University of Zurich
Institute of Evolutionary Biology and Environmental Studies

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Tree Species Diversity and the Functioning and Stability of Forest Ecosystems

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Loss of Biodiversity can harm ecosystem functioning and stability

- The idea goes back to the early-mid 1800s including Darwin's Principe of Divergence
- Occurs when loss of species leaves niches vacant or under-used
- Mainly demonstrated with lab systems or in the field grasslands
- Is the same true for forest ecosystems?

- 18th century: Overexploitation
  - Sustainability (Carlowitz 1713)
  - Silviculture as a new science
  - ➢ Production of timber

"...the mixing of deciduous and coniferous species is not advantageous, as the coniferous trees generally tend to displace deciduous ones and because one type of tree impedes the growth of the other; so that no mixed deciduous and coniferous forests should be established with intent" (Hartig 1781)
"All mixed stands with coniferous and deciduous species should be converted into pure stands of the constituent species, as soon as circumstances permit" (Hartig 1804)

Credit: Prof. Michael Scherer-Lorenzen, University Freiberg

- 19th century: Wood as the sole source of energy
  - Overall productivity more important than production of certain timber types
  - ➢ Mixed stands with 10-20 (-50)% higher yield than pure stands, although mostly on rich soils

"Endeavours to establish pure stands everywhere is based on an old and highly detrimental prejudice.... Since not all tree species utilize resources in the same manner, growth is more lively in mixed stands and neither insects nor storms can do as much damage; also, a wider range of timber will be available everywhere to satisfy different demands..." (von Cotta 1828)

Credit: Prof. Michael Scherer-Lorenzen, University Freiberg

- 20th century: Differentiated views
  - Evaluation of first long-term silvicultural experiments of the Forestry Research Stations (1870ies)

    "...if we design stands of shade-intolerant and shade-tolerant tree species, [...] the potential for timber production is raised even more; the reason being [...] the stratification of age classes" (Möller 1922)

    "...even in silviculture, room must be given to hard facts next to emotions" (Wiedemann 1951)

    ➢ Highest production in pure stands for spruce, douglas fir, pine, eucalypts on many sites

    ➢ Results highly dependent on site conditions

Credit: Prof. Michael Scherer-Lorenzen, University Freiberg

21st Century Forest Policy and Economic Frameworks

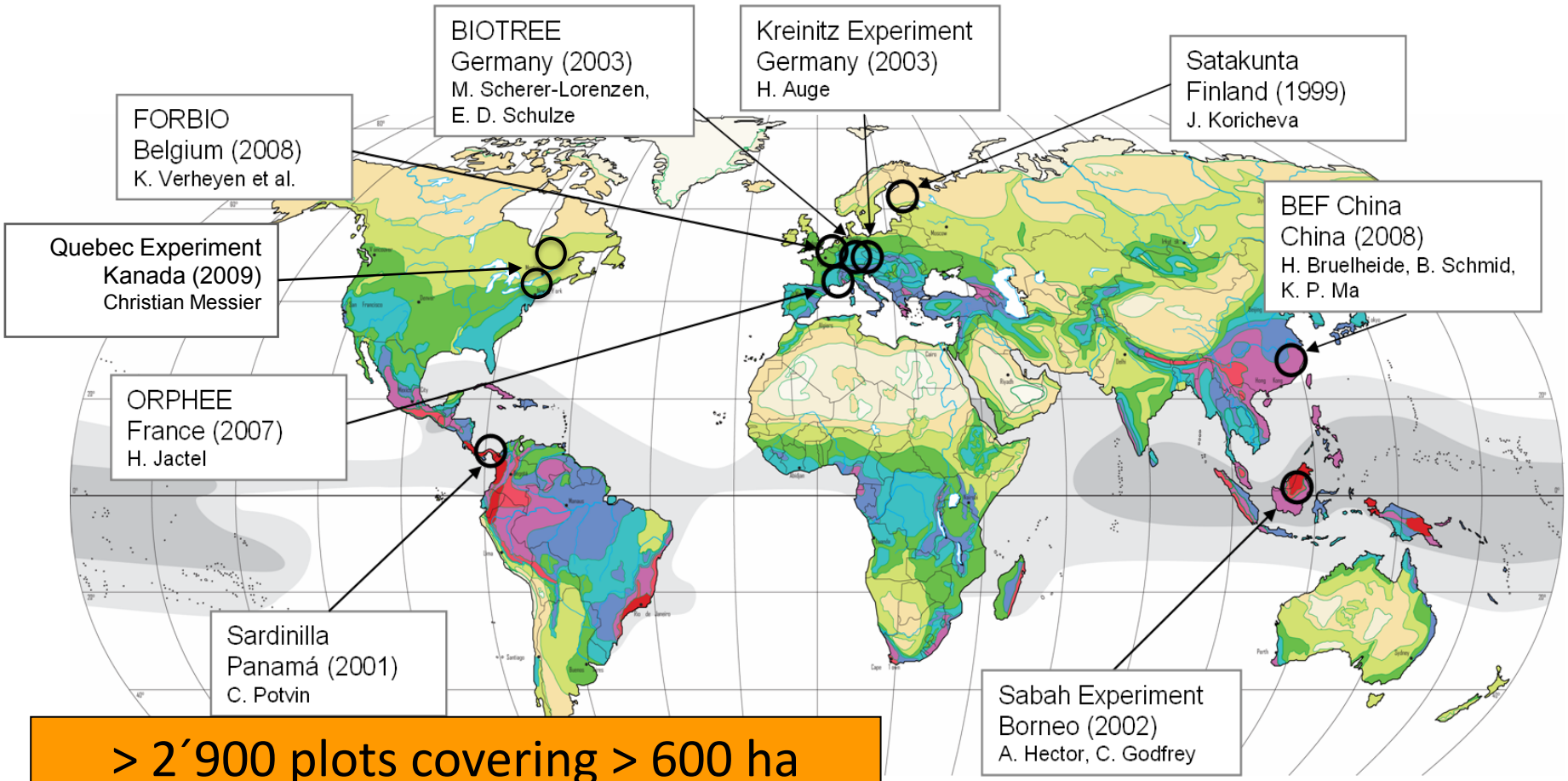
- Biodiversity and greenhouse gasses currently dealt with by different policy and economic frameworks
- Rio Convention versus Kyoto Protocol
- Carbon markets versus BioBanks
- New interest in area of overlap: REDD and REDD+
- Payments for ecosystem services

