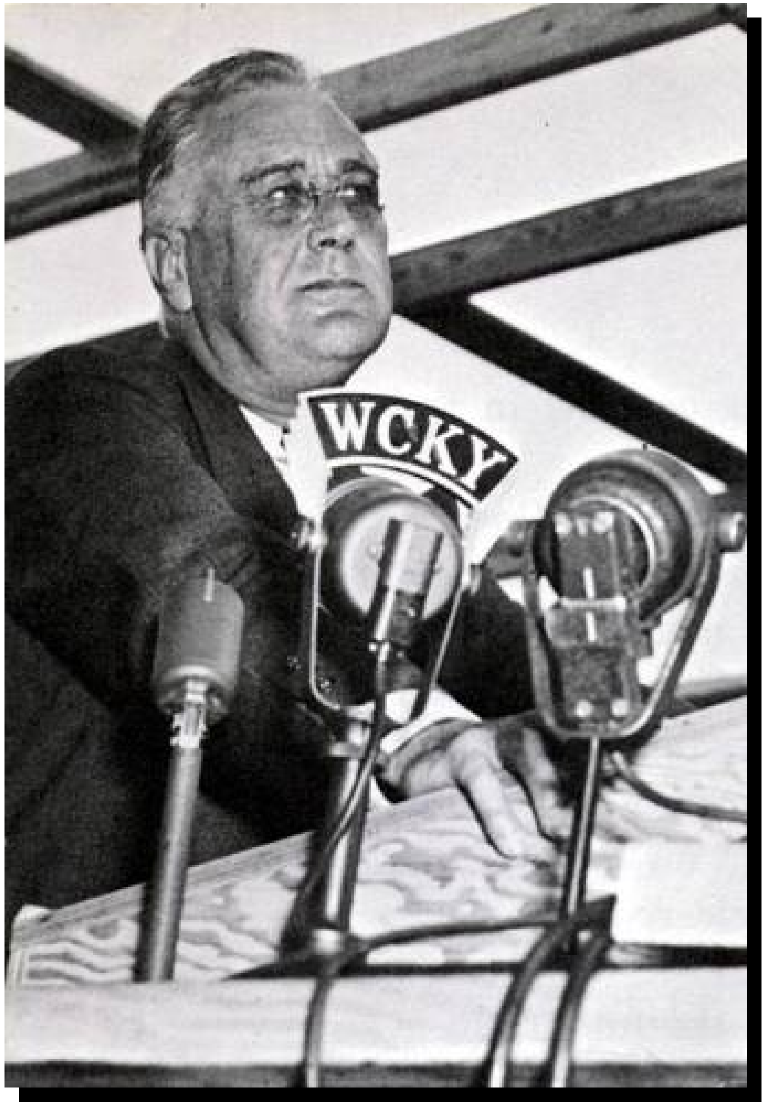
Dust bowl

Texas 1935

http://www.weru.ksu.edu/vids/dust002.mpg



“A nation that destroys its soil destroys itself”

F.D. Roosevelt

Soil Erosion and alternative strategies in Southeastern Asian catchments Laos and Vietnam

Valentin, C. (1), Huon, S. (2), de Rouw(1),
D. Orange, (1), A., Ribolzi(1), O., Thiébaux, J.-P (1), Chaplot(1), V.,
Rumpel, C.(2), Sengtaheuanghoung O.(3), Toan T (4), Vigiak O. (5)

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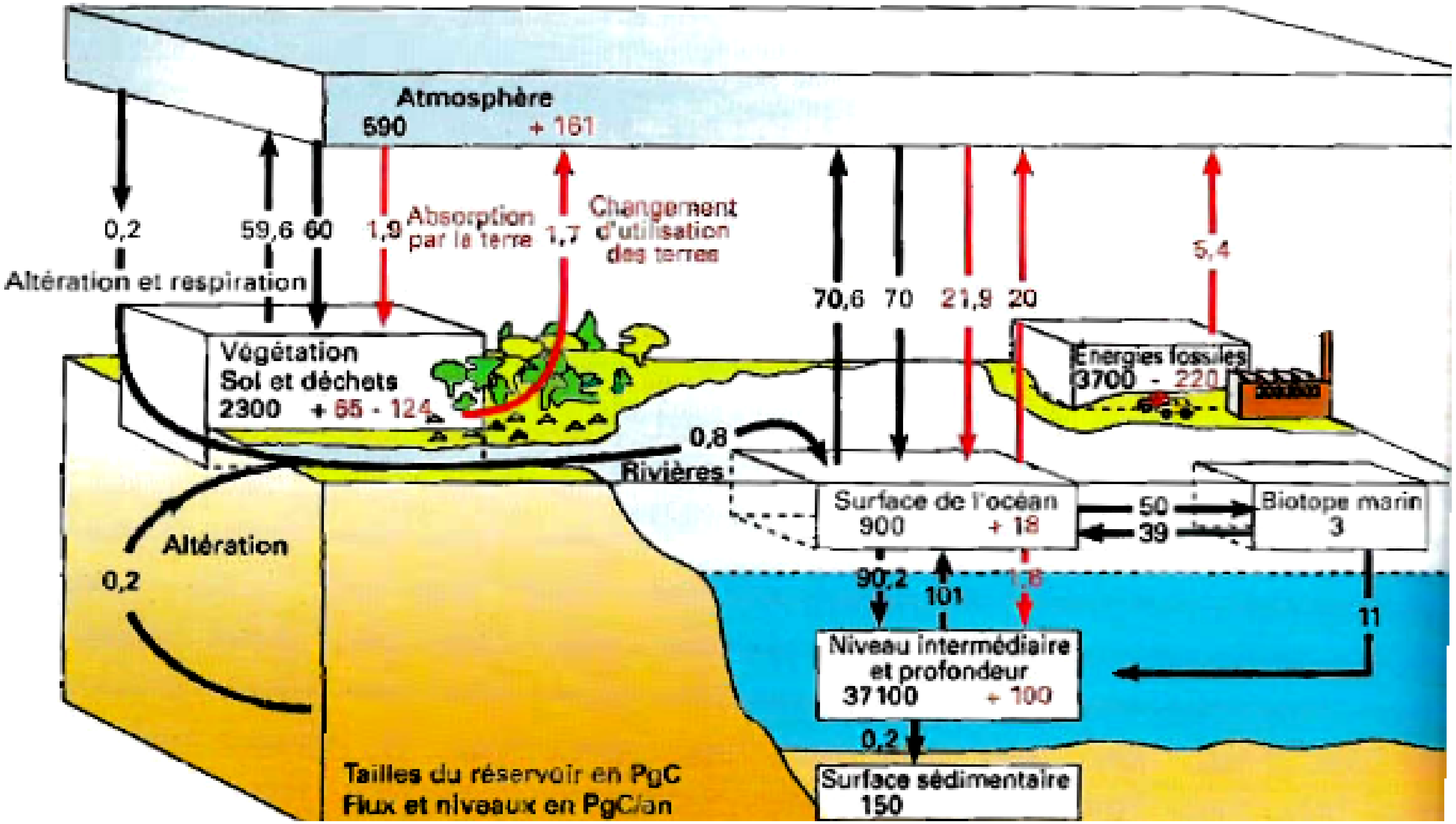
Soil Erosion versus Soil Conservation

- Context of increasing risk of soil erosion: climate and land use change (e.g, Robert, 2005):
  - More frequent high-intensity events
  - Rapid land conversions

- The crucial need for soil on-site conservation practices
  - Malagasy: (e.g., DOUZET et al, this meeting)
  - Brazil: Cogo et al., this meeting)

Off-site impacts of sediments: sinks or sources of CO_2?

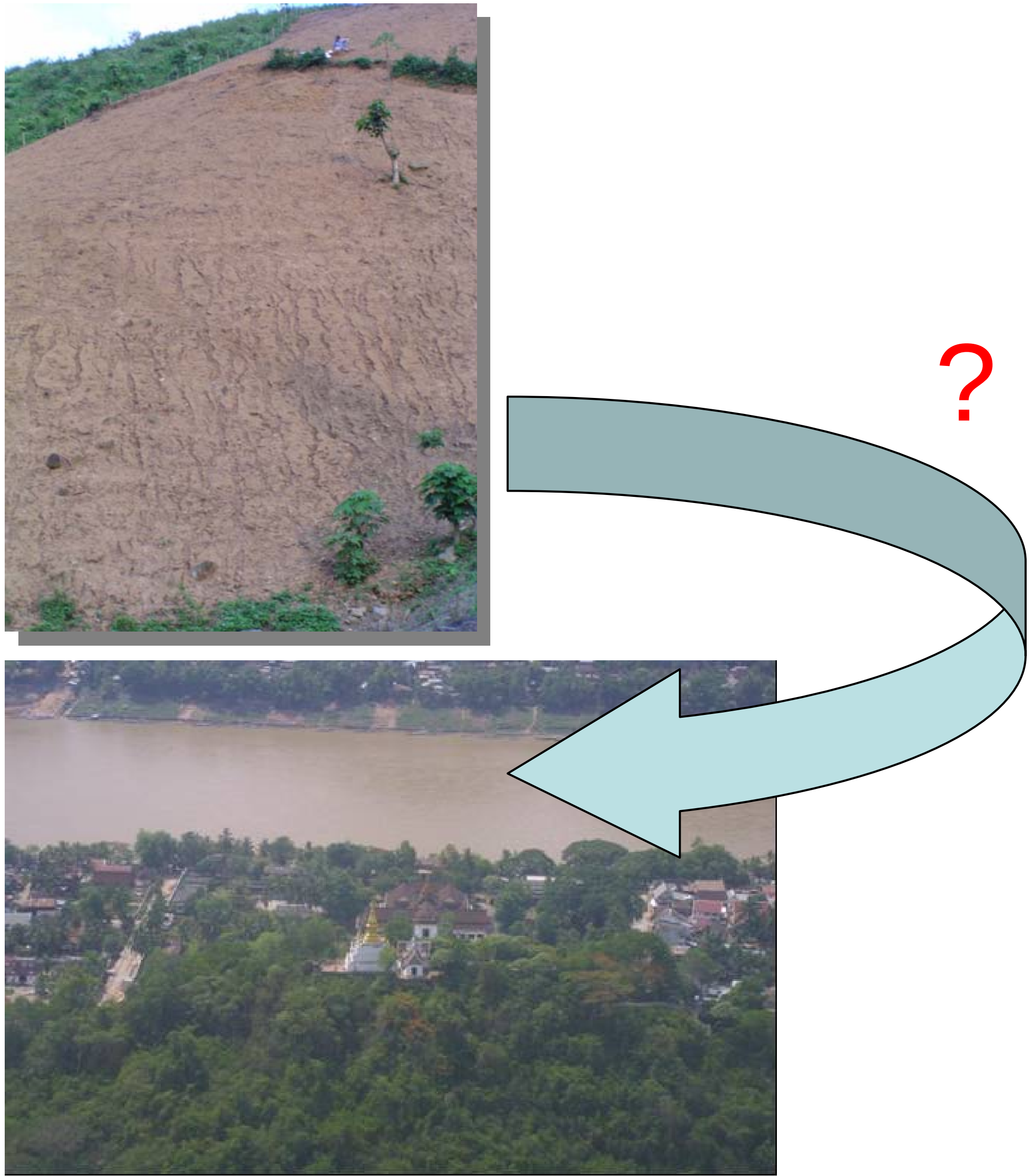
20-30% of extra-mineralisation during transport (e.g., Lal, 2005)



