

Impacts of logging on soil organic carbon and heterotrophic respiration in tropical forests in Borneo

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Logging

- extracting selected commercial trees from natural production forests
- logging damages residual stands and soils and reduces biomass and timber stocks for longer periods

Logging on Borneo

- 1973: 75.7% of Borneo covered by forest
- 2010: 266,257 km² of 1973 forest cover logged
- General: 52.8% (389,566 km²) of Borneo remain forested
- of which 209,649 km² represents intact forest landscapes (old growth forest - **OGF**)



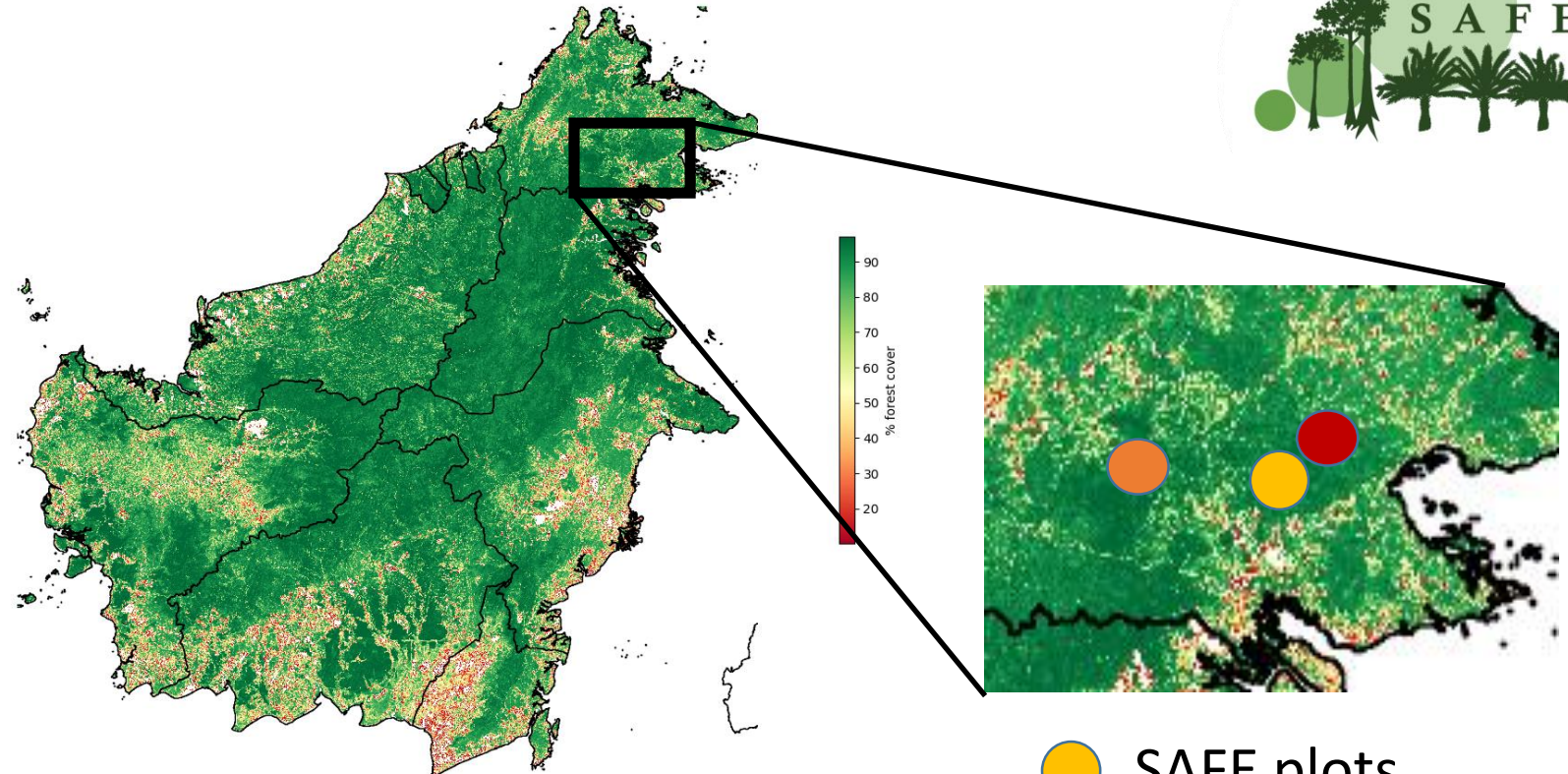
Pictures: <http://www.thirteendimensions.com/rainforests/>
<https://ethz.ch/en/news-and-events/eth-news/news/2014/07/>

Gaveau et al., 2014, Four Decades of Forest Persistence, Clearance and Logging on Borneo, PLoS ONE 9(7)

Study sites

Logged plots at SAFE Project
in Sabah, Malaysia
(SAF-01, SAF-02, SAF-03,
SAF-04)

OGF sites in Danum Valley
Conservation Area and Maliau
Basin Conservation Area in
Sabah, Malaysia
(DAN-04, DAN-05, MLA-01,
MLA-02)