The Sabah Biodiversity Experiment

Andy Hector, Glen Reynolds, Charles Godfrey, Chris Philipson, Philippe Saner

www.treedivnet.ugent.be

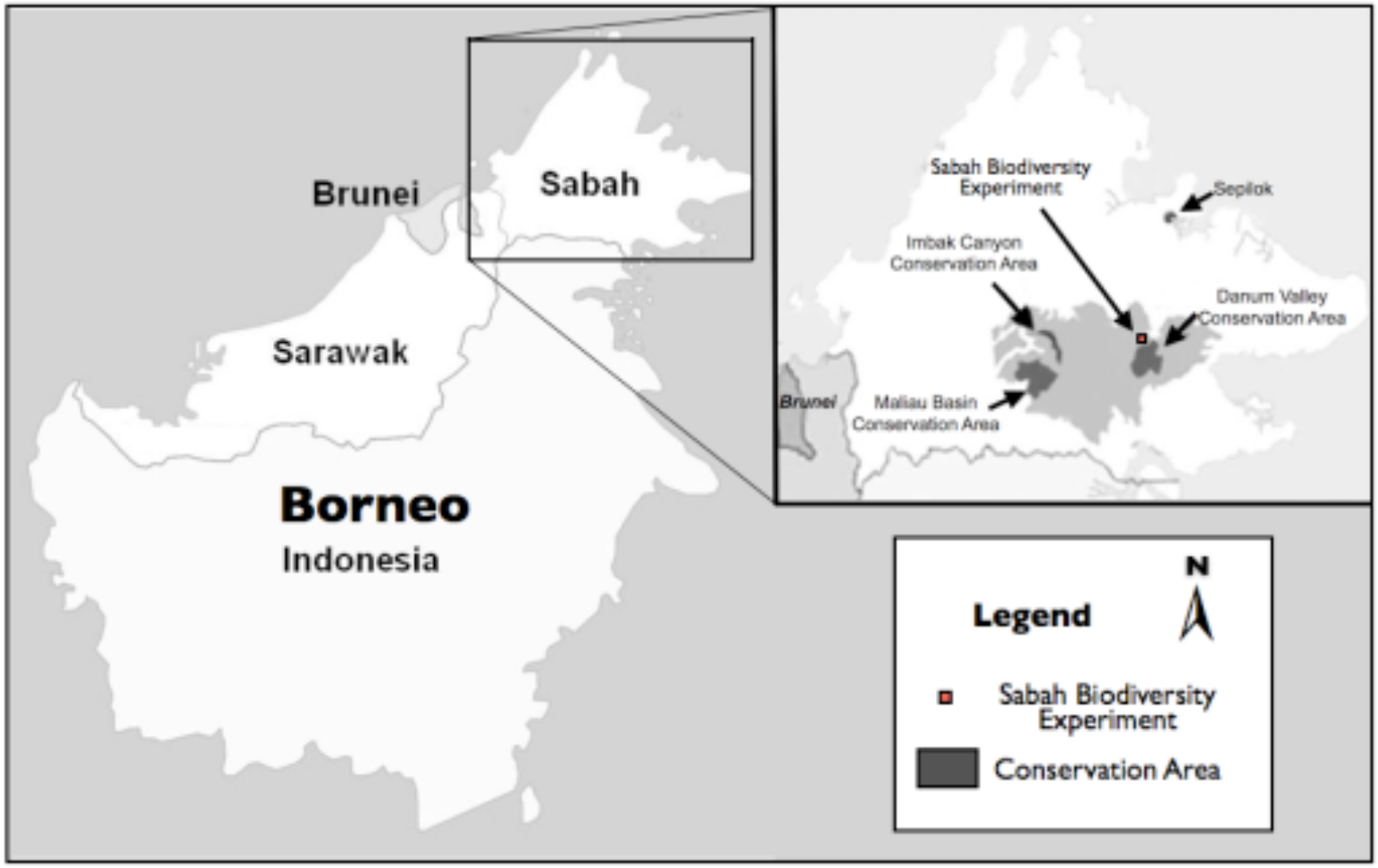
Planted Experiments: TreeDiv_Net



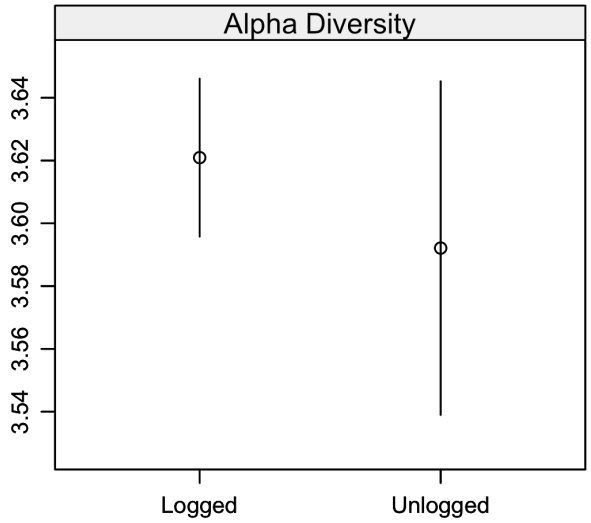
> 2´900 plots covering > 600 ha
> 610´000 planted trees

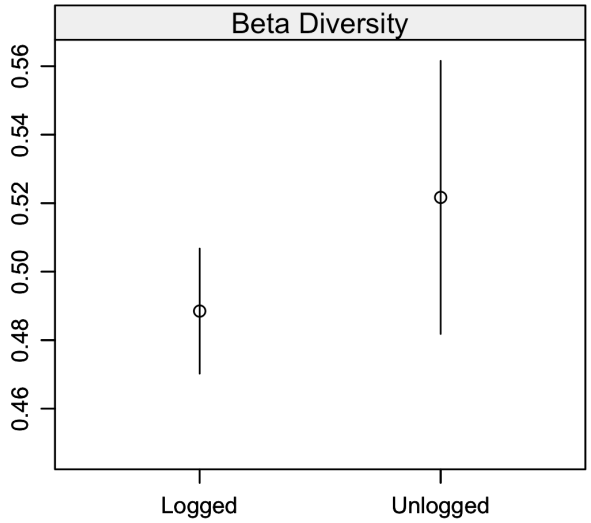
Background map: map of vascular plant diversity, Barthlott et al. 2005

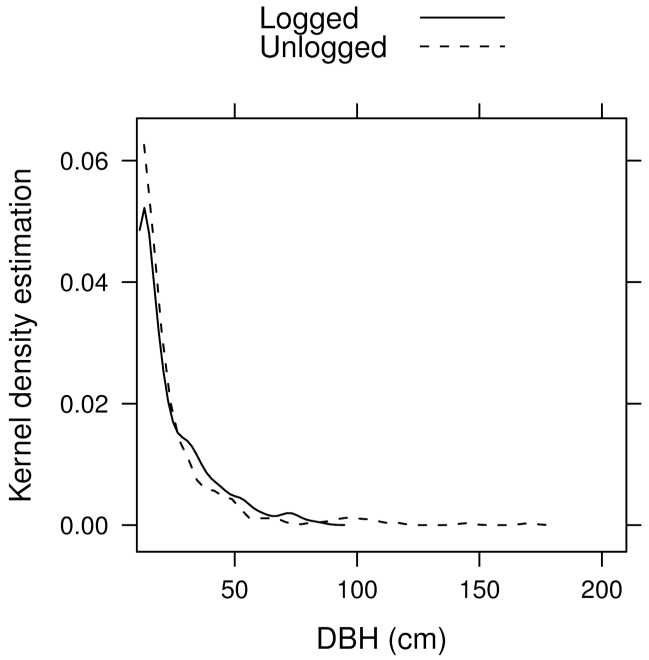
Malua Forest Reserve, Sabah, Malaysian North Borneo