Adapted from Sarmiento et al., 2000. *Global Biochemistry Cycles*, 14(4): 1267-1281, by Merle, 2006

Are researchers on track to provide useful scientific inputs for developing and testing promising new environmental policy interventions?’ (Tomich et al. 2004)

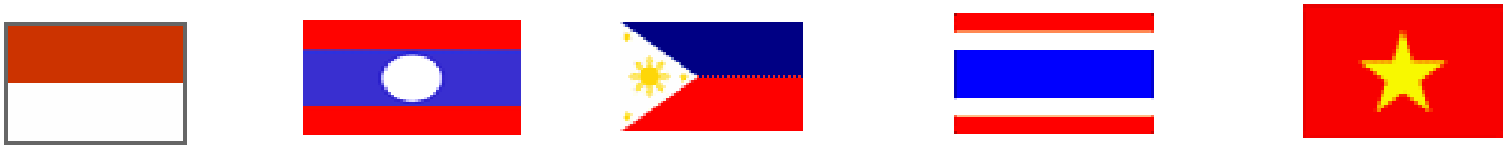
- Are larger scale processes (gully erosion, landslides, bank erosion, etc.) more important in sediment yields than plot-scale erosion processes ? Soil erosion results from scale-dependent processes
- Are the farmers really to be blamed for low water quality in the rivers and siltation of the dams ?
- Should not we concentrate on the protection of the wetlands and the riparian zones ?



Management of Soil Erosion Consortium

Indonesia, Laos, Philippines, Thailand, Vietnam,

CGIAR- ADB-IBSRAM-IWMI-IRD



Only very few data available from tropical agricultural catchment on Organic Carbon losses

- 2002 Montpellier workshop:
  - 17 presentations on soil erosion from plots
  - 12 presentations in the 'hillslope section' but only four on catchments:
    - Venezuela and Laos (Huon et al.)
    - Central France: nothing on carbon losses
    - Southern France: nothing on carbon losses
    - Poland: from soil erosion plots.
- 2007 Antananarivo workshop:
  - 8 presentations:
    - 1 on Organic C-losses from catchments.

Objectives

Main results on the impact of:

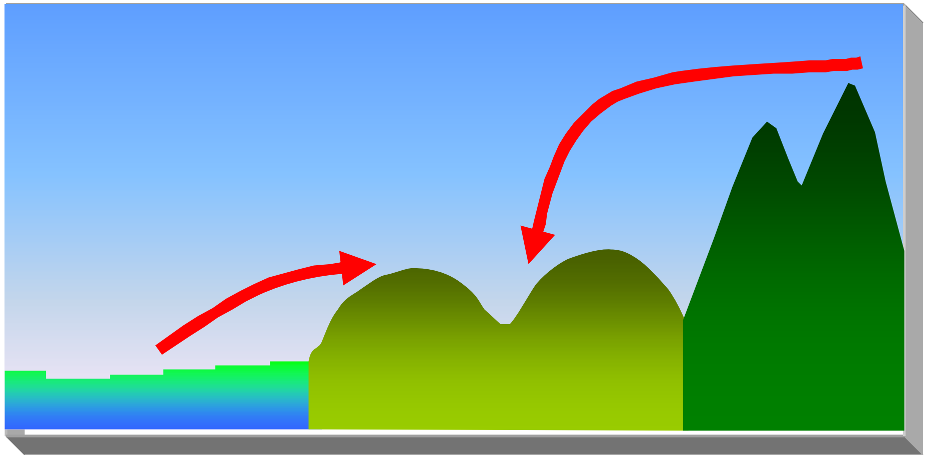
- the **current rapid land use changes**
- and **selected alternative strategies** on Organic C losses from 13 catchments of northern Laos and Vietnam.

Outline

- Context, sites and methods
- Main results
  - Under current farmer practices and changes
  - Alternative strategies : improved fallow, DMC, tree plantations, fodder crop.
- Discussion
- Conclusion

Rapid changes of the upland farming systems

- Increased population pressure:
  - natural demographic growth
  - migration to the upland areas
  - government policies for settlement and conservation



- increased dependence on ‘‘market forces’’
  - escalating market demand for agricultural products (including non-food products)
  - improved market access
  - needs of farmers to generate additional sources of short term income

The Houay Pano catchment

Lak Sip village located 10 km from Luang Phrabang

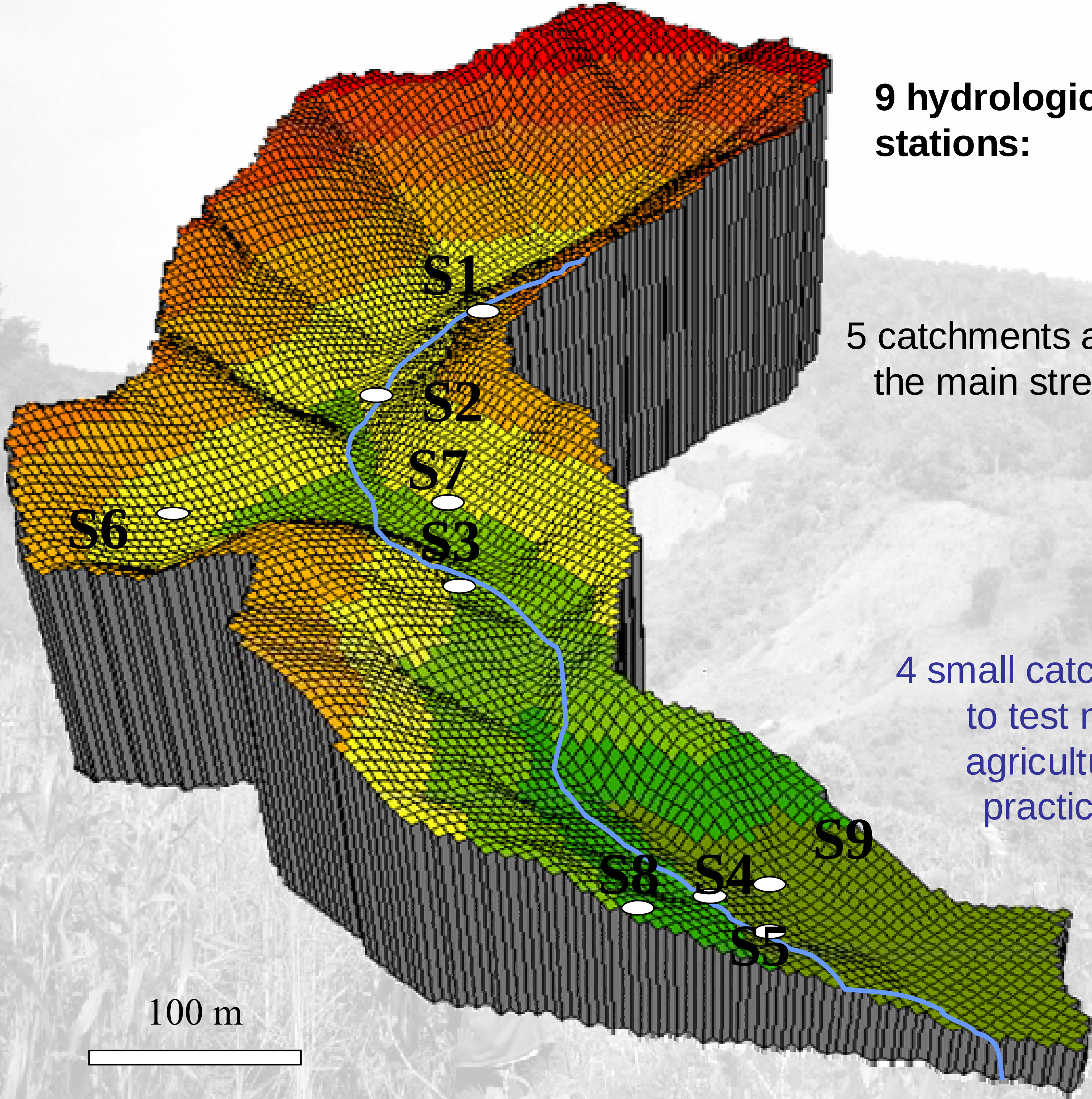
- National density : 20 inhabitants km^{-2}
- Village density : 115 inhabitants km^{-2} ➔ 0.86 ha inhabitant^{-1}
- 370 inhabitants km^{-2} of arable land ➔ 0.27 arable ha inhabitant^{-1}

Photo. I. Makin

Lestrelin G, Giordano M., 2006. Upland development policy, livelihood changes and land degradation: interactions from a Laotian village. *Land Degradation and Development,* 18 : 55-76.
Lestrelin G.., 2007. "Land degradation in the Lao PDR: discourses and policy". *Global Environmental Change*. Sous presse.

