Harvesting slash residues in forests: a sustainable opportunity for the bioenergy sector?

Laurent Saint-André, D. Achat, Nicolas Bilot, Laurent Augusto, Arnaud A. Legout, Holger H. Wernsdorfer, Jean-Paul Laclau, Christine Deleuze, Jacques J. Ranger

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Session on Biomass for Energy

Context and main issues

Energy policies

Current energy policies are characterized by two complimentary objectives:

- to reduce fossil energy consumption
- to develop renewable energies market, particularly woodfuel sector

European energy policies target a proportion of 20% renewable energies in total energy consumption of whole EU for 2020 (2009/28/CE) - France: 23%

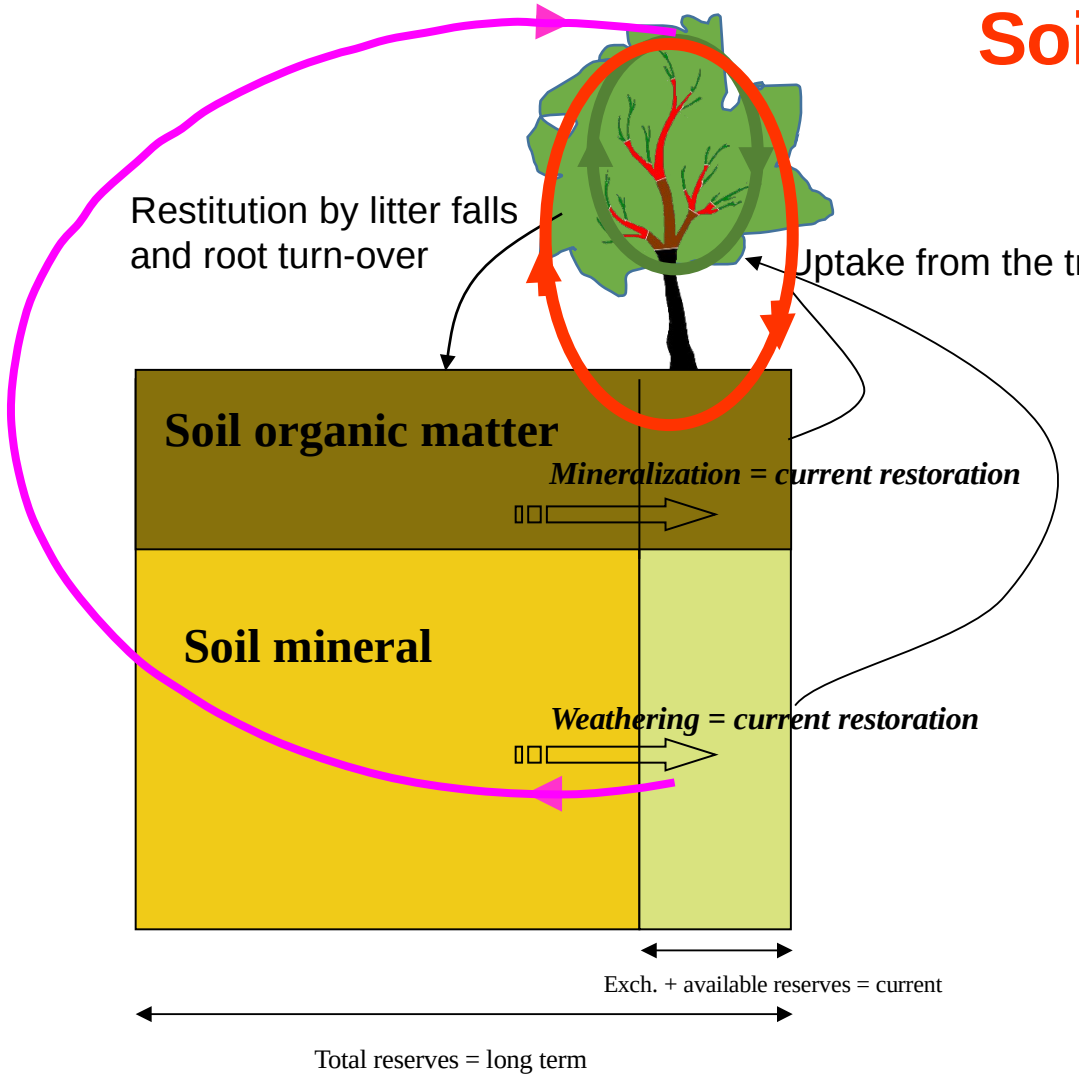
Increase forest management intensity

- Sto very short rotation cropping systems dedicated to wood production (see Marron et al. this session)
- Increased harvesting in existing forest ecosystems (this presentation)

→ Impact on soil and forest sustainability?

Context and main issues

Scientific challenges



Soil fertility in forest ecosystems ?

Soil chemical fertility is based on a small amount of nutrient circulating rapidly in the ecosystem

BIOCHEMICAL Sub-Cycle
- translocations

BIOLOGICAL Sub-Cycle
- Canopy Exchanges
- Nutrient uptake
- Immobilization
- Litter falls
- Mineralization of organic matters

GEOCHEMICAL Sub-Cycle
- Atmospheric deposits
- Weathering
- Drainage
- Run-off

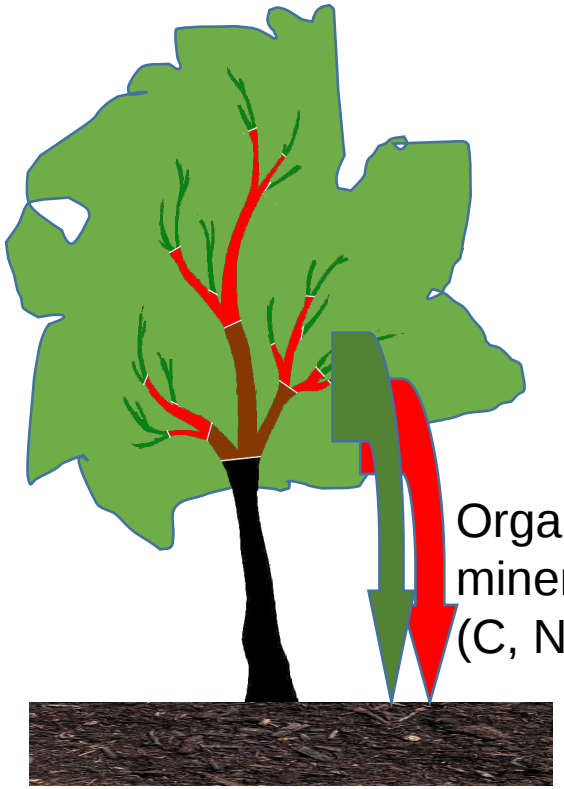
The partitionning between these sub-cycles is ecosystem-dependant