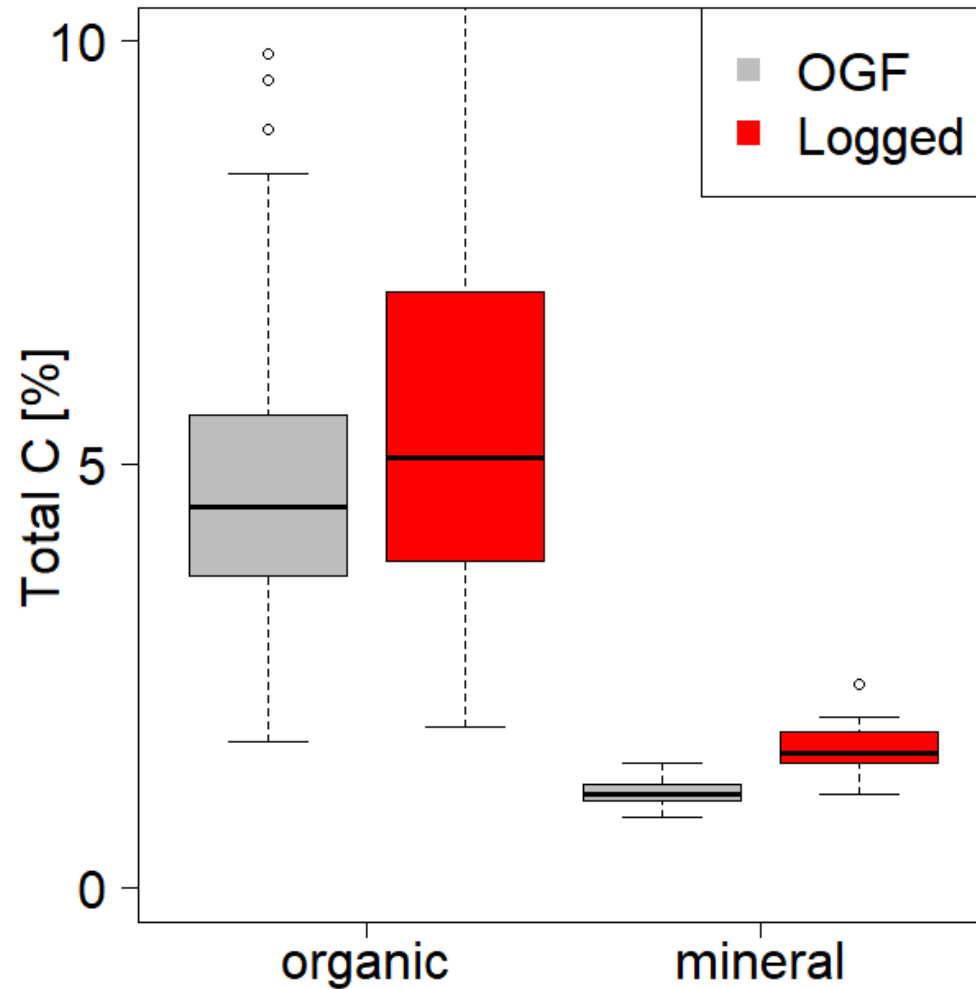


Map: forest cover on Borneo

based on Hansen et al. 2013, High-Resolution Global Maps of 21st-Century Forest Cover Change, Science 342 (6160), 850-853

