Management of fast growing pine plantations in South Brazil

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Pine plantation in South Brazil
(Photo: L. Nutto)

Myths and controversies about (fast growing/high yielding) forest plantations

Plantations have the reputation of

- ✓ representing poorly structured stands with low tree species diversity
- ✓ providing low-quality wood products
- ✓ negatively affecting regulating and supporting ecosystem services
- ❖ *'Plantations are not forests' (Carrere 2004)*

<u>Hypothesis:</u> There are options to diversify plantations and manage them in an ecosystem-friendly way!

Outline

- Introduction
- Relevance, definitions and plantation forestry systems
- Providing ecosystem services from pine plantations
- Case study:
  Pine plantations in South Brazil
- Conclusions

https://de.wikipedia.org/wiki/Berlin-Brandenburg

Relevance, definitions and plantation forestry systems

Pine plantation in South Brazil (Photo: L. Nutto, Freiburg)

Contribution of plantation forests to wood production (FAO 1995)

Countries	Area (million ha)		Share represented by plantations (%)	
	Native forests	Plantations	Forest area	Wood production
New Zealand	7	1.20	16.1	93
Brazil	566	7.00	1.2	60
Chile	7	1.45	17.1	95
Argentina	34	0.78	2.2	60
Zimbabwe	32	0.07	0.2	50
Zambia	9	0.12	1.3	50
Australia	43	1.00	2.0	50

⇒ huge supply – demand gap forecast by 2050 (Dieterle 2018)

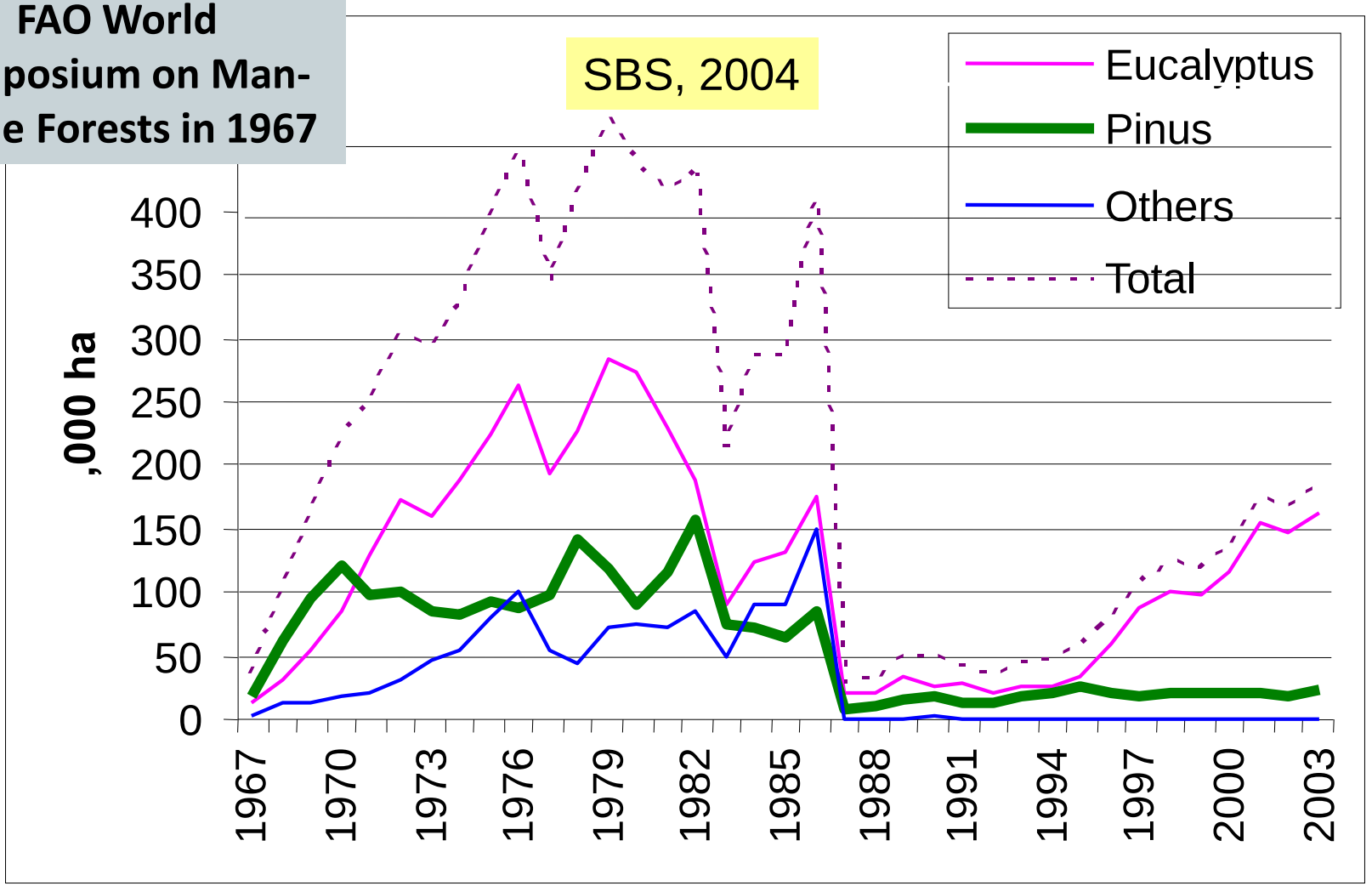
Planted forests (PF)

- *Plantation forests or Planted forests:*
  - *Forests predominantly composed of trees established through **planting and/or seeding** of native or introduced species in the process of **afforestation** or **reforestation (…one or two species at planting, even-aged, regular spacing)***
  - *includes planted component in seminatural forests*

- *Fast-growing and high yielding plantations (FGHY):*
  - *Rotation periods should be less than 30 yrs and MAI > 15 m^3 per ha/yr*

Financial incentives (Brazil 1967 – 1987)

FAO World Symposium on Man-Made Forests in 1967



Area and categories of PF

Area

- ~ 294 mill. ha out of 4.000 mill. ha of forests worldwide (→ 7 %); annual increase of 3-5 mill. ha (FAO 2020);
  29 % in tropics & subtropics and 56 % in the temperate zone; less than 20 % is alien species; focus on Asia (45 %)

Categories

➢ **either**

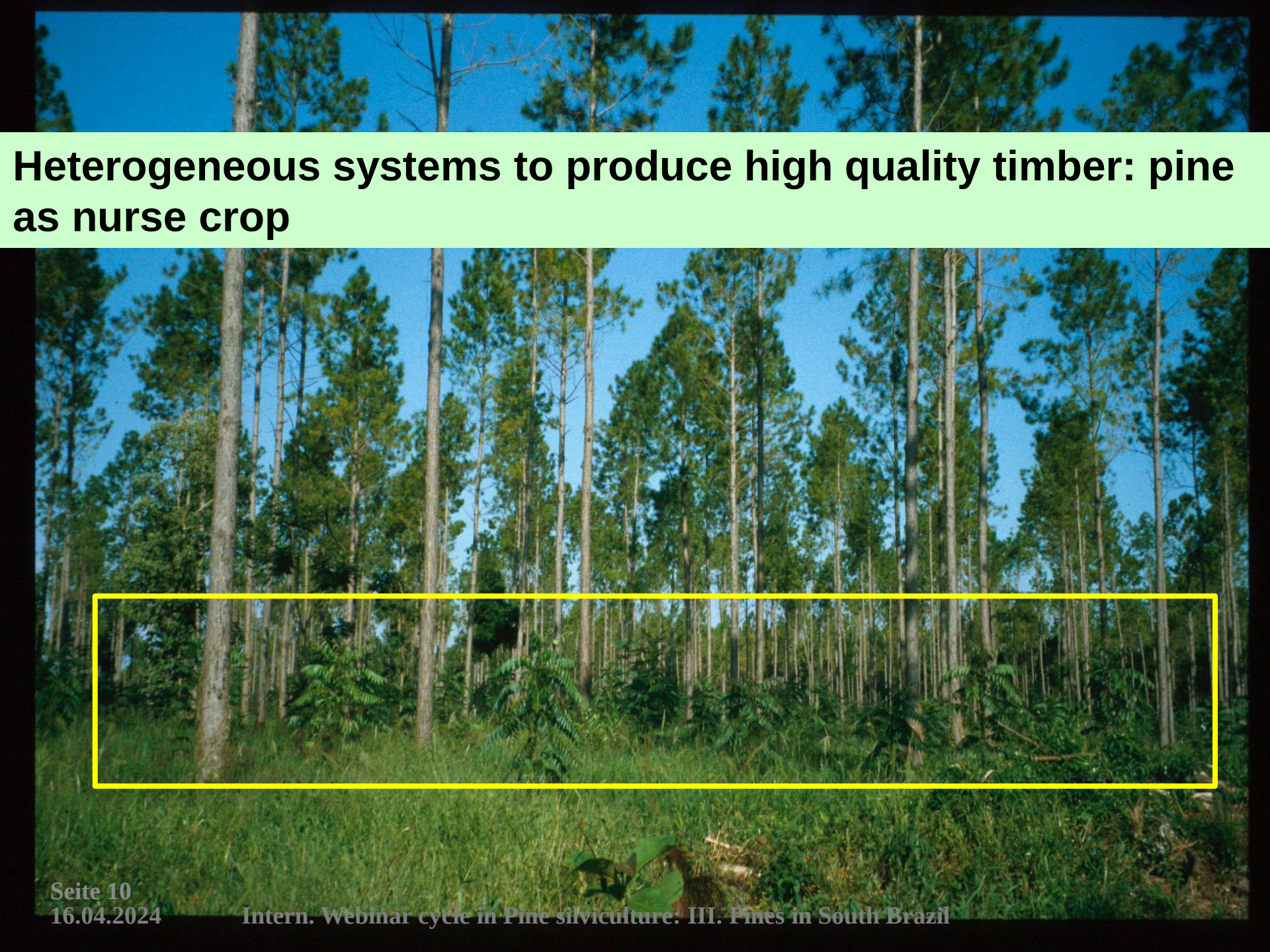
- Industrial plantations: plantations with fast-growing tree species for pulpwood, sawn wood or charcoal [80 %],
- Plantations for rural development: for fuel wood production, to protect water and other environmental services [20 %],