Hanson et al. 2015

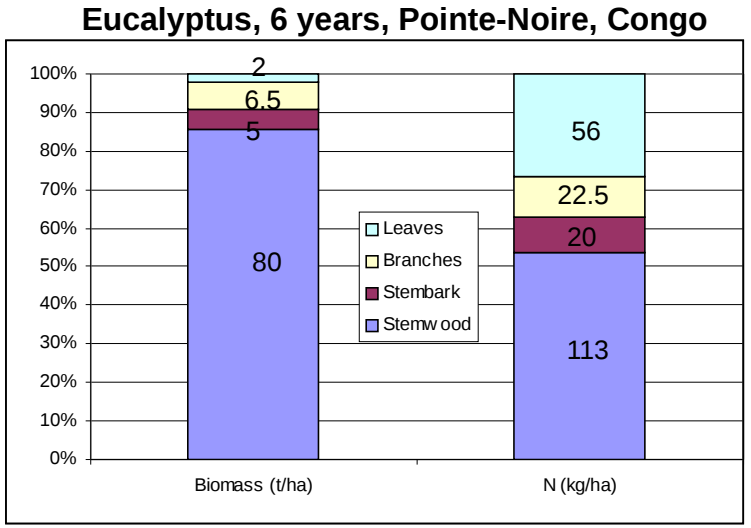
Context and main issues

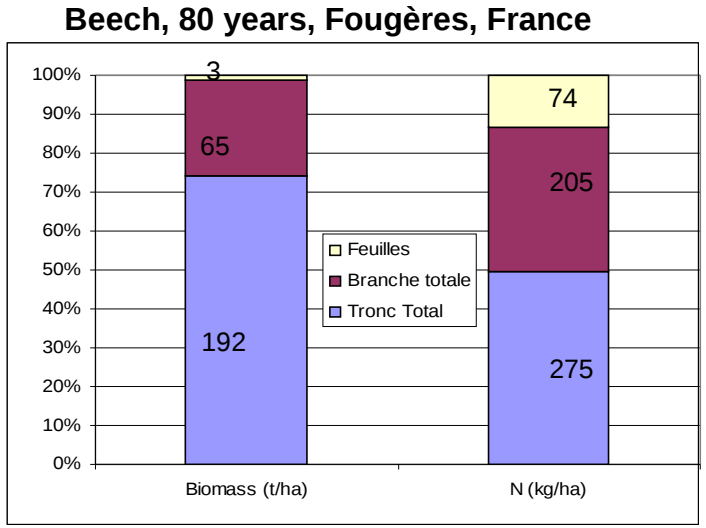
Scientific challenges

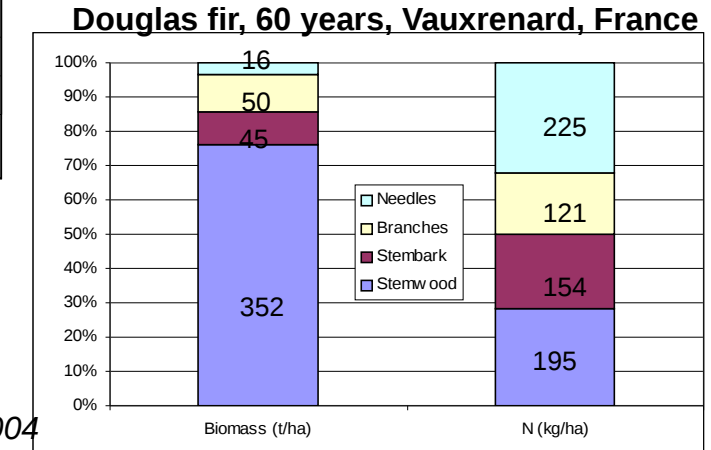
Harvesting slash residues = modification of the biological cycle



Organic matter mineralisation (C, N, Cations)







Contribute to the maintenance of soil chemical properties and soil biodiversity (macro-, meso-, micro-fauna)

From, Laclau, 2001; Nys 2007; Ranger 2004

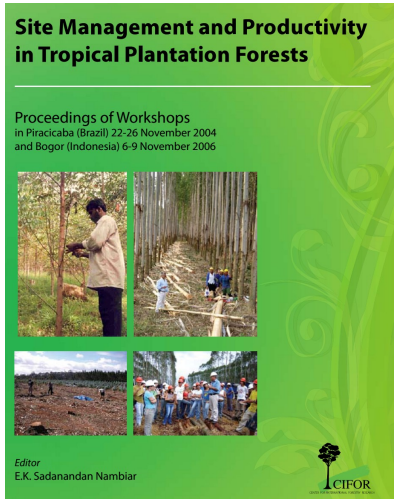
A concrete example, the CIFOR network

Assessing the Impact of Slash Management on the Eucalyptus Productivity

Definitive Designation	Designation in the published studies						Slash Management at harvesting			
	SouthAfrica	Congo	Brazil	China	India	Australia	Commercial trees			Non Commercial Trees + Litter on the soil + Understorey
							Stemwood	Bark	Crown	
SMT0	BL0	BL0	BL0	BL0	BL0	BL0	Removed			
SMT1		BL2	BL2	BL2	L	BL2	Removed			Left
SMT2	BL2	BL4	BL1				Removed	Removed	Left	
SMT3	BL3	BL3		BL3	BL3	BL3	Removed	Removed*	Left + Slash added	
SMT4	BS	BL5	SLb		BS	B	Removed	Removed**	Burnt	

* Removed in Congo, China and India
** Removed in India

- 6 countries, 10 sites
- Eucalyptus plantations
- Same treatments applied in each country (bare soil to double slash)
- Unique modelling framework to assess the impact of slash management on the site index (SI), the ability of trees to produce biomass at a given SI, the between tree competition and the height/diameter growth partitioning