- SAFE plots
- Maliau Basin
- Danum Valley

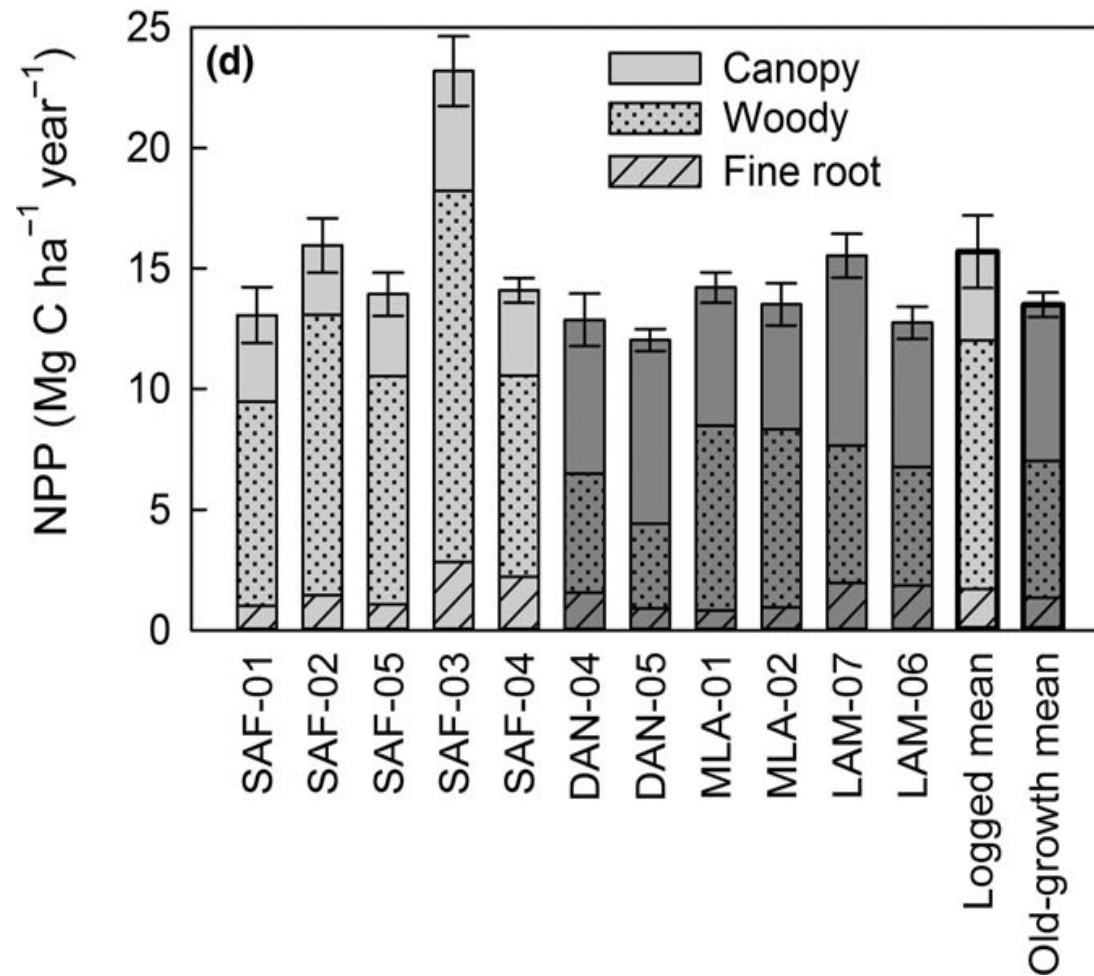
Soil carbon



Data from measurements from site plots:

- Higher carbon (C) content in logged forest

NPP



NPP at site plots:

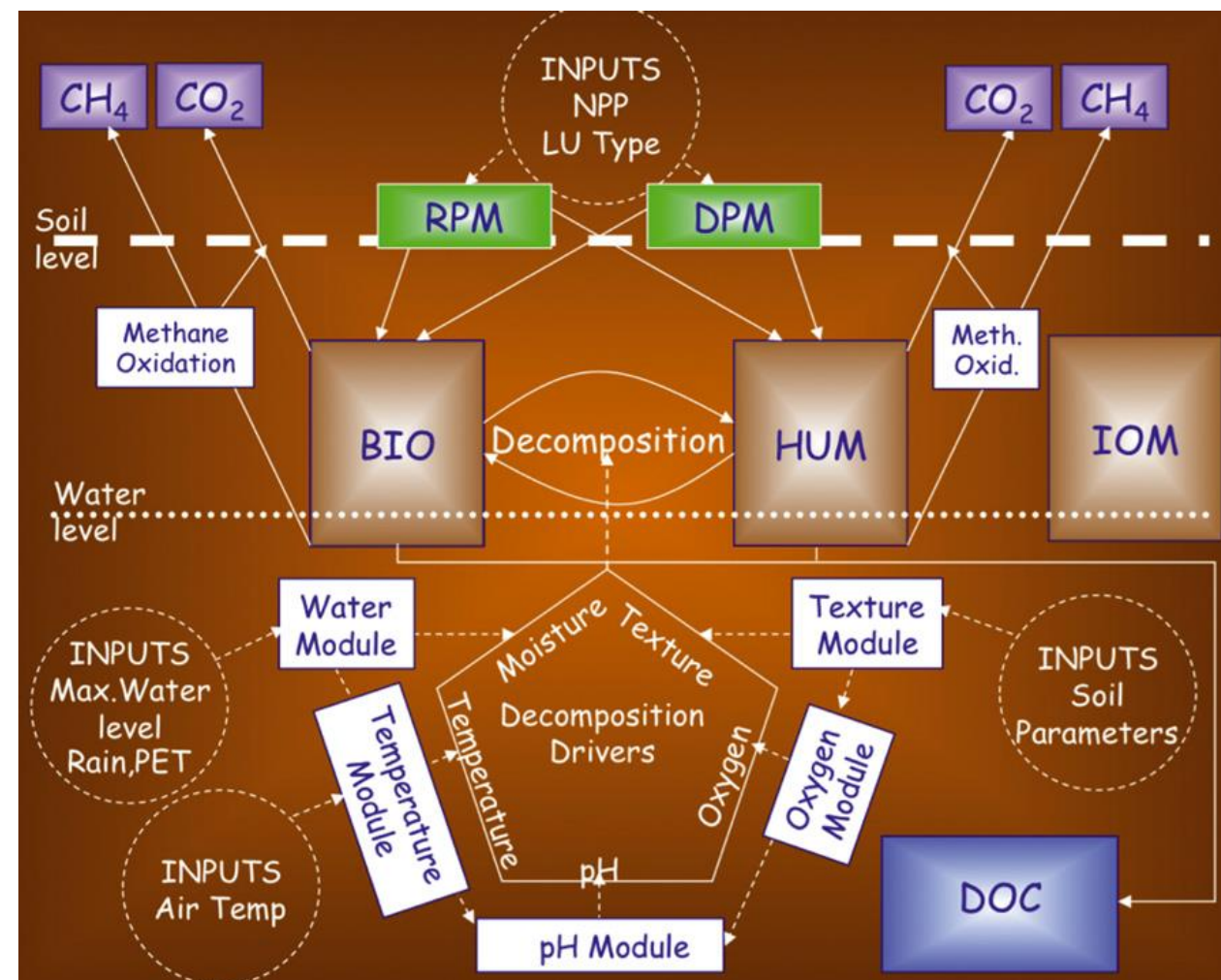
- Canopy NPP much higher in OGF
- Woody NPP is higher in logged forest

Riutta et al. (2018) Logging disturbance shifts net primary productivity and its allocation in Bornean tropical forests. *Glob Change Biol.* 2018; 1–16.

