

Carbon stocks and dynamics in landscape with intensive rubber cultivation: case study of Naban river watershed in Yunnan, China

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- replacing natural
traditional
tropical tree
degrading
areas

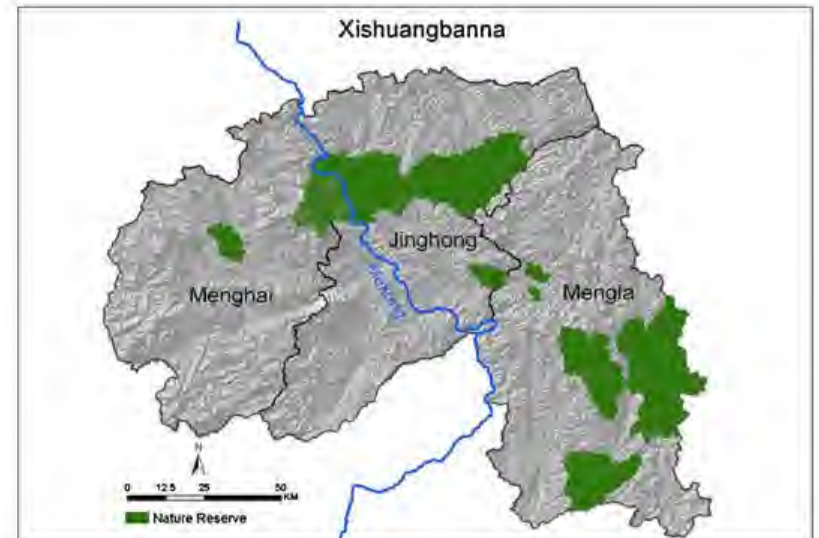
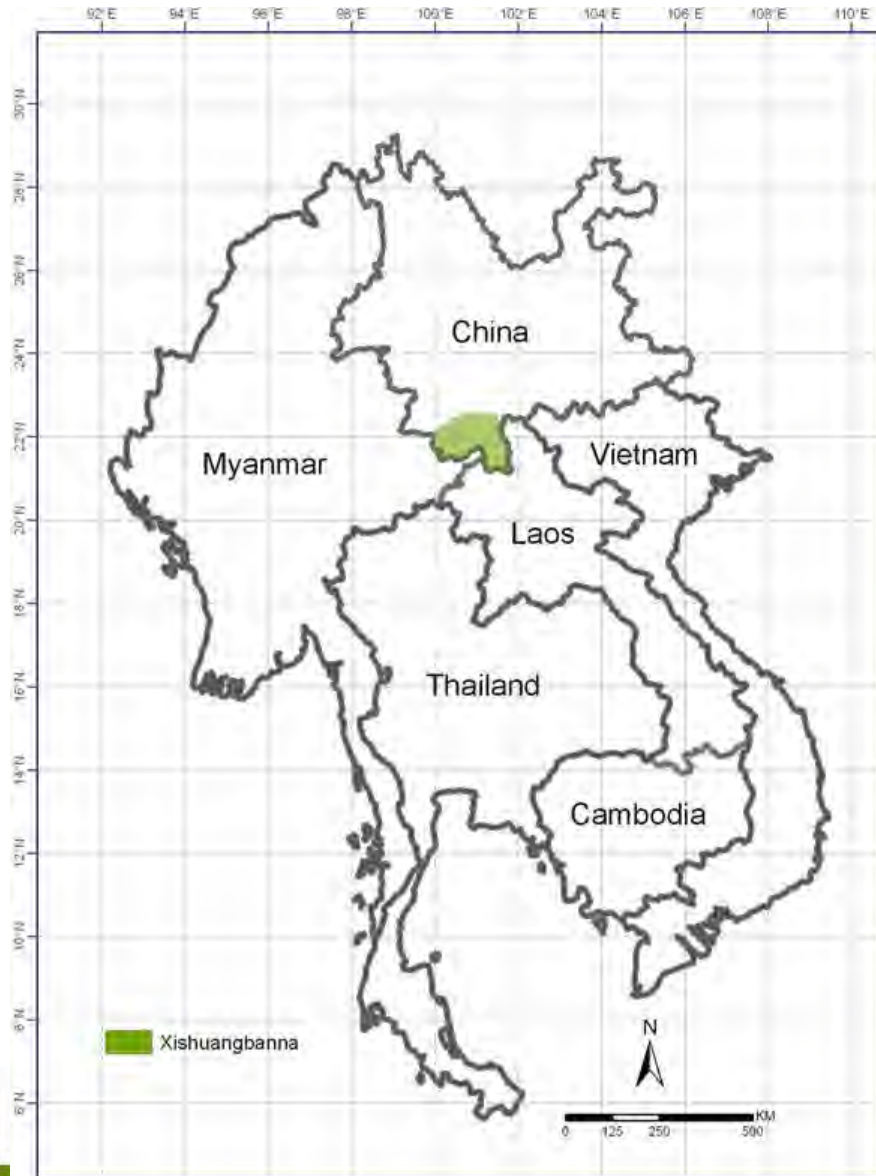


- Rubber (Hevea
region – and
increasing
(Ziegler et al.)

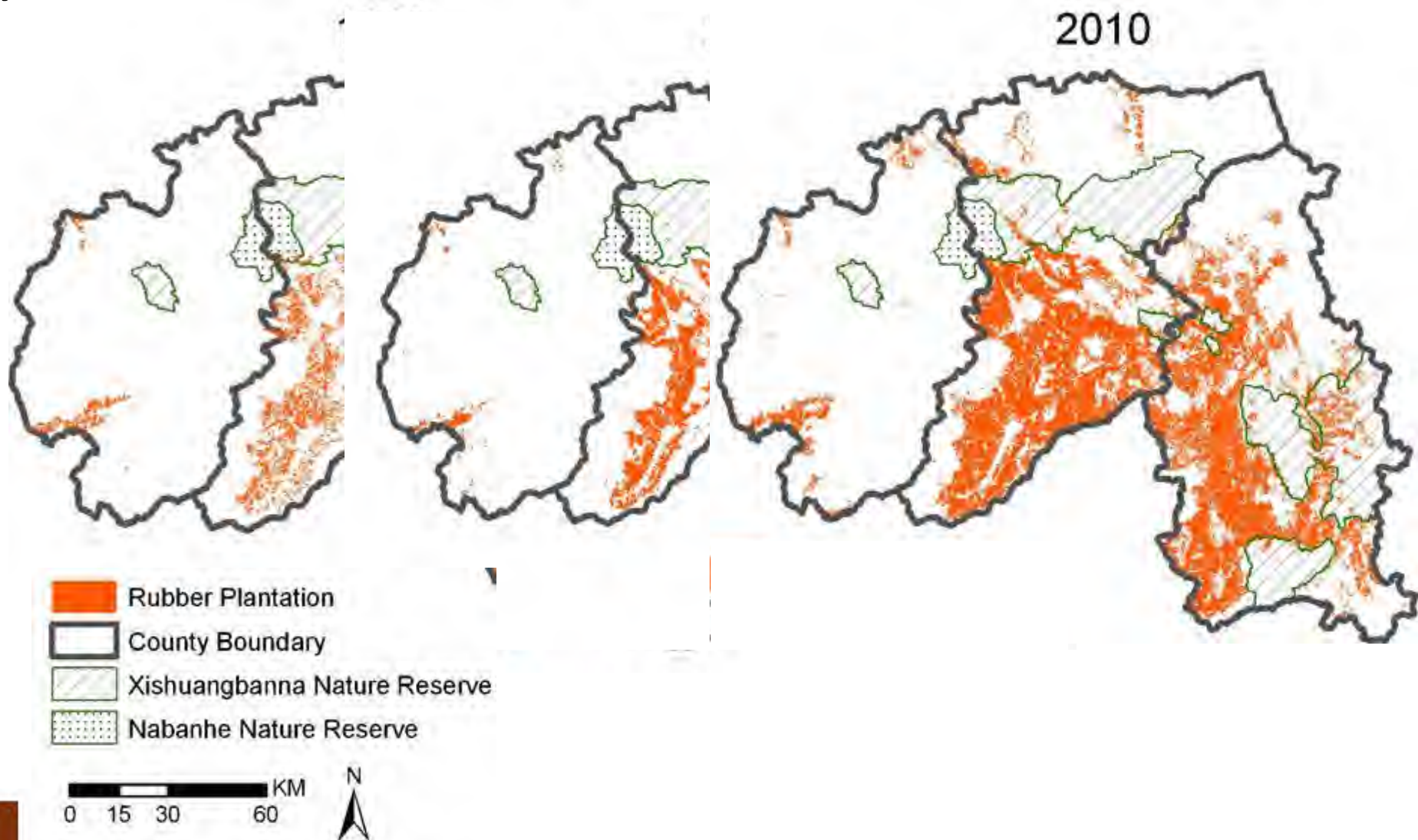


Long
s are

Location of Xishuangbanna, Yunnan, China



in Xishuangbanna, rubber plantation area increased by 175% between 2002 and 2010 (Xu et al. 2013)