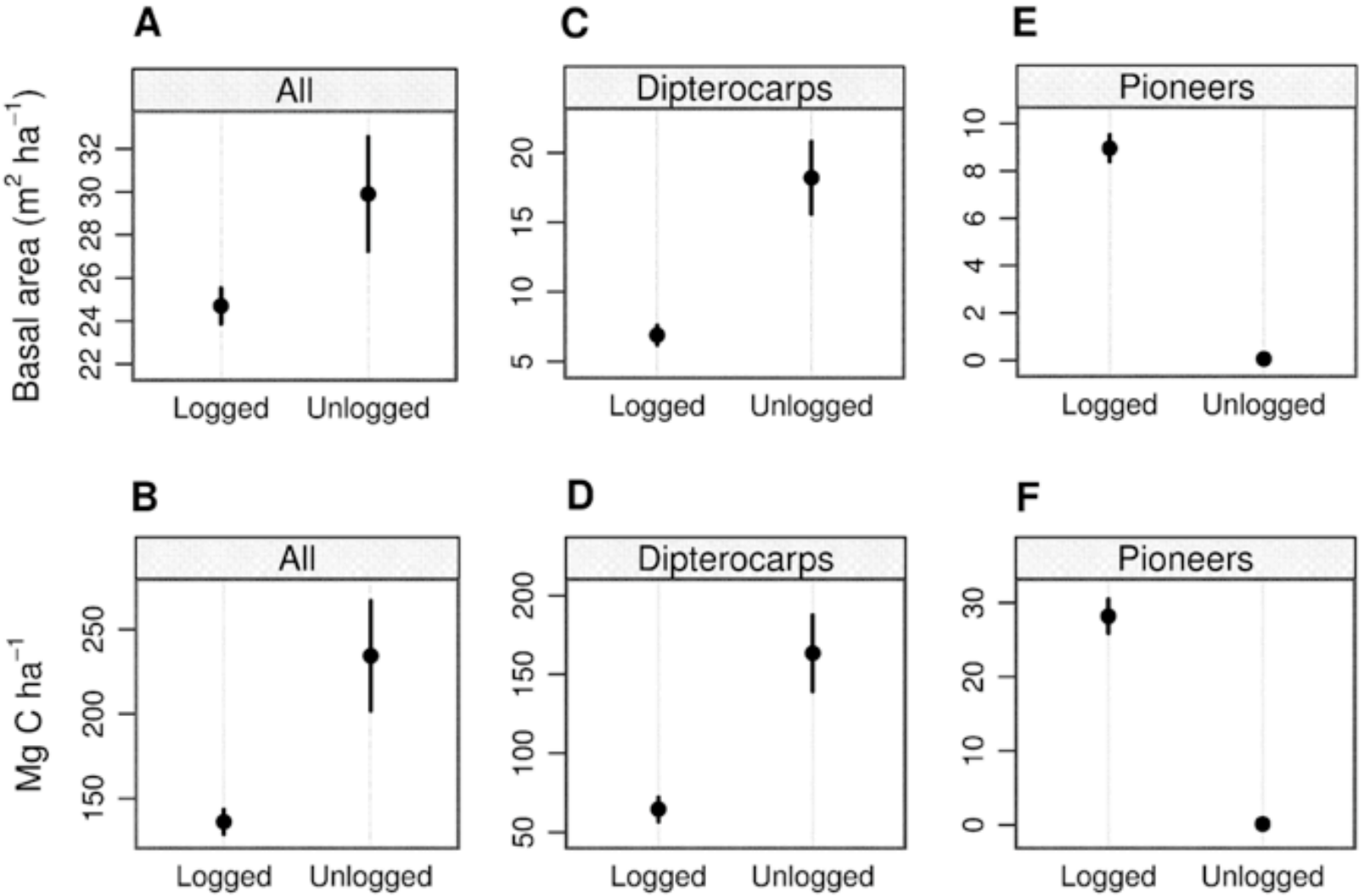
Diversity and Structure







Reductions in basal area, aboveground biomass and carbon by selective logging



Can using higher levels of tree diversity accelerate forest restoration?

- The first tree diversity experiment in palaeo-tropical forests
- Applied setting: Enrichment planting into a selectively logged forest
- Field scale: 500 ha; 100,000 seedlings; 500 km of planting lines
- Only the diversity of the dominant group of trees is manipulated against a background of selectively logged forest


THE SABAH BIODIVERSITY EXPERIMENT
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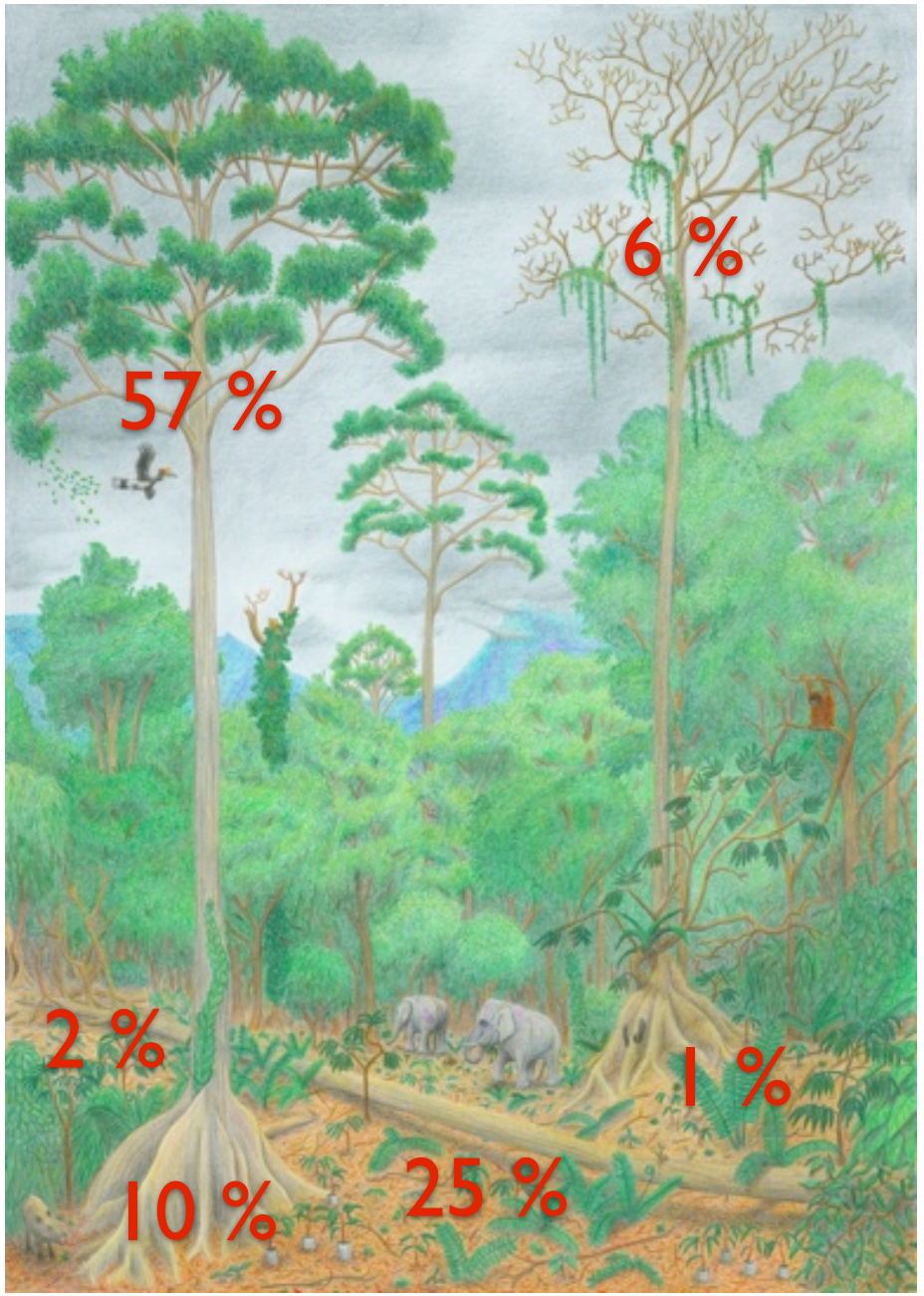
Unplanted
Monoculture
4 sp. mixture
16 sp. mixture

