5TH INTERNATIONAL CONGRESS ON PLANTED FORESTS

Session 4: Planted forests in a decarbonized bioeconomy

Co-organizers

iefc Institut Européen de la Forêt Cultivée

Food and Agriculture Organization of the United Nations

CIFOR

World Agroforestry

IUFRO

Republic of Kenya — Ministry of Environment, Climate Change & Forestry

Kenya Forest Service

Kenya Forestry Research Institute (KEFRI)

TreeDivNet MixForChange

EFI

Sponsors

scion FORESTS • PRODUCTS • INNOVATION

reforestACTION

Session 4: **Planted forests in a decarbonized bioeconomy**

- *Part 1: Context and opportunities for planted forests in a decarbonized bioeconomy*
  - Bioeconomy development and planted forests, **Vincent Gitz**
  - Spatial Database of Planted Trees v2.0, **Jessica Richter**
  - Africa's housing needs as an opportunity to drive investment at scale into sustainable forestry, **Nick Embden, Caroline Ray**
  - Isolation and chemical characterization of biopesticides from Melia volkensii against fall armyworm, Spodoptera frugiperda, and red flour beetle, Tribolium castaneum, **Victor Jaoko**
  - Bio-pesticide activity of Commiphora africana dichloromethane resin extract against Cimex lectularius (bedbugs), **Norman W. Wairagu**

- *Part 2: Measuring, estimating, projecting mitigation / emission from planted forests*
  - Carbon sequestration potential of plantation forests tree species in New Zealand: A comparative study, **Serajis Salekin**
  - Can prolonged rotation in combination of forest drainage be a solution to increased carbon storage in Scots pine forests on organic soils of hemiboreal region, **Valters Samariks**
  - Allometric equations to estimate potential biomass and carbon stocks for on-farm bamboo species in agricultural landscapes of Kenya, **John N. Kigomo**
  - Life Cycle Assessment (LCA): new poplar clones allow an environmentally sustainable cultivation, **Sara Bergante**
  - Modelling carbon capture by line-seeded reforestation sites in Australia, **Koen Kramer**
  - *Q&A and discussion*

