Agro-Silvo-Pastoral Systems in Humid Tropical and Temperate Biomes

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Latin America, Temperate Latitudes

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Industry Nature

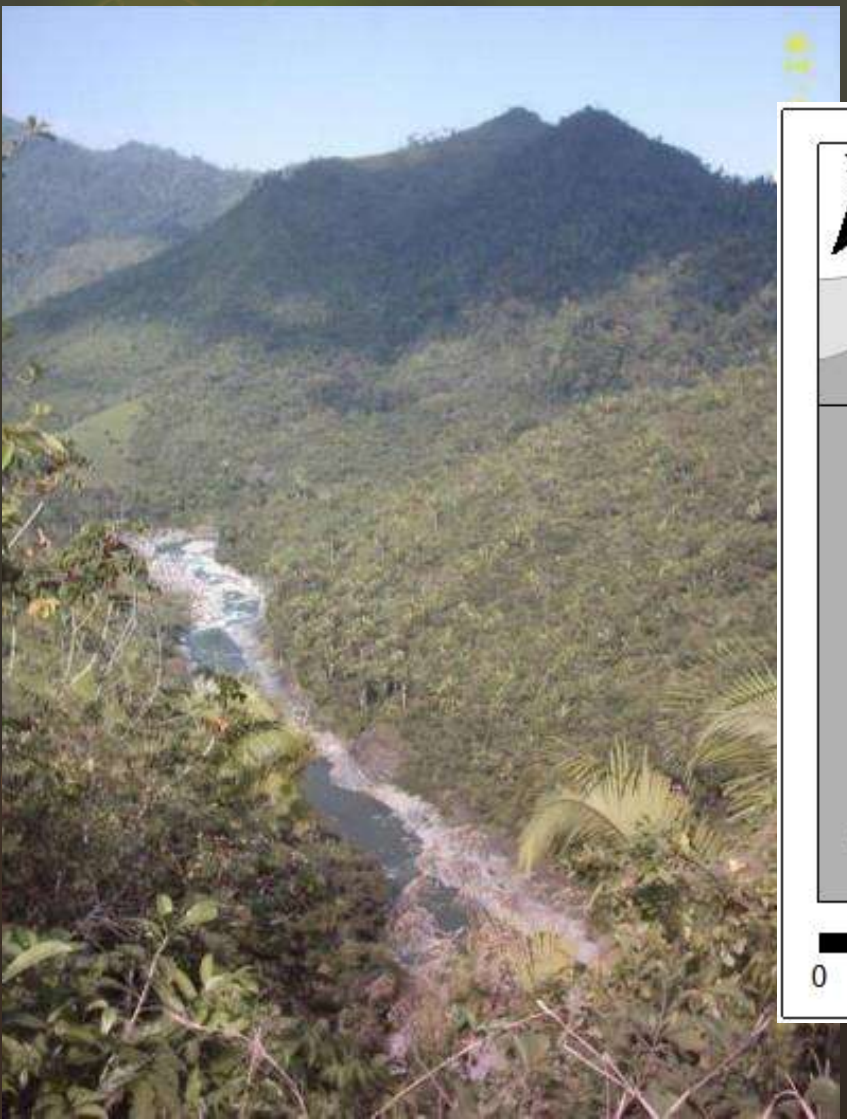
Duisburg
Bochum
Marburg
Göttingen

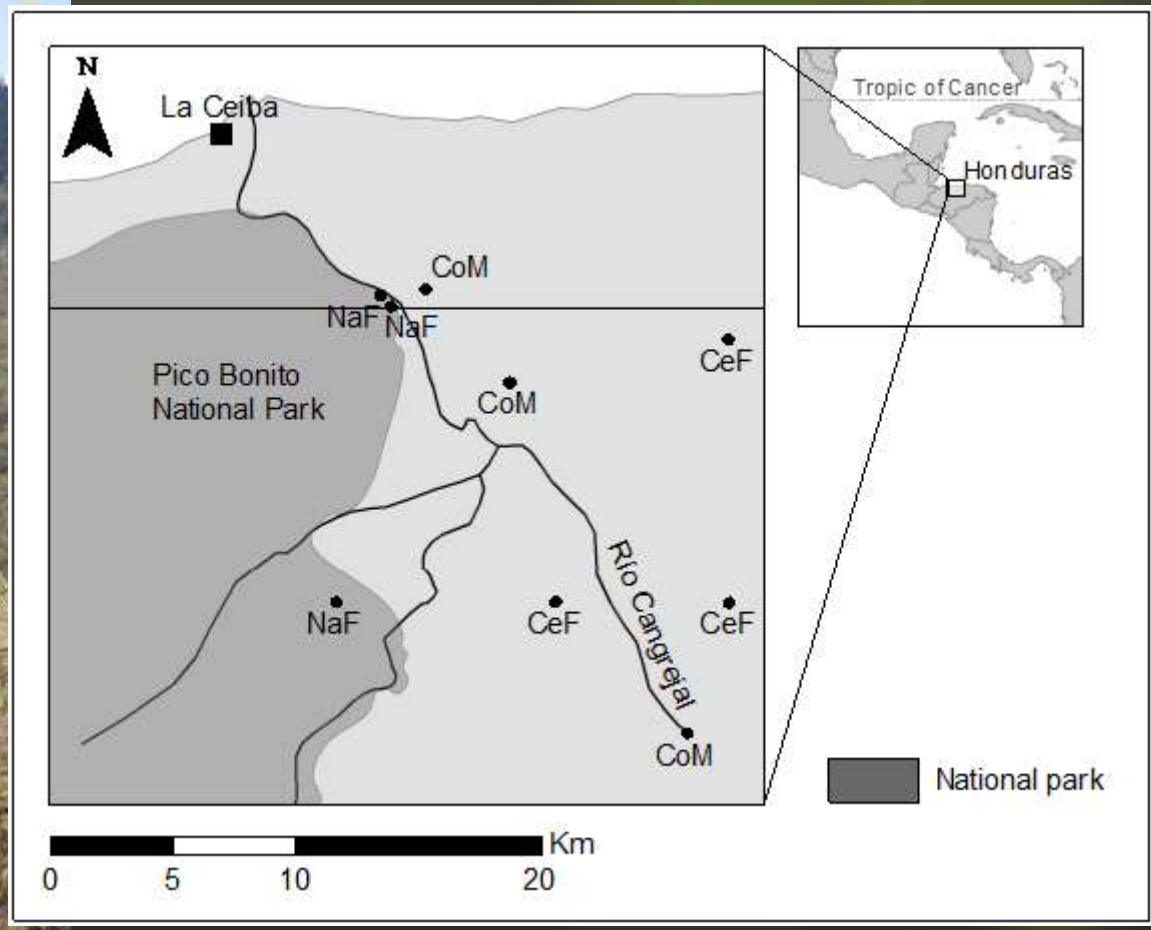
Bolivia, Dry Valleys 1995

Polylepis-Forests Boulder Slopes

Sajama, 6542 m (5200 m)

University of Helsinki
La Ceiba, Honduras, 2005





FSC-Certificated Forests

1. FSC-forests; PEFC
2. Conventional forests
3. National Park forests

(Kukkonen & Hohnwald 2008; 2009)

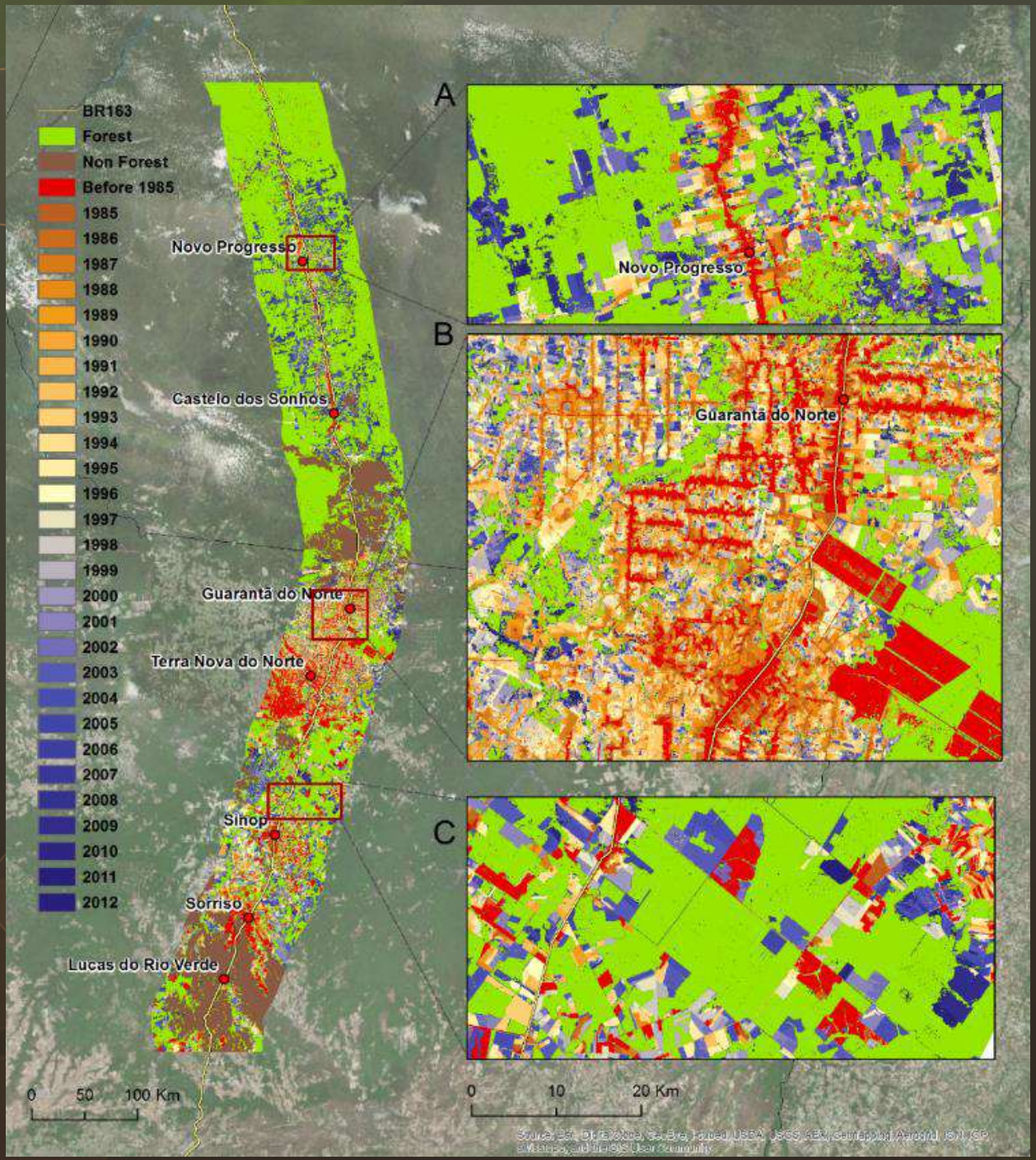
Dynamic certification for diverse Patagonian forests
PEFC- Programme for Endorsement of Forest Certification Schemes