Suspended load

Bedload



9 hydrological stations:

Station	Surface (ha)
1	19.6
2	33.2
3	51.0
4	59.8
5	62.4
6	0.6
7	0.6
8	0.6
9	0.7

5 catchments along the main stream

4 small catchments to test new agricultural practices

Dong Cao watershed

5 weirs studied

MW = 49.7 ha

W1 = 2.64 ha
W2 = 7.7 ha

W3 = 10.1 ha
W4 = 8.6 ha

Outline

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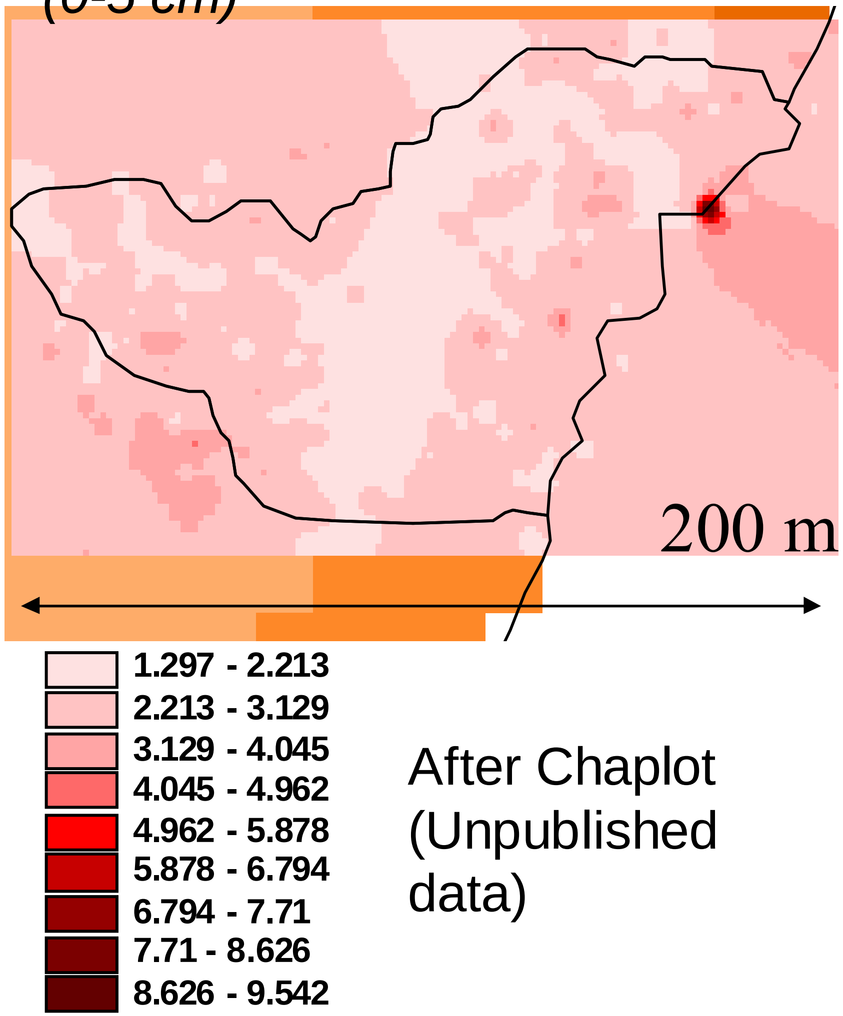
Upslope : 10%
Middleslope : 40%
Backslope : 60%

Slash & Burn Sub-catchment (0.6 ha)

Spatial distribution of Soil Carbon content in the top layer (0-5 cm)



After Chaplot (Unpublished data)

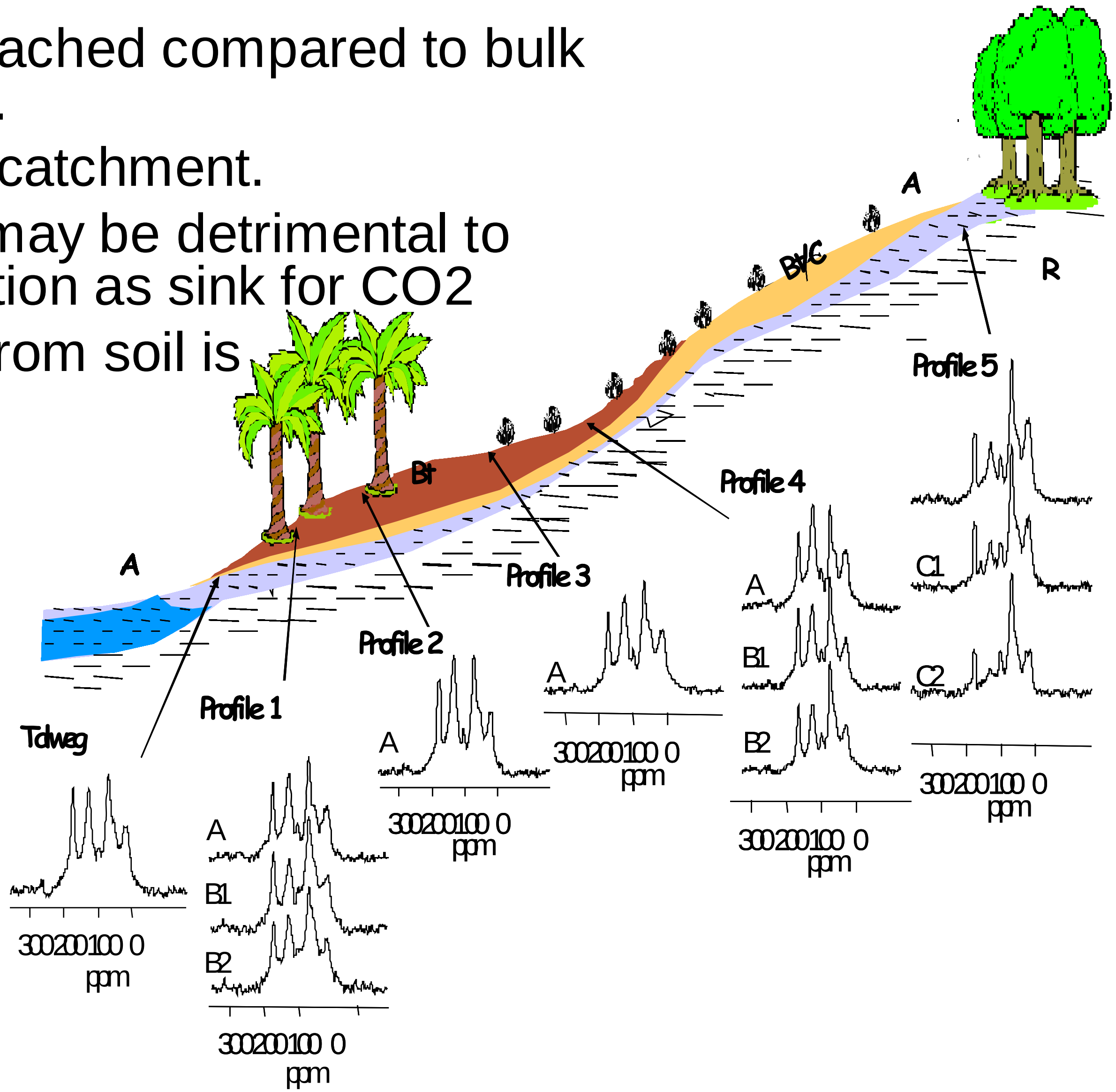
- SOC: 30% Mineral bound, 15% Black carbon
- 15 1-m² plots
- C enrichment:
  - 1 m²: 1.7-2.7
  - 0.6 ha: 1.5
- Black Carbon enrichment:
  - 1 m²: 1.1-1.8
  - 0.6 ha: 2.3
  - Readily detachable, light, resistant to biodegradation

Chaplot, V., Rumpel, C., Valentin, C., 2005. Water erosion impact on soil and carbon redistributions within uplands of South-East Asia. Global Biogeochemical Cycles, 19(4): 20-32.

Rumpel C., Chaplot, V., Planchon, O., Bernadou, J., Le Bissonnais, Y, Valentin, C., Mariotti, A., 2006. Preferential erosion of black carbon on steep slopes with slash and burn agriculture. *Catena*. 65, 1, 30-40.