Chair: Faustine Zoveda, Co-chair and reporting to plenary: Manitrala Rasoanaivo

Bioeconomy development and planted forests

Vincent Gitz, CIFOR-ICRAF

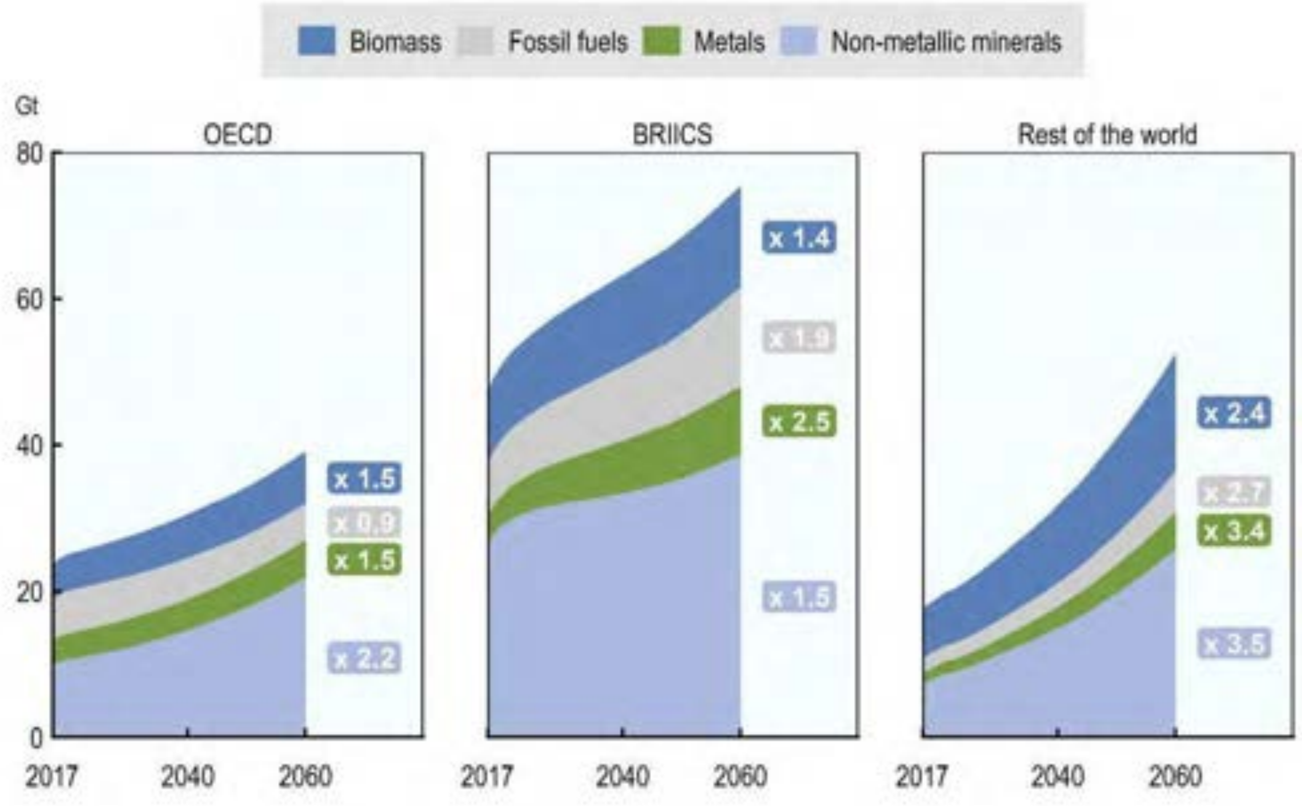
Vth International Congress on Planted Forests
Nairobi, Kenya
7-10 November 2023

