5TH INTERNATIONAL CONGRESS ON PLANTED FORESTS

Session 3a: Best practices and innovations for the sustainable management of planted forests

Co-organizers

iefc Institut Européen de la Forêt Cultivée

Food and Agriculture Organization of the United Nations

CIFOR

World Agroforestry

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REPUBLIC OF KENYA MINISTRY OF ENVIRONMENT, CLIMATE CHANGE & FORESTRY

KENYA Forest Service

KENYA FORESTRY RESEARCH INSTITUTE KEFRI

TreeDivNet MixForChange

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SCION FORESTS ▪ PRODUCTS ▪ INNOVATION

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Session 3a: *best practices and innovations for the sustainable management of planted forests*

Margarida Tomé	A tool to support landowners' and policy decisions
Daniel Dompreh	Assessing Cocoa farmers' perception on the phenological changes and resilience of five selected shade trees: a strategy for mixed plantation and an ecosystem restoration in the Adansi North District and Offinso Municipality of Ghana
Mostarin Ara	Assessment of soil nutrients and understory vegetation composition in pure vs mixed spruce–aspen forests
J. G. Kariuki	Breeding of *Melia volkensii*: Establishment of Clonal Seed Orchards and Subsequent Progeny Trials in Kenya
James K. Ndufa	Effects of different tree spacing on growth performance of *Melia volkensii* stand planted in two sites in drylands of Kenya
Abebe Damtew	Enhancing Planting Success of Native Trees in Dry Tropical Areas: implications for Restoration
Alice Adongo Onyango	Influence of cone physical characteristics and extraction exposure duration on seed yield of *Pinus patula*
Pauls Zeltins	Solution for climate-smart forestry of Norway spruce combining tree breeding and silviculture
Hervé Jactel	The importance of tree species diversity for the resistance of planted forests to insect damage
Hui Wang	The non linear relationship between tree species richness and top soil organic carbon stock in a subtropical mixed-species planted forest
Silvio Ferraz	Creating smart landscapes for improving ecosystem services in forest plantations at tropical region










ARF@Pt

A tool to suport landowners' and policy decisions in Portugal

Margarida Tomé

Susana Barreiro

Marta Baptista-Coelho

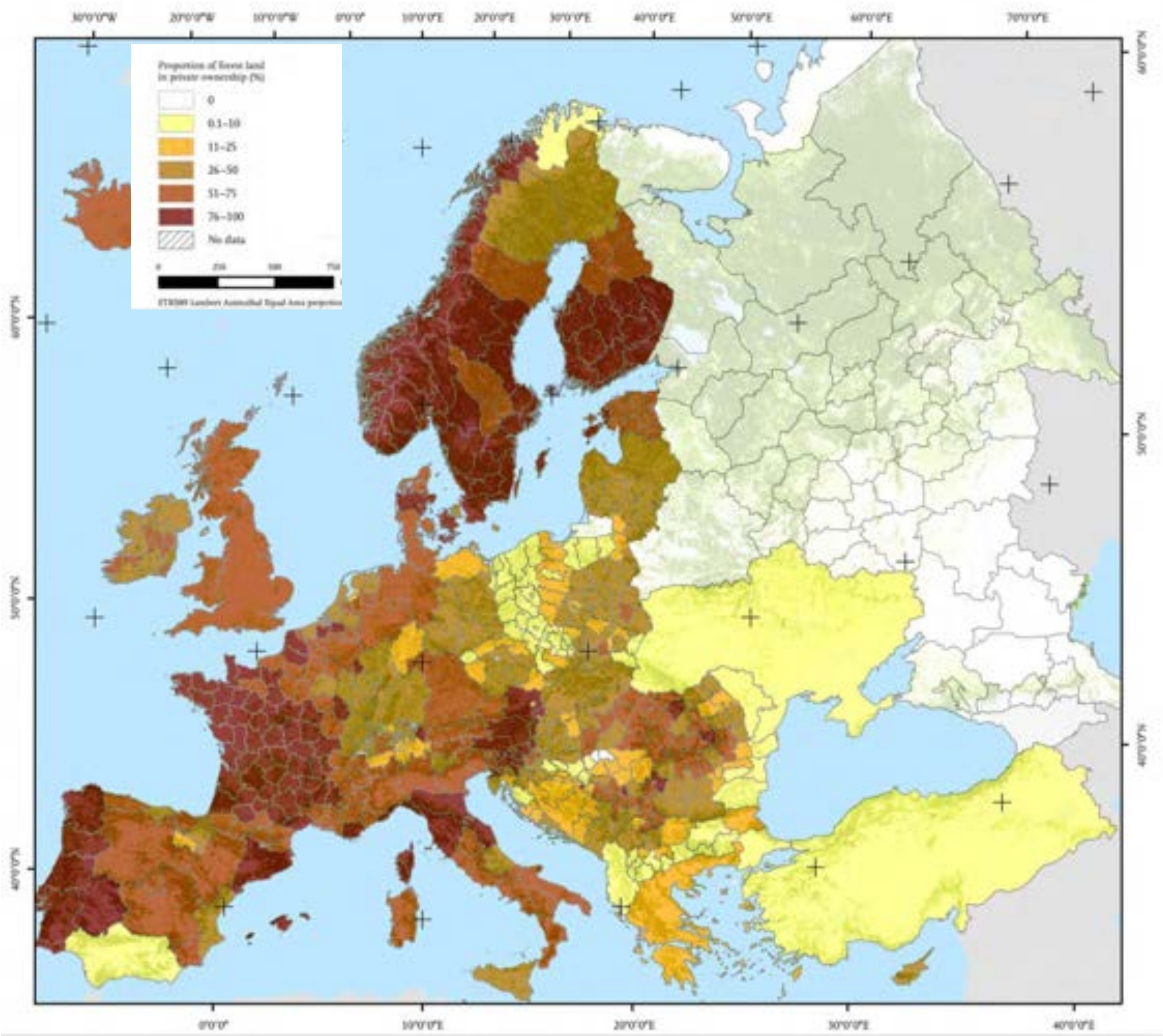
António Correia

Instituto Superior de Agronomia
Centro de Estudos Florestais
Universidade de Lisboa

▪ The “profitability” of the forest in Portugal

- ✓ Portuguese forest is characterized by a very high percentage of private forest, with very fragmented ownership

Private forest ownership - EFI TR 88



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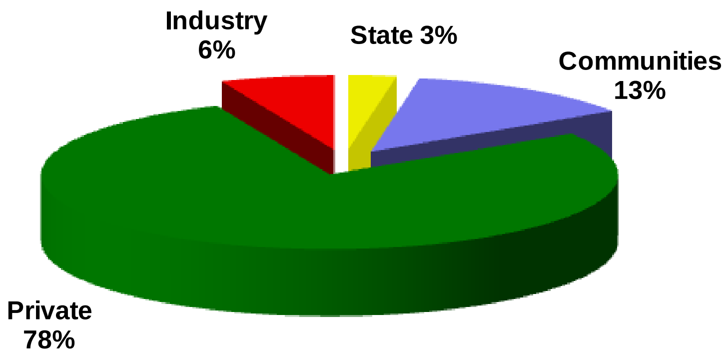
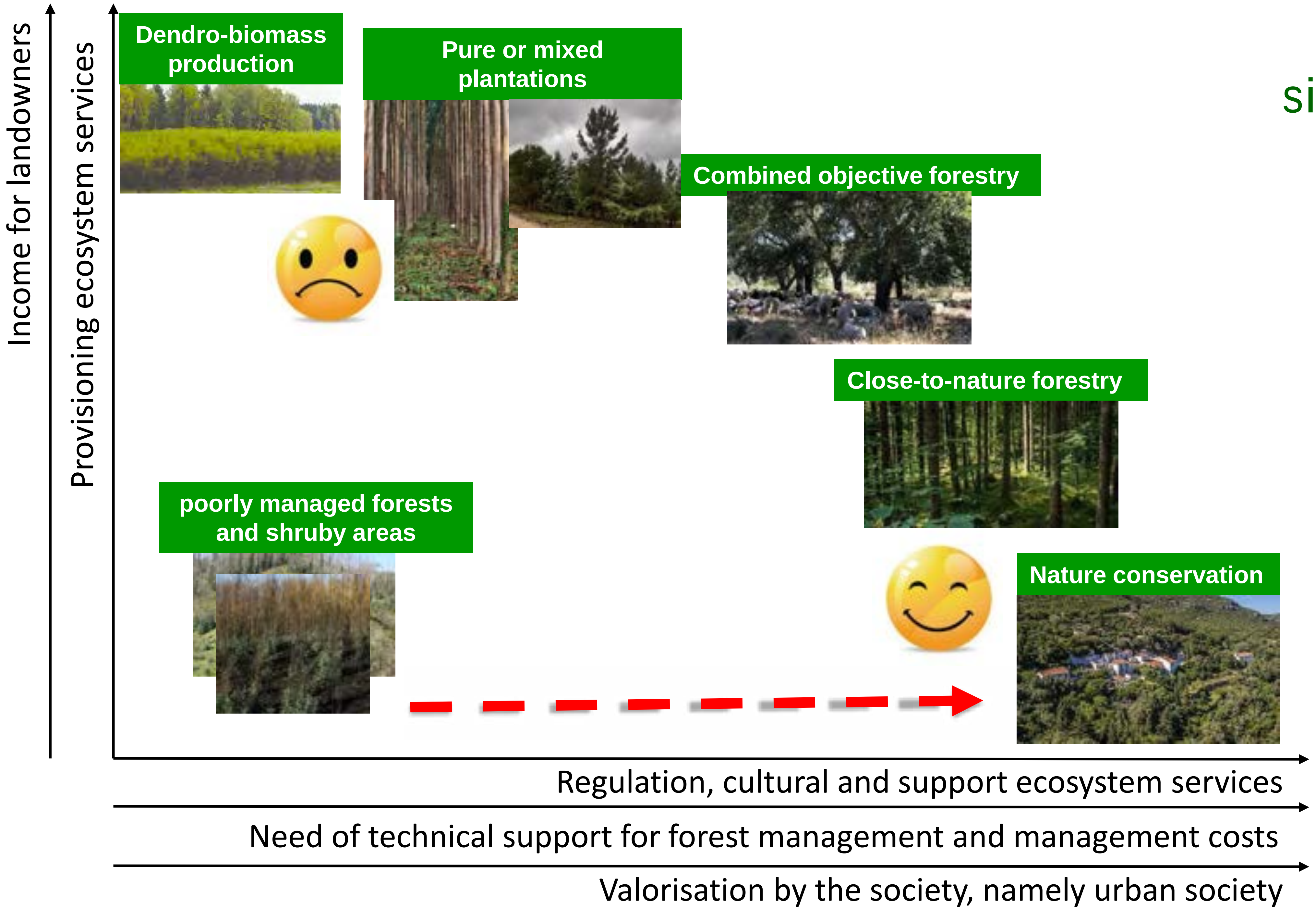
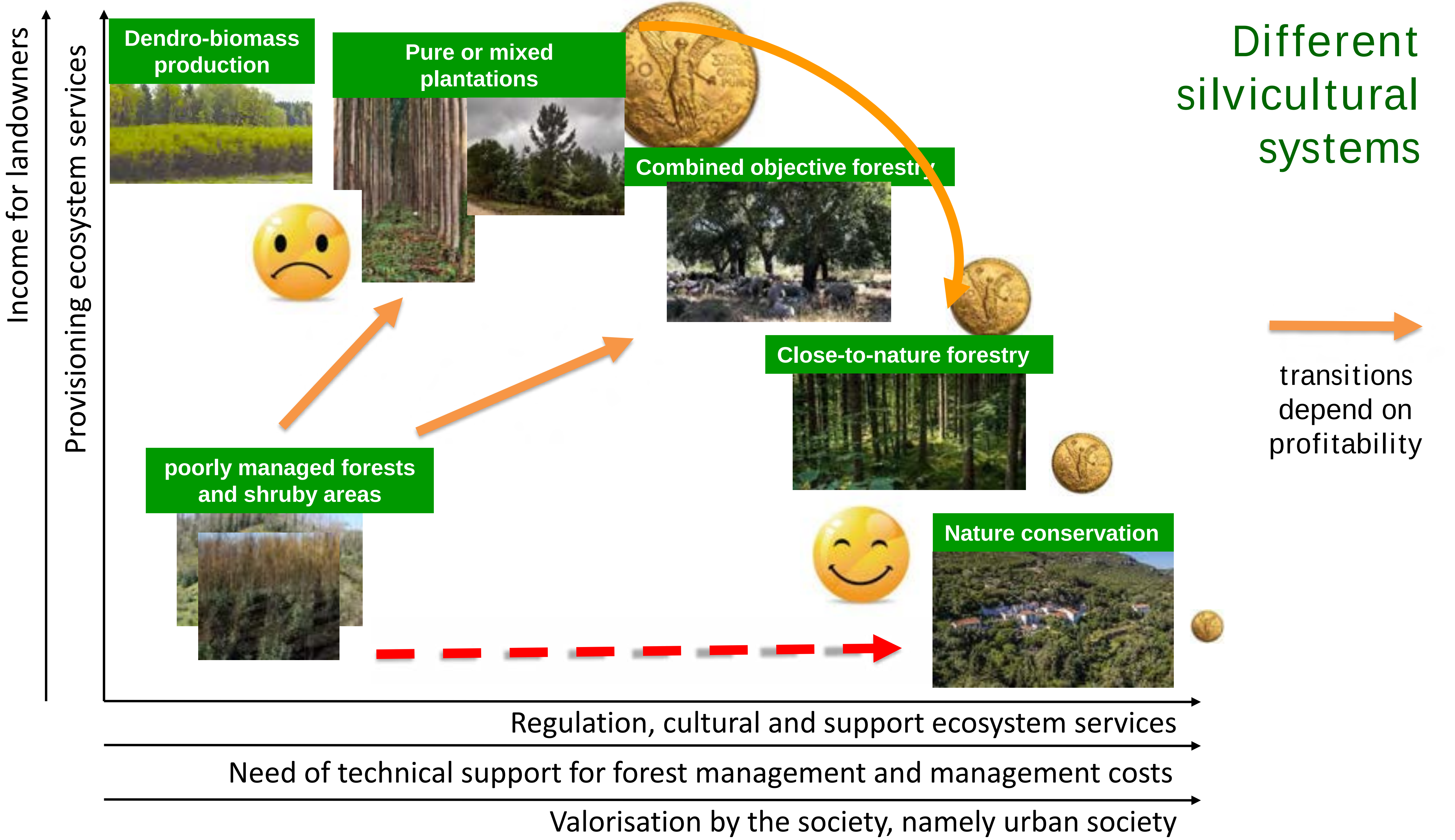


▪ The "profitability" of the forest in Portugal

- ✓ Portuguese forest is characterized by a very high percentage of private forest, with very fragmented ownership
- ✓ A large percentage of the private forest is characterized by **"poor"** or even **"non-existent"** management
- ✓ The low profitability generally associated with most forest ecosystems in Portugal is identified as one of the main causes of the poor management and leads to
  - the abandonment of a large part of the areas
  - some bias in the selection, from private owners, of species and silvicultural systems

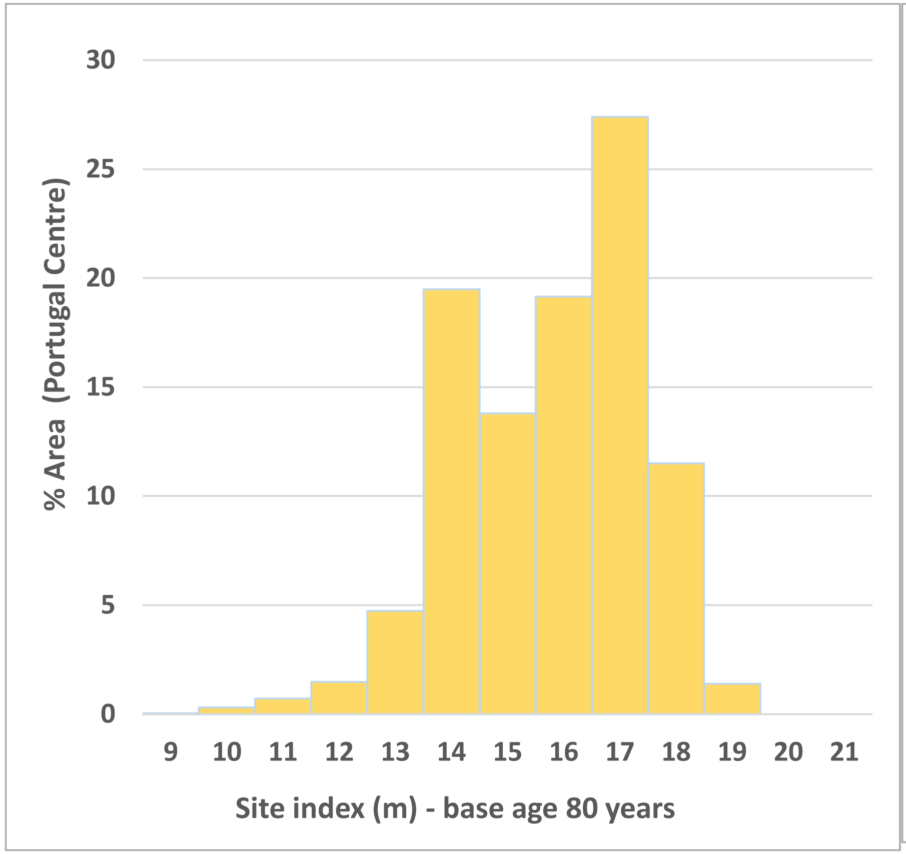
Different silvicultural systems





Income for landowners
Provisioning ecosystem services
Dendro-biomass production
Pure or mixed plantations
Combined objective forestry
Close-to-nature forestry
poorly managed forests and shruby areas
Nature conservation
Different silvicultural systems
transitions depend on profitability
Regulation, cultural and support ecosystem services
Need of technical support for forest management and management costs
Valorisation by the society, namely urban society

Cork oak



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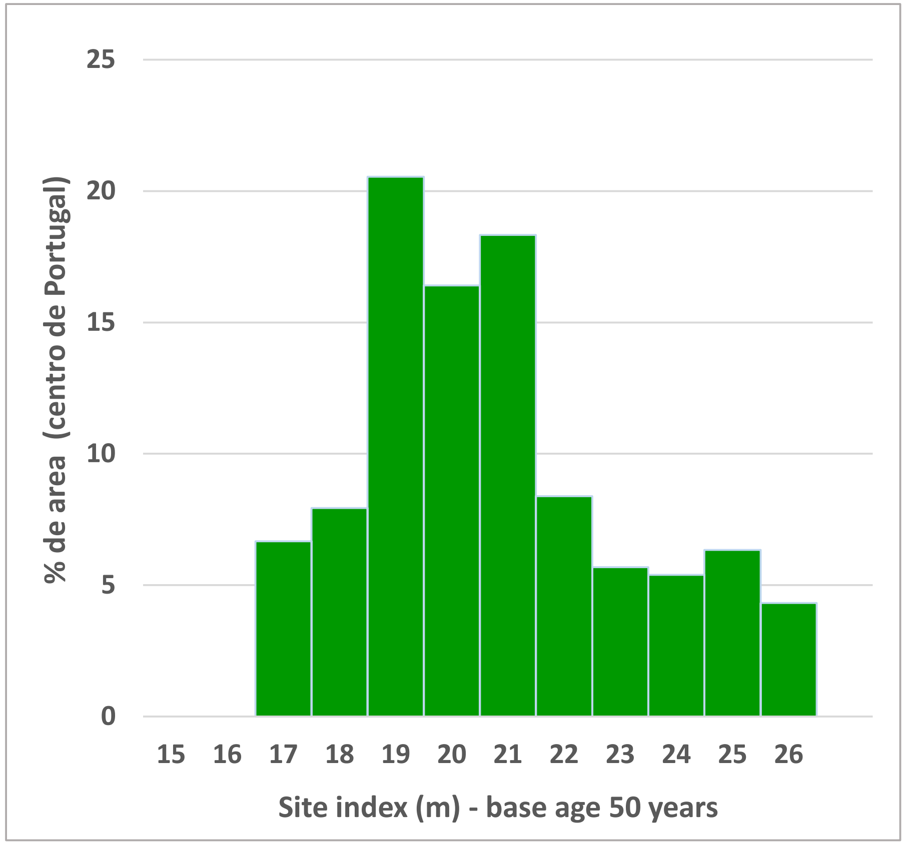
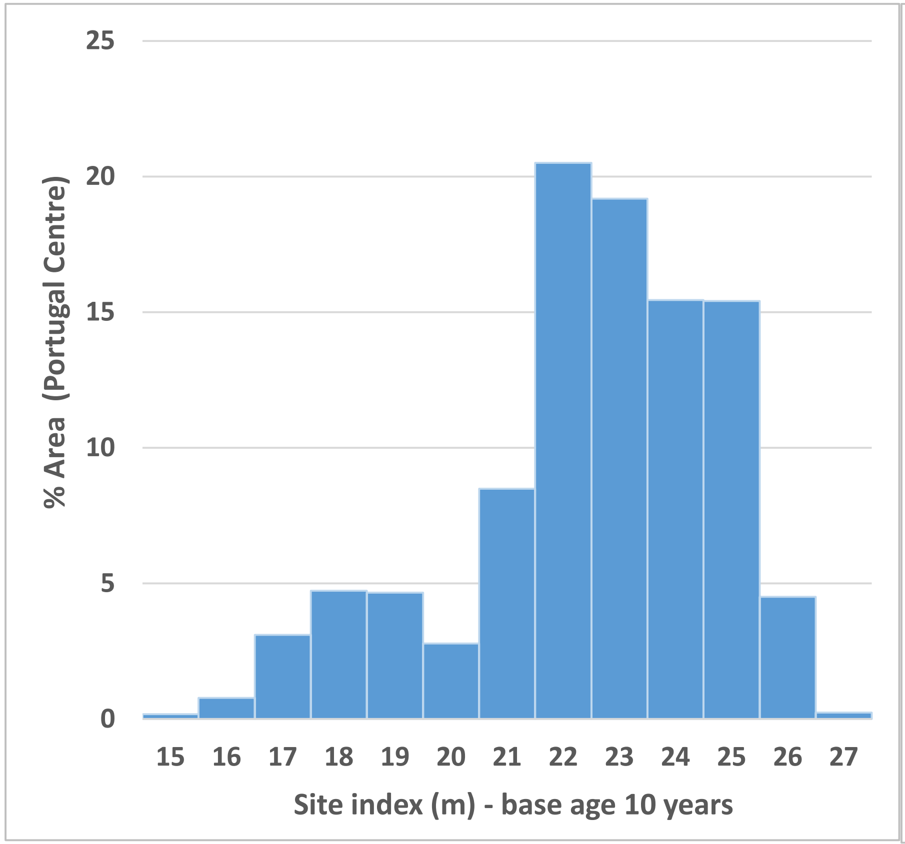
Site index (m) - idade padrão 80 anos

Maritime pine



Eucalyptus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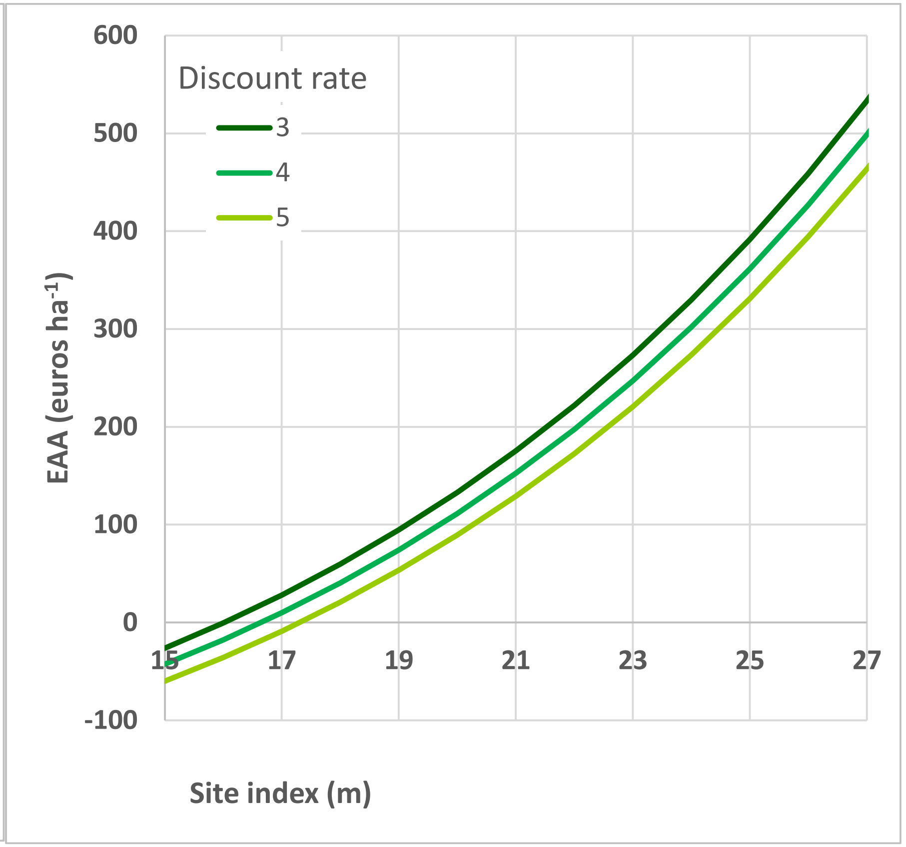
Site index (m) - base age 10 years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Site index (m)

▪ ARF@PT - a participatory task force

- ✓ A detailed and correct analysis of the costs and revenues associated with the plantation and management of stands of different species using different silvicultural systems and forest operations schedules is essential to
  - understand the true dimension of the problem (is in fact not profitable to invest in plantations in Portugal?)
  - find solutions to improve the situation
  - support policies that compensate forest owners for the selection of forestry options that are less profitable in relation to the "direct" goods but more relevant for public services provided by the forest (payment of public ecosystem services by the difference between the "best" economic solution and more close to nature solutions?)

▪ Starting point

✓ The ForChange groups has provided several tools (among which forest simulators) in the FCTOOLS website

https://www.isa.ulisboa.pt/cef/forchange/fctools/en/home (write FCTOOLS in google)

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    - PINASTER
    - PBIRROL
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    - SUBER
  - Generator
  - Simulators
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    - WebGlobulus
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      - Yield table
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      - StandsSIM.dd
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  - Yield-Safe Model
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    - Montado & Cortiça

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Search

ForChange Group

The ForChange group works in the areas of forest resources inventory and modeling, and agroforestry. As a result of several national and international research projects undergoing in these areas, the group has been developing several tools that aim to support forest management and agroforestry. Considerable efforts have been put into the development of several growth and yield models that have been integrated in stand and regional level simulators.

Being part of Centro de Estudos Florestais, the work developed has been mainly disseminated at academic level at Instituto Superior de Agronomia, being sometimes difficult to extend its dissemination, which not only compromises the knowledge transfer to the end user, but also narrows the cooperation opportunities that could bring more added value to the technical and scientific development of forest and agroforest management.

As a research group, ForChange is responsible for the constant development of new tools combined with the continuous improvement of the existing ones.

Forchange Tools website was created with the purpose of facilitating the access of all users to the existing tools allowing downloading its latest versions (registration required). In FcTools the user will find the descriptions of the models and simulators developed for the main tree species in Portugal.

For more information contact us.