Hillslope distribution

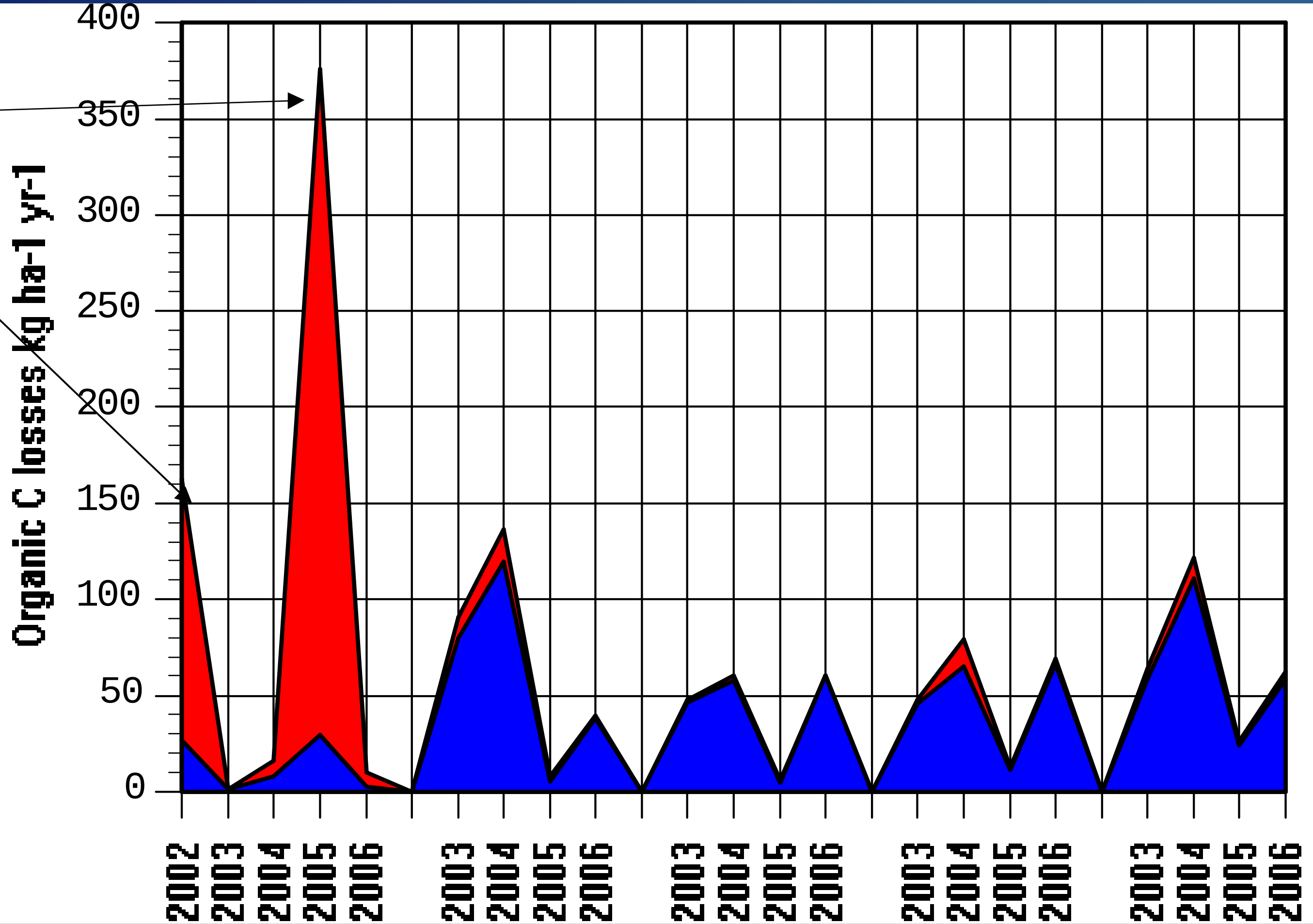
- Black carbon preferentially detached compared to bulk SOM or mineral bound carbon.
- Preferentially eroded from the catchment.
- On-site: loss of black carbon may be detrimental to soil fertility and to the soil function as sink for CO2
- Off-site: black carbon eroded from soil is a real carbon sink



Rumpel C., Alexis M., Chabbi A., Chaplot V., Rasse D.P., Valentin C., Mariotti A. 2006. Black carbon contribution to soil organic matter composition in tropical sloping land under slash and burn agriculture. *Geoderma*. 130, 35-46

Catchments: C-losses Laos

Cropping years



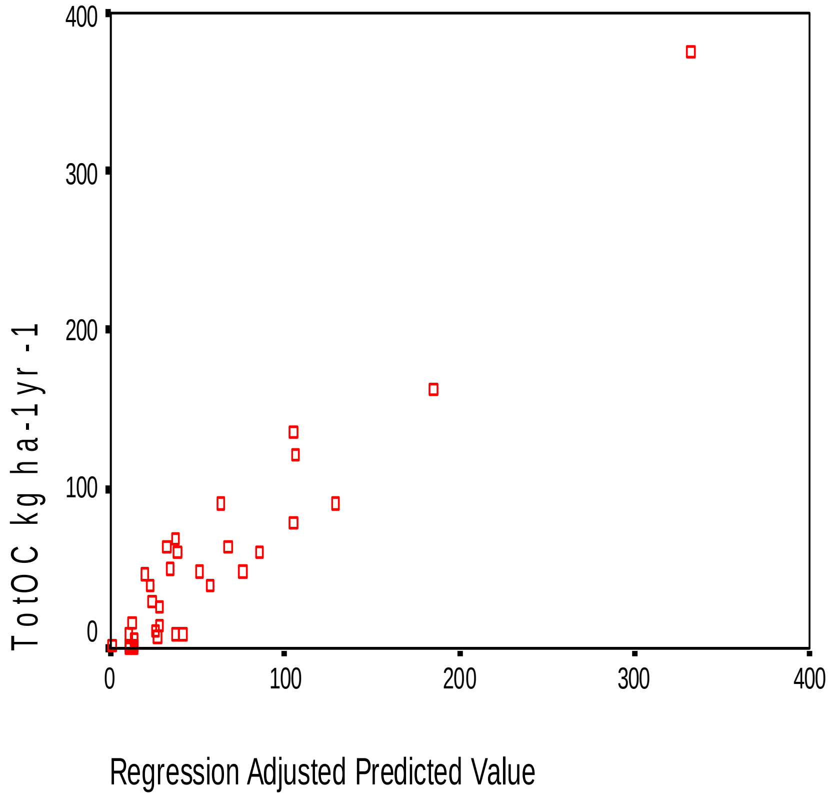
BDC

SDC

	Surface	0.6	19.6	32.8	51.4	60.2
Bed Load	Mean C/N	16.6	13.0	12.6	12.7	12.1
	St. Dev.	9.4	1.3	1.1	0.9	1.0
Suspended Load	Mean C/N	10.8	9.9	10.0	10.6	10.8
	St. Dev.	0.5	0.8	0.6	0.3	0.3

Main C-losses factors (2002-2006, n=36)

Variable	Stepwise regression equation	R^2
Total C-losses (kg ha^{-1} yr^{-1})	**Totoc= 107.0 + 6.0 Jt + 1.9 Mz - 16 R + 2.3 S**	**0.93**



Mean R = 1307 mm:

Mean S = 51.4 %

If Jt = 100% ➔ Totoc = 613 kg ha^{-1} yr^{-1}

If Mz = 100% ➔ Totoc = 206 kg ha^{-1} yr^{-1}

If Jt=Mz=0% ➔ Totoc = 17 kg ha^{-1} yr^{-1}

Outline

- Context, sites and methods
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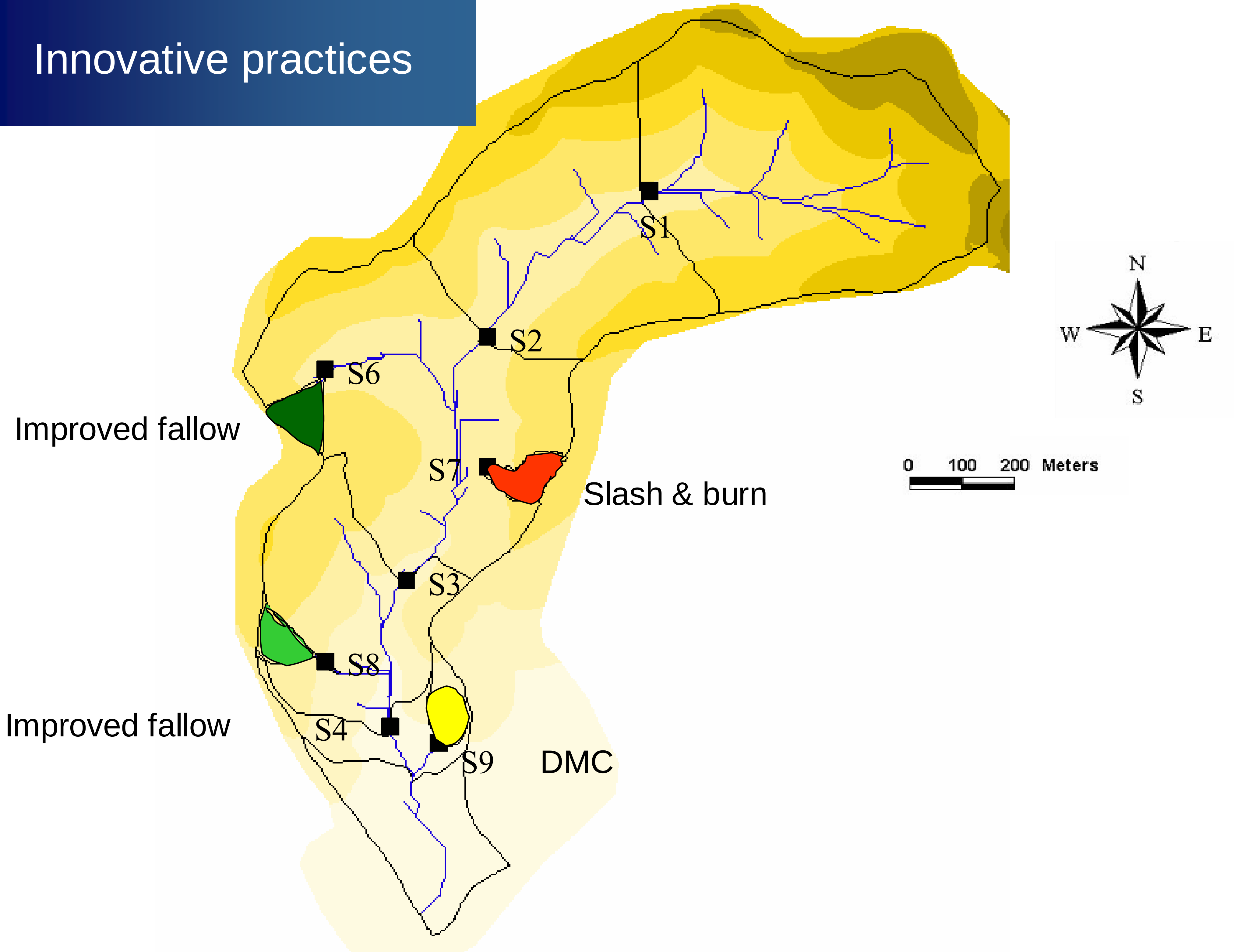
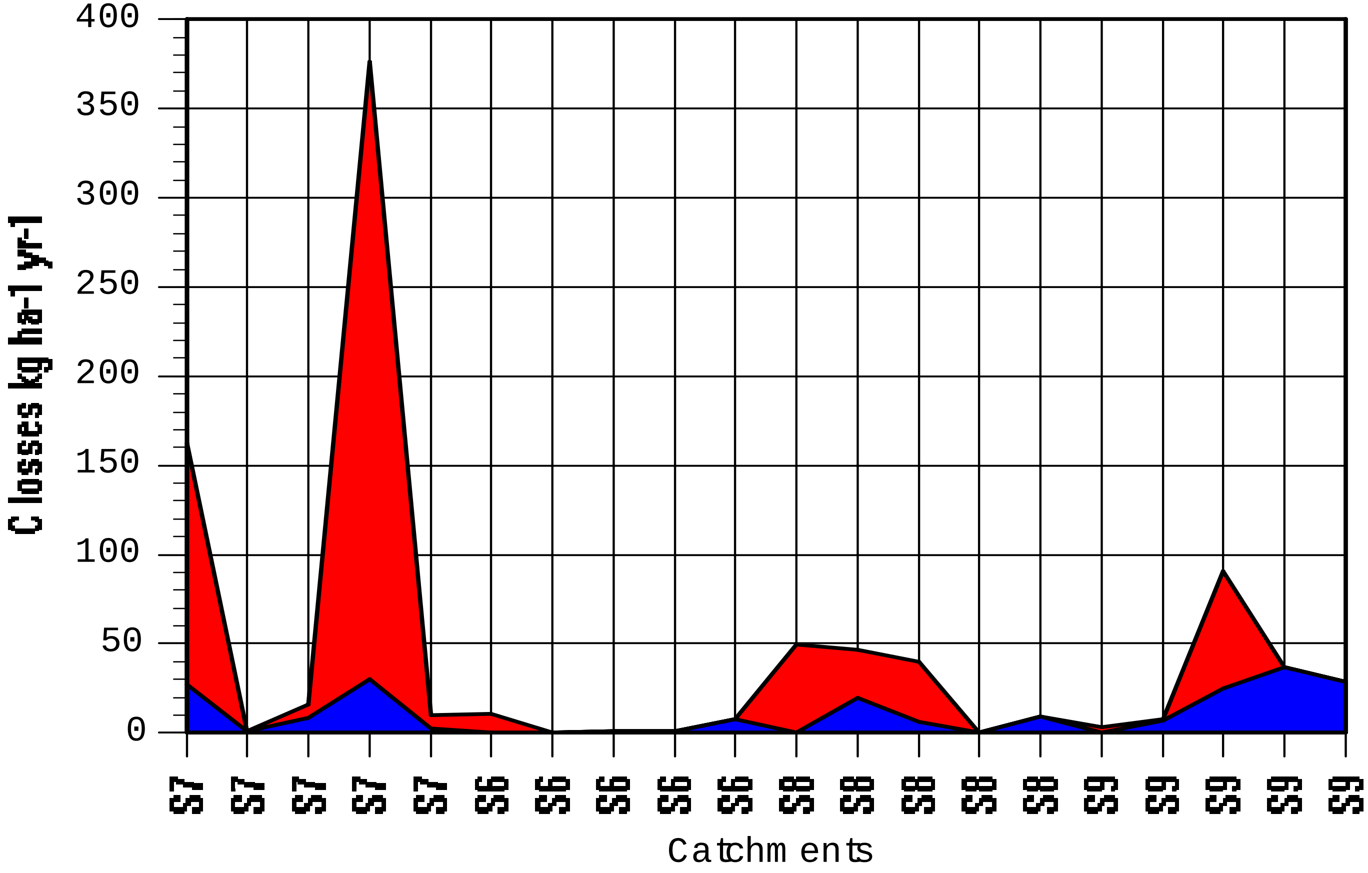
Innovative practices



Alternative strategies tested on 3 sub-catchments (0.6 ha)

