Live fences

Gliricidia sepium

Ceiba pentandra

Gliricidia sepium fodder bank: 3.7 Ha

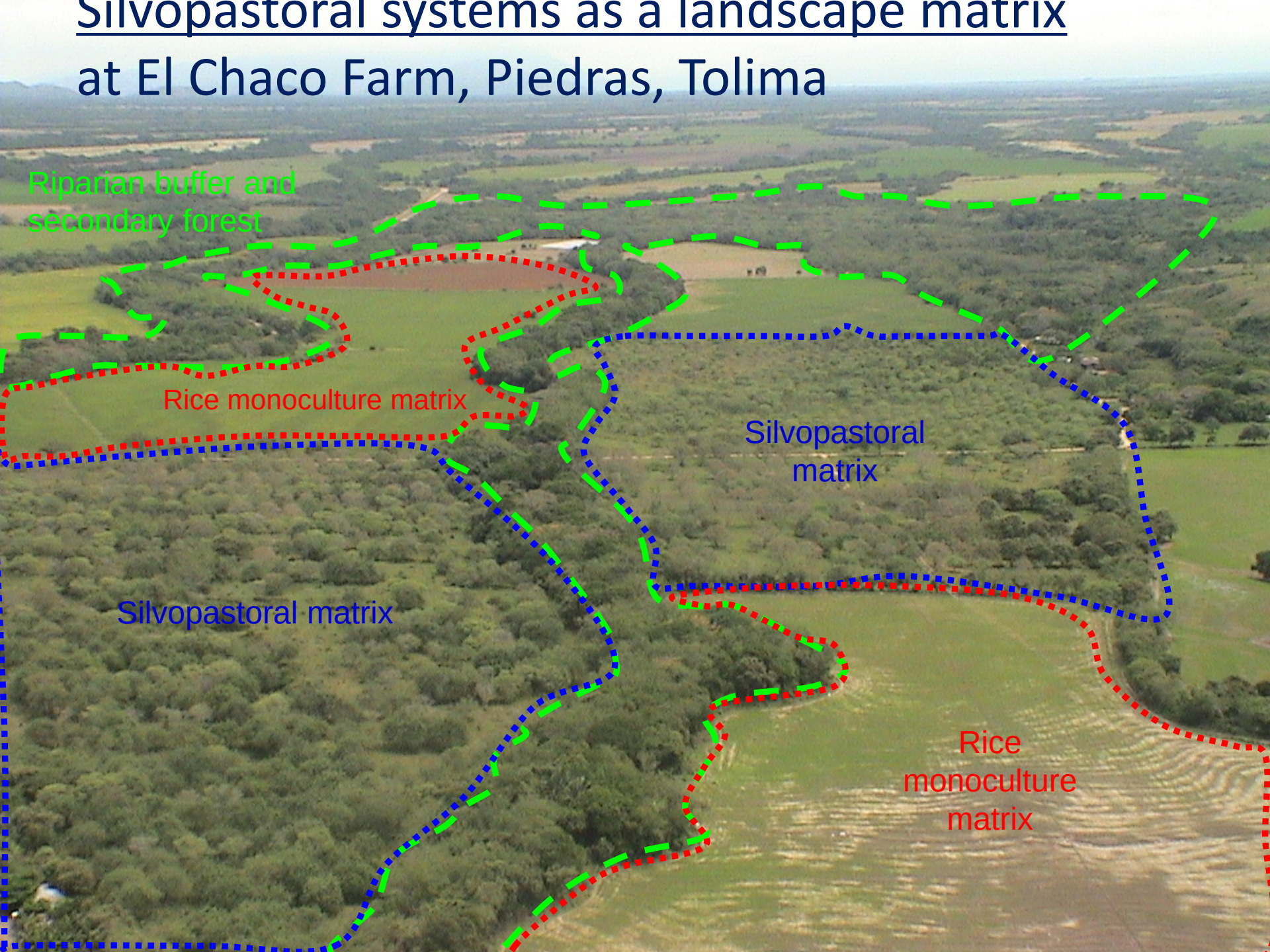
Erythrina fusca – stargrass *Cynodon plestoctachyus* silvopastoral system

20 years, continuous production

Gliricidia sepium cut-and-carry fodder bank

Harvest, and sun drying of *Gliricidia* fodder for milk cows and calves.

Silvopastoral systems as a landscape matrix at El Chaco Farm, Piedras, Tolima



Silvopastures enhance landscape connectivity

In summary, we propose that

- The mainstreaming of silvopastoral systems in degraded tropical landscapes can simultaneously address environmental and productive issues, making cattle ranching part of the solution rather than the problem.

Bayesian networks for the analyses of tree functions trade-offs in tropical agro-silvopastoral systems

C.P. Carmona, G.M. Rusch, D.N. Barton, M. Diouf, C. Armas, D. Fall and H. Guerin

FUNCiTREE

Ecosystem services (ES)

- Resources and processes produced by natural systems
- Contribute to human wellbeing
- Linked together → Covariation
- Management practices?
- Trade-offs between ES?

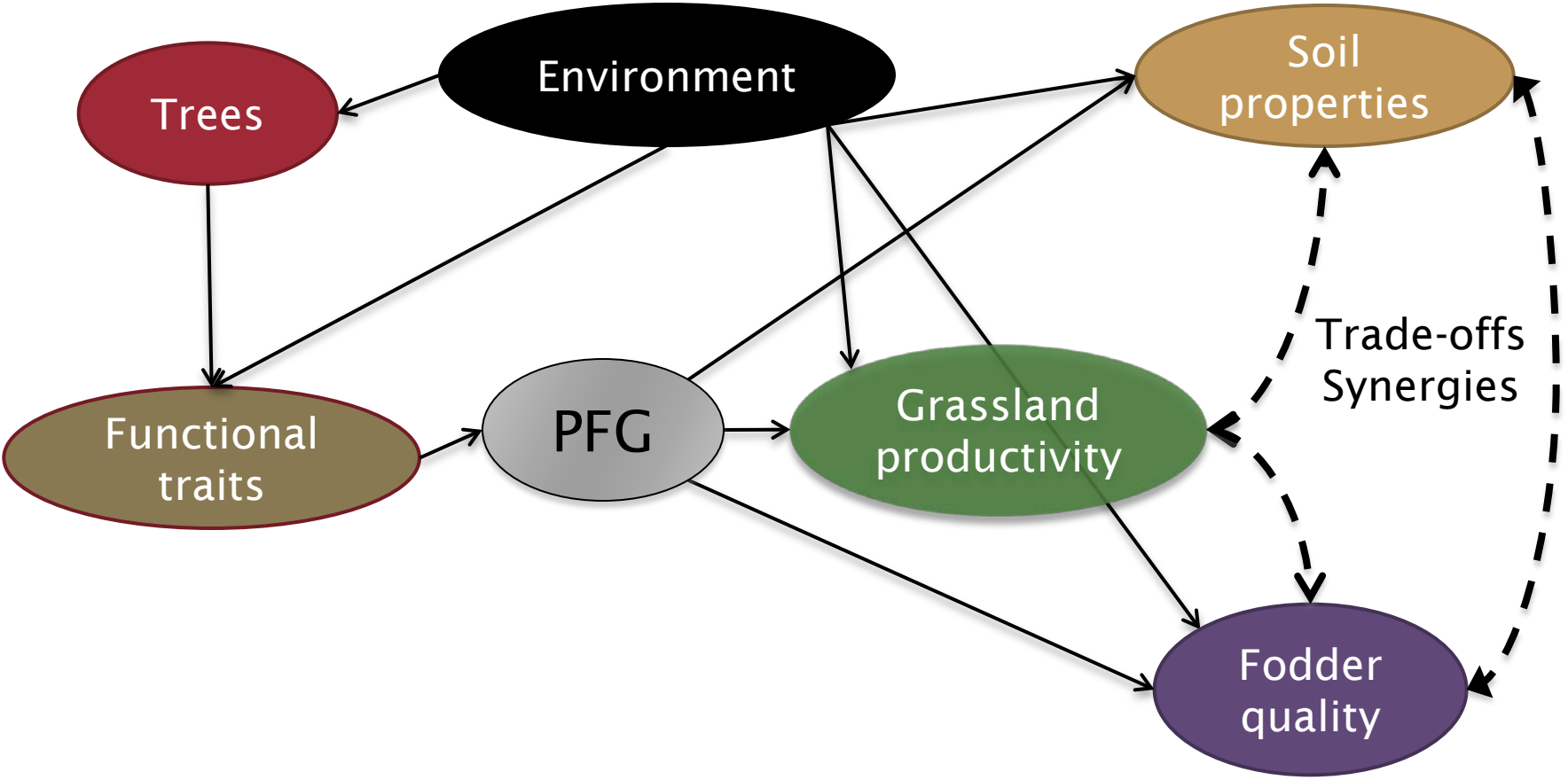
Objectives

1) To represent the effect of different functional groups of trees on three service provision functions (grassland productivity and soil properties under the trees and fodder quality of trees) in agroforestry systems.

2) To assess the existence of trade-offs among these functions.

Approach based on:

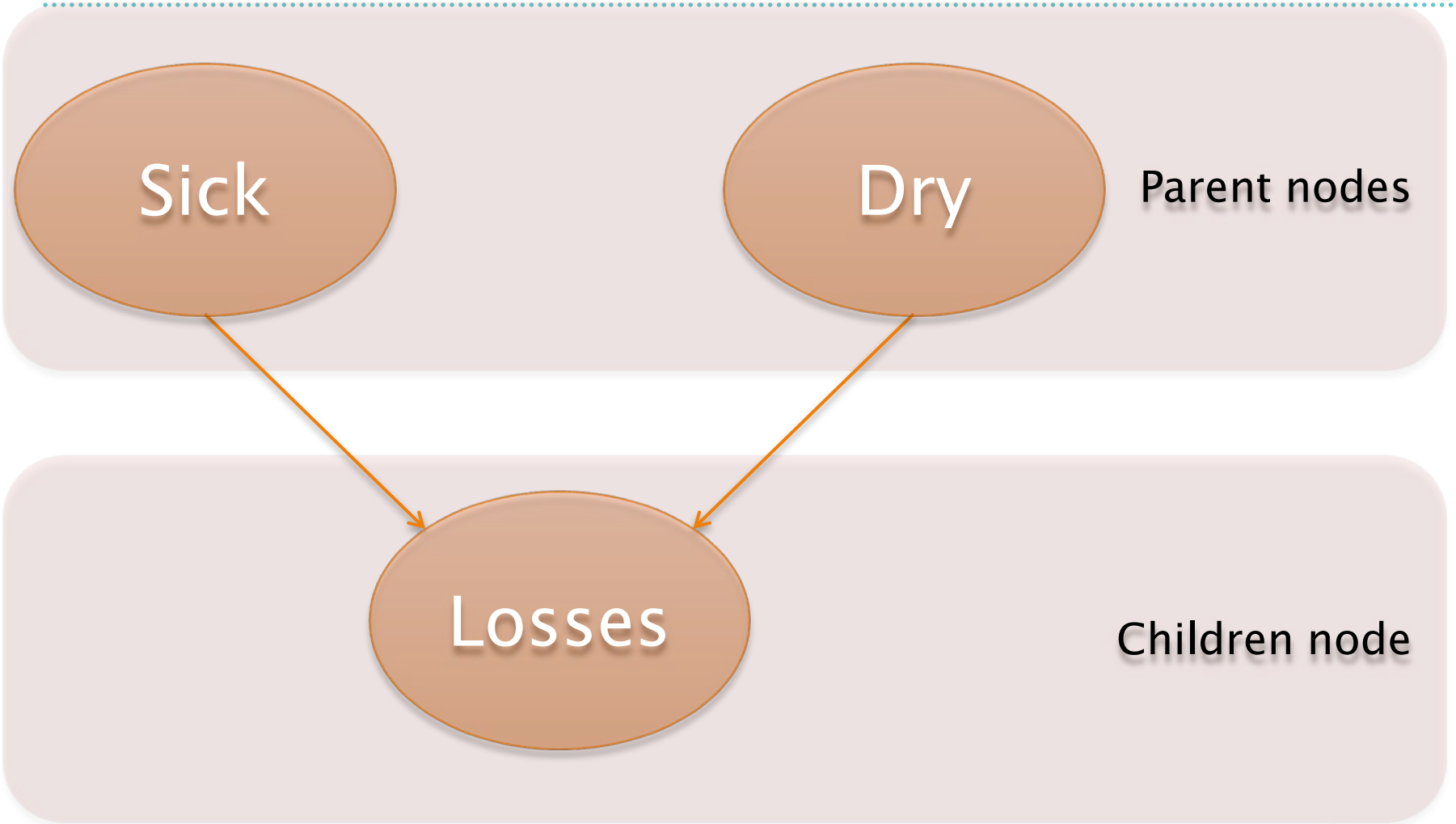
- Bayesian Networks
- Functional traits


Trees
Environment
Soil properties
Trade-offs
Synergies
Functional traits
PFG
Grassland productivity
Fodder quality

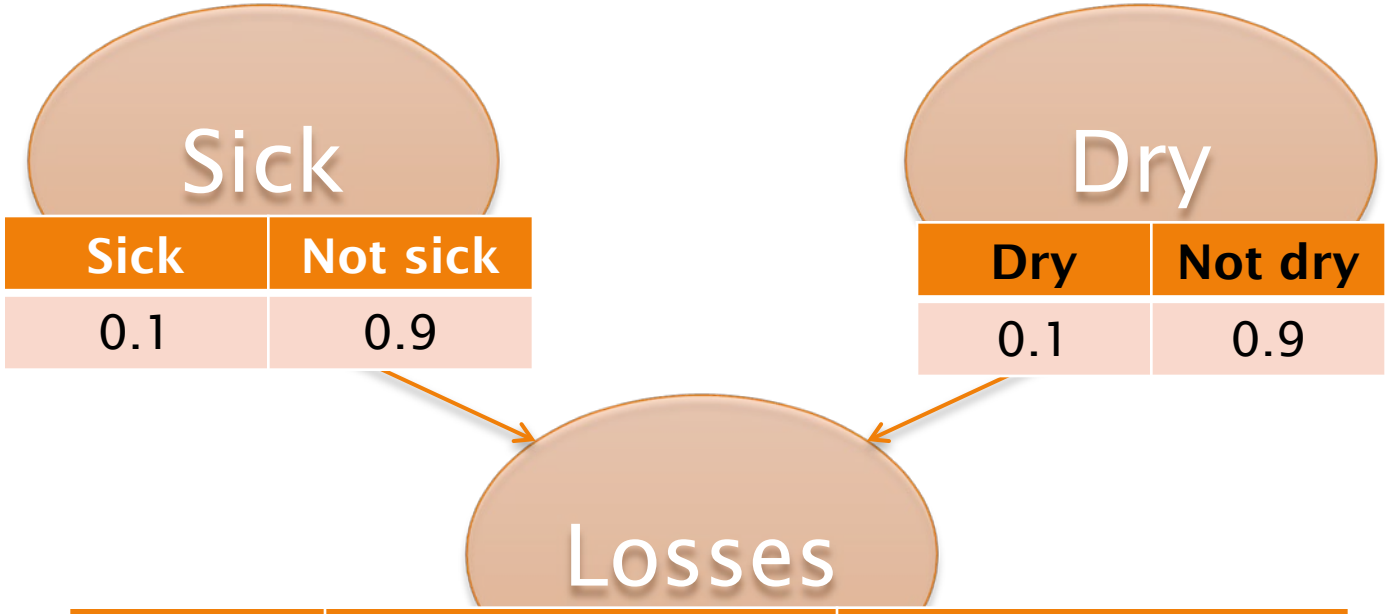
What is a Bayesian Network?