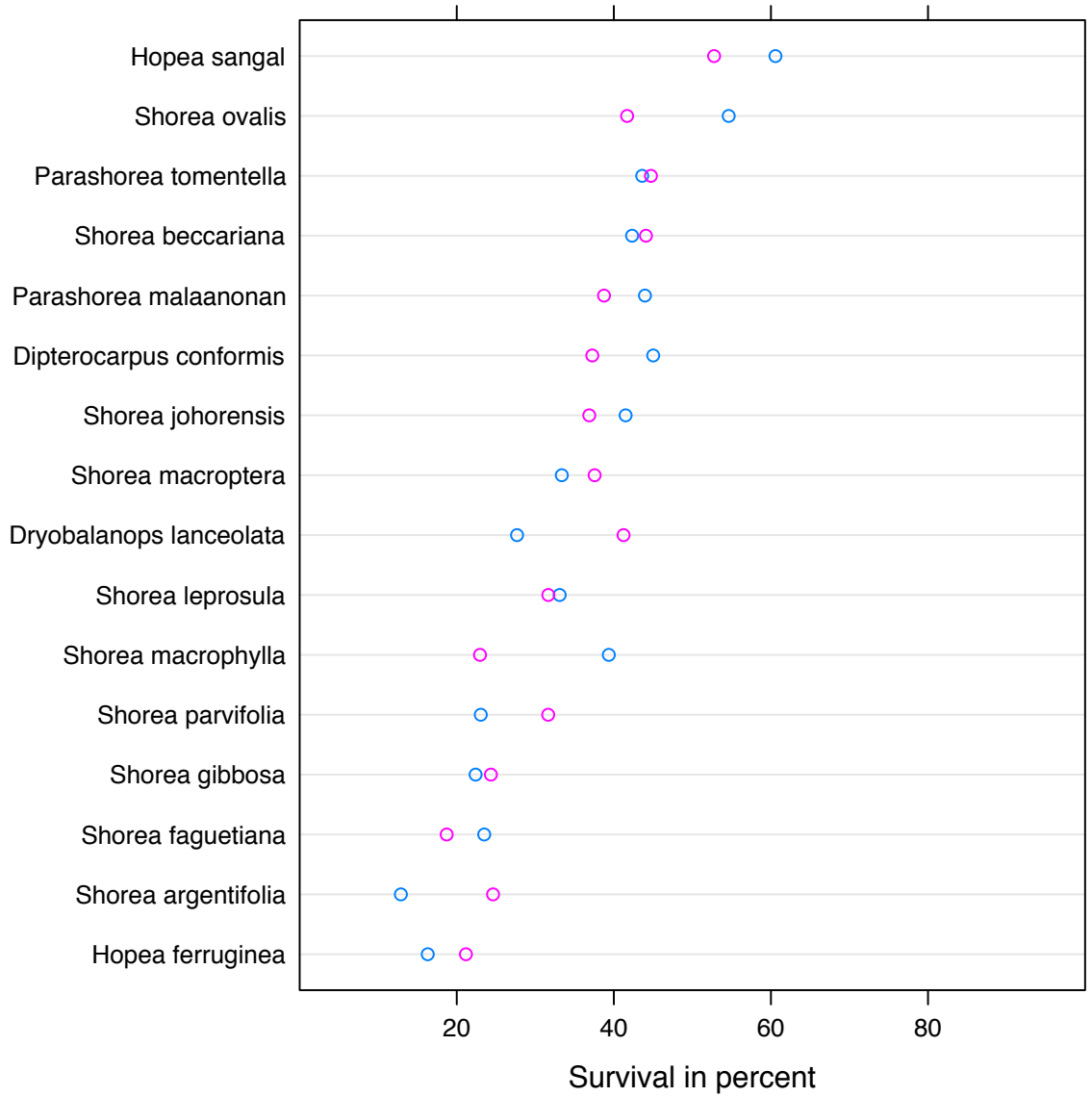
Total organic carbon stocks 237 t C ha^{-1}

Aboveground tree biomass (57%)
Aboveground non-tree biomass (2%)
Belowground roots (10%)
Forest floor litter (<1%)
Deadwood (6%)
Soil (25%)



230 t C ha^{-1} (Abu Bakar, 2000)
261 t C ha^{-1} (Pinard 1996, 1997)