POR 15:36 06/11/2023

▪ Starting point

- ✓ The ForChange groups has provided several tools (among which forest simulators) in the FCTOOLS website

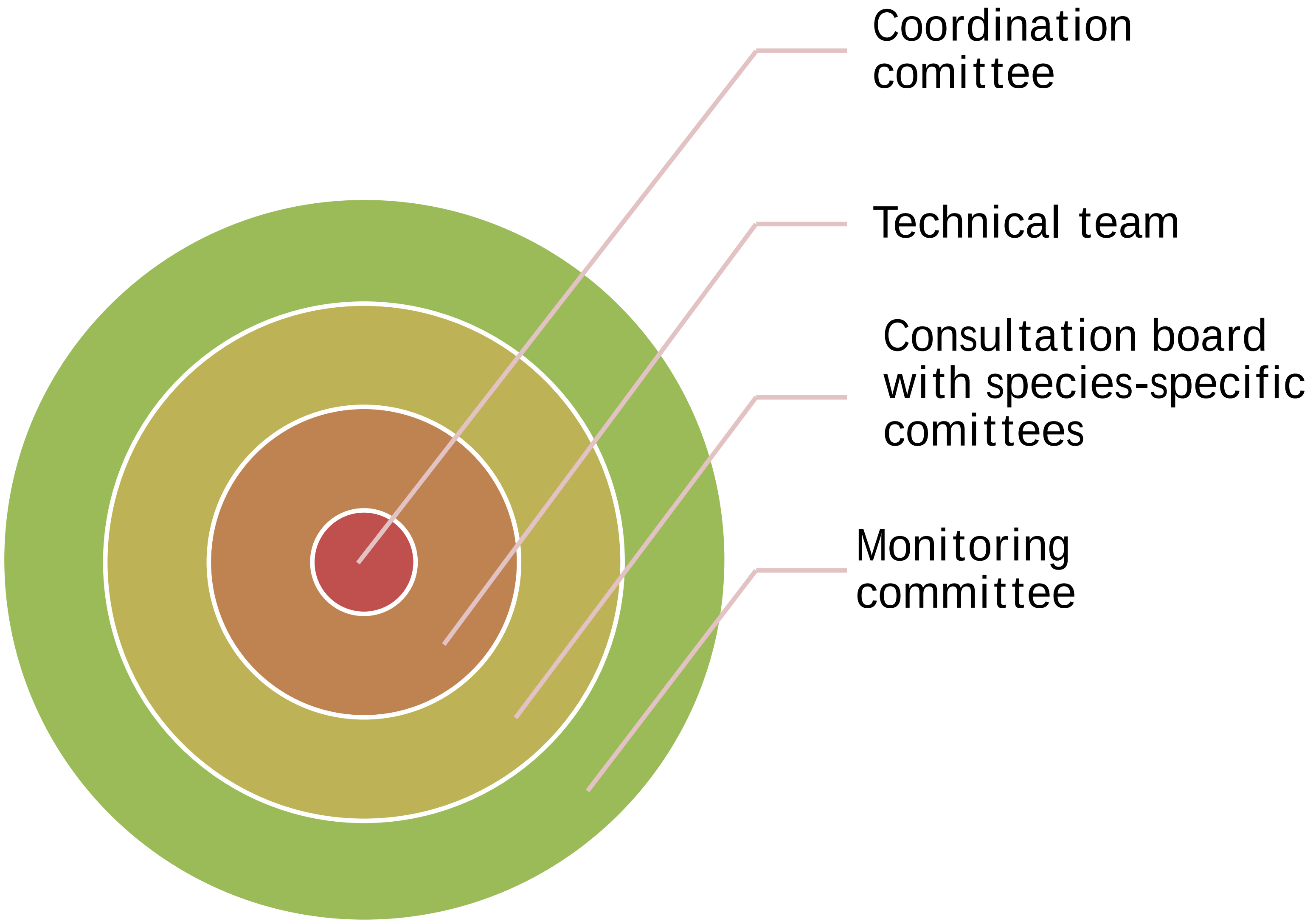
  https://www.isa.ulisboa.pt/cef/forchange/fctools/en/home (write FCTOOLS in google)

- ✓ Some of the simulators (SUBER and standsSIM) include economic analysis among the output, but they are so flexible that the users find them "too difficult" to use

- ✓ The users like the WebGlobulus simulador but this does not include economic analysis

- ✓ The objective of the ARF@pt task force is to develop an "easy to use" tool to provide the economic analysis for the most important tree species from Portugal

- Organization of the task force



Consultation board

Group	Institution
I&D	ISA
	UTAD
	UÉvora
	IPB
	IPC-ESAC
	IPCB
	INIAV
Associations of landowners	UNAC
	Forestis
	CAP
Public administration	ICNF

Group	Institution
Service provider companies	ANEFA
	Florestas Sustentáveis
Industry	CELPA
	ALTRI
	Navigator
	Centro PINUS
	SONAE
NGOs	FSC Portugal
	Casa Velha
	2B Forest

▪ Monitoring comittee and dissemination

- ✓ A wide list of everyone interested in following this study (just need to send as an email)
- ✓ There is an on-going development of an interactive tool to facilitate the use of the results of the ARF@pt project
- ✓ The interface for ARF@pt tool will be available in the FCTOOLS website
- ✓ We will organize workshops for the dissemination of the tool

▪ ARF@pt project steps (1/4)

✓ Ecological envelopes for each species (EES)

✓ Models for the estimation of site index (S) for the species that can be selected for that site

- for each IFN pixel do IFN (500 x 500 m), and for each species that may occur in this pixel according to the EES, predict the average S, as well as the 5%, 25%, 75% and 95% percentiles
- to define the conditions for a S close to the average or the upper and lower limits, preferably with a model (as exists for the cork oak), but which can just be a set of “rules”
- alternatively the user may provide detailed soil information if a more complete model is available for the species

▪ Models to estimate site index (need improvement)

Species	**Independent variables**		**Coverage of the species' distribution area with data**	**Quantile regression**
	Collected from maps	Obtained from a soil pit with analysis of soil profile		
Maritime pine	X		Reduced	No
Eucalypt	X		Good	Yes
Cork oak – reduced	X		Reasonable	No
Cork oak – detailed		X	Reasonable	No

Objective for each species:

- a quantile regression model
- a detailed model with data from a soil profile

▪ ARF@pt project steps (2/4)

- ✓ Definition, for each species, of typical **"site conditions"** (slope, stoniness, etc)
- ✓ Definition, for each "site condition", the silvicultural systems and the associated operations along the planning horizon
  - – New plantations and existing stands
  - – Alternative silvicultural systems from intensive silviculture to more "close to nature" silvicultural systems
  - – At present we are focusing just new plantations, including the ones that are managed with a 1st high forest cycle followed by a few coppice cycles, and new stands from natural regeneration

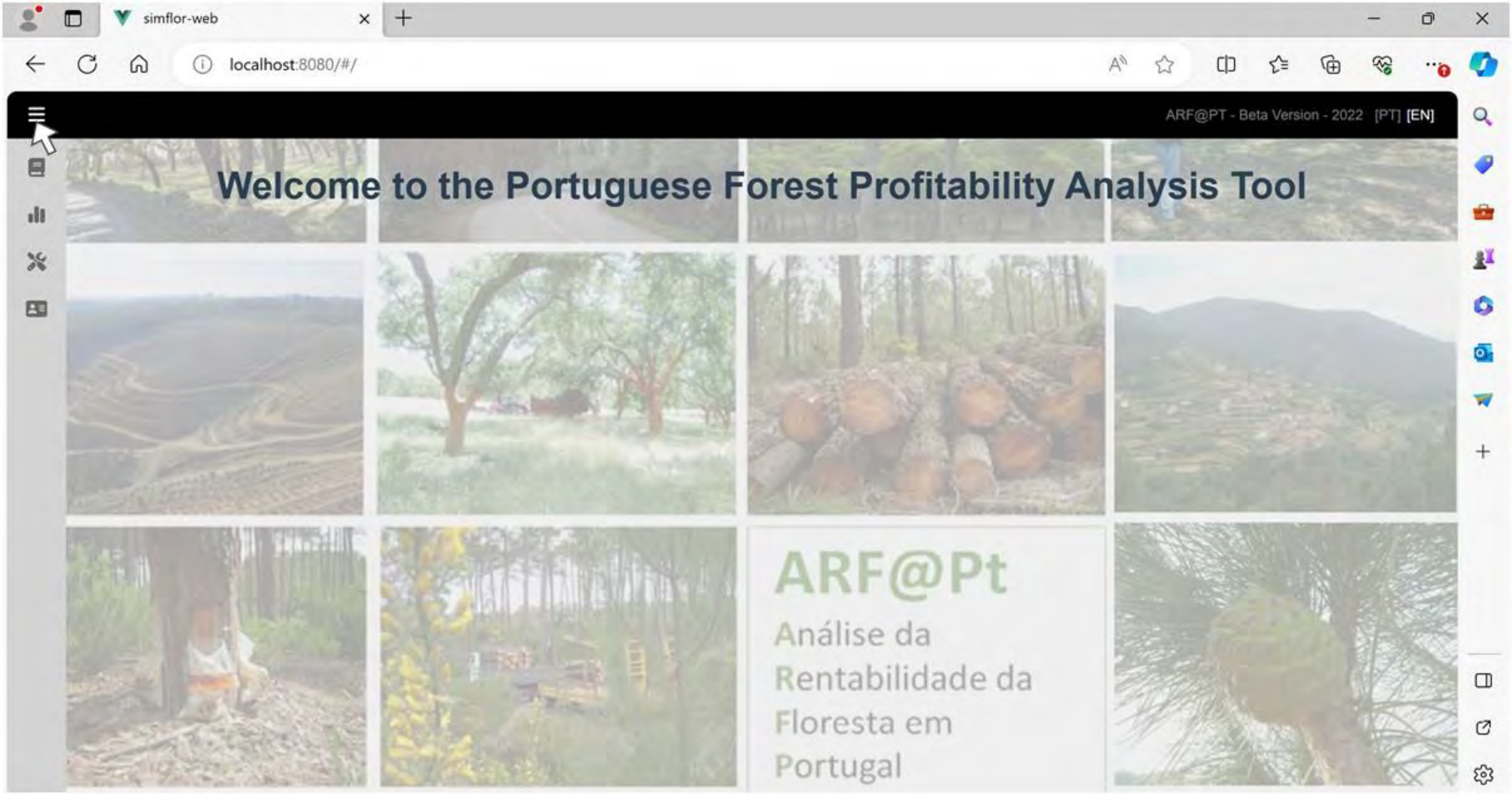
▪ ARF@pt project steps (3/4)

- ✓ Identification, for each site condition, of all the forest operations during the planning horizon
- ✓ Adoption of cost and prices to be used in the economic analysis
  - Costs of the forest operations
  - Prices for the products that will be provided during the planning horizon
  - Identification of other funding (e.g. subsidies or other incentives)
- ✓ The Consultation Board is essential for this steps

- The project is iterative

  - ✓ The methodology is being applied with the best existing knowledge
  - ✓ It allows the identification of gaps in knowledge
  - ✓ As soon as new knowledge will be available, it will be incorporated