➢ **or** Productive / Protective plantations [75 % to 25 %]

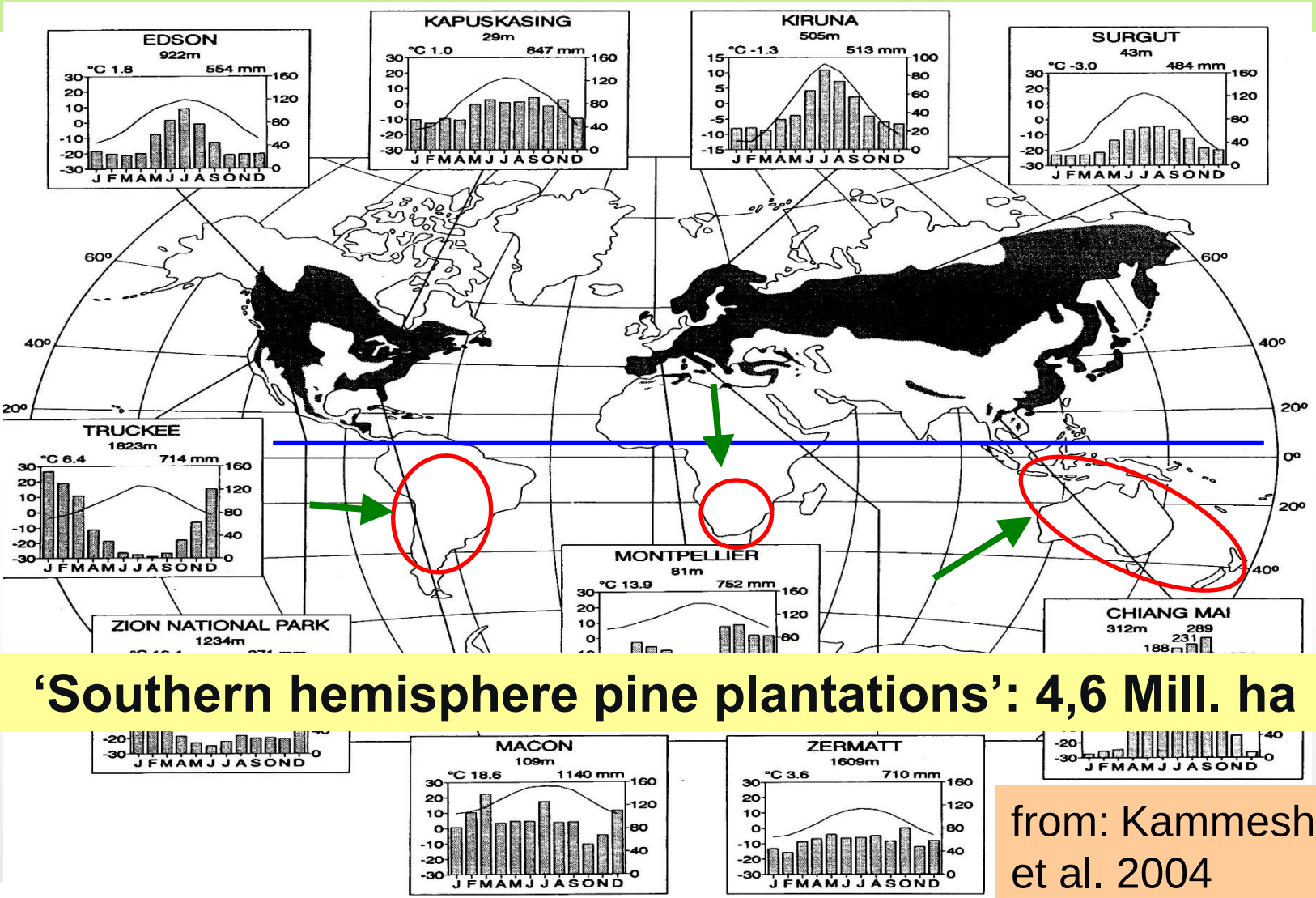
Homogenous systems to produce industrial timber

Photo: L. Nutto, Freiburg

Heterogeneous systems to produce high quality timber: pine as nurse crop



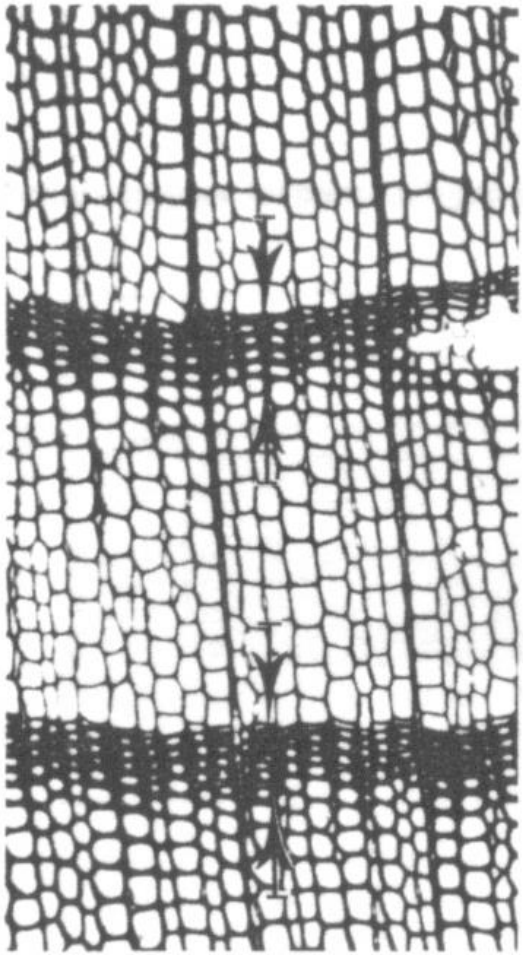
Genus pine (111 species)



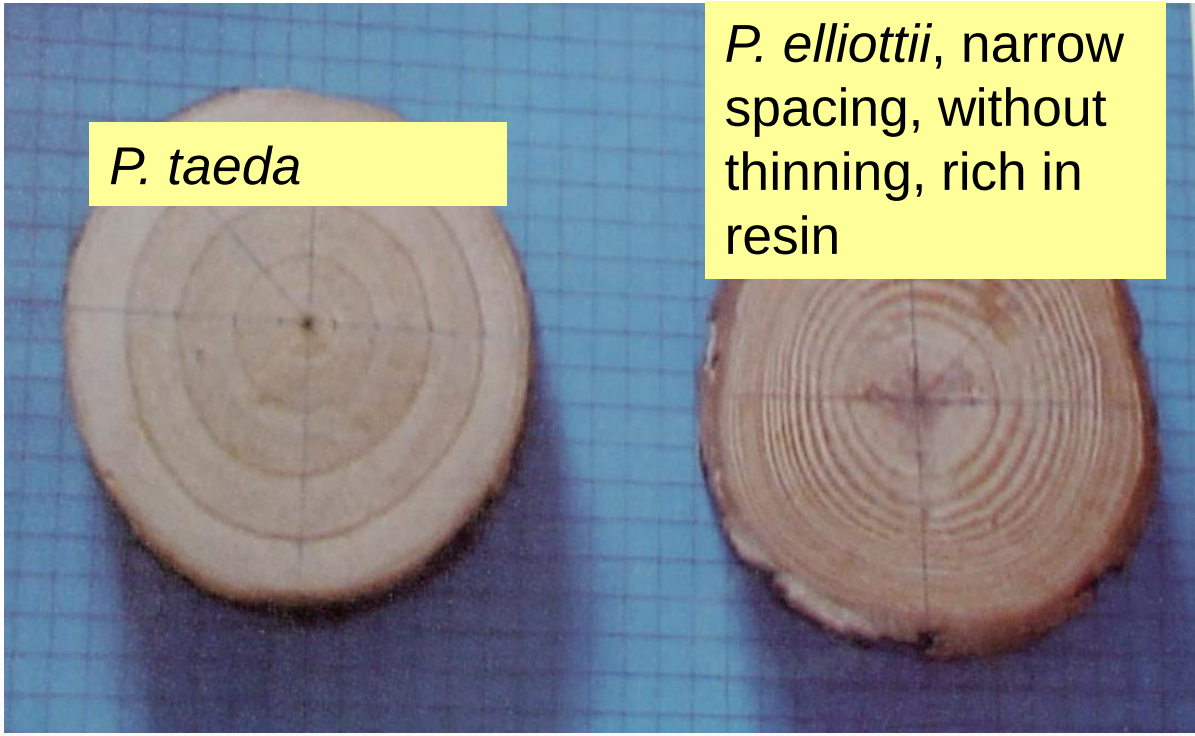
‘Southern hemisphere pine plantations’: 4,6 Mill. ha

