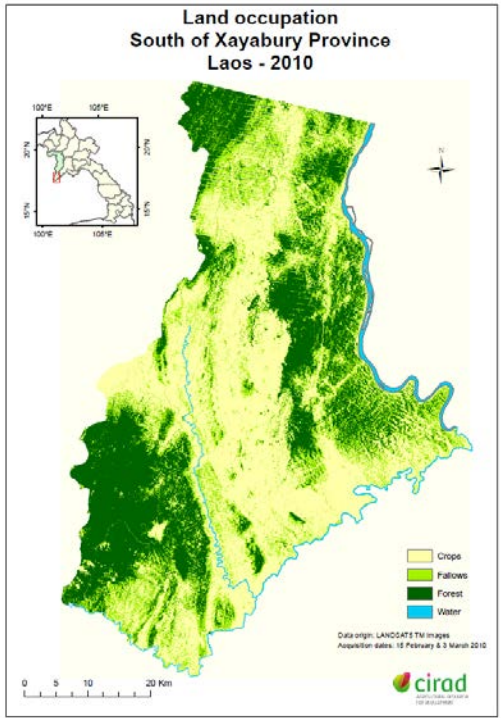
LAND OCCUPATION FROM 1989 TO 2010



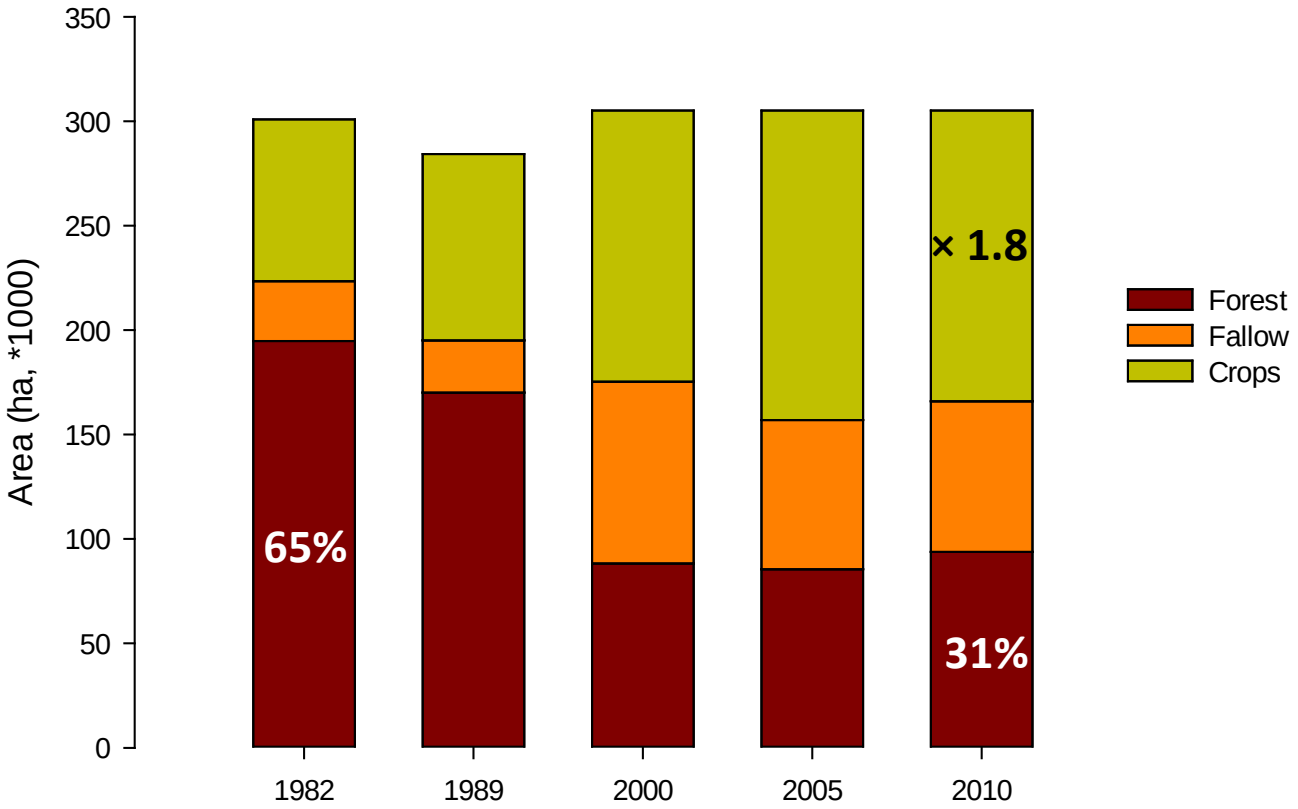








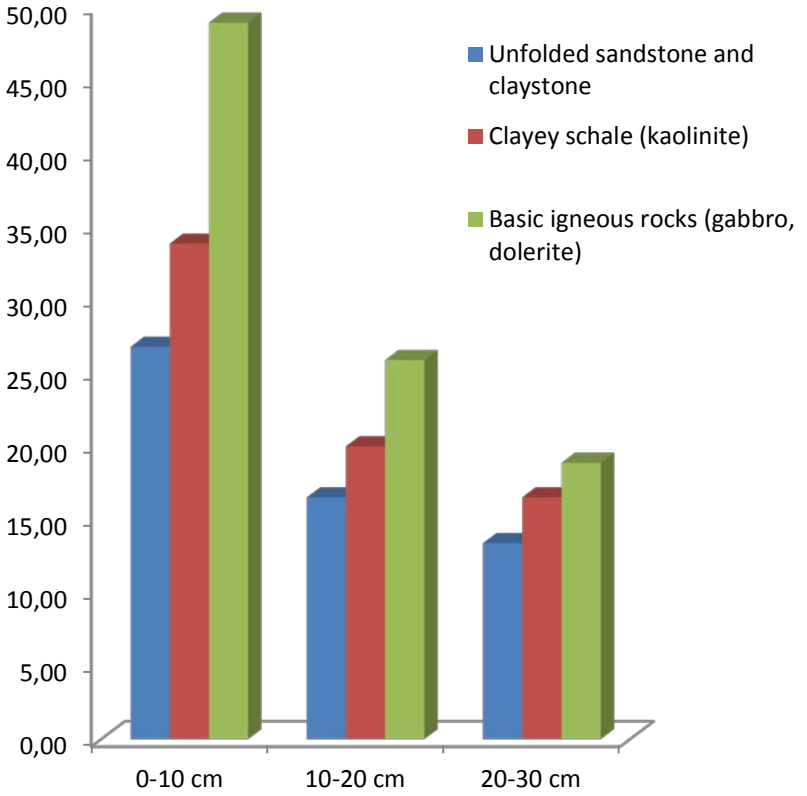
LAND OCCUPATION FROM 1982 TO 2010



During the period 1982-2010, overall forest area decreased from 194,780 ha in 1982 to 93,801 ha in 2010. By contrast, the area under cultivated lands increased 1.8 times, representing 139,130 ha in 2010.

Soil organic C (SOC) concentrations are closely related to the soil parent materials with higher SOC under soils on igneous rocks as parent material.

Concentrations of SOC were highly stratified with depth under NV.