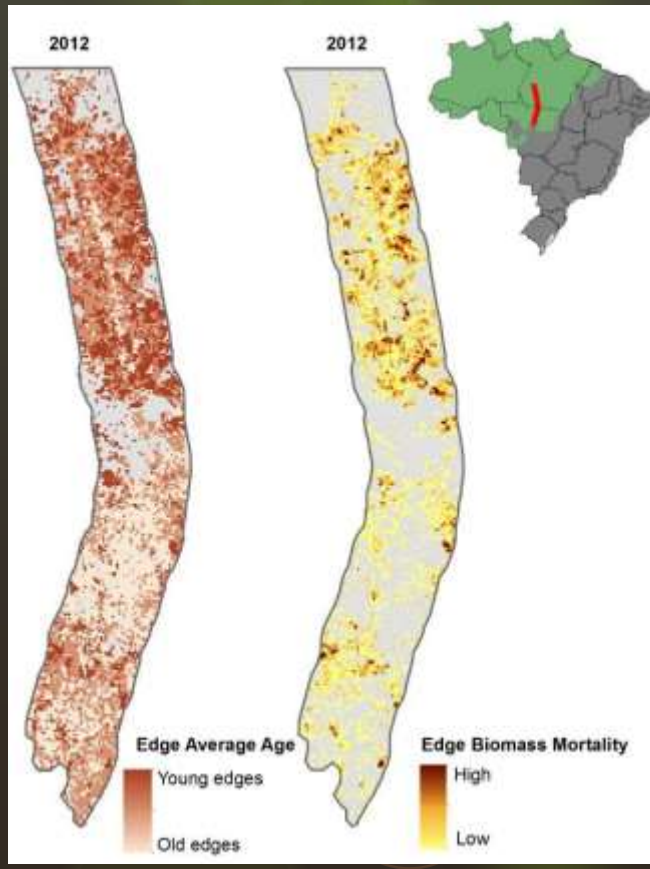

N
1
Novo Progresso
Pará
Mato Grosso
BR 163
2
Sinop
BR 163
3
Cuiabá
Pará
Mato Grosso
Brazil
Land Cover (2010)
Tropical Forest
Cerrado
Pasture
Cropland
Water
Investigation sites
Study Regions
0 50 100 200
km
Carbiocial

Inter- & trans-disciplinary project consortium

May 2011- September 2016

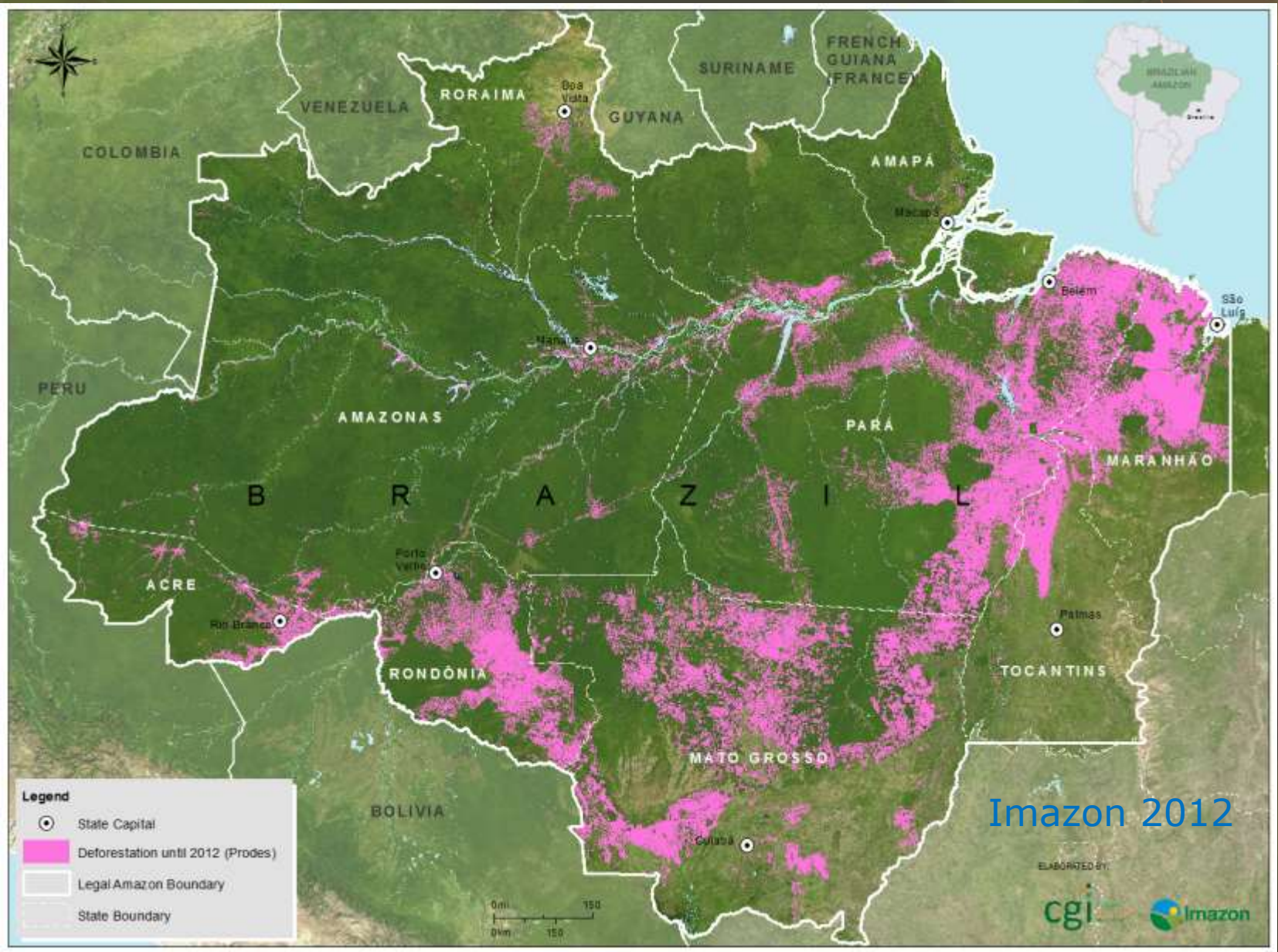
Long-Term Deforestation at the BR-163





Müller et al. 2016

Brazilian Amazon- Deforestation



Ph.D-thesis

Agro-Silvo-Pastoral Systems (AFS)

smallholder pasture, poverty alleviation

Testing innovate AFS

to avoid ecological pasture degradation

“grass-legume pasture“ or “grass-capoeira pasture“?

Brasov, 07.06.2019

Why Agro-forestry Systems in the Humid Tropics?



