CATIE
Solutions for environment and development
Soluciones para el ambiente y desarrollo

Management strategies of silvopastoral systems in the tropics

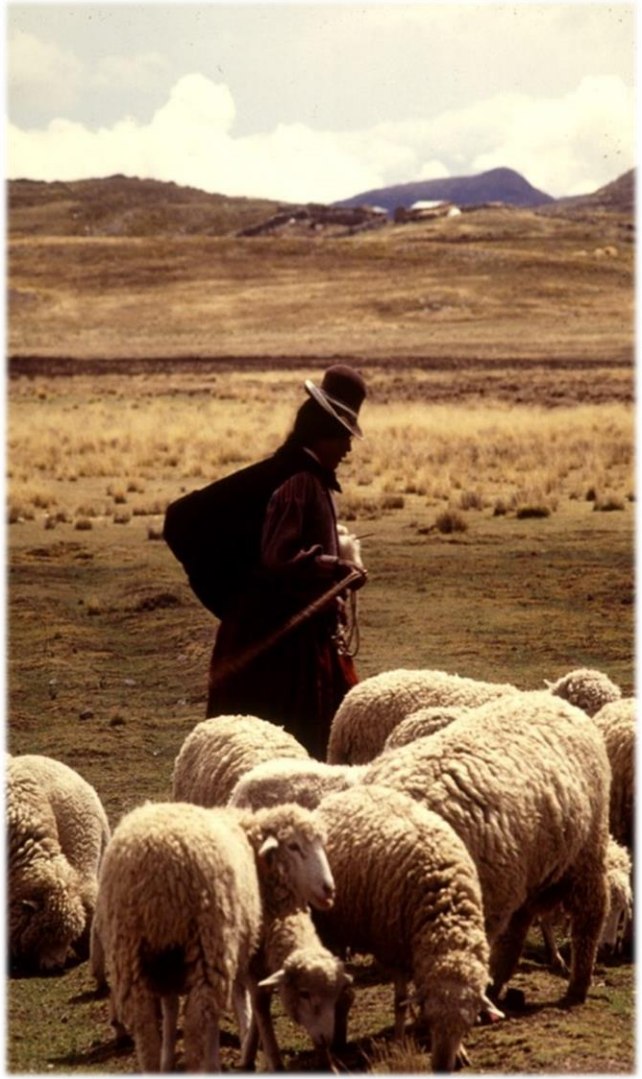
Muhammad Ibrahim, PhD

Turrialba, 23 al 25 de abril 2019

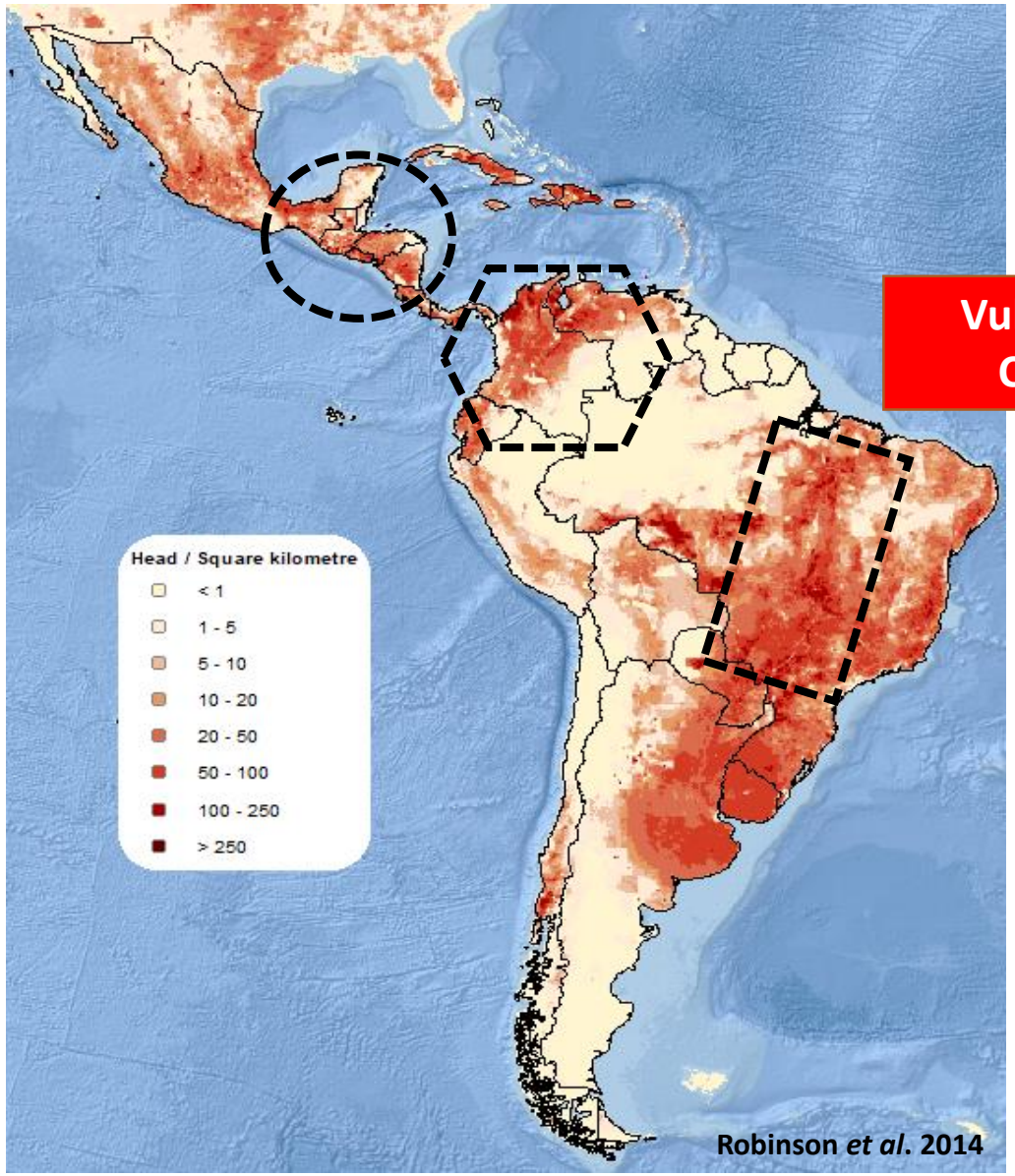
Presentation

- Type and distribution of silvopastoral systems
- Management strategies:
  - -Enhancing forage value
  - - Adaptation to Climate change
  - - Timber Value
  - - Biodiversity
- Ecosystem services