- Nodes → Variables.
- Arcs → Relationships.
- CPT → Probability of each state, given the states of the parent nodes

What is a Bayesian Network?



What is a Bayesian Network?



Sick	Not sick
0.1	0.9

Dry	Not dry
0.1	0.9

Losses	Dry		Not dry	
	Sick	Not sick	Sick	Not sick
yes	0.95	0.85	0.90	0.02
not	0.05	0.15	0.10	0.98

Why a Bayesian Network?

- It is possible to treat uncertainty explicitly
- Suitable for small and incomplete data sets
- The consequences of different decisions can be studied, not only from the perspective of expected values, but also with regard to the risks of undesirable outcomes.
- Simplify the processes of engaging stakeholders in participatory processes
- Interactions between variables
- New information → Easy to update

Functional trait-based approaches

- Aspect
- Function
- Effects of disturbances and environment
- Ecosystem processes

Plant Functional Groups (PFG)

- Similar response to environmental factors, or
- Similar effect on ecosystem functioning.
- PFG are based on functional traits that influence (or are influenced by) the studied ecosystem process.
- Plants within the same PFG have similar suites of functional traits.

Methods

- Senegal.
- 106 individual trees.
- 23 species.
- ’salty’ (harsh) and ’non-salty’ (benign) soils.

Effect of trees on services: grassland productivity and soil properties

- Under the canopy and outside the canopy:
  - Understorey above ground net primary productivity (ANPP)
  - Species richness
  - % Cover
  - Soil Nitrogen
  - Soil Carbon

$$RII = \frac{Parameter_{tree} - Parameter_{no\ tree}}{Parameter_{tree} + Parameter_{no\ tree}}$$

1) RII < -0.2
2) -0.2 < RII < -0.05
3) -0.05 < RII < 0.05
4) 0.05 < RII <0.2
5) RII > 0.2

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Effect of trees on services: fodder quality

- Animal preference for each species
- 3 animal species: cattle, sheep and goat
- 3 preference levels: low/intermediate/high

Methods

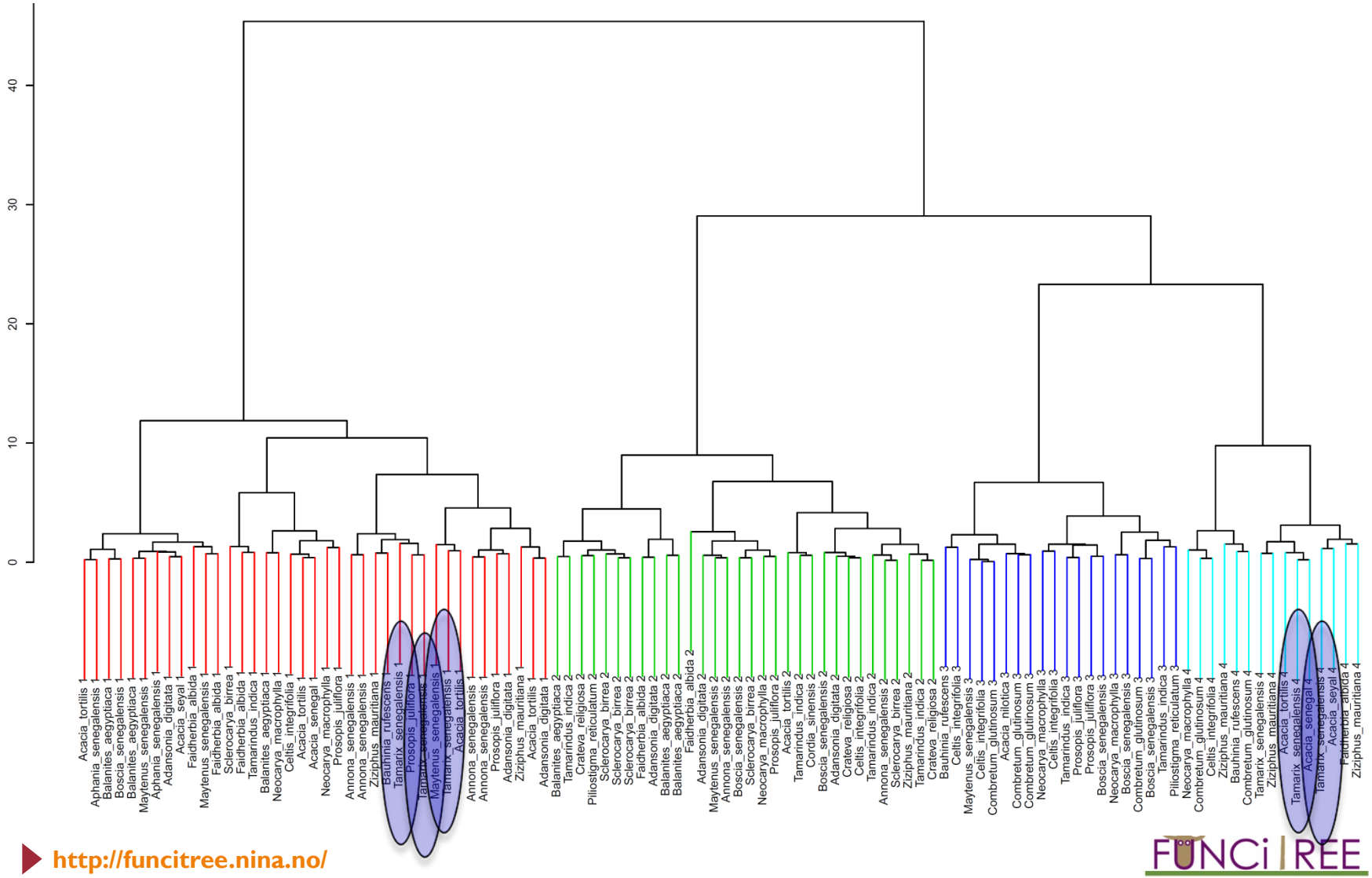
Grassland Productivity	Soil properties	Fodder provision
SLA	Tree height	Acid Detergent Fibre
Maximum LAI	SLA	Acid Detergent Lignin
Minimum LAI	Legume	Crude Protein
Leaf Phenology		Gas test value
		Neutral Detergent Fibre
		In vitro enzymatic degradation of proteins
		Soluble Nitrogen
		Total P
		In vitro degradation of organic matter
		Tannins

Intraspecific variability

Methods

- Hierarchichal cluster
- Plant functional groups (PFG)