from: Kammesheidt et al. 2004

Characteristics of pine timber

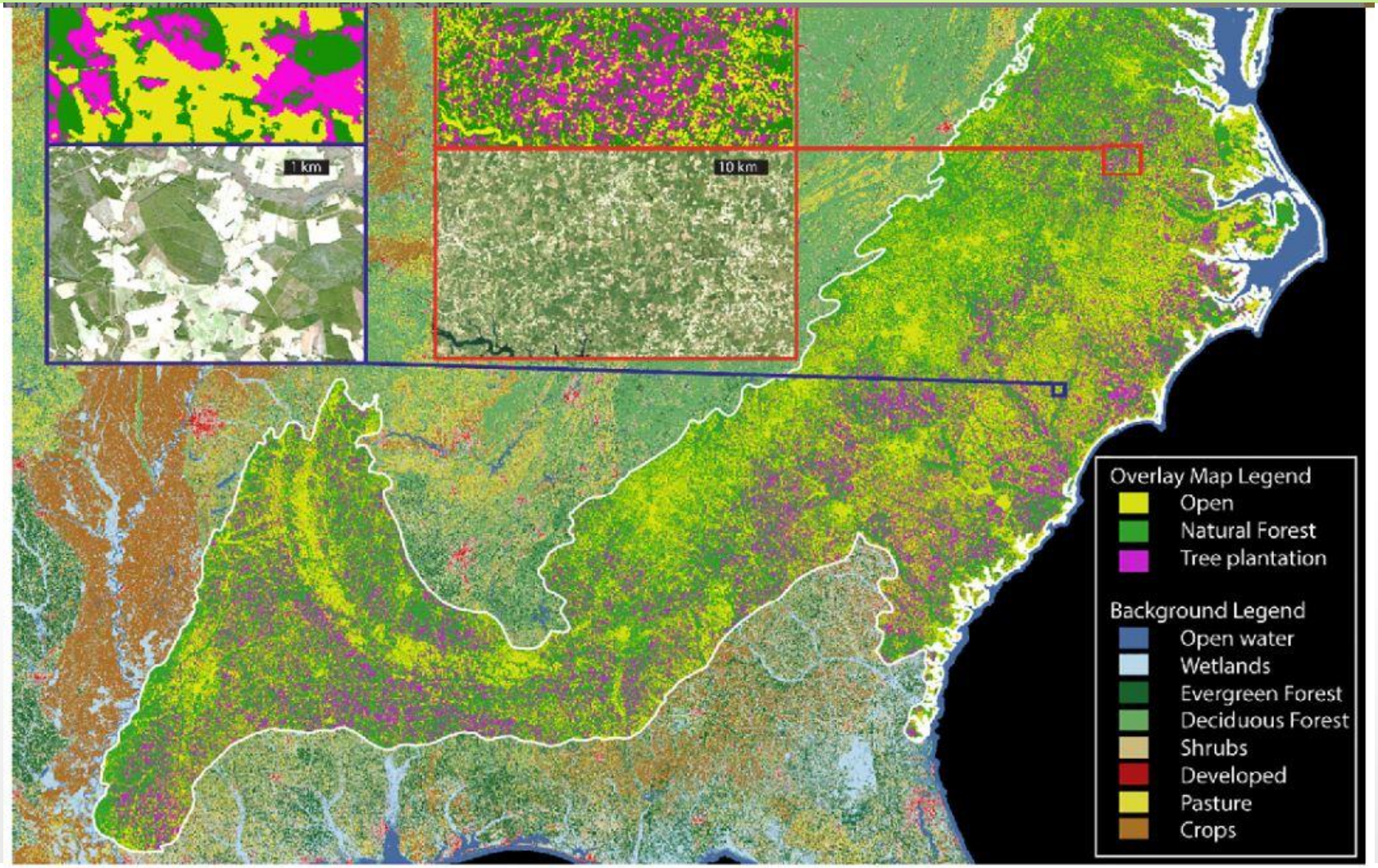


pine



from Schweingruber (1983)

Pine plantations in the US Southeast



from: Fagana et al. 2018

‚Real‘ pine plantations in Europe

(Radiata p. Ire; Maritime p., Le Landes F; Aleppo p. Esp)

Plantation tree species and productivity

Tree species	Region		Productivity	
	trop./subtrop.	temp. regions	iv [m³/ha/yr]	rotation cycle[yr]
Eucalyptus	Brazil, Uruguay	Chile, SW of Europe	12 - 30	7 - 10 (15)
Eucalyptus clone	Brazil		40 - 80	6 - 8
Pinus	Brazil, USA		15 - 25	15 - 25
Acacia mangium	South East Asia		8 - 20	7 - 10
Tectona grandis	Costa Rica, Ivory Coast, India		4 - 18	25 - 60
Populus		Italy, France	8 - 25	7 - 15
Pinus		New Zealand	18 - 24	15 - 25

diverse sources

Growth and quality enhancement through genetic impovement: Inpacel, Brazil

Plantation tree species and productivity

The different growth rates of timber species lead to the fact that for 1 mill. tons of pulp you need

- **100.000 ha of planted forests in Brazil,**
- **300.000 ha in Spain, and**
- **700.000 ha in Scandinavia**

Globally 46 % of the industrial roundwood comes from 7 % planted forests (South America > 90 %);

big 5: *USA, Brazil, China, India, Chile*

Tree species and economic return

Tree species	Region		Economic return	
	trop./subtrop.	temp. regions	IRR [%]	LEV [$ / ha]
Eucalyptus	Brazil		> 20	3000 - 5000
Eucalyptus clone	Brazil		> 25	
Pinus	Brazil USA		10 - 20 10	2500
Teak		Ghana	10	
Hardwoods		USA	2 - 5	-300
Araucaria, Nothofagus		South America	5 - 13	
Native forest, best mgt.	South America		> 10	

diverse sources

SFM and planted forests

Establishment of Criteria & Indicators for sustainable management of planted forests (E. G. Thai C & I, 2019):

- ***7 criteria and 35 indicators (among others: forest ecosystem health and adaptation, forest bidiversity, soil and water conservation)***

Certification and planted forests

Table 5. Percentage of FSC-certified forest area by forest type, '08, '13, '14, '15, '16 and 2017

Forest type	Apr 2008	Dec 2013	Dec 2014	Dec 2015[1]	Dec 2016	Dec 2017
Natural forest	65	64	64.5	65.64	65.15	65.64
Mix (semi-natural and/or mix of plantation and natural forest)	27.5	27	27	26.05	25.97	26.29
Plantations	7.5	9	8.5	8.28	8.86	8.06

Source: FSC Certificate database, 3rd Jan 2018, Jan '17, '16, 2015 ([1] as of 1 Dec 2015).

And: forest certification has not yet arrived in the tropics: only 11 % of all certified forests in 2017 !

Providing ecosystem services from pine plantations

Resin collection in pine plantations in Brazil (photo: L. Nutto, Freiburg)

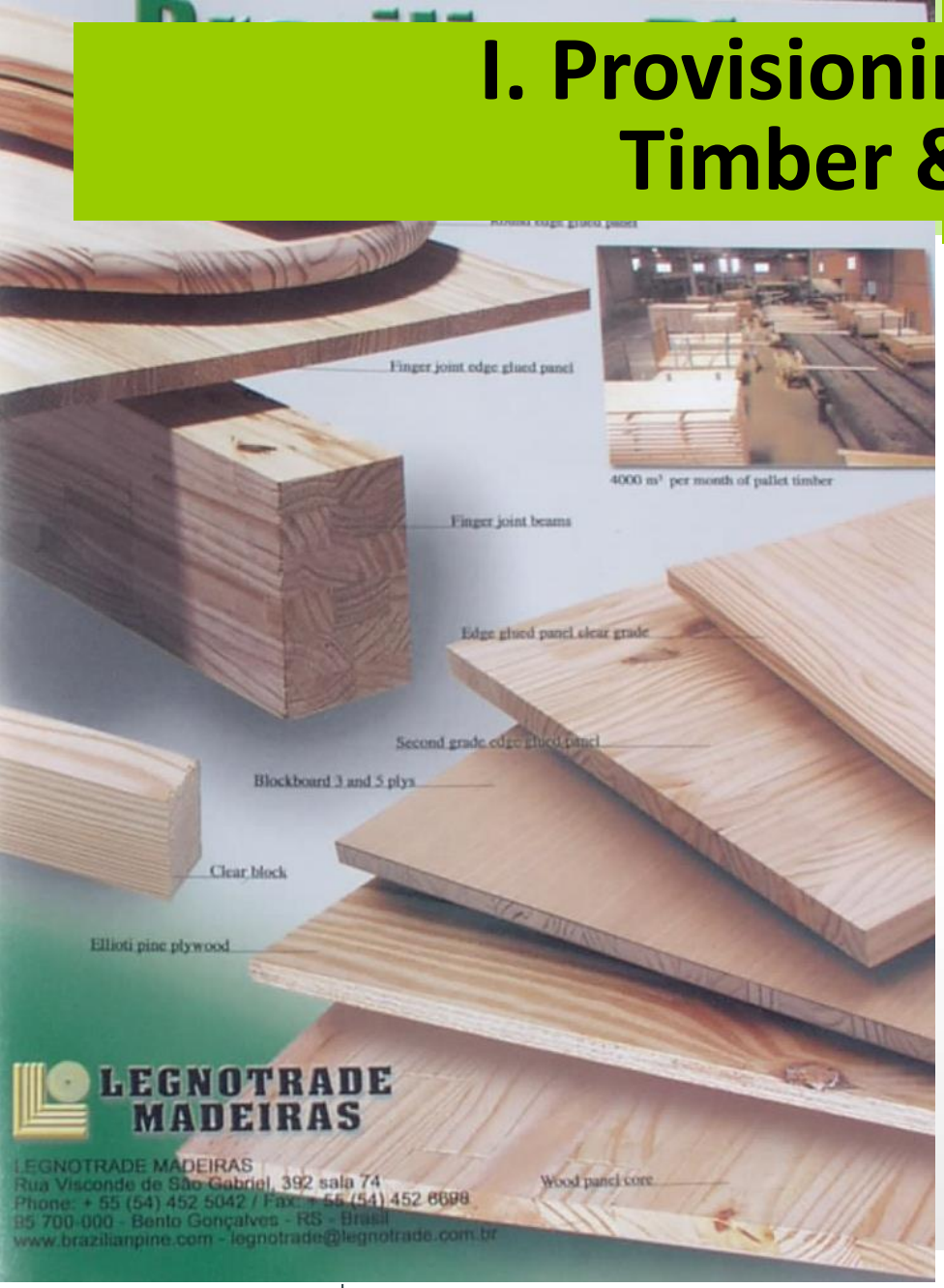
Forest ecosystem goods and services

Forest ecosystem goods and services (ES) = transformation of natural assets into goods and other products that are valuable to people (Shelton et al. 2001)