ECOSSE

Estimation of Carbon in Organic Soils—
Sequestration and Emissions

- Carbon components are calculated over 5 different storage pools
- Further information of ECOSSE:
<https://www.abdn.ac.uk/staffpages/uploads/soi450/ECOSSE%20User%20manual%20310810.pdf>



Smith et al. (2010) Estimating changes in Scottish soil carbon stocks using ECOSSE. I. Model description and uncertainties. *Clim Res* 45: 179–192

Model approach

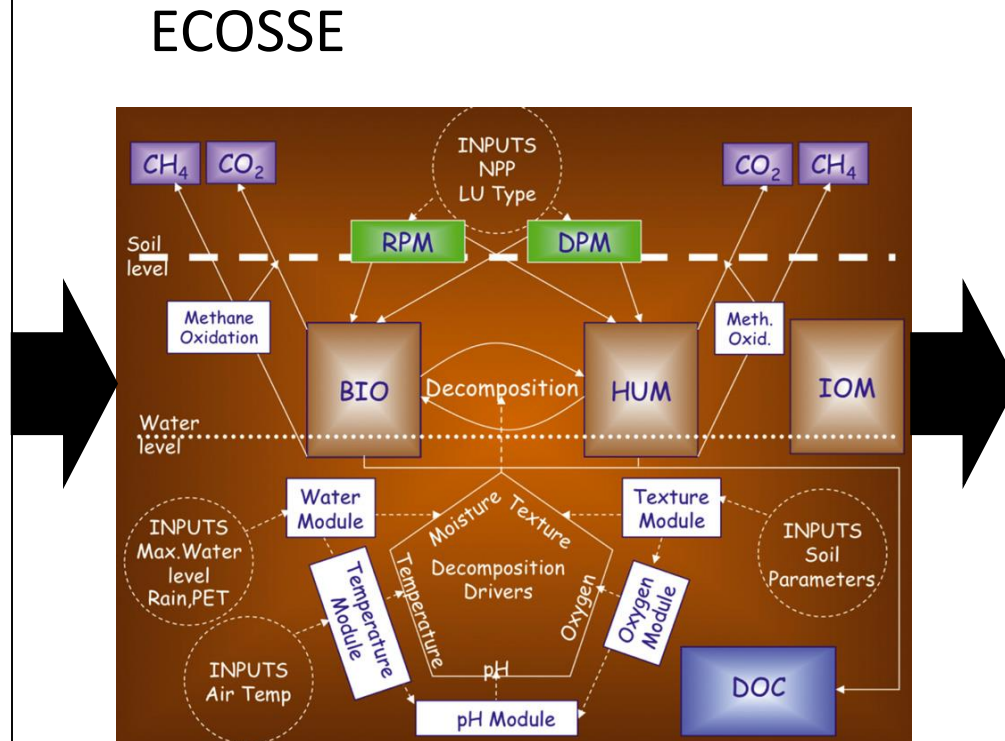
Input:

NPP and biomass input to calculate C to soil (from measurements)

Soil parameters (from measurements)

Climate from CRU dataset for location (historic and future climate)