Native vegetation

Basaltic soil and igneous rocks

Changes in SOC (0-30 cm) under plow-based tillage

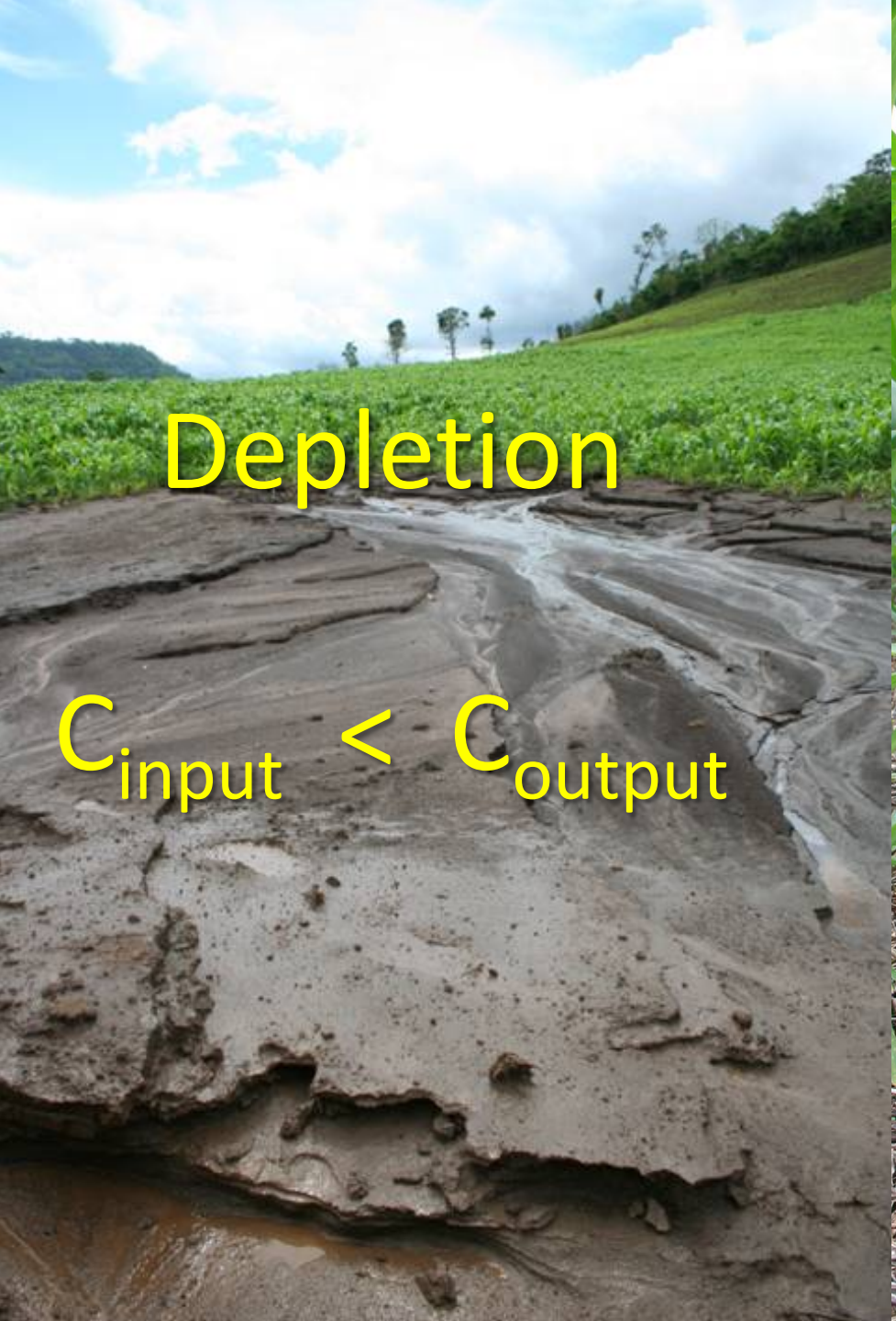
Land use	Parent material	Clay content (g kg^{-1})	SOC (g kg^{-1})		
			0-10 cm	10-20 cm	20-30 cm
NV	Unfolded sandstones and claystones	400	26.80	16.51	13.38
CT < 5 yrs, gentle slope		335	13.76	12.88	11.24
CT > 5 yrs, gentle slope		427	13.46	13.47	11.19
CT > 5 yrs, steep slope		306	9.72	9.65	9.92
NV	Clayey schale (kaolinite)	502	33.84	20.00	16.52
CT > 5 yrs, steep slope		482	21.34	17.49	11.59
CT 3 yrs, steep slope		452	15.07	14.78	13.33
NV	Clayey schale (illite) + igneous rocks	421	31.09	21.82	19.02
CT 2 yrs		339	23.68	24.43	23.84
CT > 5 yrs, flat		403	23.19	23.58	22.98
CT > 5 yrs, steep slope		473	18.53	18.53	18.44