Carbon balance in Xishuangbanna

- Conversion of forest into agricultural lands contributes to **an emission** of $0.37 \text{ Tg C year}^{-1}$ (Li et al., 2008).
- **Soil organic C stocks significantly decline** in rubber based systems compared to mature forests (Zhang et al., 2007).
- **runoff rates tripled** in rubber cultivated areas compared to forested areas in the Xishuangbanna region (Mann, 2009)

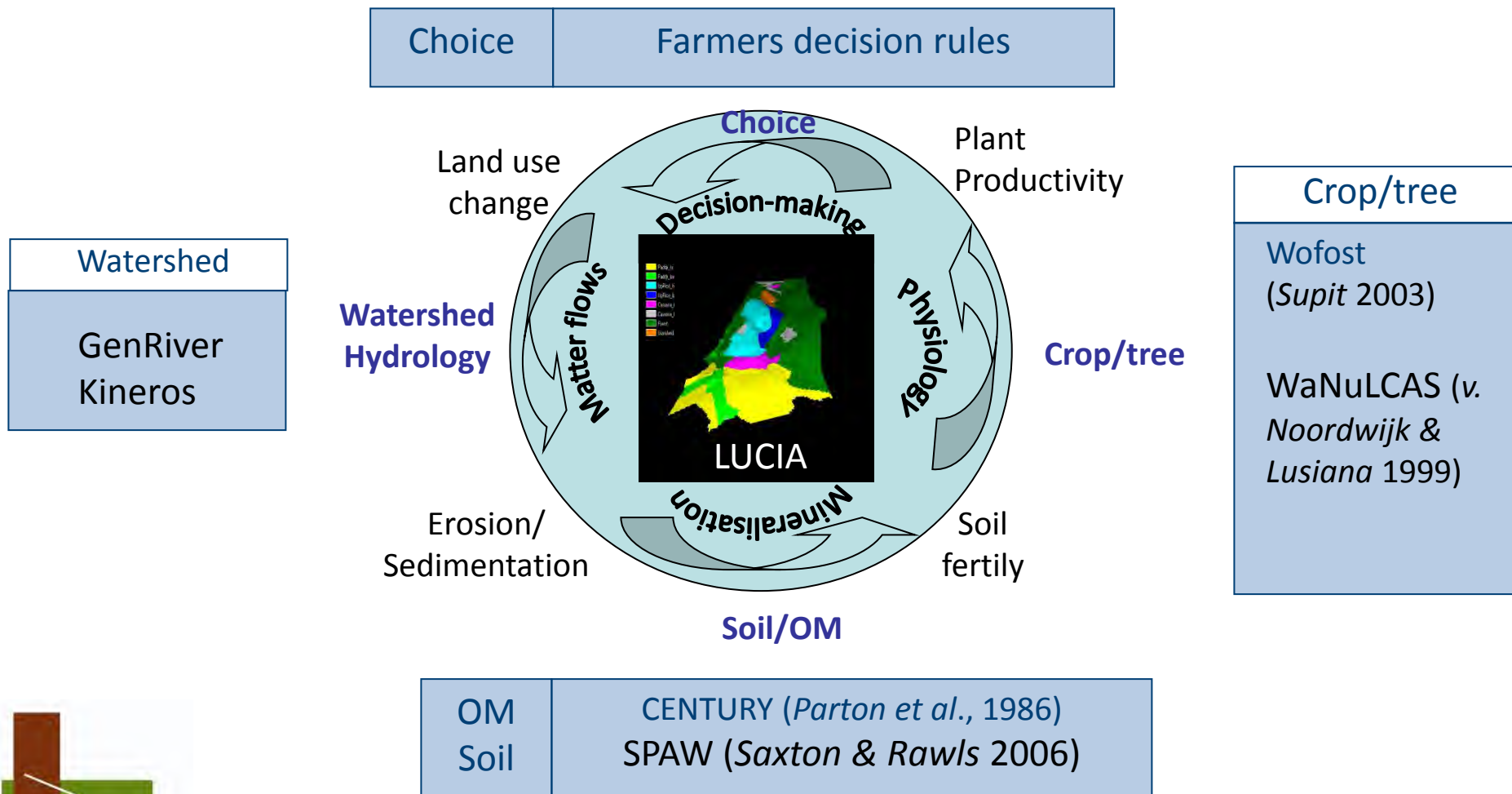
Objectives

- The main objective is to assess the impact of intensified rubber cultivation on spatial and temporal **carbon dynamics** in land use systems of southern Yunnan.
- To improve and validate the **LUCIA (Land Use Change Impact Assessment) model** as a tool for evaluating current and alternative land use systems on short and long-term effects on **ecosystem services**.

LUCIA: Land use change impact assesment

G. Cadisch & C. Marohn

Water-Soil-Crop-Landscape interactions: dynamic (daily), spatially explicit landscape (watershed) model, with process-oriented matter fluxes in the landscape



Model

Map

Test SOM

Test Erosion

Management

- Burning
- Fertiliser & Manure
- Irrigation
- Physiological stress

Land cover

- Assimilates
- Plant NPK
- Plant Quality
- Present vegetation
- Soil under LU
- Plant Impact
- Litter initialisation

Soil

- SOM
- Weather
- Output

Show default

Map section

Please select the maps referring to your catchment:
Land cover and soil type, area, digital elevation model, local
Land cover and soil legends will be read into the parameter
Maps can be viewed and edited clicking the respective button

Current map path: D:/HH/Projects/Model/LUCIA_PCR/BanTat_

Select and Show Maps

Land cover map: landcover.map

Soil map: soil.map

Area map: area.map

Dem map: dem.map

Ldd map: ldd.map

Lakes map: lakes.map

Testpoints: testpoints.map

Show Map

Edit map

Show Map

Edit map

Show Map

Edit map

Aguila - 2D Map 1

File View Help

Legend

landcover.map

- Maize_C
- Maize_F
- Maize_FM
- Cassava_C
- Cassava_F
- Cassava_FM
- Maize Cassava_C
- Maize Cassava_F
- Maize Cassava_FI
- Paddy_C

Cursor

- time: 0
- x: 0
- y: 0
- z: 0

landcover map

https://lucia.uni-hohenheim.de

Copy single map

Reload maps

Data for model initialization, parameterization and verification:

1) Carbon stocks, including

✓ Aboveground carbon stocks;

✓ Belowground C stock;

✓ Soil characteristics and the effects on soil C stock.

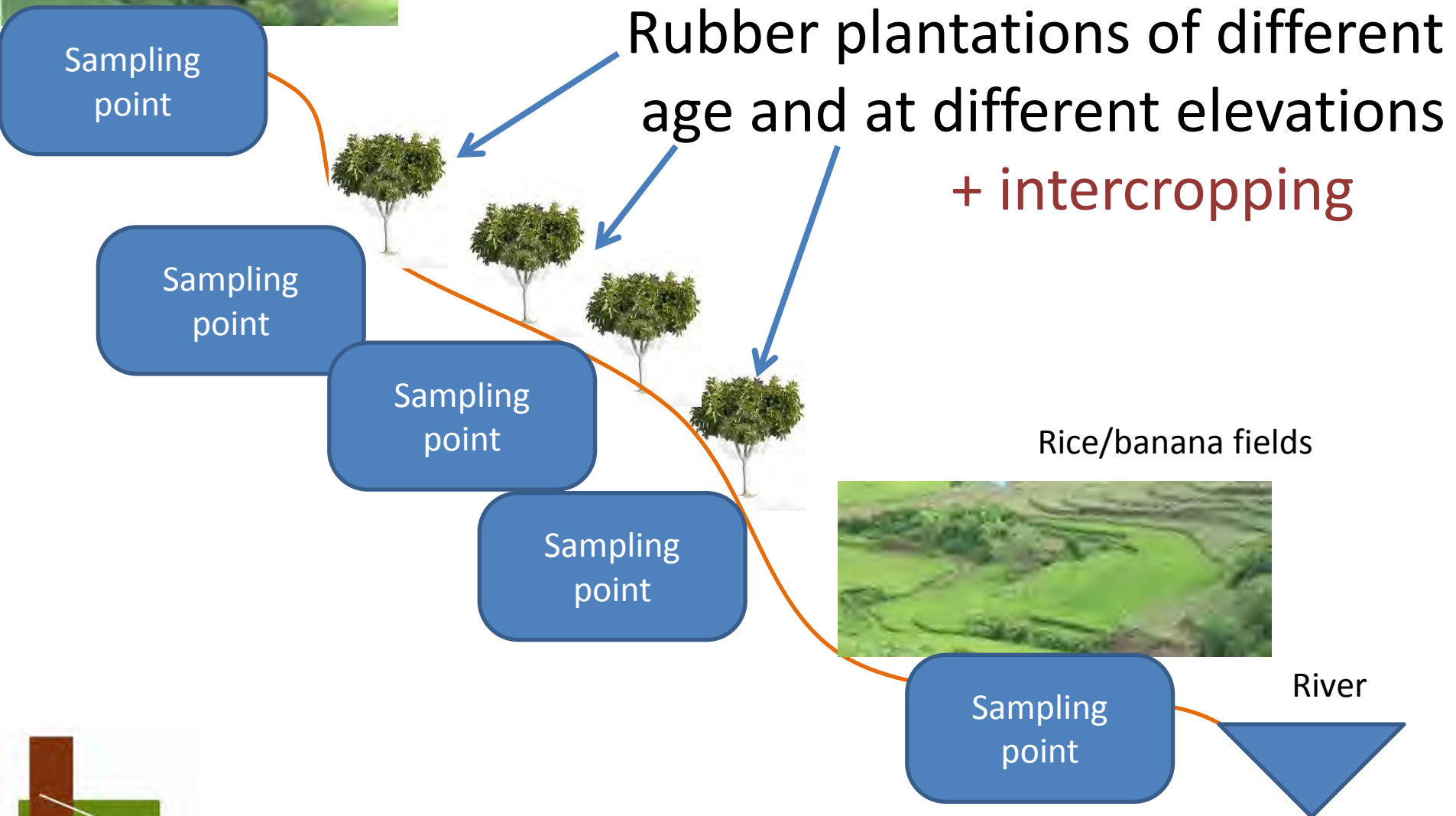
Field work regarding to biomass and C stock estimation:

AIM: to determine plant and soil **C stocks** as well as **gaseous flows** from soil to the atmosphere in rainforest and rubber plantations of different age.

Forest

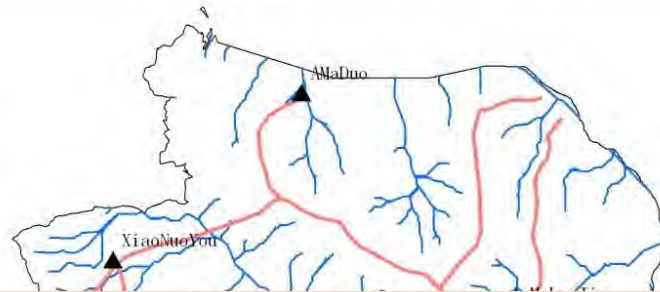


Study site scheme



Study in NRWNNR, Oct.2012- 2013

Naban River Watershed National Nature Reserve



Plant biomass estimation depending on rubber age and elevation.
45 plots:

3 elevations x 5 age types, including intercropping and rain forest;

Methodology: Rapid Carbon Stock Appraisal (RaCSA) Harriah et al., 2011;
Litter decomposition and accumulation experiment.

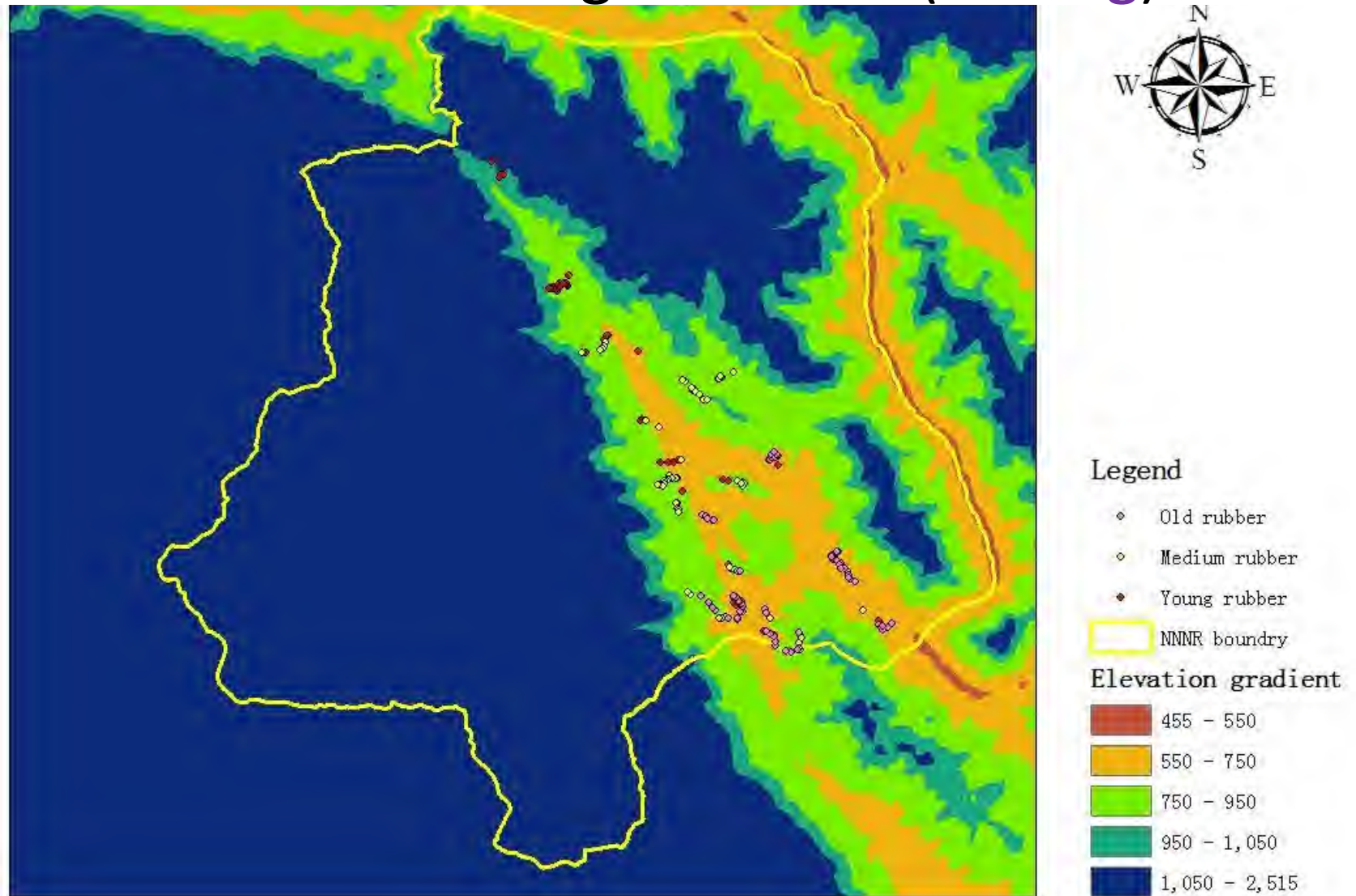


- ▲ Villages
- Roads
- Sub-watershed

0 2 4 8 Kilometers



Ground truth survey: distribution of rubber with different stand age in NNNR (X. Yang)



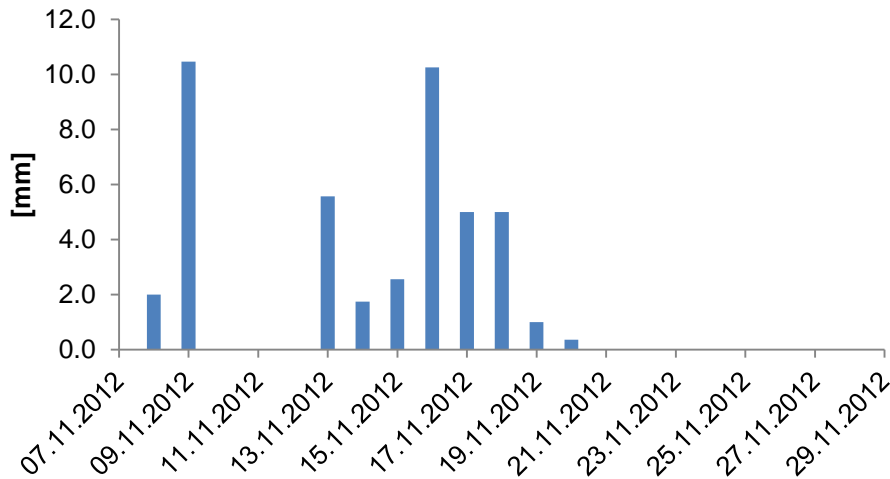
Data for model initialization, parameterization and verification: Carbon dynamics

AIM: the hydrological assessment of ***the export of different C pools*** and total N in two subwatersheds.