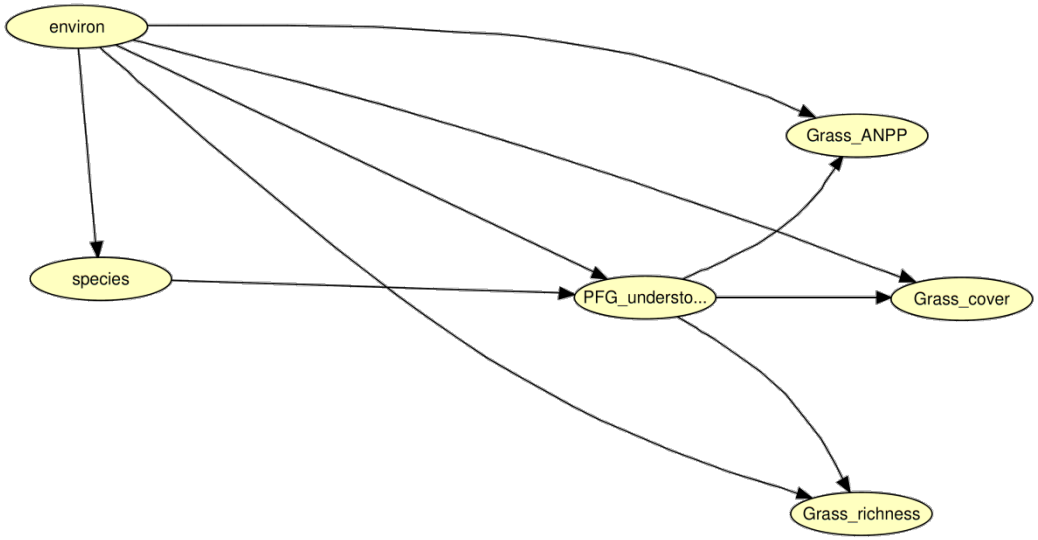
Grassland productivity PFG



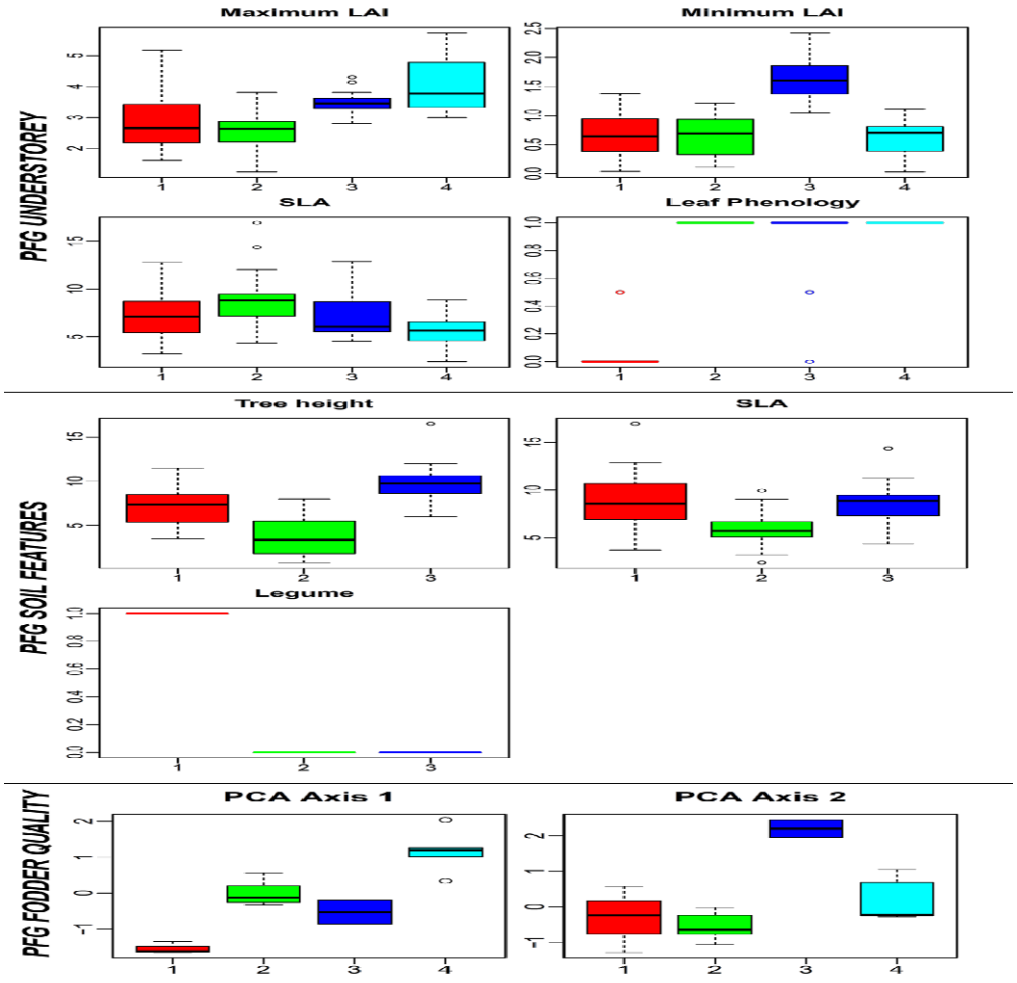
http://funcitree.nina.no/

FUNCi | REE

The Network

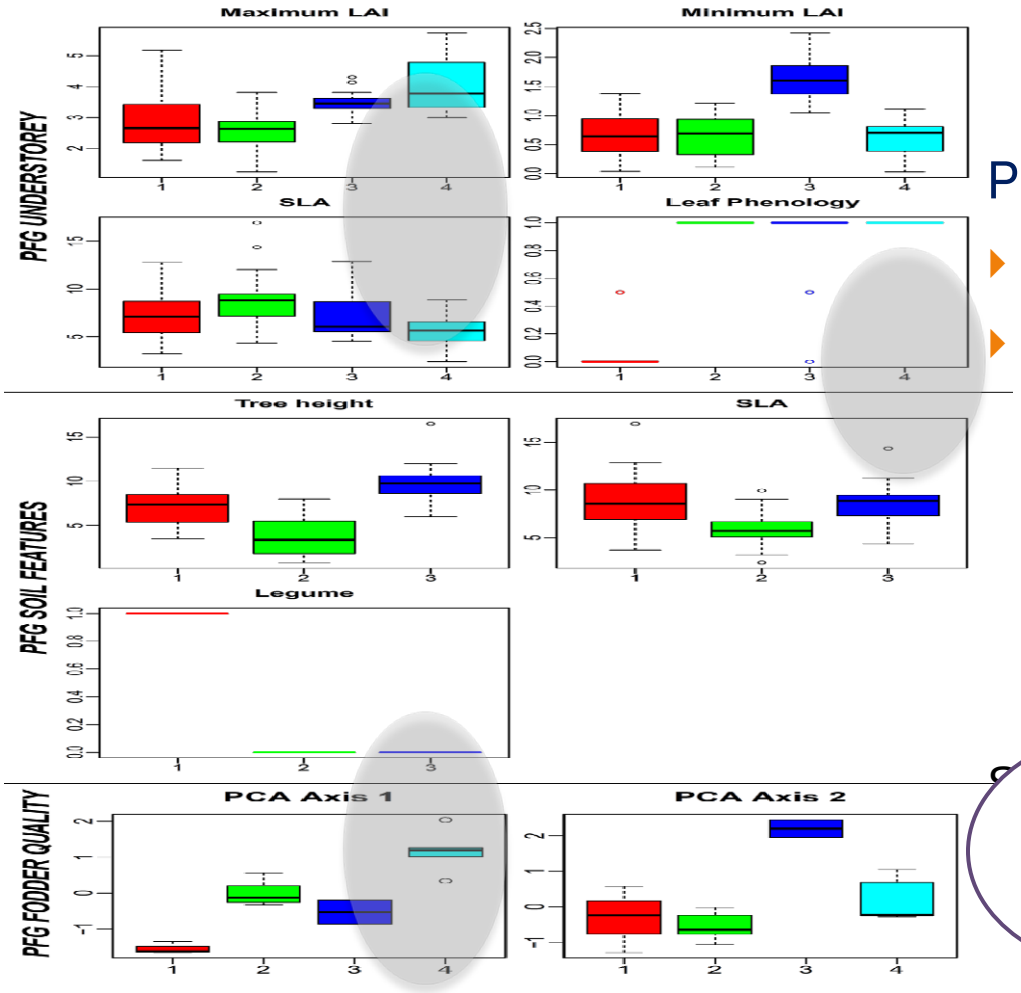

environ
Grass_ANPP
species
PFG_understo...
Grass_cover
Grass_richness

Grassland productivity PFG



- LAI
- Phenology
- Resource use strategy and litter quality: SLA

Grassland productivity PFG



PFG4

- Deciduous strategy
- Low SLA

Abundant in Salty Soils

Protection

Reduced light availability in wet season

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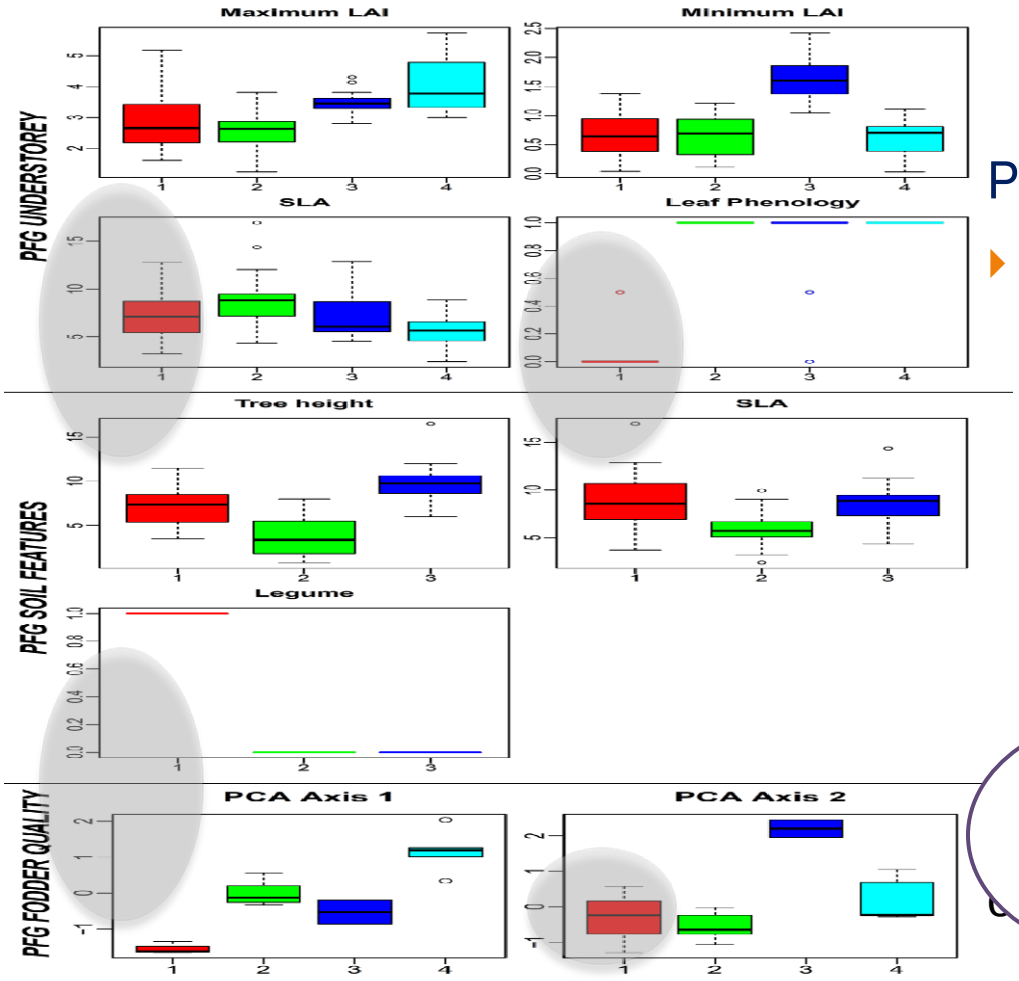
Grassland productivity PFG



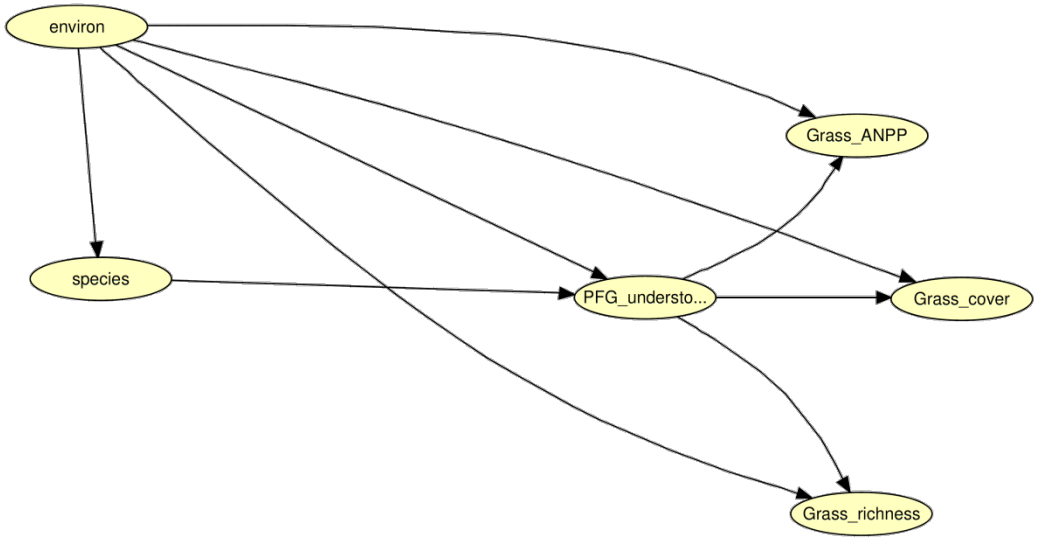
PFG1

- Maximum LAI in dry season

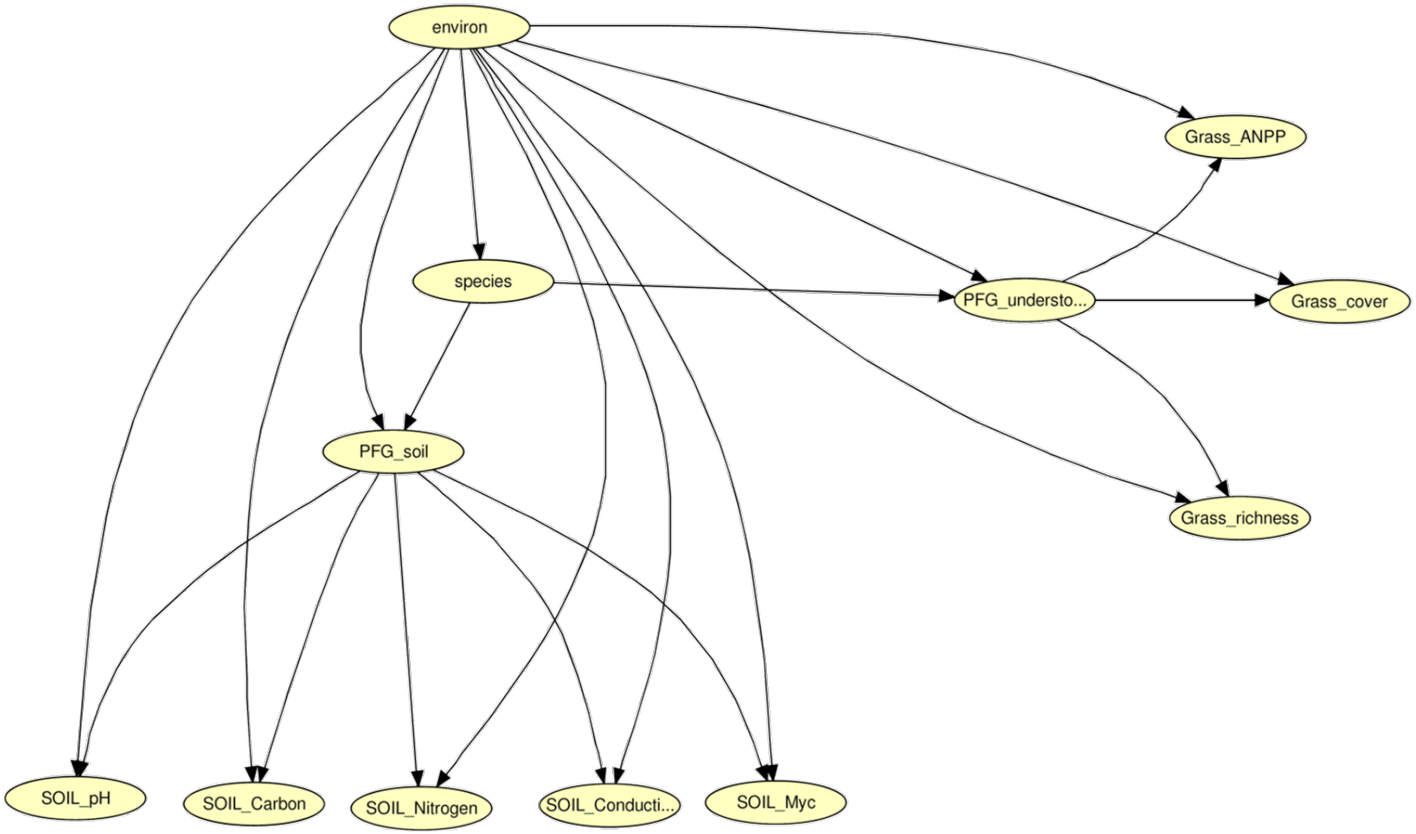
Not good shelter during wet season

Protection during dry season

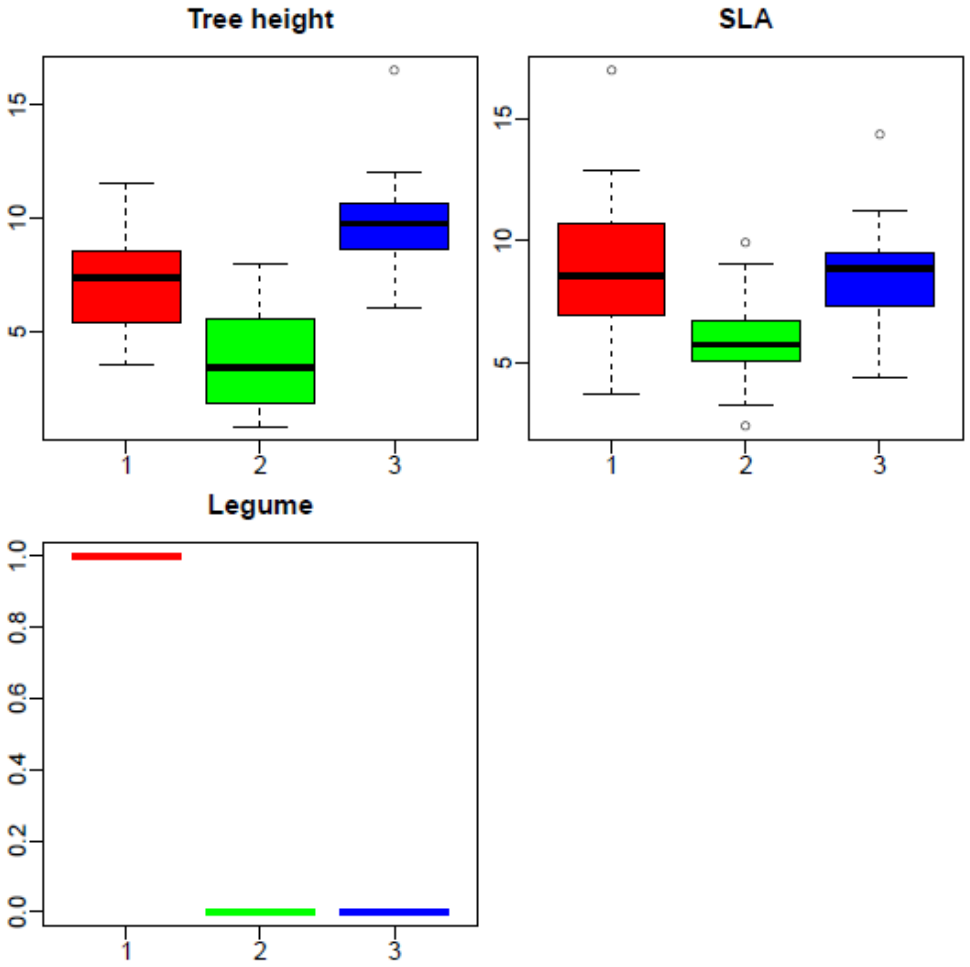
The Network


environ
Grass_ANPP
species
PFG_understo...
Grass_cover
Grass_richness

The Network


environ
Grass_ANPP
species
PFG_understo...
Grass_cover
PFG_soil
Grass_richness
SOIL_pH
SOIL_Carbon
SOIL_Nitrogen
SOIL_Conducti...
SOIL_Myc