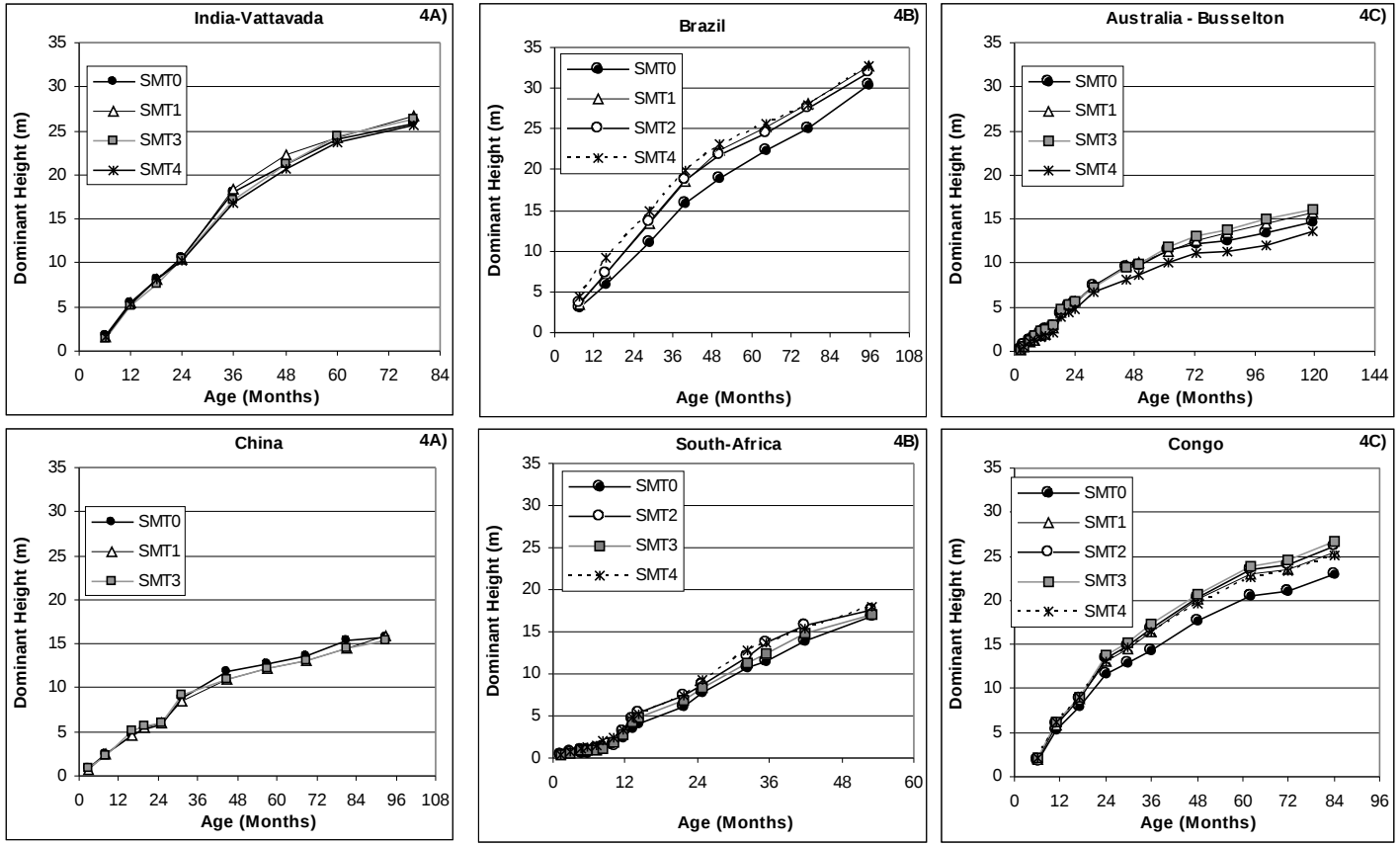
Nambiar et al. 2008

A concrete example, the CIFOR network

Assessing the Impact of Slash Management on the Eucalyptus Productivity

Dominant height as a function of age

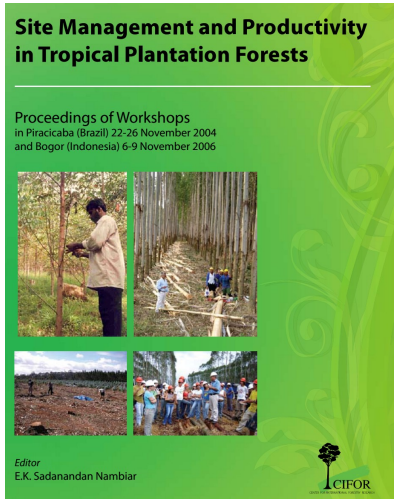
Site Index



- Unchanged

- Temporary changed

- Changed



Saint-André et al. 2008

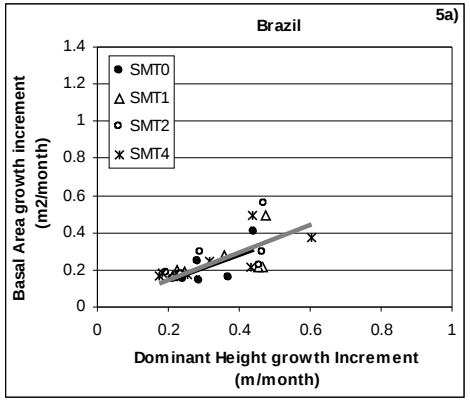
A concrete example, the CIFOR network

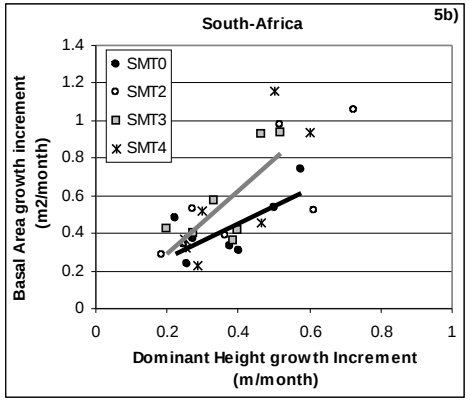
Assessing the Impact of Slash Management on the Eucalyptus Productivity

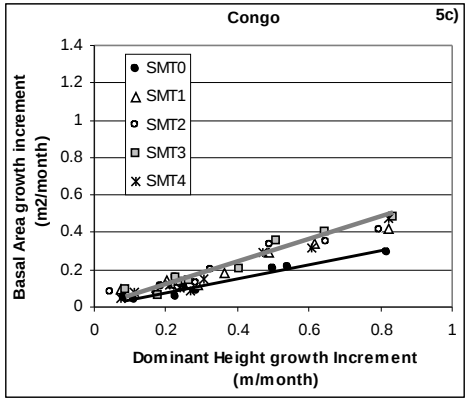
- Unchanged

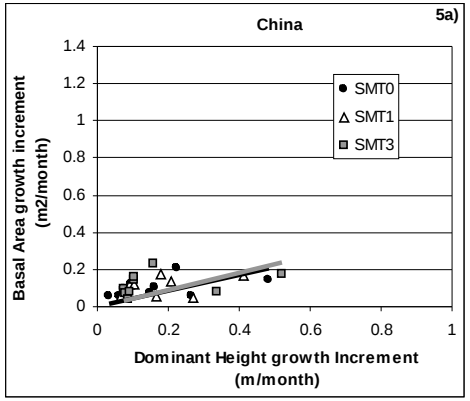
- Changed but non significantly

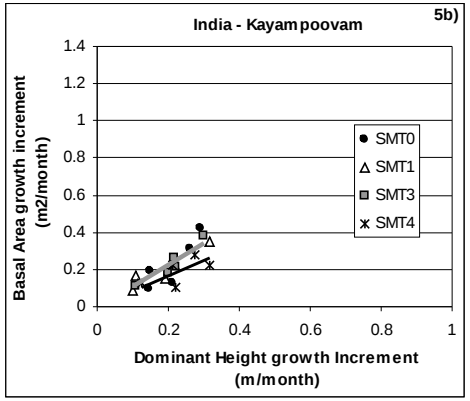
- Significantly Changed







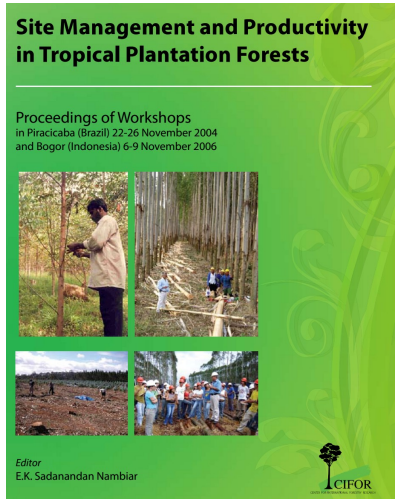




Stand Basal Area Growth as function of dominant height growth

Capacity of trees to produce biomass at a given Site Index

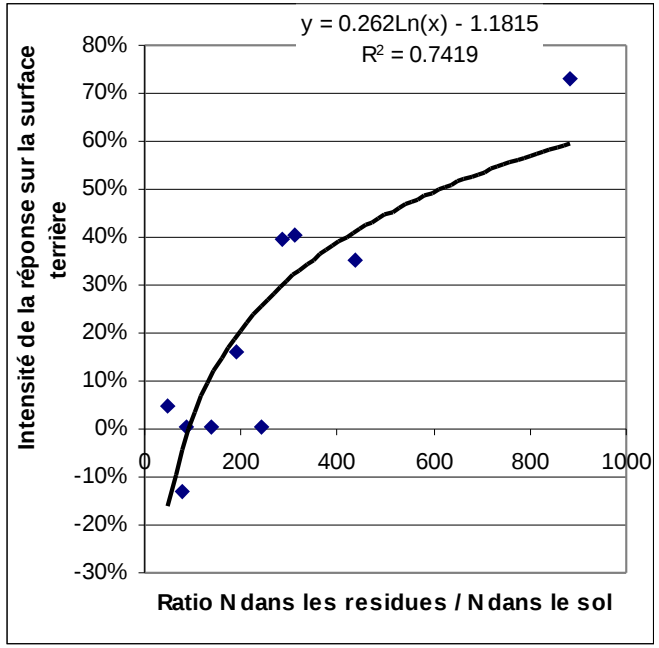
Saint-André et al. 2008



A concrete example, the CIFOR network

Assessing the Impact of Slash Management on the Eucalyptus Productivity

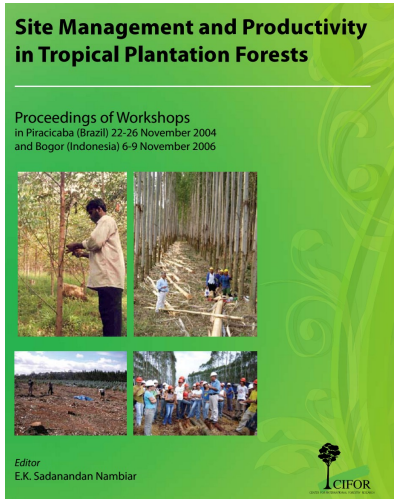
	Nitrogen			Soil properties			Intensity of the response			
Site	Fertilization (kg/ha)	Residues (kg/ha)	Total (kg/ha)	C (g/kg)	N (g/kg)	C/N	Height	Circ	G	Ratio N/soilN
Congo	16	349	365	5.4	0.34	16	30%	19%	73%	1073.5
Brazil	15	296	311	16.6	0.96	17	20%	19%	41%	324.0
South-Africa	17	1378	1395	66.5	3.2	21	16%	13%	35%	435.9
India-Kayampoovam	42	100	142	21.5	1.83	12	7%	3%	22%	77.6
China	17	134	151	8.33	0.7	12	11%	13%	18%	215.7
India-Vattavada	42	150	192	52.3	4.5	12	11%	13%	14%	42.7
India-Surianelli	42	90	132	40.9	2.49	16	10%	6%	20%	53.0
India-Punnala	42	50	92	43.6	2.89	15	12%	15%	13%	31.8
Australia-Manjimup		481	481	50	3	17				160.3
Australia-Busselton		381	381	39	1.5	26				254.0