LET'S LOOK AT A BETA VERSION OF ARF@pt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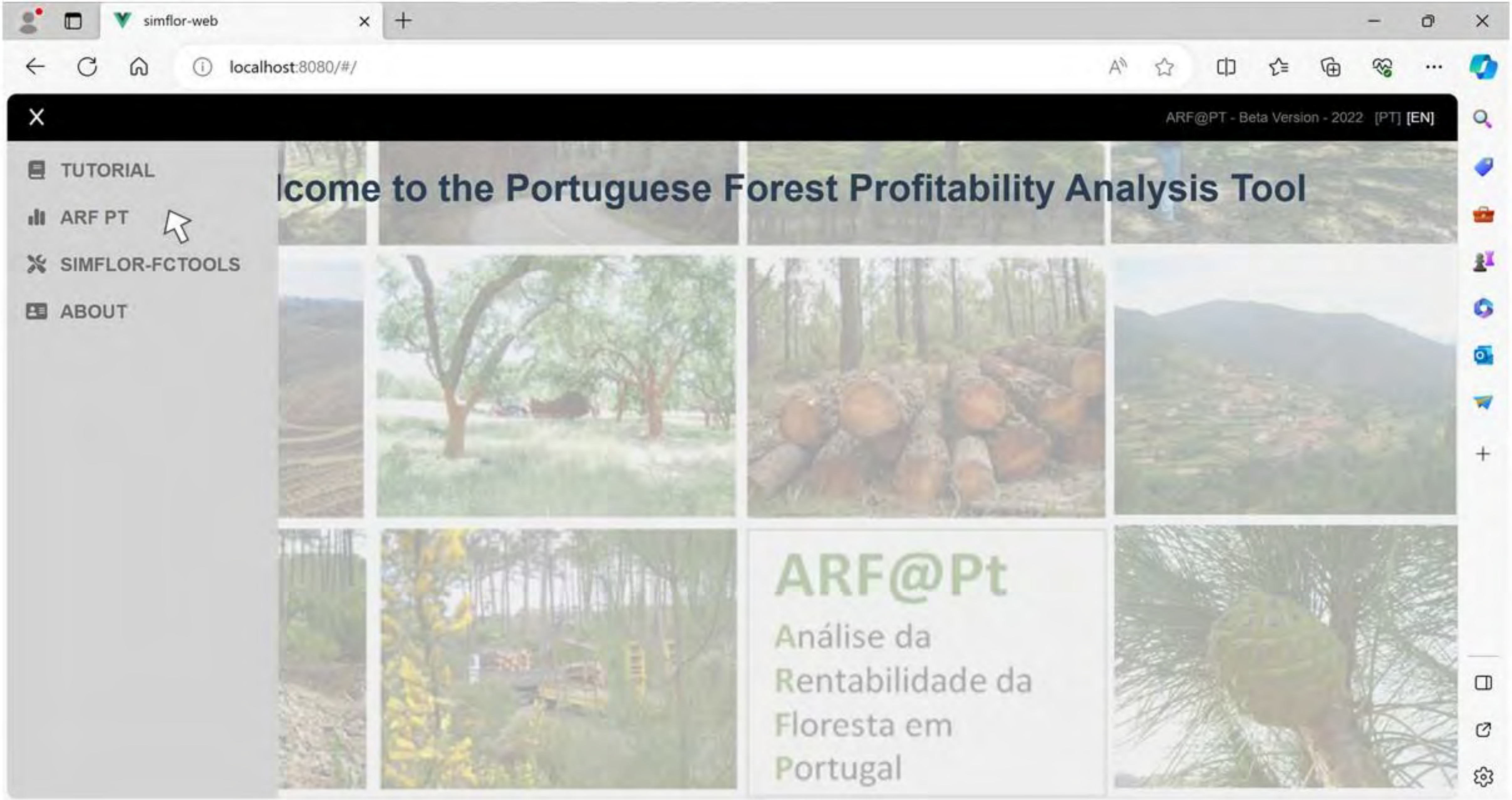
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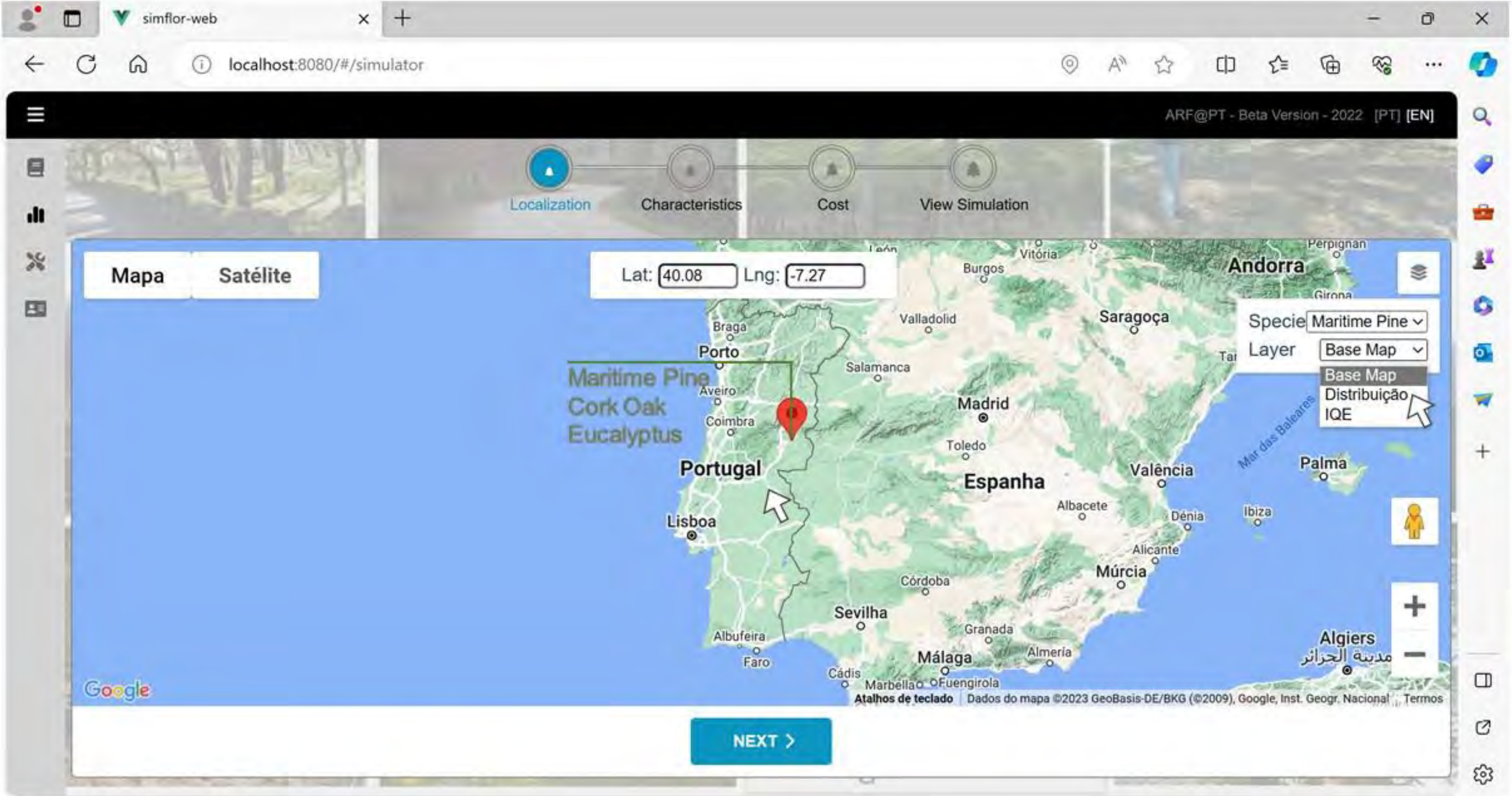
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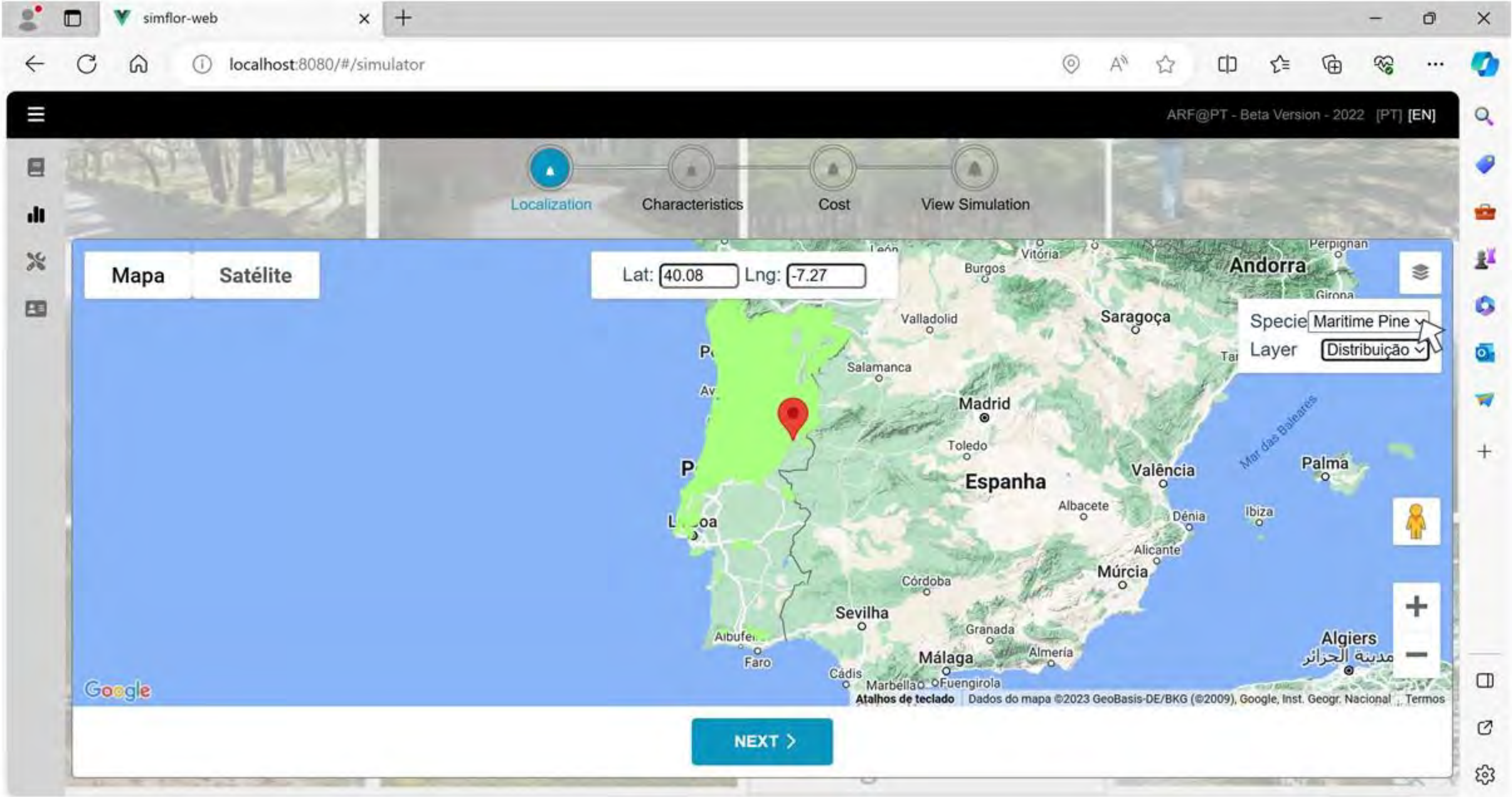
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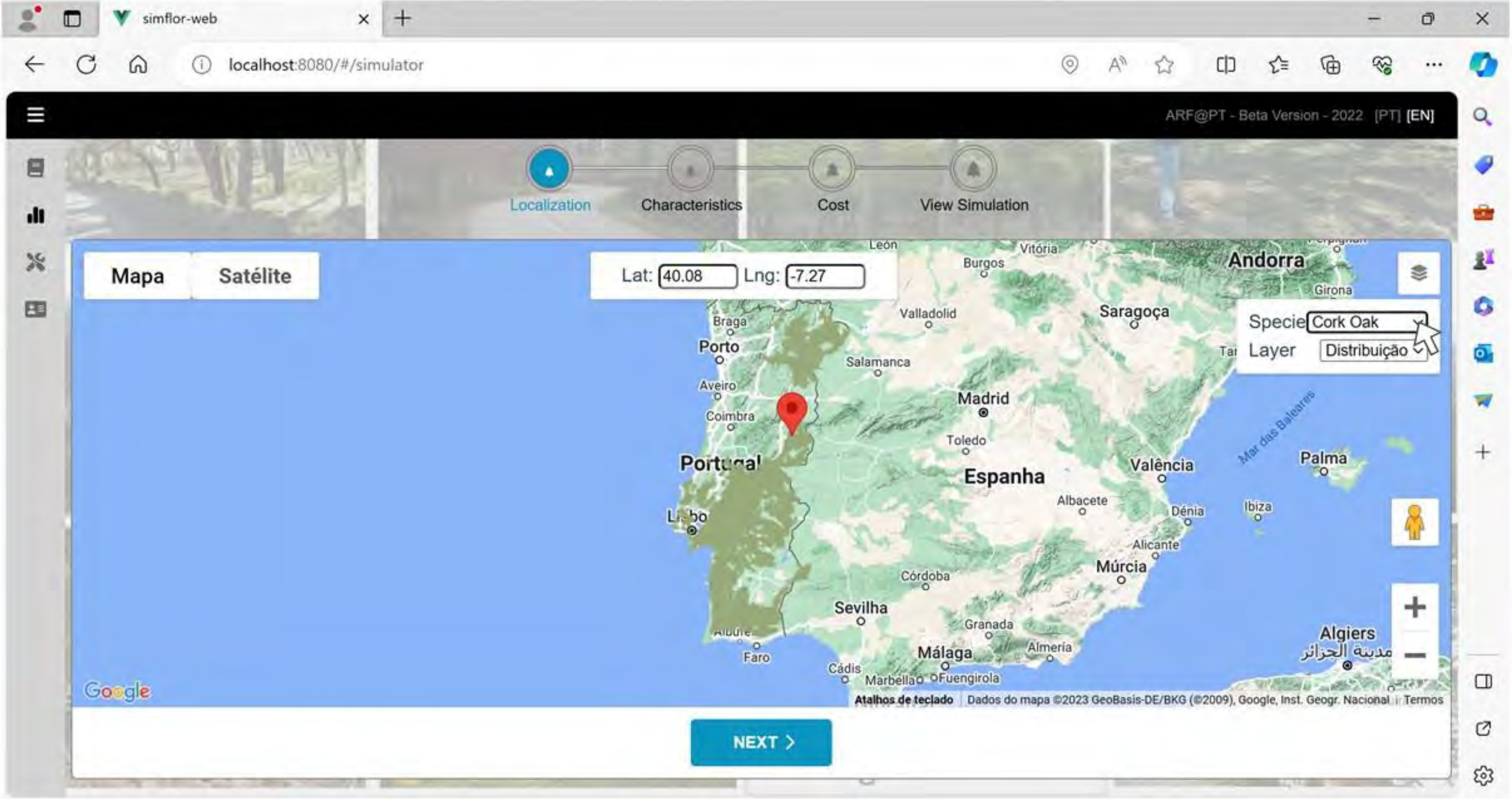
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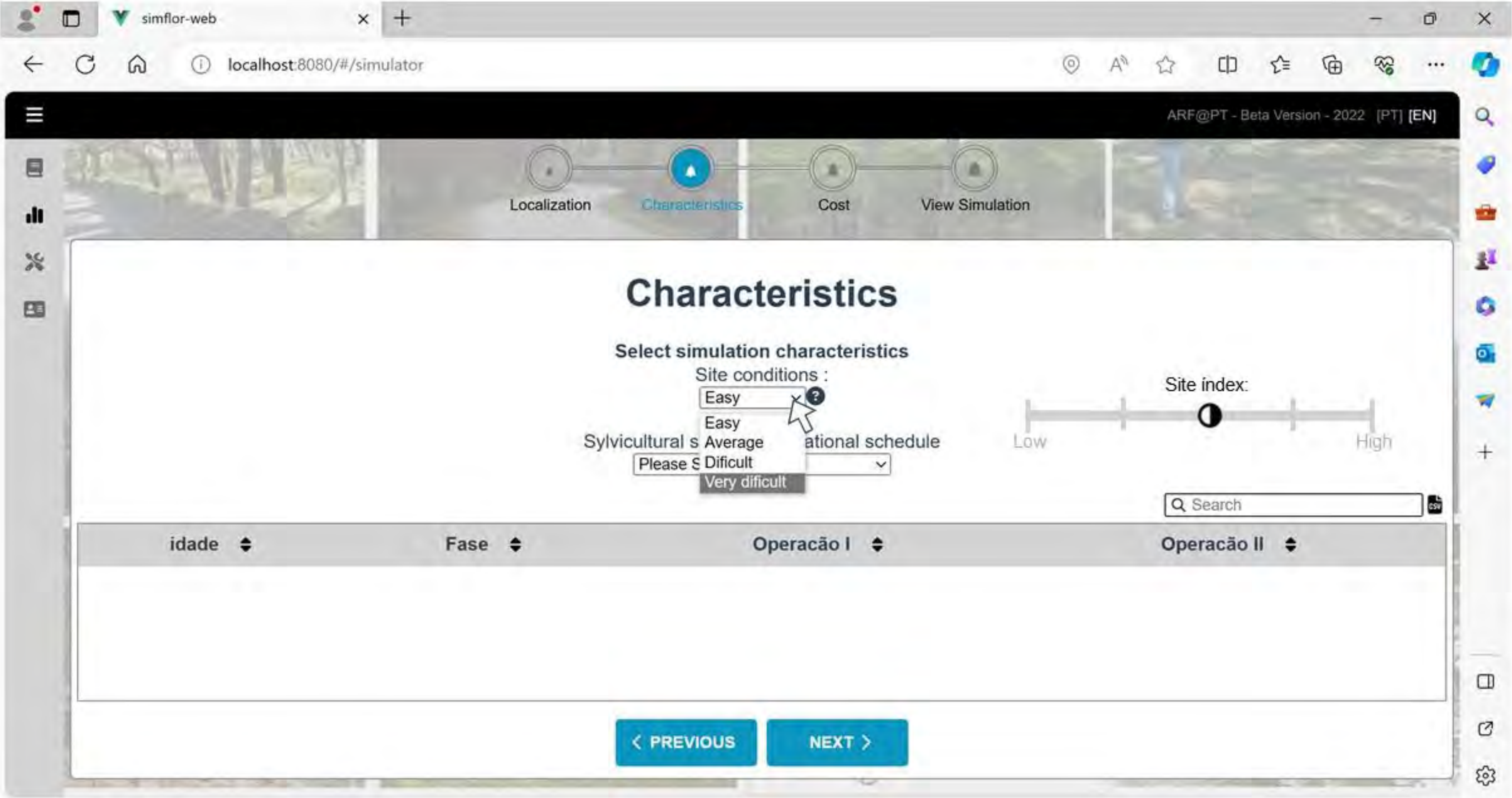
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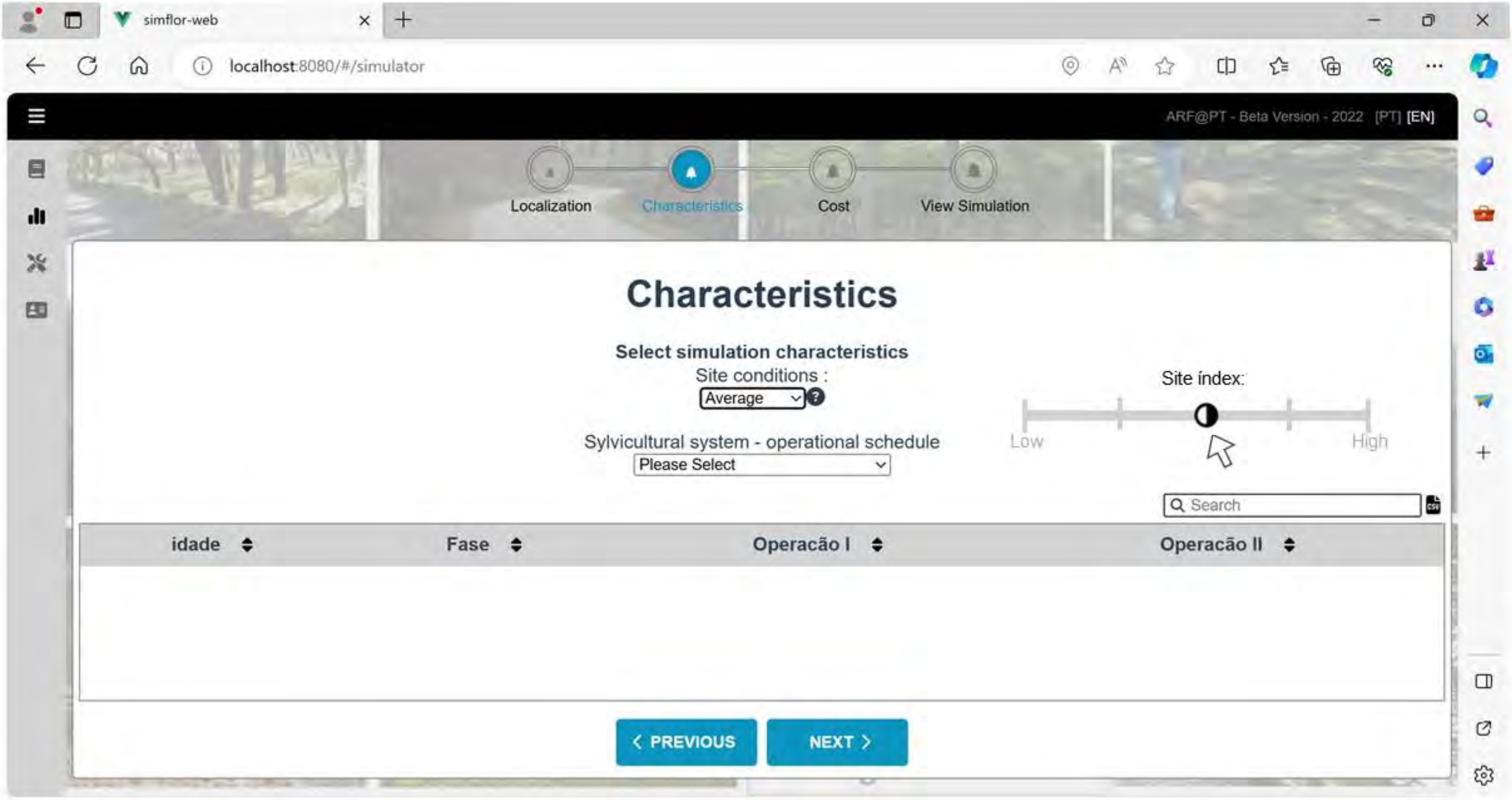
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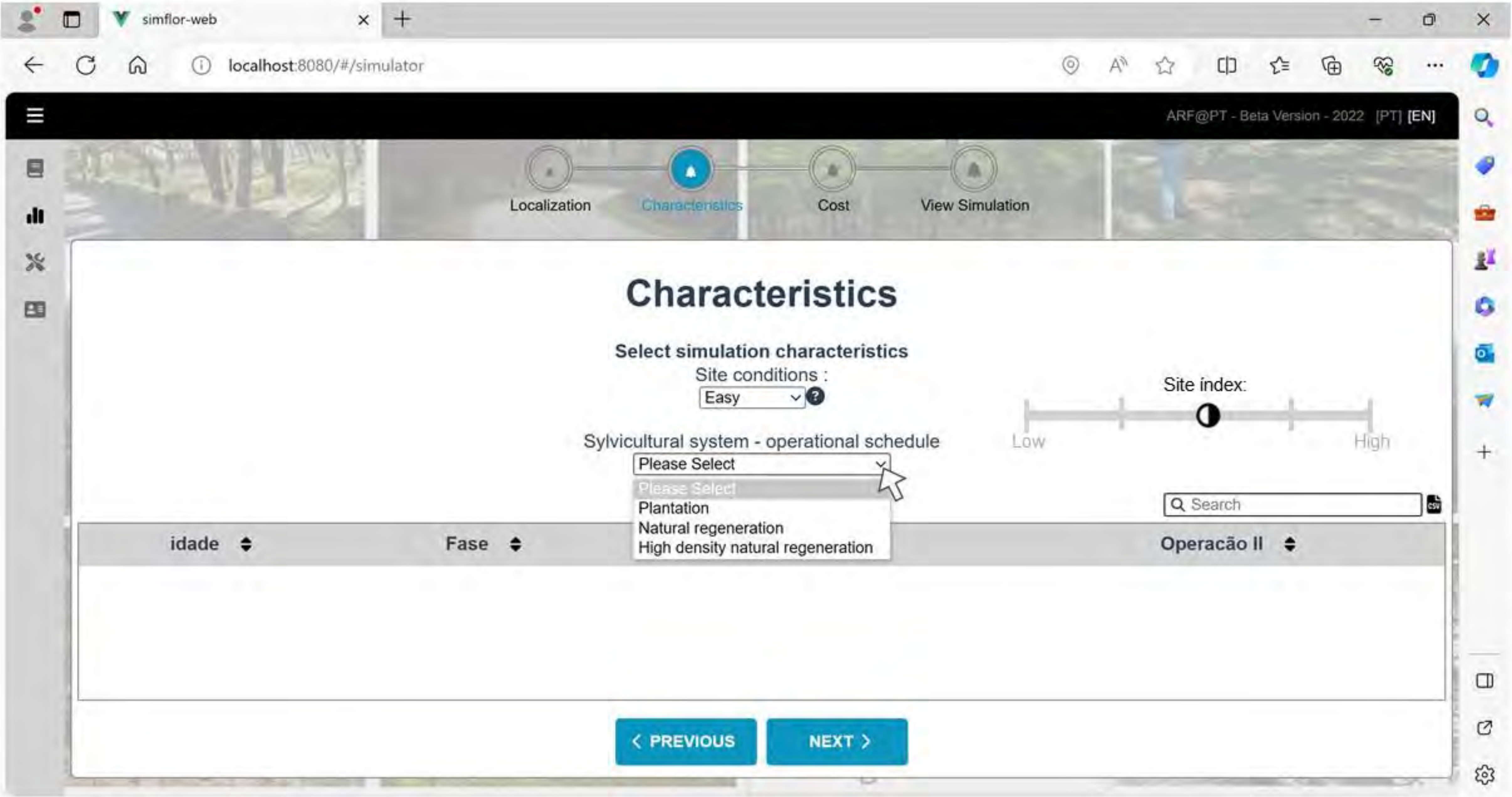
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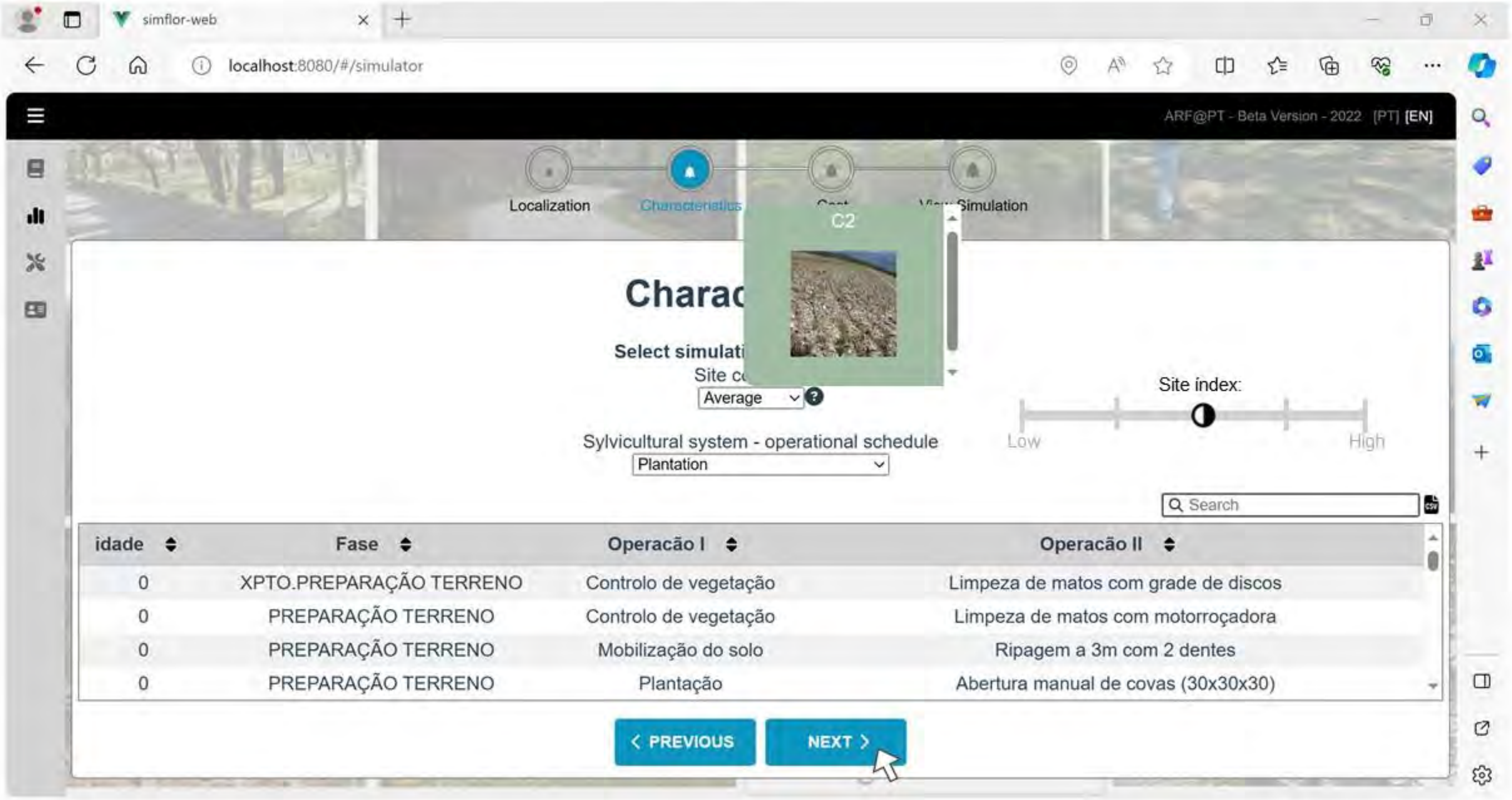
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0 | PREPARAÇÃO TERRENO | Mobilização do solo | Ripagem a 3m com 2 dentes
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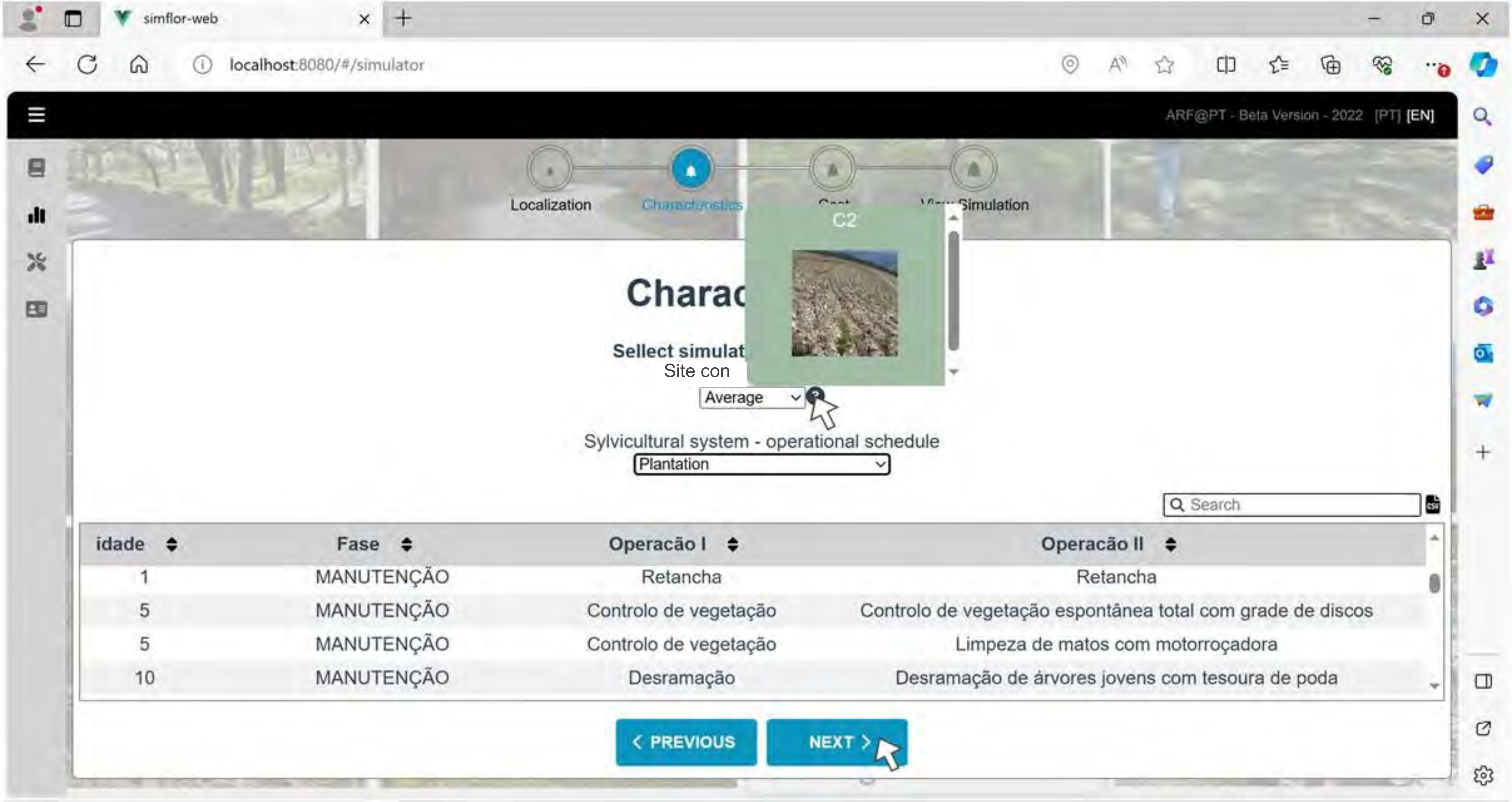
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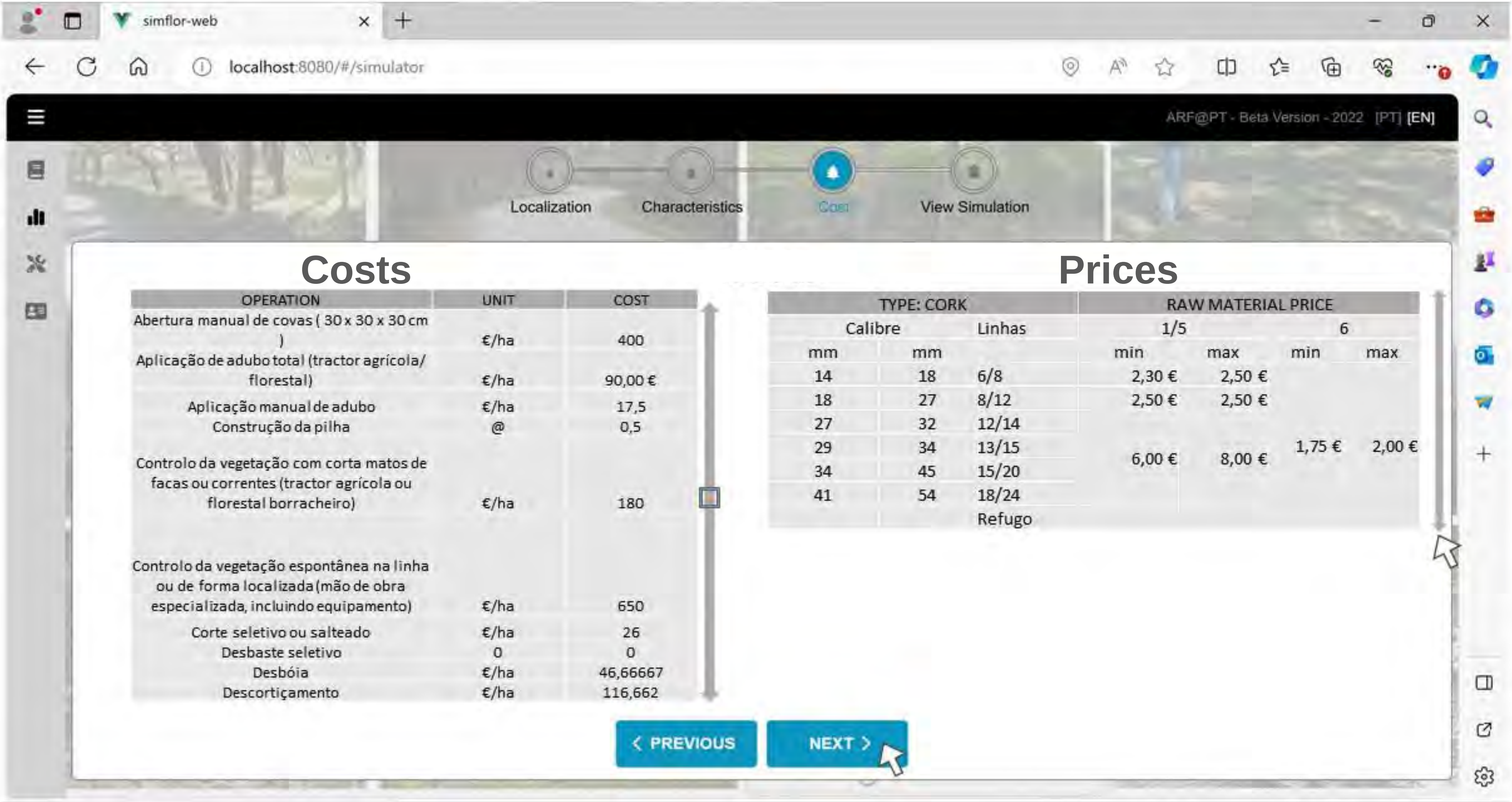

Costs

OPERATION	UNIT	COST
Abertura manual de covas (30 x 30 x 30 cm)	€/ha	400
Aplicação de adubo total (tractor agrícola/ florestal)	€/ha	90,00 €
Aplicação manual de adubo	€/ha	17,5
Construção da pilha	@	0,5
Controlo da vegetação com corta matos de facas ou correntes (tractor agrícola ou florestal borracheiro)	€/ha	180
Controlo da vegetação espontânea na linha ou de forma localizada (mão de obra especializada, incluindo equipamento)	€/ha	650
Corte seletivo ou salteado	€/ha	26
Desbaste seletivo	0	0
Desbóia	€/ha	46,66667
Descortiçamento	€/ha	116,662

Prices

TYPE: CORK			RAW MATERIAL PRICE			
Calibre		Linhas	1/5		6	
mm	mm		min	max	min	max
14	18	6/8	2,30 €	2,50 €		
18	27	8/12	2,50 €	2,50 €		
27	32	12/14				
29	34	13/15	6,00 €	8,00 €	1,75 €	2,00 €
34	45	15/20				
41	54	18/24				
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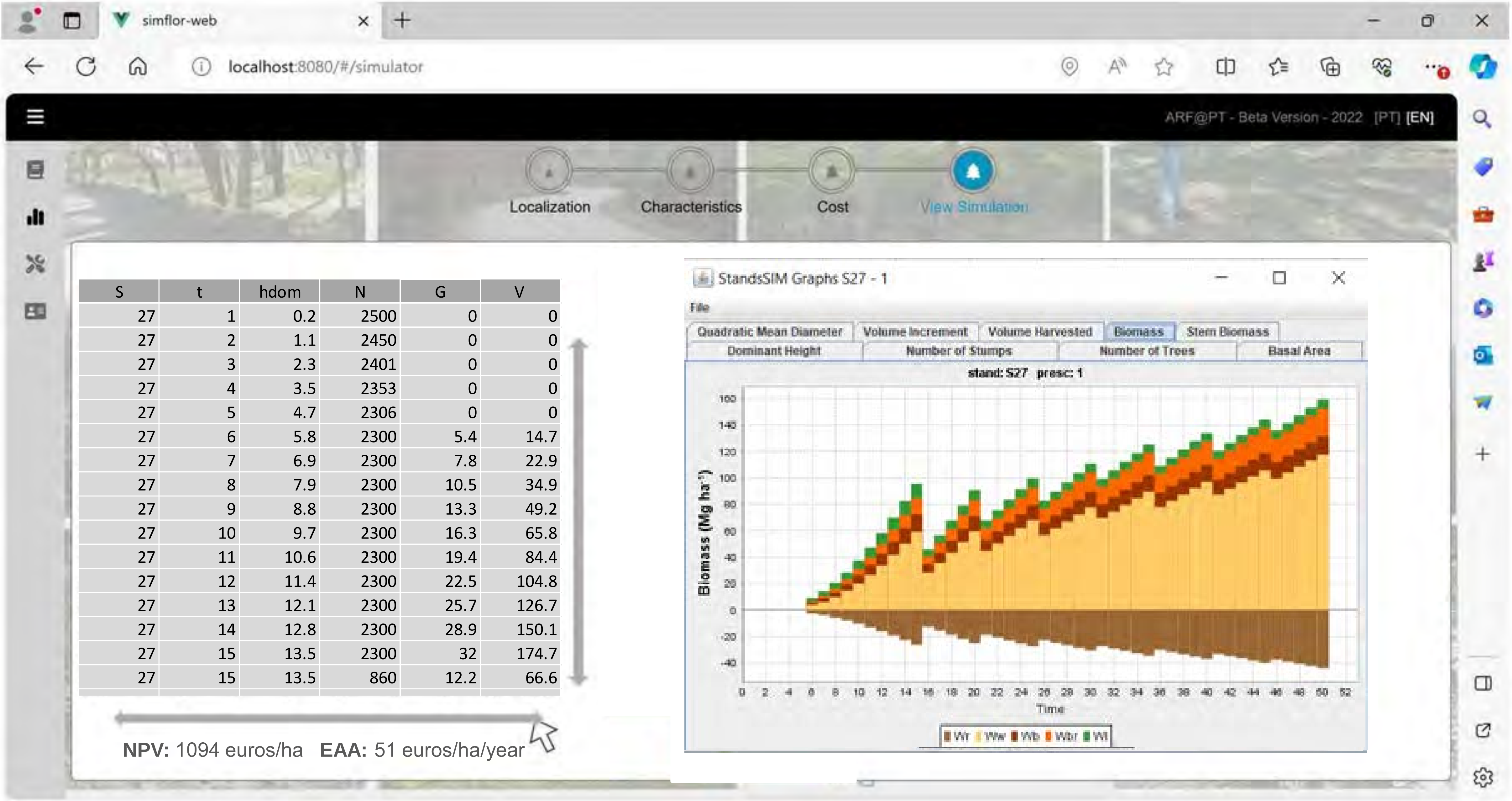
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27 6 5.8 2300 5.4 14.7
27 7 6.9 2300 7.8 22.9
27 8 7.9 2300 10.5 34.9
27 9 8.8 2300 13.3 49.2
27 10 9.7 2300 16.3 65.8
27 11 10.6 2300 19.4 84.4
27 12 11.4 2300 22.5 104.8
27 13 12.1 2300 25.7 126.7
27 14 12.8 2300 28.9 150.1
27 15 13.5 2300 32 174.7
27 15 13.5 860 12.2 66.6
NPV: 1094 euros/ha EAA: 51 euros/ha/year
StandsSIM Graphs S27 - 1
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Quadratic Mean Diameter
Volume Increment
Volume Harvested
Biomass
Stem Biomass
Dominant Height
Number of Stumps
Number of Trees
Basal Area
stand: S27 presc: 1
Biomass (Mg ha⁻¹)
Time
Wr Ww Wb Wbr Wl