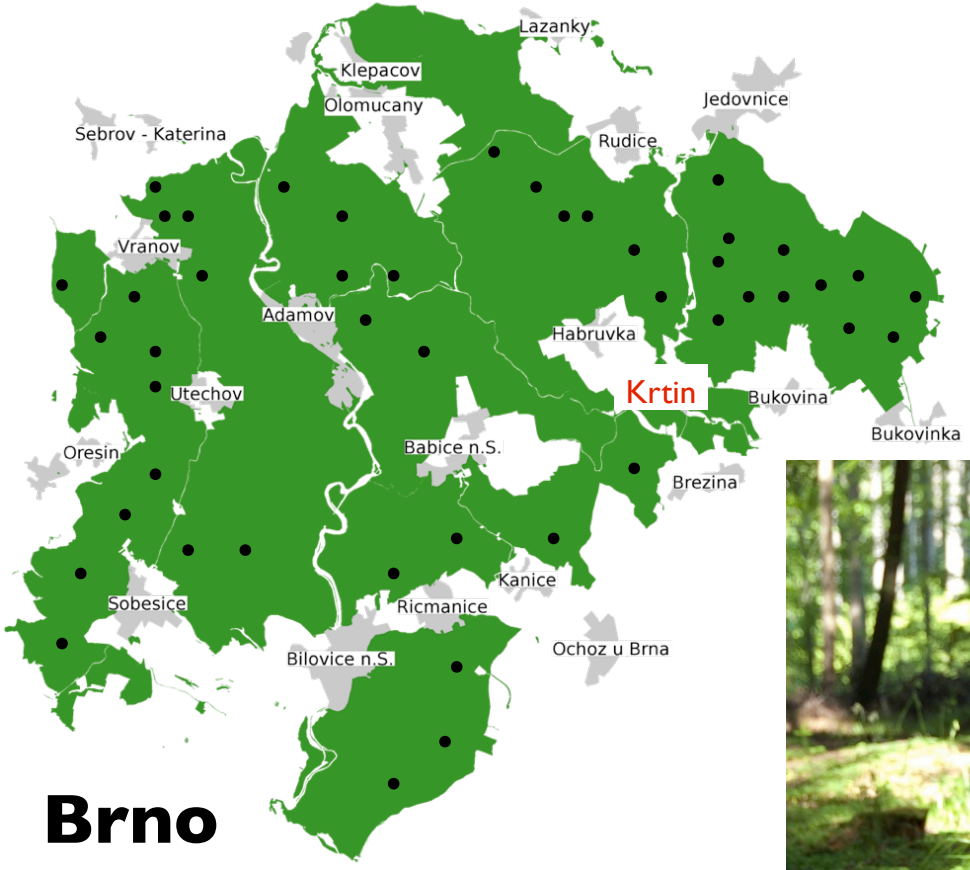
Role of Diversity? Consistent Differences in Survival



Temperate Forest Diversity and Functioning

Study in the Krtiny Training Forest Enterprise Collaboration with the Institute of Forestry, Mendel University