Soil fertility PFG



- Biomass production: Tree height
- Litter decomposability: SLA
- Nitrogen fixation: Legume

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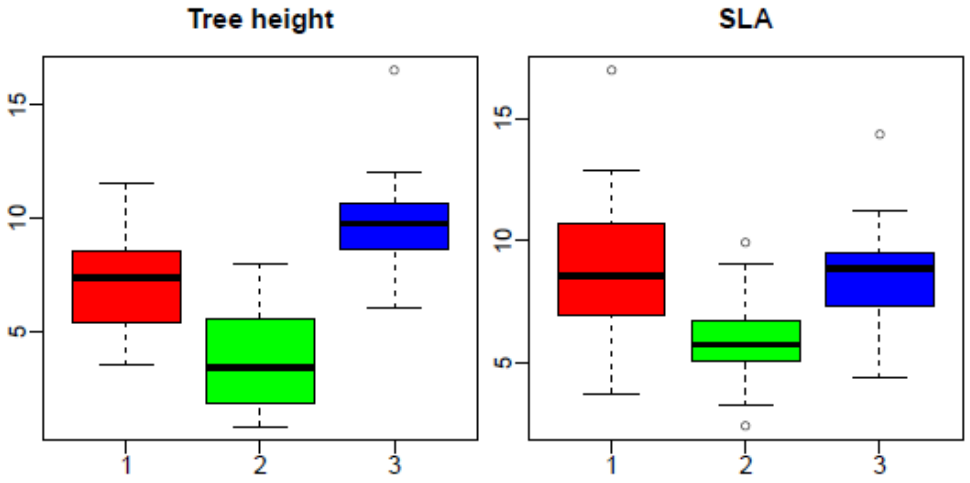
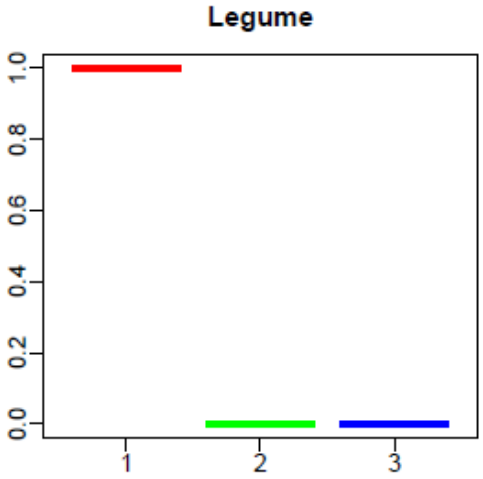
Soil fertility PFG





PFG2

- Short trees
- Low SLA

Abundant in Salty Soils

PFG3

- Tall trees
- Intermediate-High SLA

Scarce in Salty Soils

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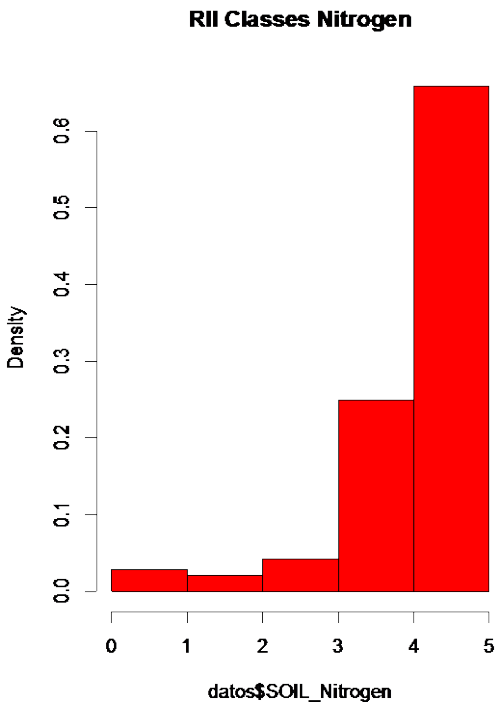
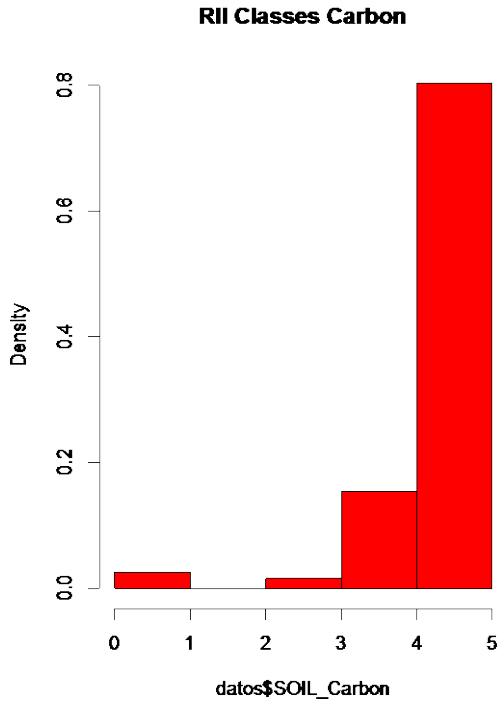
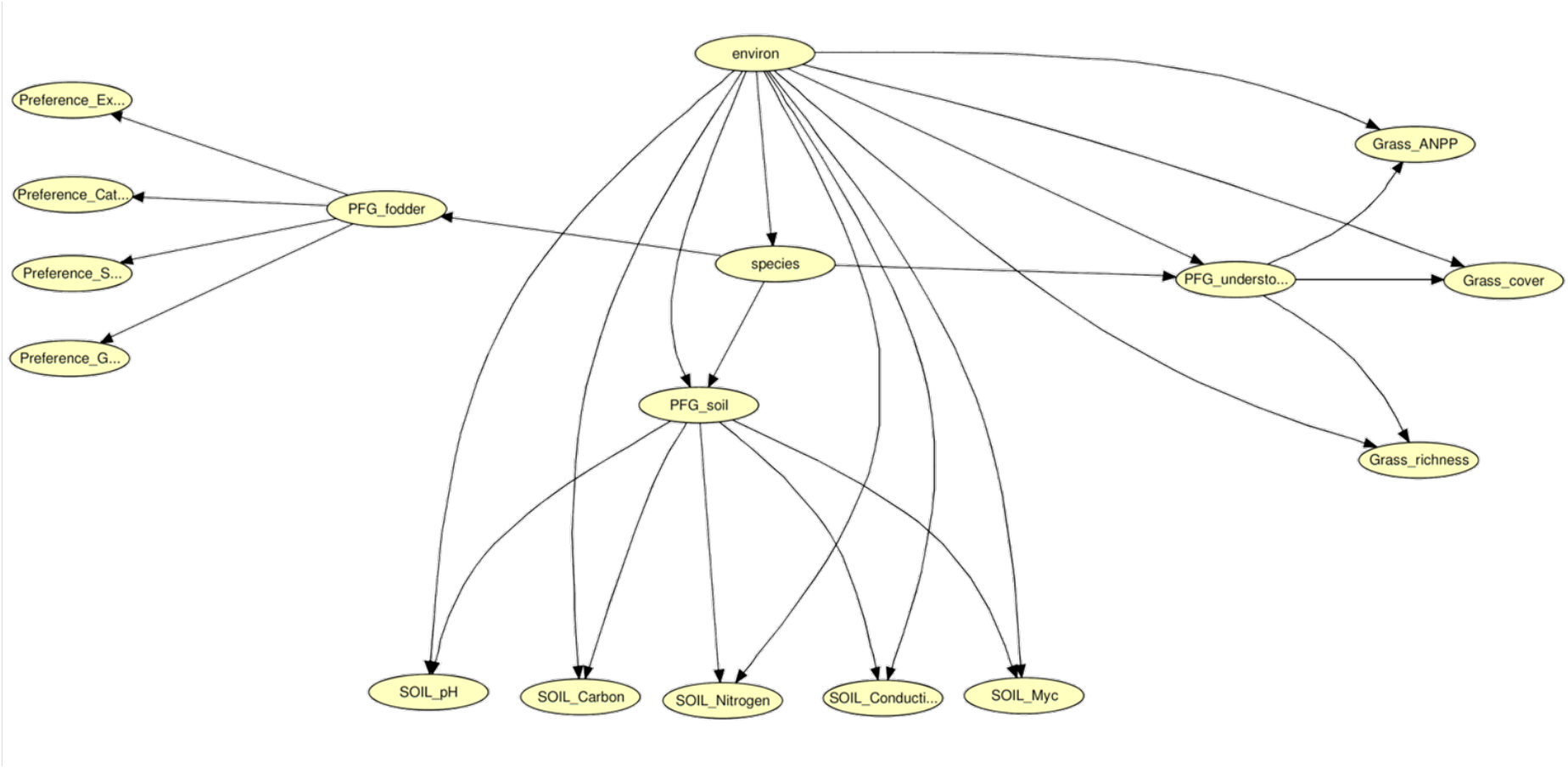
Soil fertility PFG



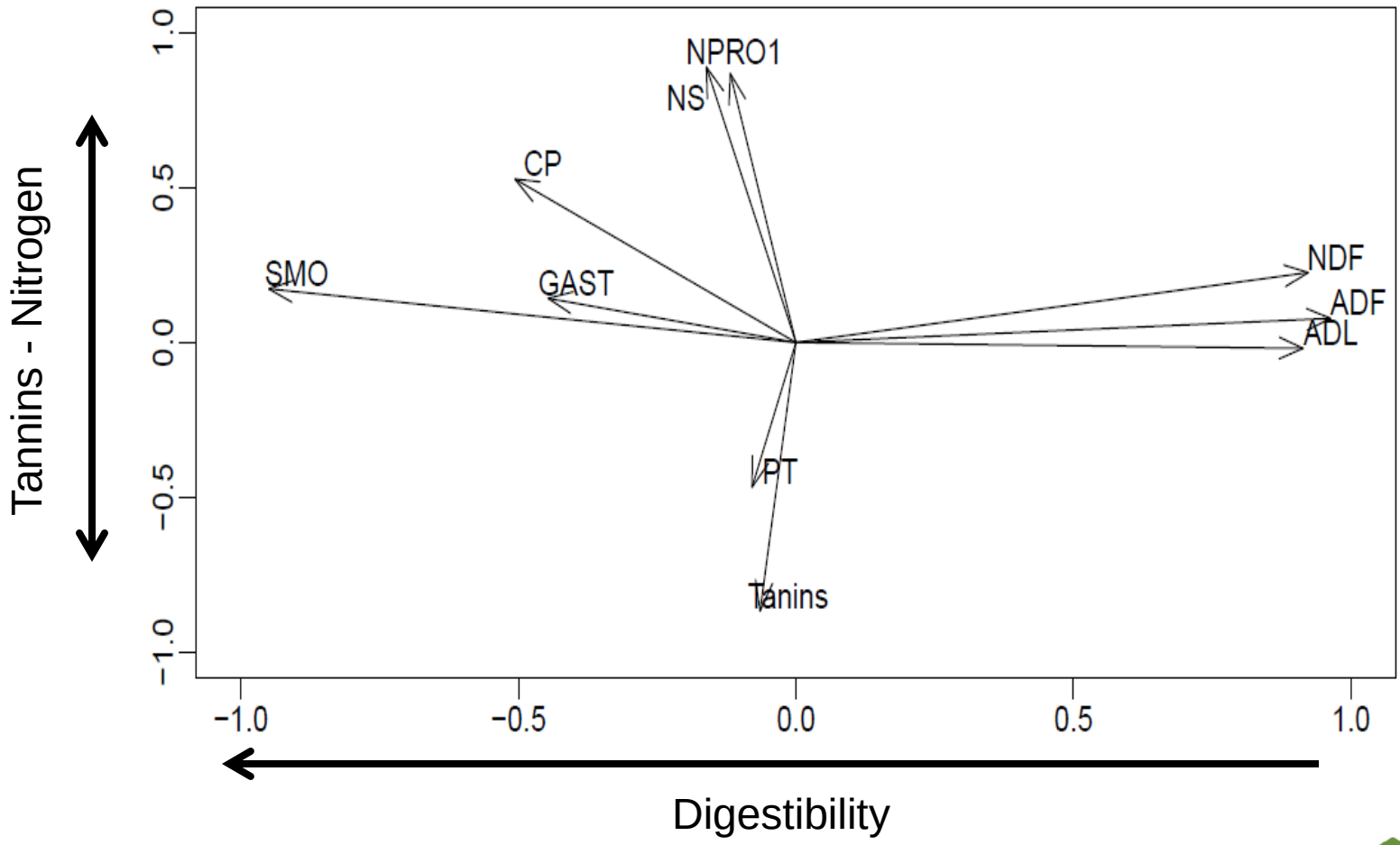


- Trees increased soil Nitrogen and Carbon content, irrespective of PFG and environment.