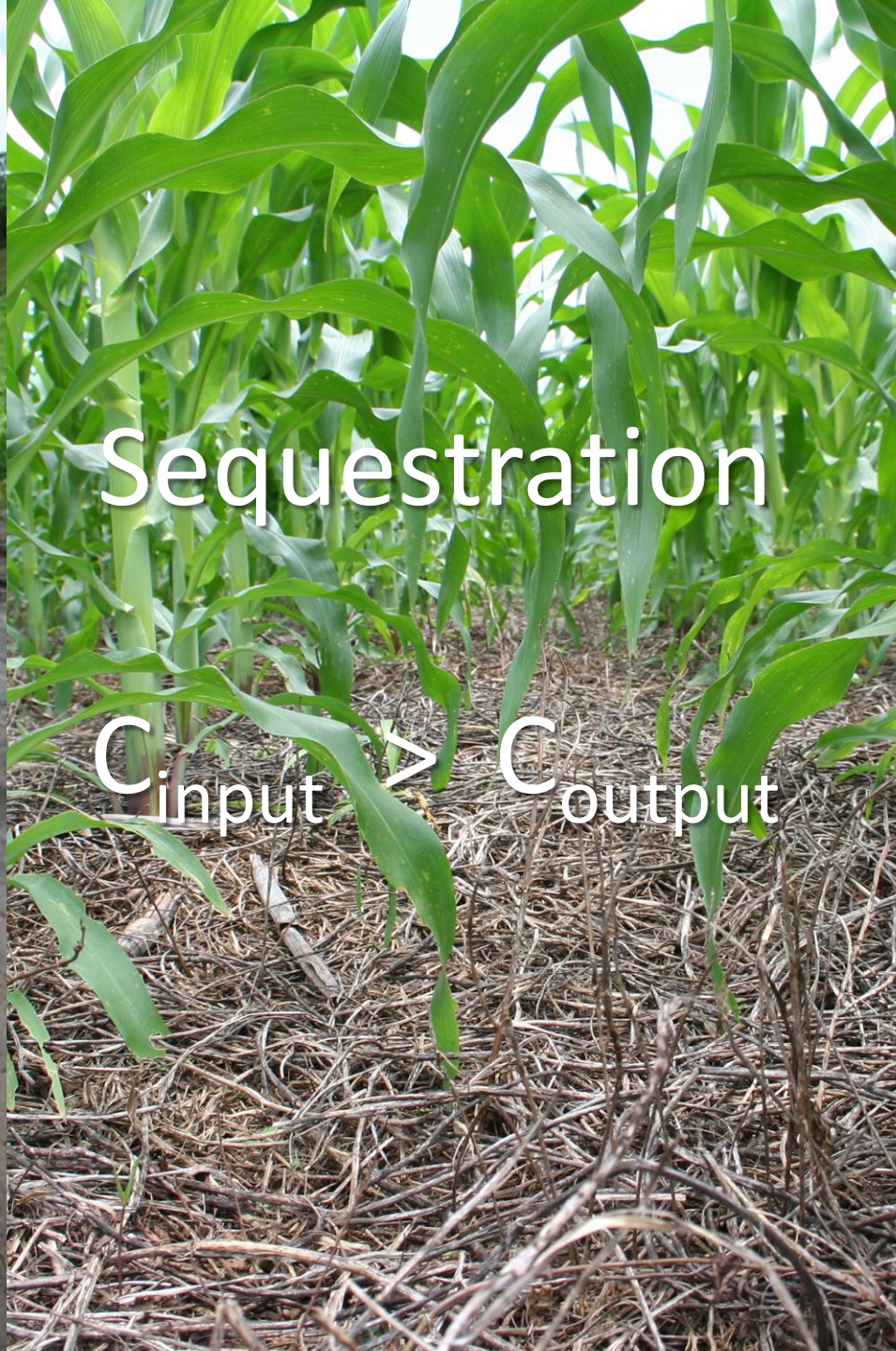
For the unfolded sandstone, the SOC concentration decreased from 26.8 to 12.3 g C kg^{-1} in the 0-10 cm depth, a decline of ~ 54% since the conversion. For the clayey shales, a decline of 46% and 30% was observed in the 0-10 cm depth under CT.