Krtiny Training Forest Enterprise: 45 Stands to sample

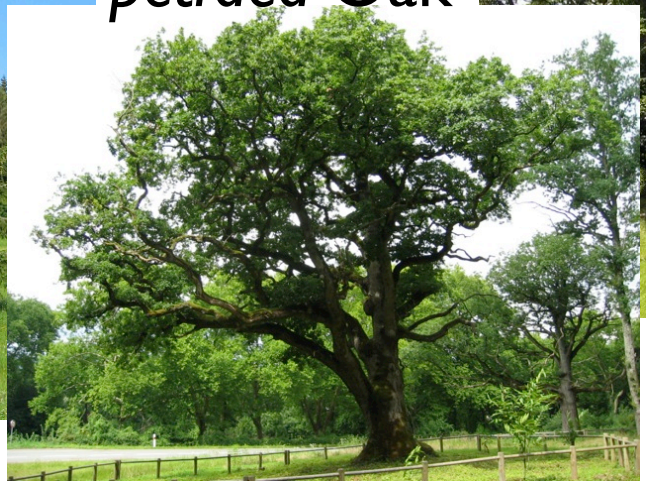


Four Species of economic Importance

Larix decidua
Larch

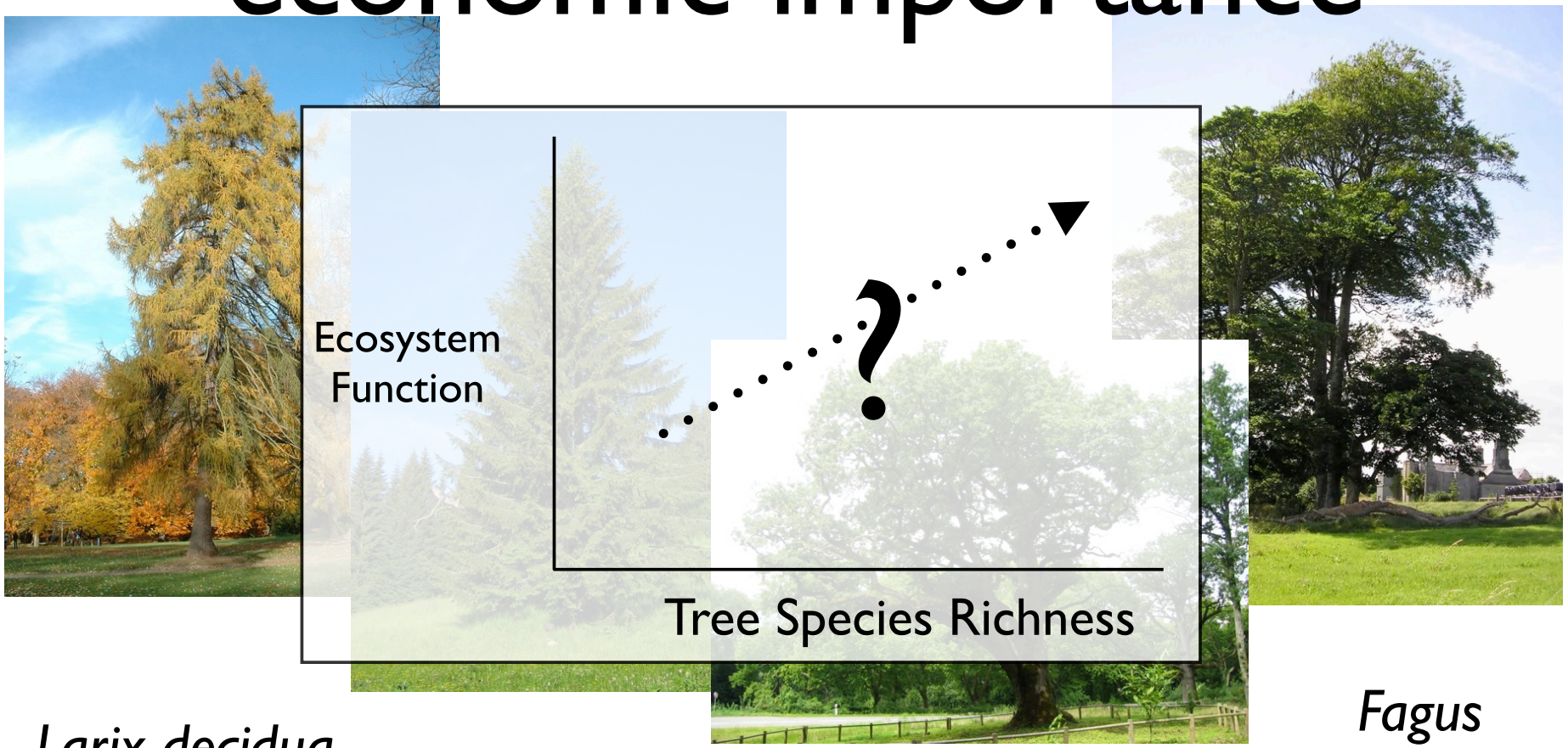
Picea abies
Spruce

Quercus petraea Oak



Fagus sylvatica
Beech

4 Species of great economic importance



Larix decidua
Larch

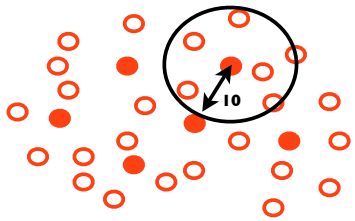
Picea abies
Spruce

Fagus sylvatica
Beech

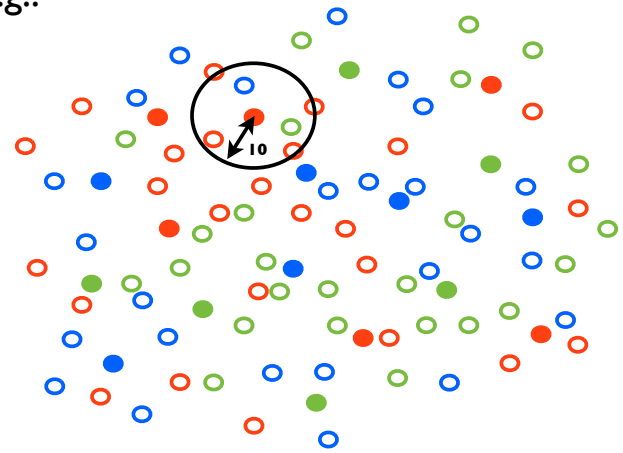
45 stands: 15 possible combinations of the 4 species, 3 replicates of each

Species	Species Combination
1	beech
1	spruce
1	oak
1	larch
2	beech, spruce
2	beech, oak
2	beech, larch
2	spruce, oak
2	spruce, larch
2	oak, larch
3	beech, spruce, oak
3	beech, spruce, larch
3	beech, oak, larch
3	spruce, oak, larch
4	beech, spruce, oak, larch

6 trees cored per species and per stand, neighbours mapped in a 10 m radius

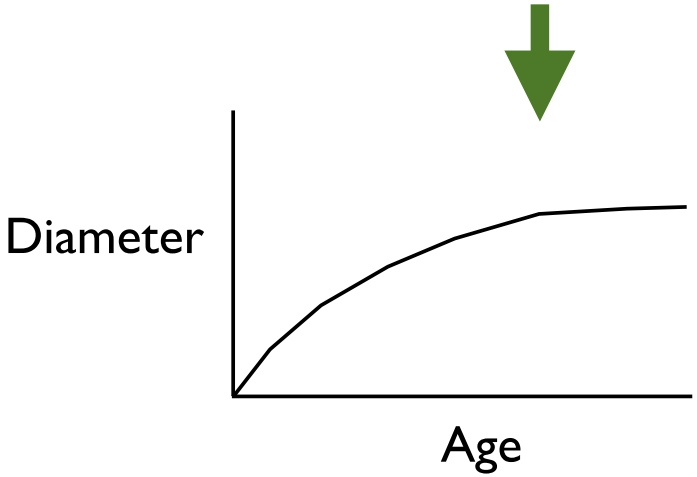


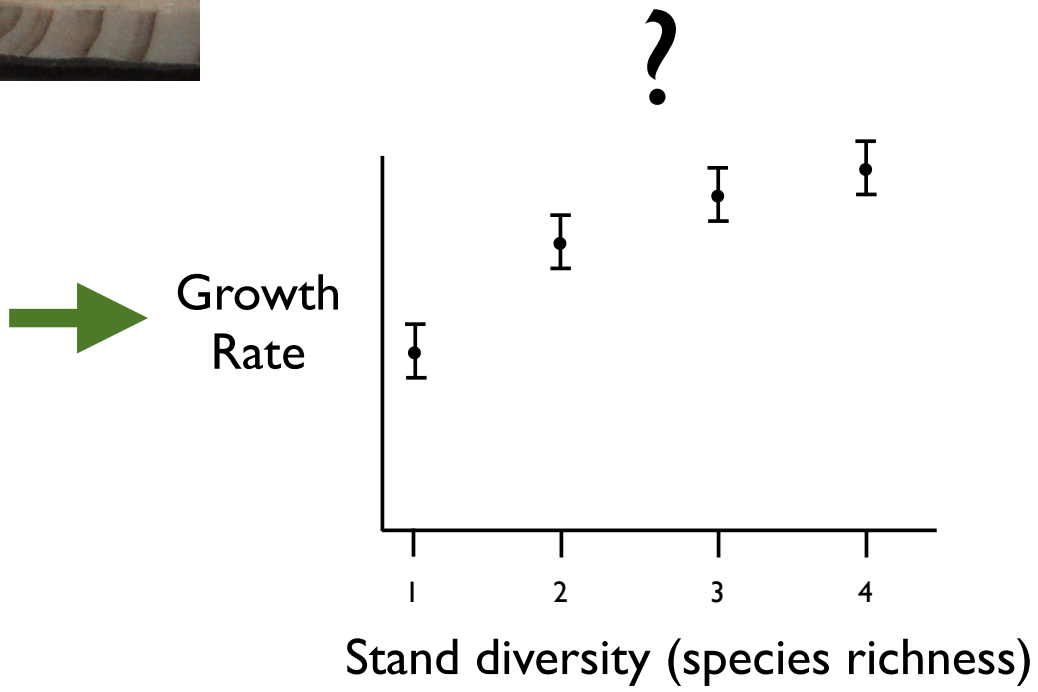
e.g.:



e.g.: 3-Species

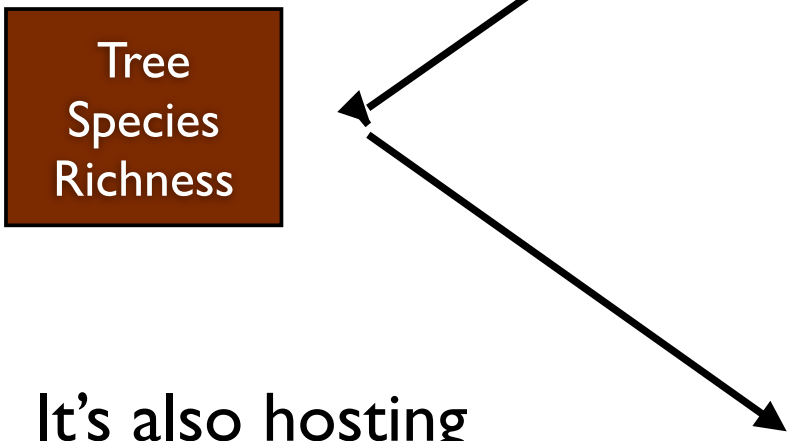
Using Tree Rings as a Measure of Growth. Do Trees grow faster/larger in more Diverse Stands?