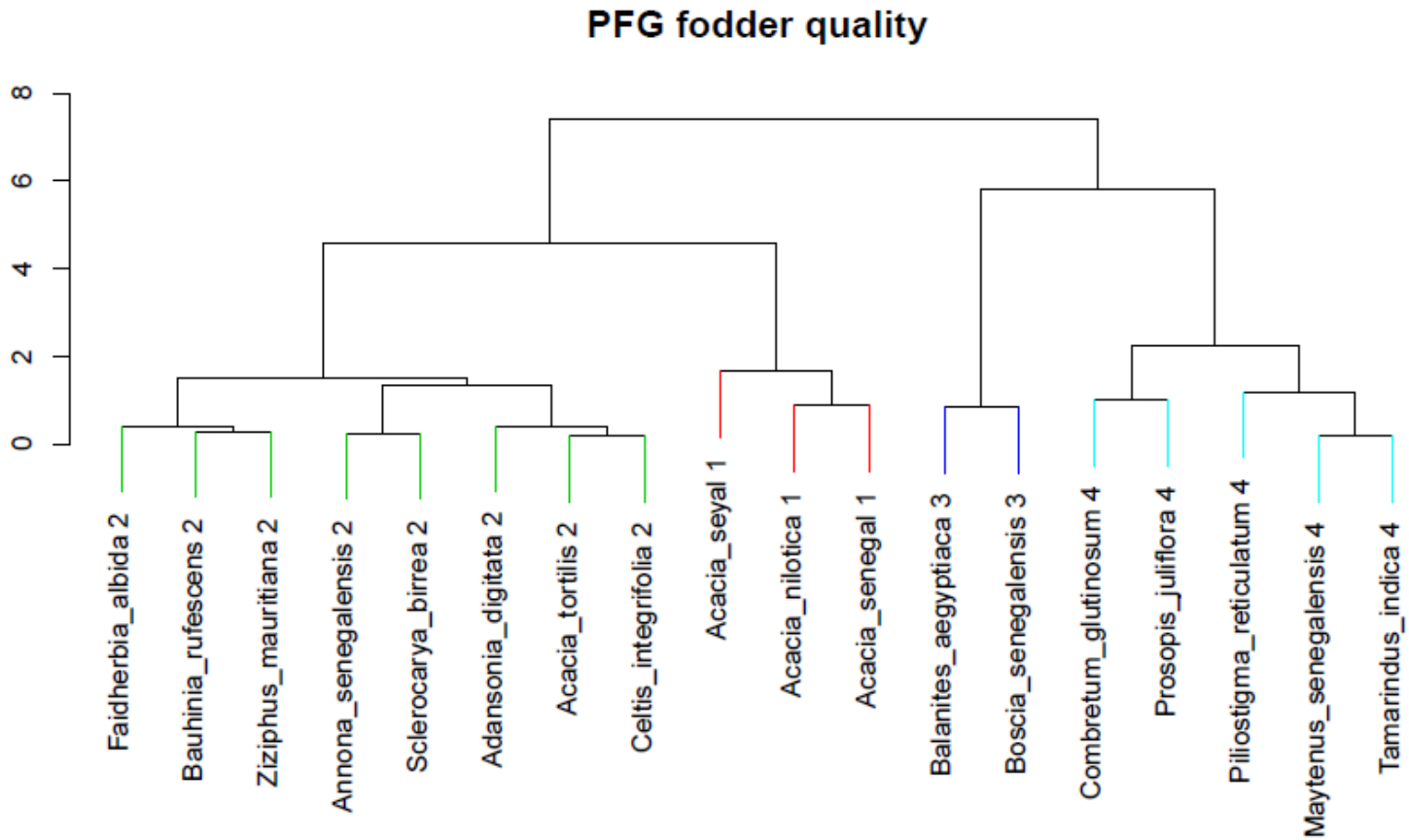
The Network


environ
Preference_Ex...
Preference_Cat...
Preference_S...
Preference_G...
PFG_fodder
species
PFG_understo...
Grass_ANPP
Grass_cover
Grass_richness
PFG_soil
SOIL_pH
SOIL_Carbon
SOIL_Nitrogen
SOIL_Conducti...
SOIL_Myc

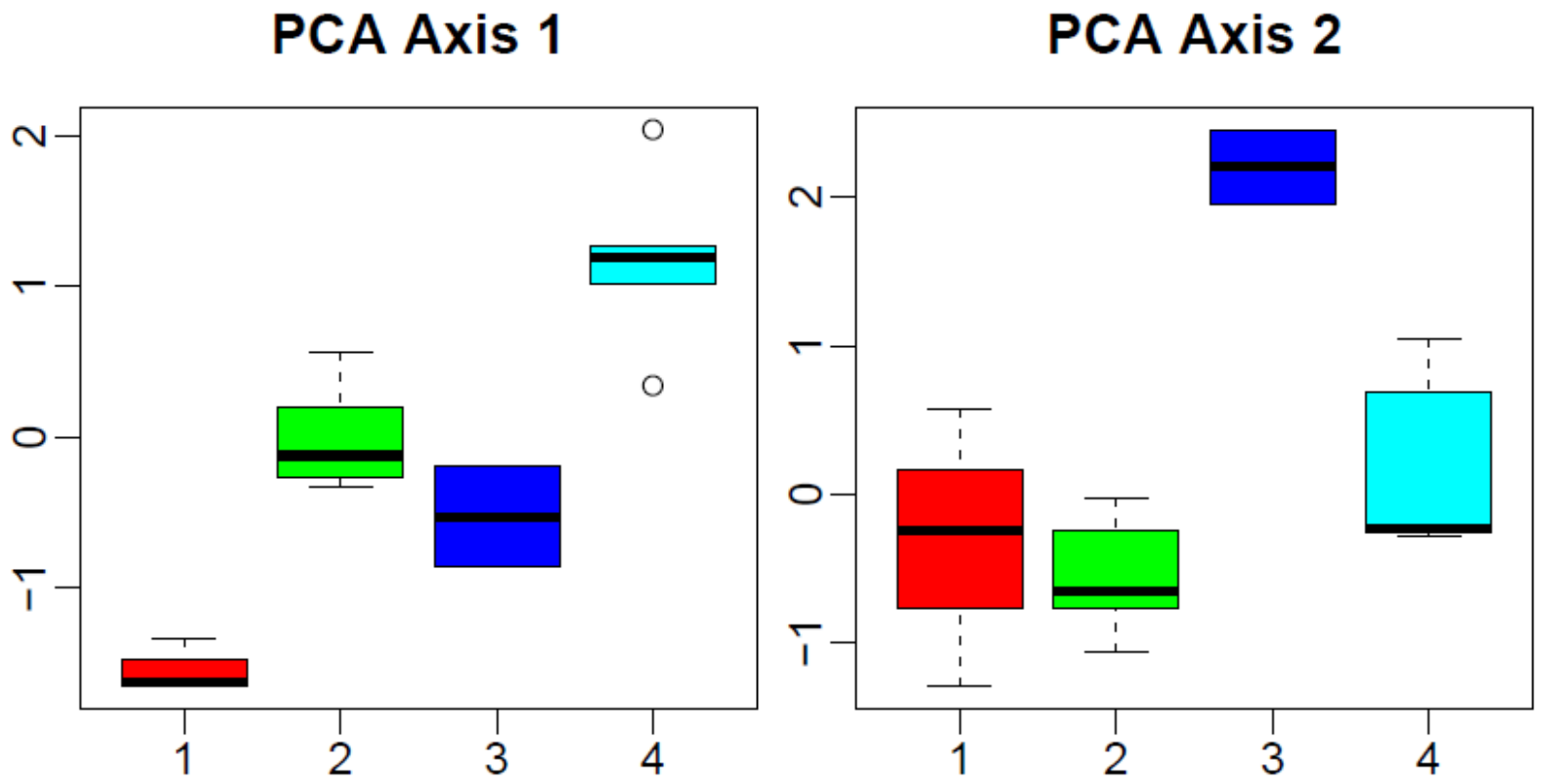
Function: forage quality



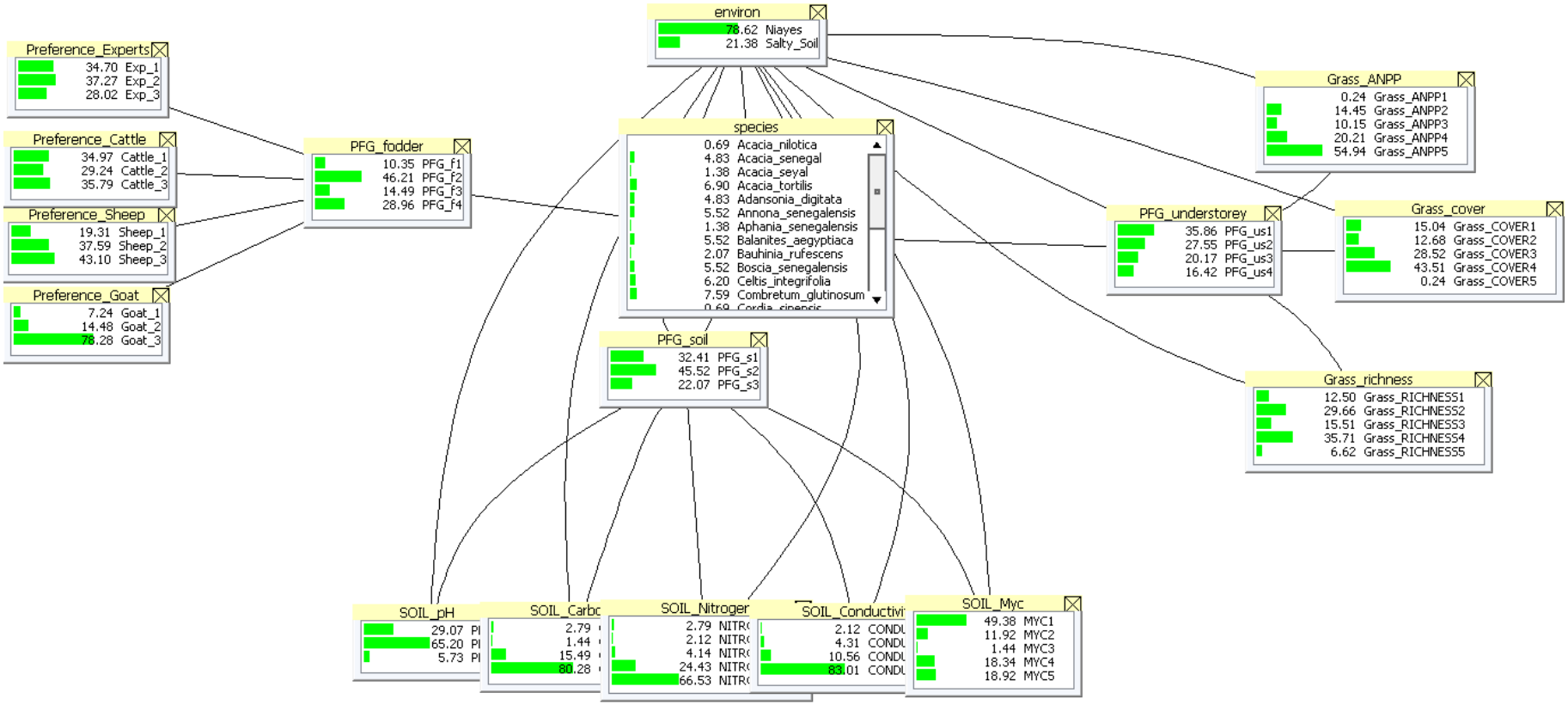
Fodder quality PFG



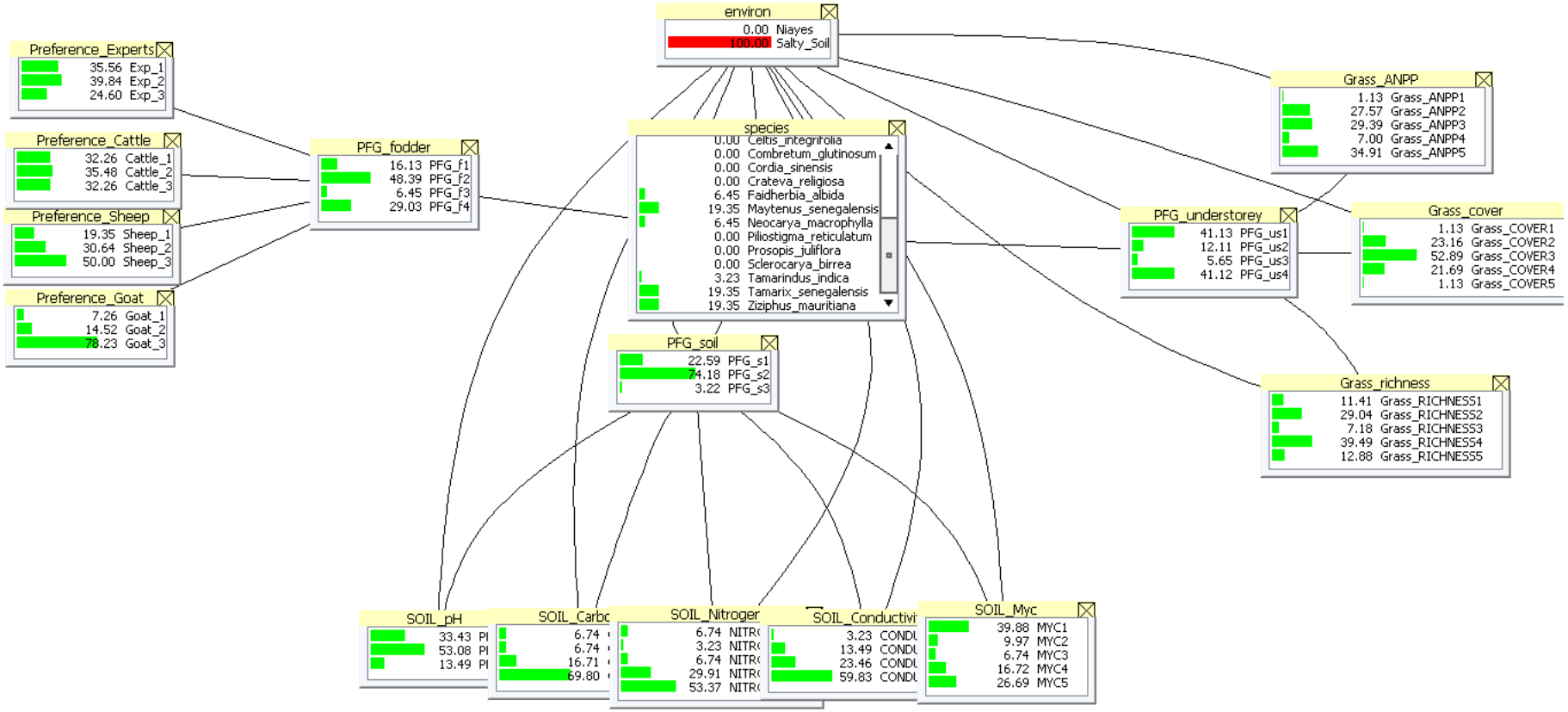
Fodder provision PFG



The Network


environ
78.62 Niayes
21.38 Salty_Soil
Preference_Experts
34.70 Exp_1
37.27 Exp_2
28.02 Exp_3
Preference_Cattle
34.97 Cattle_1
29.24 Cattle_2
35.79 Cattle_3
Preference_Sheep
19.31 Sheep_1
37.59 Sheep_2
43.10 Sheep_3
Preference_Goat
7.24 Goat_1
14.48 Goat_2
78.28 Goat_3
PFG_fodder
10.35 PFG_f1
46.21 PFG_f2
14.49 PFG_f3
28.96 PFG_f4
species
0.69 Acacia_nilotica
4.83 Acacia_senegal
1.38 Acacia_seyal
6.90 Acacia_tortilis
4.83 Adansonia_digitata
5.52 Annona_senegalensis
1.38 Aphania_senegalensis
5.52 Balanites_aegyptiaca
2.07 Bauhinia_rufescens
5.52 Boscia_senegalensis
6.20 Celtis_integrifolia
7.59 Combretum_glutinosum
Grass_ANPP
0.24 Grass_ANPP1
14.45 Grass_ANPP2
10.15 Grass_ANPP3
20.21 Grass_ANPP4
54.94 Grass_ANPP5
PFG_understorey
35.86 PFG_us1
27.55 PFG_us2
20.17 PFG_us3
16.42 PFG_us4
Grass_cover
15.04 Grass_COVER1
12.68 Grass_COVER2
28.52 Grass_COVER3
43.51 Grass_COVER4
0.24 Grass_COVER5
PFG_soil
32.41 PFG_s1
45.52 PFG_s2
22.07 PFG_s3
Grass_richness
12.50 Grass_RICHNESS1
29.66 Grass_RICHNESS2
15.51 Grass_RICHNESS3
35.71 Grass_RICHNESS4
6.62 Grass_RICHNESS5
SOIL_pH
29.07 PI
65.20 PI
5.73 PI
SOIL_Carbc
2.79
1.44
15.49
80.28
SOIL_Nitroger
2.79 NITR(
2.12 NITR(
4.14 NITR(
24.43 NITR(
66.53 NITR(
SOIL_Conductivi
2.12 CONDL
4.31 CONDL
10.56 CONDL
83.01 CONDL
SOIL_Myc
49.38 MYC1
11.92 MYC2
1.44 MYC3
18.34 MYC4
18.92 MYC5