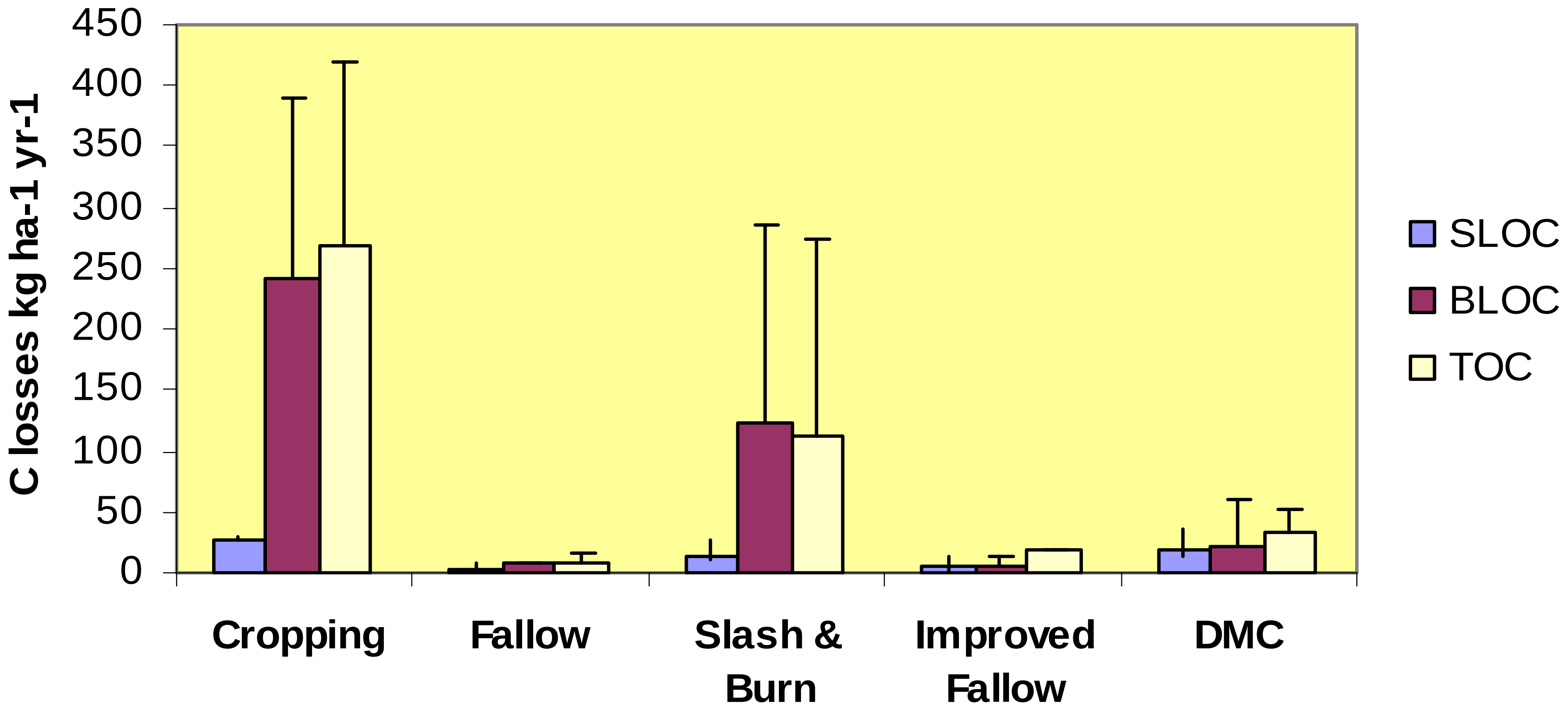


Slash & burn

Improved Fallow

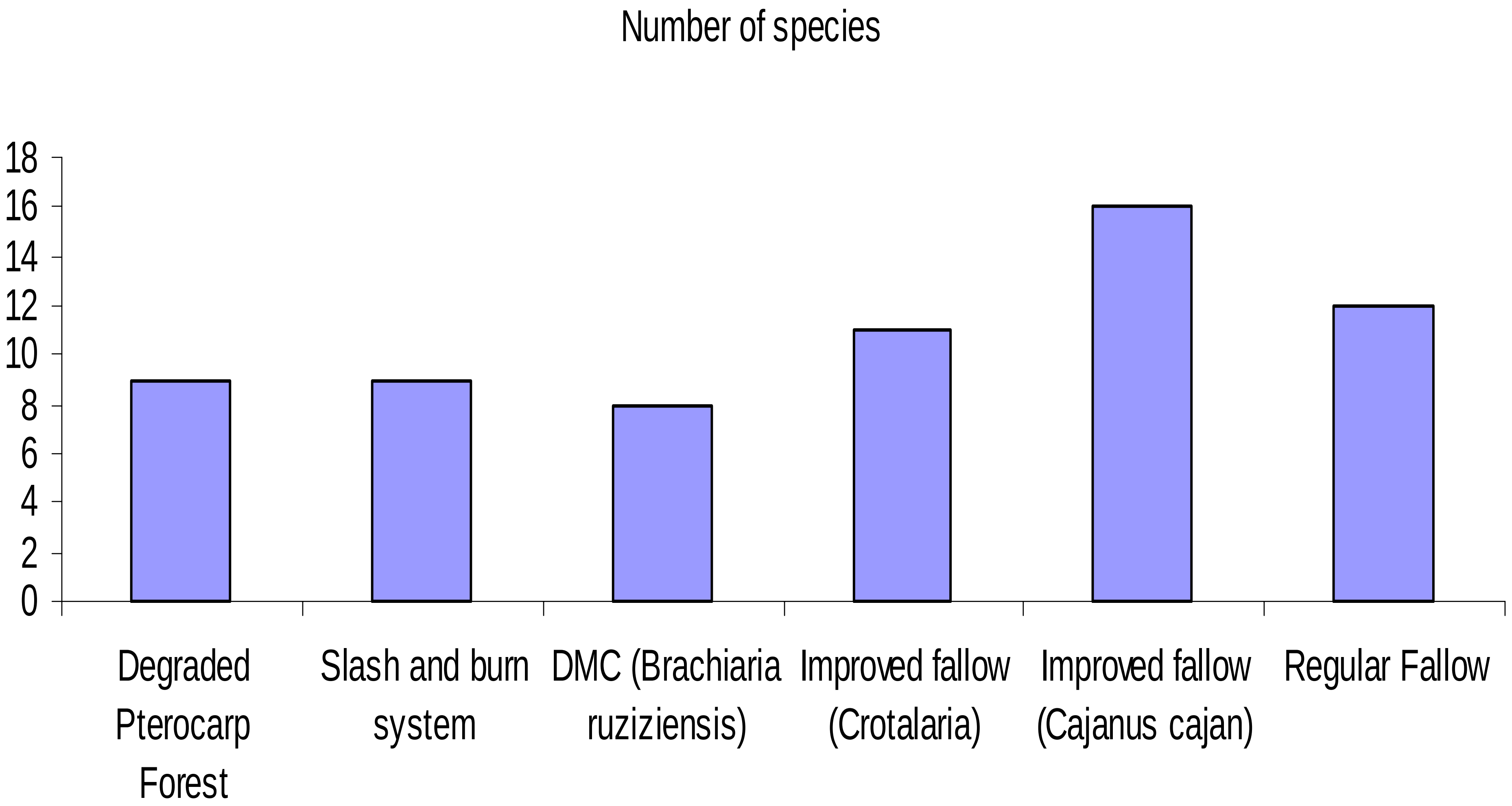
DMC

Alternative strategies tested on 3 sub-catchments (0.6 ha)



Soil Biofauna

(after Pascal Jouquet, unpubl. Data)



Prevalence of fungi termites

No statistical differences among situations

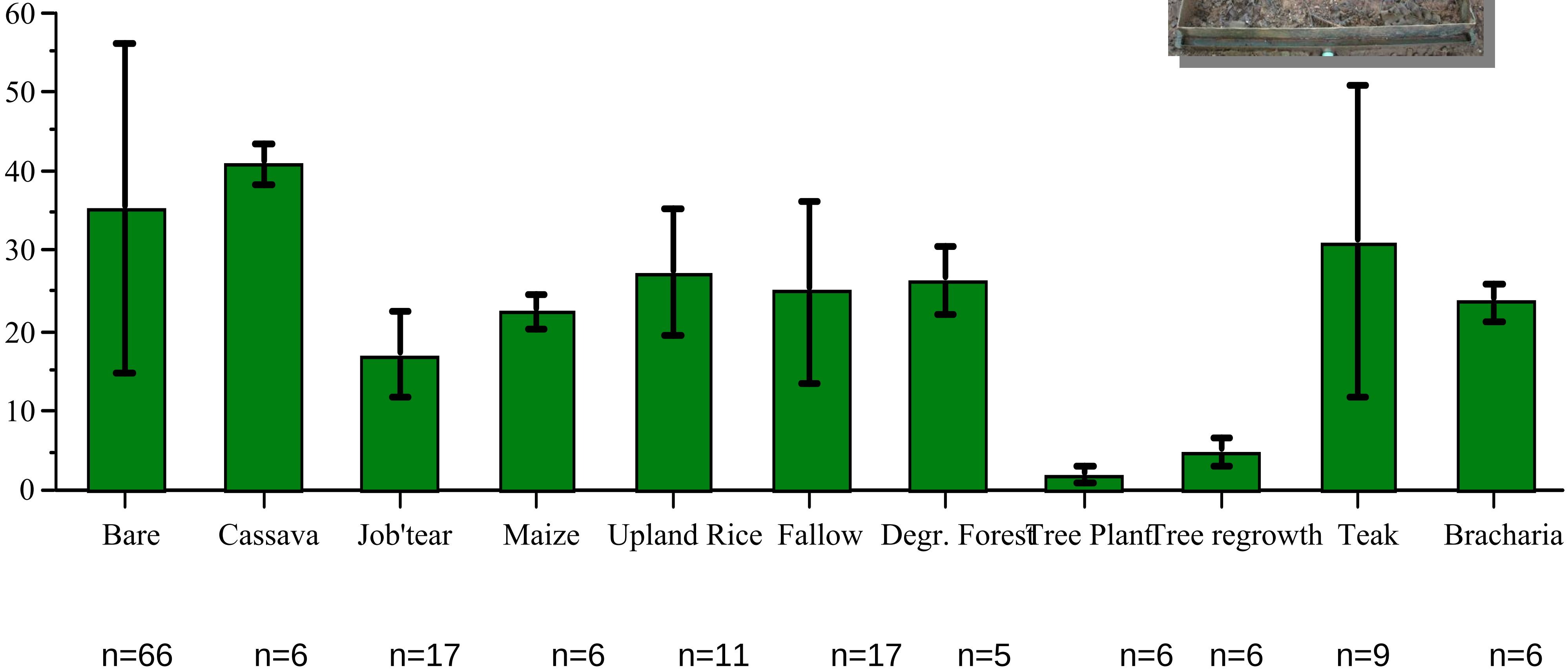
Stock variation of Organic C in DMC 2002-2007

DMC: *Brachiaria ruziziensis* killed by glyphosate + Maize, No fertilizer

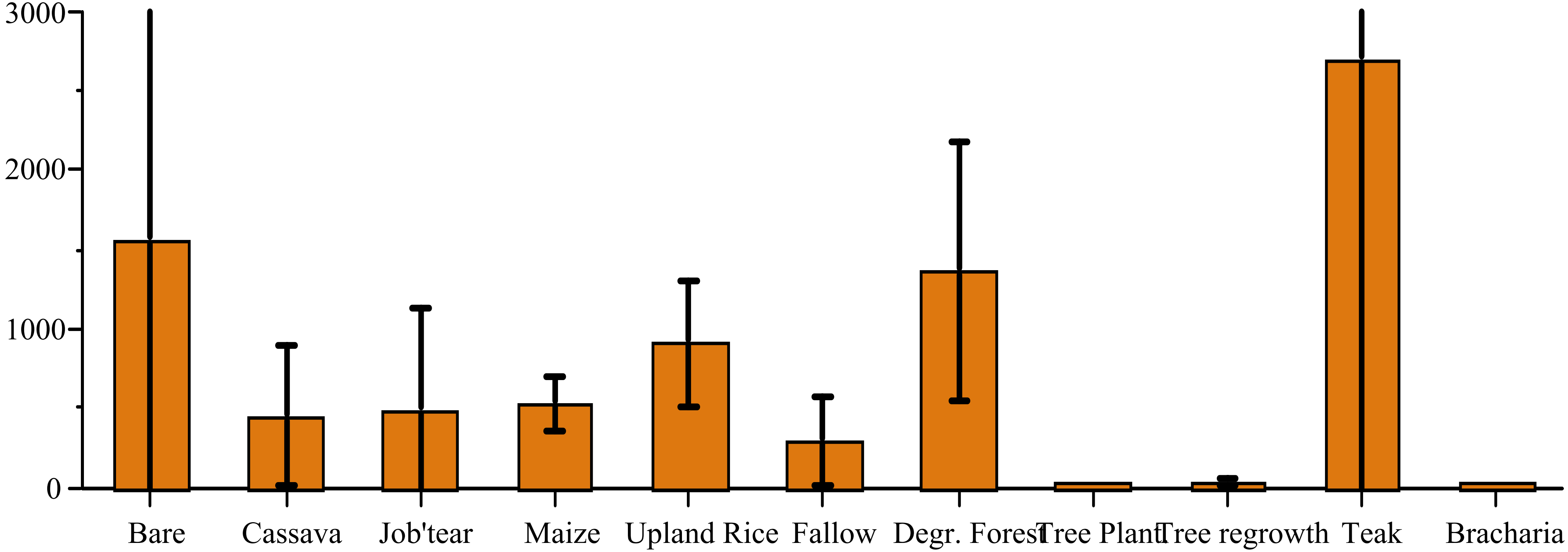
Stock C 2007 Kg C ha^{-1}	Stock C 2002 kg C ha^{-1}	ΔC kg C ha^{-1} yr^{-1}
0-10 cm	0-10 cm	0-10 cm (n=9)
17 892 ± 1 905	18 404 ± 3 979	-102 ± 1 078
0-30 cm	0-30 cm	0-30 cm (n=5)
46 952 ± 8 187	41 221 ± 6 222	1 146 ± 2 658

- High spatial variability
- More analyses in progress from this site
- Crop failure (maize) due to weed competition with *Pennisetum*
- More analyses in progress from the three other sub-catchments

Runoff coefficients (%) from 140 1-m² plots in Laos & Vietnam



Soil Detachment g m^{-2} yr^{-2}



Chaplot V., Khampaseuth X., Valentin C., Le Bisonnais Y, 2007. Interrill erosion in the sloping lands of northern Laos submitted to shifting cultivation. *Earth Surface Processes and Landform*. 32, (3) 415-428

Jouquet P., Podwojewski P., Bottinelli N., Mathieu J., Orange, D. Toan Duc Tran Binh Tran Thi Thanh , Valentin C., *Catena*. in press.

Podwojewski P., Orange D., Jouquet P., Valentin C., Nguyen Van T., Janeau J.L., Tran Duc T., 2007. Land-use impacts on surface runoff and soil detachment within agricultural sloping lands in Northern Vietnam. *Catena*, in press.