As a result the impact reached up to 30% for height growth, 20% for the circumference and 70% for the stand basal area after one rotation

Impact correlated to a loading index (N in residues/ [N] in soil)

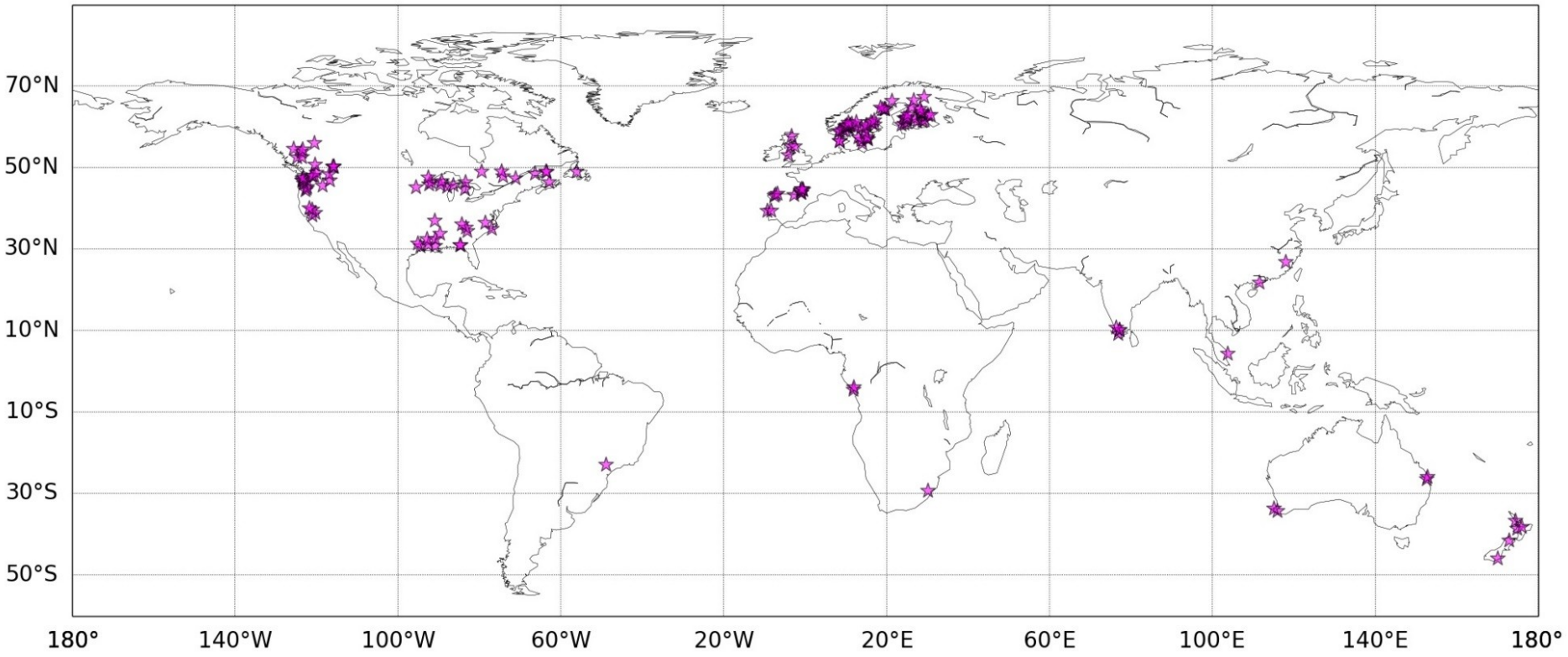
Saint-André et al. 2008



Generalisation, meta-analysis from different networks in the world

43% in North America (29% in USA, 14% in Canada)
45% in Europe (35% from Scandinavia)

Mainly:
- ‘‘North American long-term soil productivity’’ study (LTSP network)
- Experiment network in Scandinavia
- ‘‘Site Management and Productivity in Tropical Plantation Forests’’ network (CIFOR project)



Consequences on nutrient outputs (data compilation from 230 articles, 749 case studies)

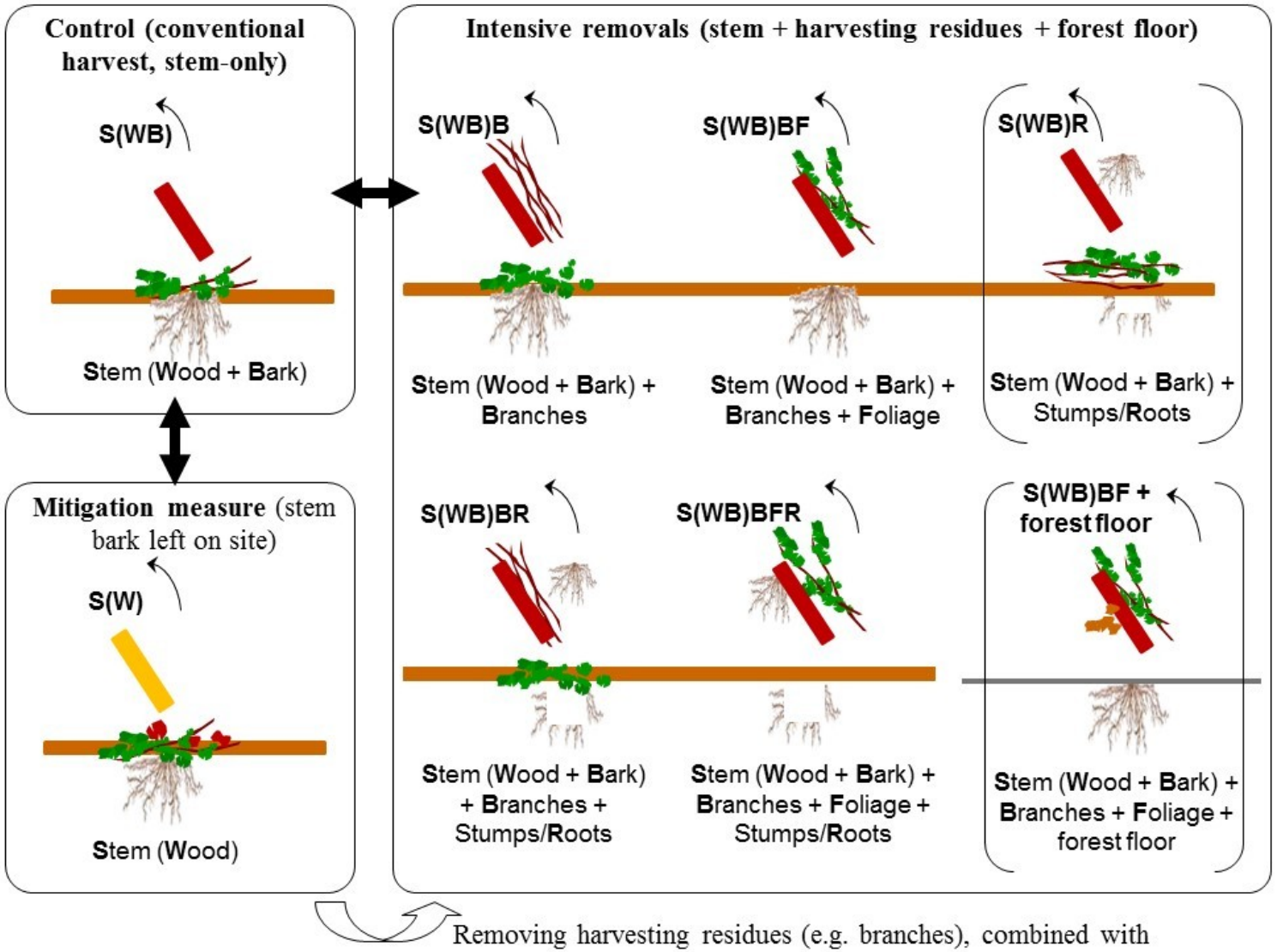
Consequences on soil properties and tree growth (data compilation from 140 articles, 168 case studies)

Achat et al. 2015

Generalisation, meta-analysis from different networks in the world

Main harvest treatments considered in the meta-analysis.