Changes in SOC (0-30 cm) under plow-based tillage

Land use	Parent material	Clay (g kg^{-1})	SOC (g kg^{-1})		
			0-10 cm	10-20 cm	20-30 cm
NV	Basic igneous rocks (gabbro, dolerite)	509	46.50	32.08	26.65
NV		446	30.27	18.20	15.13
CT gentle slope		473	18.66	17.95	13.75
CT gentle slope		500	20.59	19.88	17.08
CT, flat		493	19.95	19.10	14.85
CT steep slope		467	15.85	15.30	12.75
NV		358	48.93	25.89	18.87
CT > 5 yrs, gentle slope		437	22.73	26.80	26.81
CT > 5 yrs, gentle slope		487	24.06	23.27	23.56
NV		412	30.42	19.50	14.45
CT < 5 yrs, gentle slope		390	23.66	24.74	20.79
CT > 5 yrs, gentle slope		403	28.79	27.81	26.09
CT > 5 yrs, steep slope		456	22.27	22.69	21.24

The average SOC concentrations of the igneous soils in 0-10 cm depth decreased from 39.0 g C kg^{-1} in NV to 21.3 kg C kg^{-1} in CT fields, a decline of ~ 44% since the conversion of NV into cultivated field.


Depletion
$C_{input} < C_{output}$


Sequestration
$C_{input} > C_{output}$

Iterative approach with smallholders

using local species


Maize on former maize residues


Two years rotational sequence between maize and rice-bean

Equipments

More complex systems


Maize + pigeon pea

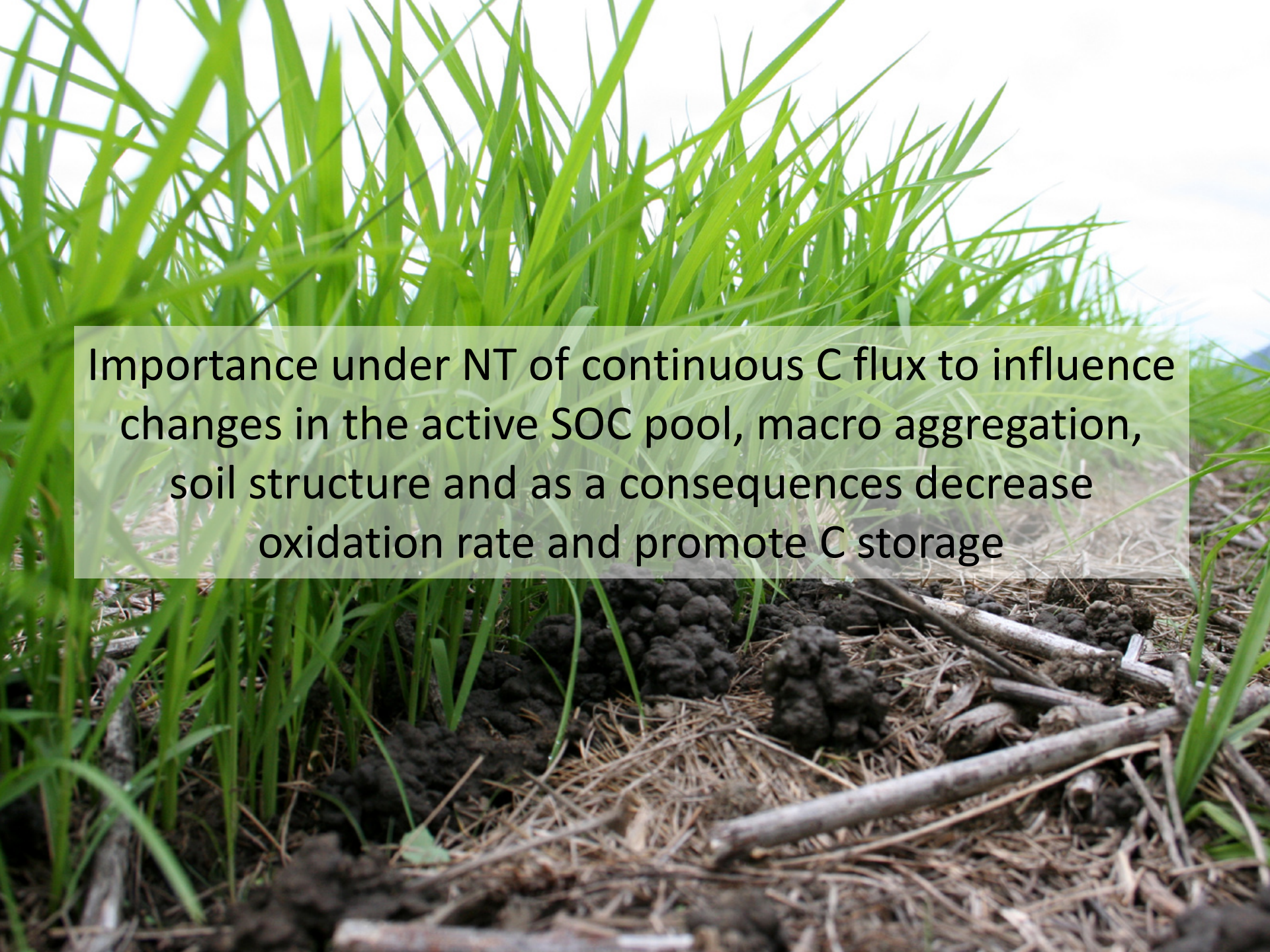

Rice-bean on maize + *Brachiaria*