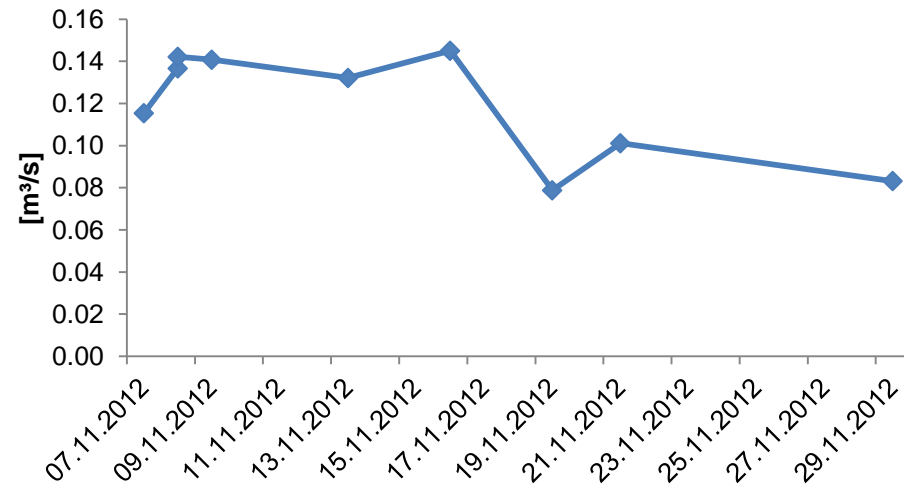
Rainfall, discharge, turbidity measurements in two selected subcatchments

First campaign with portative sensors and taking grab samples was done in November: **Thanks to help of SP3**

Rainfall Na Ban Station

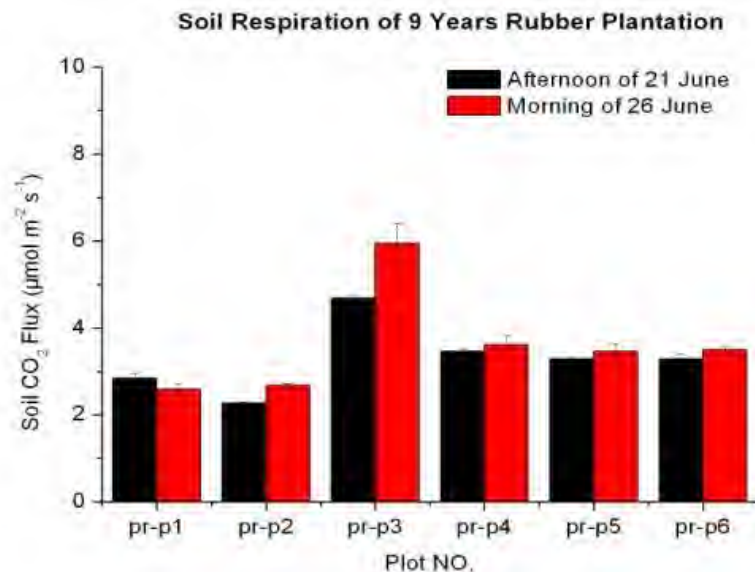


Flow rate, Na Ban

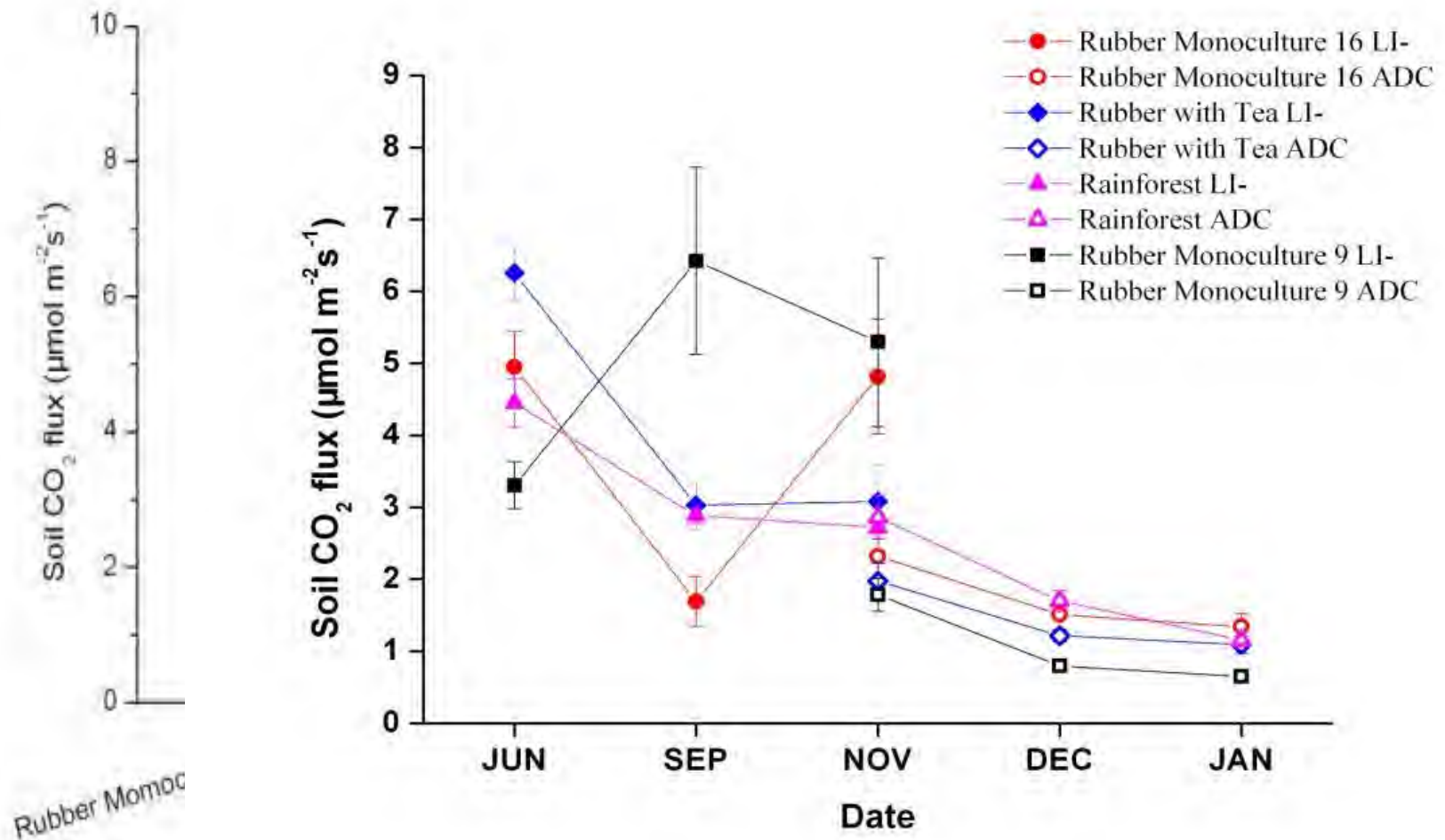


Data for model initialization, parameterization and verification: Carbon dynamics

✓ ***Gaseous dynamic*** In situ studies of spatiotemporal variation of CO₂ emissions from soils under the different land uses; R. Lang



Progress: CO₂ emission first results:



Rain forest = Rubber medium age > Rubber + tea > Rubber young mono

Modelling: Ecosystem impact assessment

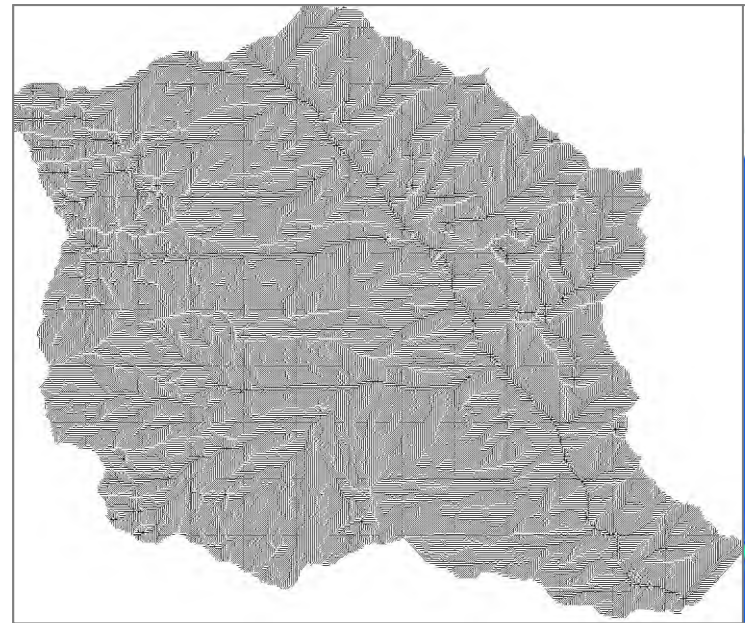
✓ Plot and subwatershed level measurements will form the data basis for parameterization, calibration and validation of the LUCIA (Land Use Change Impact Assessment) tool

Selected sub-watershed in the NRWNNR for the test runs of LUCIA, land use map is from 2006/07 gratefully provided by [Marc Cotter, LILAC project](#)