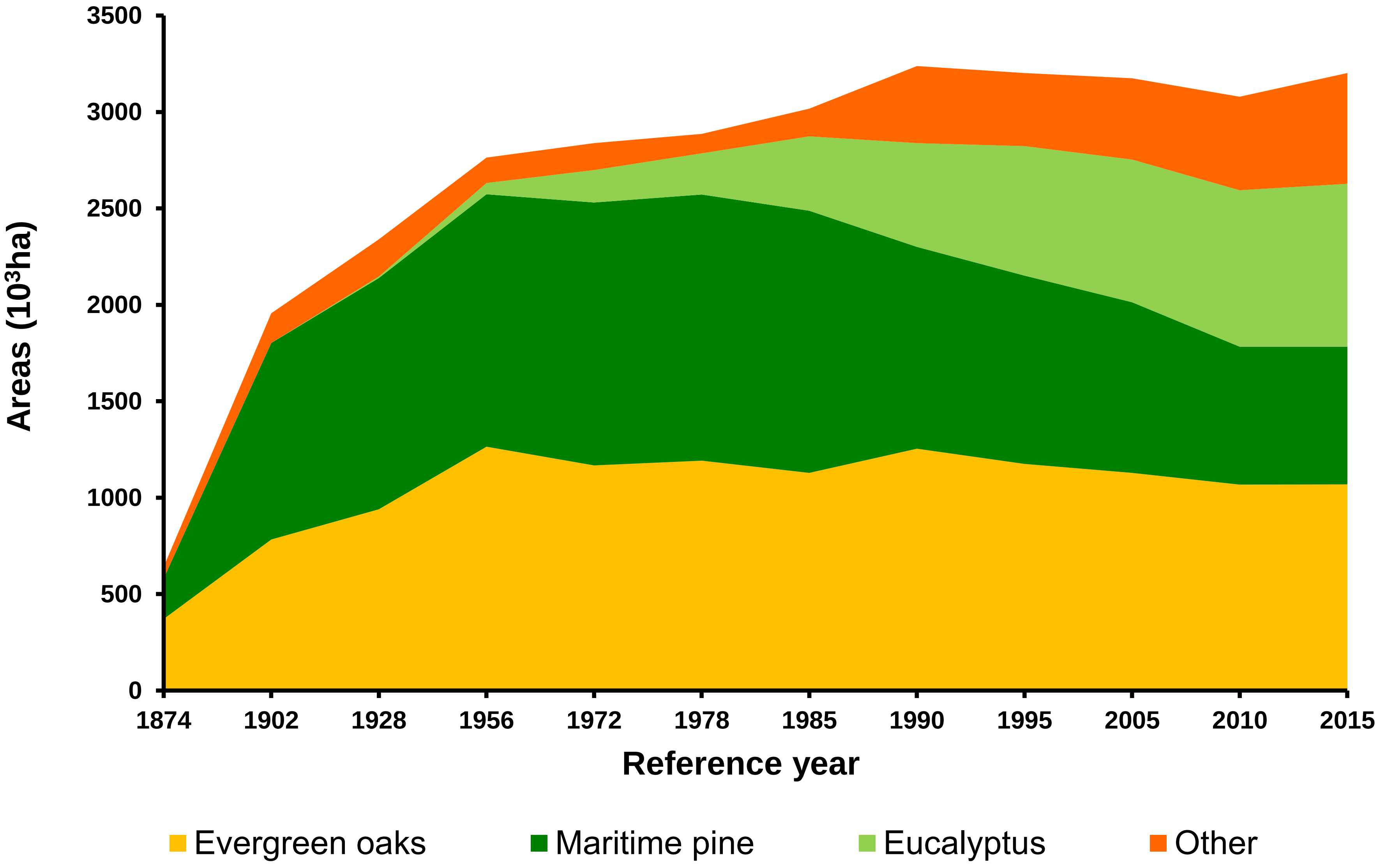






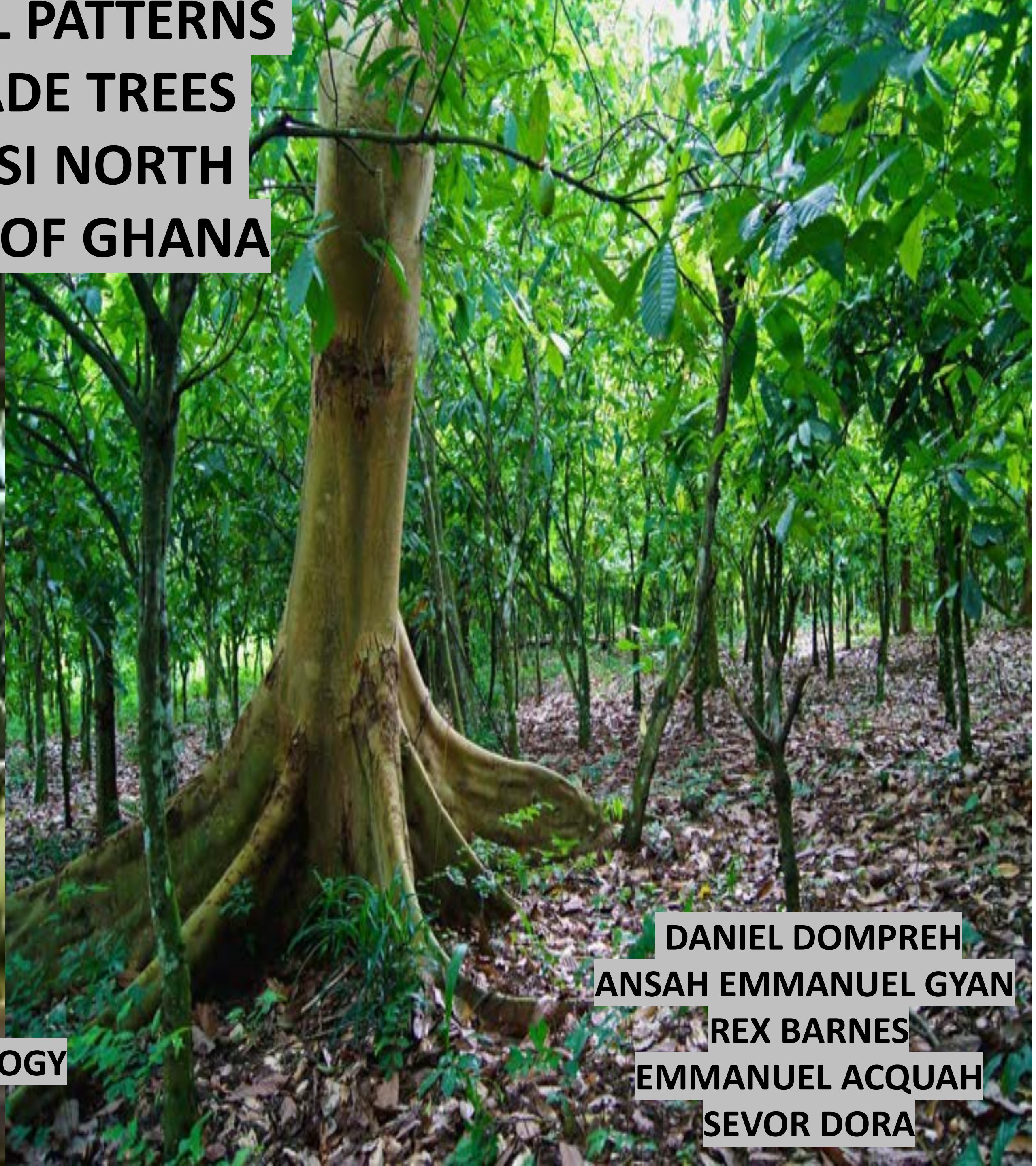

ARF@Pt

A tool tosuport landowners’ and policy decisions in Portugal



Areas (10³ha)
3500
3000
2500
2000
1500
1000
500
0
1874
1902
1928
1956
1972
1978
1985
1990
1995
2005
2010
2015
Reference year
Evergreen oaks
Maritime pine
Eucalyptus
Other

EFFECT OF CHANGES IN PHENOLOGICAL PATTERNS AND RESILIENCE OF FIVE SELECTED SHADE TREES ON COCOA PRODUCTION IN THE ADANSI NORTH DISTRICT AND OFFINSO MUNICIPALITY OF GHANA



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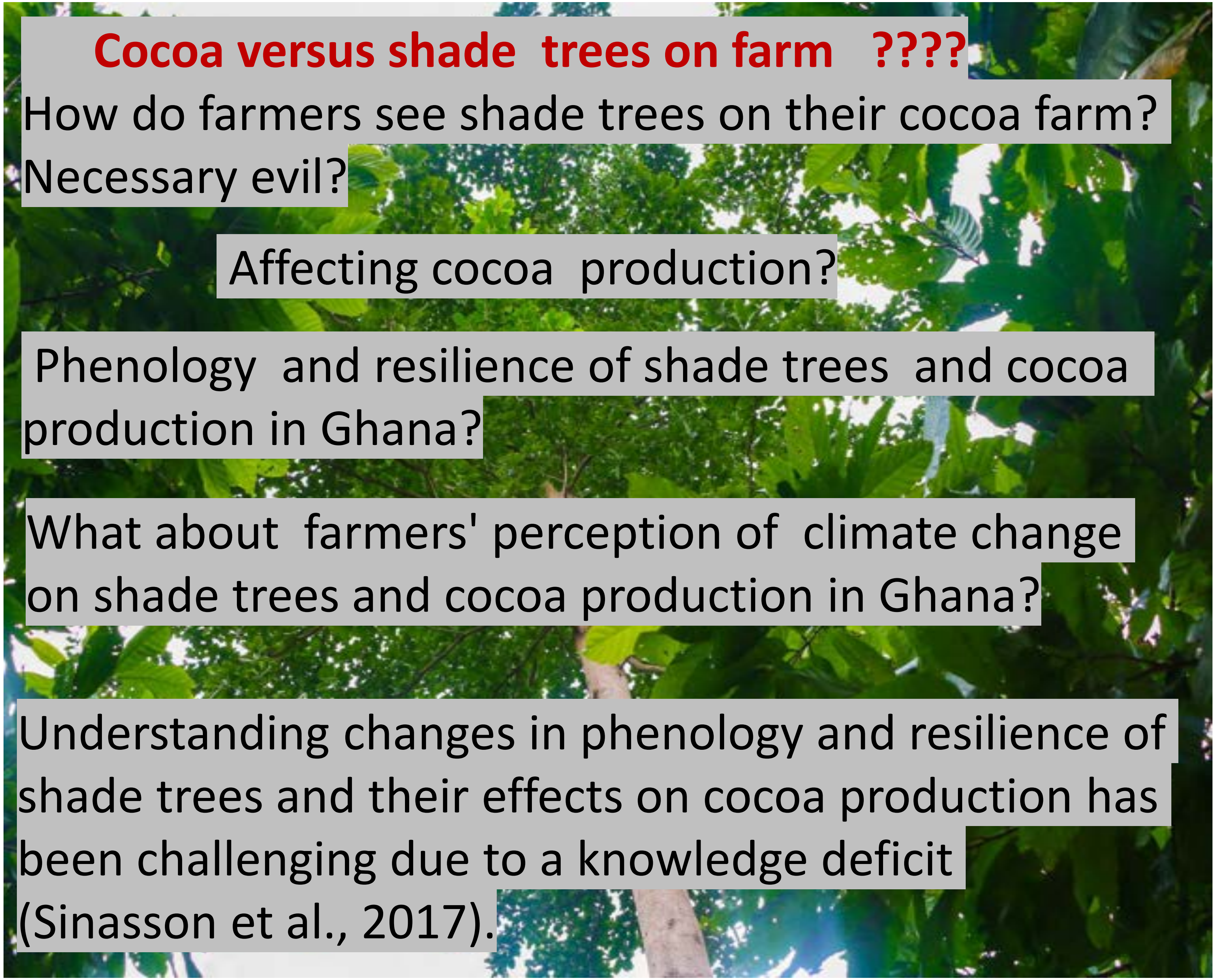
DANIEL DOMPREH
ANSAH EMMANUEL GYAN
REX BARNES
EMMANUEL ACQUAH
SEVOR DORA

Cocoa is a significant cash crop in Ghana.

why?

Major backbone of the country’s economy



Cocoa versus shade trees on farm ????

How do farmers see shade trees on their cocoa farm? Necessary evil?

Affecting cocoa production?

Phenology and resilience of shade trees and cocoa production in Ghana?

What about farmers' perception of climate change on shade trees and cocoa production in Ghana?

Understanding changes in phenology and resilience of shade trees and their effects on cocoa production has been challenging due to a knowledge deficit (Sinasson et al., 2017).

Some of the common trees used as shade trees

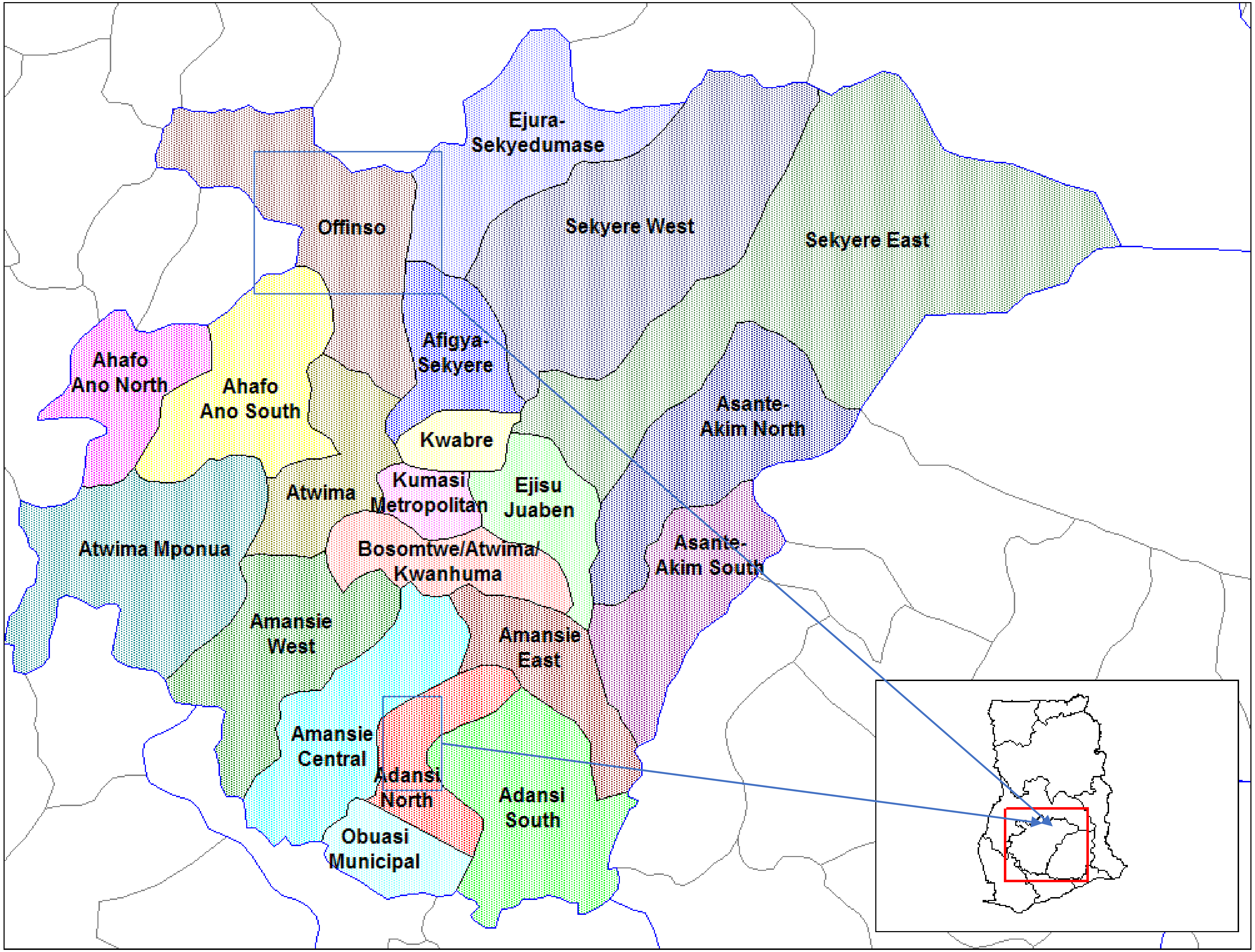
- *Citrus sinensis*
- *Entandrophragma angolense*
- *Ficus capensis*
- *Mangifera indica*
- *Morinda lucida*
- *Spathodea campanulata*
- *Terminalia superba*
- *Milicia excelsa*
- *Persea Americana*
- *Terminalia ivorensis*

What did we do in our study?

- ✓ Registered all cocoa farmers in the two districts
- ✓ Selected farmers with shade trees in their farms
- ✓ Selected farms with more than 5 types of shade trees of economic importance
- ✓ Questionnaire, farm visits, observation etc. in achieving our objectives

Objectives

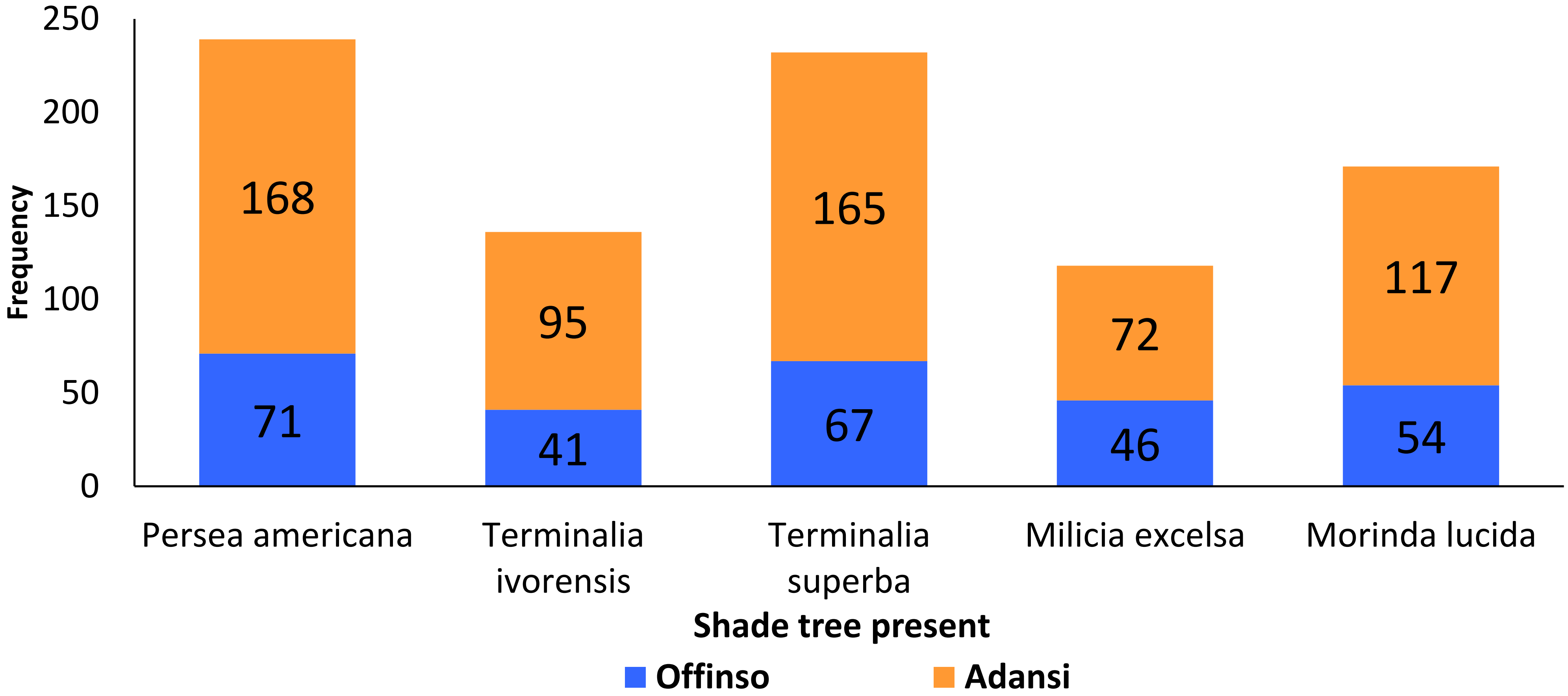
- Evaluate cocoa farmers’ perception about changes in phenology of shade trees and their effects on cocoa production
- Assess cocoa farmers perception about resilience of shade trees and their effect on cocoa production.
- Determine measures taken by the cocoa farmers to adapt to the effects from phenological changes of the shade trees.



Map of Ghana showing Adansi North district and Offinso Municipality

Frequencies of demographic characteristics of the respondents in the Offinso and Adansi districts

Characteristics		District		Count (%)	Knowledge about Shade trees		Chi-square (p-value)
		Offinso	Adansi		Yes	No	
Gender	Male	51	138	189 (67)	187	2	0.00 (0.99)
	Female	26	67	93 (33)	92	1	
Status	Native	62	129	191 (67.7)	190	1	1.641 (0.200)
	Migrant	15	76	76 (32.3)	89	2	
Age	<25	1	2	3 (1.1)	3	0	1.020 (0.796)
	25 – 45	19	46	65 (23.1)	64	1	
	46 – 65	40	127	167 (59.2)	166	1	
	66 – 85	17	30	47 (16.6)	46	1	
	>86	0	0	0 (0)	-	-	
Educational Level	No Education	12	40	52 (18.4)	52	0	2.182 (0.702)
	Primary	13	24	37 (13.1)	37	0	
	JHS	48	116	164 (58.2)	161	3	
	SHS	4	21	25 (8.9)	25	0	
	Tertiary	0	4	4 (1.4)	4	0	



Frequency of respondents with shade tree on their farms in the Offinso and Adansi district

Size of farm varied

Knowledge of the phenology of the tree of farmers in Adansi and Offinso districts

Tress	Various variables and response to them					
	Had Knowledge		TOTAL	No Knowledge		TOTAL
	Offinso	Adansi		Offinso	Adansi	
Persea americana (Avocado)	62	152	**214**	9	16	**25**
Terminalia ivorensis (Emire)	35	68	**103**	6	27	**33**
Terminalia superba (Ofram)	55	128	**183**	12	37	**49**
Milicia excelsa (Odum)	34	57	**91**	12	15	**27**
Morinda lucida (Konkroma)	34	88	**122**	20	29	**49**

**Local names in brackets*

What knowledge do the farmers have on the shade trees?

- ✓ Bud formation
- ✓ Flowering period
- ✓ Fruiting period
- ✓ Seed formation
- ✓ Period of shedding of leaves and formation of new leaves
- ✓ Good flowering of shade trees and improvement in cocoa yield

Planted forests / plantation development versus shortage of land in Ghana

- How do we plant more trees to achieve vision 2050 and 2063 goal with land -related issues in Ghana?
- Illegal mining, illegal exploitation of wood from our forest reserves
- Cocoa farmer have a lot of knowledge on phenology and resilience of shade trees
- Why not focus attention on these farmers to increase number of trees to meet our target by 2050 and 2063?
- Cocoa farmers are ready to receive and plant more trees as shade trees to increase their productivity at less or no cost to the plantation developers
- These shade trees are highly protected just as they protect their cocoa farms
- The farmers know adaptive measure to employ to mitigate climate change

Conclusion

- There are a number of cocoa farms in Ghana without shade trees or with less number of shade trees
- These farmers are begging for seedlings from Forest Services Division, Extension officers, Ghana Cocoa board etc.

- The supply of **seedlings** is less that the demand by farmers
- Let's take advantage of this <u>gold mine</u> and supply farmers with more shade trees to contribute in a small way in achieving our vision **2050** and **2063** where the number of trees on this planet will increase to meet the growing population

Vision 2050?
Vision 2063?
Just in the corner!

- No land to plant more trees?
- Complain about governments not helping? etc

Planting forests? *Task for the all not only the 4 people*

1. Somebody
2. Everybody
3. Nobody
4. Anybody

So who are you?

Farmer

DO SOMETHING!

It is never too late

Vision 2050?
Vision 2063?

Reference

Sinasson G. K. Shackleton C. M, and Sissin D. (2017). Reproductive phenology of two *Mimusapus* species in relation to climate, tree diameter and canopy position in Benin West Africa. *African Journal of Ecology*. Pp.323-333.

??

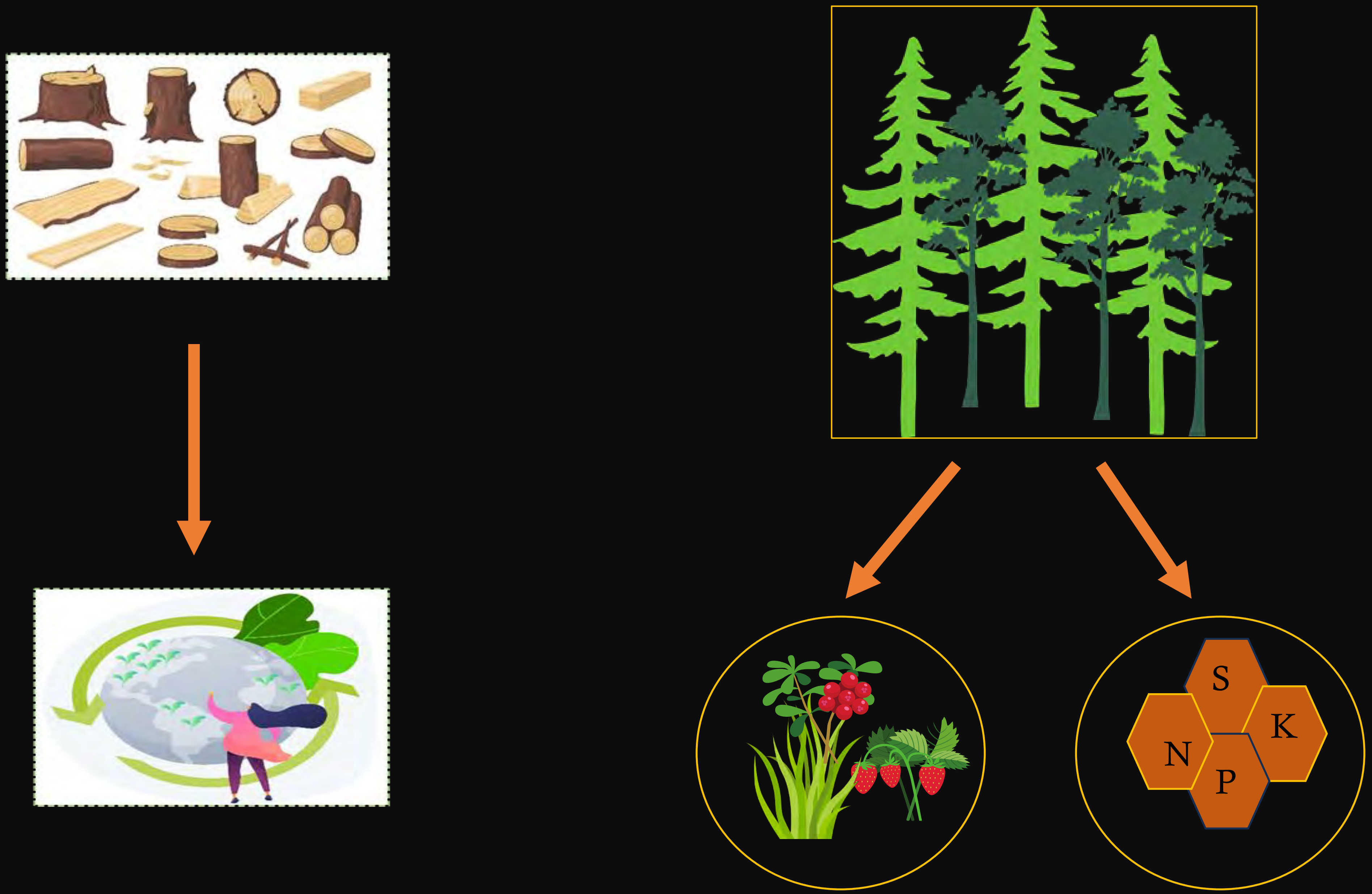
Is mixed forest always a winner?