- Provisioning services
  - *Supply of products / goods like timber, fibre, … & NWFP*
- Regulating and supporting services
  - *Climate and water regulation, mitigation of erosion*
  - *Biodiversity and carbon sequestration*
- Cultural services
  - *Spiritual enrichment and recreation*

acc. to http://www.teebweb.org/

I. Provisioning services: Timber & NWFP



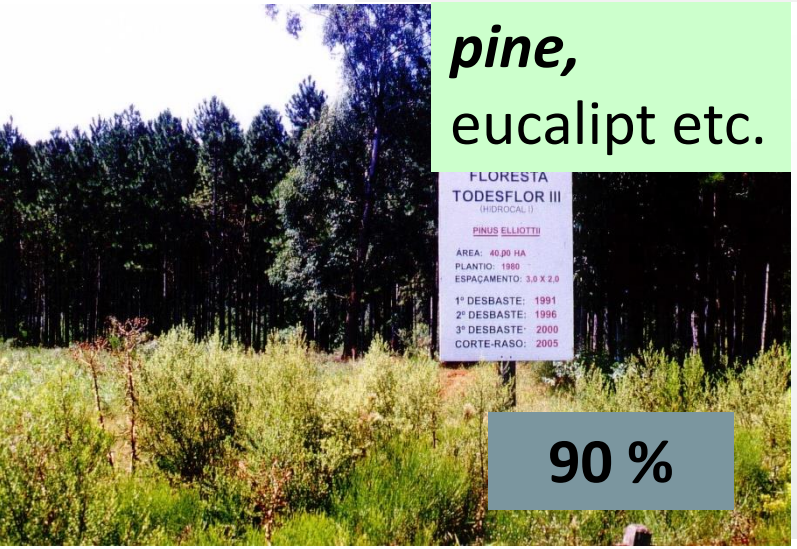
Photos: L. Nutto, Freiburg

Production strategies in pf

from Müller (2003, adapted)

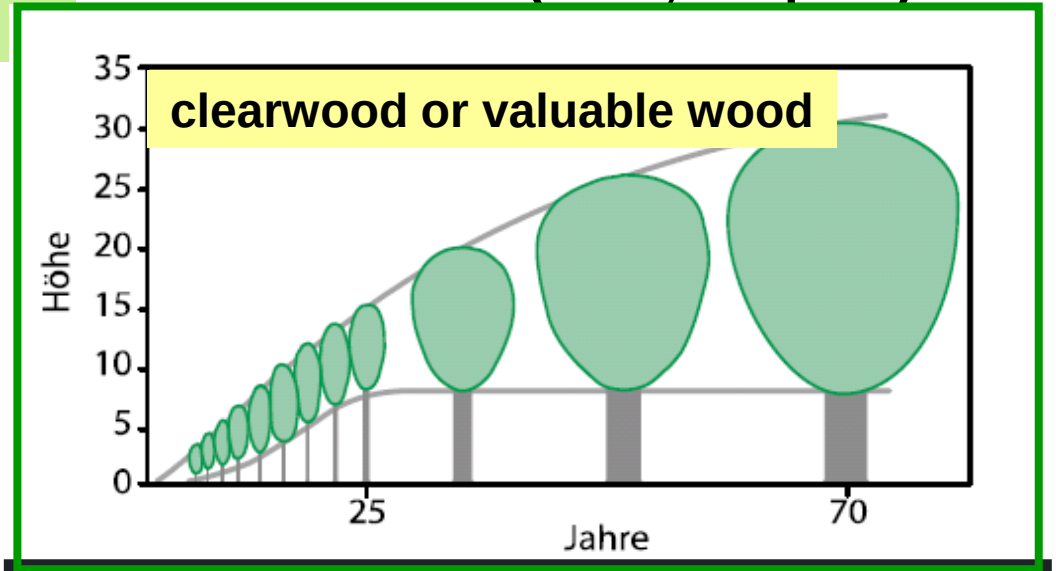
mahogany

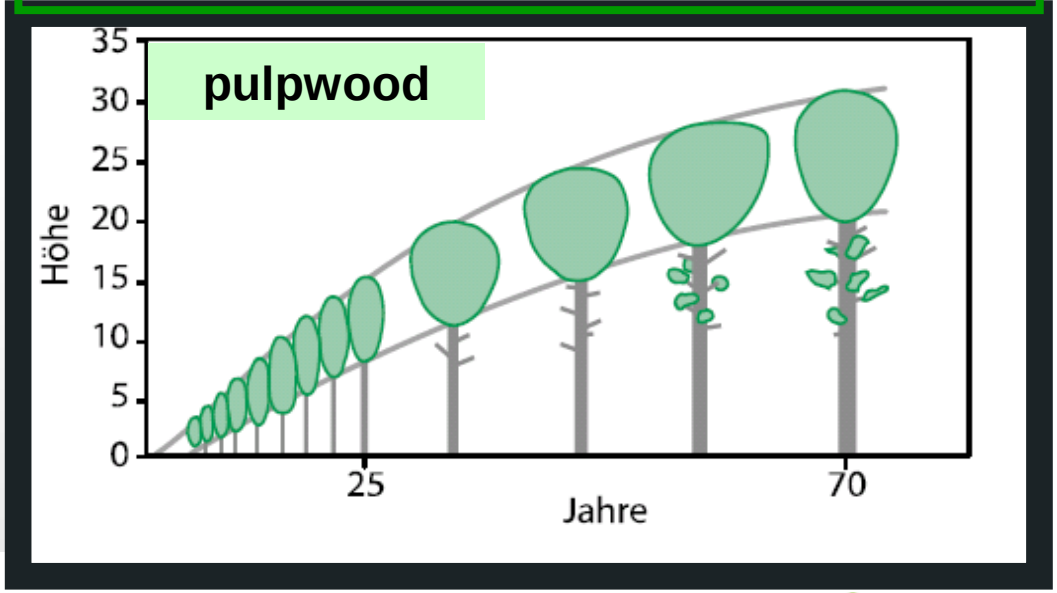
10 %
…new and promising!



pine,
eucalipt etc.

90 %





Silvicultural management

stand model: yield table Pinus elliottii

Tabela de Produção Dinâmica para *Pinus elliottii*

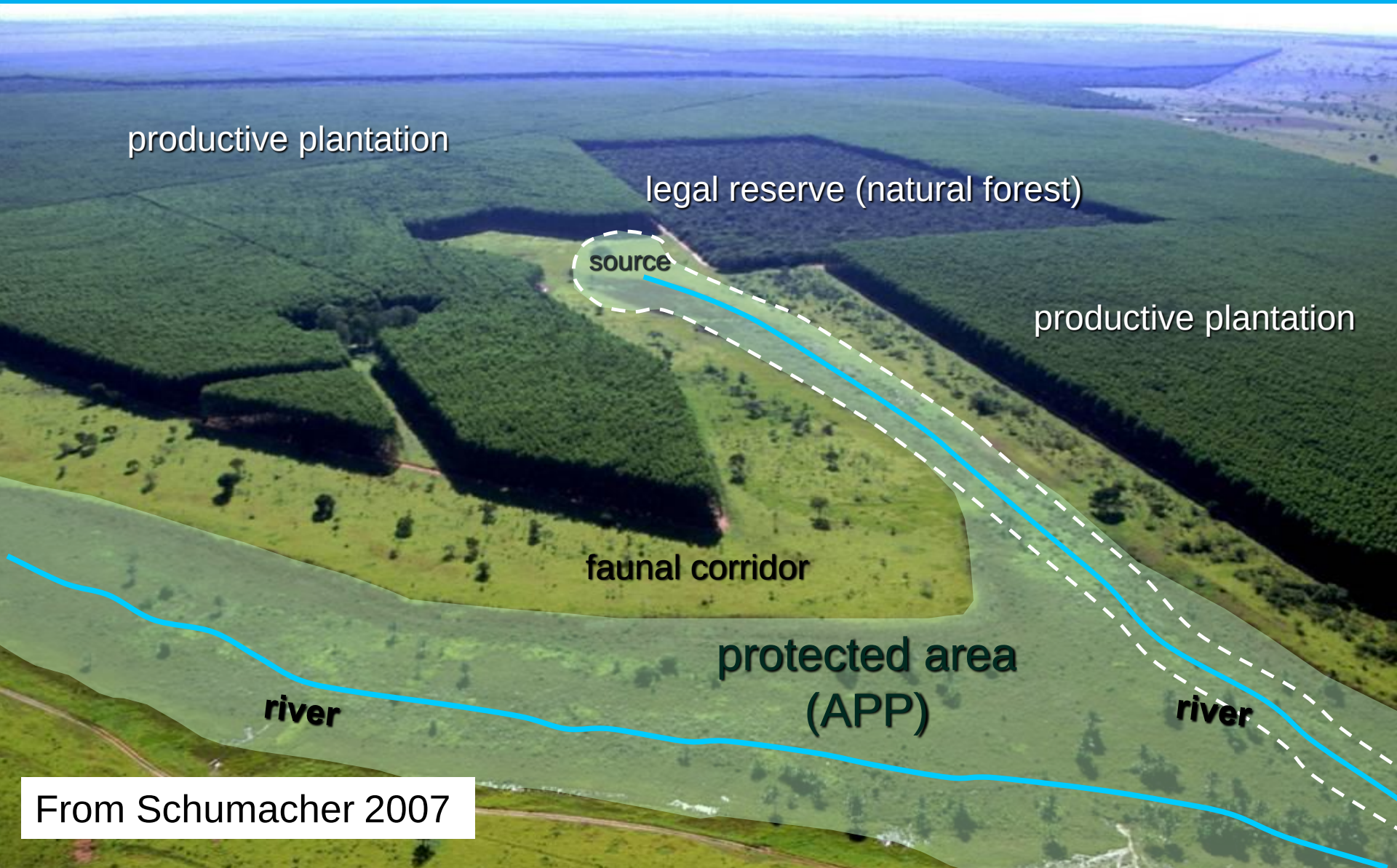
Índice de Sítio = 22

IMA (m^3/ha) 30 = 18,2

	POVOAMENTO REMANESCENTE							DESBASTE				PRODUÇÃO		TOTAL	
ANO	DG	HM	HO	N/HA	G/HA	F	V/HA	N/HA	V/HA	VAC	%	V/HA	IMA	IPA	ANO
5	10,1	4,9	5,6	2446	19,4	4696	44,8			0.0	0,0	44,8	9		5
								25	1,1					27,7	
10	13,5	10,8	11,7	2400	34,4	4913	182,3			1,1	0,6	183,4	18,3		10
								1134	114,8					30,7	
15	17,4	14,7	15	1266	30,1	4990	221,1			115,9	52,4	337,0	22,5		15
								375	64,1					19,6	
20	20,5	17,3	18,7	890	29,3	5052	255,2			180,0	70,5	435,2	21,8		20
								169	39,8					13,2	
25	22,7	19,1	20,7	720	29,3	5043	281,4			219,8	78,1	501,2	20,0		25
								89	25,5					8,9	
30	24,3	20,2	22	631	29,4	5053	300,3			245,3	81,7	545,6	18,2		30
								50	16,2					5,8	
35	25,4	20,9	22,9	581	29,6	5059	313,2			261,5	83,5	574,7	16,4		35
								28	9,9					1,6	
40	26,1	21,4	23,4	553	29,7	5063	321,4			271,4	84,4	592,9	14,8		40