<http://www.cru.uea.ac.uk/data>

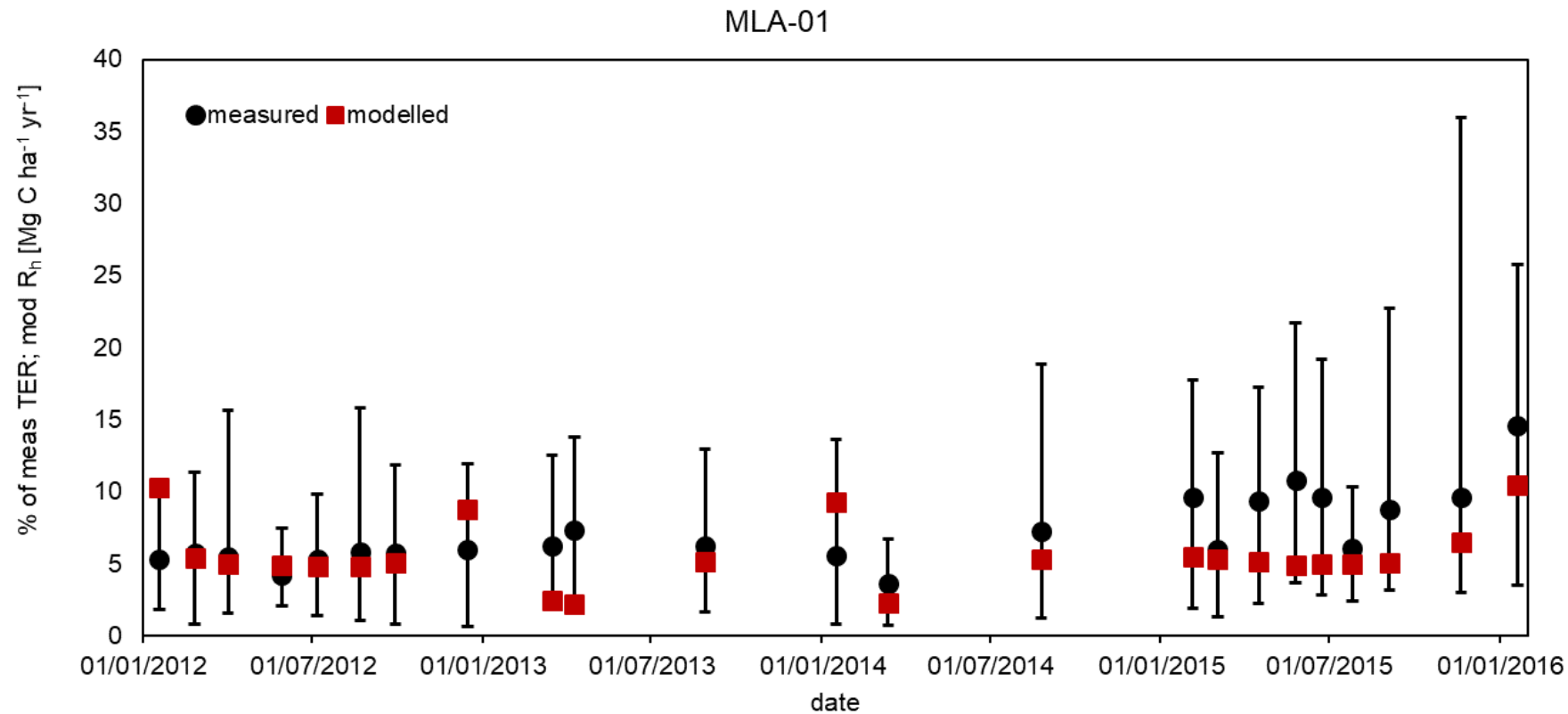


Output:
Soil organic carbon (SOC)

Heterotrophic respiration (R_h)

Results

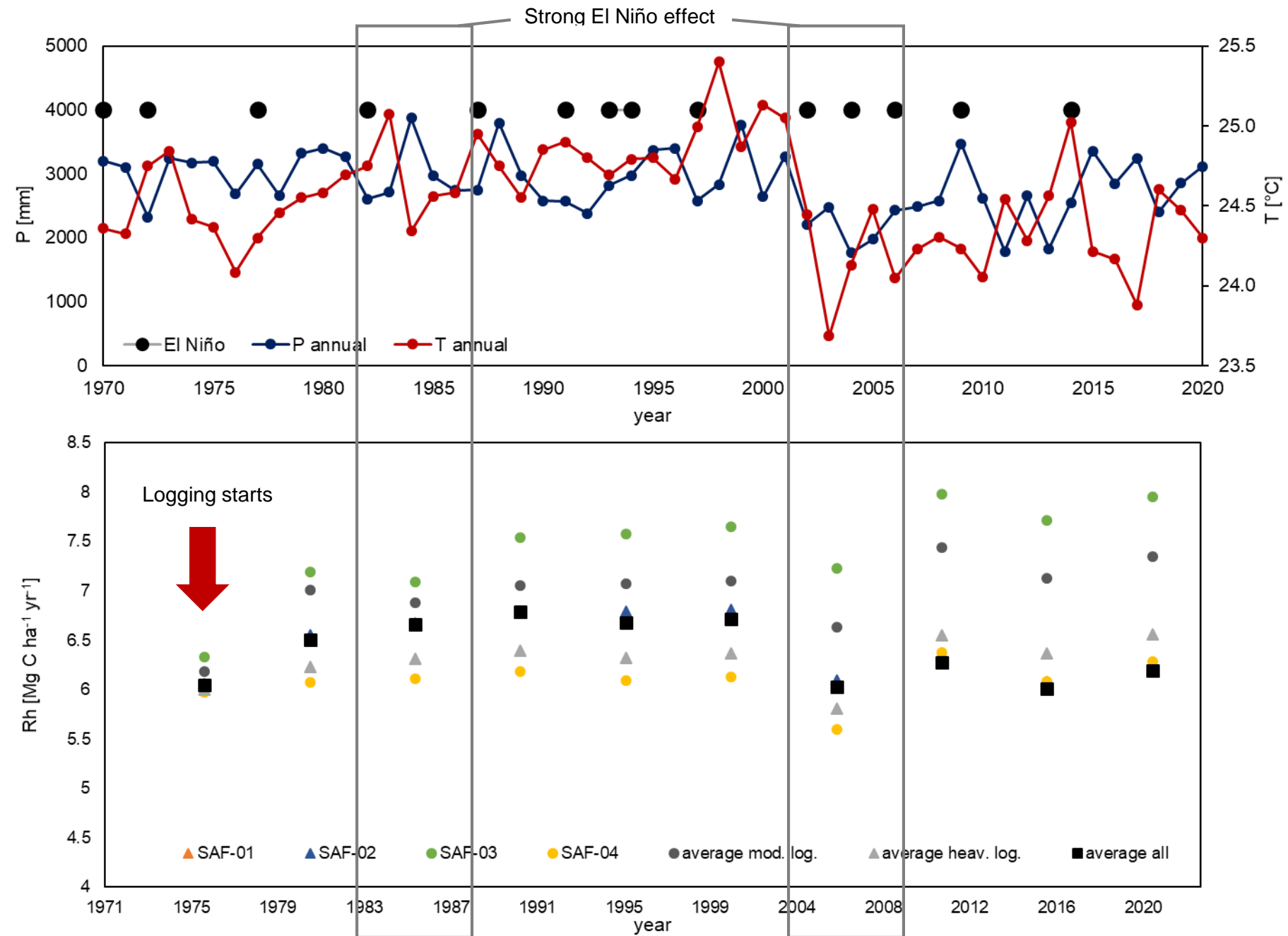
- Example: OGF site
MLA-01
- Solid model
performance for OGF
- Graph: comparison of
modelled R_h and
estimated R_h from
total ecosystem
respiration (TER)
(*paper in preparation*)