Diversty of livestock production systems

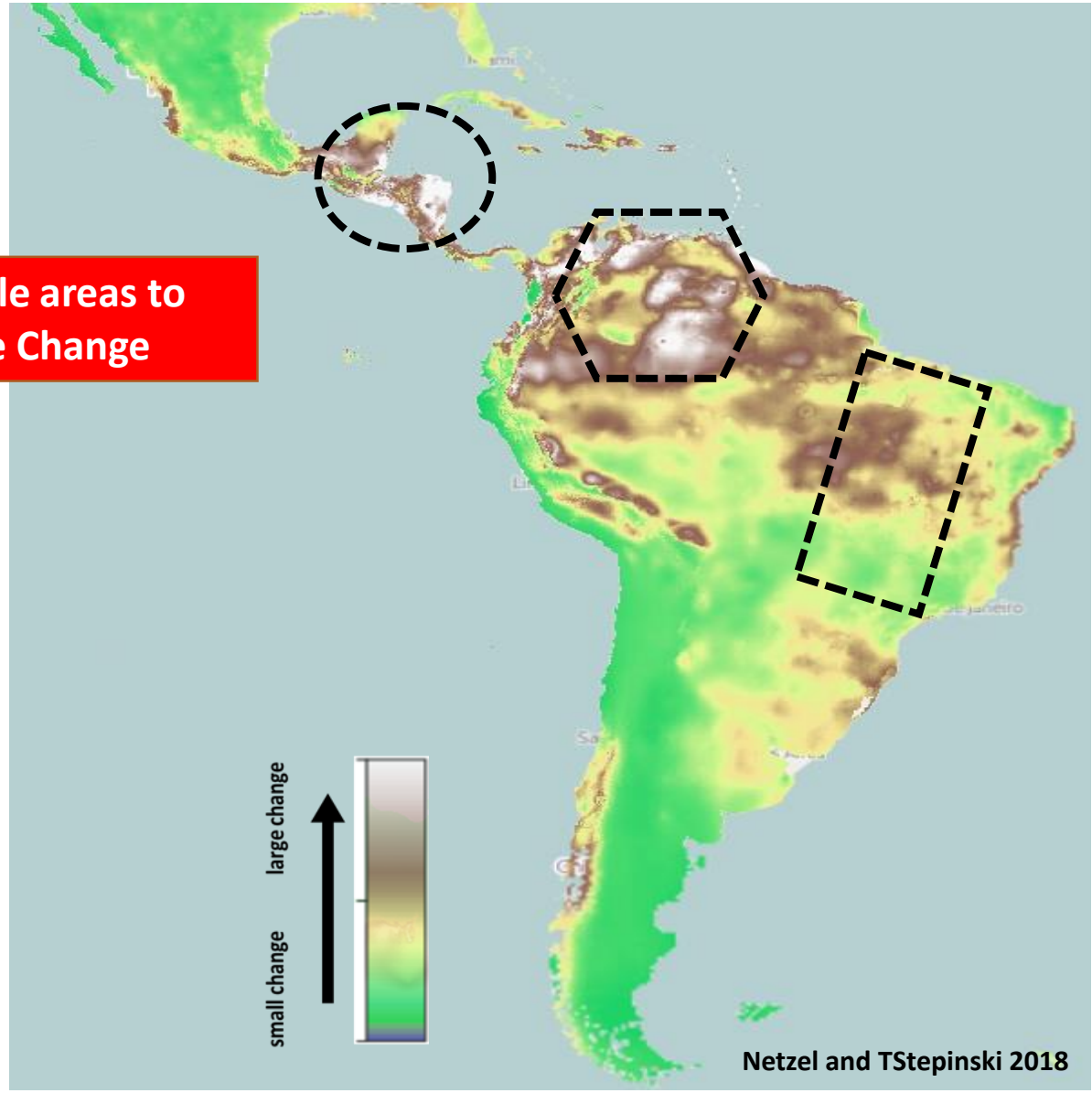


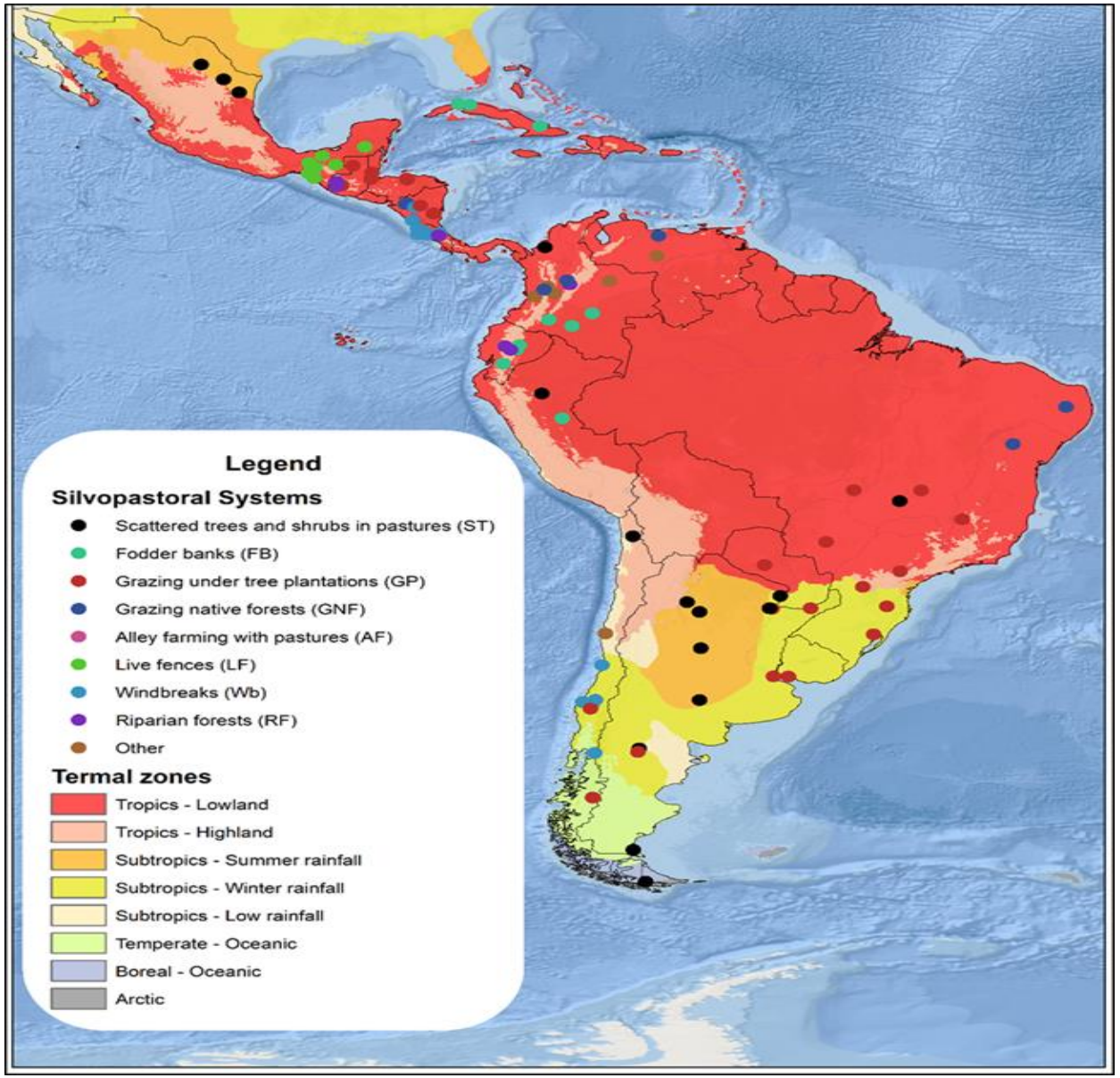
Livestock density 2014



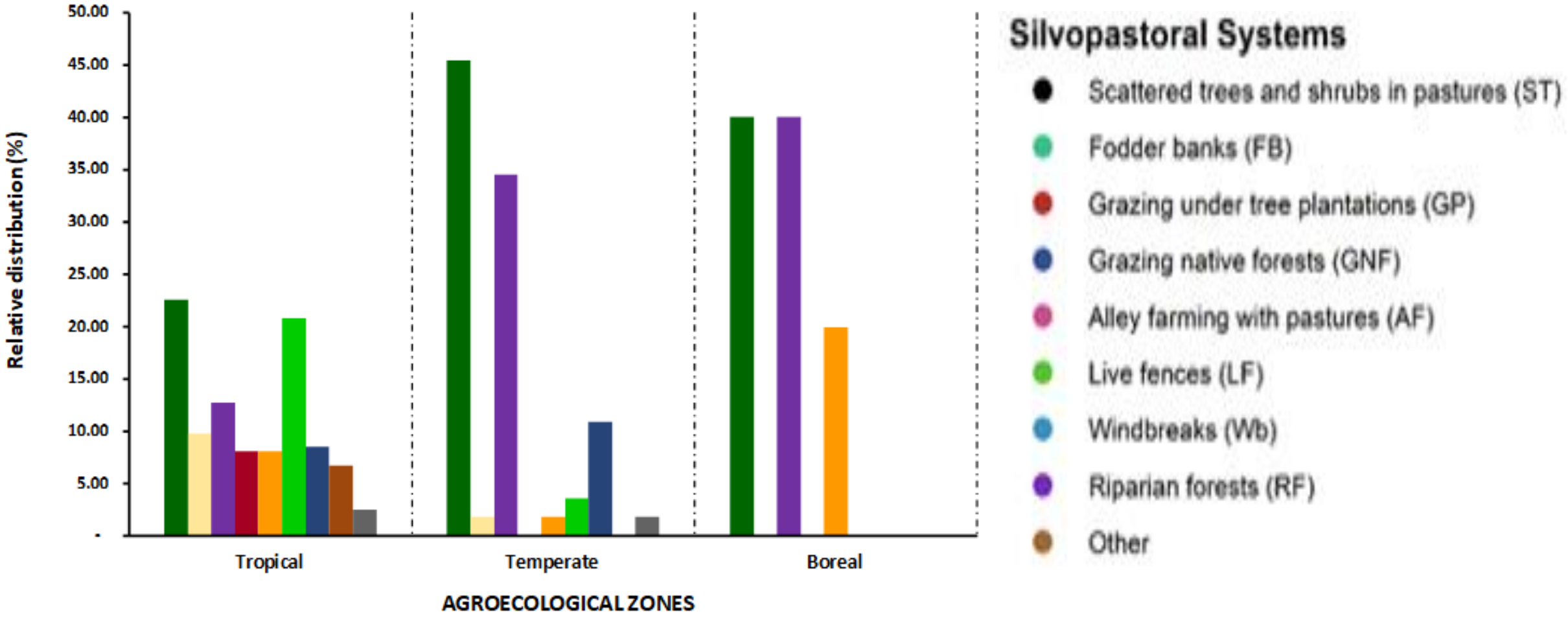
Vulnerable areas to Climate Change

Expected climate change



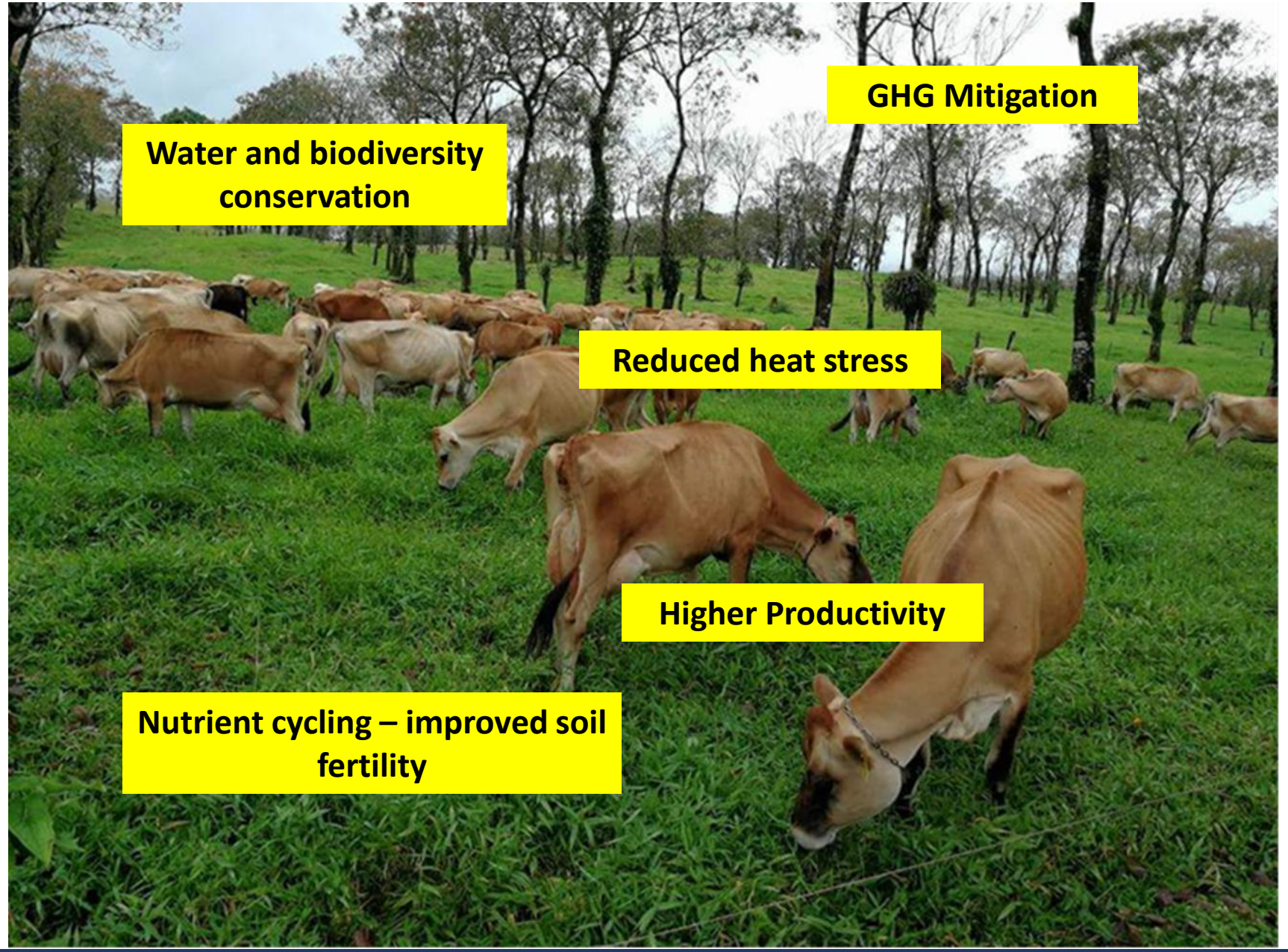


Distribution of SPS options in different agroecological zones in LAC (Pezo *et al*., 2018)