Schneider 1984

II. Regulating services
watershed protection…



From Schumacher 2007

Water loss through planted forests

Countermeasures

On landscape level

– protected area management (Brazil: *APPs*)

On stand level

– use of water efficient trees

– increase of soil carbon content

– residue management to reduce runoff and enhance infiltration

II. Regulating services:
…and site management

Schumacher 2007

See Case Study

III. Supporting services:
what about biodiversity…

Photo: L. Nutto, Freiburg

Biodiversity loss through planted forests

Countermeasures

On landscape level

- Maintain large patches, connectivity and structural complexity on landscape level (riparian/ buffer zones) in the plantation matrix; reduction of pressure on these areas through ***land sparing***

On stand level

- use stand mgmt options to create structural variability: longer rotations, thinning to enhance light conditions (understorey), retention, admixtures…
- create (micro)habitats for plants and animals on stand level (bark, uprooted tree sections, holes, ……)
- avoid soil tillage and weeding

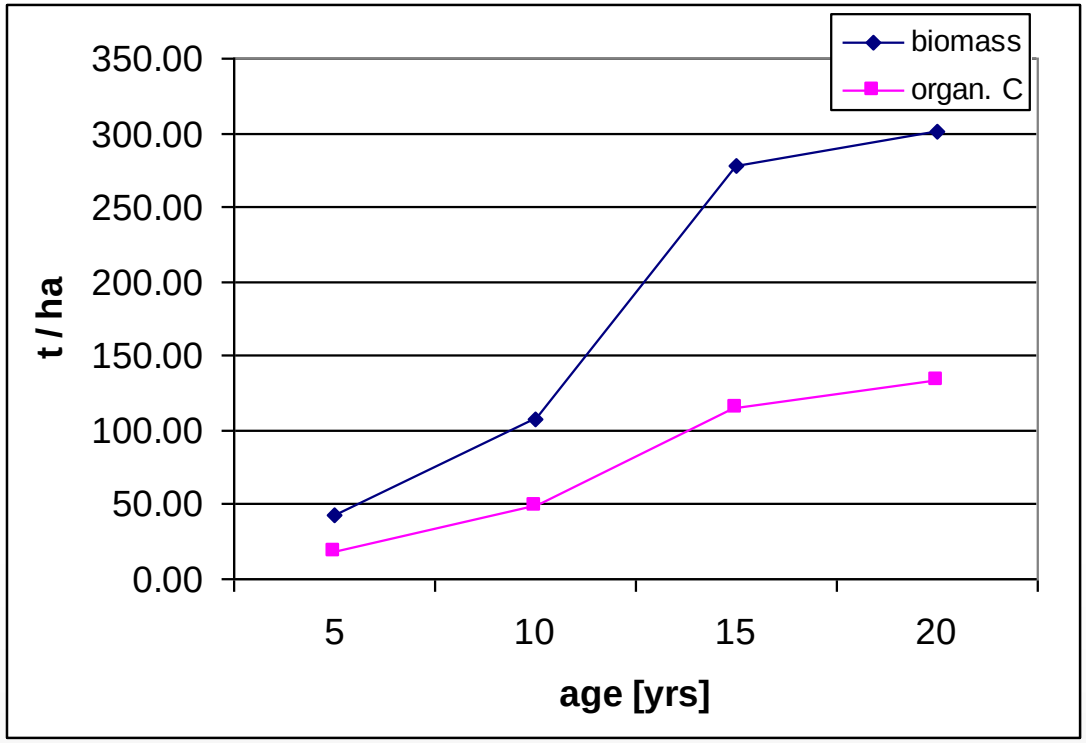
III. Supporting services:
…and carbon storage

Measures to increase carbon sinks through pf

- afforestation on ‘new lands’ (restoration)
- tree species choice (specific gravity of trees), mixture
- increase of rotation length, thus accumulation of standing volume
- reduction of thinning intensity
- reduction of disturbance intensity (pest and fire management)
- maintenance of soil fertility
- …

➢ ***Climate-smart forestry***

Carbon storage and planted forests



Biomass and organic C in loblolly pine plantations; Schumacher et al., 2002

Note:

Small carbon stocks in pf, but high sequestration rates (sink!), compared to unmanaged forests or selectively managed natural forests

Break !

10‘

PPPIB

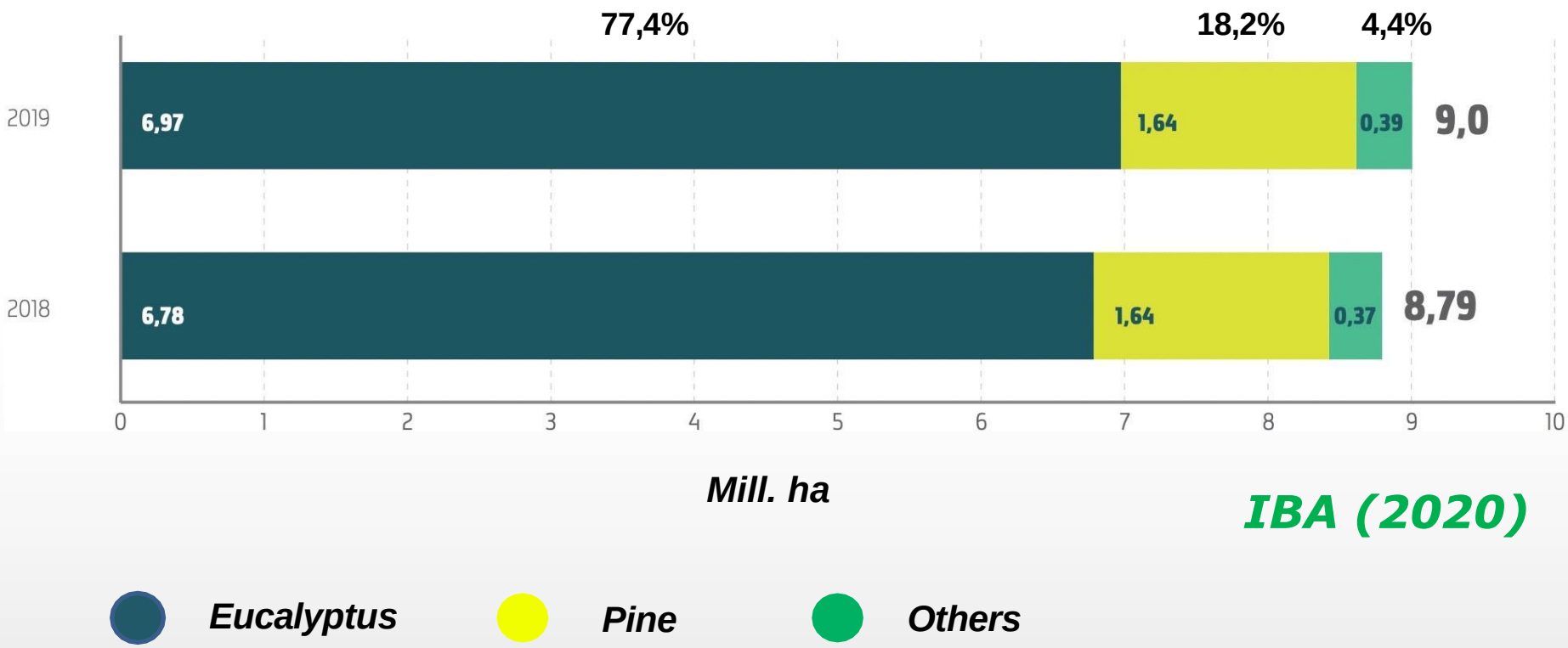
IPEF Pesquisa do Pinus

Laboratório de Ecologia Florestal UFSM

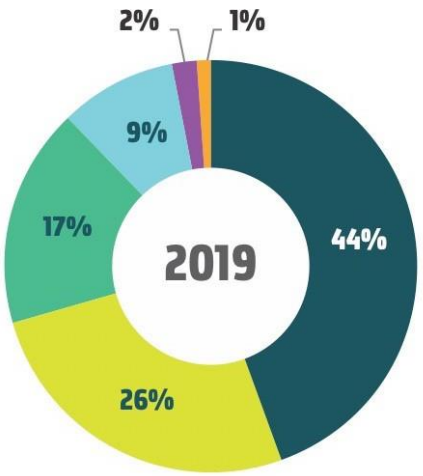
Case study: silviculture & ecology of (fast growing) pine plantations from South Brazil