Sub-watershed in the NRWNNR

- Area: 68.8 km²
- Elevation: 640 to 2200 m
→ different temperatures
- Elevation ranges (rubber, 12% of the sub-watershed):

low	530 to 650 m
medium	680 to 800 m
high	870 to 1050 m



Local drain direction map

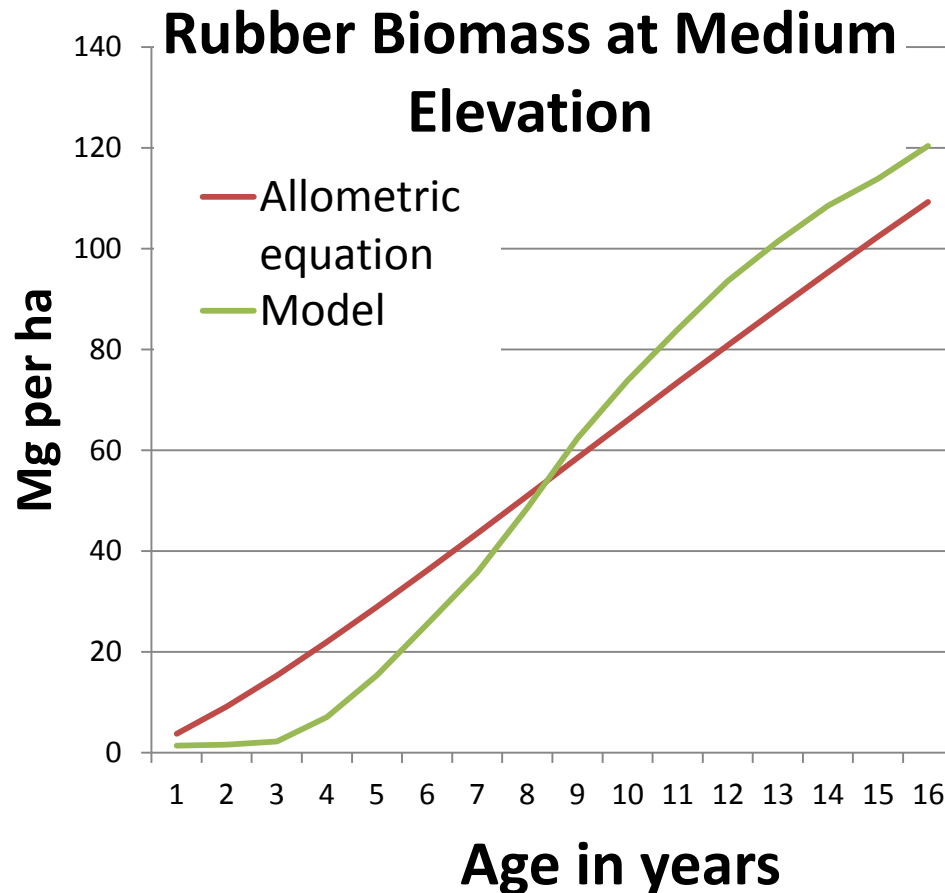
Outputs of the LUCIA model

Outputs at test points	Unit
Biomass	Mg per ha

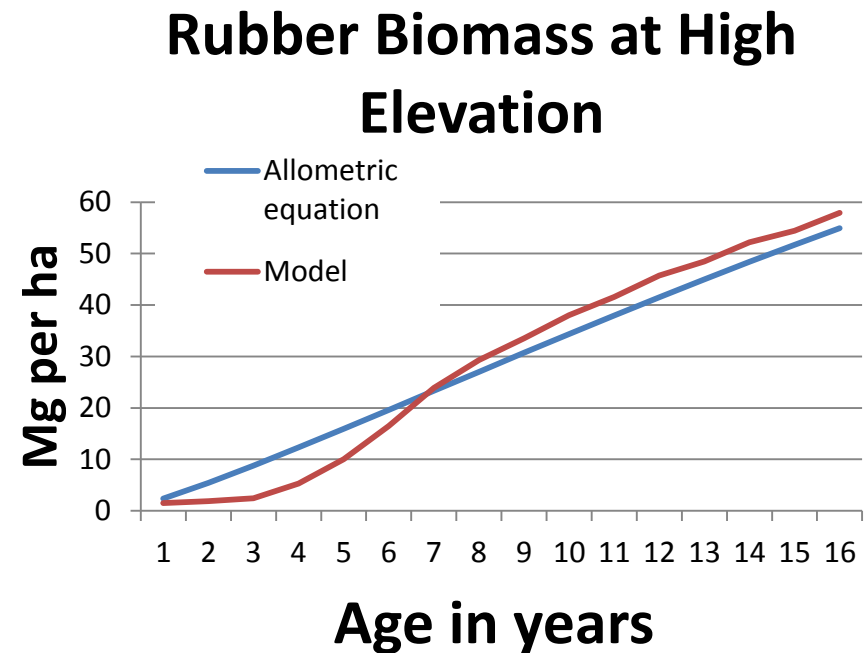
Outputs for the entire watershed area	Unit
Total Biomass	Mg per ha
Total soil CO ₂ release	Mg CO ₂ per ha
Latex export	Mg

Outputs used for the validation	Unit
Water stress	non-dimensional, 0-1
Nitrogen constraint	non-dimensional, 0-1
Phosphorus constraint	non-dimensional, 0-1
Potassium constraint	non-dimensional, 0-1
Soil evaporation	mm
Topsoil depth	cm
Rooting depth	cm
Soil loss	Mg per ha
Daily latex flow	Mg per ha

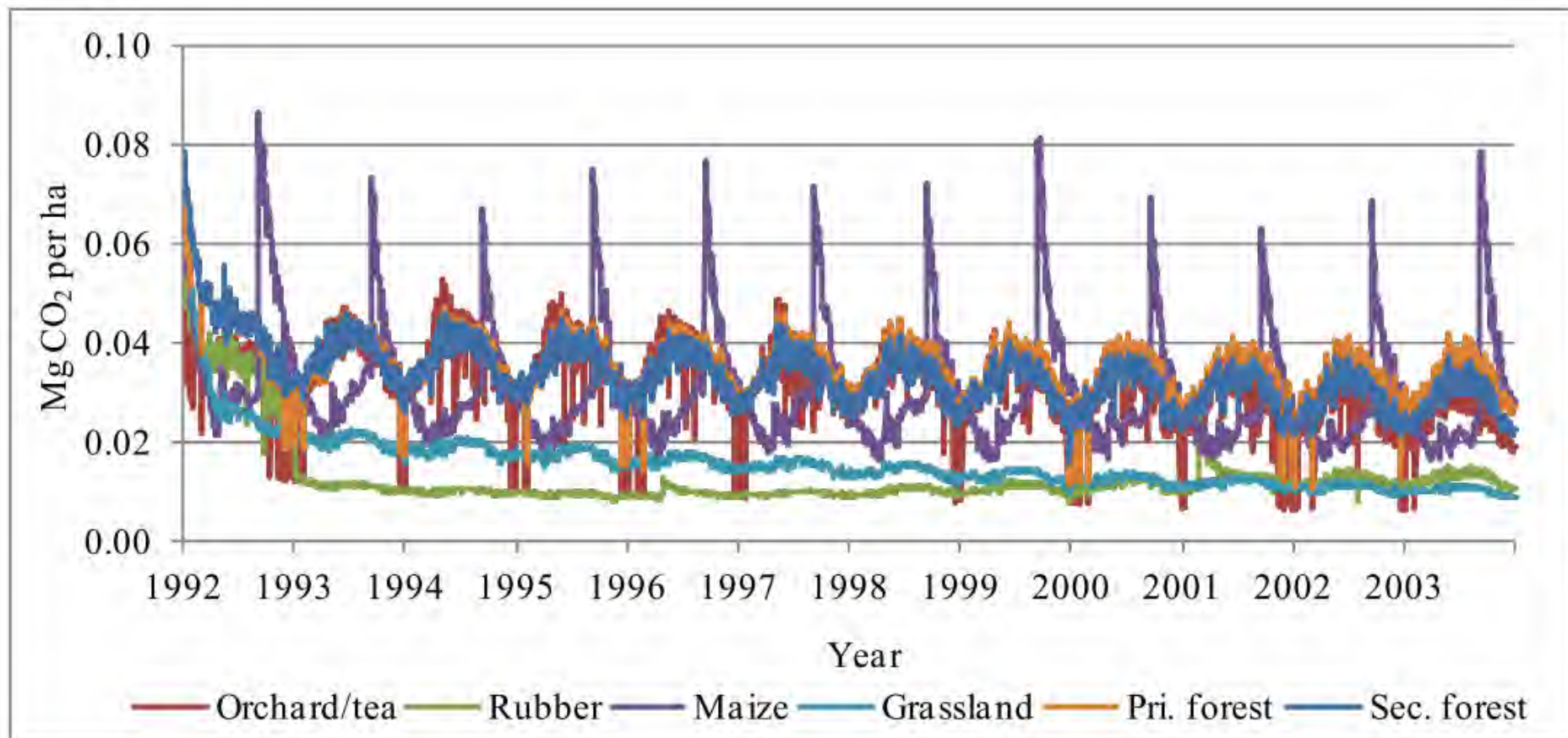
Preliminary Results – Model testing (C. Huber)