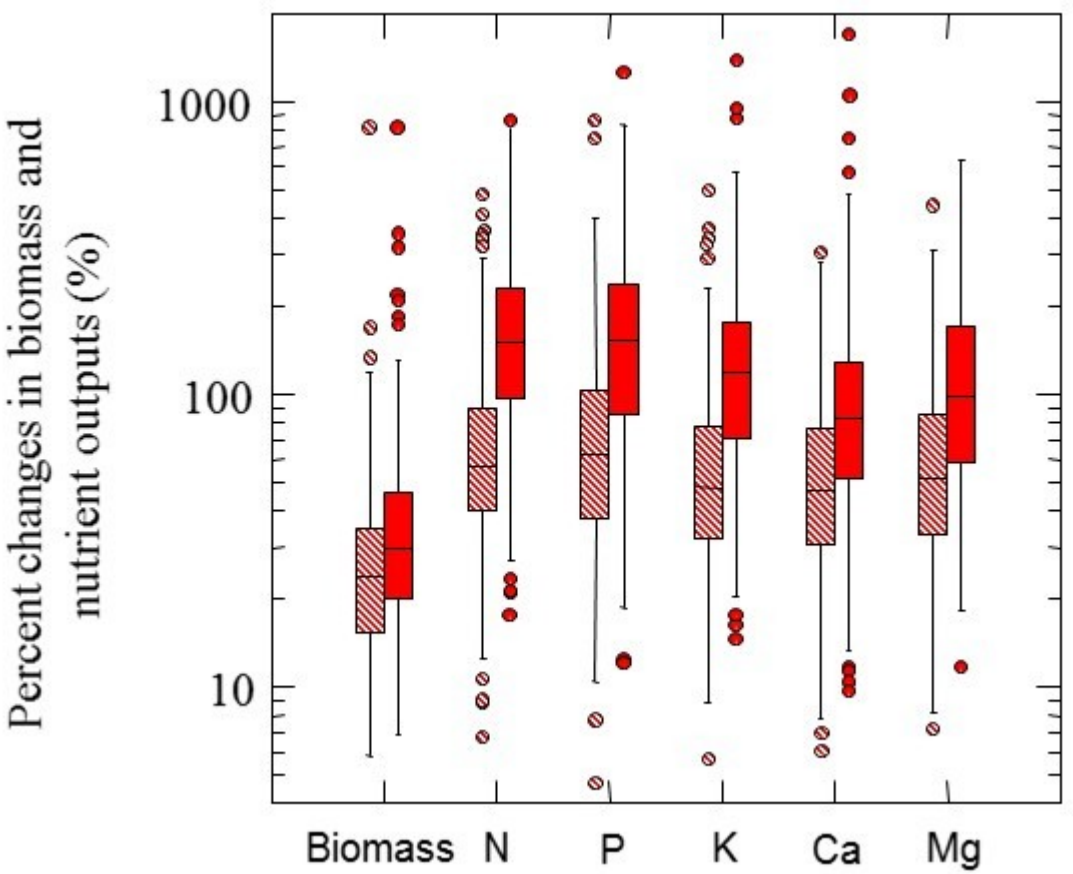
Conventional stem-only harvest (S(WB), control) compared to different types of intensive removals or to stem wood harvest (S(W), stem bark left on site; mitigation measure).



Achat et al. 2015

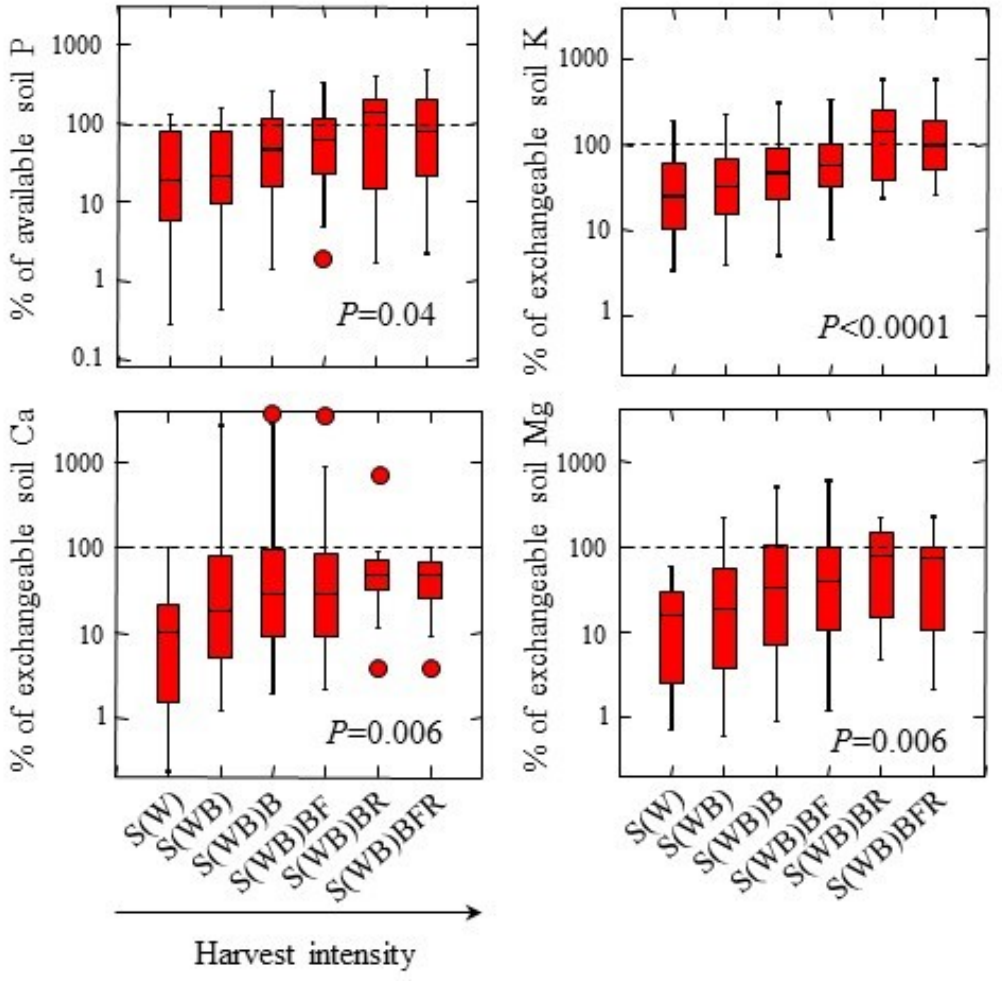
Generalisation, meta-analysis from different networks in the world

Increases in nutrient exportation (% changes)



Examples for: Treatment S(WB)B vs S(WB): *hatched boxplots*
Treatment S(WB)BF vs S(WB): *solid boxplots*