Distribution of SPS options in different agroecological zones in LAC

(Pezo *et al.*, 2018)



Contribution of SPS to livestock production

Intensive silvopastoral systems

Alley farming
(Pastures and woody perennials)

Fodder banks for cut & carry

Extensive silvopastoral systems

Scattered trees in pastures

Live fences

Agostaderos

Comparison of scattered trees in pastures systems in three localities

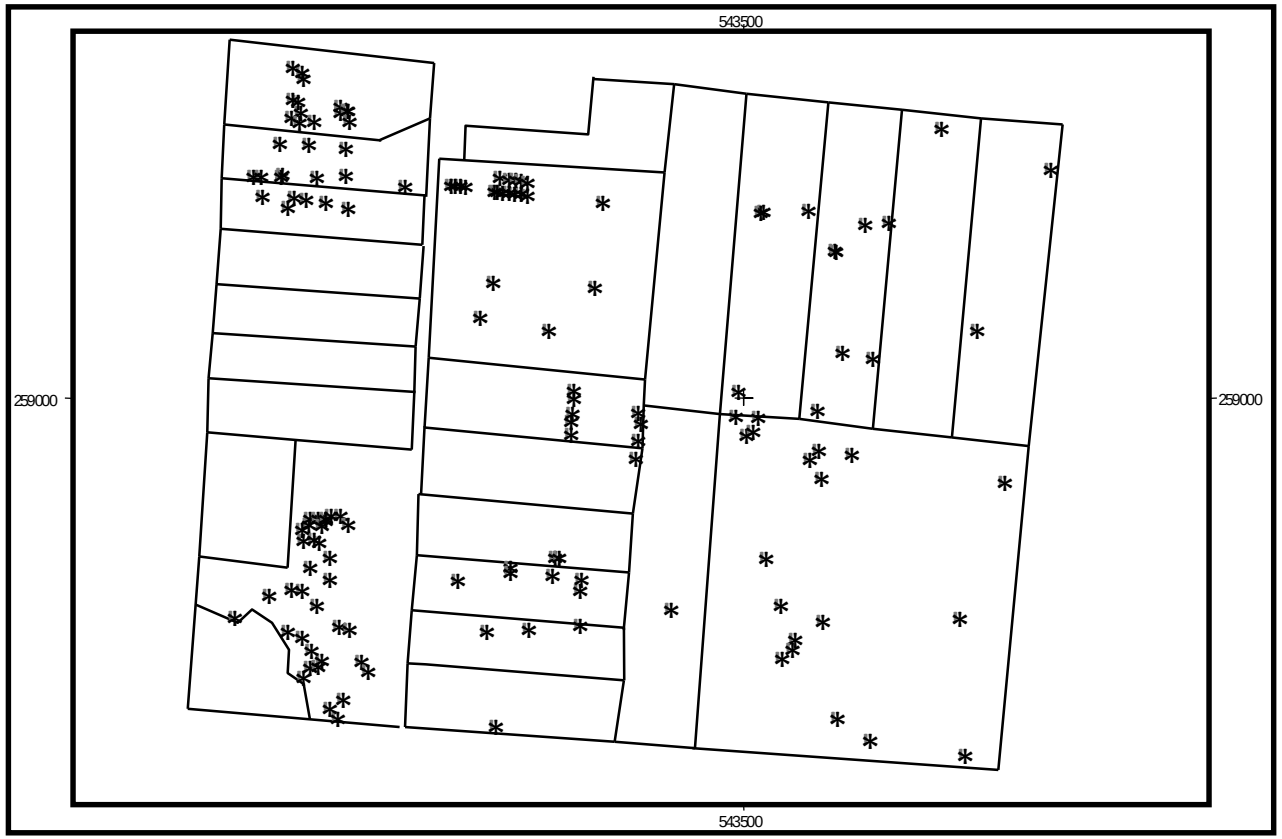
Variable	Rivas n = 2294	Cañas n = 5896	Río Frío n = 2482
Average tree density (trees/ha)	17.0	8.0	23.1
% of trees represented by the 10 most common species	**74.4**	**71.0**	**71.8**
Average number of tree species/farm	23.0	34.0	22.8
Total number of species	**72.0**	**101.0**	**106.0**

Differences in tree density in the landscape depend on the landscape history and pasture management

(Gómez, López, Esquivel and Villacis, sin publicar

Examples of how tree cover varies in different livestock farm types in Rio Frio

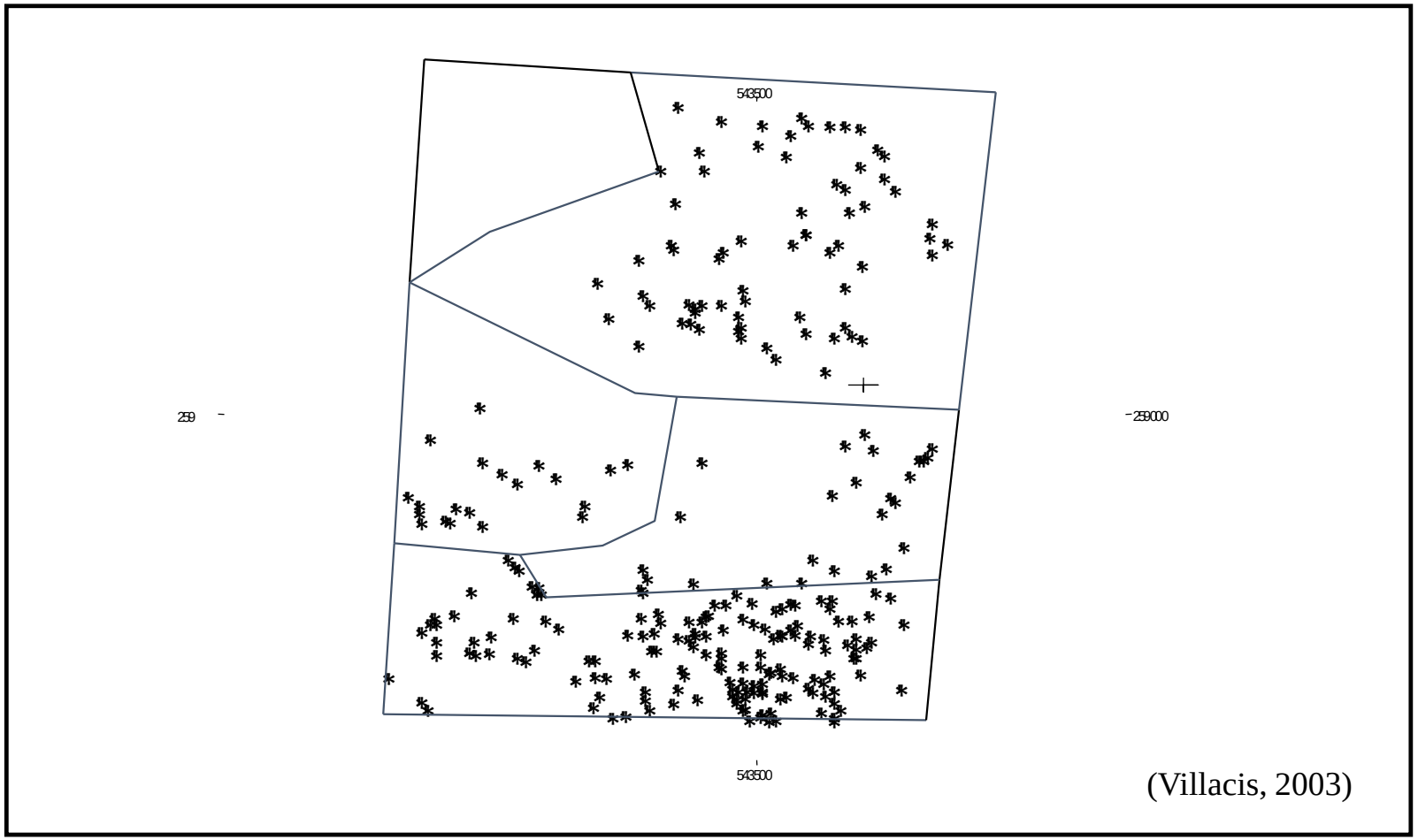
Highly intensive dairy farms



* = Scattered trees

- = Live fences

Less intensive dairy farms: dual purpose systems



(Villacis, 2003)