Allometric and modelled biomass
— Not significantly different



Daily soil CO₂ release in Mg CO₂ per ha by land use in the sub-watershed, 1992 to 2003



Estimation of Carbon budget at watershed level based on LUCIA outputs

1) for perennial woody land uses:

$$C_{balance_i} \text{ [Mg C/ha]} = B_i + C_{topsoil_i} + C_{subsoil_i} - Y_i - LA_{export_i},$$

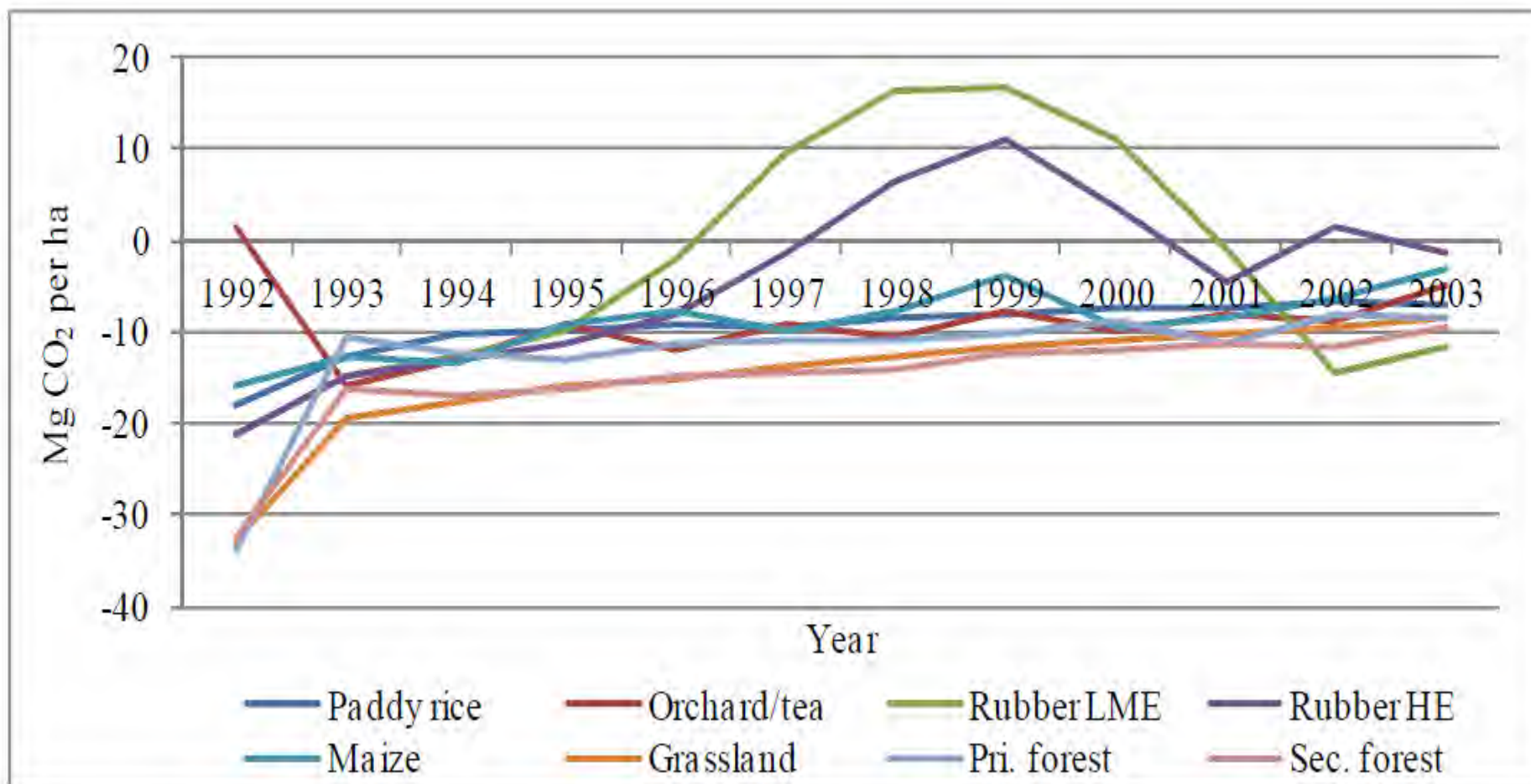
where B is biomass net change, C_{topsoil} and C_{subsoil} are the net change of total carbon in topsoil, and in subsoil respectively, Y is yield, and La_{export} is the cumulative amount of latex that is removed from rubber trees

2) for land uses with annual crops:

$$C_{balance_i} \text{ [Mg C/ha]} = C_{topsoil_i} + C_{subsoil_i}$$

as it is assumed that the biomass of one year is equivalent to biomass removed due to harvesting and mortality in that same year

Preliminary Results – Testing Phase



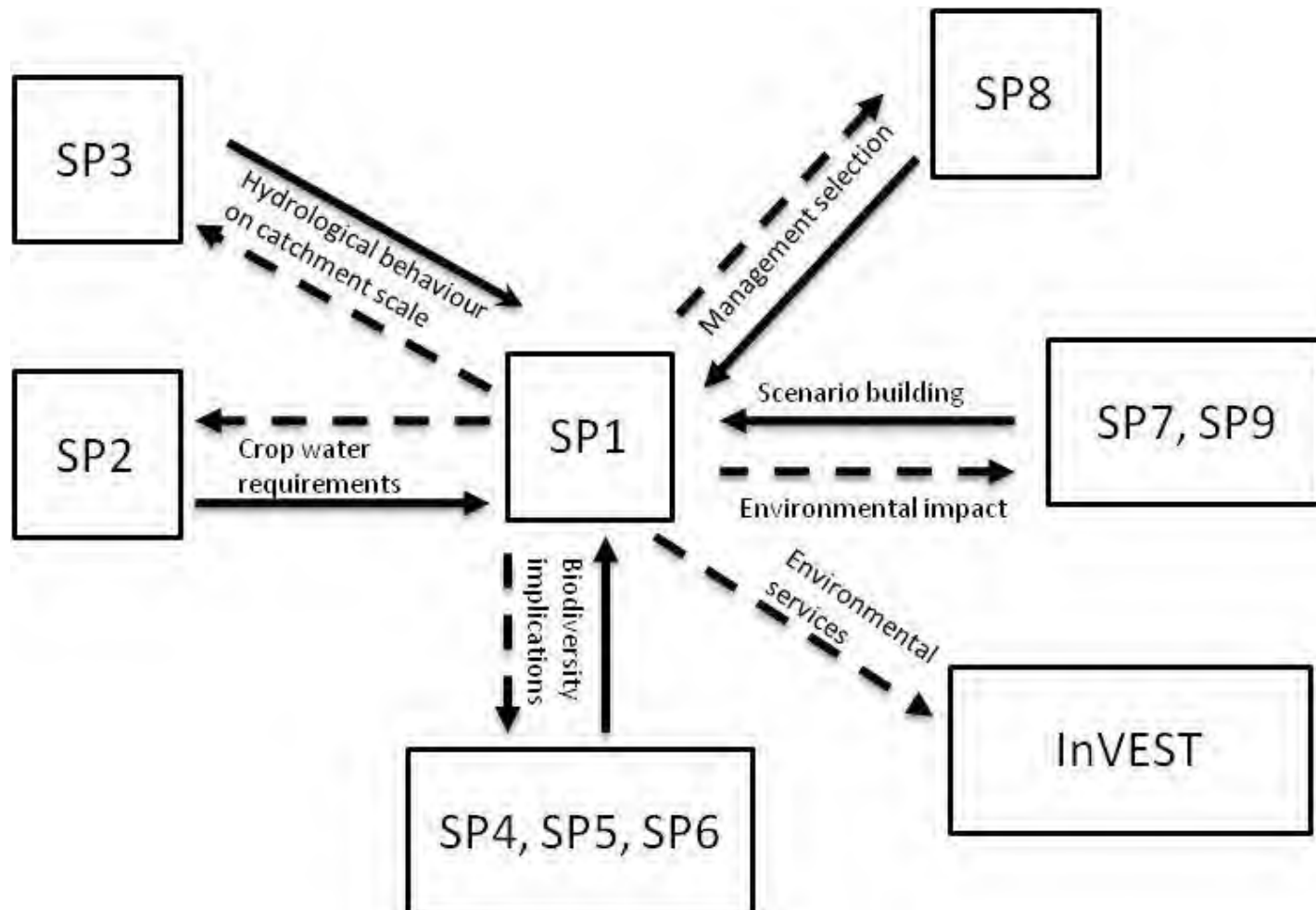
Carbon balance in Mg CO₂ per ha of the land uses in the sub-watershed, 1992 to 2003