An assessment of understory vegetation and plant available nutrients

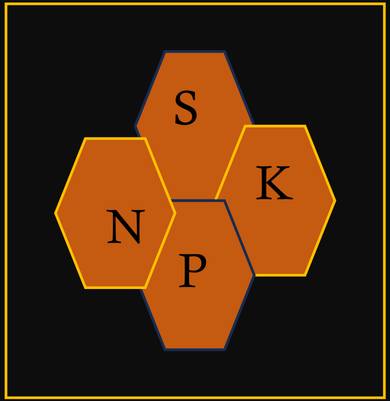
Mostarin Ara

cc-Brad Pinno, Lisa Petersson & Phil Comeau

Why understory vegetation and soil nutrient?



Research Objectives

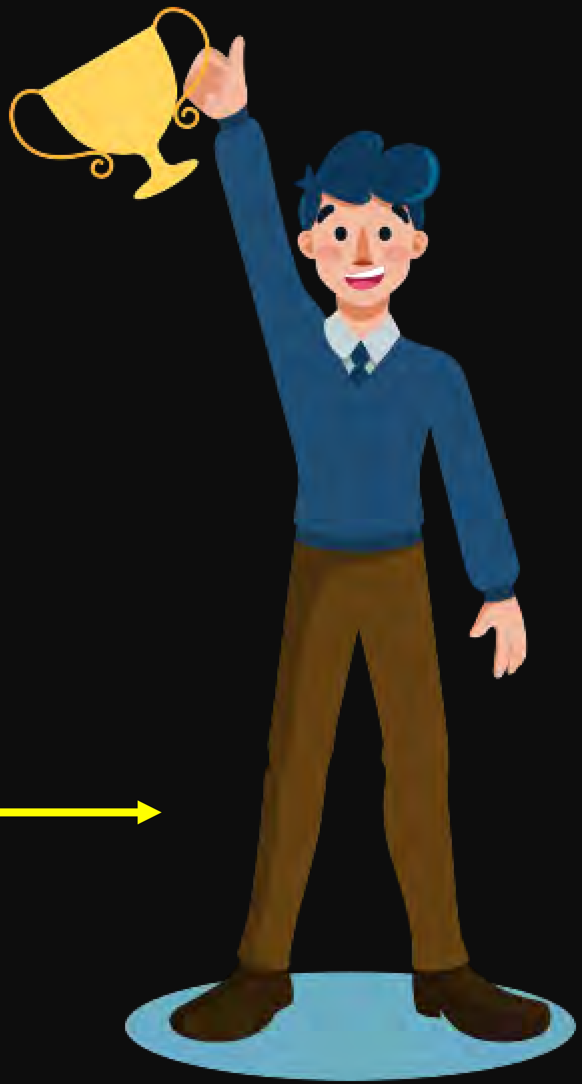



Spruce_cc
Spruce_wc
Pure aspen
Mix_unthinned
Mix_aspen2000
Mix_aspen1200
Mix_aspen800

UNDERSTORY VEGETATION

Total vegetation cover
Total vascular cover
Herbs
Grass

Bryophyte



Mixed stands

Monoculture

PLANT AVAILABLE NUTRIENTS

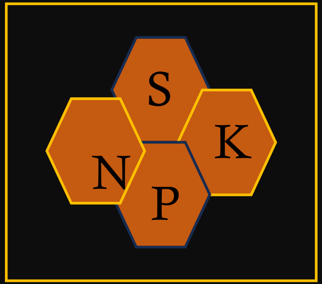
Mixed stands

N supply rates
C: N ratio
Soil pH

K,P,S supply rates

Take away

Mixture increases the vascular and spruce monoculture increases the bryophytes plant community.



Mixing aspen and spruce increases the N supply rates, soil pH and reduces C: N ratio.

Thank you

mostarin@ualberta.ca

UNDERSTORY VEGETATION

Total vegetation cover
All mixed stand

Total vascular cover
All mixed stands except stands with 1200 aspen

Herbs
Mixed stands with unthinned aspen

Grass
Mixed stands with 800 aspen

REPUBLIC OF KENYA

MINISTRY OF ENVIRONMENT, CLIMATE CHANGE & FORESTRY

Breeding of *Melia volkensii*: Establishment of Clonal Seed Orchards and Subsequent Progeny Trials in Kenya

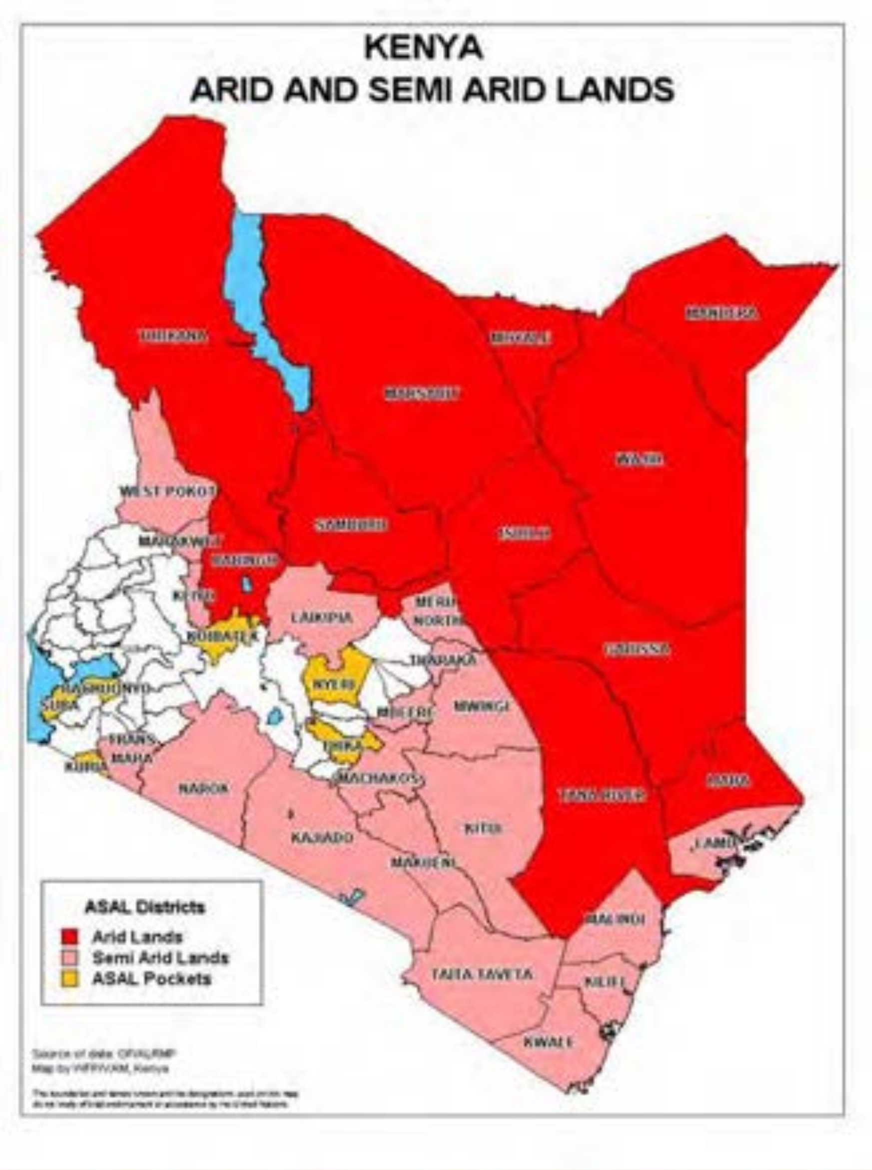
Jason G. Kariuki[1], V. Okul[1] and H. Miyashita[2]

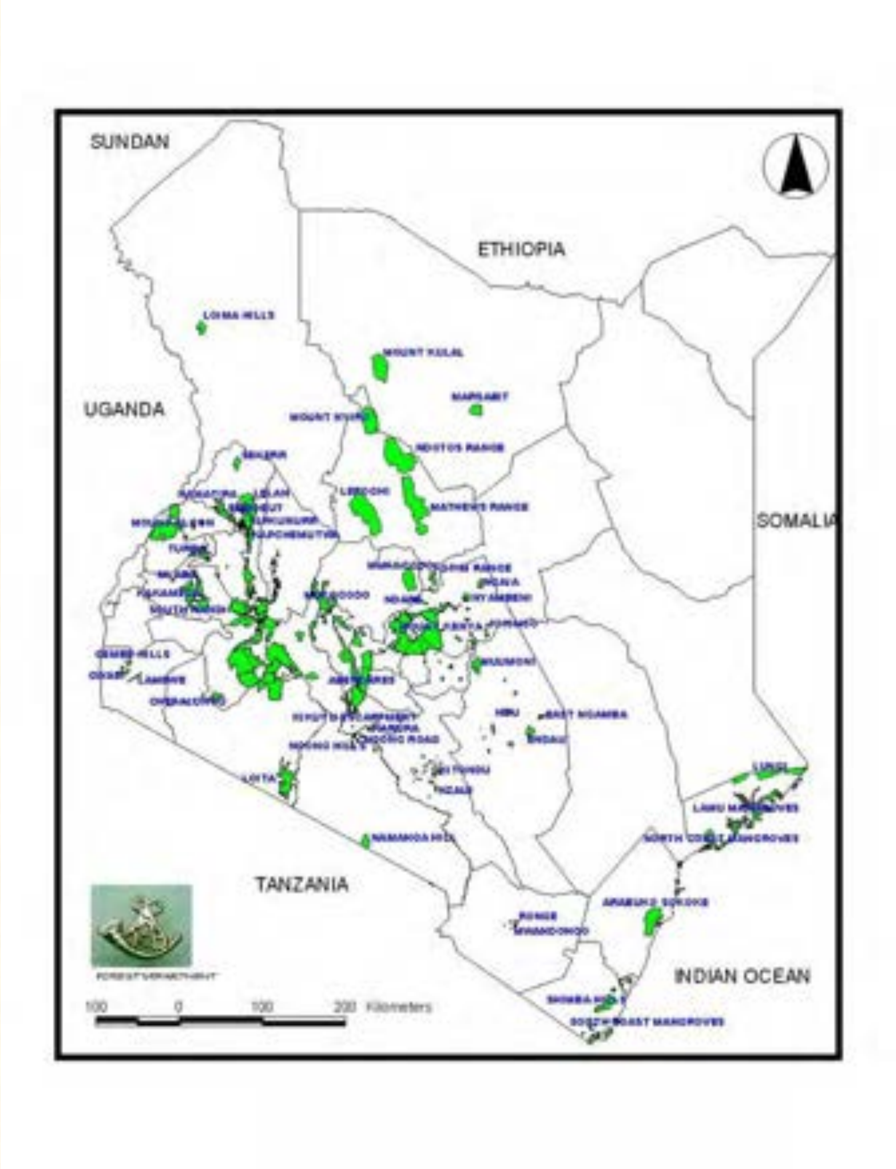
[1]Kenya Forestry Research Institute
[2]Forest Tree Breeding Centre, Japan

5th International Congress on Planted Forests; 7-10 November 2023

CIFOR-ICRAF Campus, Nairobi, KENYA

> 80% of Kenya is ASAL & forest cover < 10%





Target of breeding of Indigenous Trees in Kenya

Melia Timber

Mahogany Timber

Melia volkensii

（Family: Melieceae）

Semi arid area
Timber for furniture
Production of Commercial timber

Acacia tortilis

（Family: Mimosaceae）

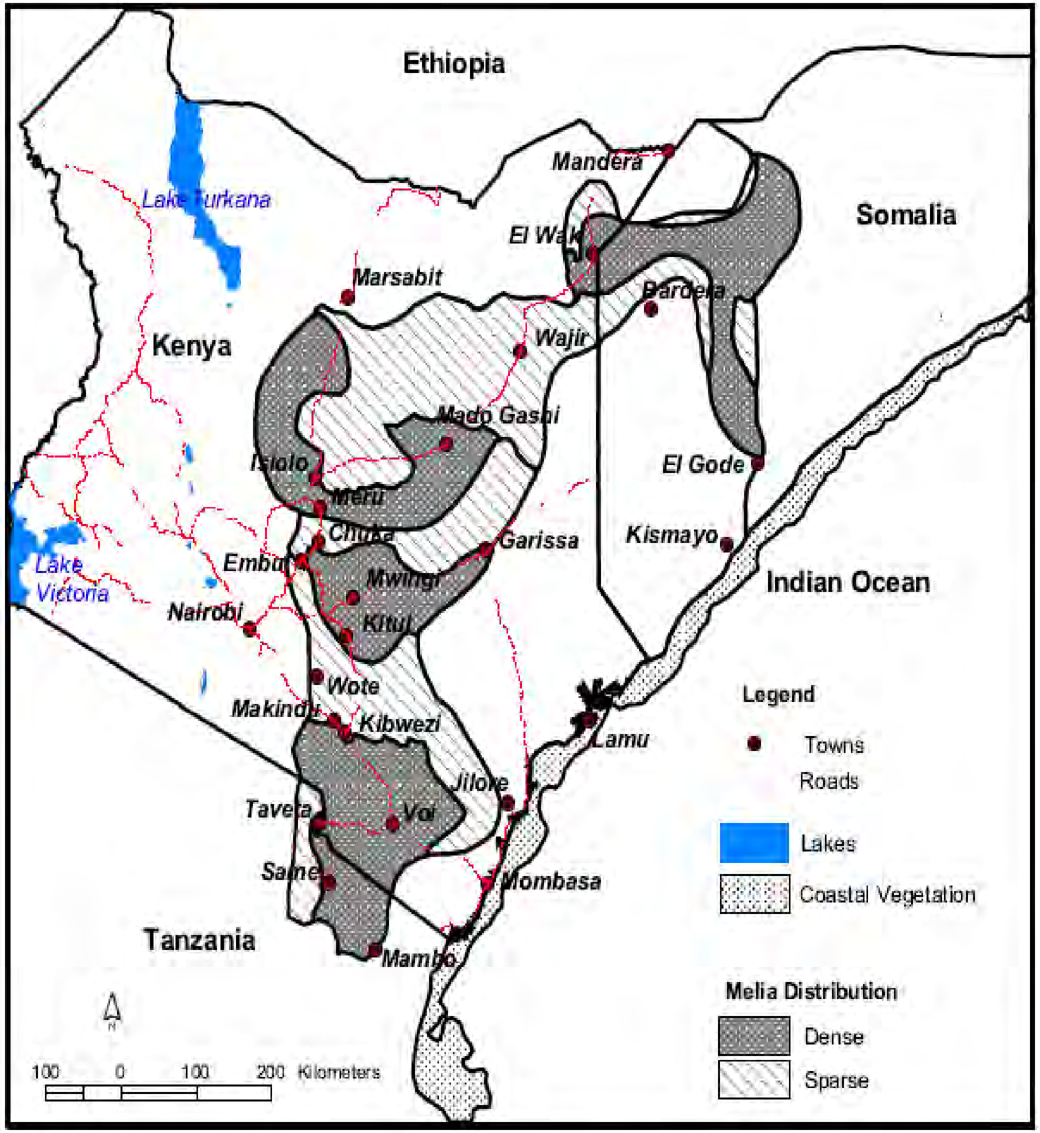
Arid and semi arid area
Fuel wood, fodder
Production for fodder and wood fuel

High quality charcoal

Acacia pods

Melia volkensii

- *Melia volkensii* found in ASALs in Kenya, Somalia, Ethiopia and Tanzania with 300 – 800 mm rainfall.
- Grows on most soils but best on sandy well drained soils
- Importance: High quality Mahogany grade timber, fodder, shade, construction, termite resistant
- Drought resistant, fast growth (unusual combination)
- 6-20m height; rotation 10-15 years.
- Early flowering - 2-3 years



M. Volkensii natural distribution

Melia physical and mechanical properties in comparison to other hardwoods

1: Physical properties of *Melia volkensii* compared to popular hardwoods

Property	*Melia volkensii*	Mahogany	Teak
Mean density (Kg/m2)	620 (Moderately heavy)	685 (Moderately heavy)	680 (Moderately heavy)
Heartwood and sapwood	Pale brown sapwood to pale red heartwood	Pale brown sapwood to pink/deep red heartwood	Light golden with dark markings
Texture and grain	Coarse texture, straight grains	Coarse texture, straight or interlocked grains	Uneven coarse textured, interlocked and wavy grains

2: Mechanical properties of *Melia volkensii* compared to popular hardwoods

Property	*Melia volkensii*	Mahogany	Teak
Bending strength (MOR) [N/mm^2]	74 - 96	50 - 110	81 - 196
Bending stiffness (KN/mm^2]	5.8 – 9.2	7.8 - 10.3	7.6 - 17.5
Crushing strength [N/mm^2]	42 - 56	24 - 53	34 - 70
Shear strength Parralel to grain [N/mm^2]	14 - 18	8 - 14	5 - 16
Hardness [N/mm^2]	3.5 – 5.1	3.4 - 5.7	3.8 - 4.8

Melia Breeding – Objectives

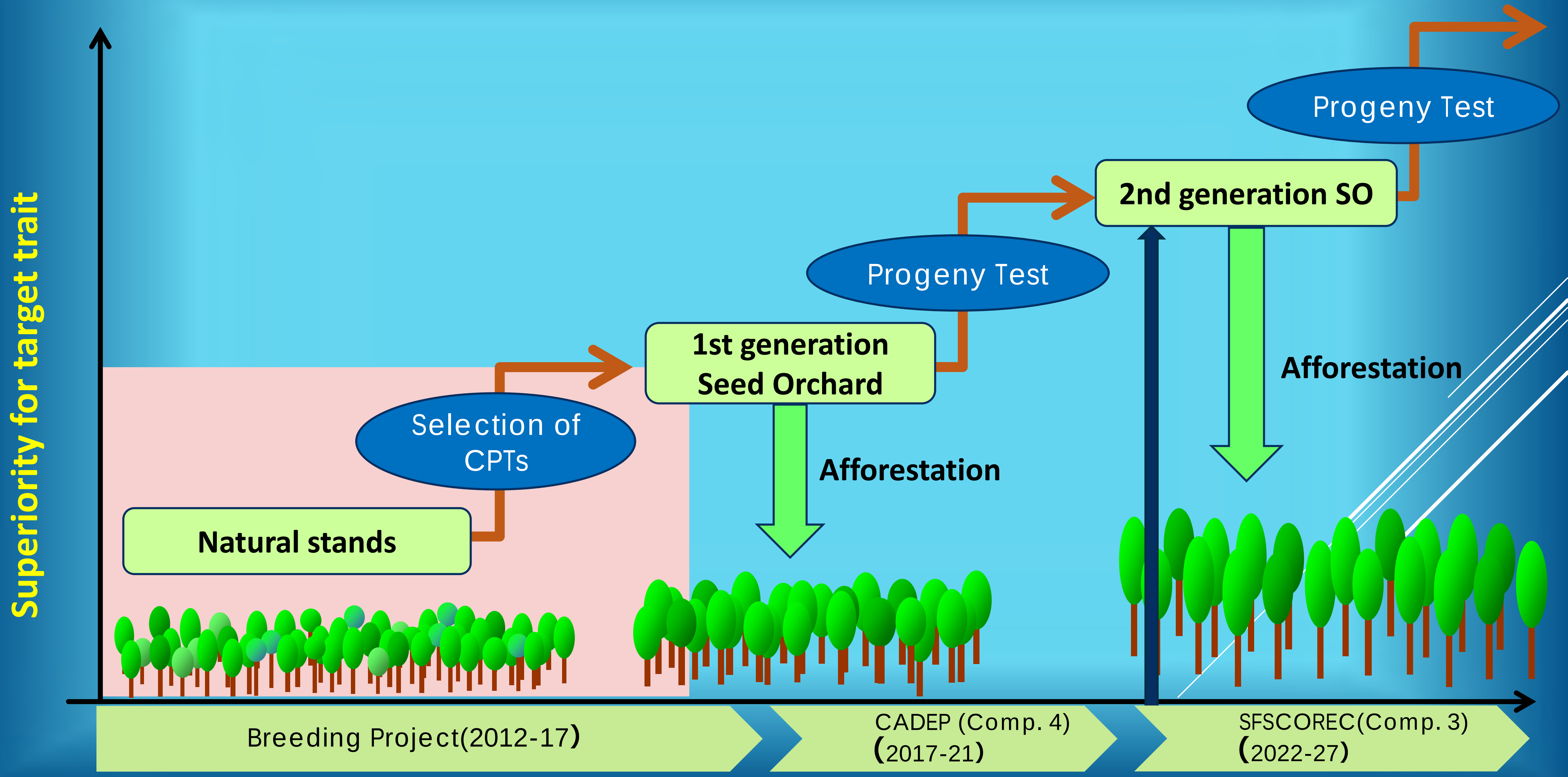
Main Objective:

- To improve forest and tree productivity within Drylands of Kenya through developing and production of quality improved seed

Specific Objectives

- Increase adaptability (survival and growth on more arid sites)
- Increase productivity (volume production)
- Improved quality (wood properties for end use)

Roadmap for *Melia volkensii* Tree Breeding



Selection of Candidate Plus Trees (CPTs)

- The 100 CPTs selected across the Melia natural range from North to coastal Kenya
- The trees were selected from across a latitudinal gradient from 80m to 1400 m a.s.l
- 80 CPTs from semi- arid and 20 CPTs from very arid areas

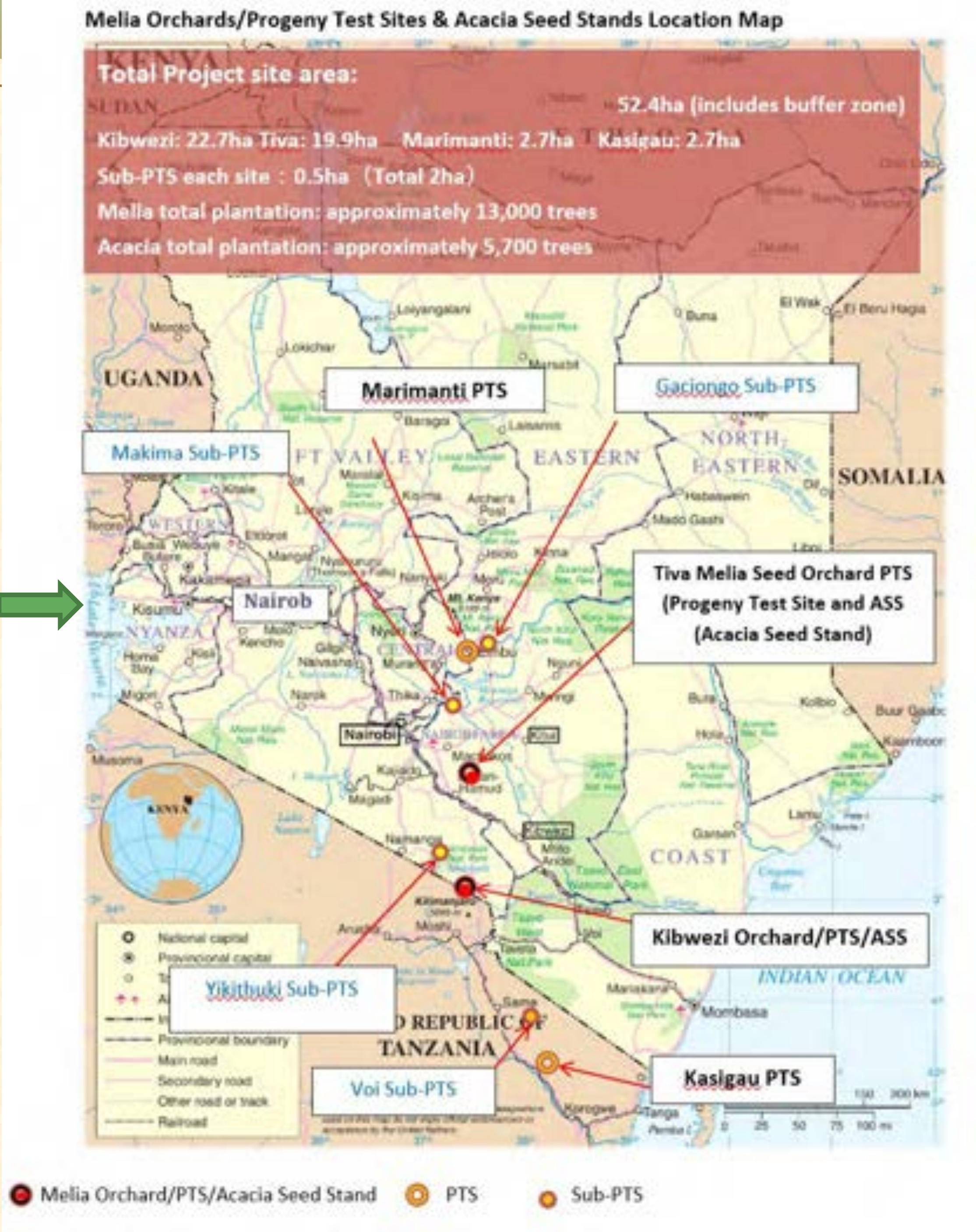
Establishment of 1st Generation Clonal Seed Orchards

3-4 months

- Two x 11 Hectare clonal seed orchards Established in Kibwezi and Tiva (Kitui)
- Each orchard contains 3,000 trees (100 CPTs x 5 ramets/Block x 6 Blocks
- Randomization done to ensure maximum outcrossing
- Yield 4,000 kg per season

Establishment of Progeny tests

- 8 progeny test sites established in 2014 and 2015
- Assessments every 6 months up to 5 years, thereafter annually
- Genetic analysis of data and used for forward selection of 2nd generation trees and est. of 2nd gen. seed orchards : 12.8 Ha