Prof. Dr. nat. techn. Mauro Valdir Schumacher ***mauro.schumacher@ufsm.br***

Plantations in Brazil

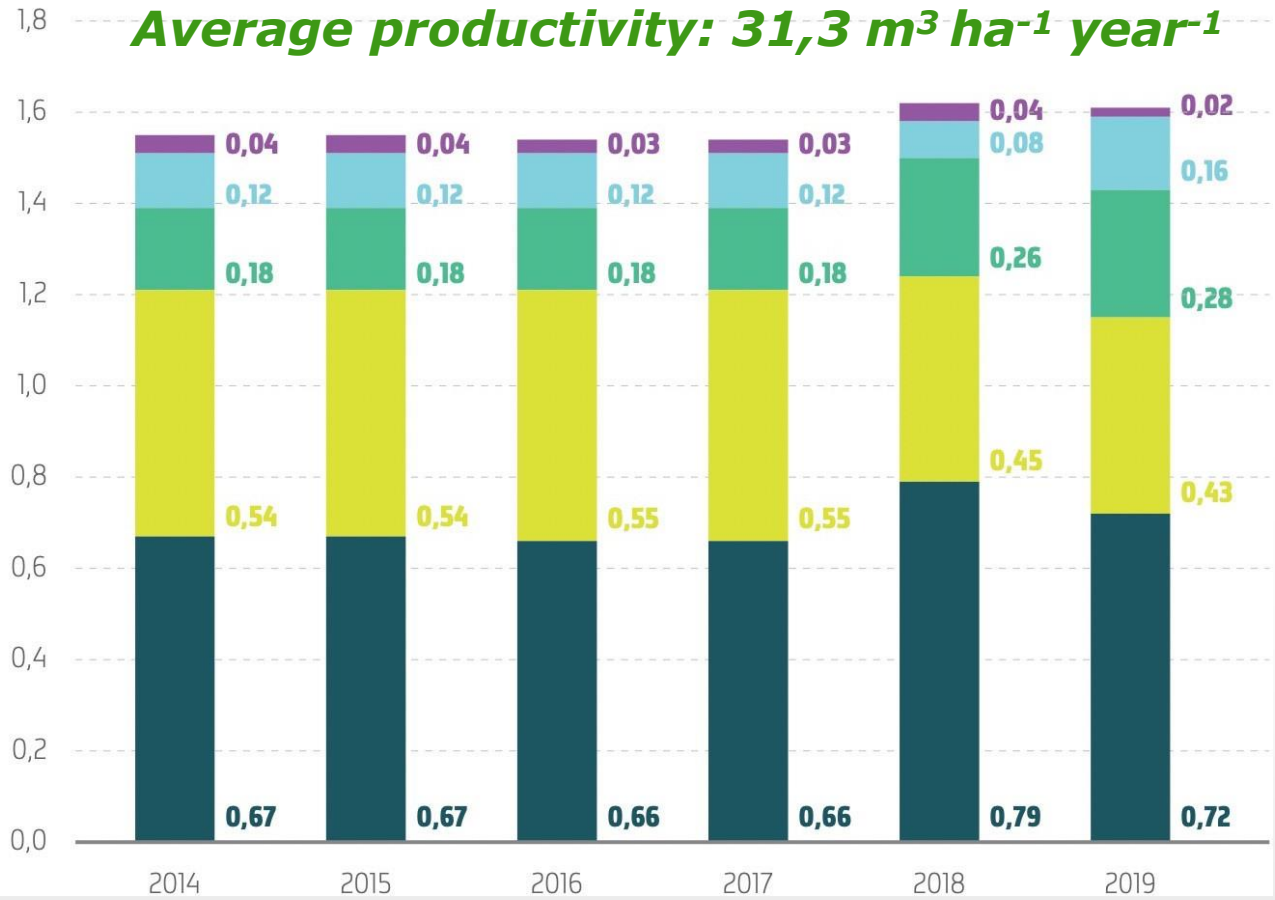


Pine plantations in Brazilian federal states



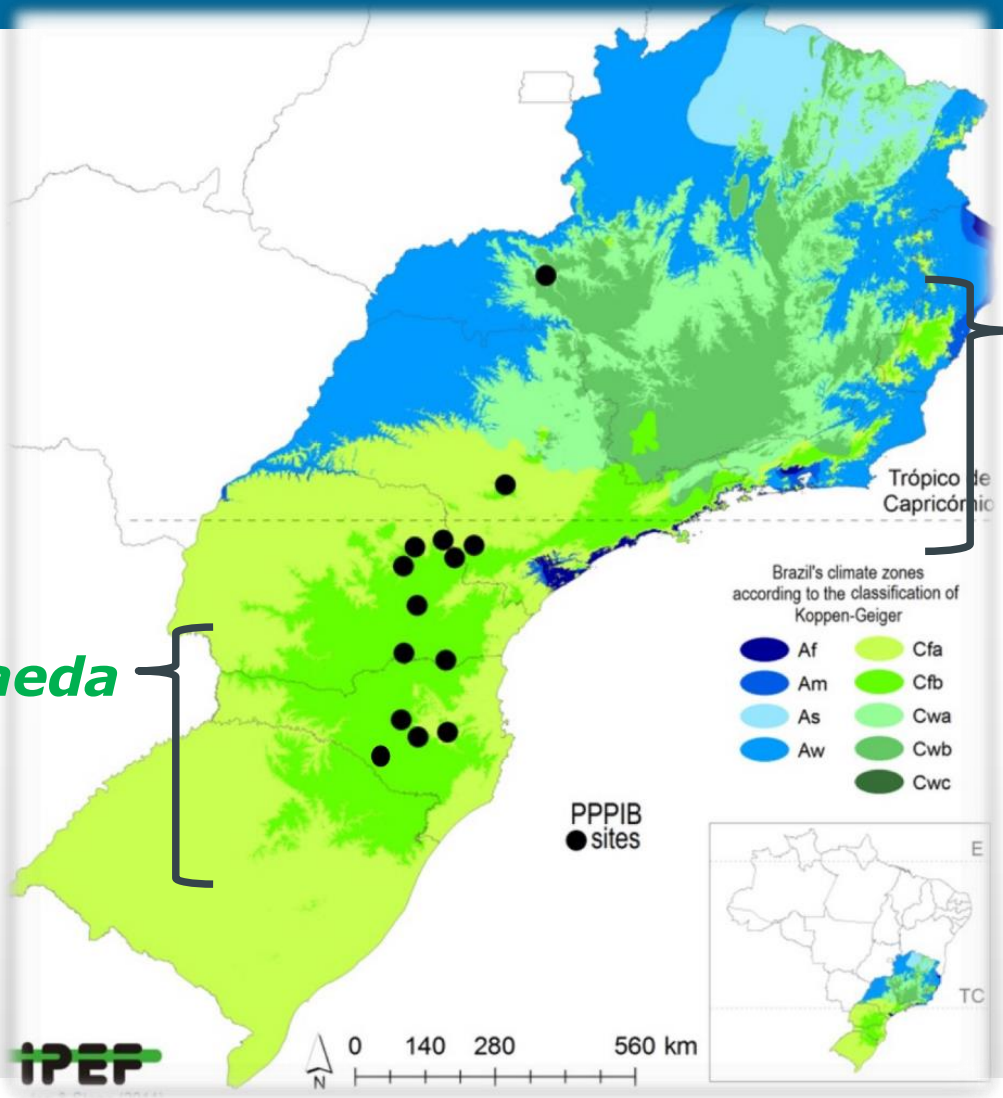
IBA (2020)

Average productivity: 31,3 m³ ha⁻¹ year⁻¹



Mill. ha

Location and natural environment



P. caribaea* var. *hondurensis

P. taeda

Mean annual temperature: 15-20 °C

Annual rainfall: 1300 – 2100 mm

Pine plantations

Photos: Schumacher

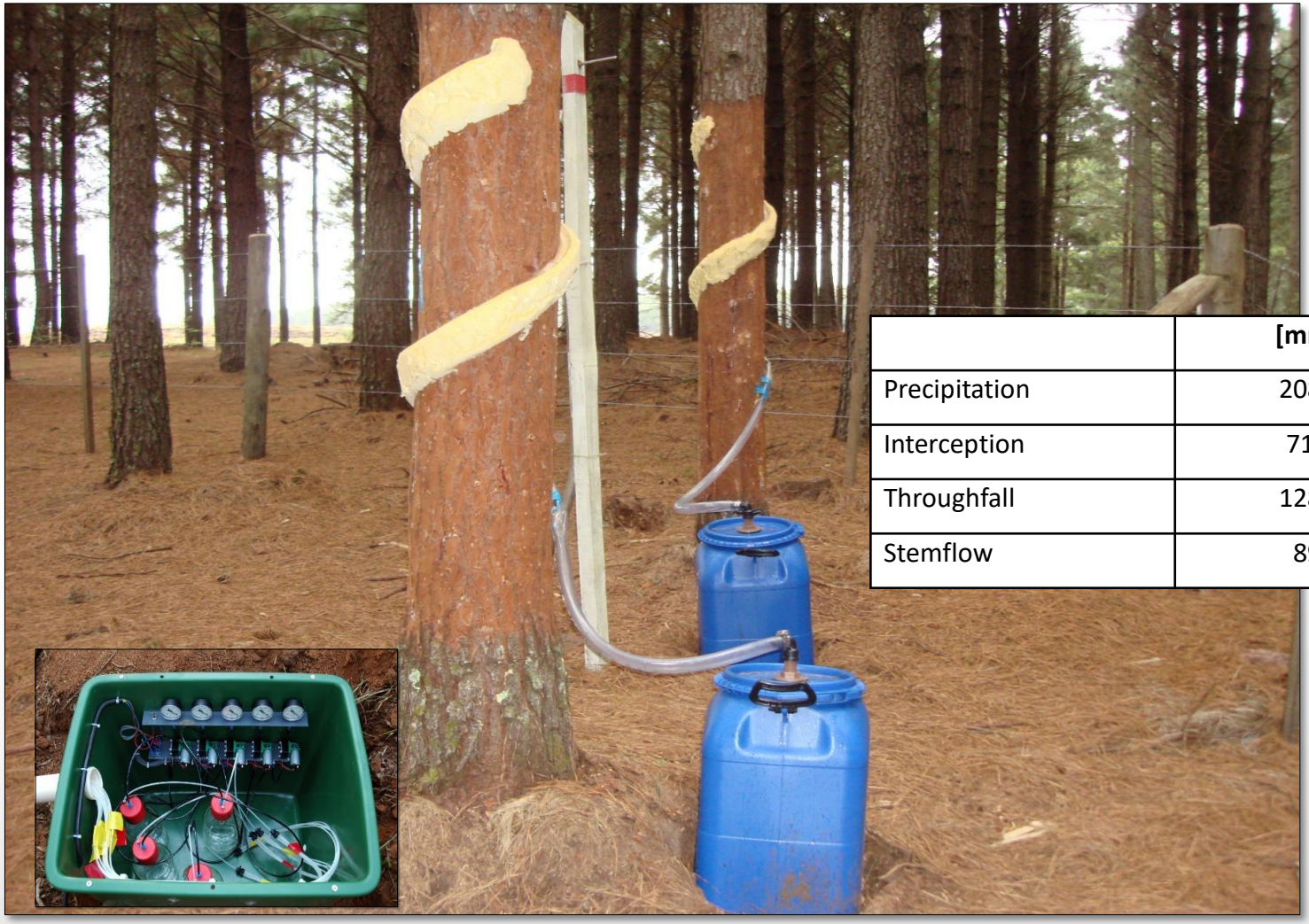
Bulk deposition open air

Schumacher (2015)