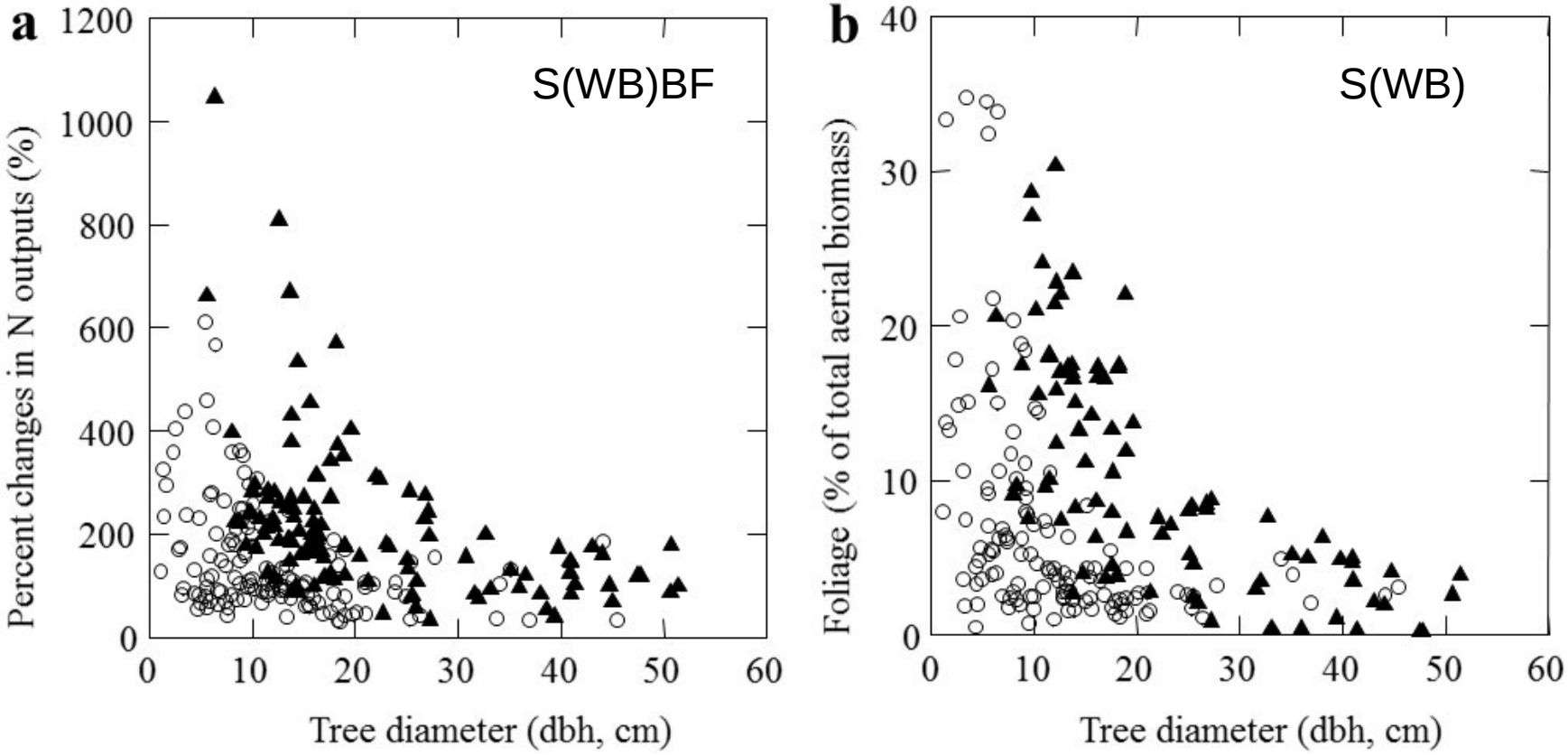
Nutrient exportation as % of nutrient socks in soils (0-80 cm)



Achat et al. 2015

Generalisation, meta-analysis from different networks in the world

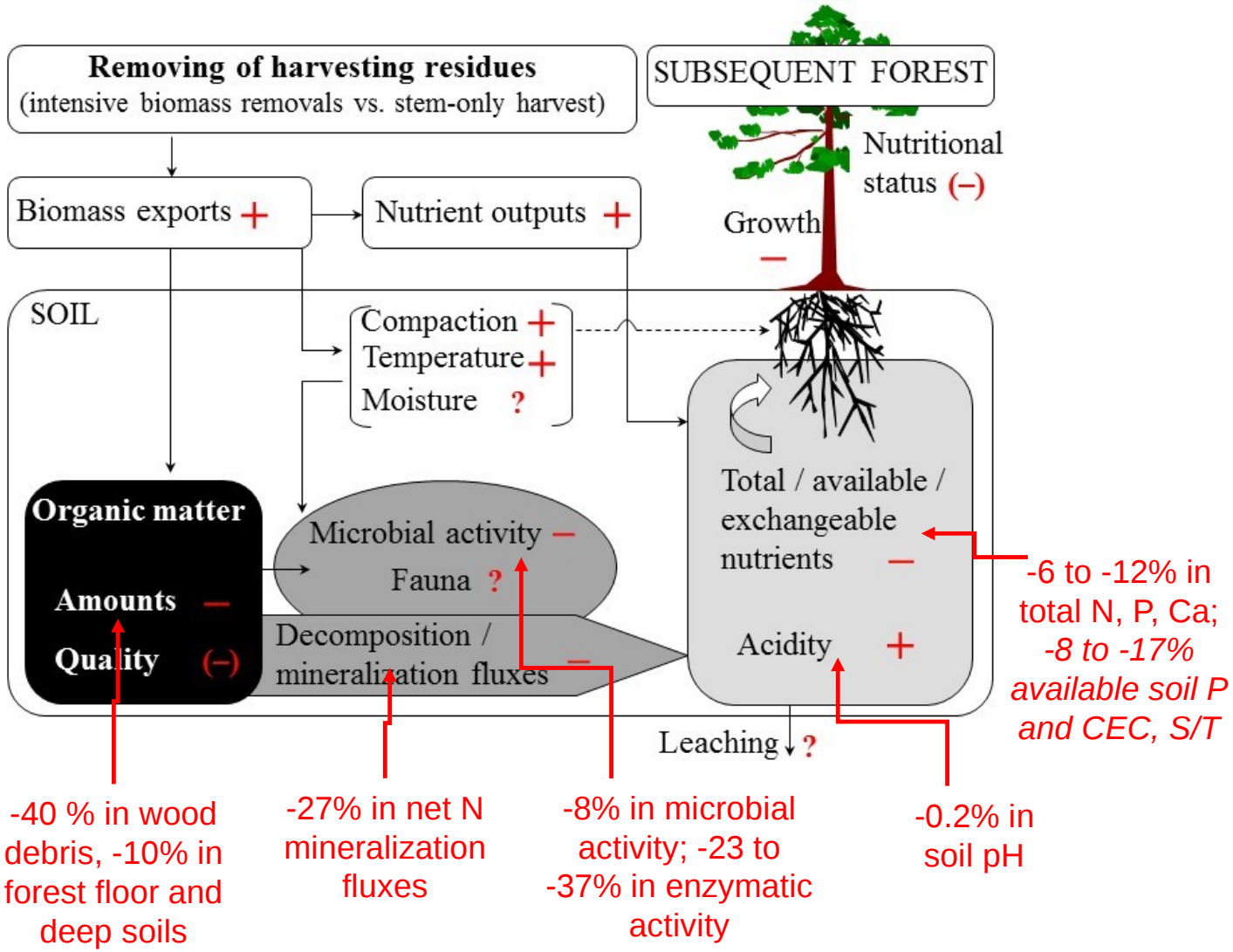
Increases in nutrient exportation (% changes): relationships with stand age

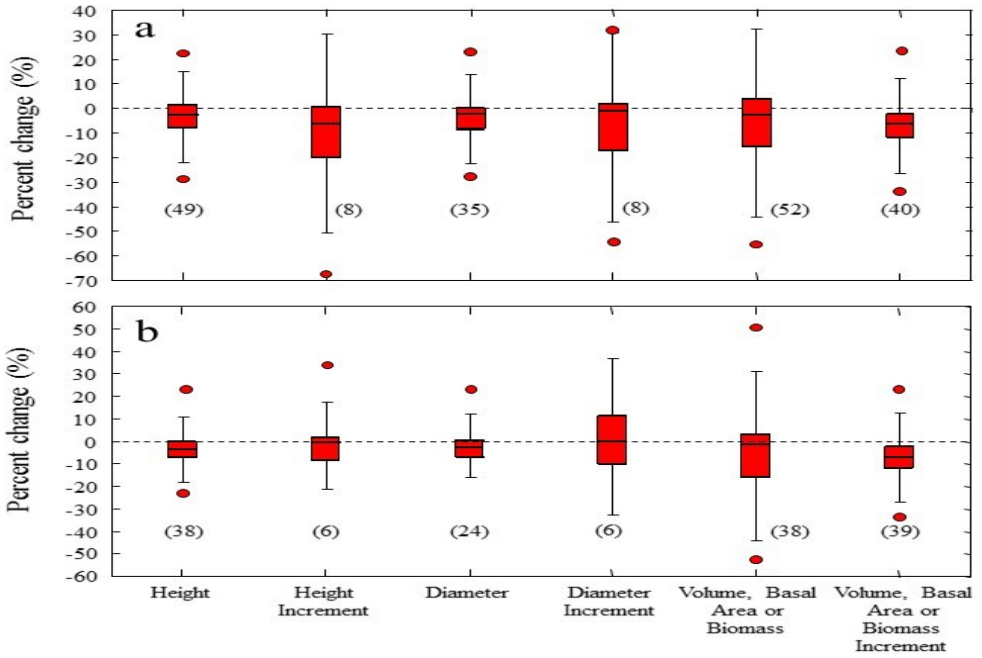


Open circle, broadleaf trees; grey square, sparse canopy coniferous (mainly *Pinus*, also *Larix* or *Agathis*); black triangle, dense canopy coniferous (*Picea*, *Abies* and *Pseudotsuga*).