The Network



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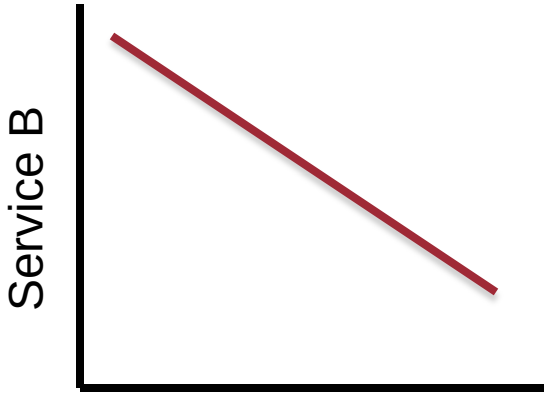
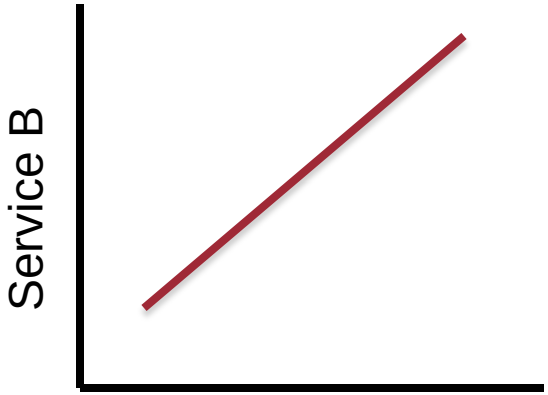
Trade-offs? Synergies?

- Study of the covariation of services

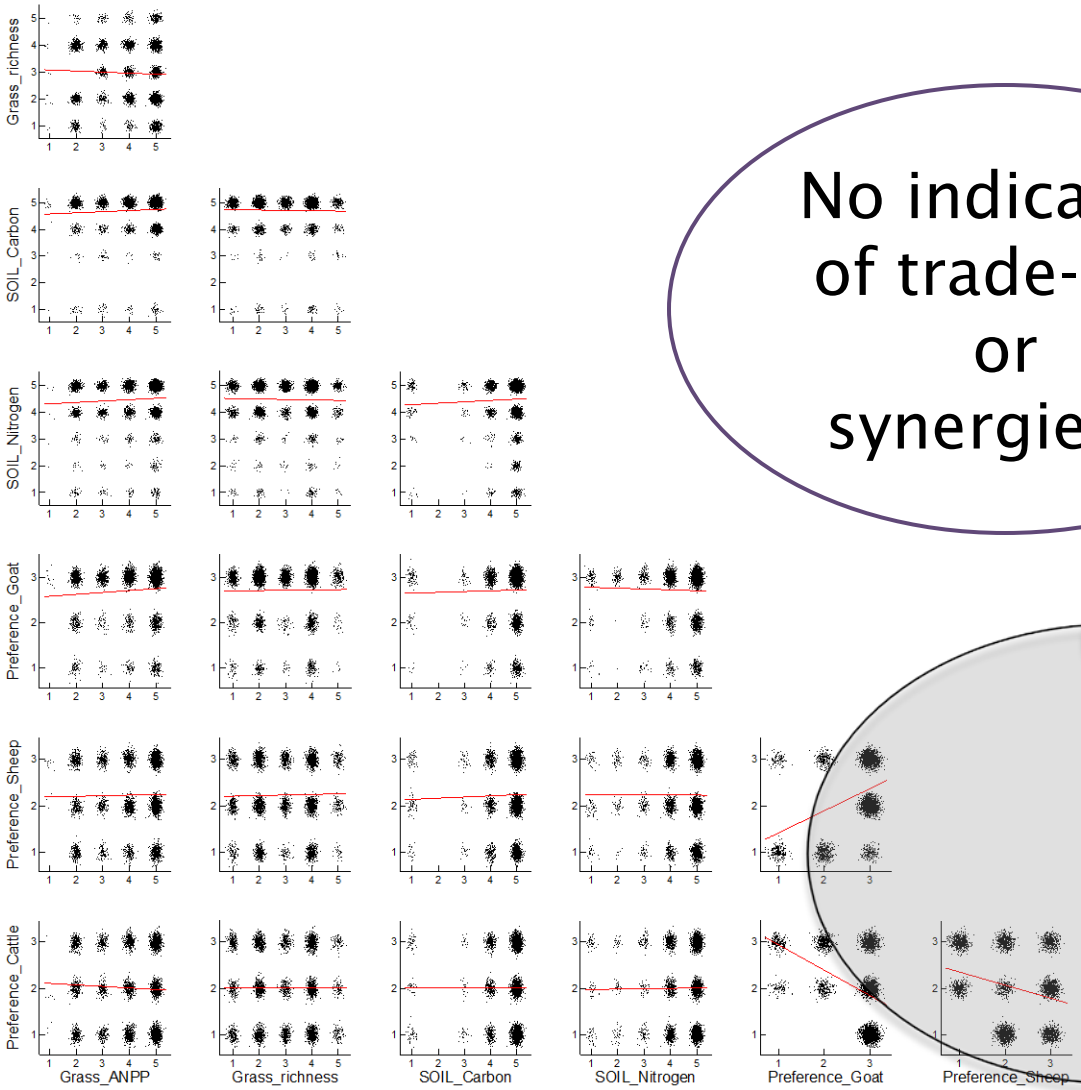
A Trade-off looks like this:



And this is a synergy:



Dataset with 10,000 simulated trees based on the BN values



No indication of trade-offs or synergies…

…except for animal preferences

CiTREE

Conclusions

- BN approach combined with the use of PFG seems adequate to study the interactions between environmental characteristics and trees and how they affect ES
- The PFG present in a given site are strongly determined by their environmental characteristics.
- Different PFG can have different effects on ES depending on environmental characteristics.
- We found no important trade-offs or synergies between different provision ES.

Thanks for your attention!!!

FUNCiTREE Final Conference, Trondheim, 23-25 May 2013

DEFINING FUNCTIONAL GROUPS OF TREE ACCORDING TO RURAL STAKEHOLDER PERCEPTIONS IN CENTRAL-MALI

FUNCITREE - WP3

Pierre CLINQUART, Bayo MOUNKORO, Hubert GUERIN,
Alexandre ICKOWICZ, Nicole SIBELET, Philippe THALER, Régis PELTIER

cirad
AGRICULTURAL RESEARCH FOR DEVELOPMENT

FUNCiTREE

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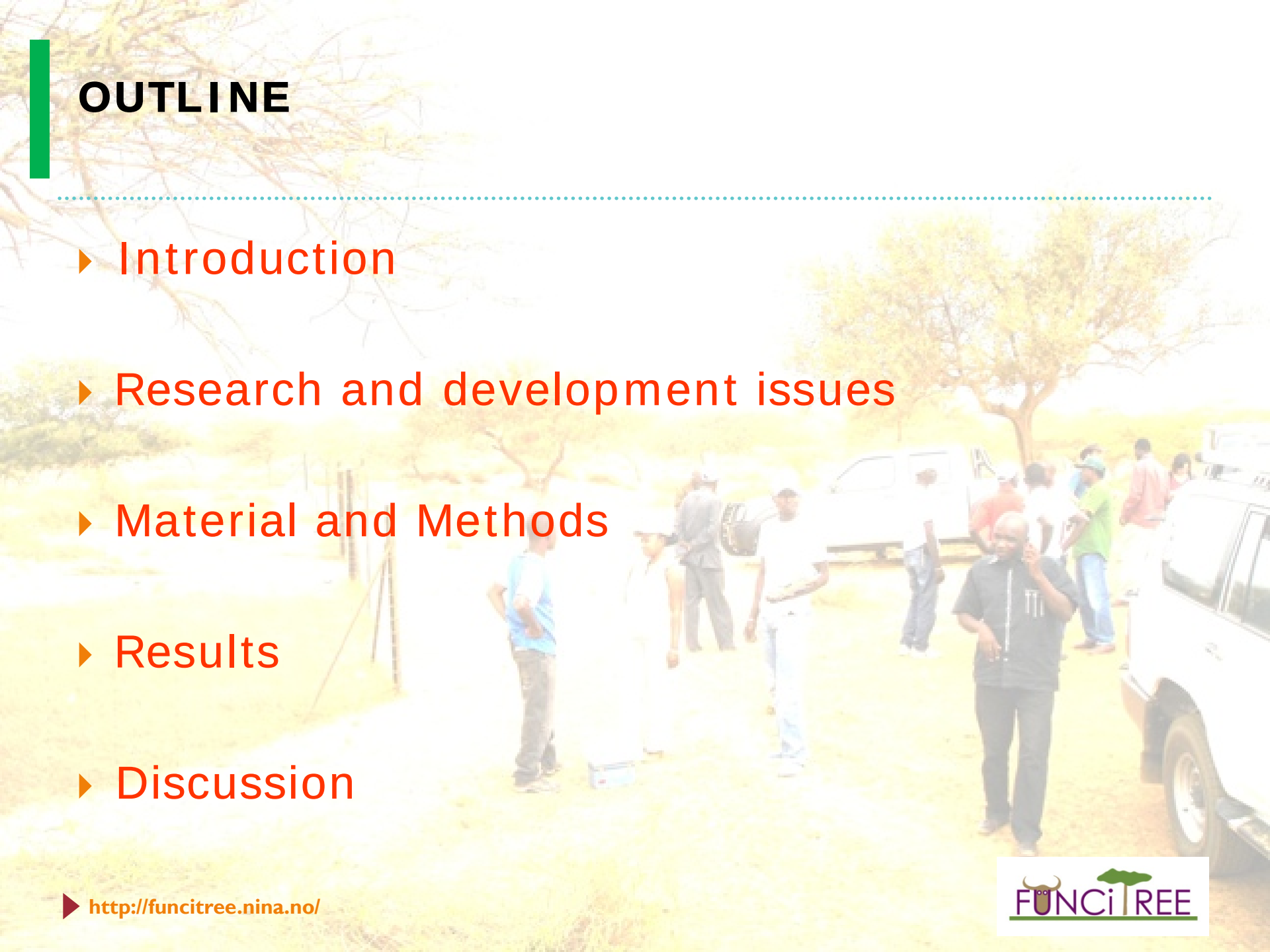
OUTLINE

- Introduction
- Research and development issues
- Material and Methods
- Results
- Discussion



INTRODUCTION

- Sahel :
  - High climate variability and drought
  - Demographic growth
  - Crop field expansion; high pressure on land
- Ecosystems :
  - Degradation of agroforestery parklands
  - Tree density globally decrease (Boffa, 2000)
  - Low regeneration; diversity loss (Rouxel et al. 2005)
  - Soil fertility loss

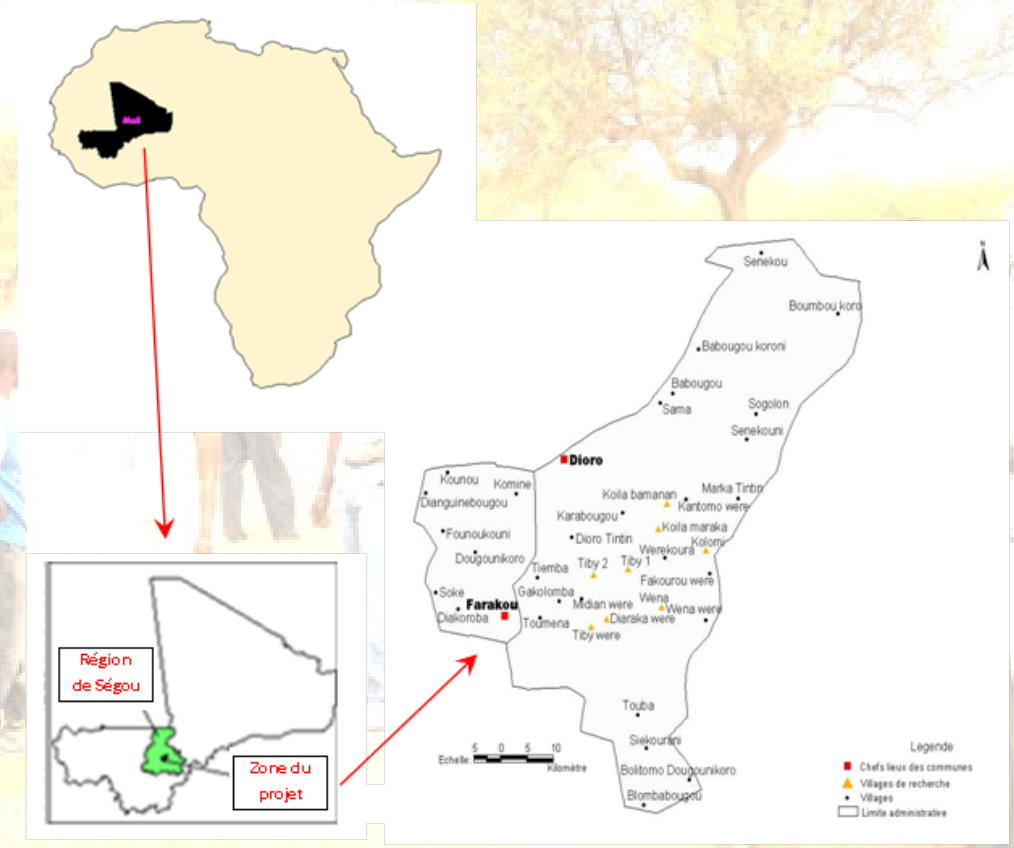
RESEARCH AND DEVELOPMENT ISSUES

- Sustainable Management of Agroforestry Systems
- Taking into account local stakeholders needs
- Diversity of stakeholders, uses and perceptions
- Management engineering of agroforestry systems
- How to help regeneration of trees and ecosystem services ?