Melia volkensii progeny trials assessment

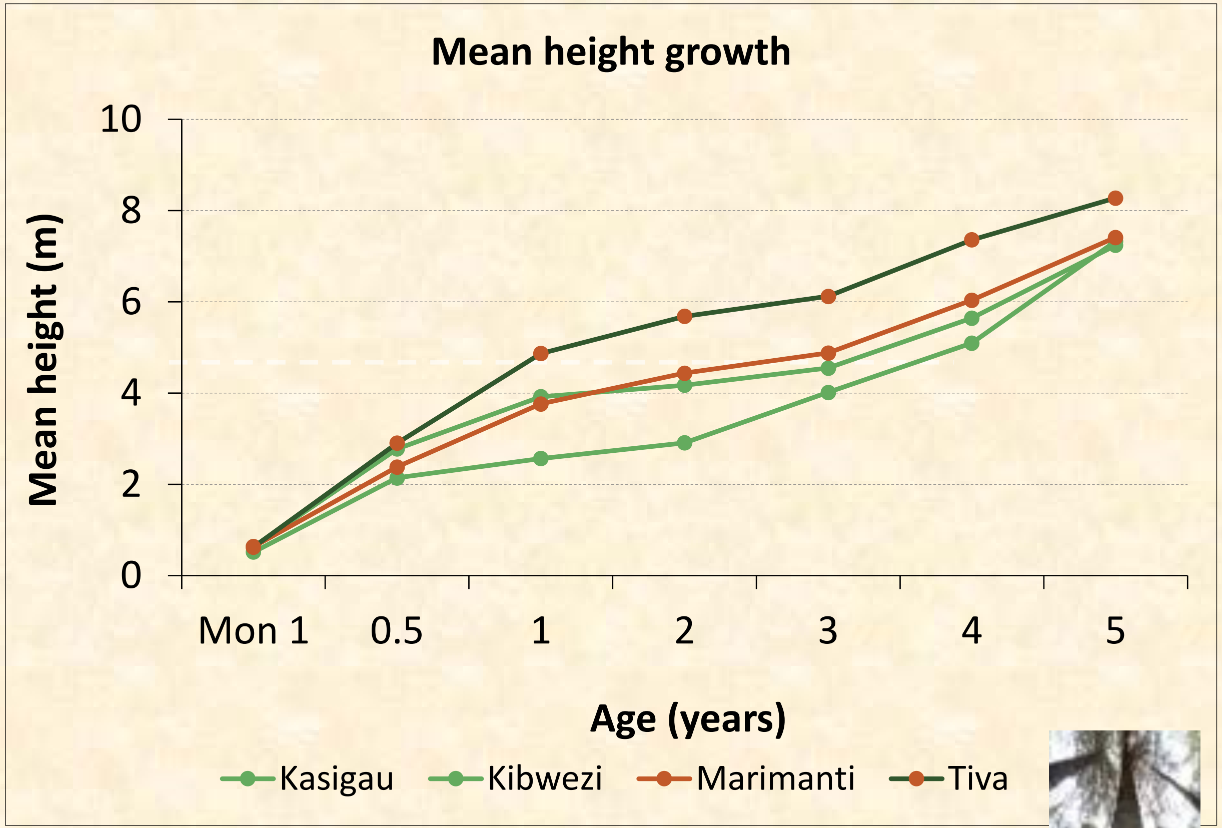
Voi

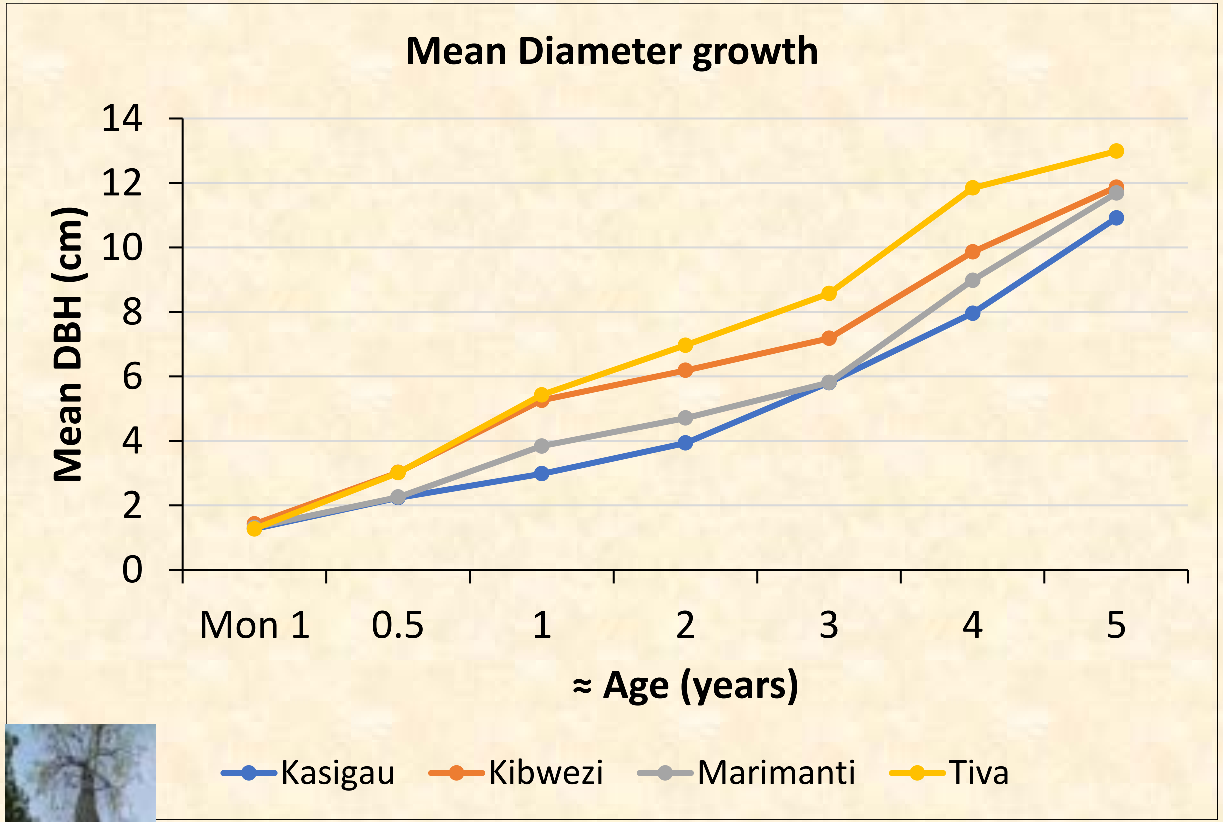
Marimanti

Kasigau

3 YEAR OLD IMPROVED MELIA FROM VARIOUS PROGENY TEST SITES

iv) Growth pattern over 5 years

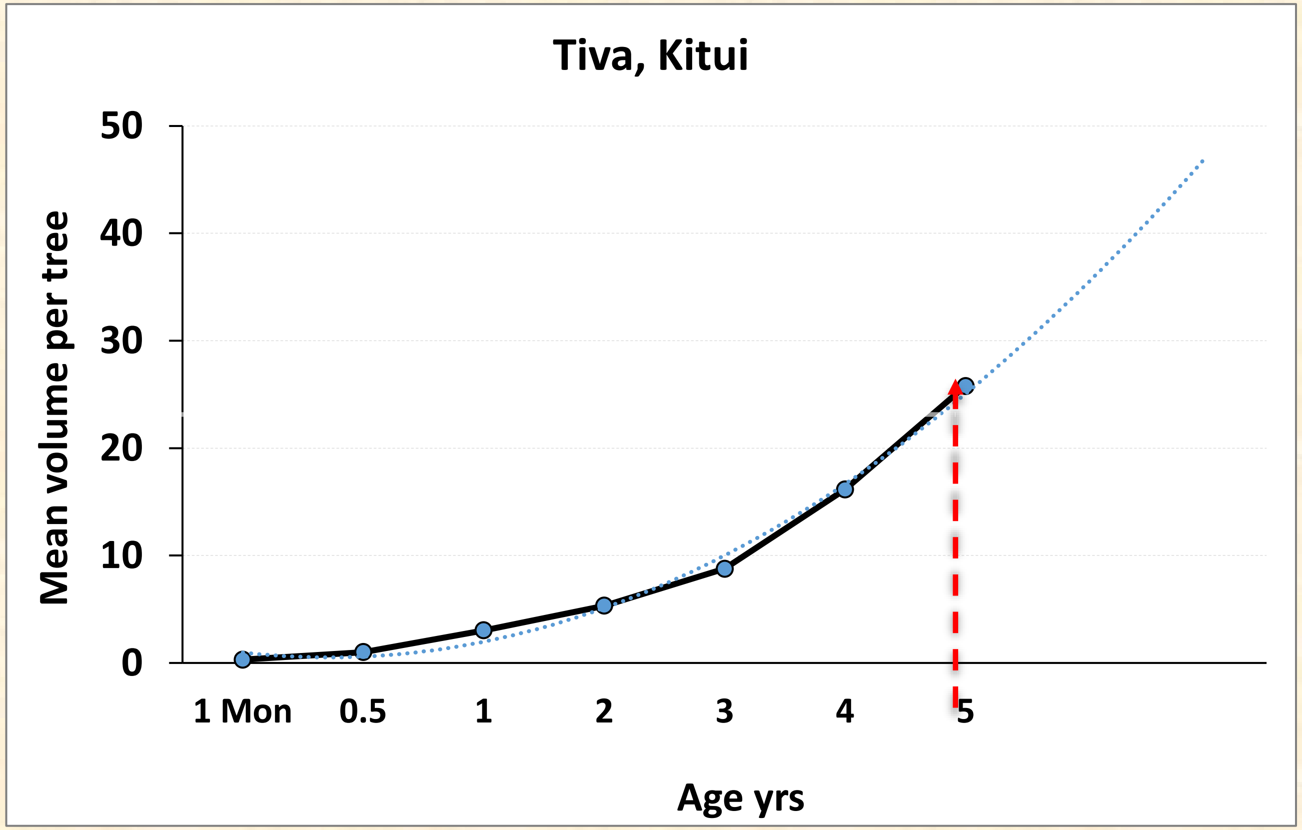


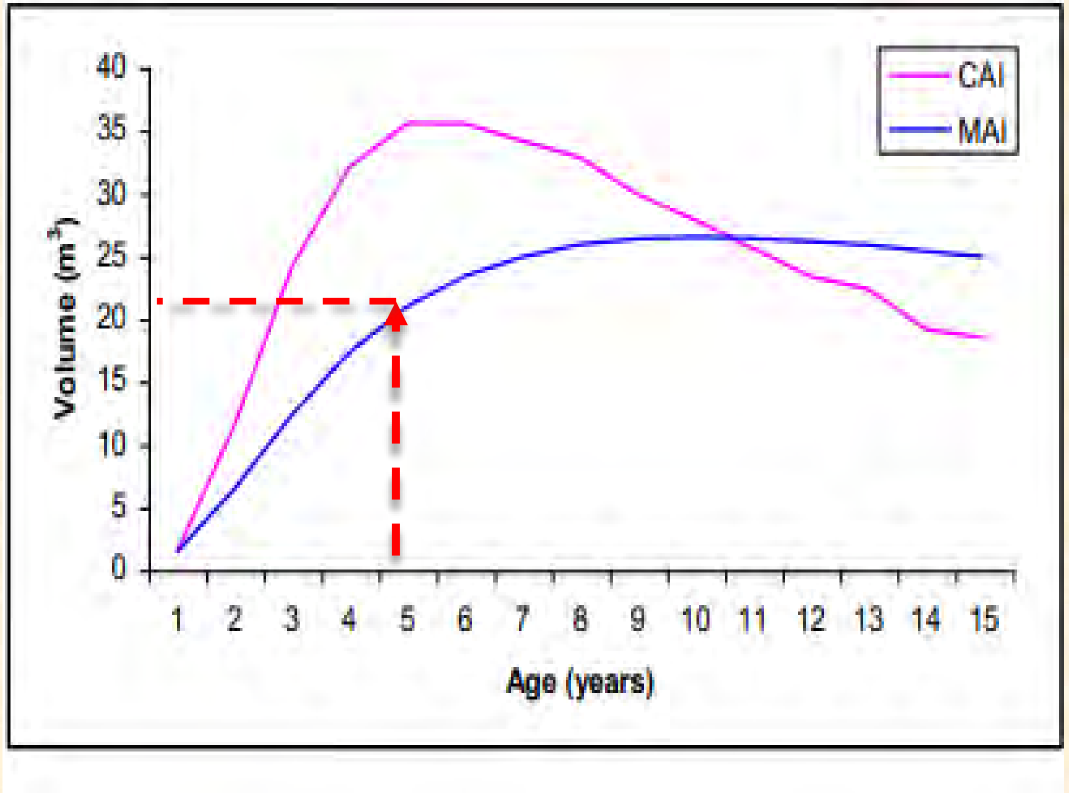


25 year old Cypress

10- year old Melia tree

Gains in volume production of improved vs unimproved Melia





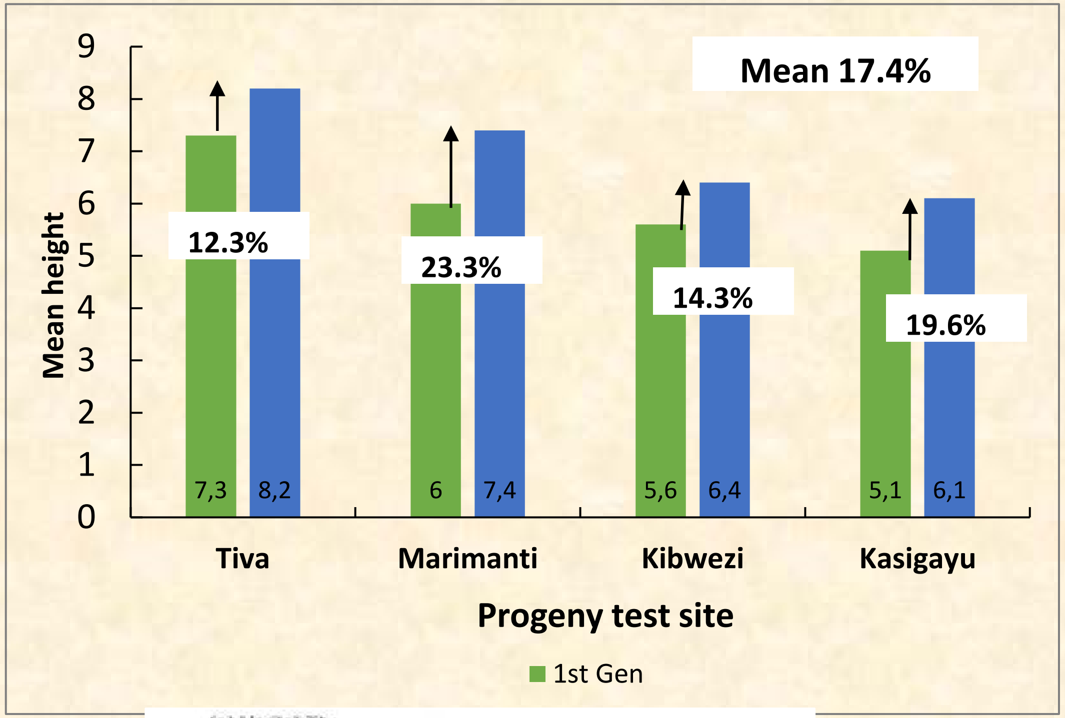
Volume growth in improved selected F2 trees
25.7 m^3 at 5 years

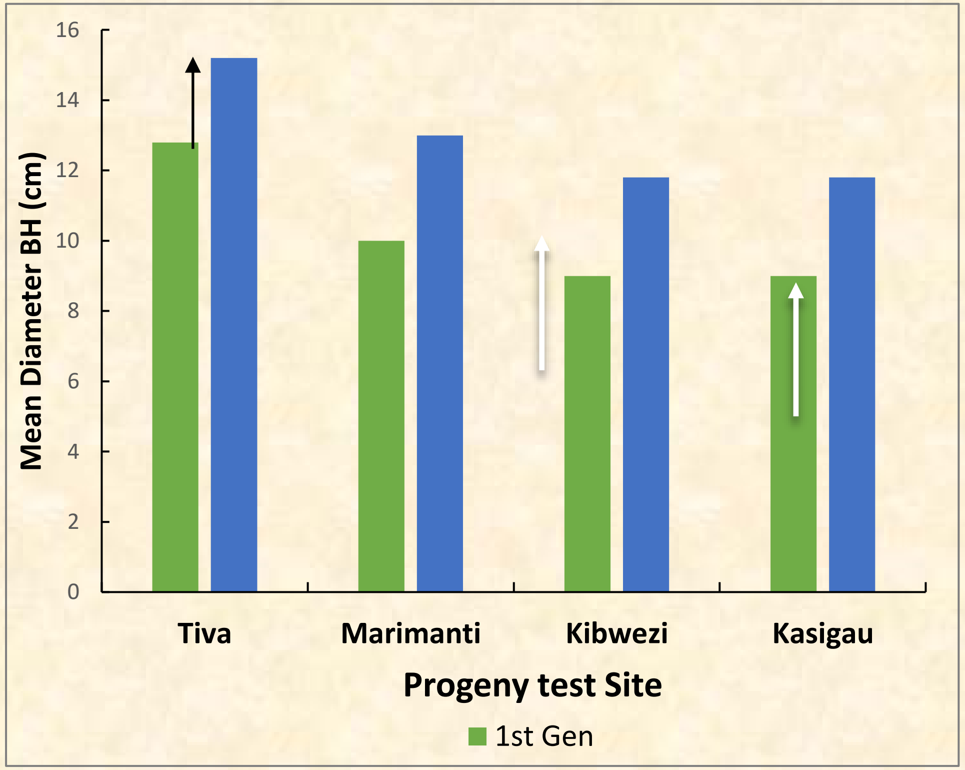
Volume growth in wild unimproved trees
20 m^3 at 5 years

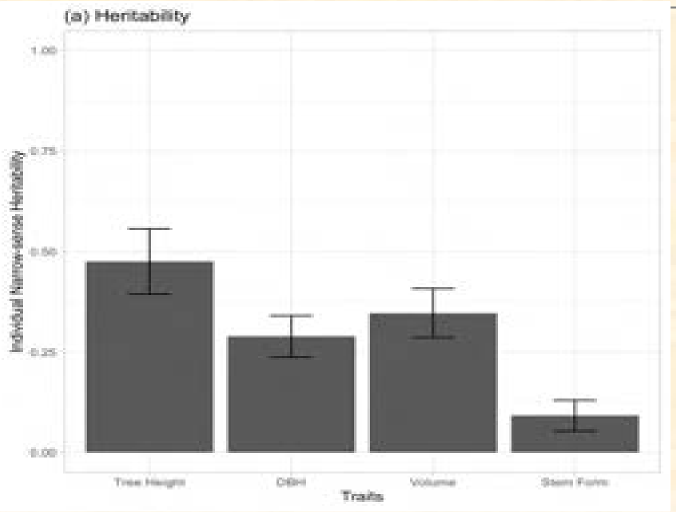
Source: Maina A.M. (2015)

Gains between wild and 2nd generation 28.5 %

Gains: 1st vs 2nd generation *M. volkensii*







Establishment of 2nd generation *Melia volkensii* in 2023

- Four 2nd generation clonal seed orchards planted in Kitui (2) and Kibwezi 2)
- Each consists of 2 ha, 100 families x 4 grafts = 400 seedlings at 7x7m spacing


Grafted seedlings


Printed double labels


Sorted grafts


Labelled grafts


Planting in Kitui


4 months grafted tree

MANUAL FOR ESTABLISHING AND MANAGING *MELIA VOLKENSII* SEED ORCHARDS IN KENYA

Jason G. Kariuki[1], Hisaya Miyashita[2] James K. Ndufa[1] and Bernard M. Kamondo[1]

[1]Kenya Forestry Research Institute, P. O. Box 20412 Nairobi 00200,
[2]Forest Tree Breeding Center, Forestry and Forest Products Research Institute,
3809-1 Ishi, Hitachi, Ibaraki 319-1301, Japan

GUIDELINE ON CLONAL PROPAGATION OF *MELIA VOLKENSII*

GENETIC PERFORMANCE AND PLUS TREE TRAITS TABLE FOR *MELIA VOLKENSII* IN THE DRYLANDS OF KENYA

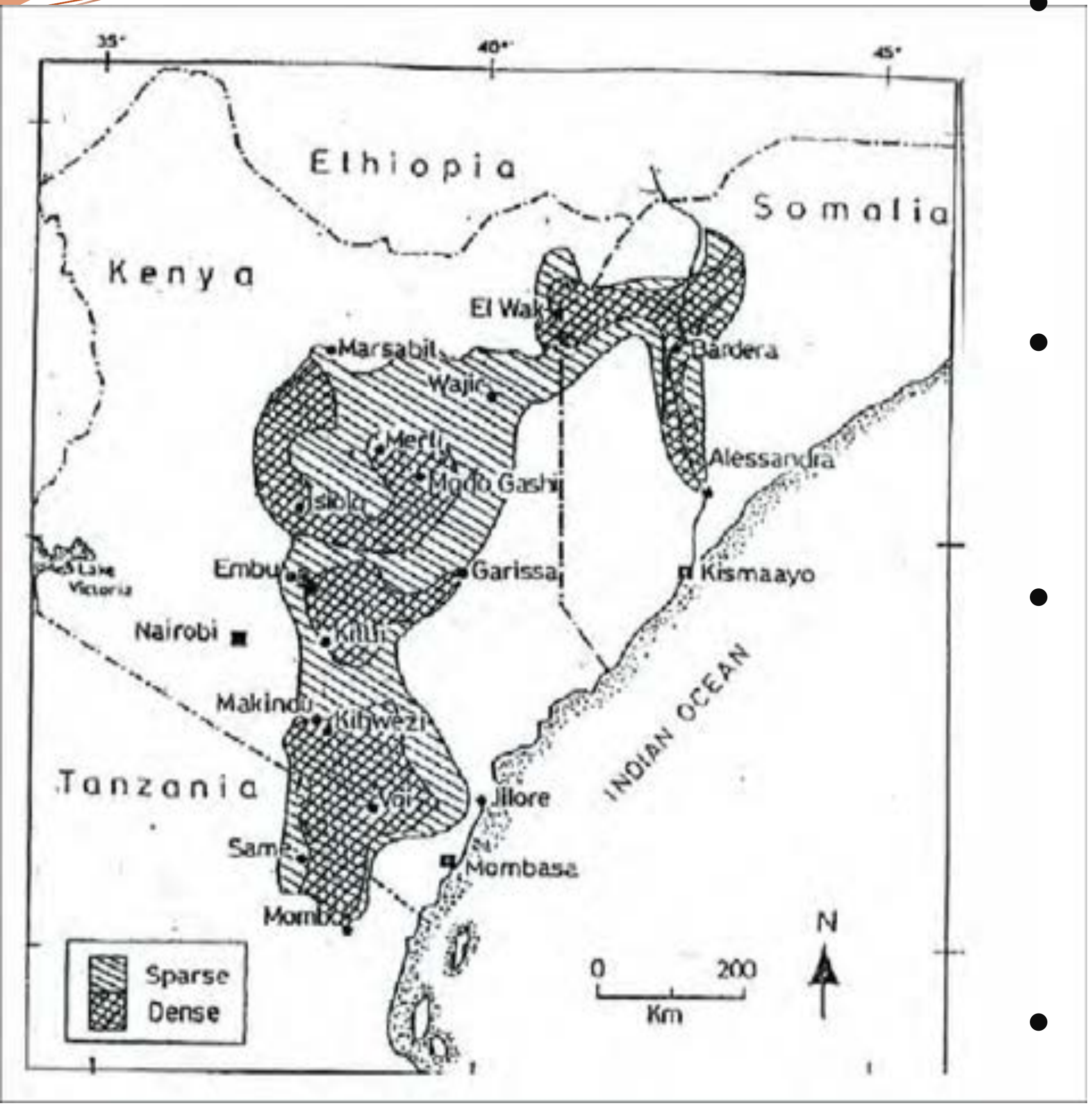
TECHNICAL NOTE

EFFECTS OF DIFFERENT TREE SPACING ON GROWTH PERFORMANCE OF *MELIA VOLKENSII* STAND PLANTED IN TWO SITES IN DRYLANDS OF KENYA

James K. Ndufa, Bernard Kigwa, Solomon Kipkoech and Samson. O. Ojung'a

A Paper Presented at the 5th International Congress on Planted Forests from 7-10 November 2023 AT CIFOR-ICRAF in Nairobi, Kenya

INTRODUCTION



- Melia volkensii is semi-deciduous tree that belongs the family Meleaceae and the species is endemic to the ASALs of Eastern Africa
- Its natural distribution range lies between 400 to 1,600 masl and grows in well drained sandy clay.
- Melia produces timber which is durable and termite resistant and pale reddish-brown in colour resembling the Khaya species (Mahogany) and matures in 15 to 25 years
- Melia wood is used for making assorted furniture and construction

INTRODUCTION CONT'

- In the natural stands, M. volkensii has been heavily exploited for timber and most trees are now found in farms.
- Currently *Melia volkensii* is currently being planted extensively by farmers and private forest companies in Kenya for drylands reforestation programmes and has become one of the most valuable timbers species
- However, there is lack of silvicultural practice especially on spacing and pruning management on growth performance Melia species.
- Melia is planted often at a spacing of 4 x 4 m a spacing adopted from the major exotic industrial species .

OBJECTIVES OF THE STUDY

1. To determine the effects of spacing and different pruning regimes on height and DBH growth
2. To determine the effects of spacing and different pruning regimes on tree volume
3. To determine the effects of different spacing and pruning regimes on biomass growth.

MATERIALS AND METHODS

- **Study area**: Mutomo and Kibwezi in Kitui County Kenya planted in 2012

- **Study Design**: RCBD, Treatment - spacing of 3 x 3 m, 4 x 4 m, 5 x 5 m and 6 x 6 m replicated 3 times within each blocks.

- **Data collection**: The variables studied were diameter at breast height (DBH), total height and height to the first live branch, survival, number of branches, basal area and volume production at age 10 years.

- **Data analysis**: Two-way ANOVAs were performed on DBH, Height, stem volume and biomass.

EFFECT OF DIFFERENT SPACING AND PRUNING REGIMES ON HEIGHT AND DBH

Spacing	Stems ha_1	Kibwezi		Mutomo	
		Mean Height (SD)	Mean DBH (SD)	Mean Height (SD)	Mean DBH (SD)
3m x 3m	1111	7.36±0.16(0.57)	10.43±0.50(1.72)	7.23±0.20(1.04)	10.16±0.39(2.01)
4m x 4m	625	7.20±0.11(0.37)	12.02±0.44(1.53)	7.47±0.15(0.77)	13.6±0.37(1.91)
4m x 4m PR	625	7.51±1.15(1.15)	12.44±0.88(3.05)	7.90±0.86(0.86)	12.82±0.41(2.13)
5m x 5m	400	7.08±0.21(0.21)	13.19±0.56(1.93)	7.29±0.99(0.99)	14.63±0.54(2.83)
6m x 6m	277	7.23±0.19(0.65)	14.85±0.77(2.65)	7.33±0.22(1.12)	17.16±0.62(3.21)
Statistics (AVOVA)	Spacing	F (4,185)=2.51,p=0.044 -Statistically significant (95%CI)			
	Site	F(1,185)=1.45,p=0.230- statistically not significant (95%CI)			
	Spacing* Site	F(1,185)= 0.41,p=0.801 - statistically not significant (95%CI)			

EFFECT OF DIFFERENT SPACING AND PRUNING REGIMES ON TREE VOLUME

Site	Spacing	Vol (m^3 $tree^{-1}$)
Kibwezi	3m x 3m	0.036±0.004ab
	4m x 4m	0.046±0.003abc
	4m x 4m PR	0.054±0.007abc
	5m x 5m	0.053±0.004abc
	6m x 6m	0.069±0.007cd
Mutomo	3m x 3m	0.035±0.003a
	4m x 4m PR	0.060±0.004bc
	4m x 4m	0.058±0.004abc
	5m x 5m	0.069±0.005cd
	6m x 6m	0.093±0.007d
Statistics (ANOVA)	Spacing	F(4,183)= 10.42,p=0.001-statistically significant at 95%CI
	Site	F(4,183)= 24.60, p=<.001-statistically significant at 95%CI
	Site*Spacing	F(4,183)= 1.65,p=0.163--statistically not significant at 95%CI

EFFECT OF DIFFERENT SPACING AND PRUNING REGIMES ON BIOMASS AND CARBON PRODUCTION

Site	Spacing	AGB (Kg/ha)	BGB (Kg/ha)	Carbon ha_1
Kibwezi	3m x 3m	49,791±4809	13,444±1298	29,720±2870
	4m x 4m	37,482±3047	10,120±0823	22,375±1819
	4m x 4m PR	• 44,528±5904	12,023±1594	26,579±3524
	5m x 5m	30,785±3293	8,312±889	18,375±1965
	6m x 6m	30,594±3940	8,260±1064	18,262±2352
Mutomo	3m x 3m	48,153±3496	13,001±944	28,742±2086
	4m x 4m PR	52,121±3709	14,073±1001	31,111±2214
	4m x 4m	46,006±4329	12,422±1169	27,461±2587
	5m x 5m	43,648±4575	11,785±1235	26,053±2731
	6m x 6m	49,385±4488	13,335±1212	29,478±2679
Statistics (ANOVA)	Spacing	F(4,183)= 1.26,p=0.228		
	Site	F(4,183)= 9.01, p=0.003,		
	Site*Spacing	F(4,183)= 1.65,p=0.163		

CONCLUSIONS AND RECOMMENDATION

- Tree spacing significantly affected DBH, tree height, bole height, basal area and the volume of Melia at aged 10 years.
- Wider the spacing, the larger the diameter for timber production, the higher stem volume and the lower carbon sequestration per unit area.
- For timber production we recommend wider spacing > 4 m and for biomass production we recommend all spacing depending on farmers priority on desired products
- Prunning did not adversely affect DBH, tree volume and Biomass
- At 6m x 6m, Malia can be intercropped with crop (agroforestry) or fodder grass (silvipasture)

Enhancing Planting Success of Native Trees in Dry Tropical Areas: implications for Restoration

5th International Congress On Planted Forests

Abebe Damtew Awraris

(PhD researcher)

Contributors:

Bart Muys, Emiru Birhane, Christian Messier, Alain Paquette,

07/12/2023

Division of Forest, Nature and Landscape,

KU LEUVEN

Introduction

Why drylands?