CIFOR World Agroforestry Global Landscapes Forum Resilient Landscapes

Increasing demand for raw materials…

Figure 1.4. Growth in materials use is projected for all regions

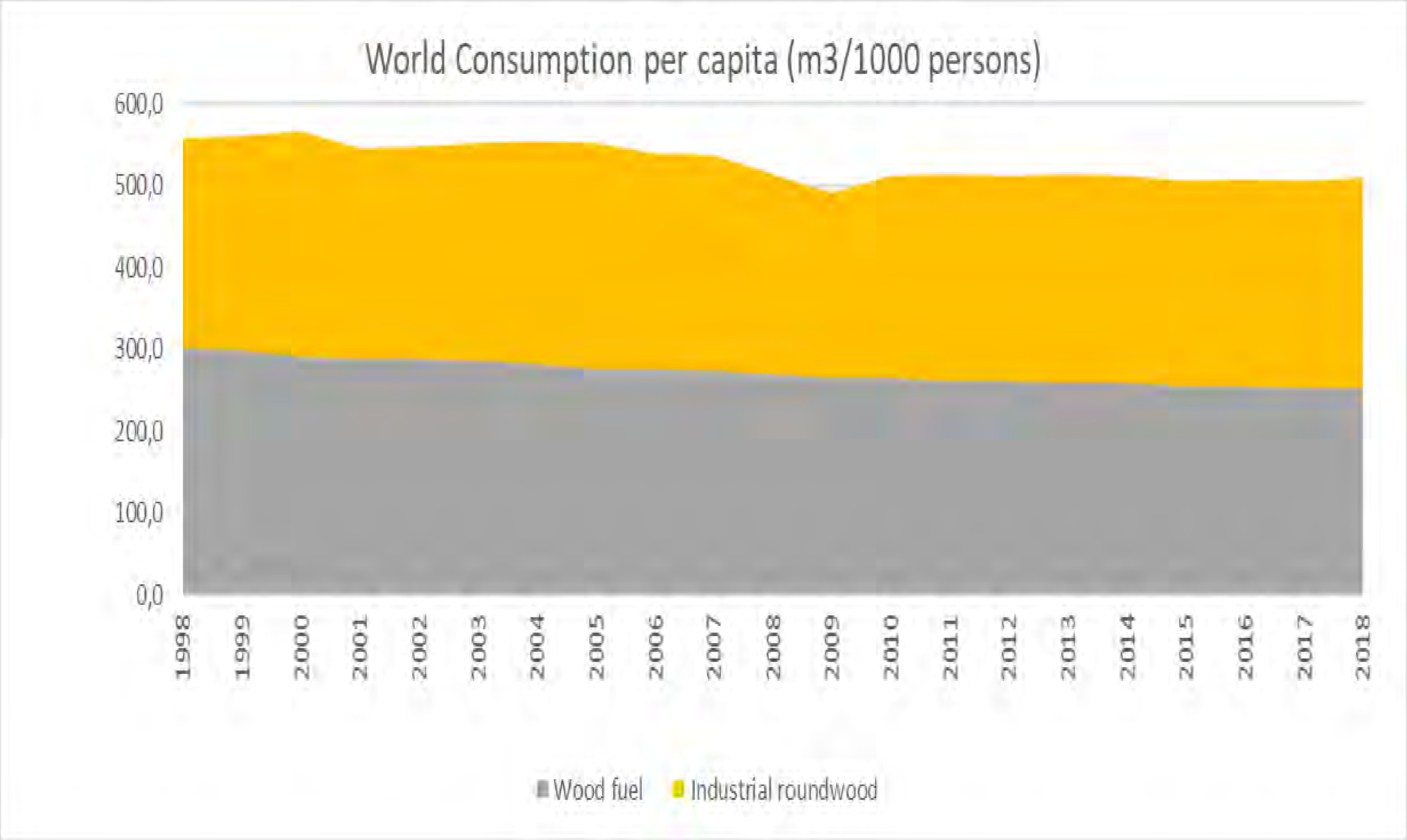
Materials use in Gt



Source: OECD ENV-Linkages model.