Precipitation throughfall in the pine stand

Schumacher (2009)

Stemflow pine



Schumacher (2008)

	[mm]	[%]
Precipitation	2081	100
Interception	712	**34**
Throughfall	1280	**61**
Stemflow	89	**5**

Use of biomass for energy by industry

Schumacher et al. (2007)

Impact of harvest system on soil fertility

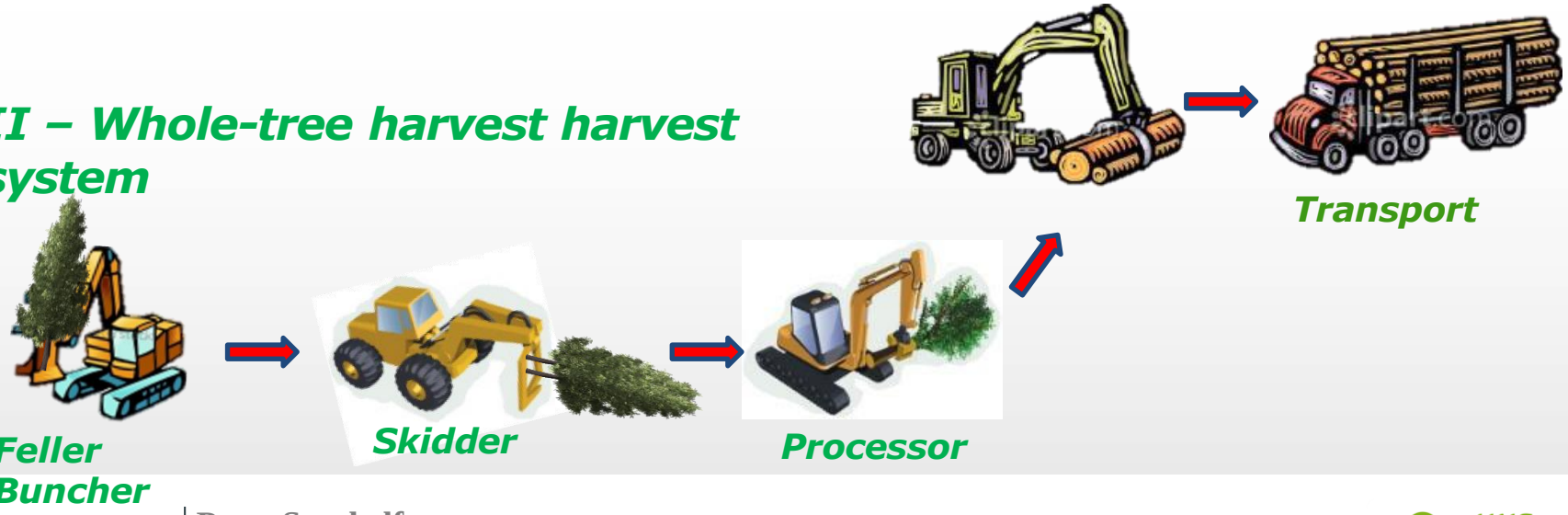
I – Stemwood harvest system

Harvester *Forwarder*

Guerra (2019)

Which one is more sustainable?

II – Whole-tree harvest harvest system



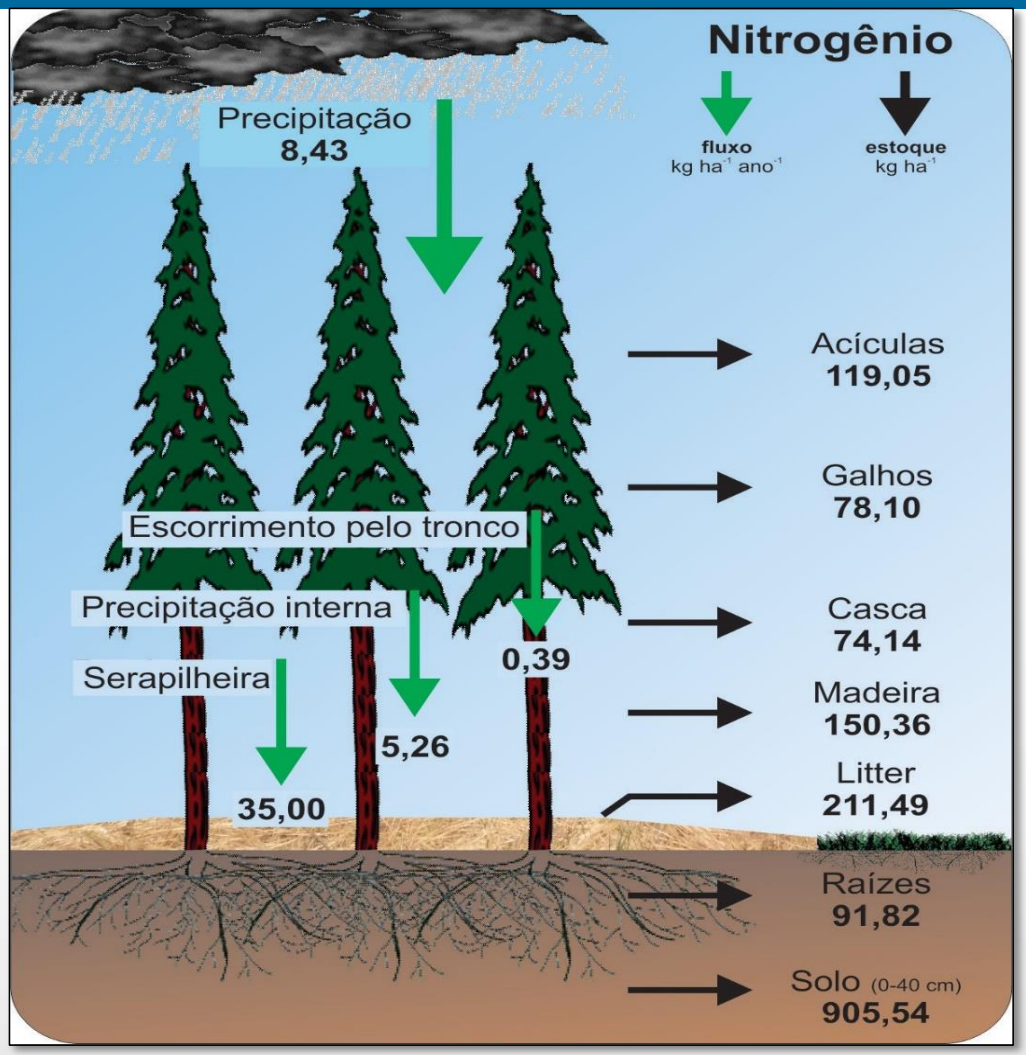
Feller Buncher *Skidder* *Processor* *Transport*

Nutrient removal and intervention type (*P. taeda, 27 years*)

Schumacher et al. (2007)

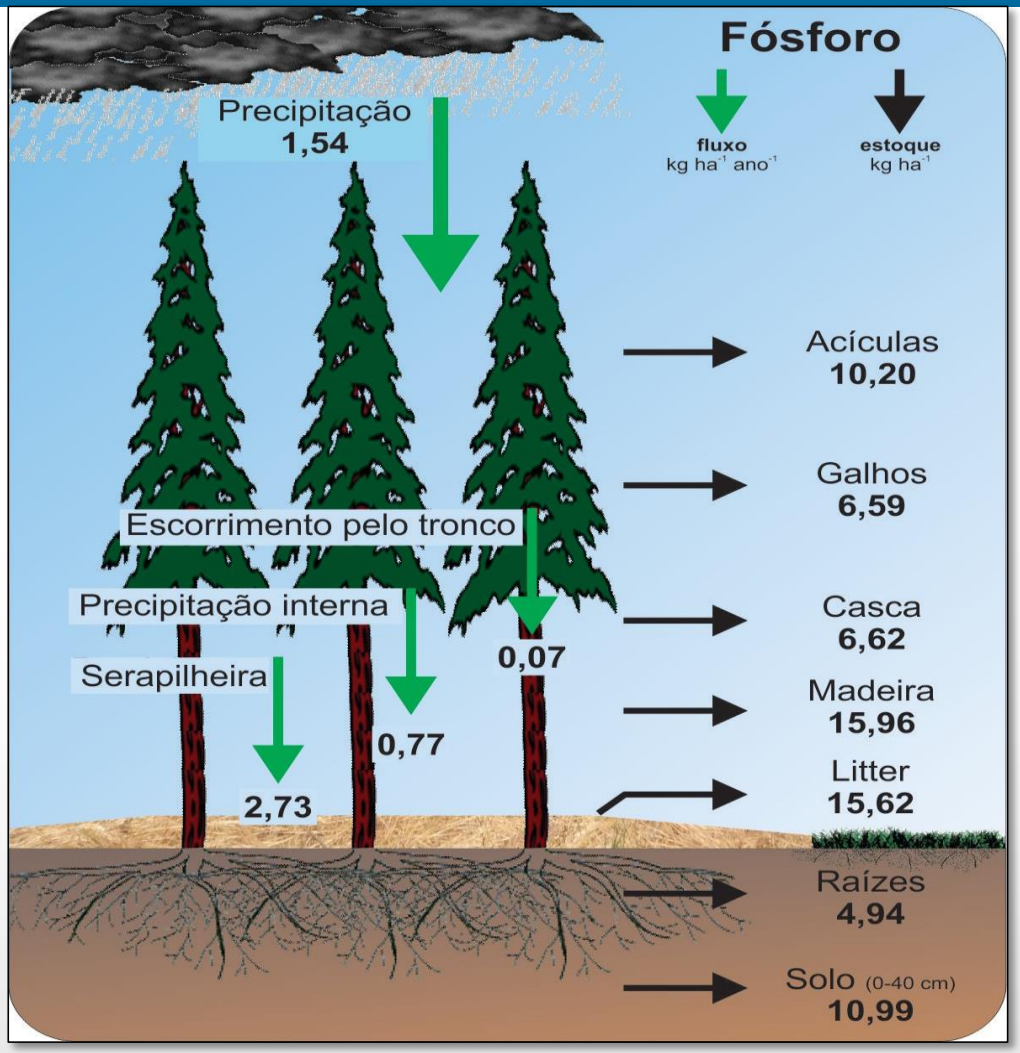
Type of intervention	Removal (kg ha^{-1})			Average annual removal (kg ha^{-1})		
	N	*P*	*K*	*N*	*P*	*K*
Total	527,2	46,6	186,8	19,5	1,72	6,29
Stemwood with bark	269,0	23,3	98,2	9,96	0,86	3,63
Stemwood	210,8	18,8	79,5	7,8	0,69	2,94