MATERIAL AND METHODS

- Central Mali; Segou Area; Tiby village

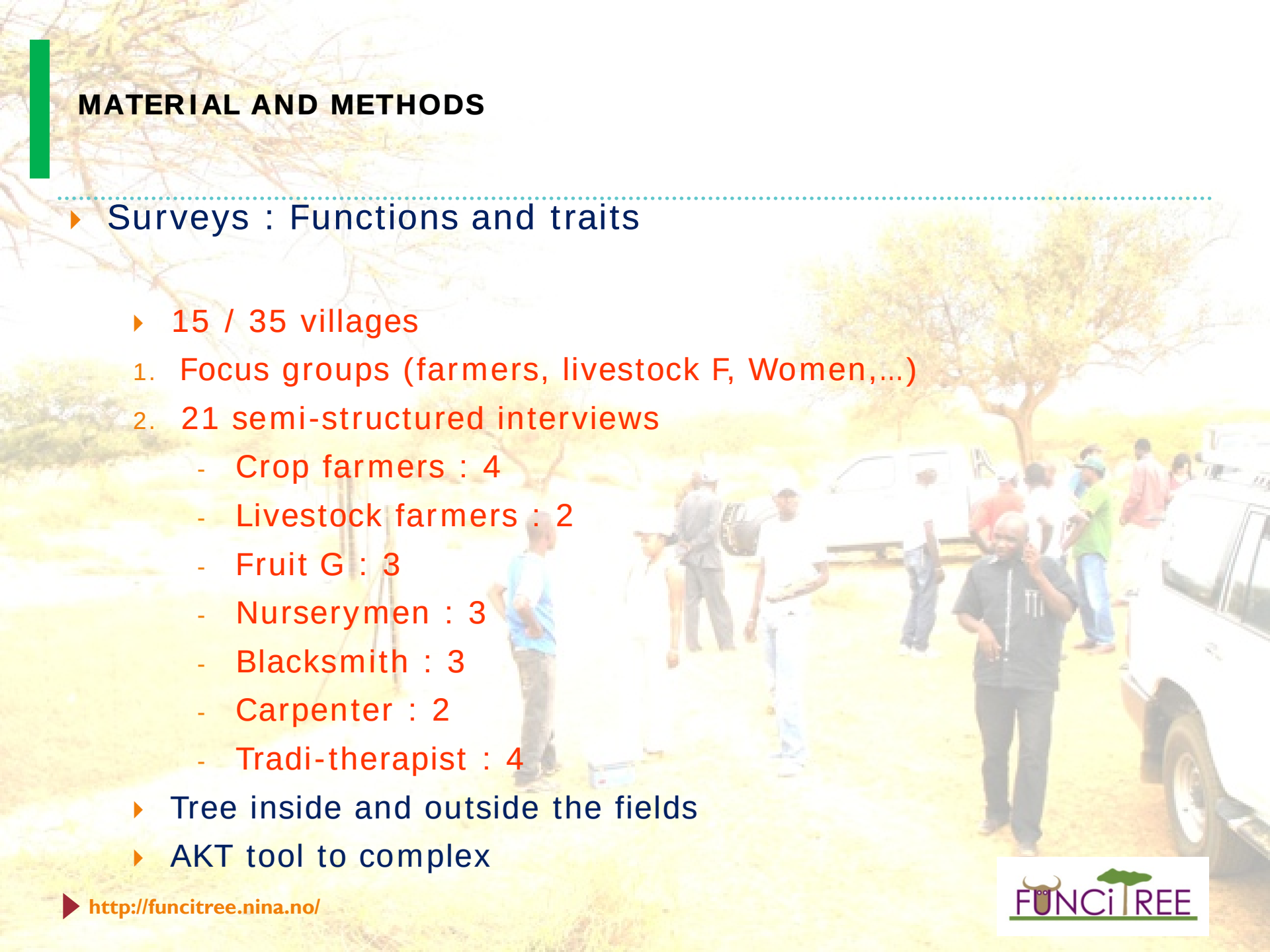
  - Soudano-sahelian zone
  - 600-800mm
  - Agrosylvopastoral
  - Rice
  - Rainfed crop
  - Gardening
  - Orchard
  - Livestock
  - Others stakholders



MATERIAL AND METHODS

- Surveys : Functions and traits

  - 15 / 35 villages
  1. Focus groups (farmers, livestock F, Women,…)
  2. 21 semi-structured interviews
     - Crop farmers : 4
     - Livestock farmers : 2
     - Fruit G : 3
     - Nurserymen : 3
     - Blacksmith : 3
     - Carpenter : 2
     - Tradi-therapist : 4
  - Tree inside and outside the fields
  - AKT tool to complex



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Results : Tiby database on tree functions and traits

Local knowledge about functions and functional traits of tree species in the agroforestry parklands of Tiby area, Segou region,										
Data collected by Pierre Clinquart from May to June 2010, Master										
Tree species			Organoleptic qualities					Consis		
N°	Common name (Bambara)	*Scientific name*	Bitter fruits	Acid fruits	Sweet fruits	Bitter leaves	Acid leaves	Fruits with few pulp	Fruits with dusty pulp	Fruits with firm pulp
1	Dogo iri	*Acacia colei*	0	0	0	0	0	0	0	0
2	Boina	*Acacia nilotica*	0	0	0	0	0	0	0	0
3	Patuku	*Acacia senegal*	0	0	0	0	0	0	0	0
4	Zadjé	*Acacia seyal*	0	0	0	0	0	0	0	0
5	Baki	*Acacia tortilis ssp. raddiana*	0	0	0	0	0	0	0	0
6	Zira	*Adansonia digitata*	0	0	1	0	0	0	1	0
7	Yégéré	*Albizia chevalieri*	0	0	0	0	0	0	0	0
8	Somo	*Anacardium occidentale*	0	1	1	0	0	0	0	0
9	Toubabou Sunsu	*Annona squamosa*	0	0	1	0	0	0	0	0
10	Galama	*Anogeissus leiocarpus*	0	0	0	0	0	0	0	0
11	Iri cunamani, Sa irini, Sumaya irini	*Azadirachta indica*	0	0	0	0	0	0	0	0
12	Zekené	*Balanites aegyptiaca*	0	0	1	0	0	0	0	1
13	Gessemé, Shiflé irini	*Bauhinia rufescens*	0	0	0	0	0	0	0	0
14	Diafarané	*Bixa orellana*	0	0	0	0	0	0	0	0
15	Bumbu	*Bombax costatum*	0	0	0	0	0	0	0	0
16	Sebé	*Borassus aethiopium*	0	1	1	0	0	0	0	0
17	Fogo fogo	*Calotropis procera*	0	0	0	0	0	0	0	0
18	Ndi	*Capparis sepiaria*	0	0	0	0	0	0	0	0
19	Mandjé	*Carica papaya*	0	0	0	0	0	0	0	0
20	Sinjan	*Cassia sieberiana*	0	0	0	0	0	1	0	0
21	Bana, Bané	*Ceiba pentandra*	0	0	0	0	0	0	0	0
22	Gamiah	*Celtis integrifolia*	0	0	1	0	0	1	0	0
23	Leburu kumuni	*Citrus limon*	0	1	0	0	0	0	0	0
24	Leburu ba	*Citrus sinensis*	0	0	0	0	0	0	0	0
25	Irini blé, Tangara	*Combretum glutinosum*	0	0	0	0	0	0	0	0
26	Golobé	*Combretum micranthum*	0	0	0	0	0	0	0	0
27	Dugura	*Cordyla pinnata*	0	0	0	0	0	0	0	0
28	Balembo	*Crossopteryx febrifuga*	0	0	0	0	0	0	0	0
29	Toubabou Néré	*Delonix regia*	0	0	0	0	0	0	0	0
30	Sunsu	*Diospyros mespiliformis*	0	0	0	0	0	0	0	0
31	Matolatun irini	*Eucalyptus camaldulensis*	0	0	0	0	0	0	0	0
32	Sinjiba	*Euphorbia balsamifera*	0	0	0	0	0	0	0	0
33	Balanzan	*Faidherbia albida*	0	0	0	0	0	0	0	0
34	Djatigifa iri, Zeré, Zerenijé	*Ficus iteophylla*	0	0	0	0	0	0	0	0
35	Gaba	*Ficus platyphylla*	0	0	0	0	0	0	0	0
36	Toro	*Ficus sycomorus ssp. gnaphalocarpa*	0	0	0	0	0	0	0	0

Results : Relationship between functions and species

Production functions in Tiby (Clinquart et al, in prep)

Production functions	Human food	Animal feed	Firewood	Timber	Income	Human pharmacopeia	Animal pharmacopeia	Various domestic uses	Magic-religious uses
Number of species	32	46	49	35	42	55	14	17	8

Results : Relationship between functions and species

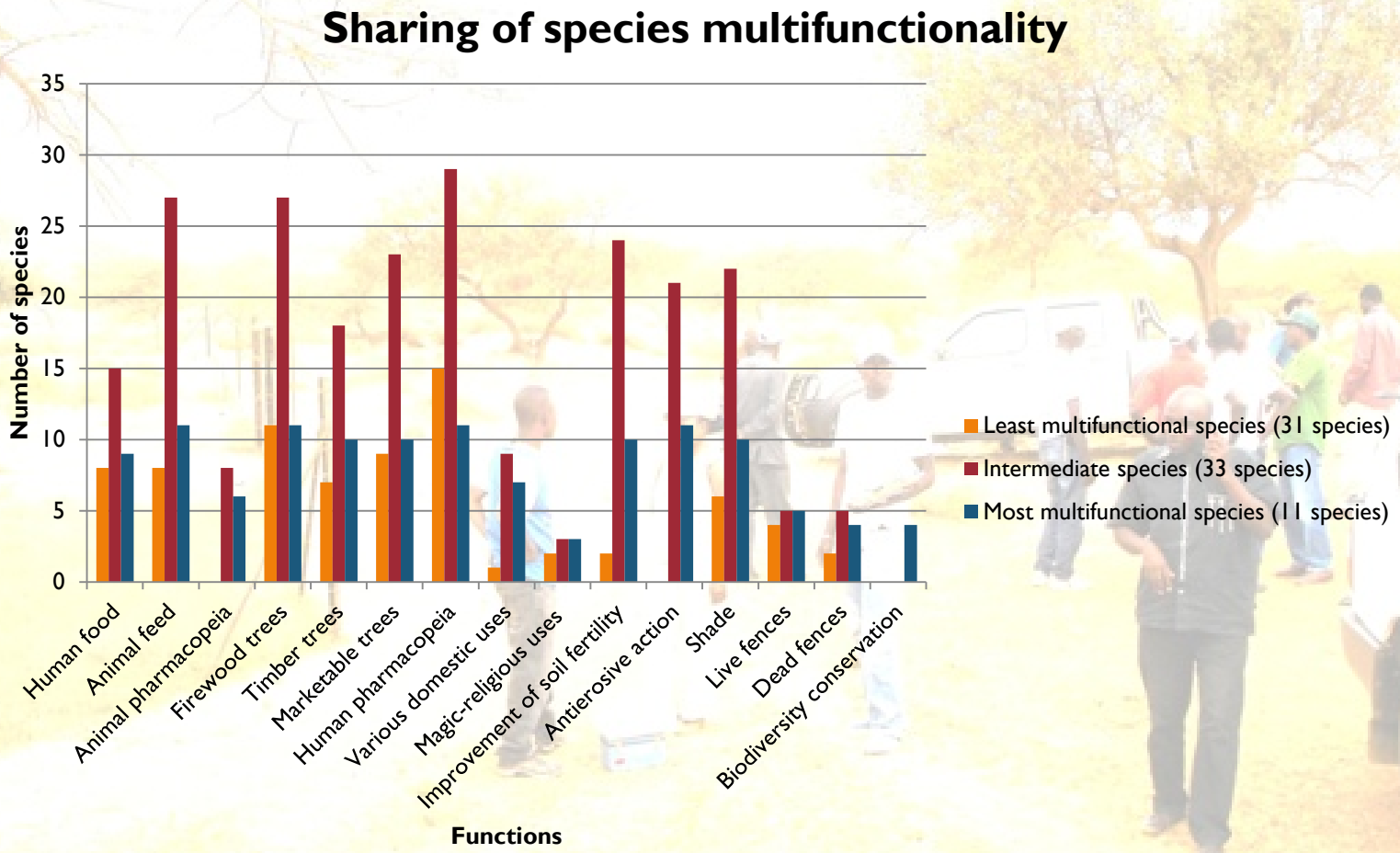
Support functions (Clinquart et al, in prep)

Support functions	Improvement of soil fertility	Antierosive action	Shade	Live fences	Dead fences	Biodiversity conservation
Number of species	36	32	38	14	11	4