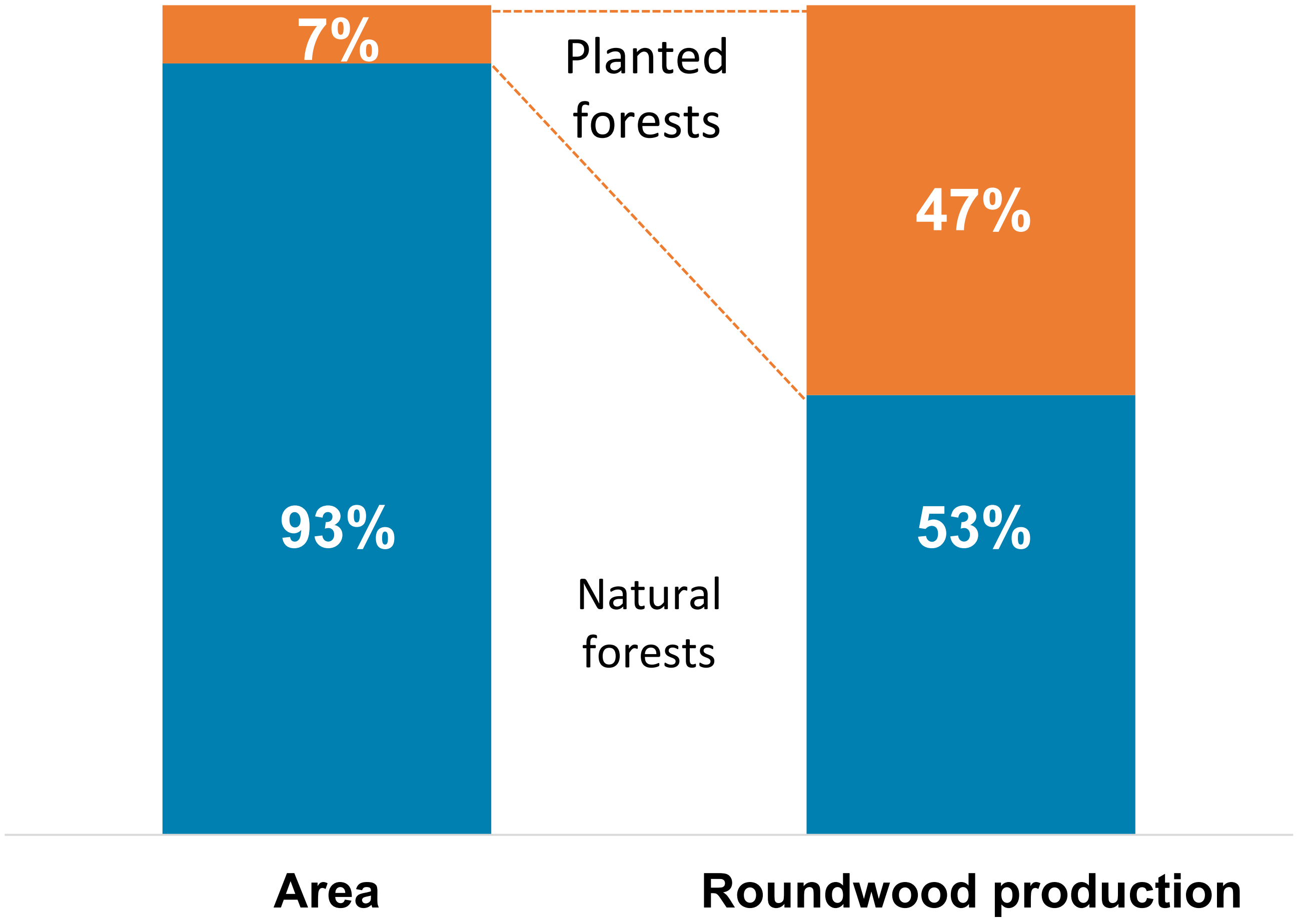
According to the OECD global use of materials Will increase from 89 Gt in 2017 to 167 Gt in 2060. For biomass (including food and feed) it will increase from 22 Gt to 37 Gt, with a major increase for wood than for other biomass (OECD 2019)

Consumption of Wood per capita



Source: FAOStat

Planted forests and production of roundwood



Source:
FAOStat

Process & Products Innovations (Forest Industry)

- Refined site preparation, planting and management
- Improved harvesting and transportation (RIL)
- Improved industrial processing (more efficient, improved recovery rate)
- Engineered wood products (CLT)
- Bioplastics, biochemicals, pharmaceuticals
- Bioenergy products (resources, species)
- Bamboo products (repl. wood & plastics)
- Nanotechnology

1. Structure value chains and build capacities of actors

2. An integrated plan for planted forests

3. An enabling environment for a forest-based bioeconomy, from Production to consumption

1 Structure value chains and build capacities of actors

- Optimize wood product match to uses.
- Integrate the possibility of reuse and recycling into the product design and the value chain design.
- Develop sustainable business models.
- Logistics.
- Capacity building.

2 An integrated plan for planted forests

Spatial (areas, landscape approaches, restoration)
Improved TGR (right tree, right purpose, productivity)
Management efficiency (inputs, short rotations)
Risk management (pests, weather, fire)

Fotos: Page, A Lata, J Roshetko

3 Working on the enabling environment for a forest-based bioeconomy, from P to C

1. **Public policies** for the development of the forestry sector and bioeconomy.
2. **Forest information service/systems** (e.g. SNIF in Brazil)
3. **Land zoning,** including legal land cover classifications
4. **Attract financial flows** to the forestry sector, and for innovations and intermediate value chains (different instruments).
5. **Promote and support emerging markets:** communication (SW4SW), public procurement, certification and standards, incentives, taxes on waste disposal.
6. **Support the organization of value chains,** logistics, recycling.
7. **Support the creation of "bioeconomy" clusters** for technological innovation, business incubation, R&D, value chain development: Amazon 4.0, final bioeconomy cluster, poles of excellence.