Possible further work

Forest functioning is not just producing wood



Understory Diversity ?

Collaboration with Radim Matula, Daniel Volařìk, Jan Šebesta, and Tomáš Koutecký

Infection by Fungi ?

Collaboration with Tomàs Majek and Libor Jankovskỳ

Infection by Bark Beetles ?

Collaboration with Robert Stejskal

It's also hosting biodiversity, resisting pests etc

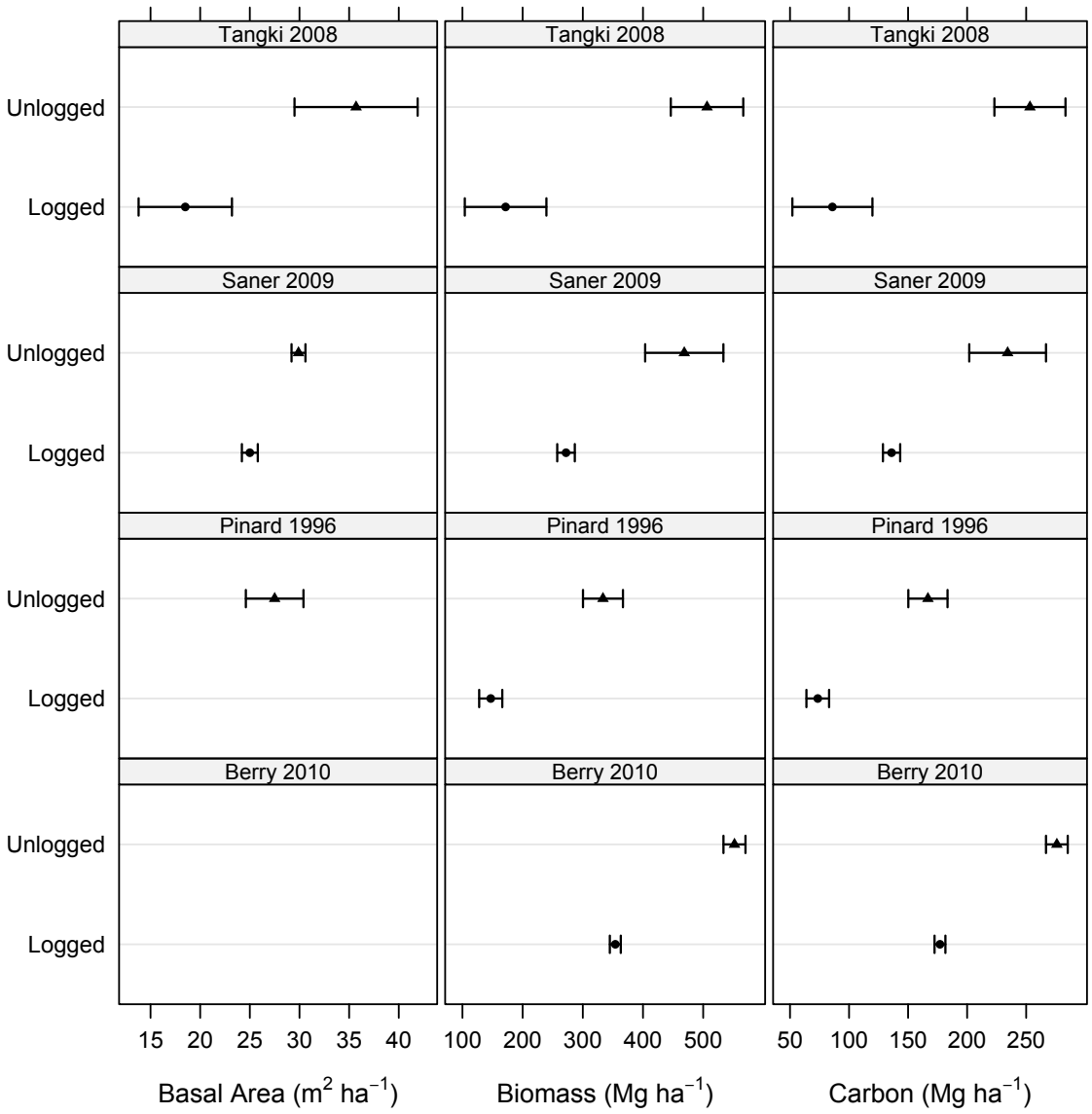
Acknowledgements

- Libor Jankovskỳ, Tomàš Žid, Martin Svàtek, Radim Matula, Daniel Volarik, Tomàs Majek and all the people from the Forestry department who helped mapping and coring, or gave ideas.

Malua SBE site vs. comparable Danum Valley

Stand volume and edaphic conditions	Malua SBE (logged 1986)	Danum Valley (unlogged)
1983 Pre-logging Volume	171.5 m^3 ha^{-1}	207 m^3 ha^{-1}
Elevation	< 250 m	< 250 m
Topography	Slope 15-25	Slope 0-20
Parent Material	Mudstone	Mudstone
Soil Type	Orthic Acrisol	Orthic Acrisol
Soil Family	Bang	Kretam and Mentapok
Rainfall (2005-07)	3432 mm	2818 mm