Achat et al. 2015

Generalisation, meta-analysis from different networks in the world





-3 to -7% in tree growth

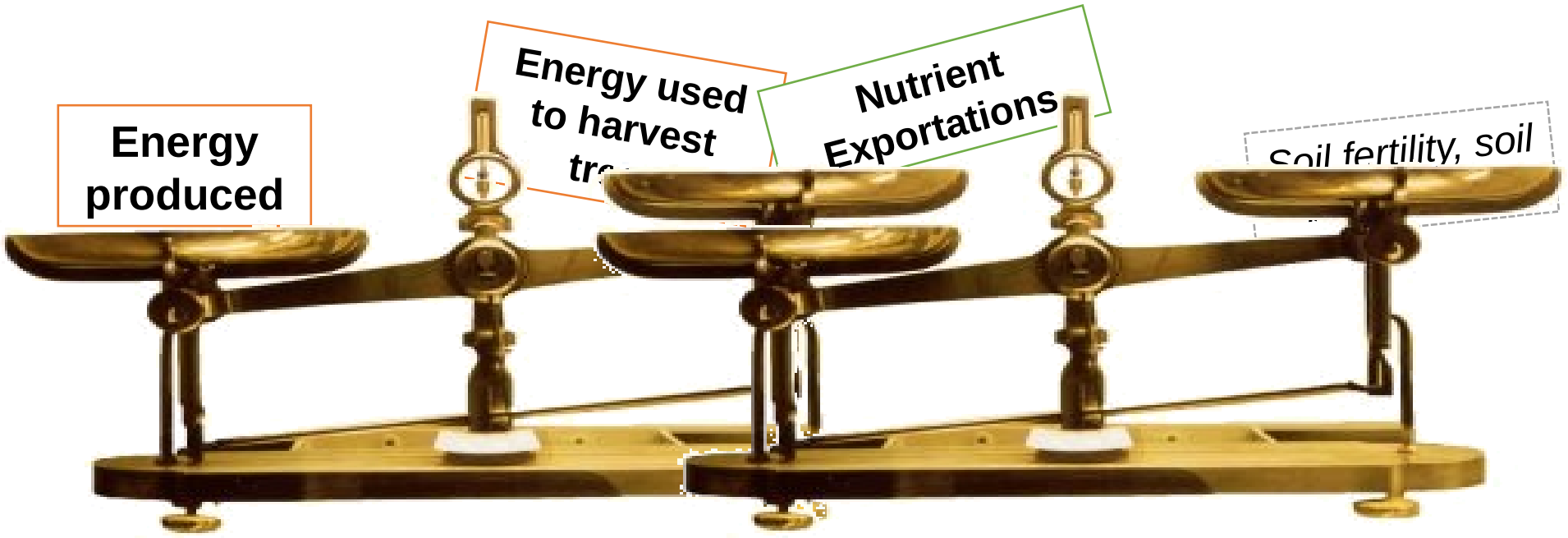
mean changes for S(WB)BF vs S(WB

Achat et al. 2015

Toward an optimized chain for the sustainable use of forest biomass for energy

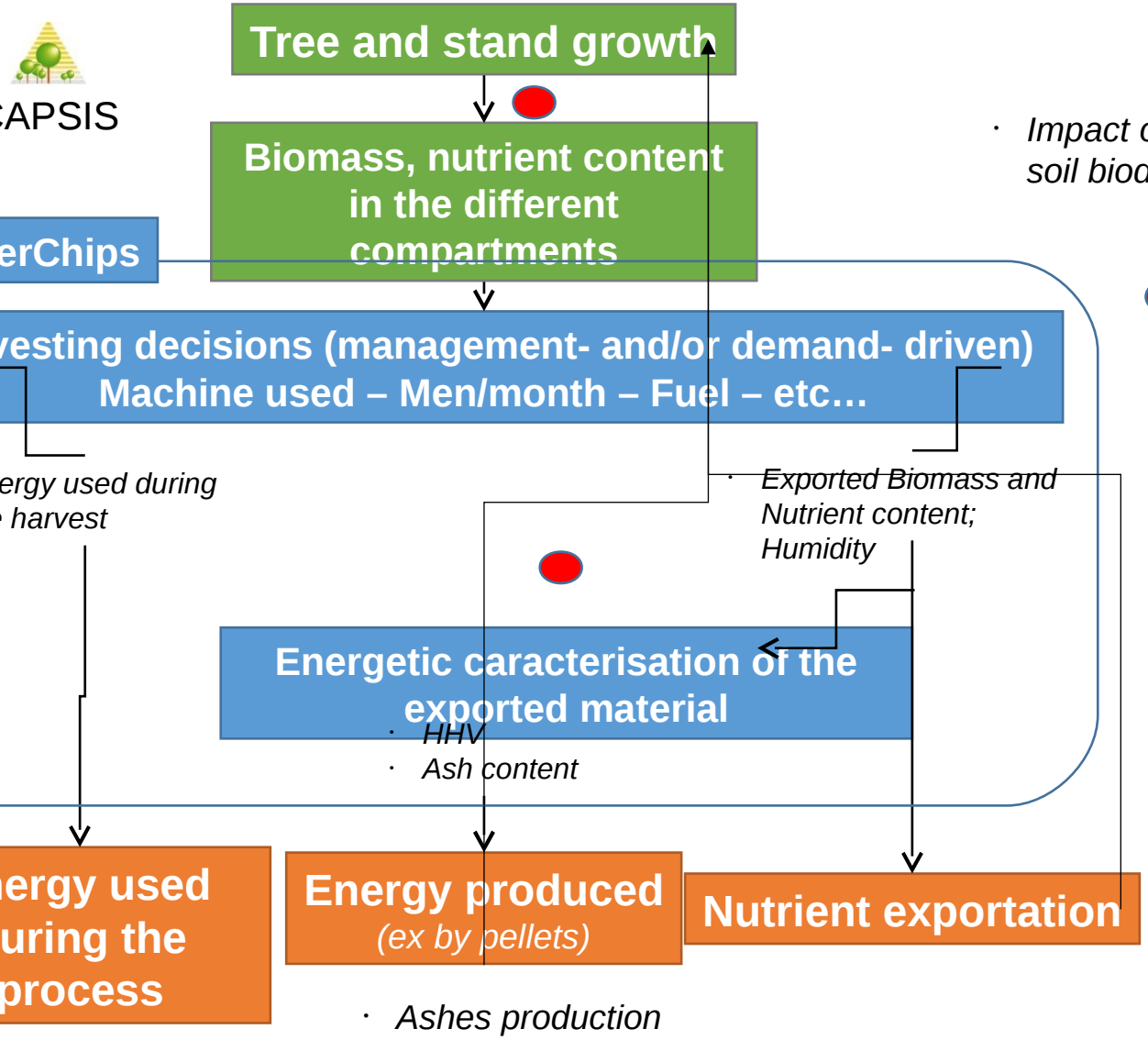
Energetic issue

Sustainability



Bilot 2015

Toward an optimized chain for the sustainable use of forest biomass for energy



Critical point 1 : Site effect on nutrient concentration in the tree compartments