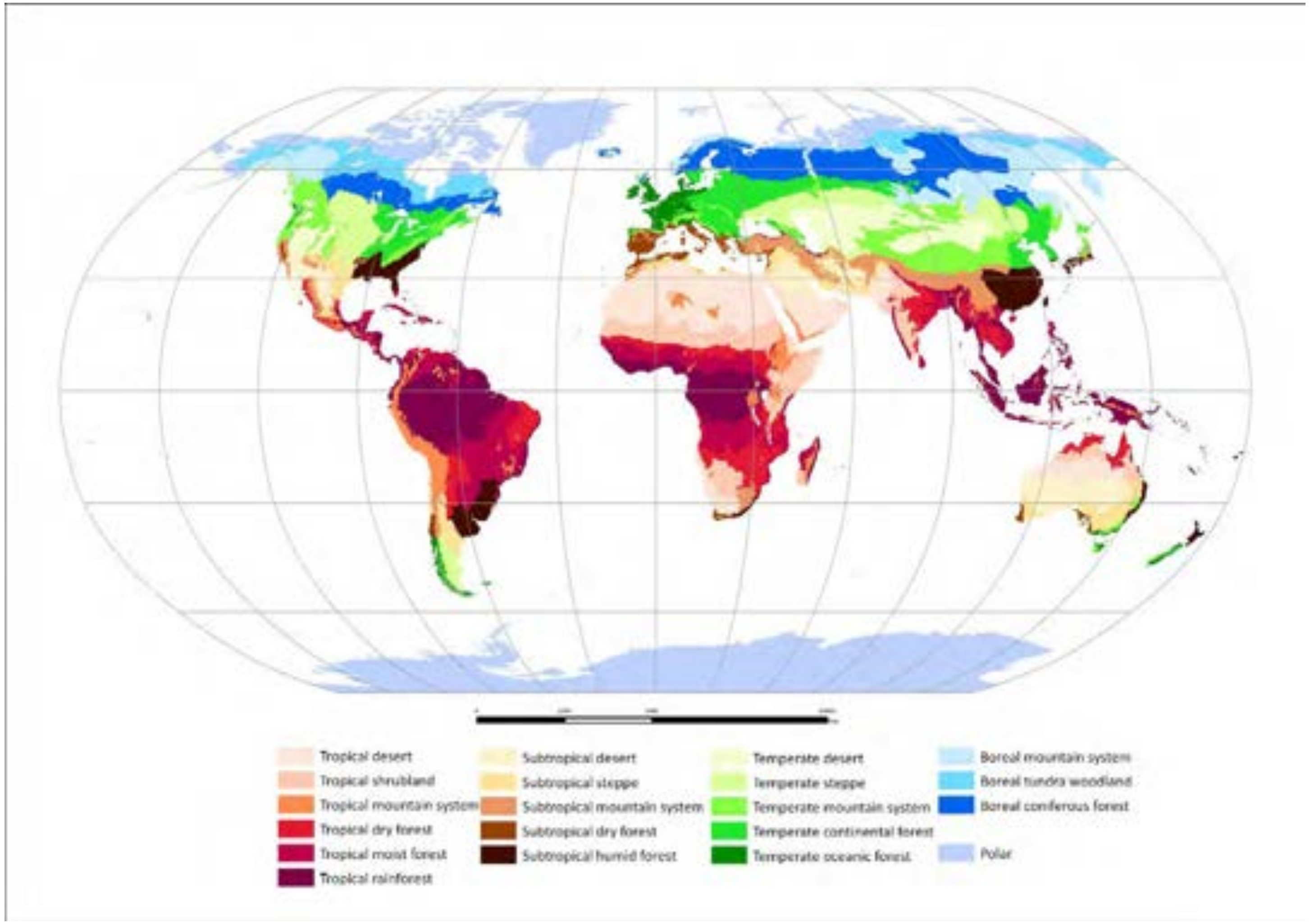
Drylands cover about 41% land surface

Management strategies -focused on highly diverse tropical humid forests

Tropical dryland forests - least studied ecosystems and

Underestimated in many countries

TDFs continued to degrade at higher rates



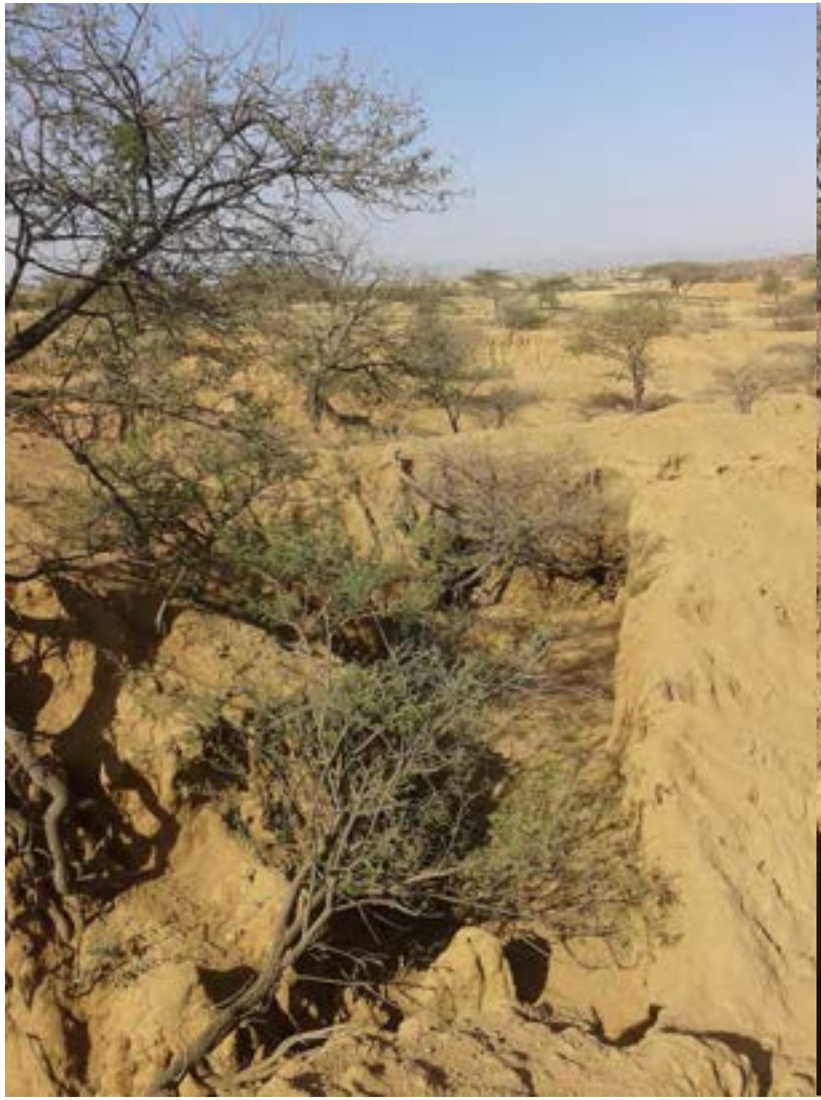
World ecozones showing the distribution of dry forests (Source: FAO 2018)

CONT.

It is urgent to reverse the situation through forest restoration

Several large-scale forest restoration initiatives are being undertaken globally

Ethiopia has committed to restore 22 million ha of land by 2030 –SLM and GLI



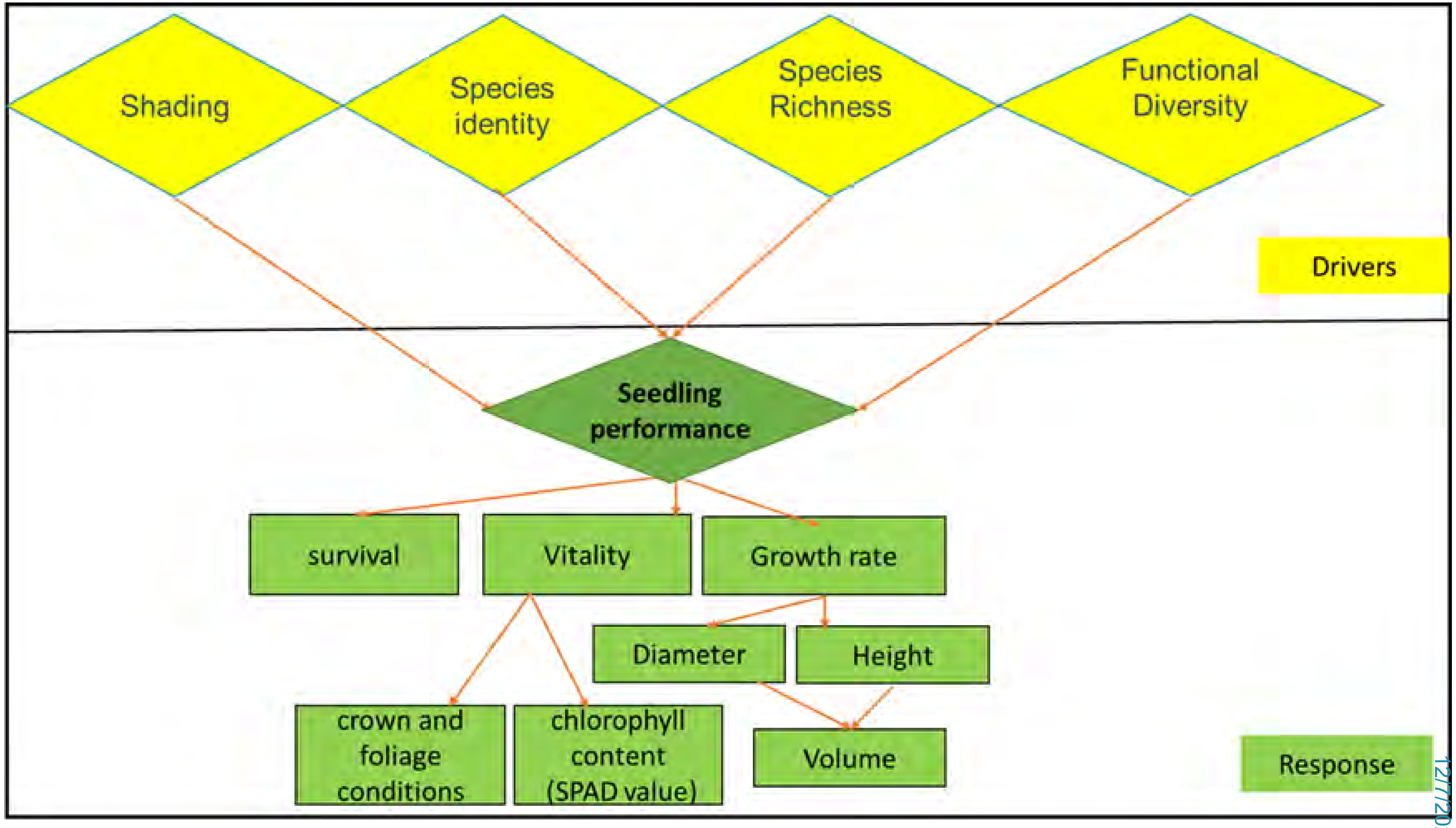
Cont…

We established a high-density tree diversity experiment

IDENT- Ethiopia - Part of the IDENT

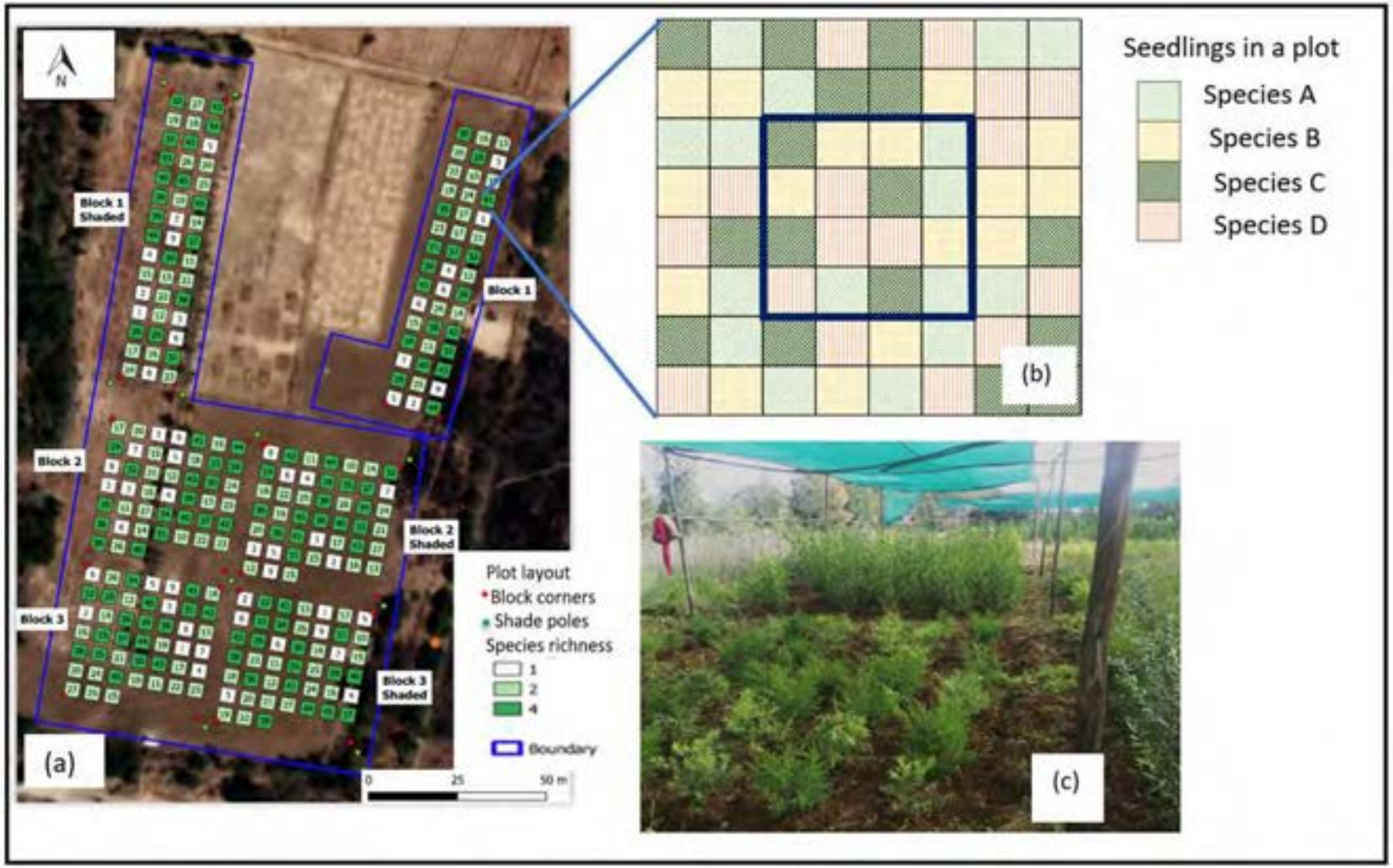
Represents tropical dry climate

More emphasis on native species, manipulating tree species interactions and shading



Experimental design and Treatments

- Consisting of 17,280 seedlings of 9 native dry Afromontane tree and shrub species
- Distributed across 270 plots and three blocks.
- Each block contains a shading treatment (Shaded versus non-shaded)
- with 3 levels of species richness (SR) (1, 2,4) and
- Functional diversity (FD) treatments (low, medium, High)



Monitoring of seedling growth

Seedling measurements were undertaken to assess seedling

- **Diameter**
- **Height**
- **survival,**
- **Vitality (SPAD value and crown and foliage condition)**
- **stem volume was estimated**
- **Partitioning Diversity Effects (**Loreau and Hector, 2001**) and (Fox, 2005)**

Statistical analyses

The binary survival and vitality response was modeled using generalized linear mixed-effect models with logit link function

logit (survival/Vitality) ~ Shading + Sp_richness + Species + Functional_Div + Shading * Sp_richness + (1 | Sp_comp) + (1 | Plot_ID/Block))

We used the odds ratios to compare the odds of survival and vitality

The SPAD value and stem volume of the seedlings were modeled using a linear mixed effects model

lmer (SPAD_value ~ Shading + Species richness + species identity + Functional_Div + Shading * Species + (1 | Sp_comp) + (1 | Plot_ID/Block)

lmer (Dsqrtvolume ~ Shading + Species richness+ species identity + Functional_Div + Shading * Species + ((1 |Plot_ID/Block))

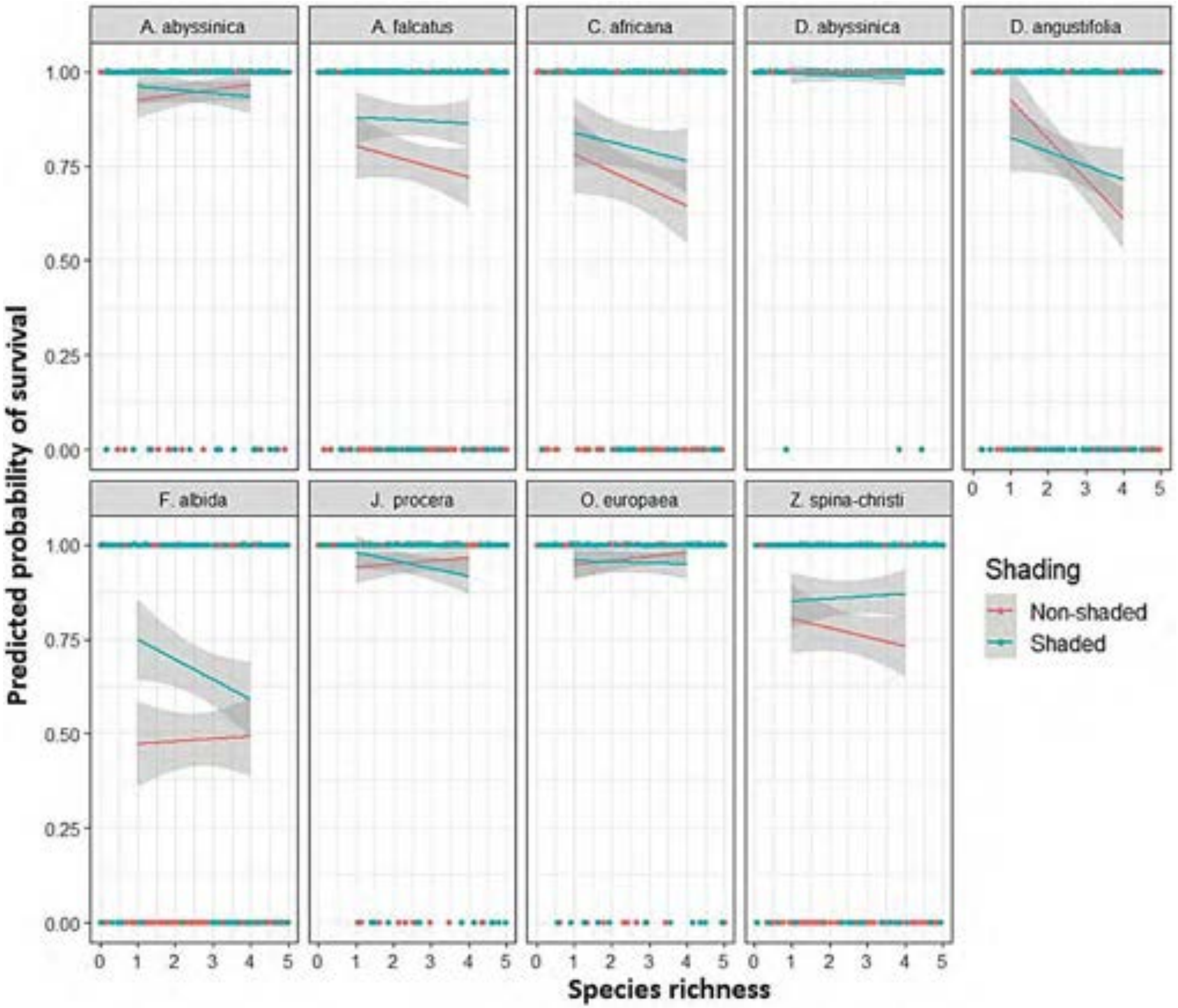
Results

Seedling survival

- The odds of seedling survival increased with shading (odds ratio = 1.52, $p < 0.05$)
- The odds of survival increased by 52%
- The odds of survival increased by 73% in monoculture
- There was a significant variation in the survival probability of species.
- *Dovyalis abyssinica* had the highest survival rate (99.4%)
- The overall seedling survival rate was 84%

Parameter	Survival Odds Ratio (S.E)	95% CI
Intercept	15.33*** (0.27)	9.04 – 26.01
Shading = Shaded	1.52* (0.19)	1.04 – 2.22
Species richness = Monoculture	1.73* (0.27)	1.01 – 2.92
Species richness = Two-species	1.20 (0.19)	0.82 – 1.75
Species = A. falcatus	0.22*** (0.25)	0.13 – 0.36
Species = C. africana	0.16*** (0.25)	0.09 – 0.25
Species = D. abyssinica	9.31*** (0.63)	2.73 – 31.76
Species = D. angustifolia	0.16*** (0.25)	0.10 – 0.25
Species = F. albida	0.06*** (0.25)	0.04 – 0.11
Species = J. procera	1.09 (0.31)	0.59 – 2.00
Species = O. europaea	1.35 (0.32)	0.72 – 2.51
Species = Z. spina-christi	0.23*** (0.25)	0.14 – 0.38
Functional Diversity = Low	0.91 (0.17)	0.65 – 1.27
Functional Diversity = Medium	1.01 (0.17)	0.71 – 1.40
Shading * Monoculture	0.93 (0.36)	0.45 – 1.91
Shading * Two-species	1.09 (0.27)	0.63 – 1.89
N	4320	
N (plot)	270	
N (species composition)	45	
N (Block)	3	
AIC	3111.91	
BIC	3232.59	
R^2 (fixed)	0.36	
R^2 (total)	0.44	

Predicted probability of seedling survival

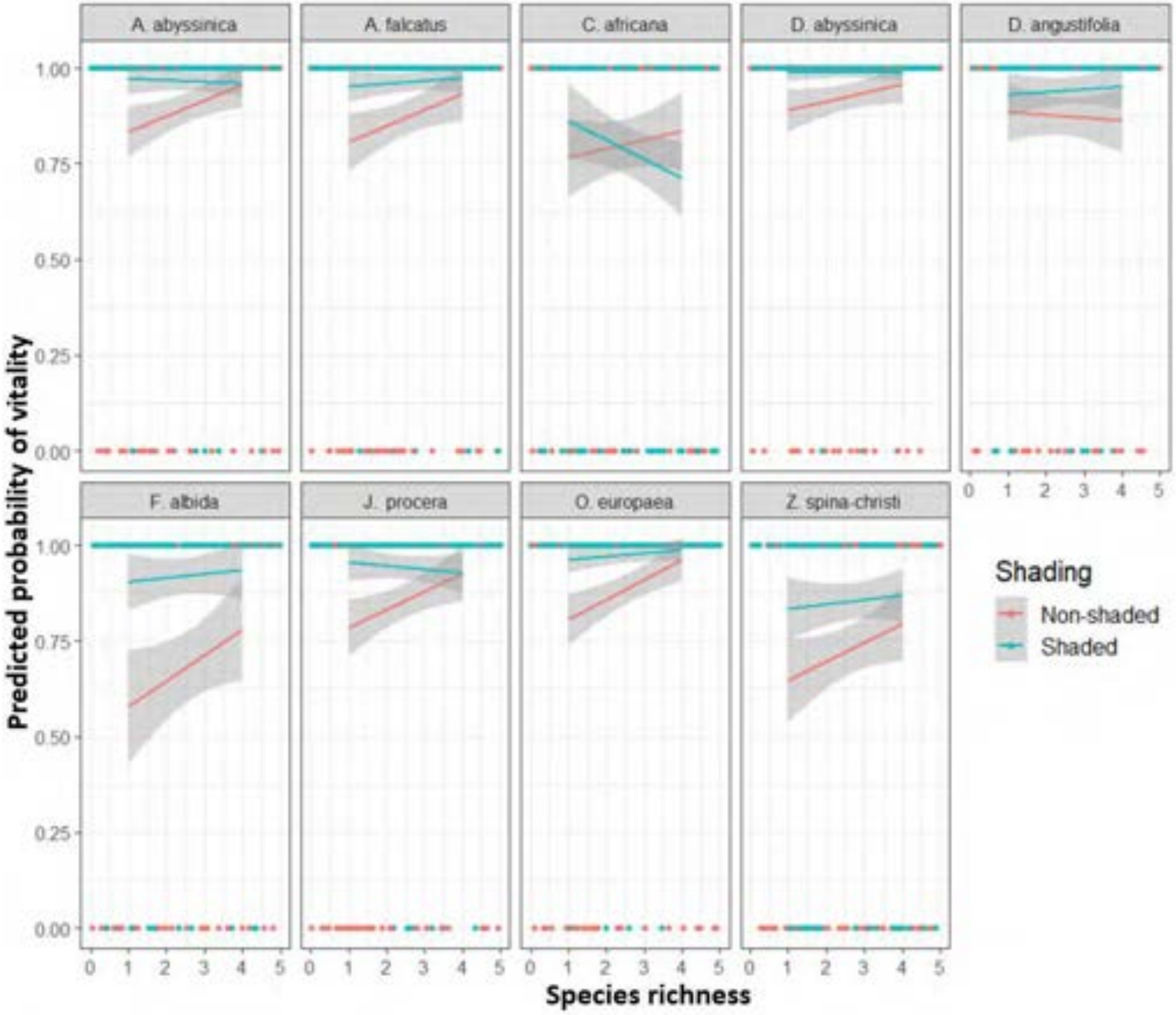


Seedling Vitality based on crown and foliage condition

- Shading was positively associated with seedling vitality (odds ratio = 1.95, P < 0.001)
- Meaning the odds of survival increased by 95%
- The likelihood of seedling vitality was significantly lower in the monoculture plots (odds ratio = 0.30, P < 0.001)
- Indicates the odds of vitality are reduced by 70% in monoculture