Outlook – Next Project Phases

- Scenario identification/ scenario building
- Ecosystem service and ecosystem functions analysis, i.e. LU intensification effect on habitat fragmentation, hydrological cycle, agroecosystem productivity, biodiversity change, pollinator services: [Data exchange between subprojects](#)
- LUCIA- Choice, module for decision making, stakeholder dialog

Work Package 4: LUCIA an integrated assessment tool

✓The subproject 1 will be interconnected with several other subprojects in order to enhance the evaluation on environmental services



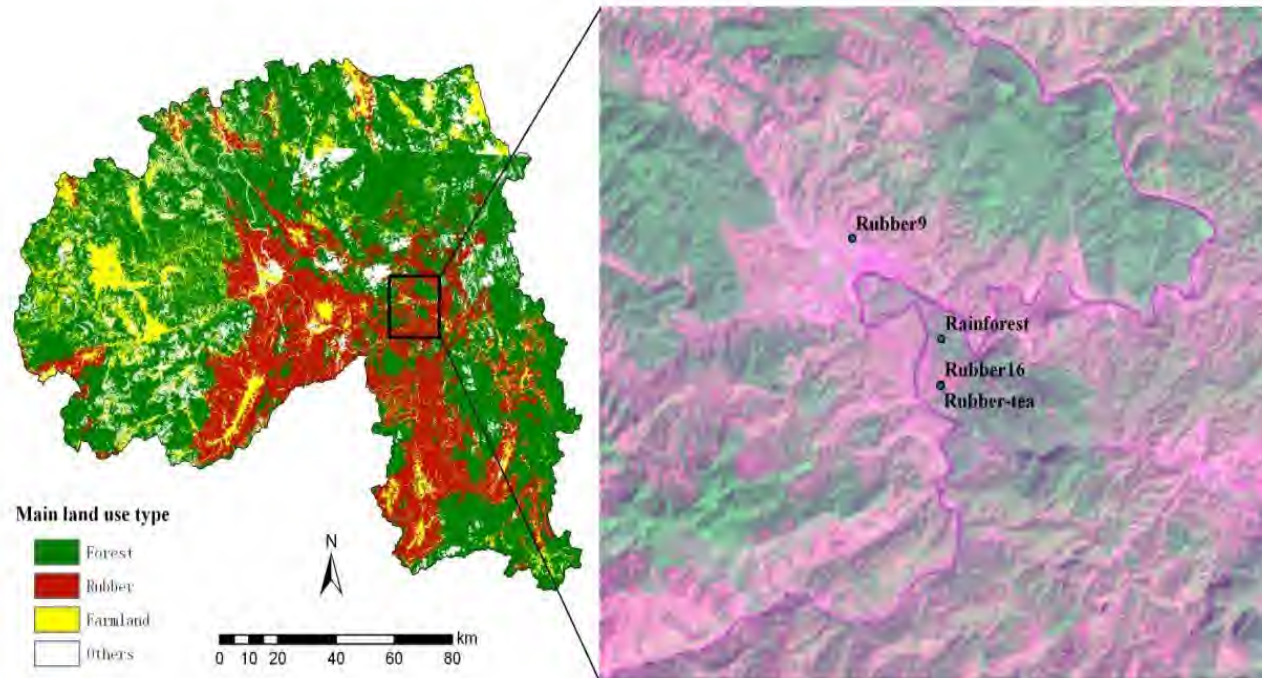
Thank you for attention!

The support by project
sponsors is greatly
acknowledged!

The project upon which the presentation is based was funded by the German Federal Ministry of Education and Research under project number 01LL0919. The responsibility for the content of this publication lies with the author.

Location of observation points near XTBG

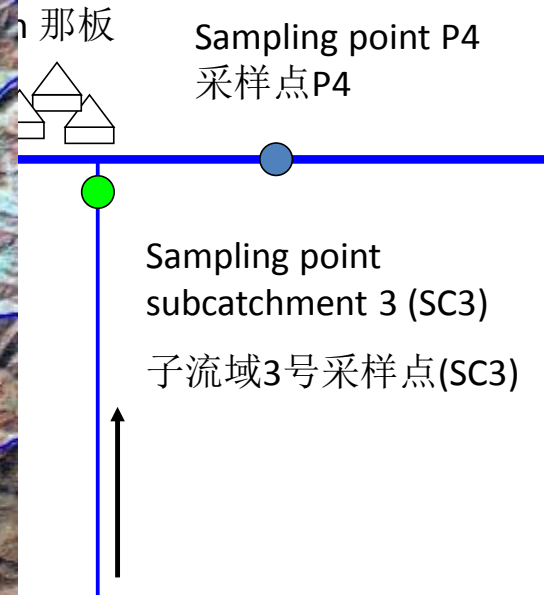
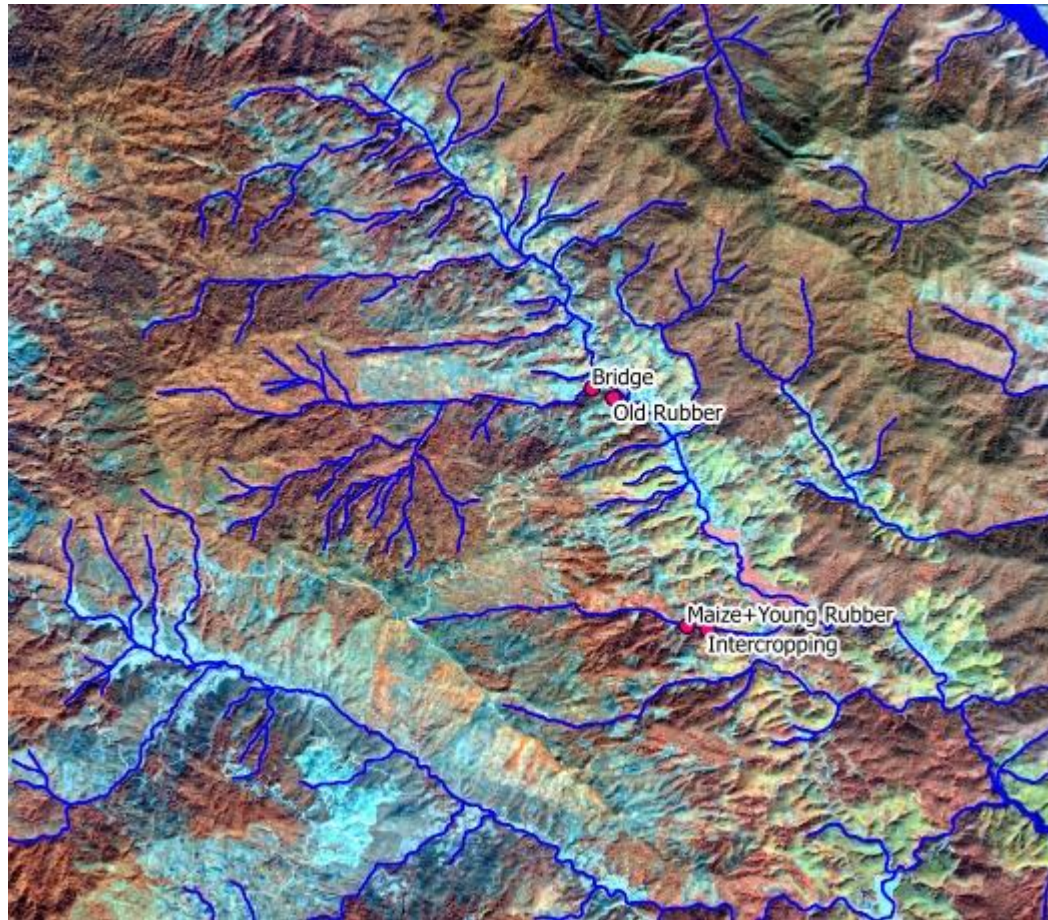
Site	Location (UTM, 47N)	Elevation (m asl)
Rubber monoculture 16 years	734581, 2424327	567
Rubber-tea intercropping 16 years	734550, 2424315	590
Rubber monoculture 9 years	731646, 2428283	595
Rainforest	734542, 2425609	582



Minimum dataset for LUCIA modelling

- **Weather data at**
 - Rainfall (more than 0
 - Air temperature
 - Soil temperature
 - Solar radiation
 - ETO
- **Management data**
- **Plant and land cover related data**
- **Soil data for two horizons:**
 - Horizon thickness
 - Stone contents
 - Bulk density
 - Texture
 - SOC
 - NT
 - Nmin
 - P Bray
 - P sorption
 - K plant available