Example of Brazil, Pará State. Strategy and plan for bioeconomy PLANBIO PARA 2022

Research, Development and Innovation

- Promote and apply scientific knowledge and technological research to value and produce innovations in an inclusive way and with integrated social, economic and environmental benefits
- Identify and map knowledge about the bioeconomy of Pará, contained in the state's various research. institutions, in order to encourage applied research, and transform it into new technologies, training, and tools capable of guaranteeing the improvement of local production

Cultural Heritage and Genetic Knowledge

- Recognize traditional practices, protect and value them, integrating them into the low-emissions socioeconomic development policy of the state of Pará, with socio-environmental safeguards and guarantees for genetic heritage associated with cultural knowledge and biodiversity
- Guarantee the rights of local populations, provide sustainable development alternatives, training and socio-environmental integrity

Production Chains and Sustainable Businesses

- Value the territory's biodiversity products, in order to add specificities of the region to local products, through certifications, protection of cultivars, geographic identification, among other strategies.
- Invest in the establishment of attractive investment environments for production chains and new socio-biodiversity businesses, strengthening and verticalizing production, generating local development, employment and income and distributing benefits in an equitable manner

Bioeconomy : Prioritization and mapping of contributions

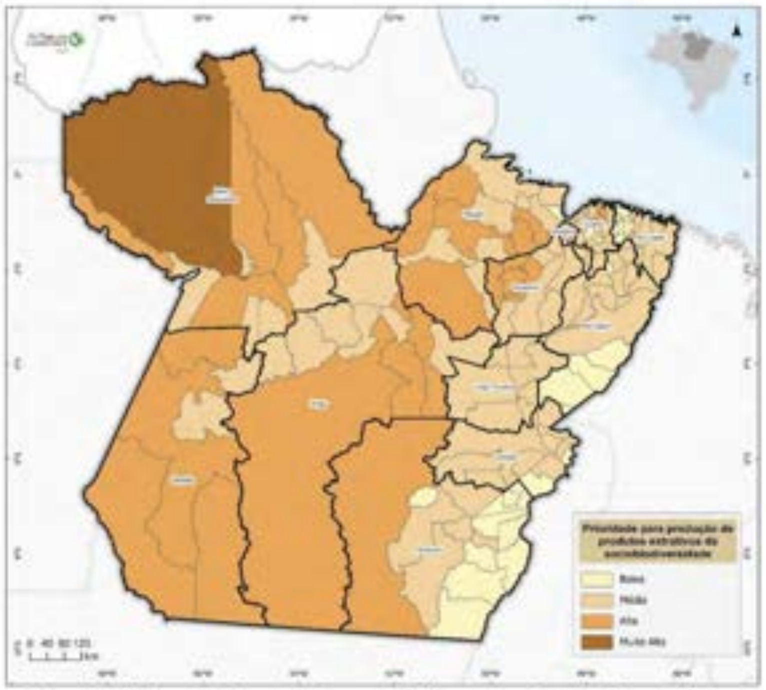


Figura 6 - Municípios de importância econômica na produção dos produtos ex da sociobiodiversidade