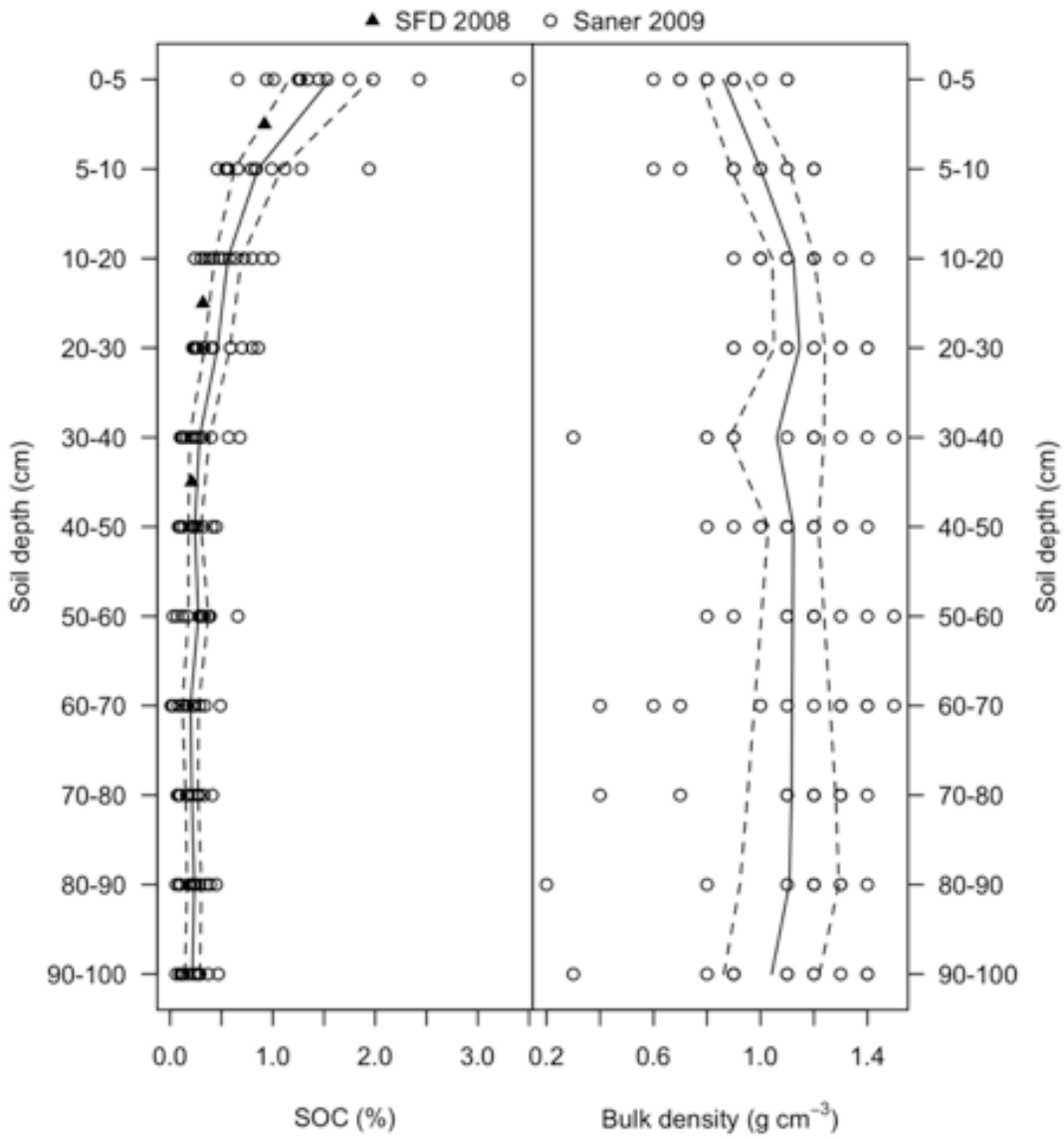
Values broadly in line with literature



Soil organic carbon stocks: 58 t C ha^{-1}

Top soil (<0.2m):
8.4 ± 0.3 Mg ha^{-1}

Sub soil (>0.2m):
4.1 ± 0.3 Mg ha^{-1}

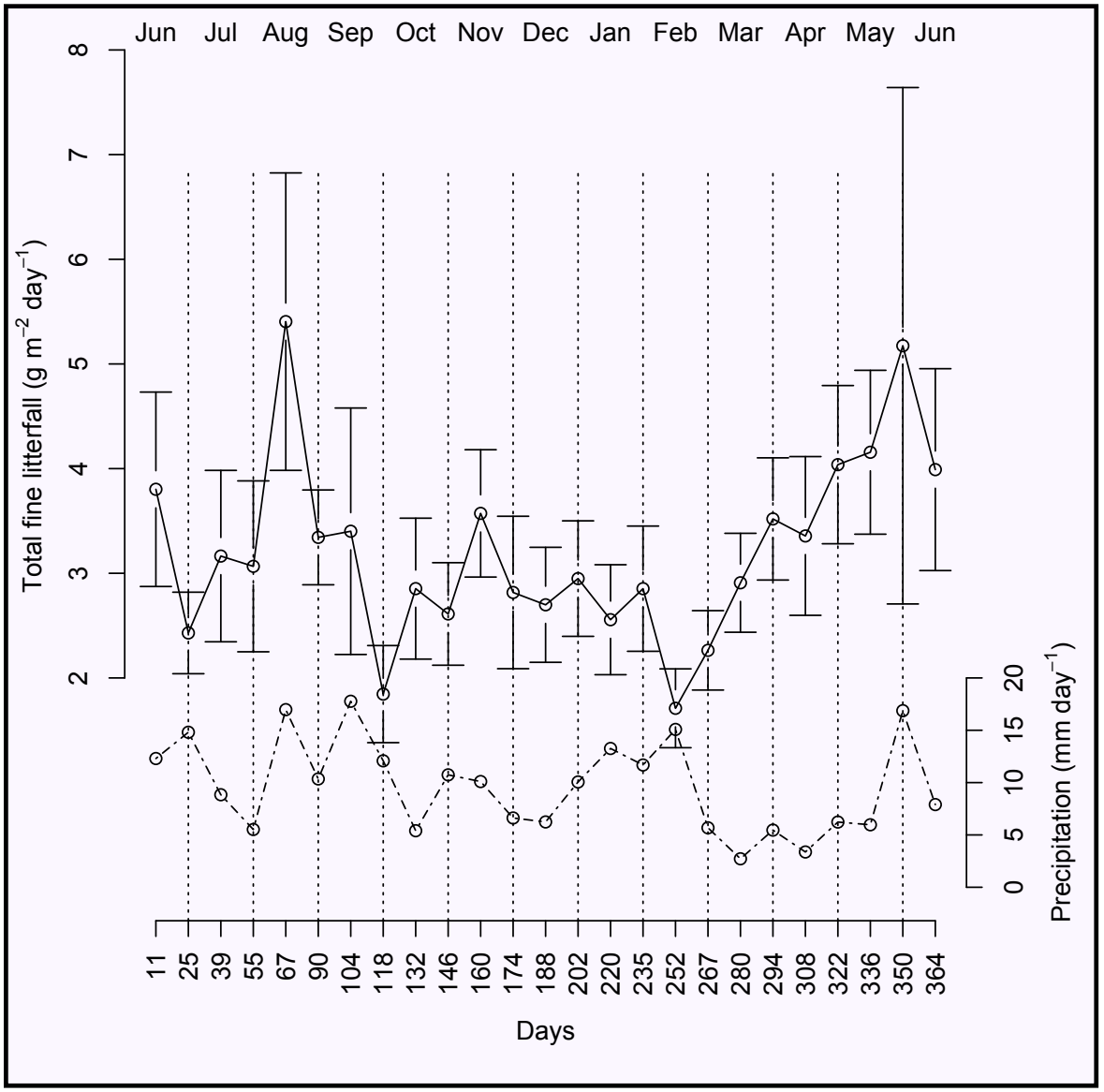


Fine Litterfall: 12 t ha^{-1} yr^{-1}

No apparent relation between rainfall and litterfall

Northeast Monsoon: November–March

Southwest Monsoon: June–July



Indicators of carbon turnover

Unlogged vs. logged forest

Litterfall Burghouts, 1992	ns
Dead trees Gale, 2000	ns
Fine roots Green et al., 2005	ns
Woody debris Gale, 2000	*
Soil respiration Katayama, 2009	*