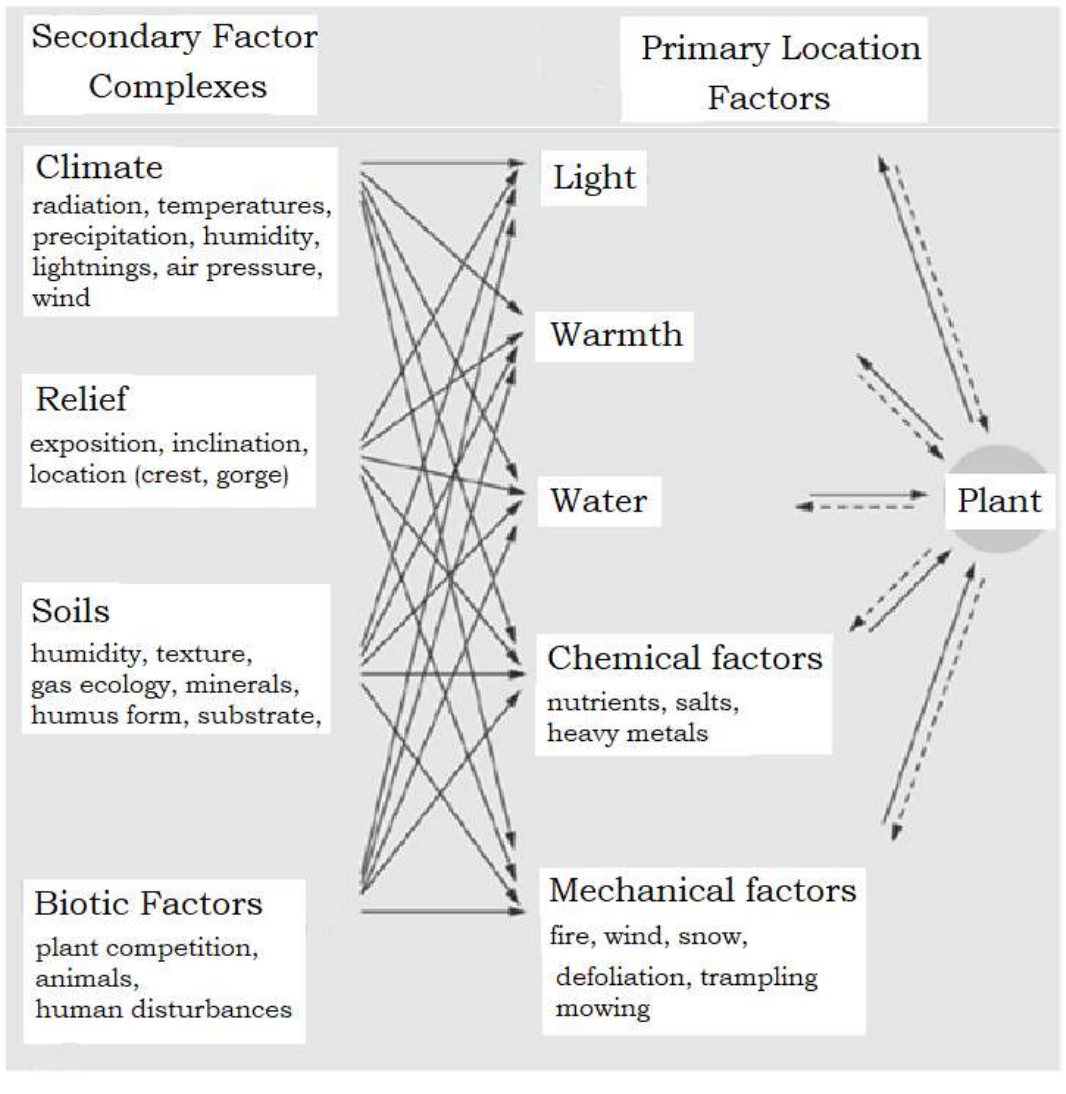

(and why Agro-forestry Systems in the Humid Temperate Biome?)

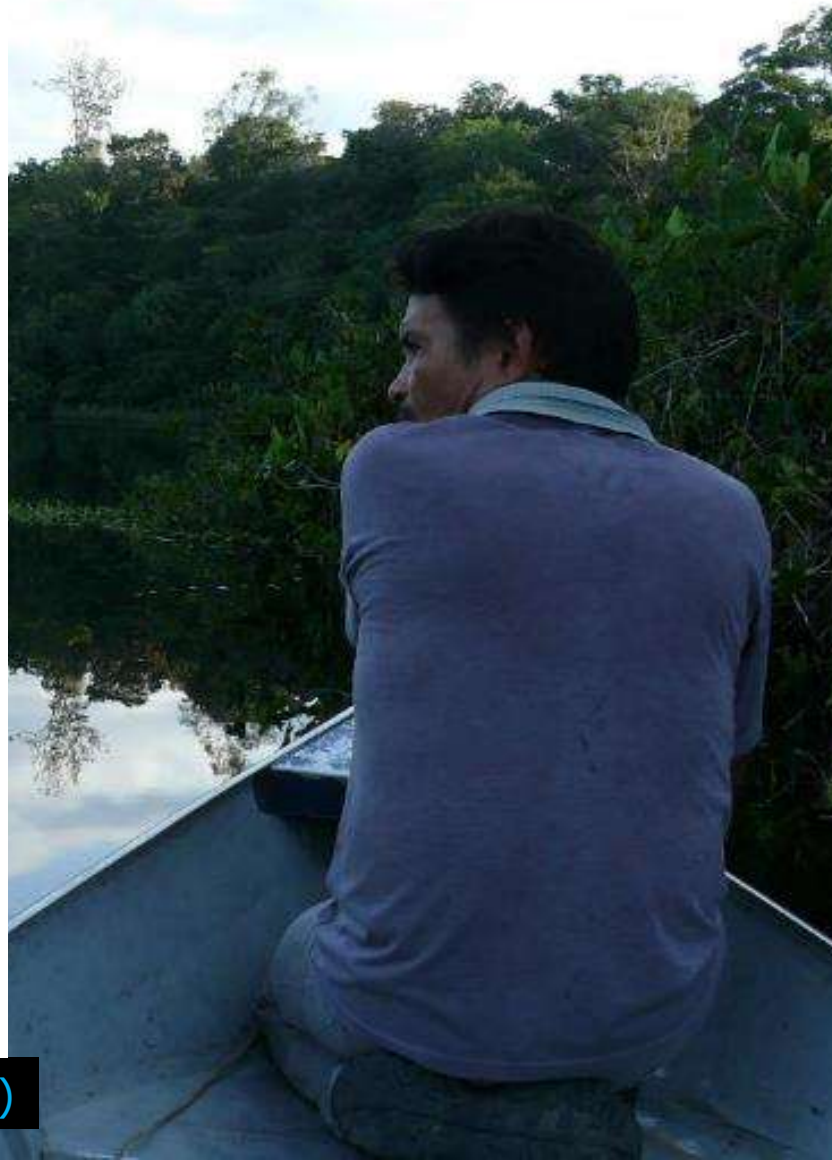
Agro-Silvo-Pastoral Systems

…because of the ecological constraints of the Humid Tropics- poor soils!

Terra Firme Rainforest- Lush Vegetation

Primary und Secondary Location Factors





(Ellenberg 1996; Klink 1998; Glawion et al. 2002)

Shifting Cultivation

Slash-…

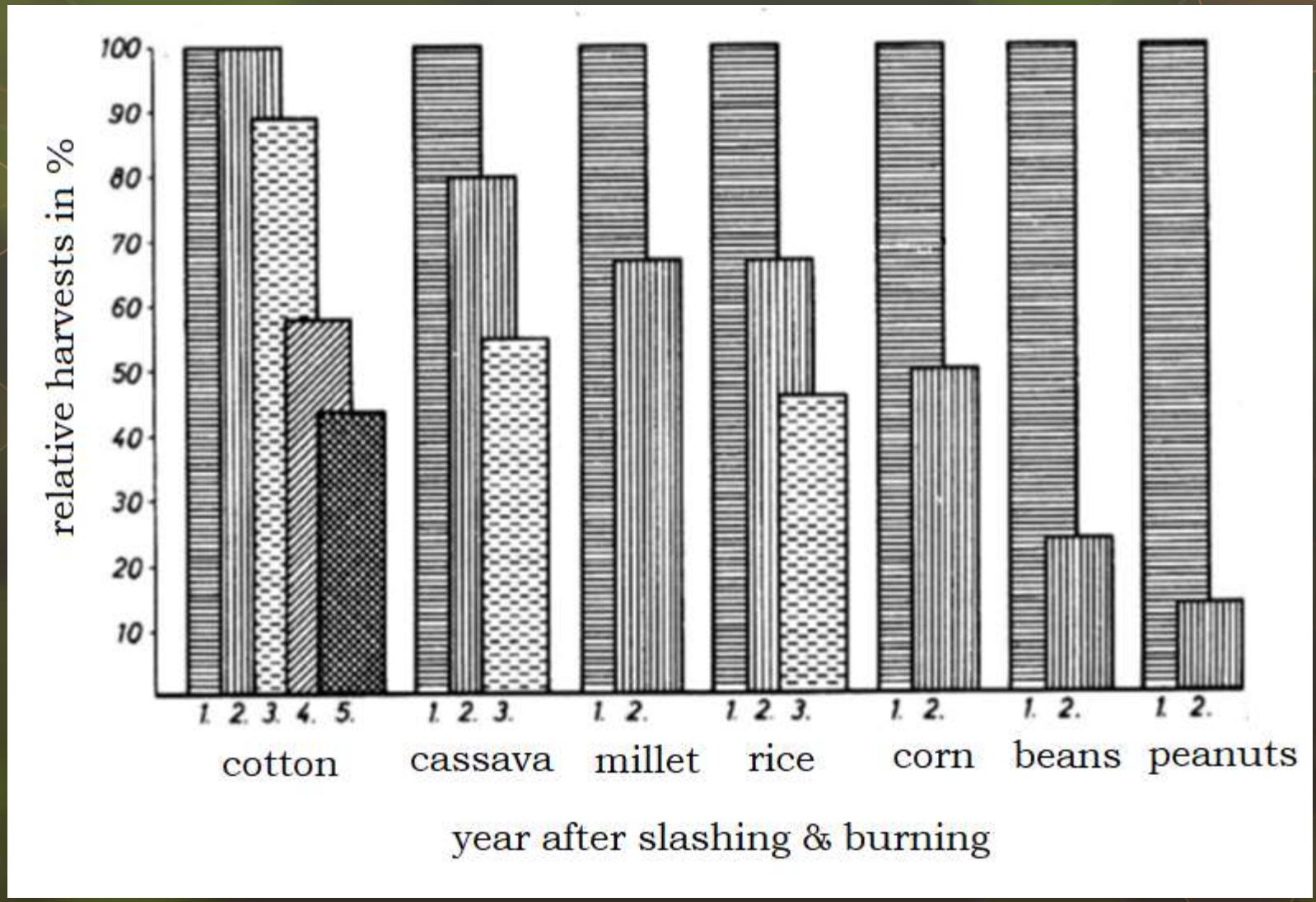
…and-Burn Agriculture

Nutrient Losses by Burning a 7-year-old forest (31 t/ha)

Losses in kg/ha and % of the Biomass		
Carbon	14378	98%
Nitrogene	205	96%
Sulphur	14	76%
Phosphorus	55	47%
Potassium	39	47%
Magnesium	18	40%
Calcium	107	35%
Natrium	6	30%

(Hölscher 1995; Mackensen et al. 1996)

Dramatic Harvest Decline



(Weischet 1980, slightly altered)