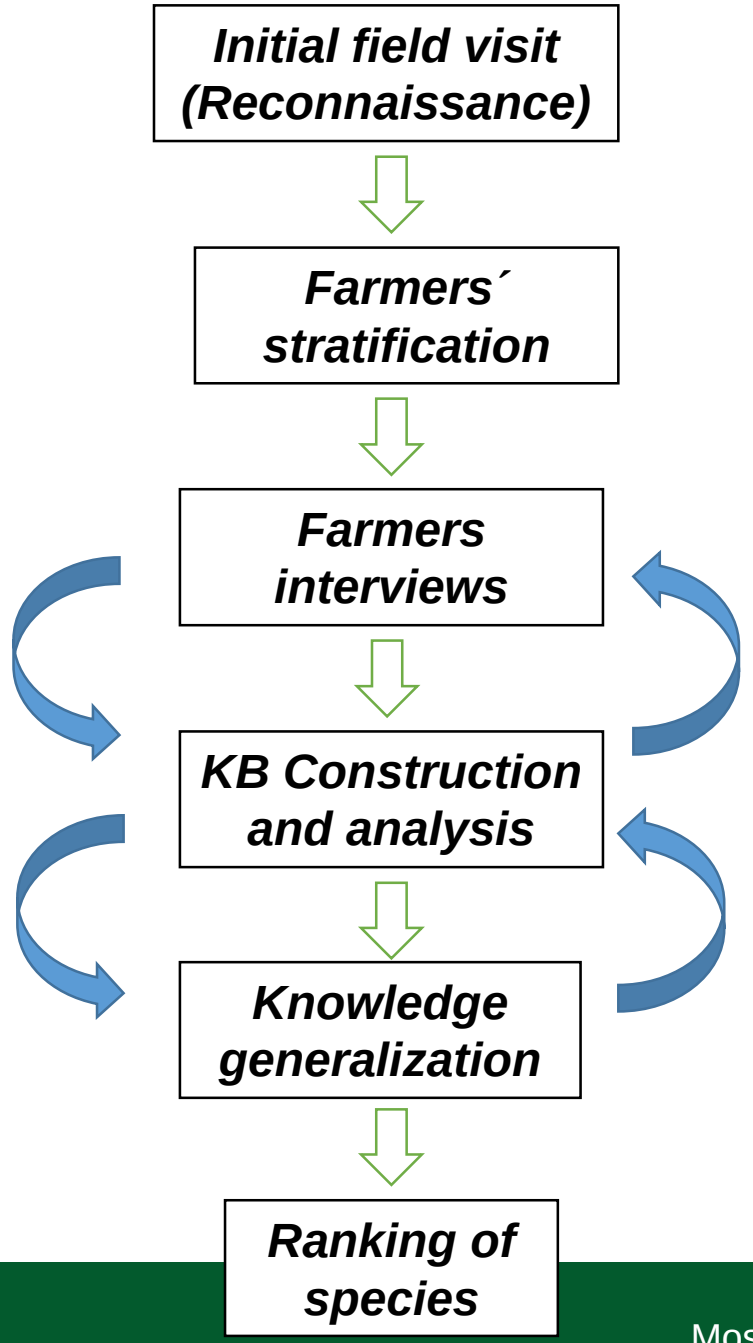
* = Scattered trees - = live fences

Abundance of woody perennials that provide fodder or fruits for livesock feeding in three agroecological zones in Costa Rica

Humid tropics		Subhumid tropics		Dry tropics	
Río Frío		Esparza		Cañas	
Species	Abundance %	Species	Abundance %	Species	Abundance %
Psidium guayaba	22	*Acrocomia aculeata*	11,5	*Guazuma ulmifolia*	12,6
Guazuma ulmifolia	2	*Psidium guayaba*	7,9	*Acrocomia aculeata*	10,3
Otras especies leñosas	76	*Guazuma ulmifolia*	4,2	Otras especies leñosas	77,1
		Manguifera indica	1,9		
		Enterolobium ciclocarpum	1,8		
		Otras especies leñosas	72,7		

Villanueva *et al.* 2018

Local knowledge on traits and ecosystem services of tree cover in livestock farms



Mosquera (2010)

Ranking of species under the nutrition service

Nutrición	Medias		Servicios						Bienes			
			Sombra para el pasto y ganado	Rompevientos	Protec. de fuentes de agua	control de erosión y Mejoramiento de suelos	Protec. Biodiversidad	Resistencia sequía	Leña	Medicina	Madera	Frutos al. Humana
Guásimo	6.87	A	X	x		x			x	x		x
Madero negro	5.16	B				x			x	x	x	
Genízaro	4.68	BC	X	x	X	x		x	x		x	
Jícaro	4.11	CD	X				x					
Carao	3.89	CD				x			x			x
Leucaena	3.89	CD										
Guanacaste	3.74	D	X	x	X	x		x	x		x	
Mango	3.66	D	X	x			x					x

Mosquera (2010)

Management –fodder value

Plant traits:

- Nutritional value
- Regrowth capacity
- Productivity
- Drought tolerance and water use efficiencies

SPECIES WITH POTENTIAL FOR EVALUATING REGROWTH CAPACITY

Guazuma ulmifolia
(Malvaceae, Byttnerioideae)

Cordia dentata
(Borraginaceae)

Non legume species

SPECIES WITH POTENTIAL FOR EVALUATING REGROWTH CAPACITY

Albizia saman
Fabaceae, Mimosoideae

Pithecellobium dulce
(Fabaceae, Mimosoideae)

Albizia Naipoides
Fabaceae, Mimosoideae

Gliricidia Sepium
(Fabaceae)

Legume species

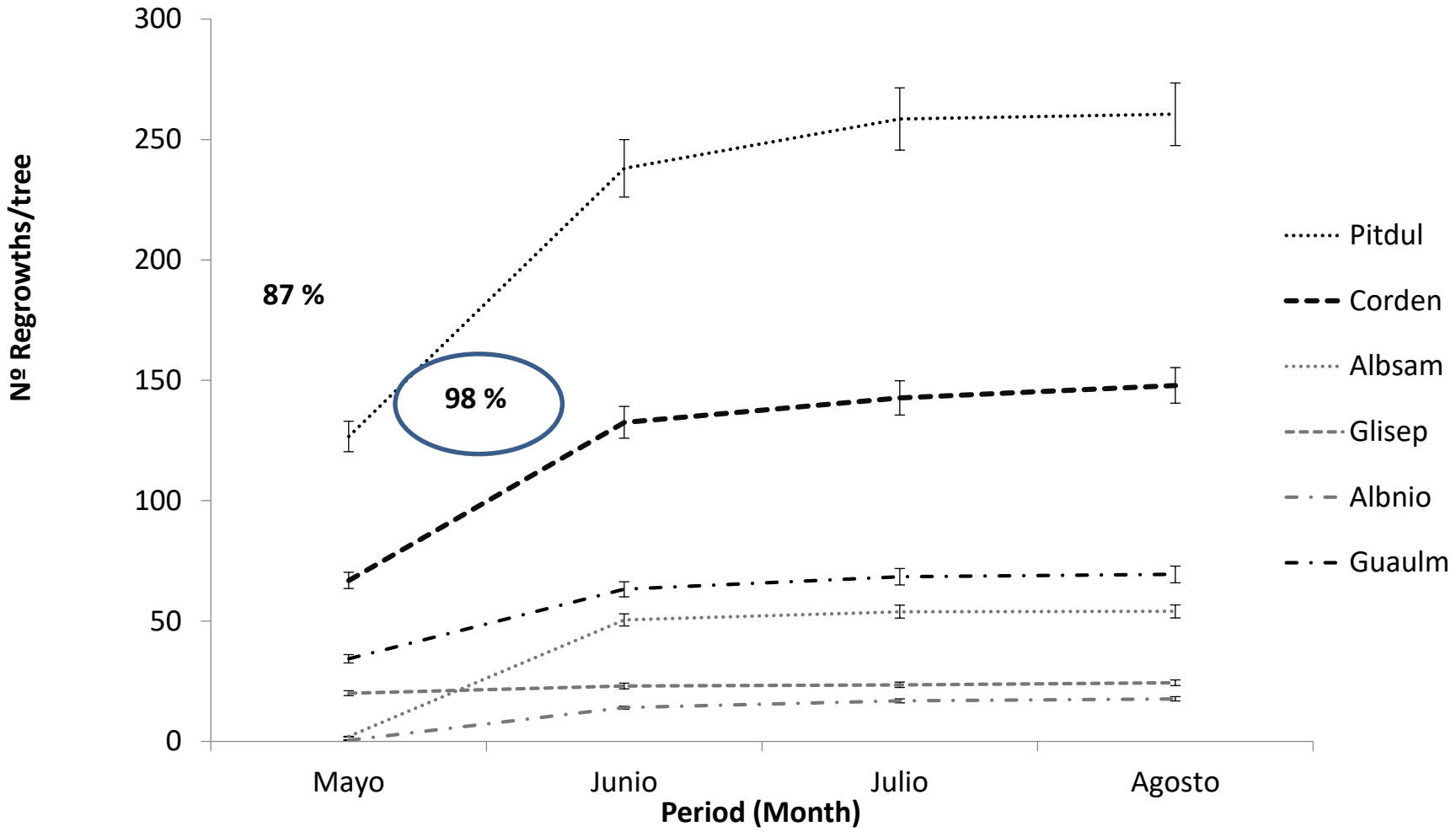


Figure 2. Cumulative curve for average number of regrowths per tree for six woody perennials present in pastures in the dry tropics of Nicaragua