Priority economic importance for **Socio-biodiversity** products

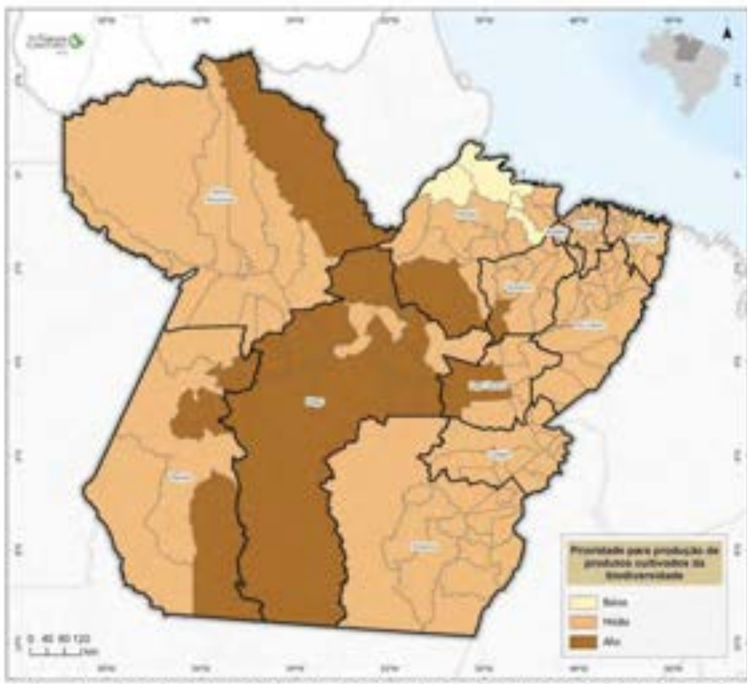


Figura 7 - Municípios de importância econômica na produção de produtos c compatíveis com a floresta

Priority economic importance
For “**products compatible with forests**”

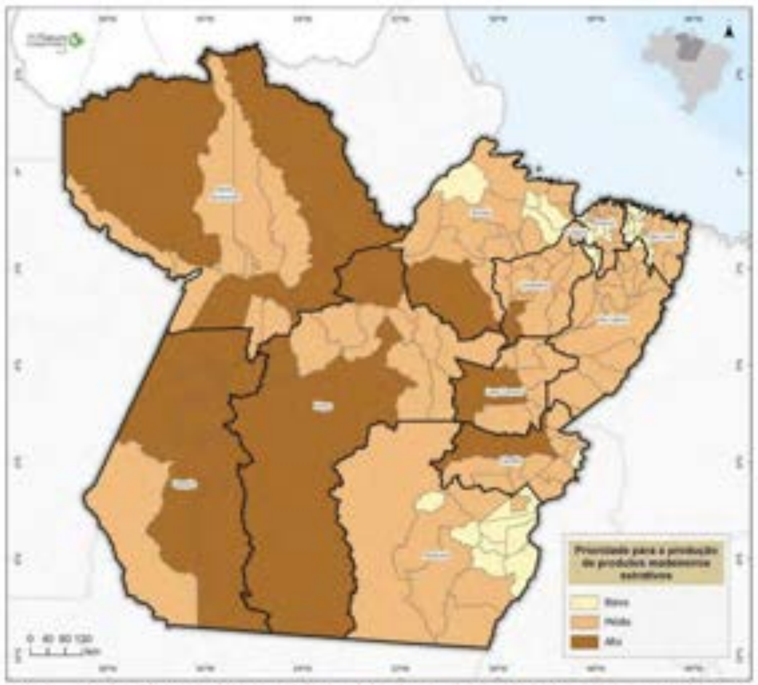


Figura 8 - Municípios de importância econômica na produção de produtos madeireiros extrativos

Priority economic importance
For **timber**

Source, PlanBIO Government of Pará, 2022

Key questions

What space for planted forests within bioeconomy strategies and plans ?

How can bioeconomy be as a key driver of growth for planted forests?

How can planted forests a key sustainable resource to fuel the bioeconomy?

Thank you!

www.cifor-icraf.org | globallandscapesforum.org | resilient-landscapes.org

The Center for International Forestry Research (CIFOR) and World Agroforestry (ICRAF) envision a more equitable world where forestry and landscapes enhance the environment and well-being for all. CIFOR–ICRAF are CGIAR Research Centers.