Contradiction & Fallacies

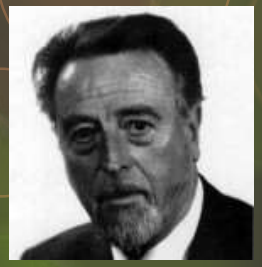
- Strong forest production ≠ low-yielding crop land?
- Forest fallow is an agricultural necessity (compulsory)
- space consuming (Shifting Cultivation)

- Humid tropics were commonly considered fertile areas
- Until the 1930s, the most fertile agricultural areas on earth
- 200 people per km², twice as many as in the outer tropics

(Carol 1970; Kreus & von der Ruhren 2008)

“Persisting Ecological Constraints of Tropical Agriculture”

Prof. Wolfgang Weischet



Humid tropics are inherently much less favorable in terms of agrarian production potential than temperate latitudes and subtropics

„From the interaction of water balance, soil formation processes, nutrient cycles, and landscape processes, there are certain limiting factors that inevitably fix the possible agricultural production of food crops to a much lower level“

(Weischet 1977; 1980)

Basic Hypotheses

- Deficient agricultural production
- Nutrition problems even with low population densities
- "The tropical rainforest is a desert covered with trees"

(Goodland & Irvin 1975)

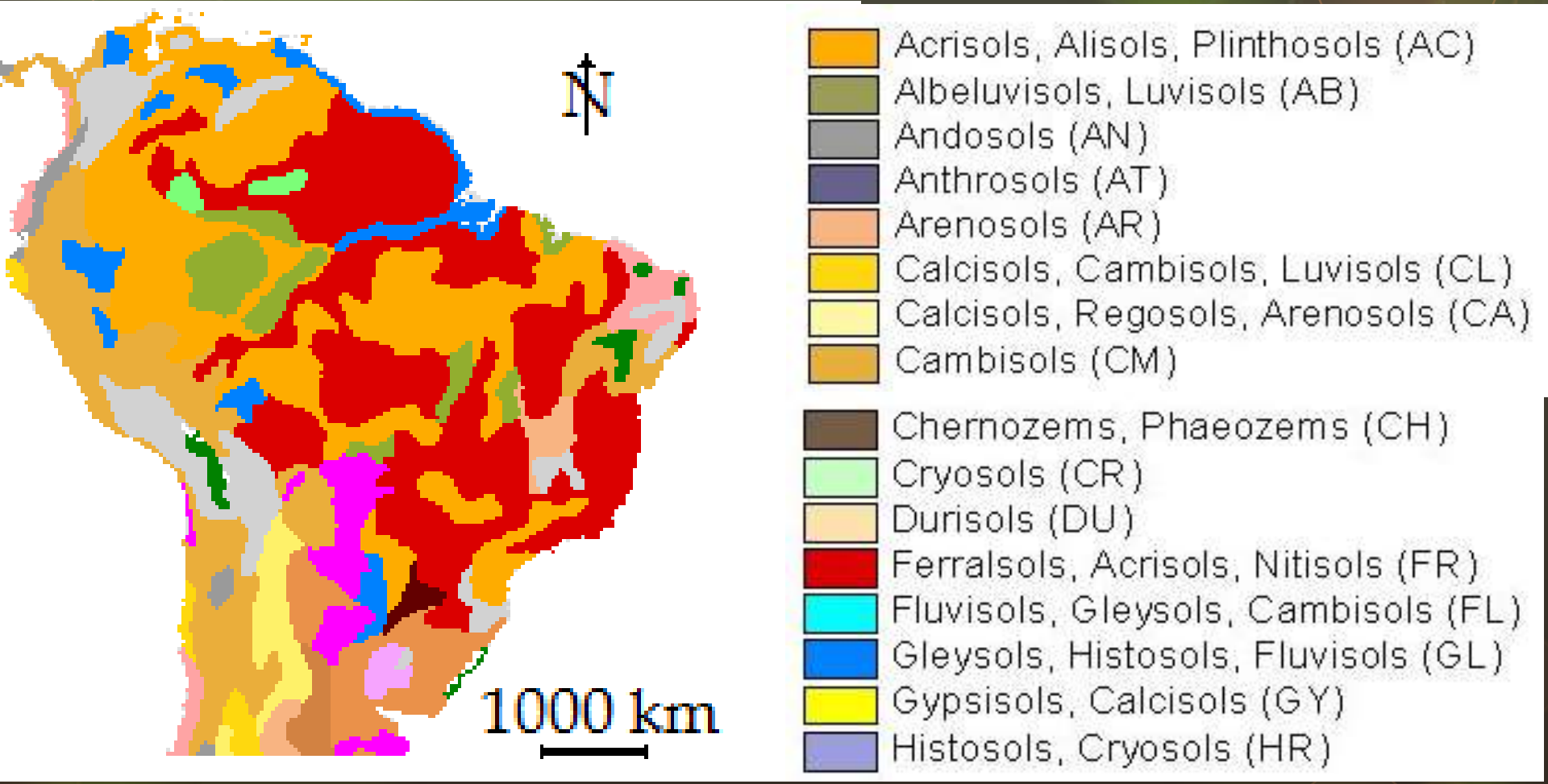
- Underdevelopment, poverty
- Time problem: Daily struggle for survival

- All technical aids can only partially overcome the crucial restrictions
- Poor soils- low cation exchange capacities

"Persisting Ecological Constraints of Tropical Agriculture"

(Weischet & Caviedes 1993)

Soils of Tropical South America



(FAO 1999; Šubelj 2008)

Soil Formation in the Humid Tropics

- climate over long periods leads to ferralisation and plinthisation

- since 1-55 million years (Eocene)
- water permeability, washout
- acidification + desilication
- soils > 80 m

- sandy soils
- silt fraction: few primary silicates
- clay fraction: two-layer clay minerals

- pseudo-sand, pseudo-silt

(Weischet 1980)

Ferralsol- Low Activity Clays

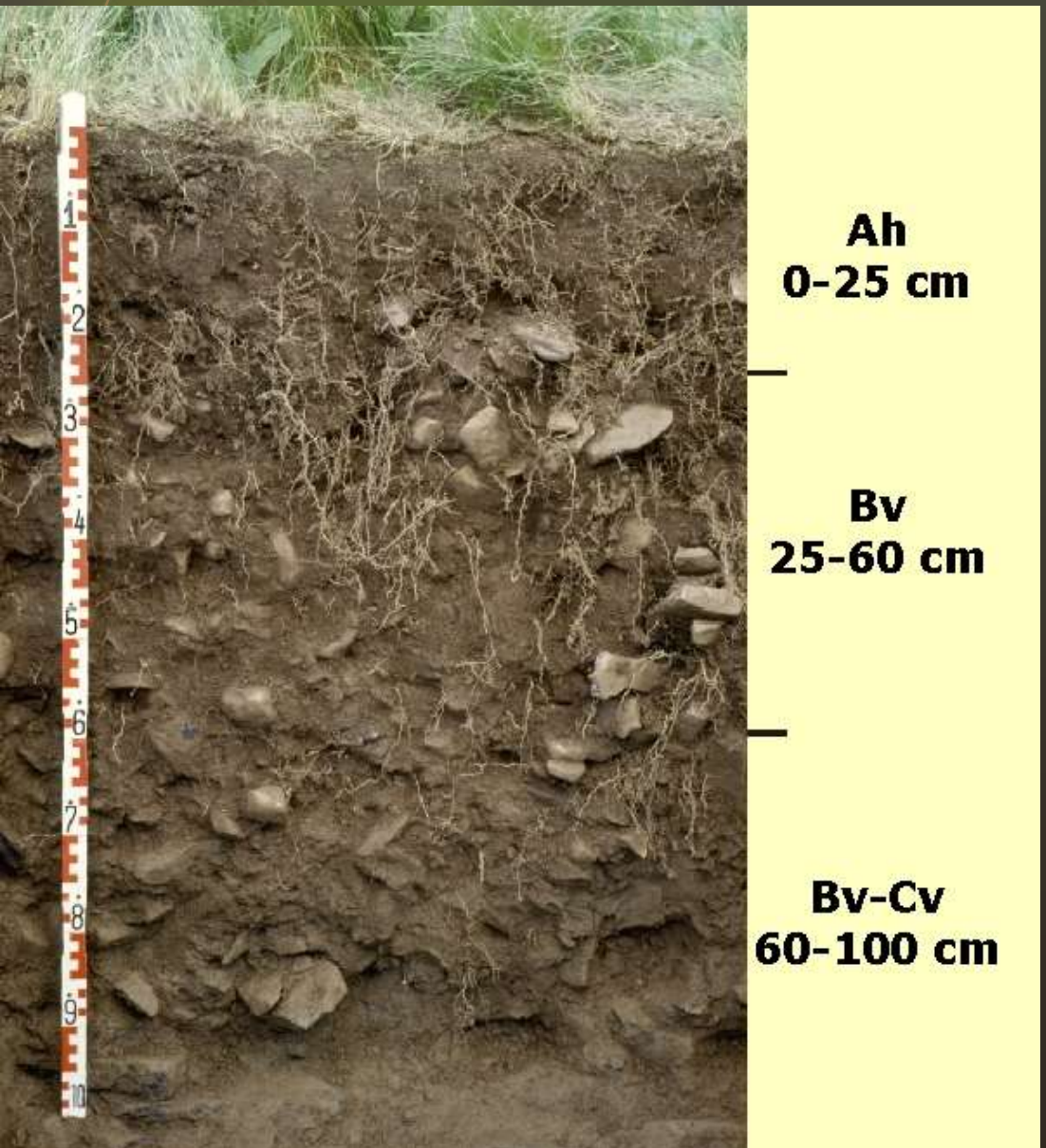
- Fe_2O_3 Sesquioxides, Al_2O_3

- pH ca. 4.5
- pH under forests 6.5

- caolinite
- goethite
- haematite
- gibbsite
- halloysite

(Zech & Hintermaier-Erhard 2002)