Maize & rice-bean intercropping

Changes in SOC stock (0-30 cm) – soil on igneous rocks

Tillage	Different position			Mean	Δ SOC
	Stock SOC Mg ha^{-1}				(Mg ha^{-1} yr^{-1})
Maize monoculture	flat	gentle			
CT	68.0	70.9		69.4	
NT0	70.1	73.0		71.5	0.26
NT1	75.3	79.3		77.3	0.98
Maize/ricebean	gentle	flat	flat		
CT	71.9	81.8	74.0	75.9	
NT0	70.7	83.0	86.9	80.2	0.53
NT1	71.3	84.1	88.3	81.2	0.66
Maize + ruzi/ricebean	flat	steep	steep		
CT	69.8	79.4	60.3	69.8	
NT0	72.1	82.6	76.2	77.0	0.89
NT1	73.4	90.2	82.4	82.0	1.52

Different position on the toposequence (steep, gentle and flat land). ΔSOC = (NT – CT)/8 years.


Importance under NT of continuous C flux to influence changes in the active SOC pool, macro aggregation, soil structure and as a consequences decrease oxidation rate and promote C storage

A global approach of landscape management and productivity enhancement

Small-scale farming, southern Brazil

Reforestation with multipurpose species to recreate buffer zones (continuous fauna corridor, rivers protection: water quality, biodiversity, infrastructures protection…) & integration of NT cropping systems (soil potentialities, diversification) with animal husbandry.

Rice direct seeded on *Stylosanthes guianensis* residues