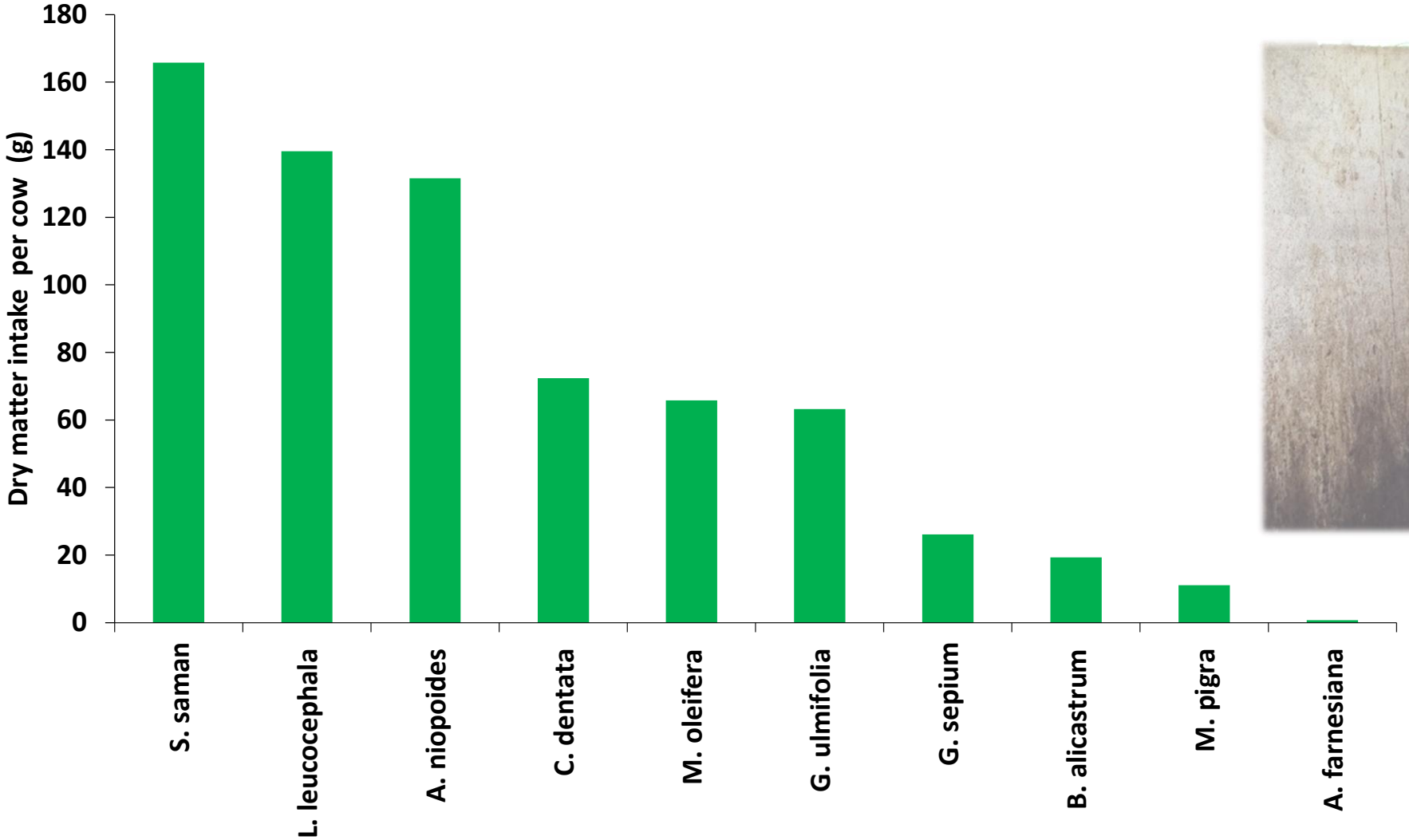
Regrowth traits

Correlation analysis between regrowth traits

	Long	D Base	Vol	TR	THR	TH	TLA	TSLA	H(MS)
Long		0,74	0,85		0,2	0,25	0,28	0,3	0,44
D Base			0,88	**0,51**	**0,52**	**0,55**	**0,54**	**0,58**	0
Vol				0,35	0,39	0,42	**0,49**	**0,48**	0,56
TR					0	0	0	0	0
THR						0	0	0	0
TH							0	0	0
TLA								0	0
TSLA									0
H(MS)									

** ($p < 0,05$); Length (**Long**), basal diameter (**Dbase**); Total number of branches(2º,3º,4º,5º) (**TR**); Total number of leaves in branches (2º,3º,4º,5º) (**THR**); Total number of leaves in the regrowth (**TH**); Regrowth volume (**Vol**) y DM of leaves in the regrowth (**MS**), Specific leaf area of the regrowth (**TSLA**) and leaf area (mm^2)

SPECIES PREFERENCE



Perez, (2011)

Impact of the use of fodder banks on livestock production

Fodder banks	management	system	Milk Kg/cow/day Beef Kg/a/day	reference
Erythrina poeppigiana	Supplement	Intensive dairy	7.3	Camero et al. 2001
Tithonia diversifolia	Suplementation 6%, concentrate and star grass	Intensive dairy system	11.7	Chacón 2018
	Suplementation 12%, concentrate and star grass	Intensive dairy system	11.8	
Leucaena leucocephala	*Brachiaria brizantha* with *Leucaena leucocephala*	Beef system	0.49-0.68	Jiménez 2007

Milk yield and quality in cows eating diets including woody perennials

Diet	Milk yield (lt/cow/dí)y	Milk fat (%)	Total Solids (%)
L. leucocephala* + *C. dentata	**7.01±0.1**	**4.27±0.13**	**13.74±1.19**
S. Saman* + *C. dentata	**6.9±0.13**	**3.98±0.14**	**13.28±0.20**
A. niopoides* + *C. dentata	**6.68±0.89**	**4.13±0.1**	**13.58±0.09**
Control	**6.65±1.09**	**3.97±0.22**	**13.39±0.05**

Control: grazing + poultry litter + molases + minerals

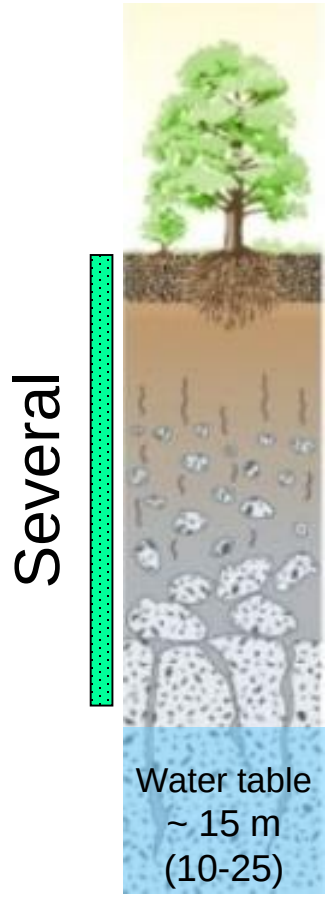
Silvopastoral systems with Leucaena - 13 kg milk/day
Raza Carora

Native pastures with *Acacia pennatula* at high density

Designing climate-smart silvopastoral practices

- Climate impacts- > 80% of production is rainfed
- Prolonged droughts- water scarcity major problem for forage production and conservation
- Use scientific and local knowledge for designing SPS to improve water use efficiencies

Plant water sources



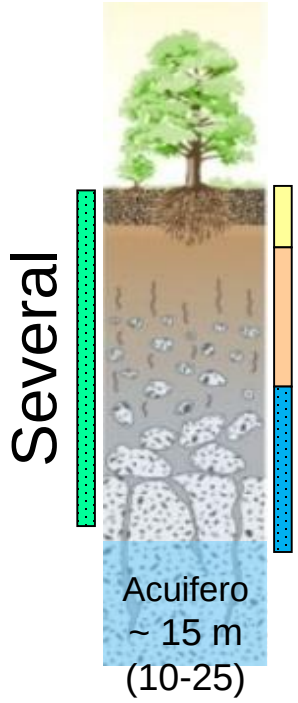
Profundidad de suelo (m)

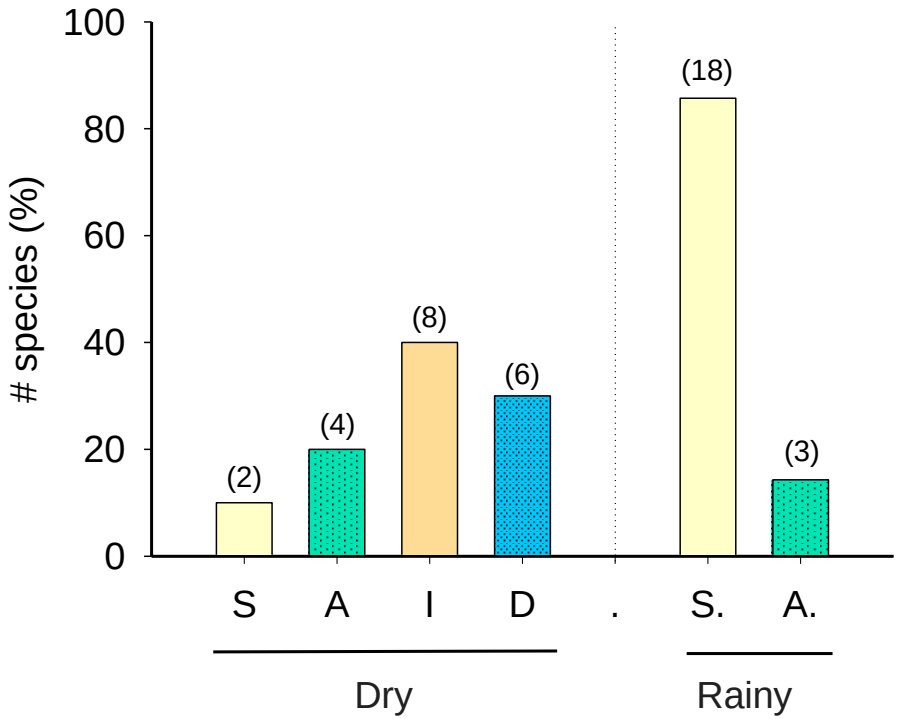
Top (0.2-0.5)

Intermediate (0.5-1.0)

Deep (≥ 1.0)

Source: Armas et ál. 2013





Dry season

S: Karwinskia calderonii, Spondias purpurea

I: *Byrsonima crassifolia, Cordia alliodora, C. dentata, Guazuma ulmifolia, Simarouba amara, Spondias mombin, Swietenia humilis, Tabebuia rosea*

Variable (A): *Albizia saman, Cassia grandis, Crescentia alata, Gliricidia sepium*

***Deep* (D):** *Albizia niopoides, Ceiba pentandra, Coccoloba caracasana, Enterolobium cyclocarpum, Mangifera indica, Myrospermum frutescens*

Rainy season

S: All (except sp A)

A: *Ceiba pentandra, Myrospermum frutescens, Spondias mombin*

All species changed preferred wáter source according to seasons, except for *Spondias purpurea*

Source: Armas et ál. 2013

Efficiency (grams of DM MS per Kg of H_20) in pastures: interactions between species

Tree species	*B. brizantha*	*H. rufa*	Media
P. Saman [1]	**2.6**	**1.7**	**2.2**
D. Retusa	**2.3**	**4.8**	**3.6**
D. robinioides	**1.1**	**1.1**	**1.1**