Cambisol (Brown Earths)



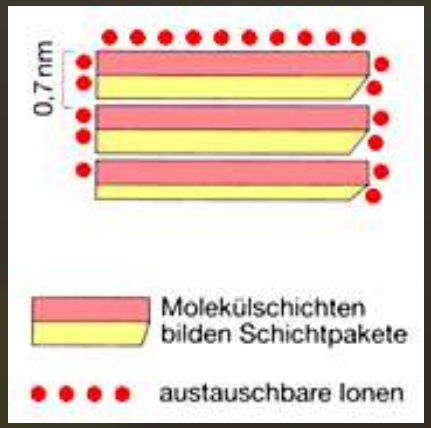
- hydrous phyllosilicate minerals
  - Illite
  - Vermiculite
  - Smectite
  - Chlorite
  - Montmorillonite

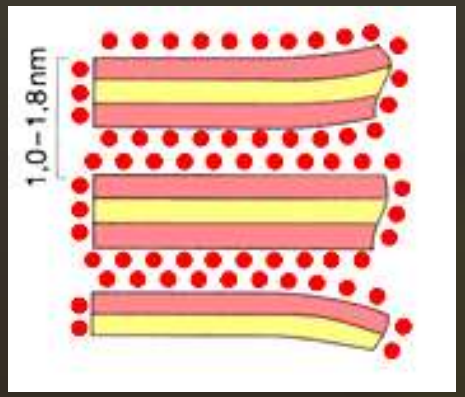
High activity clays

(Zech & Hintermaier-Erhard 2002)

Cation Exchange Capacity (CEC)

caolinite-group:	3- 15 cmol (+) kg^{-1}
Illite-Chlorite-group:	10- 40 cmol (+) kg^{-1}
Montmorillonite-group:	60- 150 cmol (+) kg^{-1}
Mull:	200- 500 cmol (+) kg^{-1}





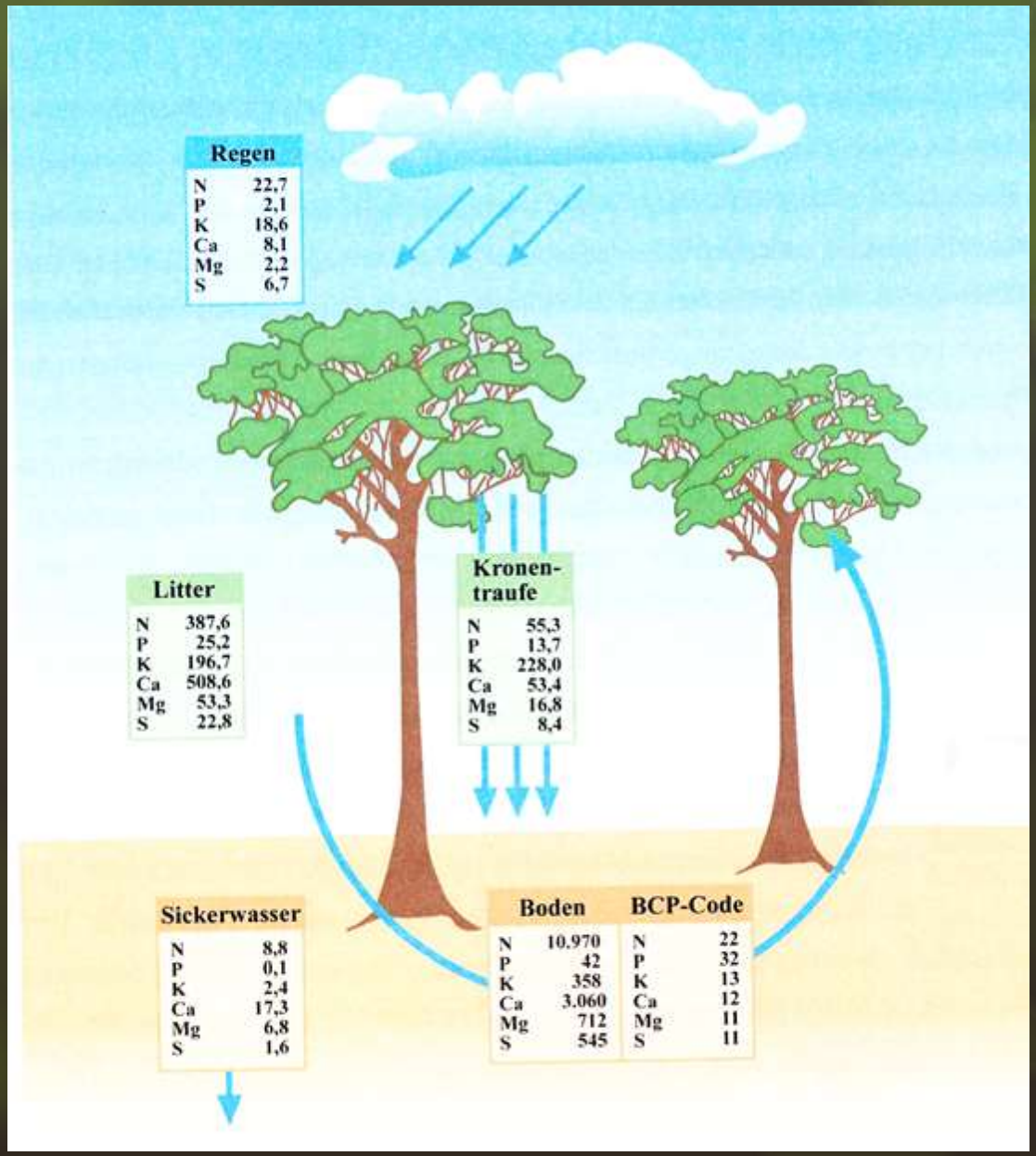
(Gernandt 2007, Scheffer-Schachtschabel 2010; Schultz 2016)

Soils of the Tropics

- Technologies cannot exchange clay minerals or increase residual mineral content
- Fertilizing is useless→ immediate leaching
- Nutrients directly back to the plants
- Mycorrhiza = symbiosis of mushrooms and plants
- missing storage capacity of soils must be replaced by trees
- Soils cannot store fertilizers- in the above ground biomass!

(Weischet 1988)

Short Nutrient Cycle



(Lanfer 2003)

Vegetation

Capoeira

(B. Jhikan 2017)

Biomass Production

Biomass [t ha^{-1}]	Years	Region	Author
48.8	4	Pucallpa, Peru	(Loker 1993)
31.7	4	Bragantina	(Brienza Junior 1999)
28.0	4	Bragantina	(Nunez 1995)
21.4	3,5	Bragantina	(Sommer 2000)
19.9	4-5	Bragantina	(Denich 1989)
15.7	3	Bragantina	(Schuster 2001)

Consequences for Agriculture

- Total nutrients in the soil → just decrease slightly
- pH 5.2 → 3.8
- Phosphate fixation + aluminum toxicity → Production collapses

- Major gain of the ashes: less the release of nutrients!

But: Raising the pH! For a short time!

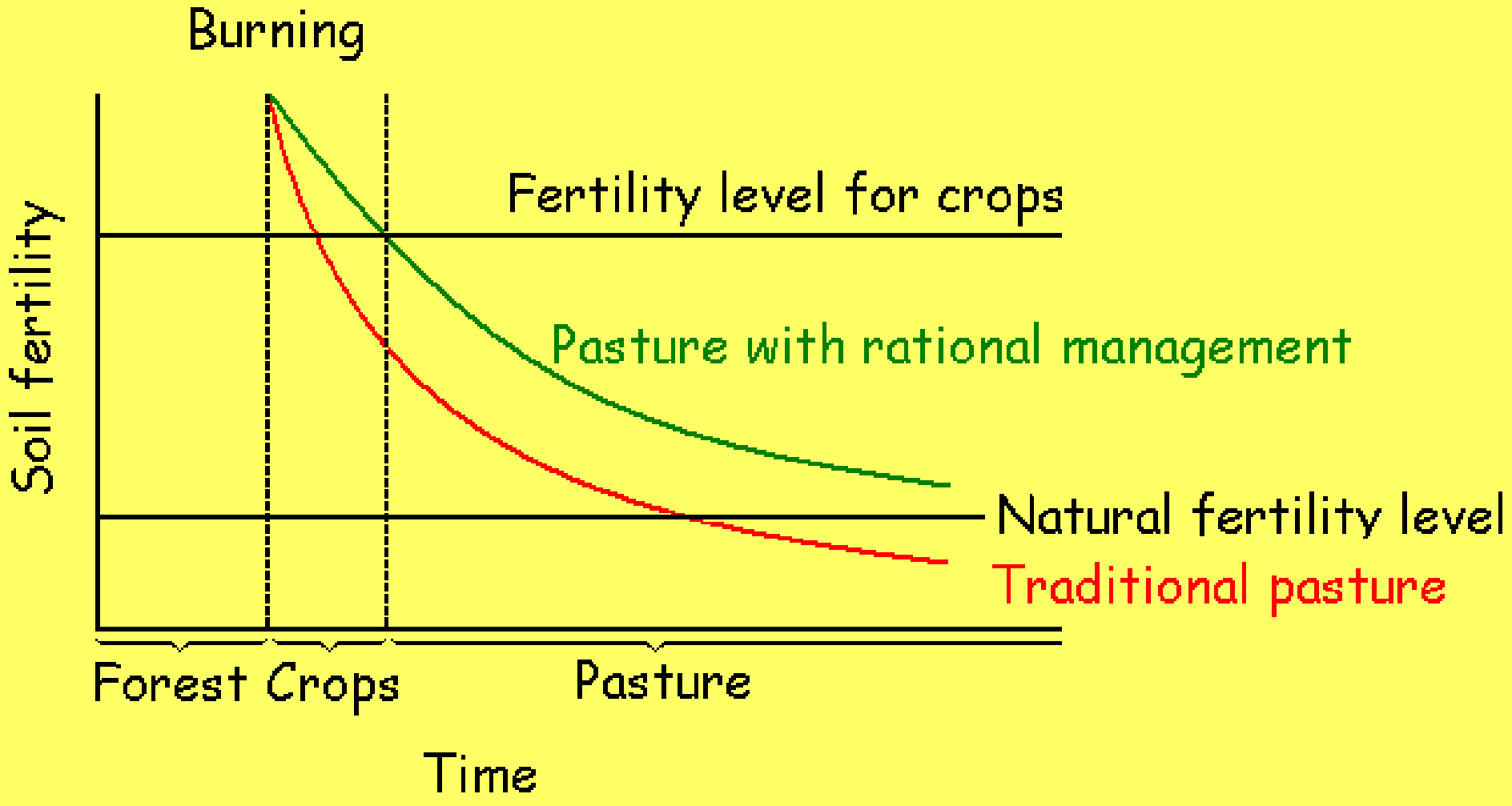
- Ash + liming: elimination of Al-toxicity, P availability
- Modern technologies for small farmers – mulching
- Agro-Forestry Systems!