Results

Logged sites

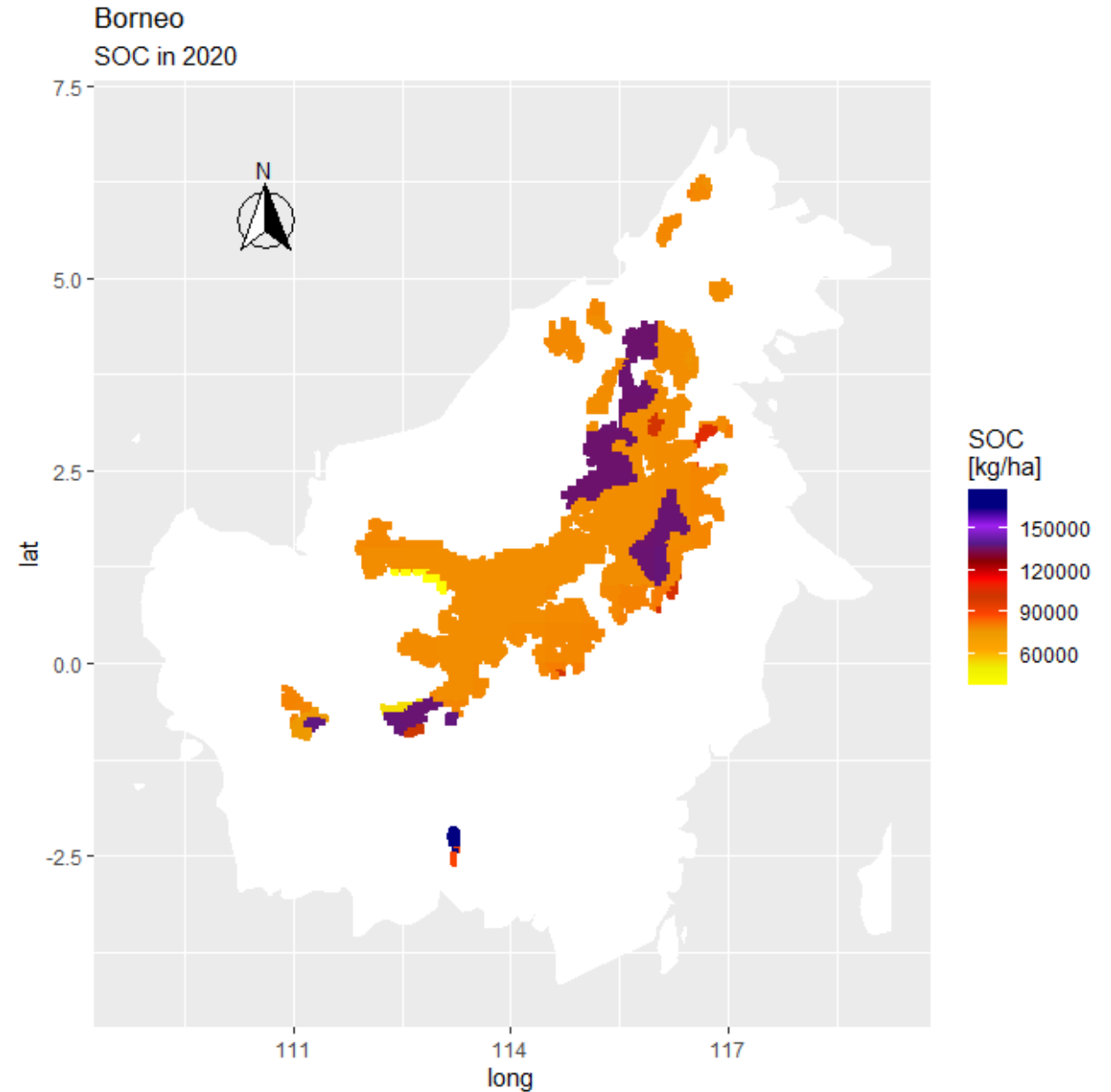
- After ~30 years R_h seems to be in a new equilibrium
- El Niño effect on R_h when several strong events



Results

Spatial modelling:

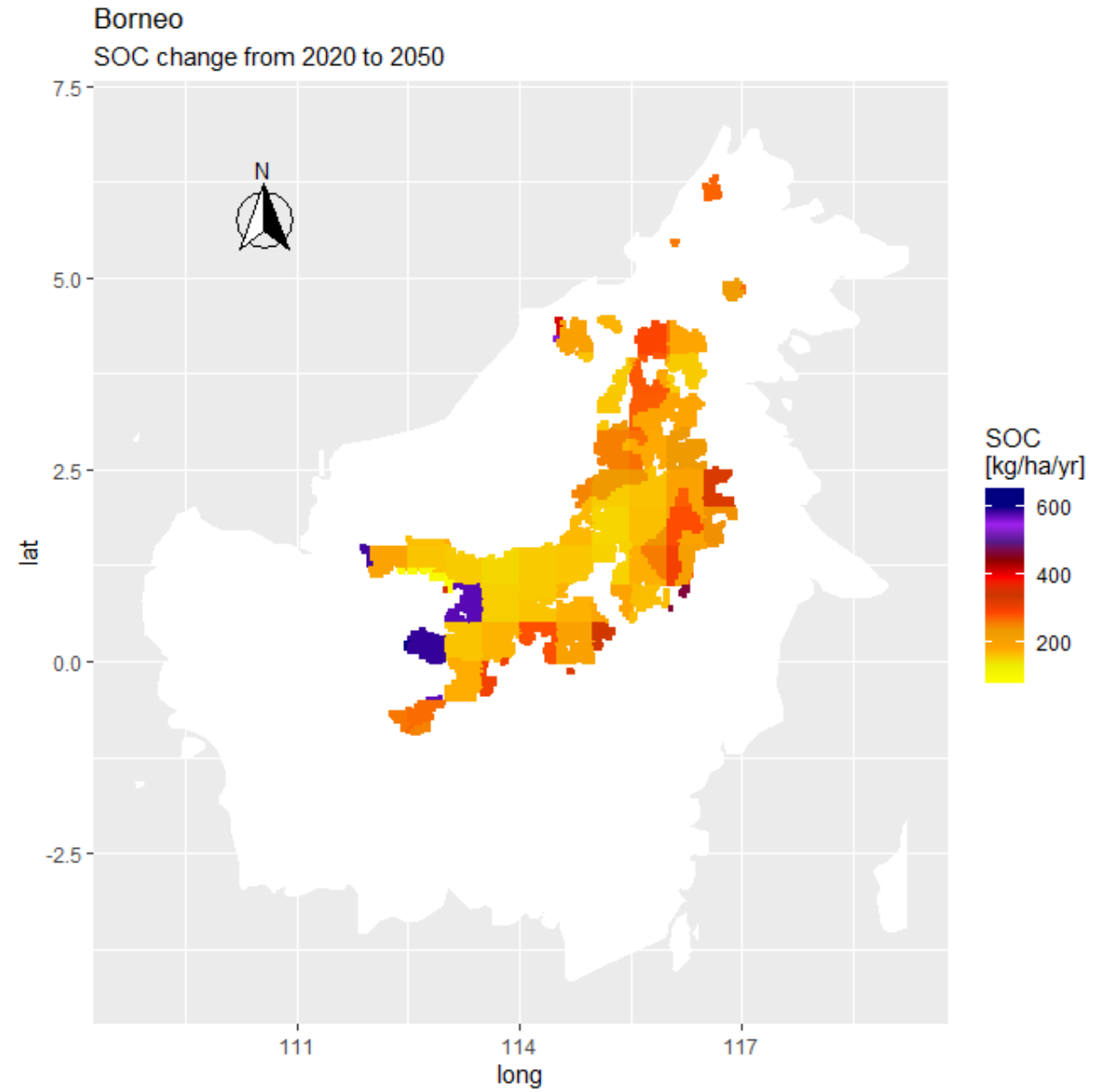
- Map of SOC in 2020 for OGF (intact forest sites)
- Total area: 80315.7 km²



Results

Spatial modelling:

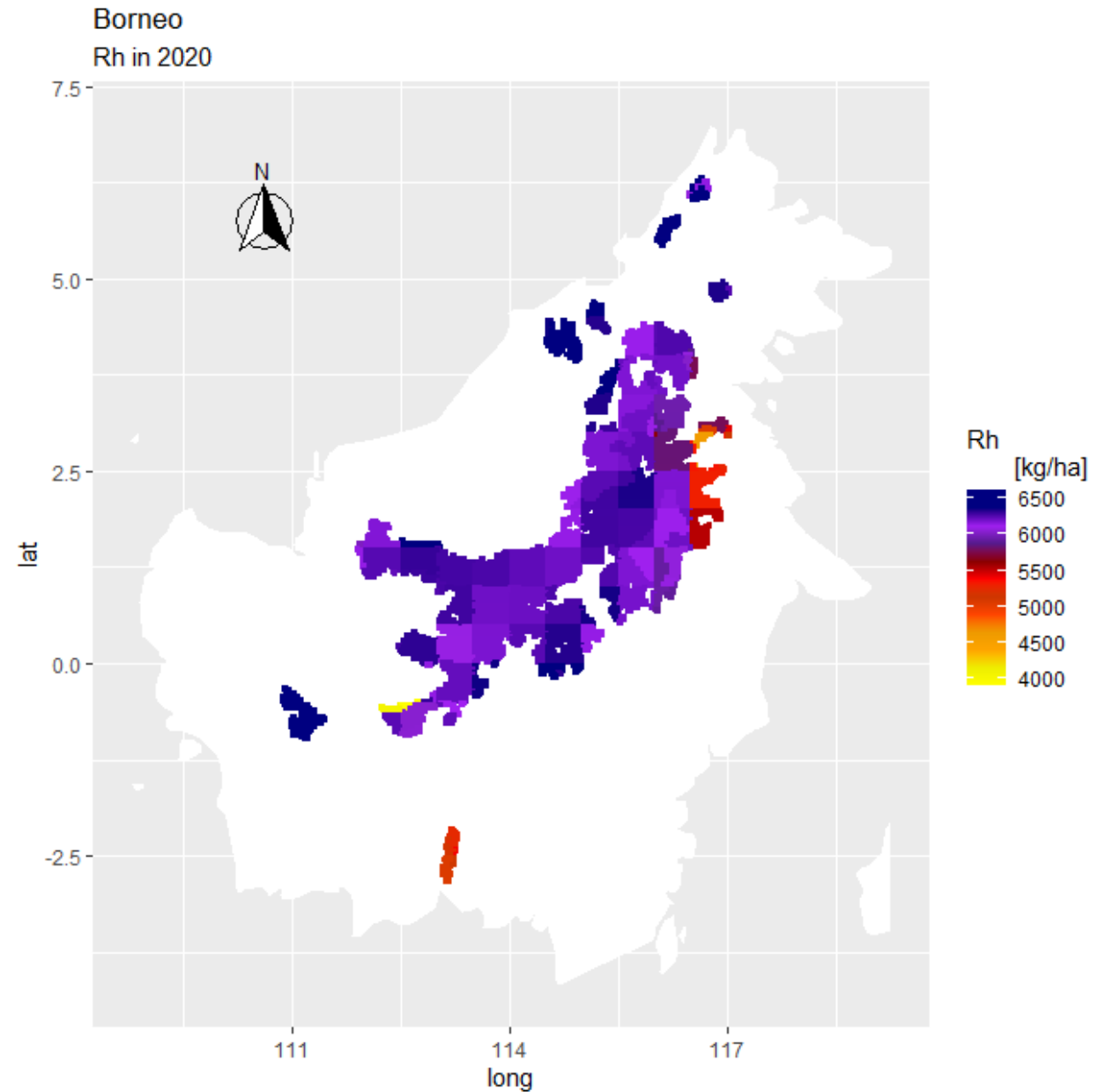
- Model scenario: SOC of OGF after land use change (LUC) to moderate logging
- Annual increase in SOC $\sim 144 \text{ kg C ha}^{-1} \text{ yr}^{-1}$ on average
- In line with model calibration based on measurements