Based on trees´ evapotranspiration

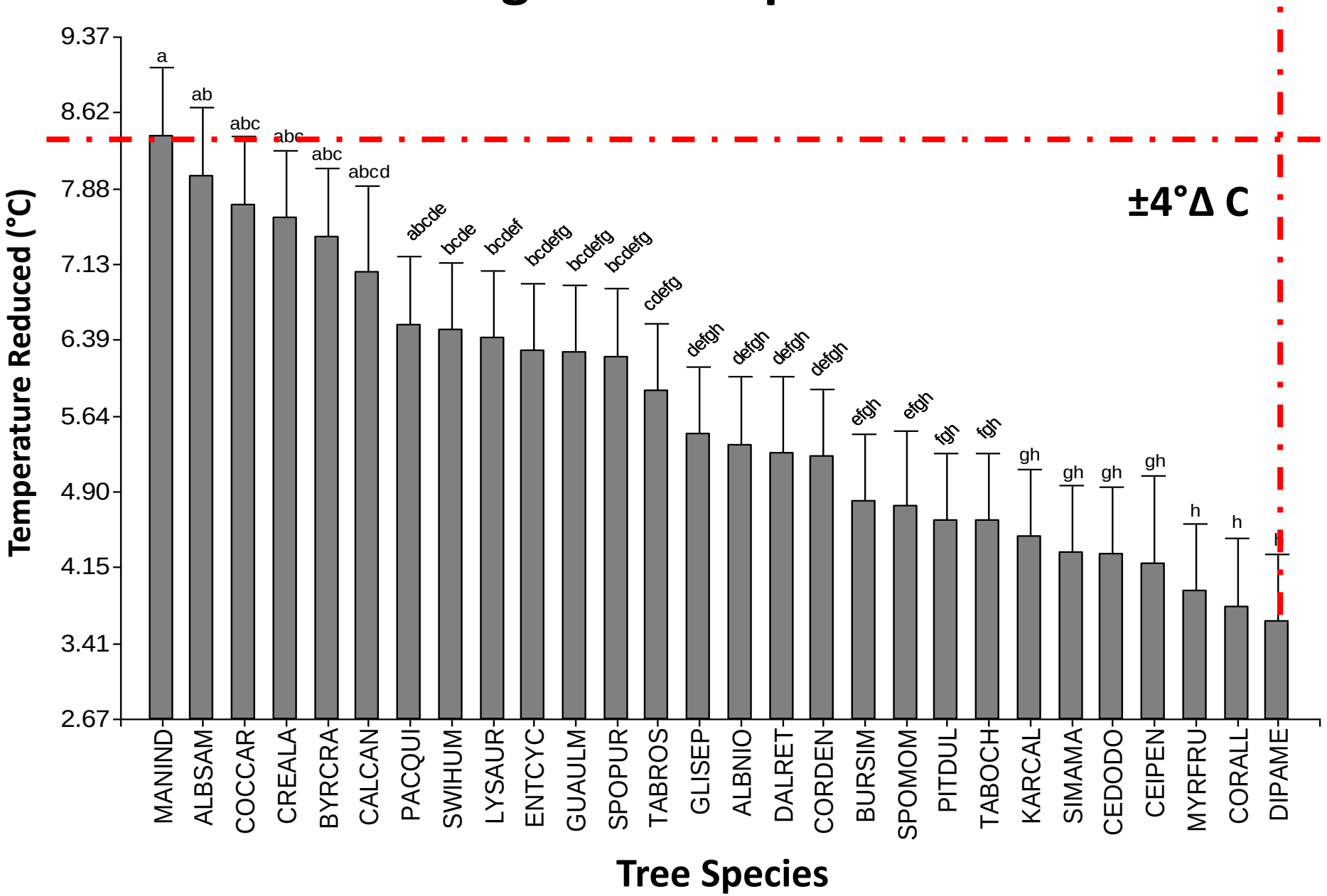
Fuente: Andrade 2007

Contribution of woody perennials to adaptation of grazing animals to climat change

- <u>Heat stress reduction</u>
  - Lower respiratory frequency
  - Less rectal temperature
  - Longer grazing time
- <u>Herbage quality improvement</u>
  - Some tree fruits and fodder available during the dry season

All these contributes to higher livestock production yields

Changes in Temperature



Average milk production and respiration rate for Jersey cows grazing in paddocks with and without trees

Treatment	Milk yield (kg/cow/day)	Respiration rate (respirations/min)
* Without tree	11.37	80
With trees	12.48	65

* monoculture
** 246 observations per treatment

Cows with access to shade produce 11-15% more milk

Adaptation to CC- Feed and nutritional value

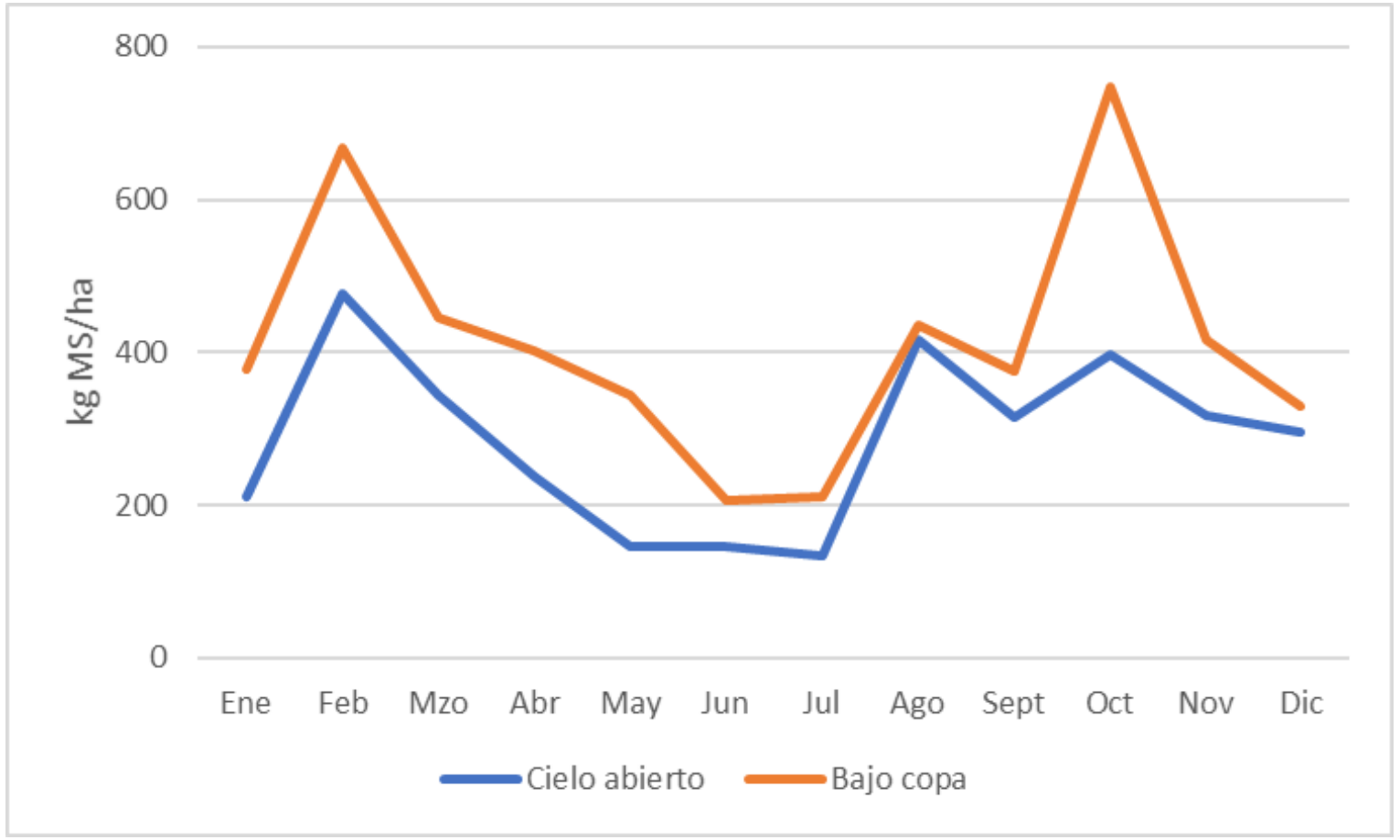
- Prolonged drought conditions
- Trees produce fruits of high value- critical dry period

Contribution of woody perennials to CC adaptation

Effects on pastures

Effects on animals

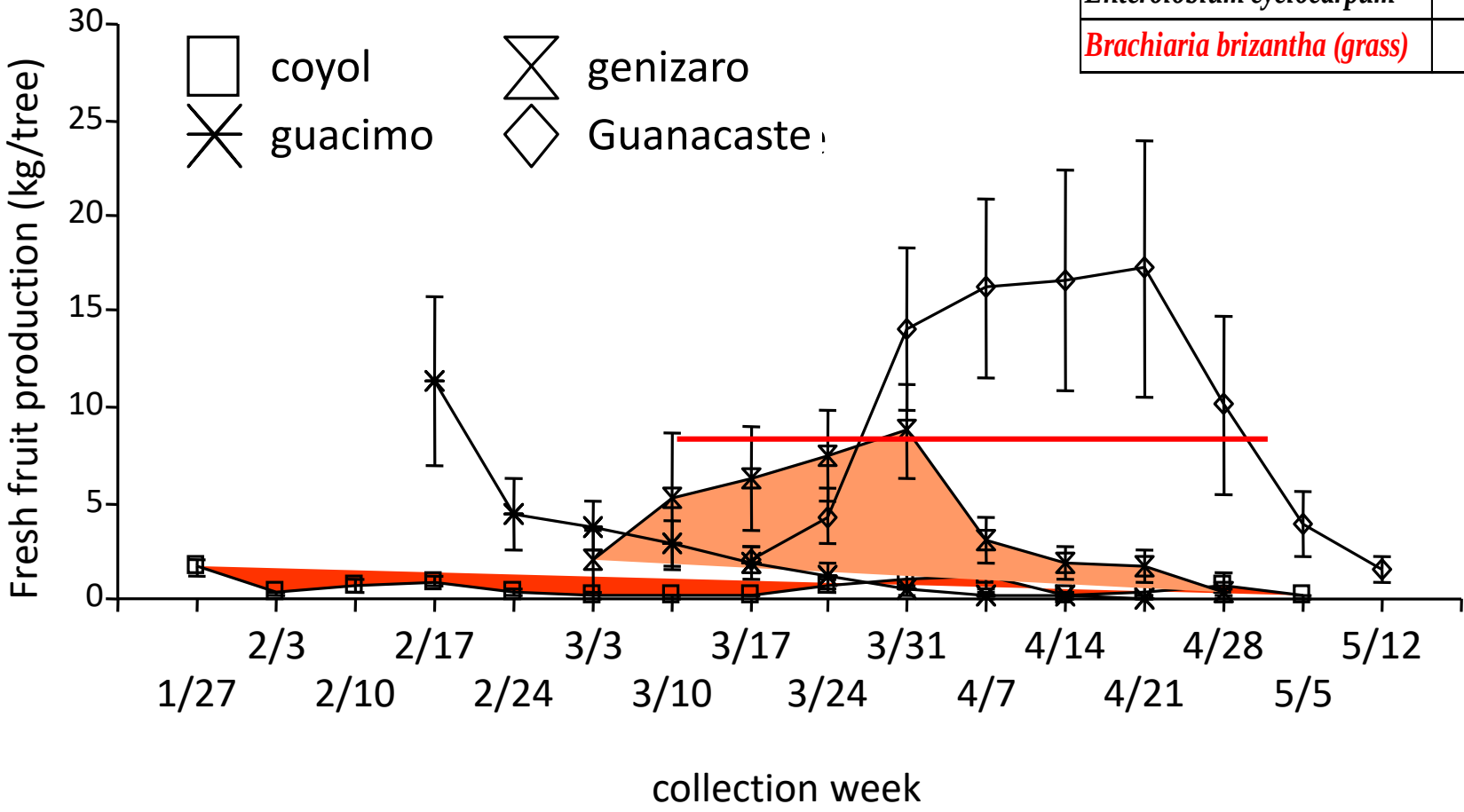
Monthly forage production under the trees canopy and the open space in Corrientes, Argentina