(Jordan 1985; 1987; Denich et al. 2005; Schulz 2016)

Animal Production

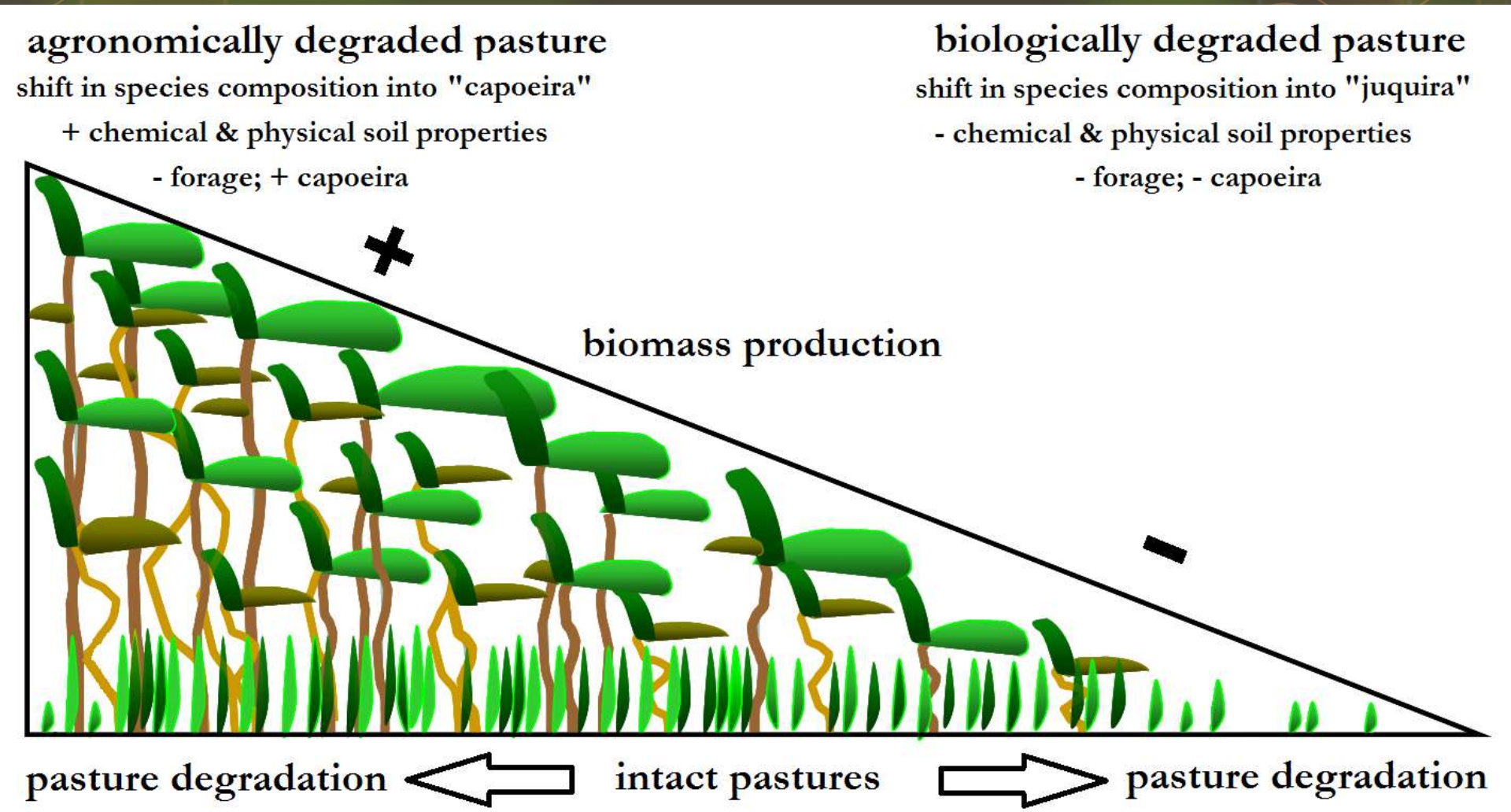
- What do the limiting landscape ecology factors in the humid tropics mean for tropical animal production systems?
- Why are Brazilan farmers copying the idea of European/ American style of pastures?
- The need for innovative agro-silvo-pastoral systems for the tropics

Production

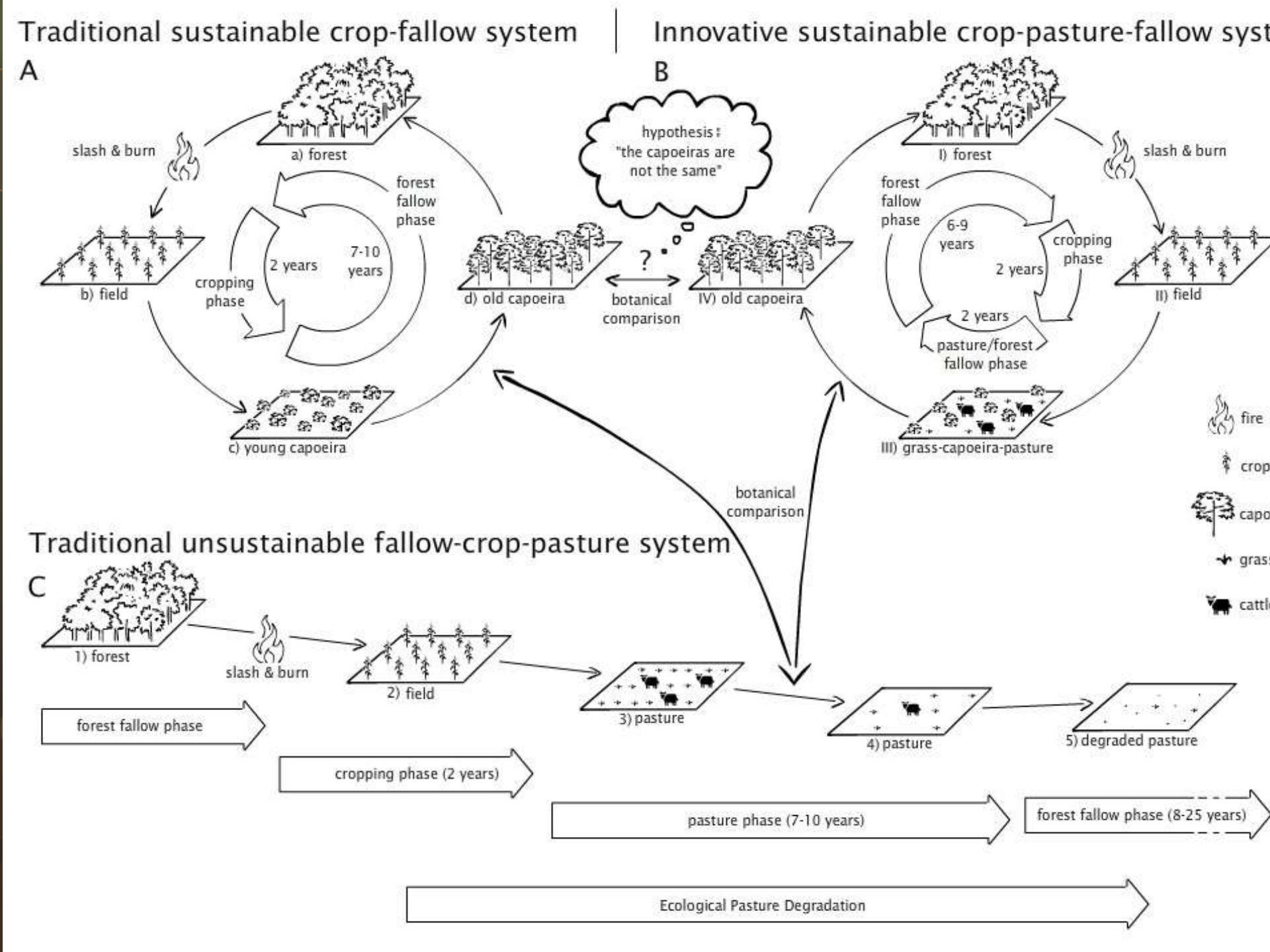


(Toledo & Serrão 1982)