Teak

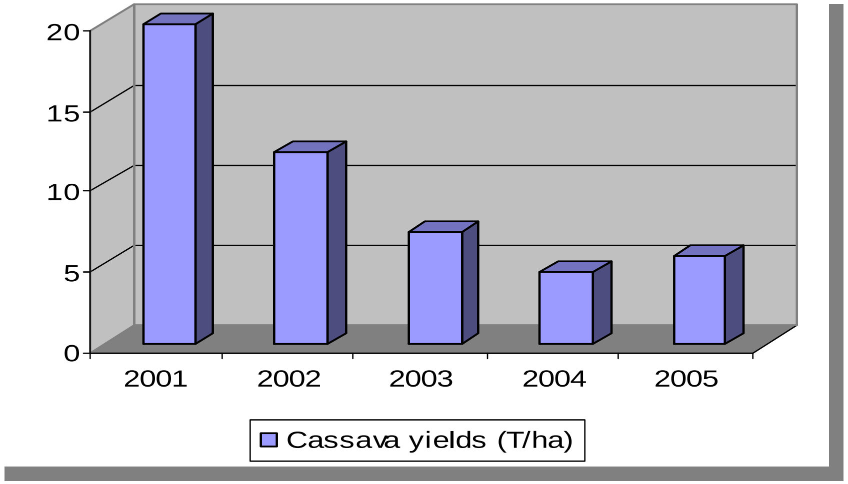
Large drops

Intercepted drops Kinetic energy > free falling drops

No understorey

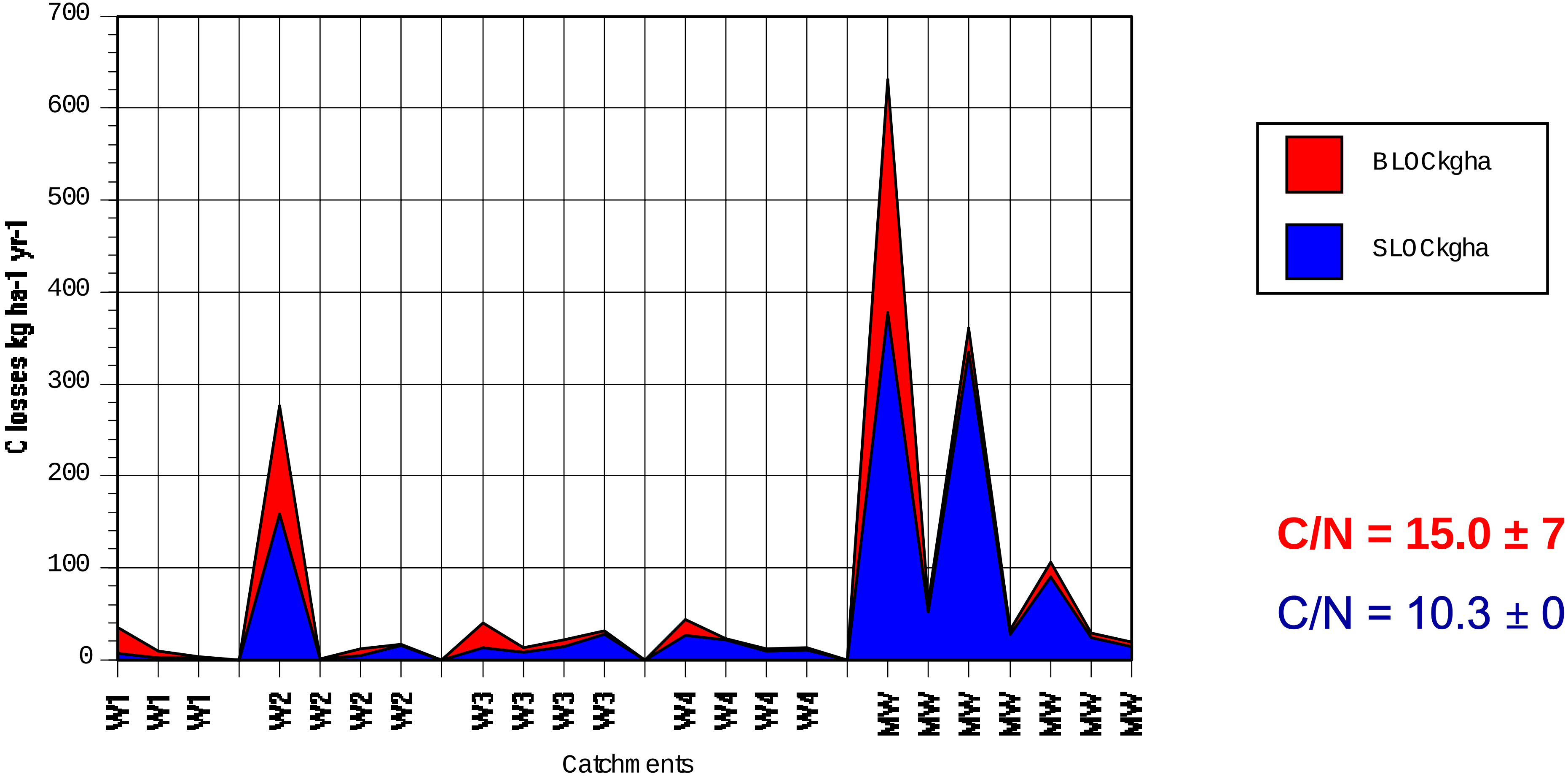
2-3 mm of topsoil removed every year by splash erosion

Land use change in Vietnam 2001-2005





Vietnam



C/N = 15.0 ± 7.0

C/N = 10.3 ± 0.7

Surface (ha)	2.6	7.7	9.9	8.4	46.0

Main C-losses factors – Vietnam (2002-2006, n=22)

Variable	Stepwise regression equation	R^2
Total C-losses ($kg\ ha^{-1}\ yr^{-1}$)	**Totoc= -708.4 + 10.6 Ca + 0.9 MxR + 11.8 S**	0.83

Factors increasing C-losses

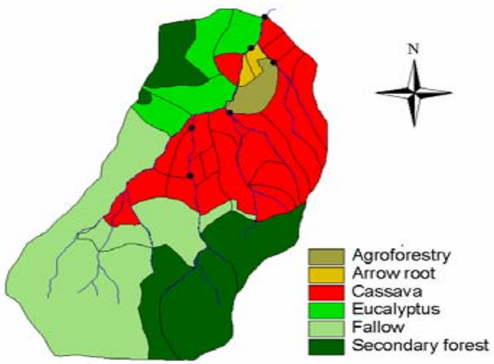
+ Ca : Cassava (%)
+ MxR : Maximum monthly rainfall (mm)
+ S: Mean Catchment Slope

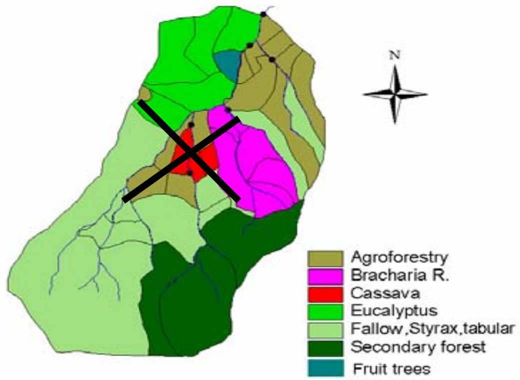
Mean MxR = 423.4 mm:

Mean S = 31.3 %

If Ca = 100% ➔ Totoc = 1 102 $kg\ ha^{-1}\ yr^{-1}$

If Ca = 0% ➔ Totoc = 42 kg ha-1 yr-1





2001 631 kg ha-1 yr-1 ➔ 2006 20 kg ha-1 yr-1

Outline

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Main factors of soil erosion on hillslope: tilled annual crops

27 catchments in 5 countries – n=90, R^2=0.39

TSY = 2.78+ 0.12 Mz + 0.17 Ca – 0.03 CpFw

TSY: Total sediment yield (suspended load + bedload), Mg ha-1 yr-1
CpFw: Total conservation practices + fallow (%)

The farmers with the highest incomes are not necessarily those who are the most ready to invest in soil conservation

Valentin C., F. Agus, R. Alamban, A. Boosaner, J.P. Bricquet, V. Chaplot, T. de Guzman, A. de Rouw, J.L. Janeau, D. Orange , K. Phachomphonh, Phai Do, P. Podwojewski, O.Ribolzi, N. Silvera, K. Subagyono, J.P. Thiébaux, Tran Duc Toan, T. Vadari, submitted. Runoff and sediment losses from 27 upland catchments in Southeast Asia: Impact of rapid land use changes and conservation practices. Submitted to Agriculture, Ecosystems & Environment.

Main factors of C-losses on hillslope: tilled annual crops

1- Cassava:	Totoc = 1 102 kg ha-1 yr-1
2- Job's tears:	Totoc = 613 kg ha-1 yr-1
3- Maize:	Totoc = 206 kg ha-1 yr-1

(same order of magnitude of C-losses from plots in Columbian Andean hills: 991 kg kg ha-1 yr-1 (Ruppenthal et al., 1997. *Experimental Agriculture*)

No one of these crops:

Totoc = 17 kg ha-1 yr-1 in Laos

Totoc = 42 kg ha-1 yr-1 in Vietnam

Why no or only little upscaling effect for Carbon Losses?