Nitrogen - *P. taeda*



Lopes (2013)

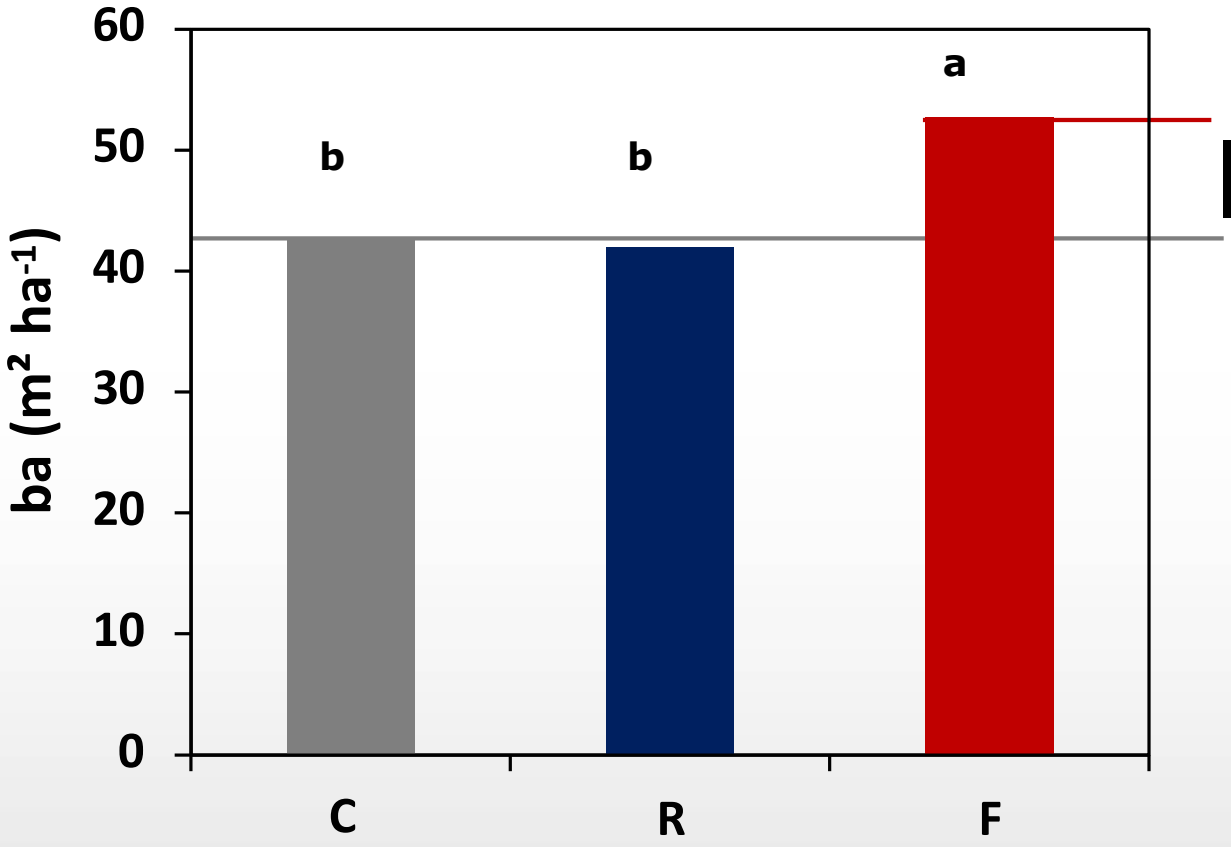
Phosphorous - *P. taeda*



Lopes (2013)

Impact of treatment

Dominating factor = nutrition

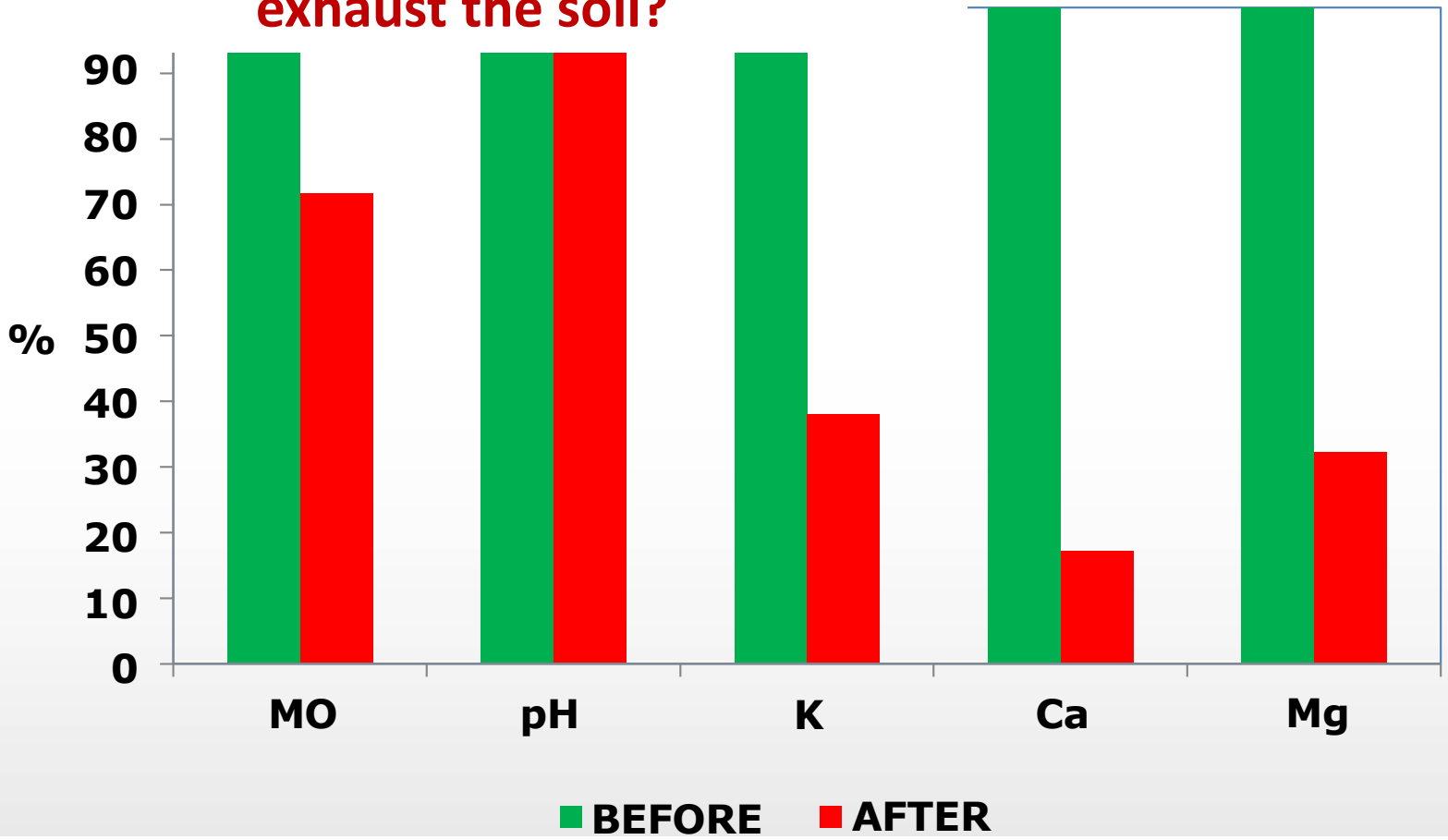


PPPIB (2016)

Change of soil characteristics in *P. taeda* after 15 years

Sustainability question: do plantations exhaust the soil?

Lopes (2009)



Pine – an option for the restoration of degraded areas (acc. to Souza 2015)

Planting of *P. taeda*

Fertilization of *P. taeda*

P. taeda after 10 months

Liming of *P. taeda*

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P. taeda after 29 months

Some conclusions on the case study

Nutrient loss can be avoided by

- managing the internal nutrient cycle (residue management/ mulching; no burning of residues)
- leaving foliage, branches and bark on the site (no whole-tree harvesting)
- practicing cautious harvest operations (no soil compaction)

Synthesis: Pine plantation forestry…

1. can provide the raw material for growing economies (e.g. pulpwood, sawn wood, valuable timber, NWFPs…)
2. and valuable contributions to the socioeconomic conditions of a region (…e.g. regulating and supporting ecosystem services)
3. is an option to restore degraded land

Thank you!

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