Source: Fernández-Mayer, 2017

Availability of fruits in pastures in the dry tropics of Costa Rica

Especie	kg arbol^{-1}	% PC	% DIVMS
Acrocomia aculeata	8.6	5.5	66.4
Guazuma ulmifolia	26.4	7.5	62.8
Samanea saman	36.1	15.6	71.5
Enterolobium cyclocarpum	86.0	13.2	67.8
Brachiaria brizantha (grass)		4.9	46.2



Fuente: Esquivel 2007

- The diversity of species favors the availability of fruits in the dry season and contributes to prevent weight losses

Integration of tree resources – adaptation strategy at farm level

Fodder banks for cut&carry

Scattered trees in pastures

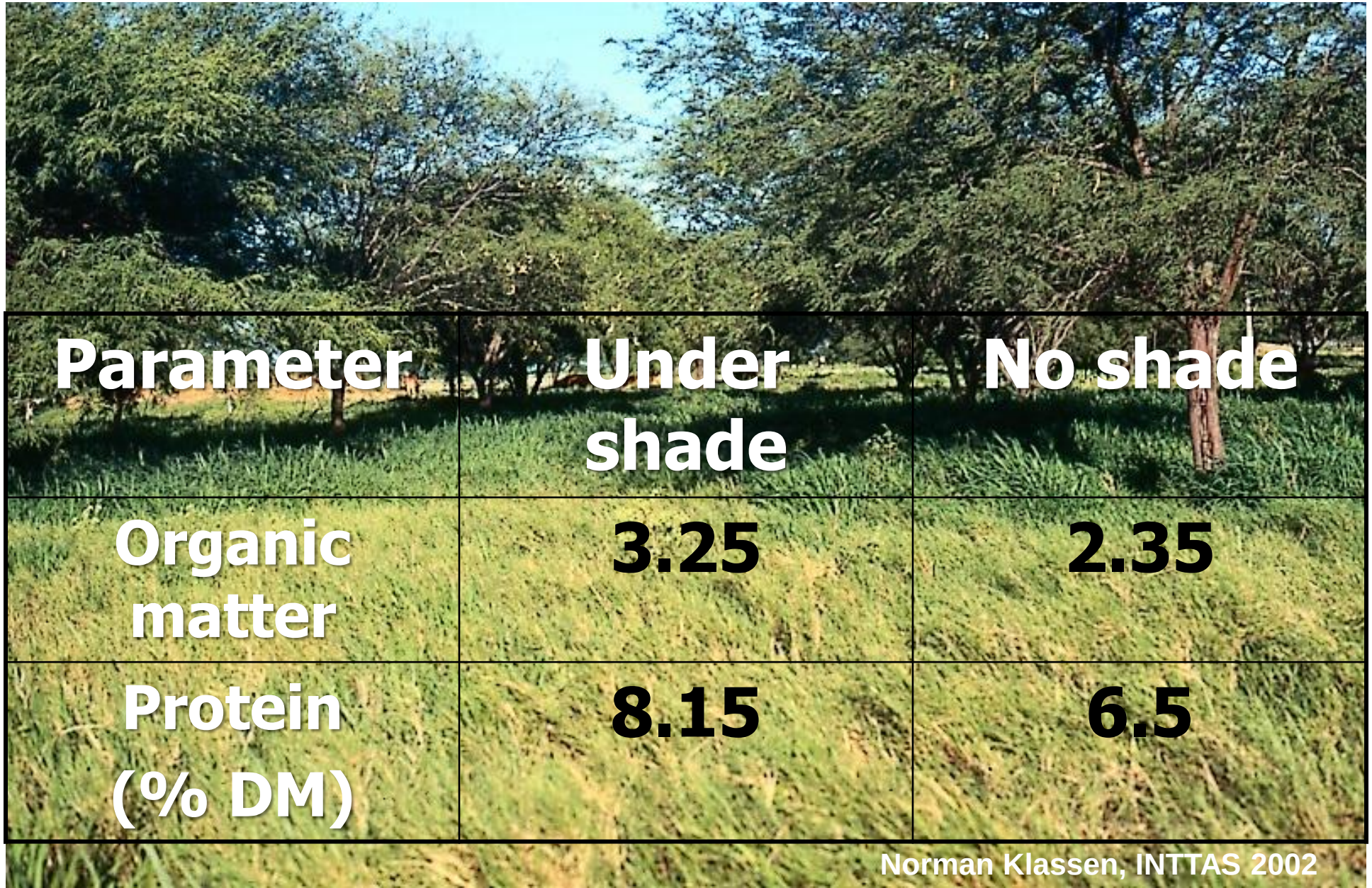
Grazing under the forest

Prosopis spp a flag species in semi-arid and arid environemnts

- Importance will increase in the context of Climate change
- Manage natural regneration
- Distribution and densities
- Question of invasive species in

Some countries

Potential for *Prosopis* based systems



Parameter	Under shade	No shade
Organic matter	3.25	2.35
Protein (% DM)	8.15	6.5

Norman Klassen, INTTAS 2002

Prosopis potential

Prosopis prodution

Podd = Maize

1.800 kg per canopy area/ ha

30% of the canopy área = 600 kg / ha

Milk

Ad lib Grazing on Gatton Panic under the tree canopy

2.5 kg Guandú leaves/ cow

2.5 kg Prosopis pods/ cow = 9 L /cow/day

Hugo Báez, INTTAS 2004

Effect of four tree species on the of % total soil N

Tree species	**Mean under tree canopy**	**Mean outside**	**p<0.1) ***
Genizaro	0.40	0.34	***0.026 ****
Guácimo	0.37	0.33	***0.037 ****
Guanacaste	0.37	0.35	0.154
Roble	0.37	0.36	0.639

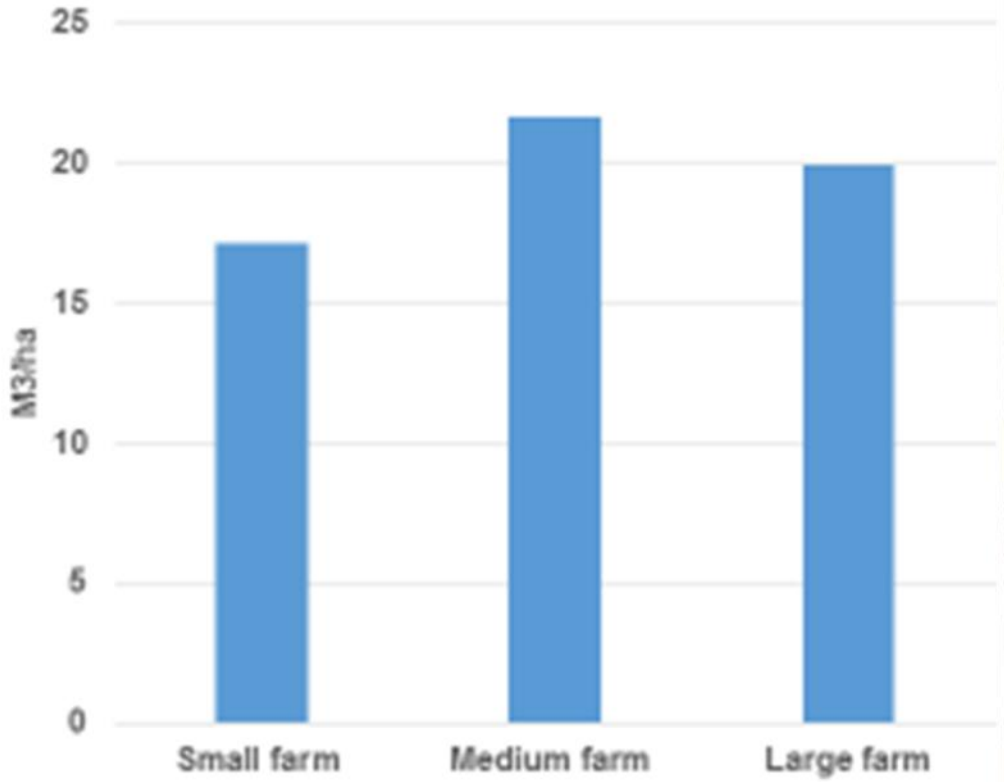
Source: Romero (2013)

Financial contribution of timber in linear plantations

Simulating the introduction of *Cedrella odorata* in 2,5 km long perimetral fences in livestock farms in Cayo District, Belice resulted in an increas in Net Actual Value to (NAV):

Small farm (les than 40 ha):	29%
Medium size farm (40-100 ha):	10%

Timber production under the scattered tres in pastures system in grazing areas (Guanacaste, Costa Rica)



Timber production under this system is equivalent to 15-20% of the yield obtained under tree plantations