Socio-cultural functions

Socio-cultural functions	Land mark	Patrimony	Esthetic
Number of species	21	10	2

Results : Multifunctionality of species



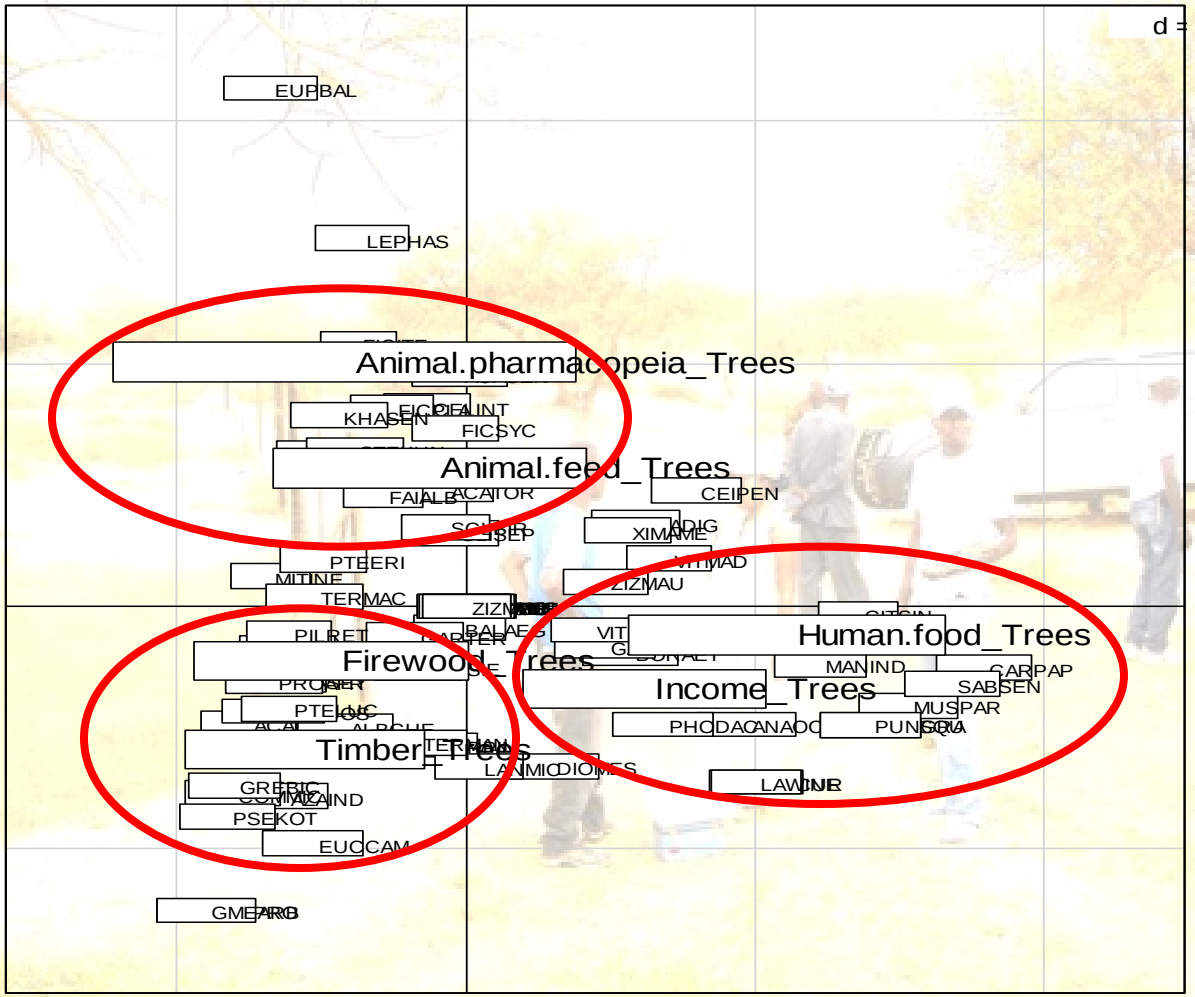
http://funcitree.nina.no/

Results : Relationship between functions and species

Unifunctional species (Clinquart et al, in prep)

Unifunctional species	Function fulfilled
Acacia colei	Firewood
Bixa orellana	Domestic use (food condiment)
Carica papaya	Human food
Delonix regia	Shade
Gmelina arborea	Timber
Maerua angolensis	Human pharmacopeia
Maytenus senegalensis	Human pharmacopeia

Results : Functional groups

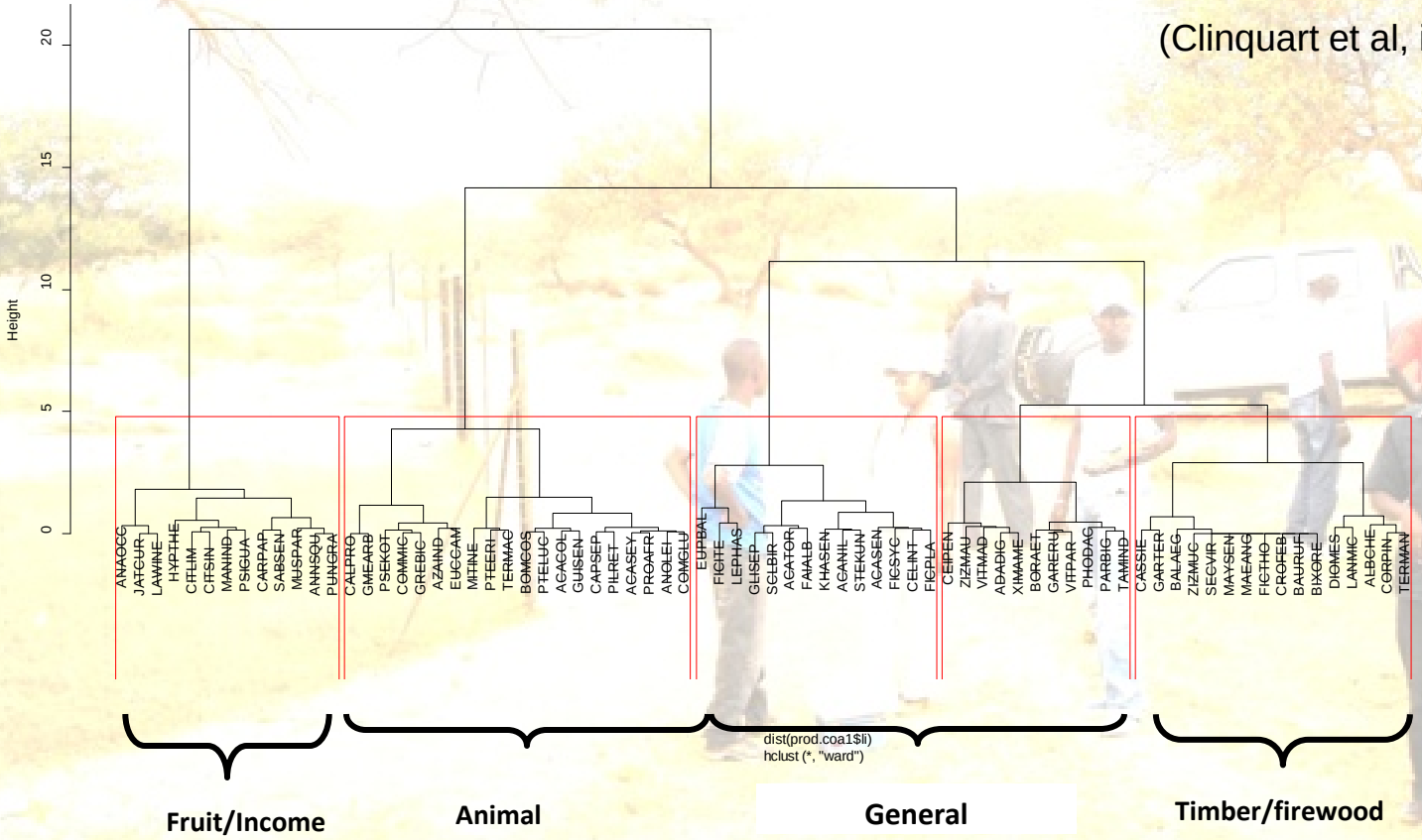


http://funcitree.nina.no/

Results : Identification of functional groups

Figure 5: Hierarchical classification resulting of the COA concerning production functions of tree species according to farmers in Tiby (Mali)

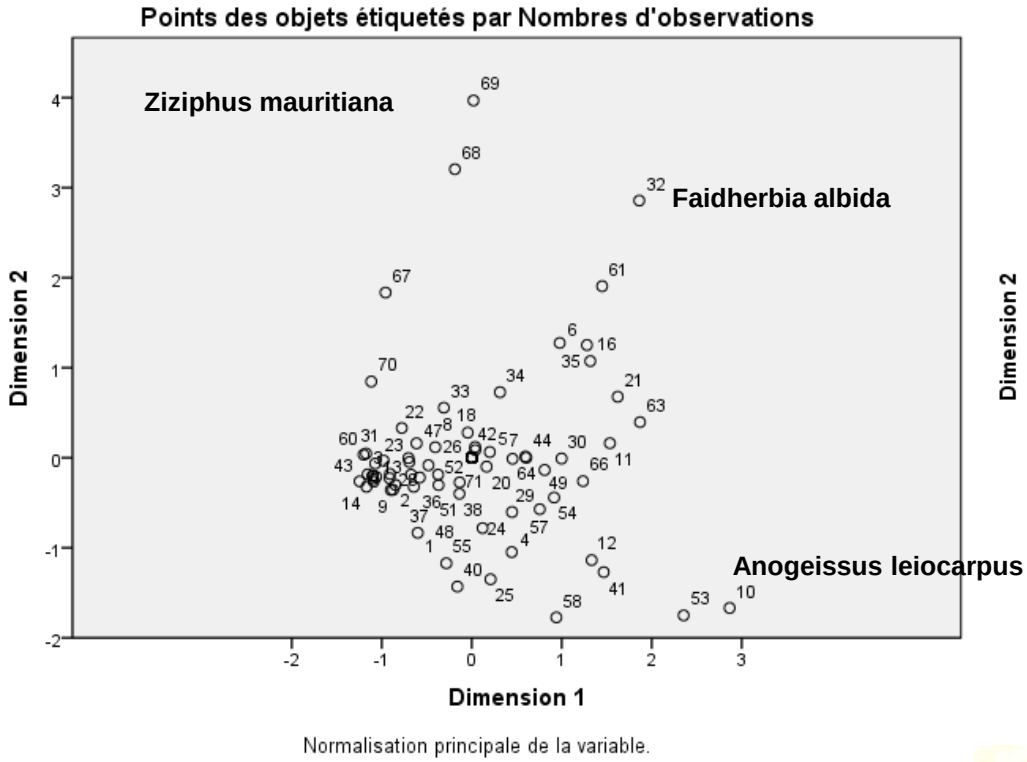
(Clinquart et al, in prep)

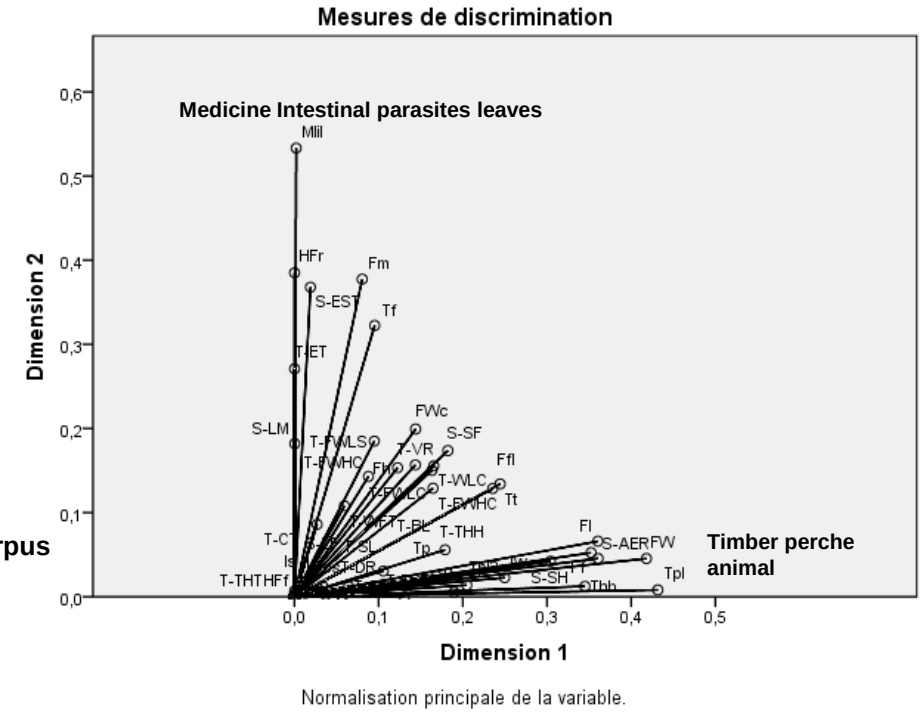


http://funcitree.nina.no/

Results : Functional groups

Relations between traits and funtions and functional groups





http://funcitree.nina.no/

CONCLUSION : FUNCTIONAL GROUPS ACCORDING TO FARMERS PERCEPTIONS OF TREE SPECIES AND THEIR TRAITS

- Important and diversified local needs from trees
- Many functions and multifunctional trees but some are more looked for
- Some functions relate on few species (cultural)
- Change of species when overexploited
- Relevant traits/functions need to be well understand
- Integrate local knowledge in AF Ingeneering

FUNCiTREE

Functional Diversity:
An ecological framework for sustainable and adaptable agro-forestry systems in landscapes of semi-arid ecoregions.

Based on the principles of functional ecology, FUNCiTREE addresses the provision of multiple services of silvopastoral systems (SPS) in semi-arid regions in Africa and Central America. FUNCiTREE aims to provide farmers in the regions with a portfolio of regionally suitable tree species that are capable of providing multiple services. The project integrates theories and concepts from agroforestry and ecological science and will provide a scientifically based model for the design of modernized SPS.

NINA (Norway): The leading research center in Norway on applied ecology, emphasizing the interaction between human society, natural resources and biodiversity

CATIE (Costa Rica): A regional research and education centre about agricultural sustainability, environmental protection and poverty eradication

WUR (The Netherlands): Internationally leading university in agricultural Almeria has a focus on organism responses to drought, ecological interactions, biodiversity conservation, desertification, and soil science

CIRAD (France): Research on agro-ecosystems for international sustainable development, environmental, and climate research

CSIC (Spain): Research at the Arid Zones Research Station,

ISRA (Senegal): Priority areas relate to agronomic, animal and forest production, and rural economy

IER (Mali): The leading research centre in Mali on agriculture and agro-ecosystems.

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