2 Types of Pasture Degradation

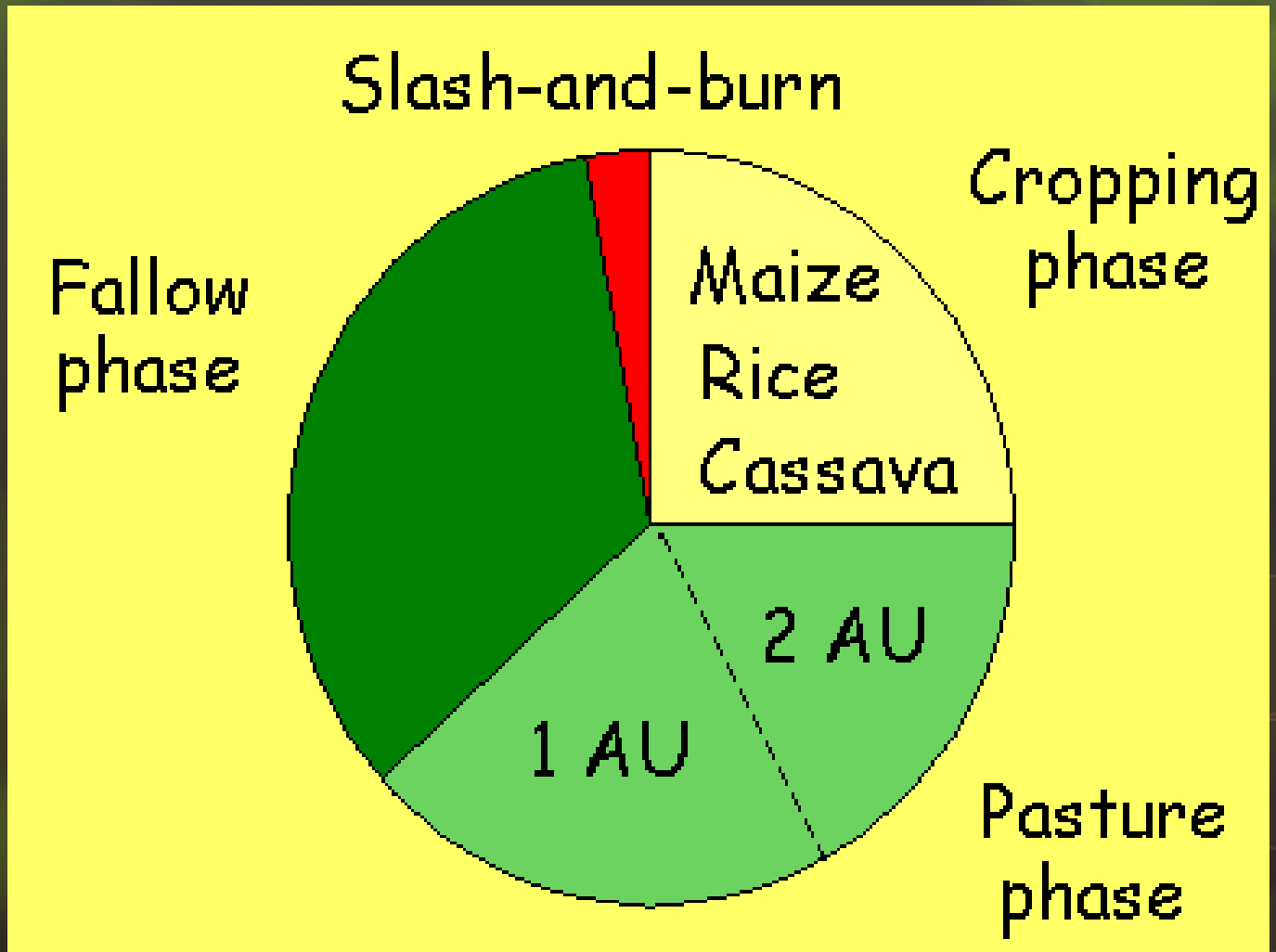


Agriculturally degraded pasture


Traditional sustainable crop-fallow system
A
slash & burn
a) forest
forest fallow phase
2 years
7-10 years
cropping phase
b) field
c) young capoeira
d) old capoeira
botanical comparison
hypothesis:
"the capoeiras are not the same"
?
Innovative sustainable crop-pasture-fallow syst
B
I) forest
slash & burn
forest fallow phase
6-9 years
cropping phase
2 years
II) field
2 years
pasture/forest fallow phase
III) grass-capoeira-pasture
IV) old capoeira
botanical comparison
fire
crop
capo
gras
cattl
Traditional unsustainable fallow-crop-pasture system
C
1) forest
slash & burn
2) field
3) pasture
4) pasture
5) degraded pasture
forest fallow phase
cropping phase (2 years)
pasture phase (7-10 years)
forest fallow phase (8-25 years)
Ecological Pasture Degradation

Grass-Capoeira Pasture

"Cattle must not alter the capoeira"



(Loker 1994)

Grass-Capoeira Pasture

Grass-Legume pasture

Traditional pasture improvement by the use legumes

N-Fixation
additional fodder plant
nutrient pump

Legumes are responsible for nutrient enrichment in a capoeira fallow

Disappointing Grass-Legume Pasture

Conclusion

Both systems accumulate above ground biomass

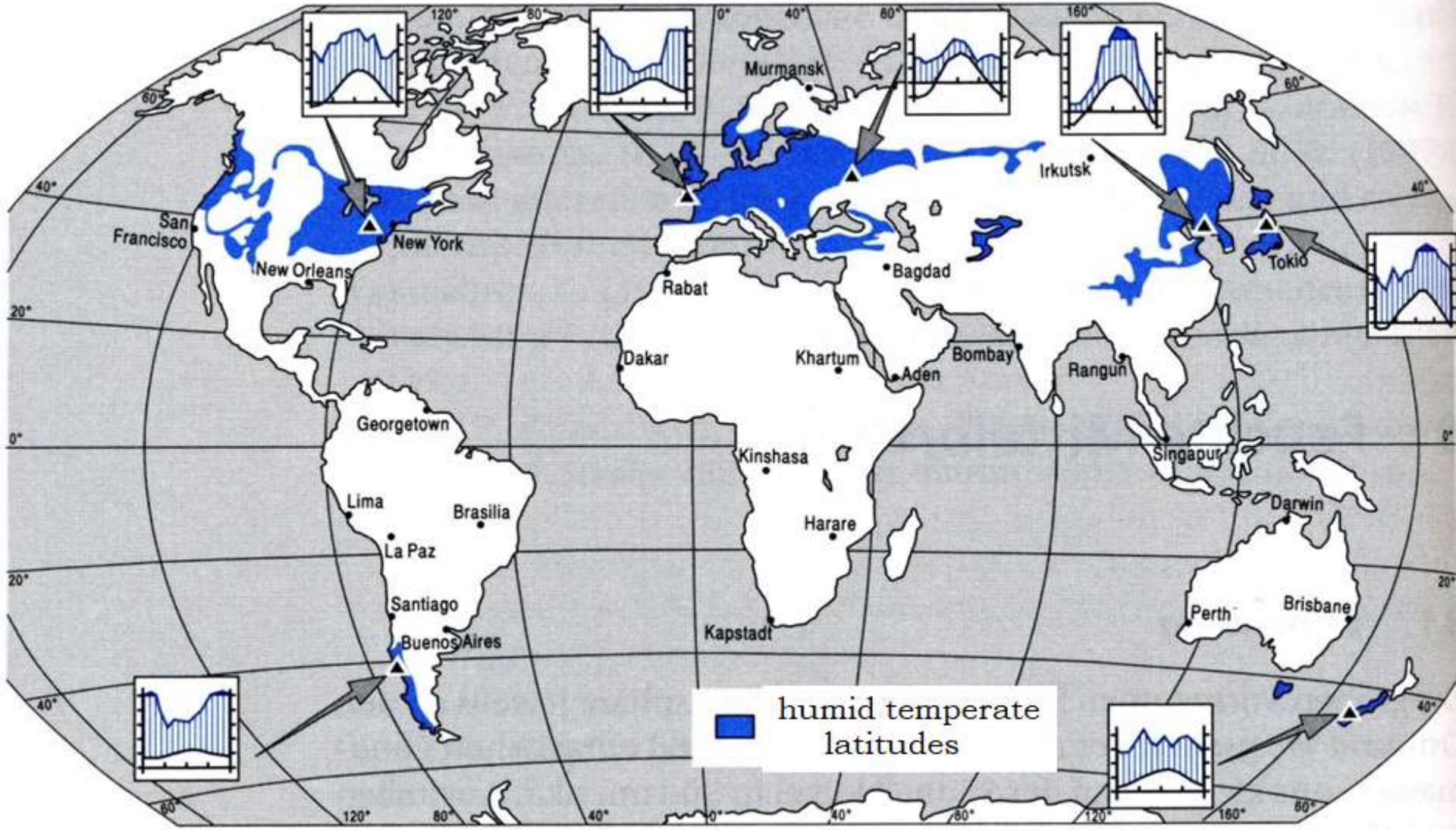
both systems need frequent management

A Grass-Capoeira pasture is in a far advanced state of land rehabilitation than a Grass-Legume pasture

A combination of a both models?
A Grass-Capoeira-Legume-Pasture

Secondary Vegetation for Sustainable Silvo-Pastoral Systems in the Humid Neotropics

Humid Temperate Latitudes



(Schulz 2013)

Production Systems in Germany

landless

Meadow Orchards

„Farmer Bashing“

Organic Farming, Traditional silvo-pastoral systems (middle-ages)

„Streuobstwiesen“= Meadows with scattered fruit trees

DeFAF

- Since 25.06.2019
- In Göttingen 70% of AFS have vanished
- 360 ha Streuobstwiesen
- 75% are unkempt, too old, not re-planted for decades
- Due to economic pressure, liberalisation of marekts, world market
- EU-product standardization
- EU 9% agroforestry systems, Germany 1.6%
- Organic farming 6.8%
- privacy shield, visual cover, lower social stress

Bioenergy & Animal Production

- KUP- Kurzumtriebsplantagen → alley cropping
- 3-6 years, maximum 20 years
- Bioenergy + chicken *Salix* + *Populus*
- Insect pests are decimated (during soil maintaining phase)
- Sheep diminish mice by trampling

- 10% lost by Hawks (Rahmann 2004)
- Chicken would not necessarily prefer outside foraging