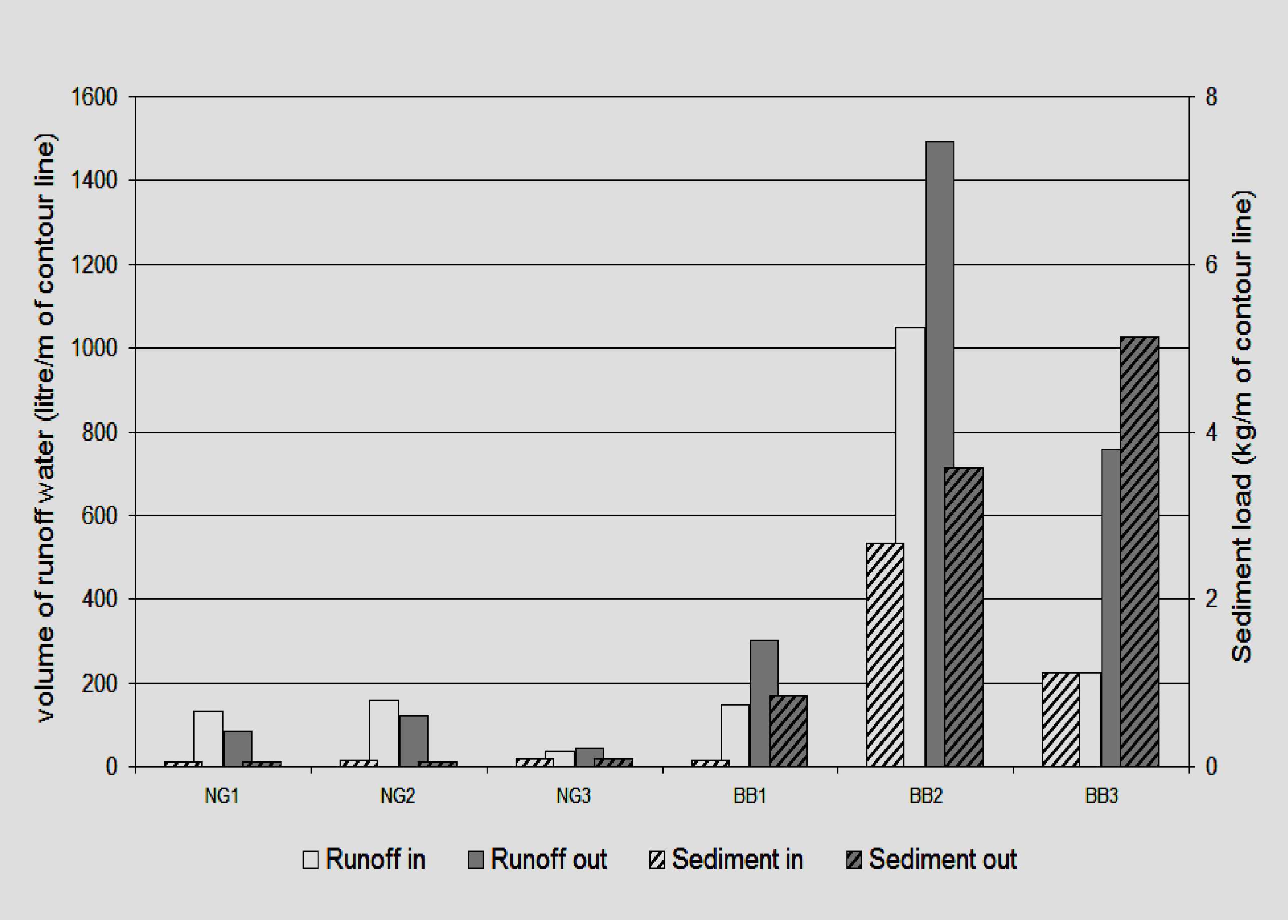
- OC enrichment and Black Carbon enrichment
- High connectivity through the rills and gullies that develop with annual crops
- Hence no or little mosaic effects

Chaplot V., Coadou le Brozec E., Silvera N. Valentin, C., 2005 Spatial and temporal assessment of linear erosion in catchments under sloping lands of Northern Laos. *Catena*, 63 :167–184

Chaplot V., Giboire G., Marchand P. Valentin, C, 2005. Dynamic modelling for gully initiation and development under climate and land-use changes in northern Laos. *Catena*, 63 : 318–328

Valentin, C., Poesen, J., Yong Li, 2005. Gully erosion: impacts, factors and control. Catena, 63 :132–153

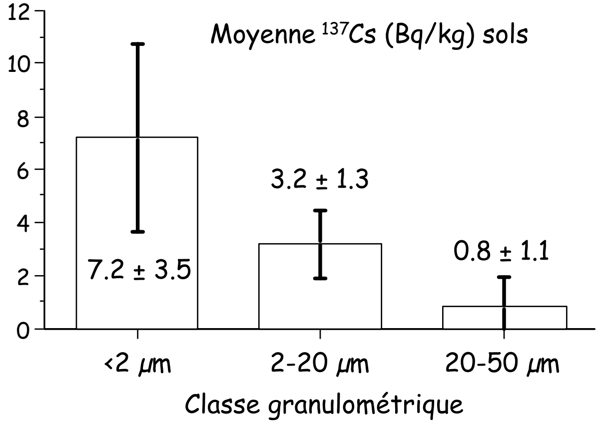
Low or no trapping efficiency of riparian vegetation

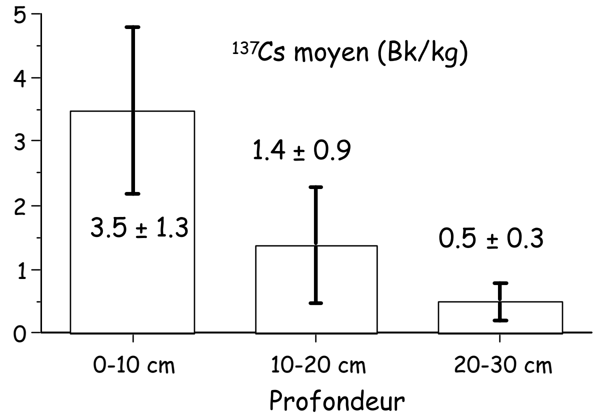


Total volume of runoff water and sediment load (expressed in L and kg per meter of contour line) entering (in) and exiting (out) the native grass and bamboo sites monitored in 2005 and 2006 monsoon season.

Vigiak, O., Ribolzi, O., Pierret, A., Sengtaheuanghoung, O., Valentin C., in press. Trapping efficiencies of cultivated and natural riparian vegetation 1 of northern Laos. *Journal of Environmental Quality.*

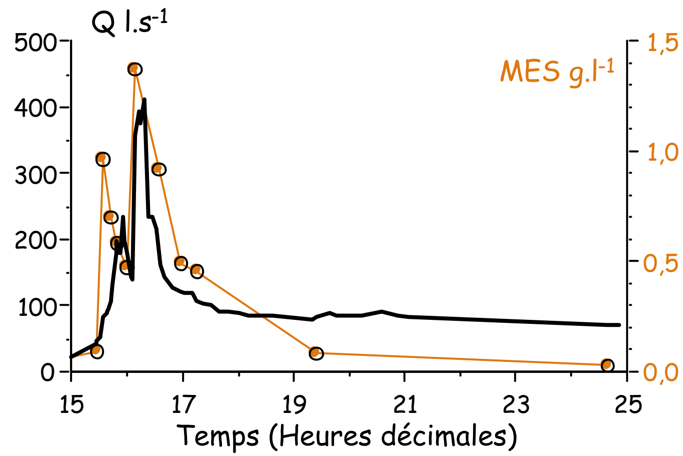
Probably rather low residence time of Organic C
(after Huon unpubl. Data)

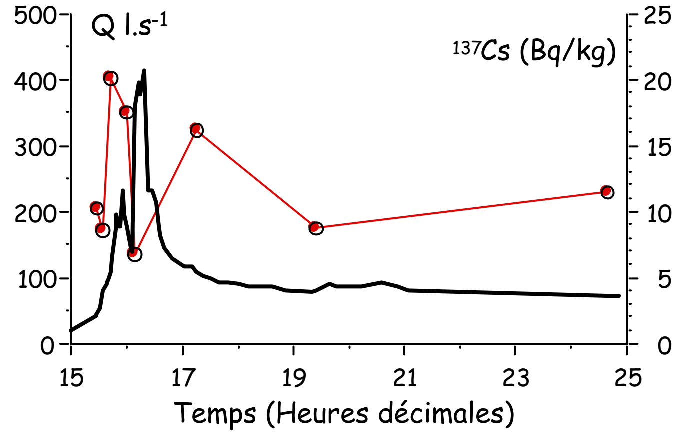




137Cs enrichment in suspended load

suspended load no earlier than 1963





CONCLUSIONS

- C-losses can be very high due to soil erosion even at the catchment scale and should not thus be neglected in assessing C-budget.
- Dissolved C-losses should be accounted for especially under permanent flow conditions.
- The primary profit of conservation agriculture is to prevent C-losses. This gain should be accounted for.
- Improved fallow and fodder crops are more adapted to current farmers constraints in the two studied sites.
- Tree plantation is a valuable alternative but the trees' species should be selected with care.
- Upland farmers provide ecological services that should be paid for; they could thus afford the use of fertilizers, which in most case is the main limiting factor to yield increase.


Thank you for your attention
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SFI

‘Are researchers on track to provide useful scientific inputs for developing and testing promising new environmental policy interventions?’ (Tomich et al. 2004)

- Deforestation has little impact on large scale flooding (Kiersch and Tognetti, 2002; Bruijnzeel et al.; 2004)
- Catchment erosion rates derived from plot studies overestimate catchment erosion rates (van de Giesen et al., 2000)
- Major sources of sediments can be roads, poorly constructed and maintained terraces, coffee plantations, bank erosion (Sidle et al., 2006).

Main catchment attributes

Country	Site	Catch.	Years	Mean Slope (%)	Rainfall (mm)
Indonesia	Kalisidi	3	3	30-46	1,208-3,840
Laos	Huay Pano	8	7	18-61	1,305-1,414
Philippines	Mapawa	5	3	18-26	347-548
Thailand	Huay Yai	5	7	8-15	1,028-1,493
Vietnam	Dong Cao	5	7	28-38	1,048-2,368

150 catchment-years

Main runoff and sediment yields factors (2002-2006, n=44)

Variables	Stepwise regression equation	R^2
Runoff coefficient	Rc= 21.795 + 4.287 Ar – 0.148 Lsp -0.163 Fw	0,70
Suspended load	Ln(Sl)= 0.248 + 0.04 Ar- 0.29 Fw	0,46
Bedload	Bd= 0.0032 + 0.169 Jt + 0.064 Mz– 0.035 Ur	0,85
Total sediment yield	SY= 0.667 + 0.177 Jt + 0.077 Mz	0,75

Factors increasing runoff and soil losses

+ Ar : Catchment area

+ Jt : Job's tears (*Coix lacryma-jobi* L.) (%)

+ Mz : Maise (%)

Factors reducing runoff and soil losses

- Lsp: Stream length (m)

- Fw: Fallow (%)

- Ur : Upland rice (%)