Critical point 4 : Indicators on the impact, responses curves

Critical point 5 : Non desirable elements in ashes, impact on ecosystem functionning

Critical point 2 : Knowledge on the energy used in a given harvesting operation

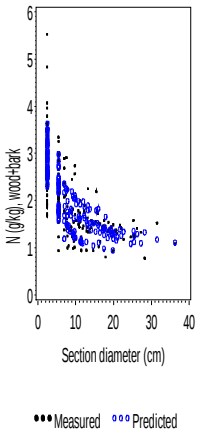
Critical point 3 : Conversion matrix to assess PCI and Ash content

Modified from Bilot 2015

Toward an optimized chain for the sustainable use of forest biomass for energy

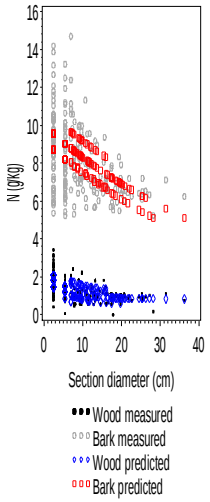
Critical point 1 : Site effect on nutrient concentration in the tree compartments

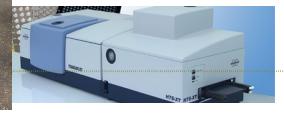
Conc. Tot
(Wood + Bark)



Conc. Bark

Conc. Wood





M-POETE, A Mobile-Platform for the Observation and the Experimentation in Terrestrial Ecosystems (Zeller et al)

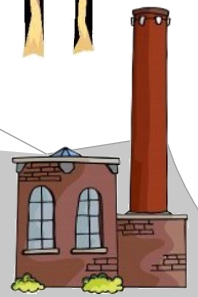
Infra-red spectrometry in situ
Translation of the curves (site effect) by making few measurements on the field

Size of the compartment
Site effect on the curve – **not directly related to soil concentrations**

Wernsdörfer et al. 2014

Toward an optimized chain for the sustainable use of forest biomass for energy

Critical point 2 : Knowledge on the energy used in a given harvesting operation

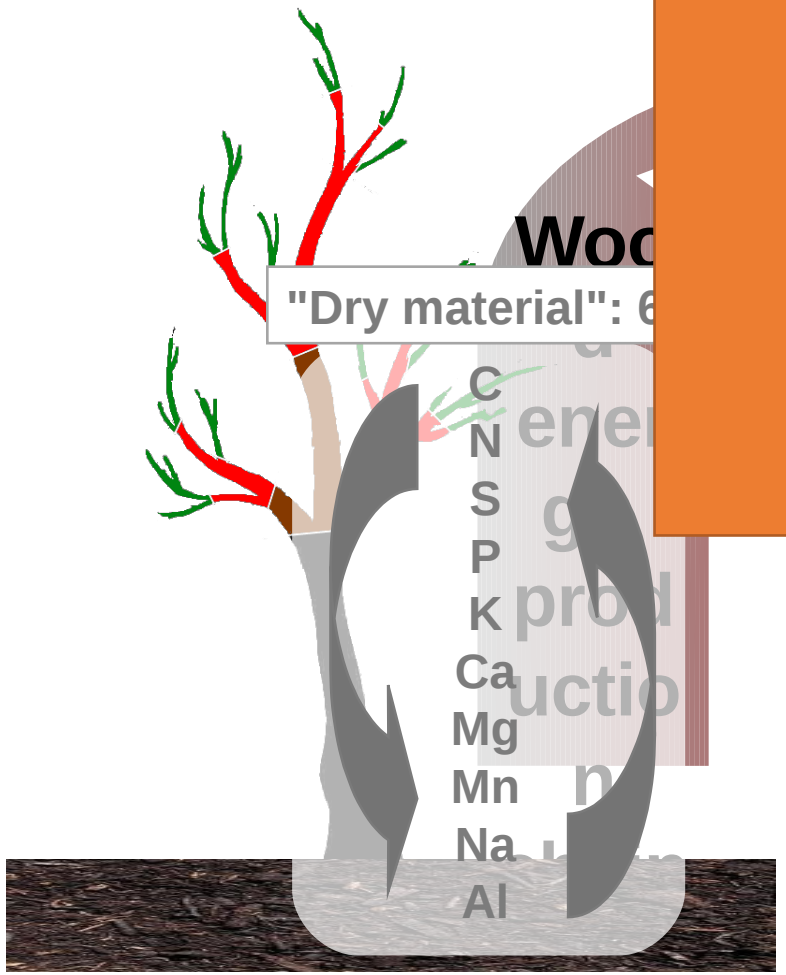


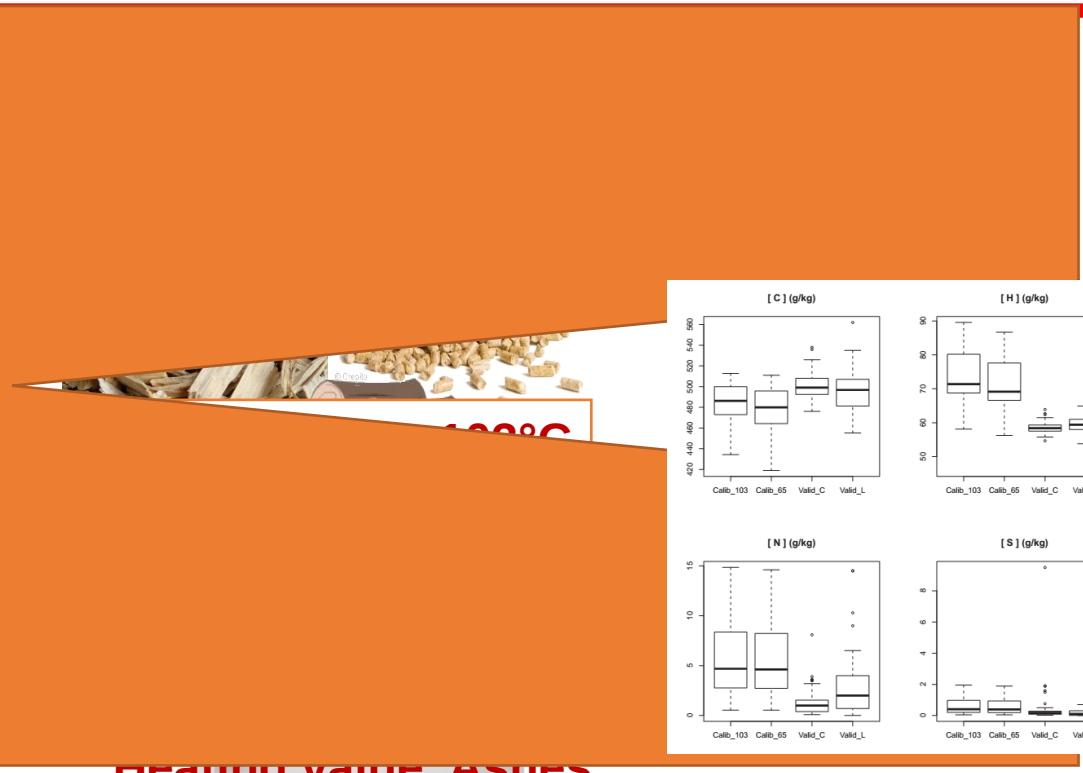
Simulation of different scenarios at each step from the forest to the mill

Toward an optimized chain for the sustainable use of forest biomass for energy

Critical point 3 : C

Ecology, Biogeochemis





Heating value, Ashes

Bilot et al. 2015

Toward an optimized chain for the sustainable use of forest biomass for energy

Critical point 4 : Indicators on the impact of increased harvest on tree growth, responses curves

Critical point 5 : Non desirable elements (such as heavy metals) in ashes, impact on ecosystem functioning

Two projects have started in 2014, funded by the French environmental and energy management agency (ADEME)

- INSENSE: Ecosystems sensitivity indicators to increased biomass removal in forests
- RESPIRE: Slash management in forests: potentialities, environmental impact and compensation by wood ashes.

Starting points for a future collaboration ?