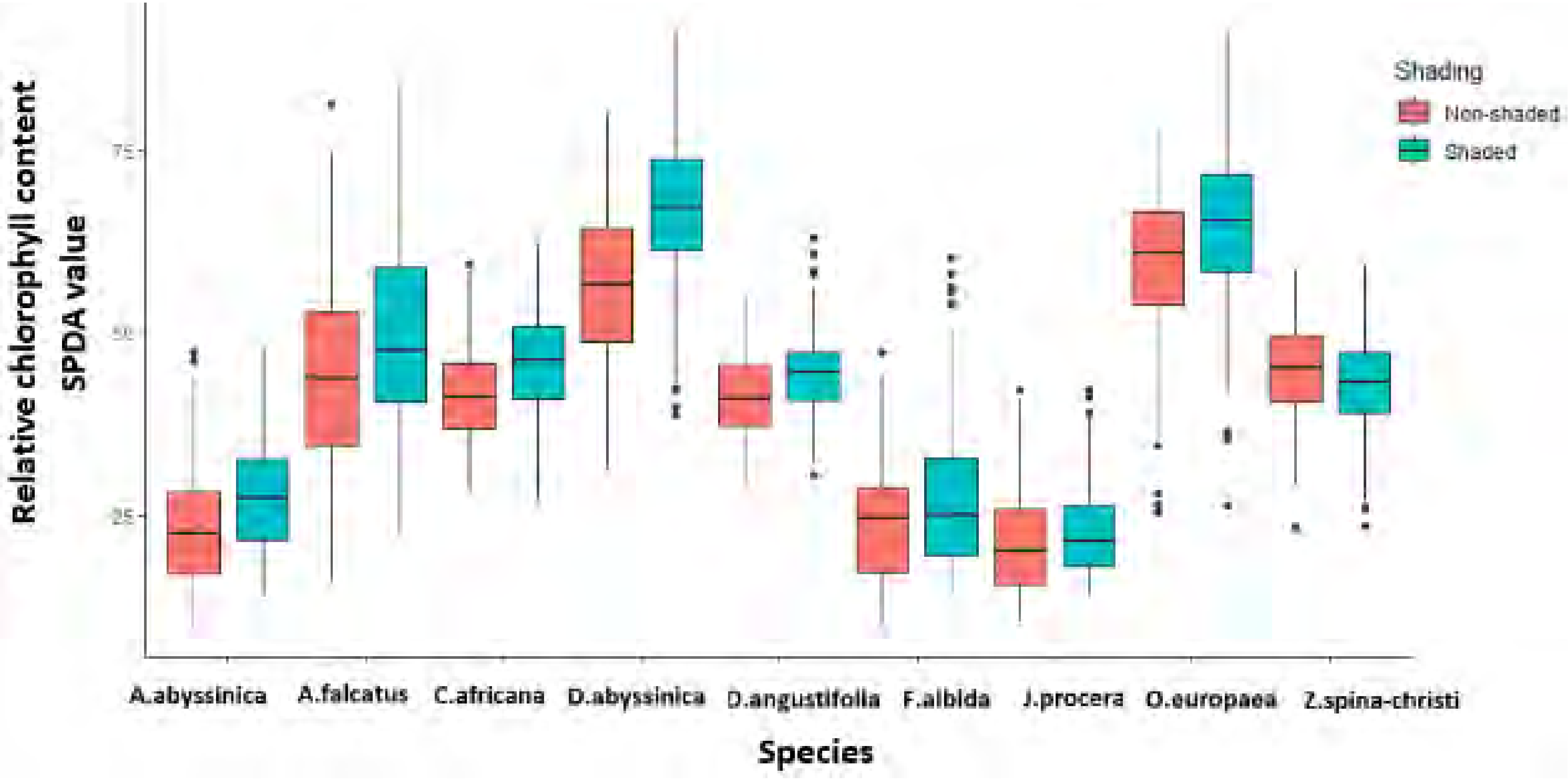
Parameter	Vitality Odds ratio (S.E)	95% CI
Intercept	15.06*** (0.28)	8.71 – 26.04
Shading = Shaded	1.95* (0.23)	1.25 – 3.03
Species richness = Monoculture	0.30* (0.25)	0.18 – 0.49
Species richness = Two-species	1.02 (0.21)	0.68 – 1.54
Species = A. falcatus	0.79 (0.29)	0.45 – 1.38
Species = C. africana	0.24*** (0.27)	0.14 – 0.39
Species = D. abyssinica	1.63 (0.32)	0.85 – 3.02
Species = D. angustifolia	0.67 (0.29)	0.37 – 1.17
Species = F. albida	0.28*** (0.29)	0.16 – 0.50
Species = J. procera	0.62 (0.27)	0.36 – 1.05
Species = O. europaea	1.06 (0.29)	0.60 – 1.90
Species = Z. spina-christi	0.23*** (0.26)	0.14 – 0.39
Functional Diversity = Low	1.04 (0.10)	0.71 – 1.52
Functional Diversity = Medium	0.92 (0.19)	0.63 – 1.35
Shading * Monoculture	3.94*** (0.37)	1.90 – 8.20
Shading * Two-species	0.91 (0.31)	0.49 – 1.69
N	3659	
N (plot)	270	
N (species composition)	45	
N (Block)	3	
AIC	2775.30	
BIC	2775.51	
R2 (fixed)	0.17	
R2 (total)	0.24	

Predicted probability of seedling vitality



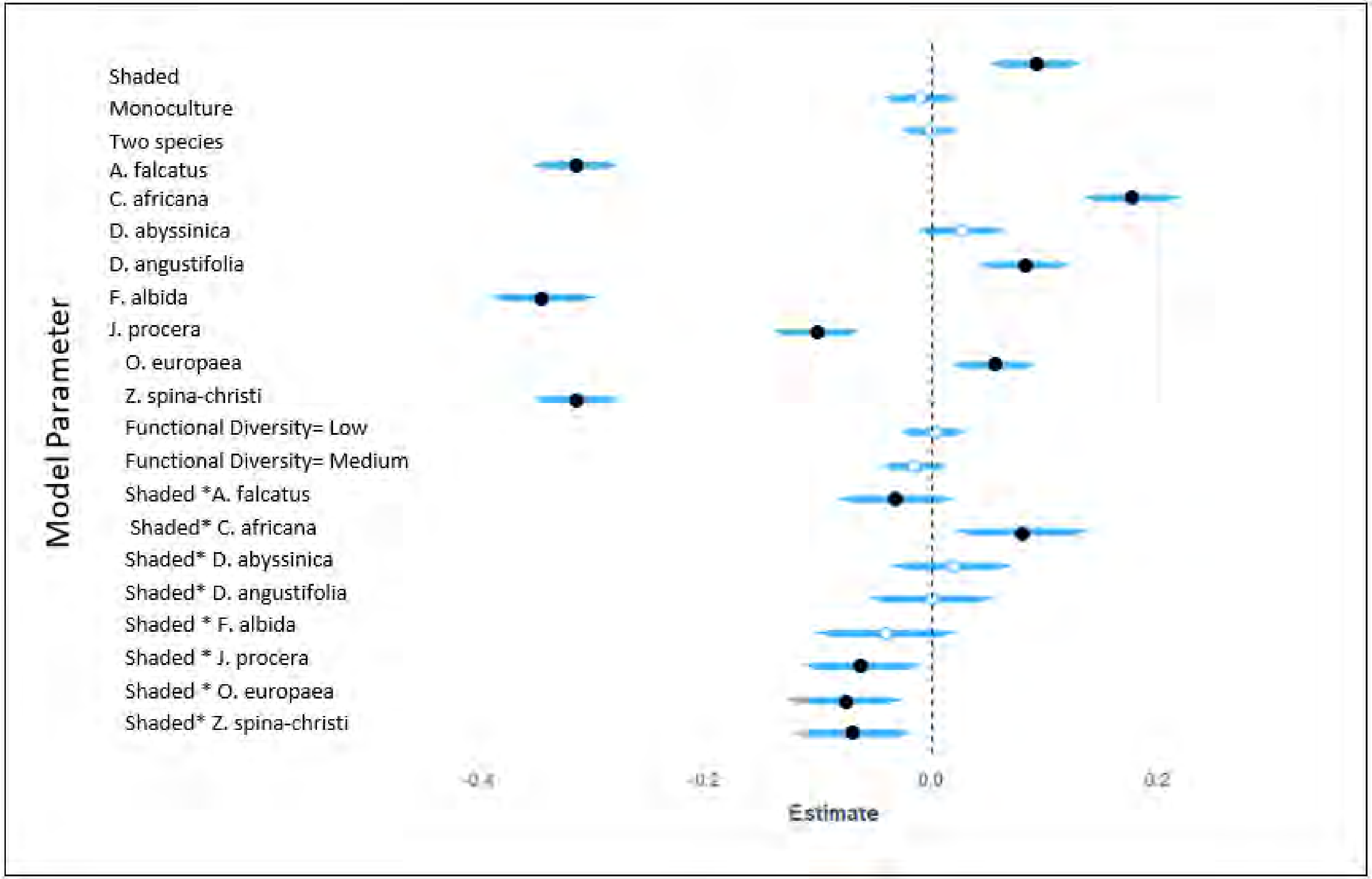
Seedling Vitality (SPAD value)

- Shading was positively associated with SPAD value (estimate = 4.44, t(3631) = 3.78, p < .001)
- (SPAD value) increased by 10.28% in a shade
- Significant variation in chlorophyll content among species
- However, neither SR nor FD significantly influenced SPAD value



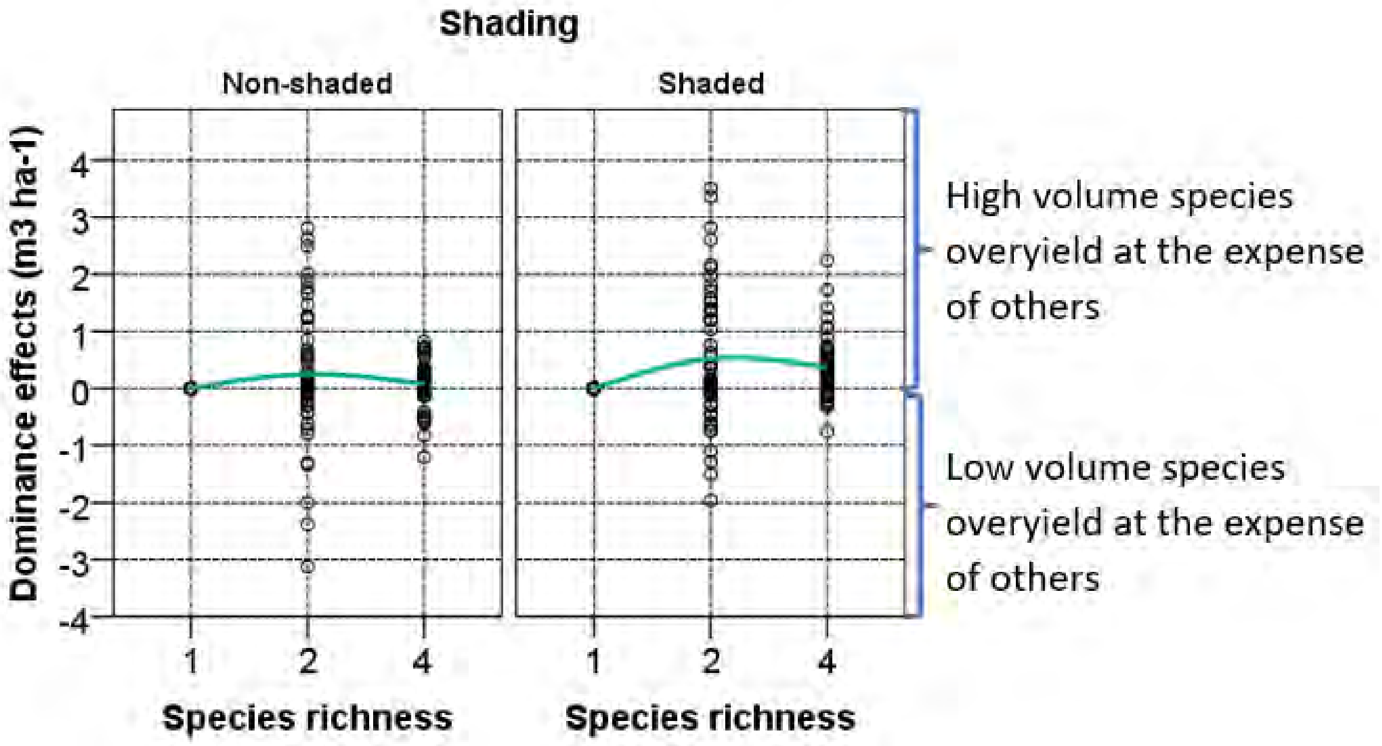
Stem volume productivity

- Stem volume significantly associated with shading (Estimate ± SE: 0.092 ± 0.020, $t = 4.495$, $p < 0.001$)
- The mean stem volume increased by 10.1%
- Stem volume production of seedlings varied significantly among species
- The interaction between shading * species identity also has significant effects on stem volume productivity



Plot-Level Diversity Effect

- Net diversity effect was positive in 57% of mixtures
- A positive (DOM) was observed in 64% of mixtures under non-shaded conditions, and 74% in shaded conditions.
- Overyielding through (DOM) was significantly associated with both shading and species richness
- Thus, the selection effect hypothesis due to competitive dominance explains the diversity effect



Conclusions

- **In conclusion, shading consistently improved the likelihood of planting success by enhancing seedling survival, vitality, chlorophyll content, and stem volume growth.**
- **Therefore, it can be concluded that most dry Afromontane species require temporary shelter to establish themselves in drylands effectively.**
- **Moreover, species richness contributed to seedling vitality and growth in drylands.**
- **An increase in species richness negatively impacts seedling survival.**
- **57% of all mixtures showed a positive diversity effect, indicating higher productivity compared to monoculture**
- **Overyielding, resulting from species mixture, was mainly attributed to competitive dominance (selection effect) rather than niche complementarity.**

Take-home message

- Planting seedlings in sheltered microhabitats can greatly improve their survival and performance in dry environments.

- To ensure successful enrichment planting, it is recommended to avoid uprooting, clearcutting, or bulldozing tracts.
- Species mixing is an efficient silvicultural strategy to prevent the total failure of some species in monospecific plantations.

- Carefully selecting tree species, maintaining appropriate shade levels, and promoting species mixing are crucial steps in the restoration of dry forests.

- However, further research is needed to understand how other factors, such as belowground competition, will affect the performance of trees over time in upcoming research works

Thank you for your attention!

Effect of cone characteristics, extraction period and germination temperature on seed yield and quality of *Pinus patula*

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Introduction

- Pines are one of commercially planted trees species (Aniszewska et al., 2020; Savill, 2019;Barbour, 2007).
- Seed extraction has been challenging to the forestry sector as the conventional method is drying in beds to facilitate seed release (Bhat et al., 2017; Reyes and Casal, 2001).
- The major risk associated with natural sun drying of cones is the possibility of losing viability due to moisture loss and temperature variation (Aniszewska and Zychowicz, 2020).
- Artificial drying of cones in heated kilns has been recommended for cool moist climate species where the climate is not suited for air drying (Singh et al., 2017)

Introduction cont'

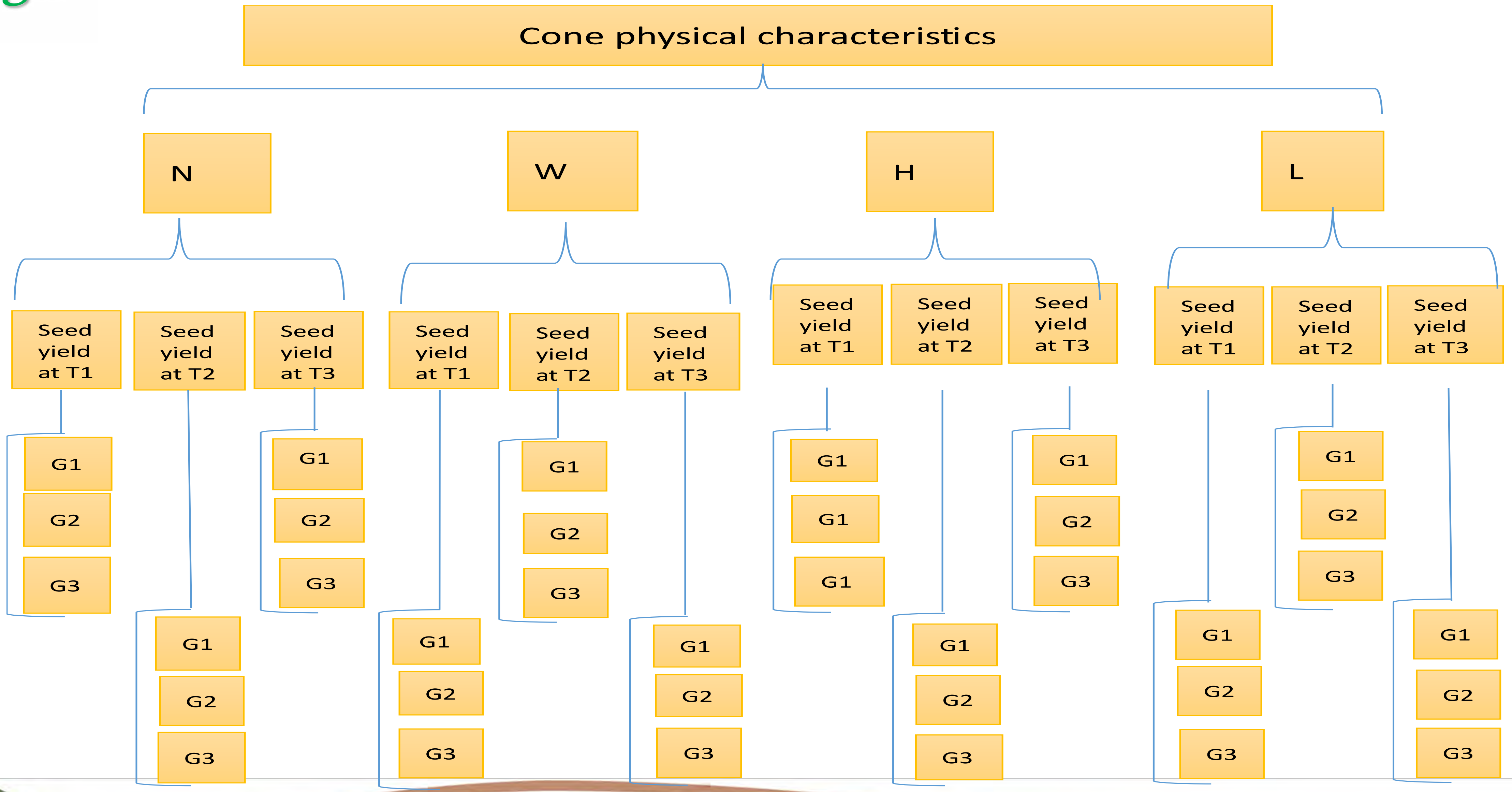
- Pinus patula represents 27% of plantation species in Kenya grown for industrial production of pulpwood and sawn wood (Kuria et al, 2019; Ngugi et al., 2000).

- P. patula is a serotinous pine (Orwa et al., 2009) and thus produces serotinous cones (Bastien & Ganteaume, 2020, Lamont *et al*., 2020). Seed release is environmentally stimulated (Rhoades et al., 2022; Wyse et al., 2019).
- Cone collection is seasonal and seed yield is weather dependent, i.e slower and uneconomical in cooler weather. Thus, the need to improve extraction efficiency and germination performance (Tulska et al., 2022; Kaliniewicz et al., 2014) .

Objectives

1. To determine the effect of cone width and exposure period on seed release.
2. To determine the effect of cone weight and exposure period on seed release.
3. To analyze the correlations between cone width, exposure period and germination temperature on viability.
4. To analyze the correlations between cone weight, exposure periods and germination temperature on viability.

Design



Cone physical characteristics
N
W
H
L
Seed yield at T1
Seed yield at T2
Seed yield at T3
Seed yield at T1
Seed yield at T2
Seed yield at T3
Seed yield at T1
Seed yield at T2
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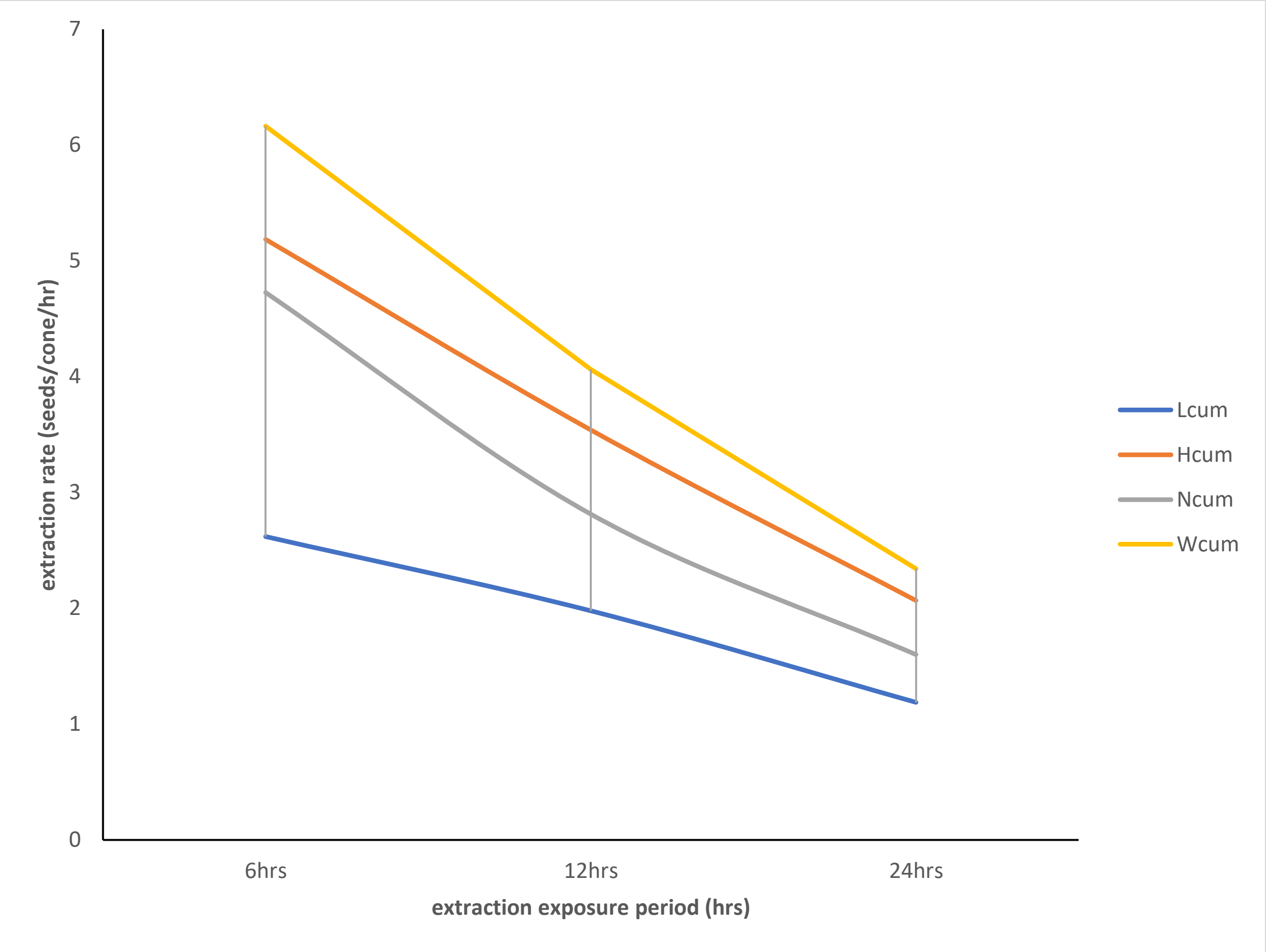
Cone characteristics, extraction periods and seed yield

Treatment	L1	H1	N1	W1	L2	H2	N2	W2	L3	H3	N3	W3
Mean seed yield (x±se)	15.7±1.38	30.9±2.31	29.8±3.15	37.0±3.36	8.0±0.62	11.3±0.86	6.2±0.69	11.8±1.45	4.76±0.42	7.1±0.72	5.2±1.10	7.5±1.13
sd	15.49	27.58	25.59	26.05	6.96	10.28	5.61	11.25	4.66	8.61	8.93	8.74
ci	2.733	4.561	6.292	6.731	1.227	1.699	1.379	2.907	0.821	1.424	2.194	2.258
% seed yield	55	63	74	66	28	23	14	21	17	14	12	13
% cumulative seed yield	55	63	74	66	83	86	88	87	100	100	100	100
Performance-based on the extraction phase	64				22				14			

*L,H,N,W : cone characteristics light , heavy, narrow, wide and wide cones, 1,2,3 : seed extraction exposure periods from 0 to the 6th hour, 6th hour to the 12th hour and the 12th hour to the 24th hour, x:group mean, se:standard error, sd: standard deviation, ci: confidence interval

Extraction efficiency

- The extraction rate was highest within the first six hours and with wide cones demonstrating the best performance yielding an average of six seeds per cone per hour .
- The extraction rate in all the groups dropped as the extraction period increased with the lowest observed in narrow cones 0.4 seeds per cone per hour between 12 and 24 hours.



Pearson correlation coefficient for seed germination

Variables N	Germination temperature	Extraction period	Germination performance
Germination temperature	1		
Extraction period	.100ns	1	
Germination performance	$-.244^{**}$	$-.323^{**}$	1

**. Correlation is significant at the 0.05 level;
ns: p>0.05 correlation not significant

Variables L	Germination temperature	Extraction period	Germination performance
Germination temperature	1		
Extraction period	.007ns	1	
Germination performance	.085ns	$-.618^{**}$	1

**. Correlation is significant at the 0.05 level;
ns: p>0.05 correlation not significant

Variables W	Germination temperature	Extraction period	Germination performance
Germination temperature	1		
Extraction period	-.085ns	1	
Germination performance	.086ns	-.128ns	1

ns: p>0.05 correlation not significant

Variable H	Germination temperature	Extraction period	Germination performance
Germination temperature	1		
Extraction period	-.004ns	1	
Germination performance	-.034ns	.089ns	1

ns: p>0.05 correlation not significant

- Temperature among other factors is most influential in germination rate and synchrony (Bravo-Navas & Sánchez-Romero, 2022).
- Seed germination deteriorated more when extracted in phases or in breaks than when exposed to a full 6 hours or an entire 24 hours.
- Seeds from light and narrow cones showed low germination: higher intolerance to temperature variations, (cooling within breaks) as extracted seeds showed more deterioration with changes or increase in exposure periods and germination temperature (Bae & Kim, 2020; Koba & Zhigalova, 2019).
- Thermal shocks, sensitivity and insulation capacity

Regression equations

G_{Width}=40.7+0.700gt -0.913ex

R^2=87.7%

G_{weight}=35.5+0.500gt-0.238ex

R^2= 7.3%

*G=germination performance (%), ex= extraction period (hours), gt_1= germination temperature (°C)

Conclusion

1. Seed extraction could be focused within six hours for energy conservation and improved efficacy in seed extraction through artificial heating.
2. Wide cones demonstrated better responses to heat by yielding higher seed numbers.
3. Warmer temperatures (27°C to 32°C) had higher germination performance.
4. Cone sorting of *Pinus patula* for wider and heavier cones is recommended from improved seed extraction and germination potential.

Acknowledgement

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On-going Research

❖ **Silvicultural management requirements for transformation of planted forests in riparian zones for enhanced ecosystem functions**

Thank you