Fuente: CATIE, 2017

Ecosystem services- biodiversity

- Conservation of key species
- Structural and functional connectivity

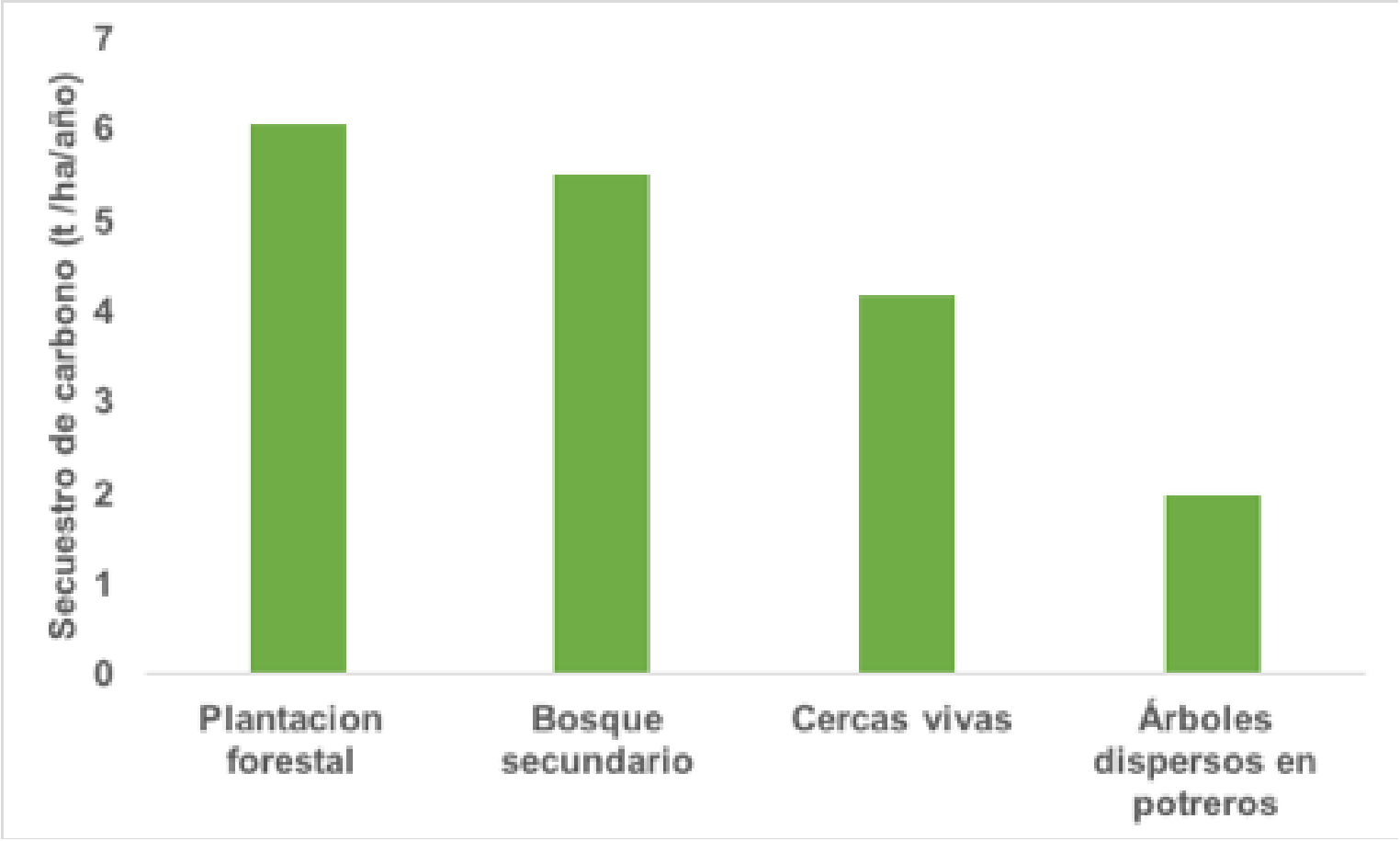
Bird richness in three countries

Land use type

CONTRIBUTION OF WOODY PERENNIALS TO CC MITIGATION

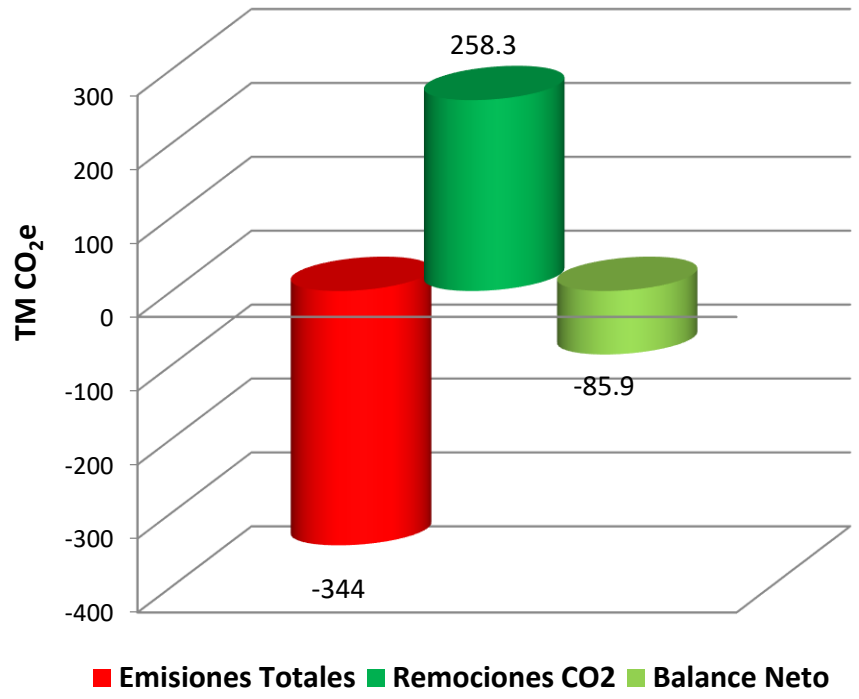
- Woody perennials in general: Sequester C in the aerial and root biomass.
- Edible fodder and fruits:
  - Help to reduce enteric CH_4 emissions by improving the ruminal degradation of fiber fractions; however, if used in excess may result in higher N_2O emissions.
  - Some have secondary metabolites (i.e. tannins, saponins) that contribute to reduce CH_4 emissions.

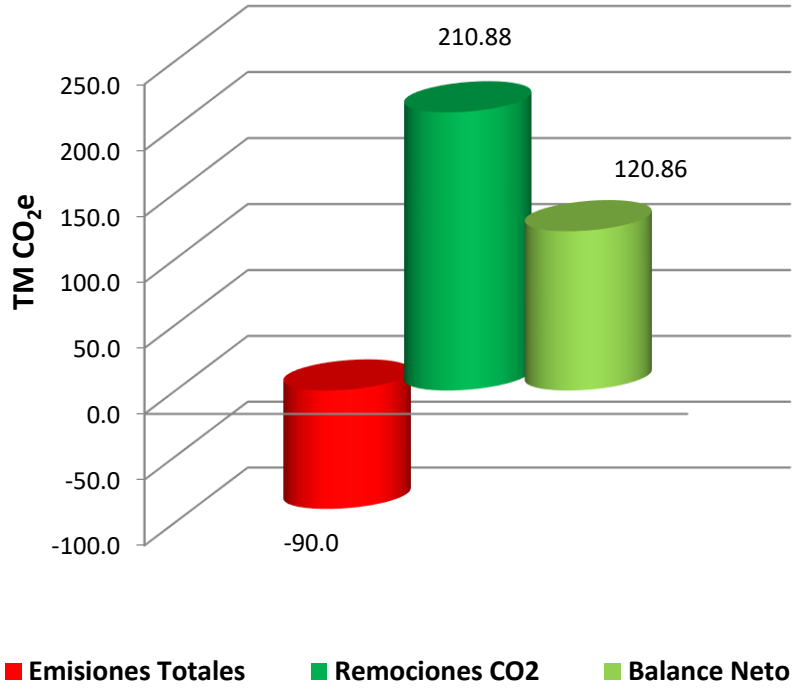
C-sequestration in the aereal biomass under different land uses in livestock farms in Southeast Guatemala (Villanueva et al., 2018).



The contribution of tree cover to the reduction of GHG emissions vary with the composition and structure of the tree component

Carbon balance in livestock farms in the dry tropics of Costa Rica (MAG/CATIE, 2010)



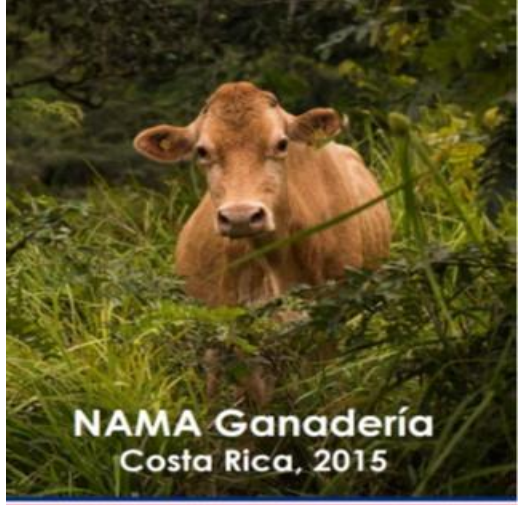


Cattle fattening farm (74 ha) with few silvopastoral options

Dual purpose cattle farm (35 ha) with several silvopastorale options

Some national and international policy initiatives– oportunities for SPS

- NAMAs – Strategies for low GHG emissions de producción baja en emisiones
- REDD+ - Prevention/avoidance of deforestation
- 2020-Iniciative – Recovery of degraded lands
- Agricultural insurance



Research questions

How to promote a higher adoption of intensive SPS (i.e., Leucaena) which have demonstrated benefits on productivity, economics and CC mitigation?

The use of functional traits for diet composition and its implications on productivity and GHG balances, and products´ quality

How changes in climate patterns could affect species diversity and its impact on herbage quality?

What is the impact of integrating trees for improving resilience to climate change?

To evaluate the performance of a new generation of forage species under different silvopastoral arrangements and variable climate conditions: Mixtures with legumes, herbage quality, composition, persistence , etc.