Results

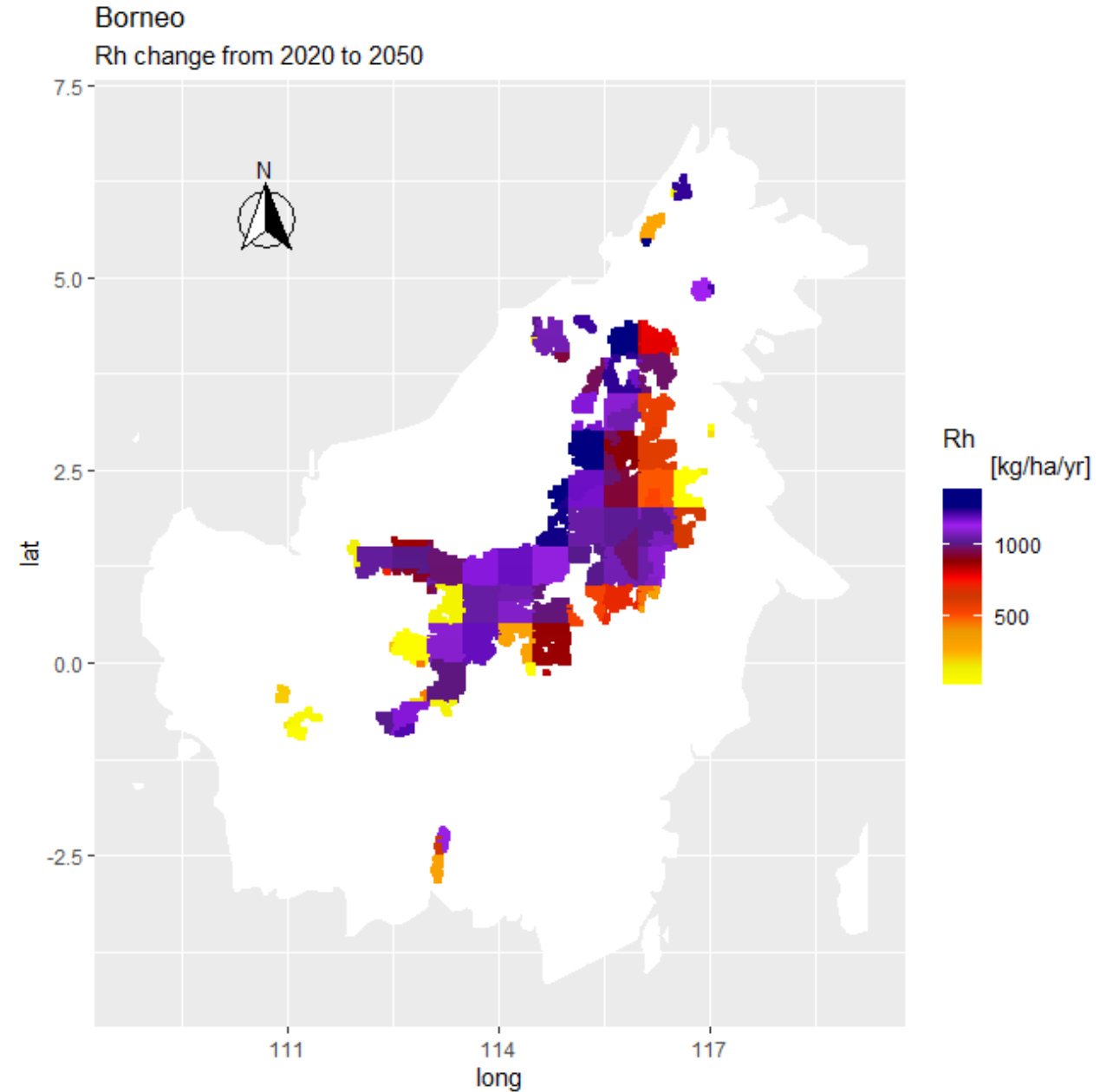
Spatial modelling:

- Graph shows R_h in 2020 for old growth forest (intact forest sites)
- Total area: 80315.7 km²



Results

- Model scenario: SOC of OGF after LUC to moderate logging
- Increase in R_h in 30 years between 20 to 1400 kg C ha⁻¹ yr⁻¹



Conclusion

- El Niño can have decreasing effect on R_h
- Strong increase in R_h after LUC from OGF to logging in following 30 years
- Small increase in SOC in top layer of soil after LUC from OGF to logging in 30 years

Overall:

- logging changes SOC and R_h with indication of further disturbance of ecosystem
- Forest needs at least 30 years to balance carbon fluxes on a new equilibrium

Thank you