- 62% goats, 20% sheep, 10% cow

LER- Land Equivalent Ratio

- Land equivalent ratio 1.4-1.6
- Biodiversity border effects , mid-disturbance hypothesis
- Hotspots, biocorridores, habitat-networks

- Soil erosion by 80%

- Microclimate wind protection

- Trees have to root deeper than grasses or crops

(Dupraz et al. 2004, Mead et al. 2004)

Political Sustainability

- Promotion law 50% of income
- Knowledge deficit for tree component
- Property rights, tenant
- Time horizon: “more-generation-project“

- AFS are multi-functional resilient agro-ecosystems
- recommendable
- Cascade use

- Win-win-win situations

Birds in German Silvo-Pastoral Systems

Number of bird species (standard deviation)

	SPS	intensive plantation of fruit trees
Passing birds	326 (31)	180 (25)
Feeding	209 (18)	22 (4)

Harbig 2015

Beyer 2015

Profiting Birds in German AFS

Deible 2011

Greiner 2011

Silvo-Pastoral Systems in Winter

Silvo-Pastoral Specialists

Endangered species

Semi-open habitats

Jynx torquilla, Picidae
Wryneck , Torcecuello

Ficedula albicollis, Muscicapidae
Collared Flycatcher
Papamoscas Acollarado

Müller 2009

Rössner 2009

Upupa epops, Upupidae (Hoopoe, Abubilla)

Will 2012

Kählert 2008

IV Argentinian Congress on Silvopastoral Systems

- in Villa La Angostura
- Huge interest in AFS
- Improve extensive smallholder systems in Patagonia

AFS in Temperate Latitudes

- In short, there is nothing better than a tree to simultaneously:

- Sequester carbon from the atmosphere
- Bring up water and nutrients from deep in the ground
- Provide a framework for above- and belowground biodiversity

- Build soil organic matter and thus soil carbon
- Create regulating micro-climates
- Provide fodder and shelter for livestock

- Innovate diversified farm enterprises
- Make agricultural landscapes more resilient
- Mitigate climate change

Excursion to the Andes

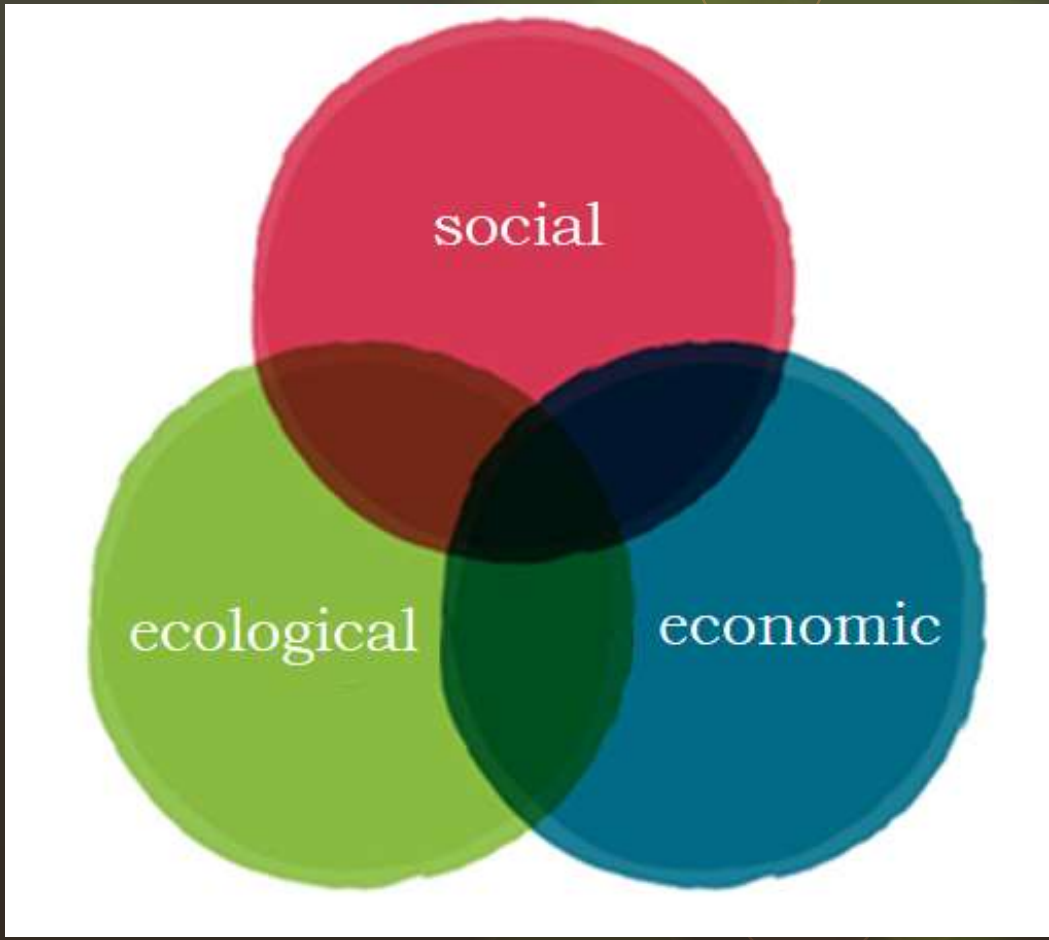
- Calf fattening
- Extensive Transhumance systems (ca. 500 m vertical shifts)
- Hereford + Ñire (*Nothofaus antarctica*)
- Forage grasses, shrubs, Europian legumes
- on Andosols
- Future research area of the University of Applied Sciences and Arts Göttingen

Shrubs in Patagonian SPS to be investigated

- Alpataco — *Prosopis alpataco* (legume)
- Piquillín — *Condalia microphylla*
- Flexuosa — *Prosopis flexuosa* (legume)
- Barba de chivo — *Caesalpinia gilliesii*
- Olivillo — *Aextoxicon punctatum*
- Crataebus — *Crataegus monogyna*
- Zampa — *Atriplex lampa*
- Chañar — *Geoffroea decorticans* (legume)

Three-Pillar Model of Sustainability

- Each area is considered to have the same importance
- They are equally valued
- Sustainability only with consideration of all three areas



(Deutscher Bundestag 1998)

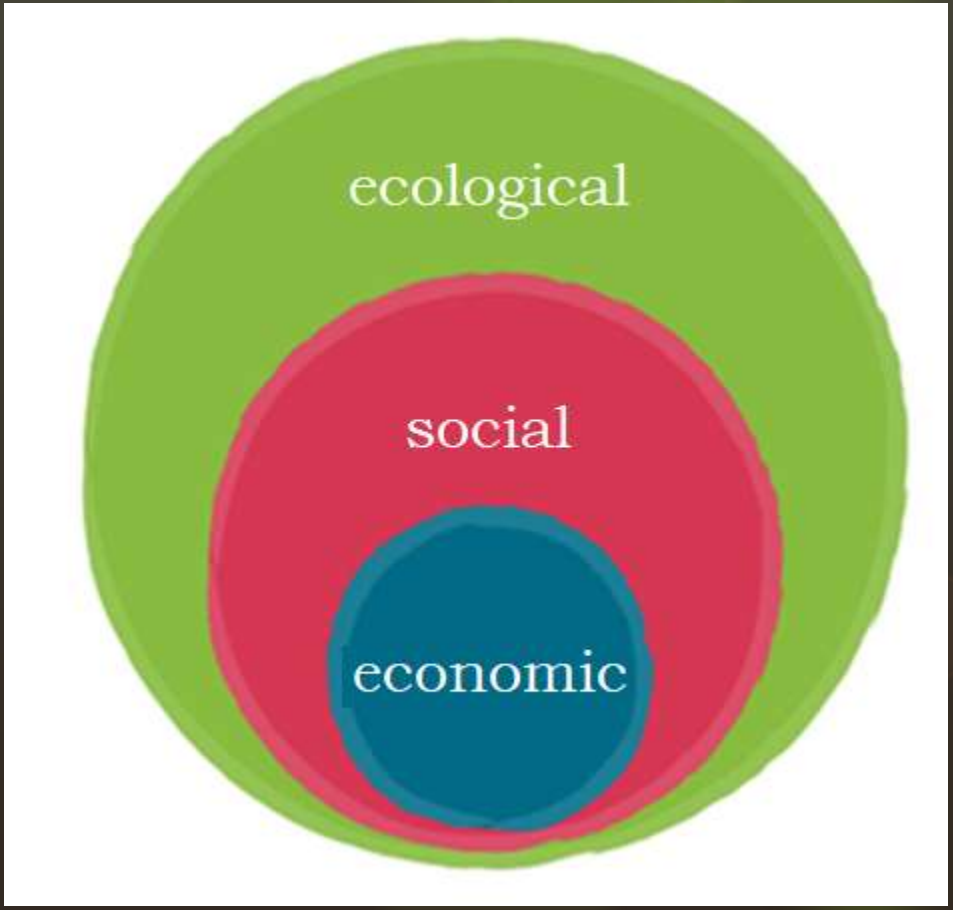
Priority Model of Sustainability

- Individual areas are seen in its relationships and dependencies

- No economy without a society,
- no society without ecology

- Without eco-dictatorship!

- Is there:
- "a little bit sustainable"?
- or "more sustainable?"



(Ekardt 2005; 2006)

Take-Home Message

- In the humid tropics AFS are imperative necessity against degradation, for not loosing scarce land resources
- In the temperate humid latitudes they will improve ecological sustainability, protect environmental resources, enrich biodiversity, stabalize wellfare
- German „Landwirt"= farmer; „serves the land"! Meanwhile, there are many other interests as to maximise economic gains
- Farmers live mainly from subsidies of the society; society is not amused about how farmers are producing

  society has the right to implement its objectives as it pays also for the ecological and social costs
- No "farmer bashing"

¡Muchas gracias!

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