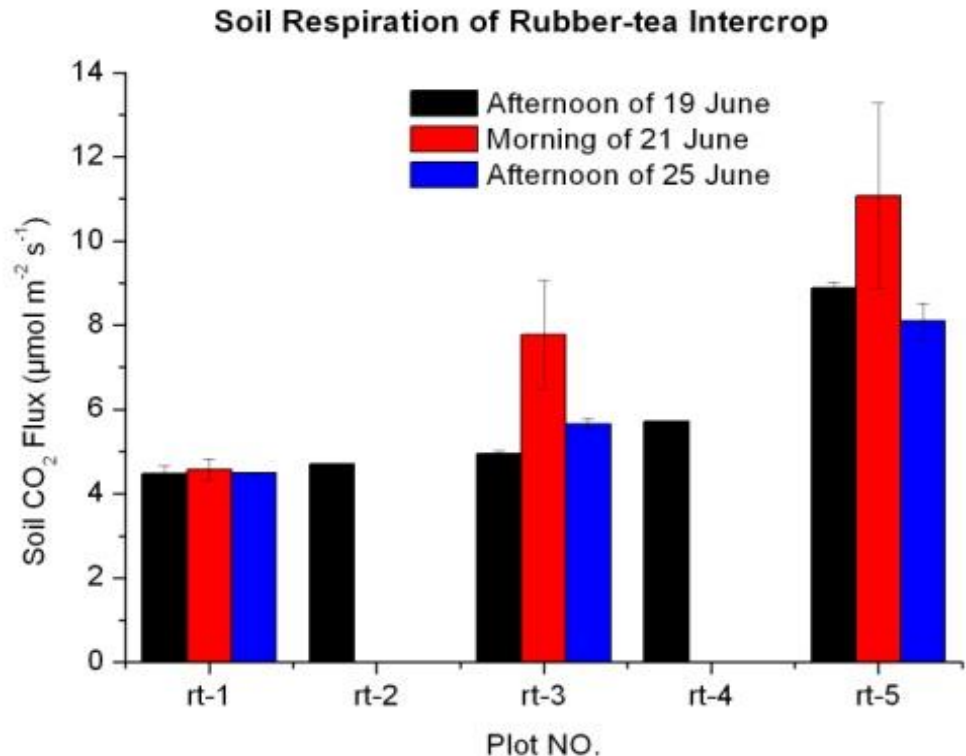
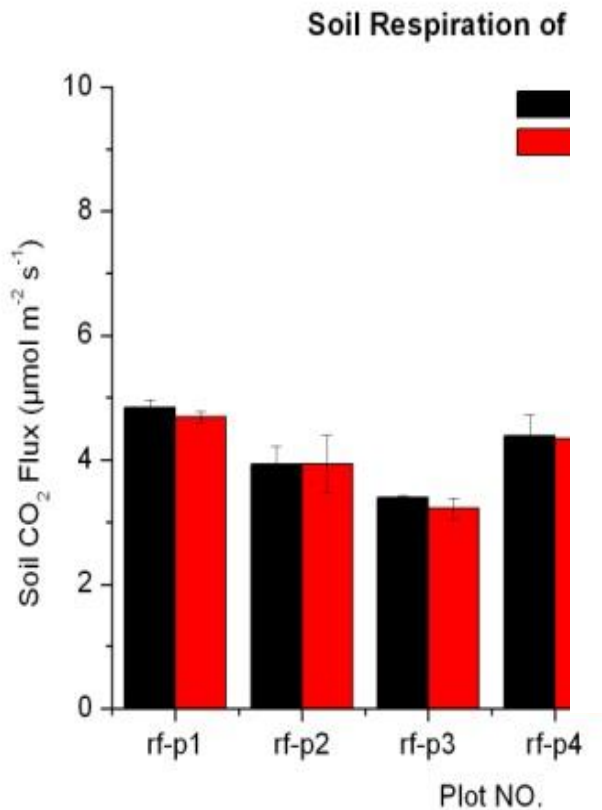
Joint sampling scheme and co-operation with SP3 (water management)



Joint erosion study plots in two selected subwatersheds

More details: data on soil respiration

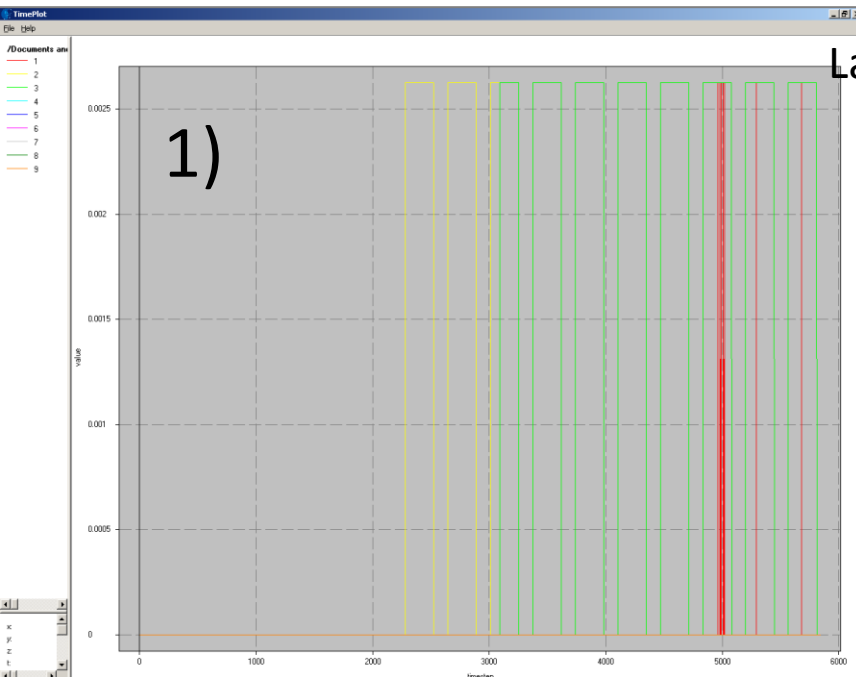
Comparison of soil CO₂ flux, temperature and moisture in 4 sites



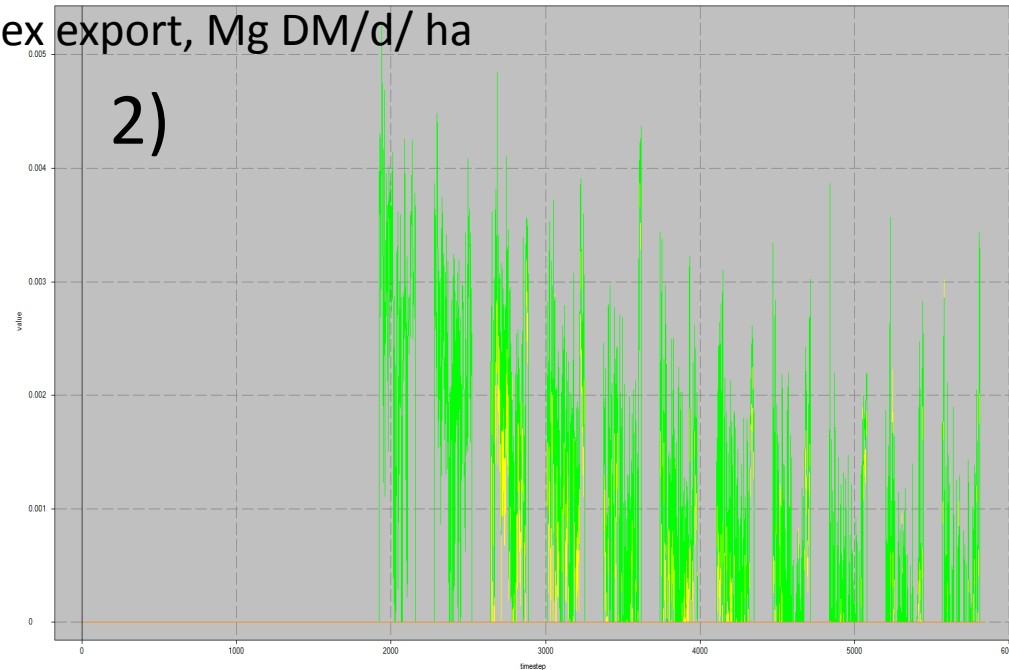
moisture
3)
0.01 c
0.01 b
0.02 a

Development of the 'Latex export' subroutine in LUCIA

1. Default **simplified approach**: daily latex flow depends on tapping frequency, total stem biomass and empirical constant factor
2. **Physiology driven** daily latex flow: depends on tapping frequency and daily assimilates fraction in stem
3. **TO DO**: Approach 2 amended with **mechanistic description of tapping panel**: maximal latex export corrected for the length (shape) of tapping line



Latex export, Mg DM/d/ ha



Time, 0-16 years of rubber growth

Progress: CO₂ emission first results:

Collected Data	Description
Ground truth points	GPS coordinates and land use type
Soil CO ₂ respiration	4 plots in XTBG (5+2 measurements), 2 plots in Naban (2 measurements)
Soil samples	Sampled plots in XTBG and in selected potential intercropping experimental sites at 4 depth: 0-15cm, 15-30cm, 30-45cm, 45-60cm.