CIFOR World Agroforestry Global Landscapes Forum Resilient Landscapes

SPATIAL DATABASE OF PLANTED TREES V2.0

Jessica Richter – WRI

ICPF 2023 – 9 November 2023

Land & Carbon Lab

GLOBAL FOREST WATCH

Image Credit: CIFOR

WORLD RESOURCES INSTITUTE

MAPPING PLANTED FORESTS ON A GLOBAL SCALE

TREE COVER

NATURAL FOREST

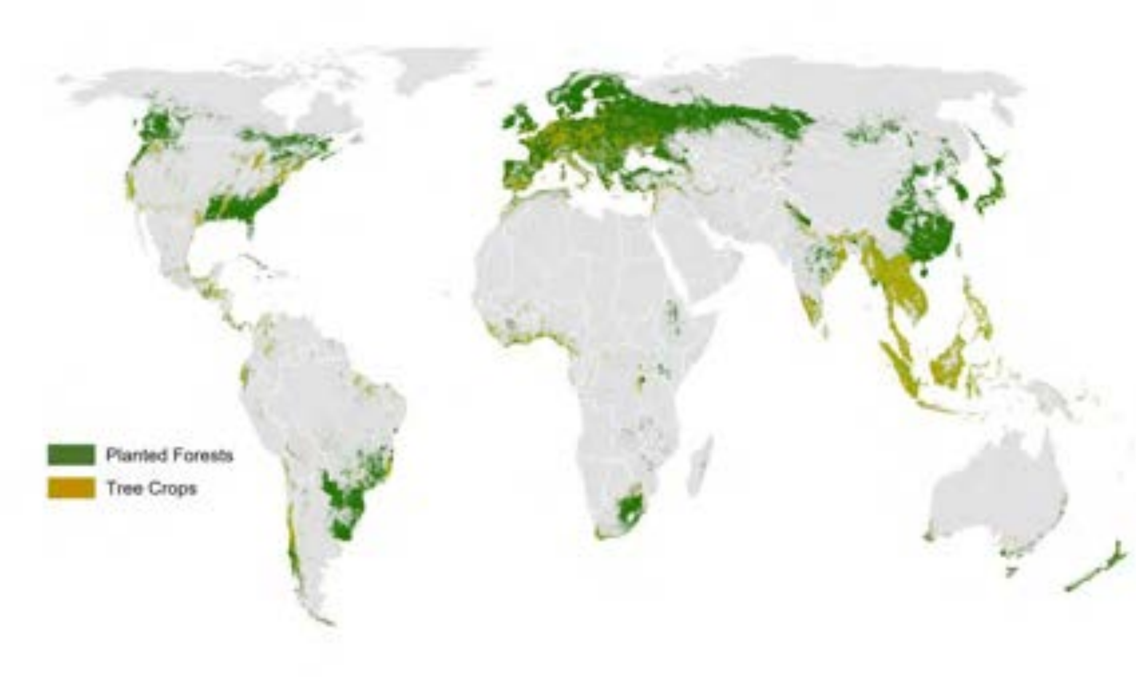
PLANTED FOREST

WHAT IS THE SPATIAL DATABASE OF PLANTED TREES (SDPT)?

- Global, spatial database of planted forests and tree crops
- Created by harmonizing national and regional data sources
- v1.0 first launched in 2019

SDPT V2.0

- Set to be published on Global Forest Watch in November 2023



WHAT'S NEW IN SDPT V2.0?

Improvements	v1.0	v2.0
Mode Year	2015	2020
Coverage	82 countries	158 countries
# of Countries w/ Species Info.	43 countries	52 countries

WHAT'S NEW IN SDPT V2.0? (CONT.)

Reaches near-global coverage

- 90% of total planted forest area reported by FAO FRA 2020
    - SDPT v2.0: 264 million ha
    - FAO FRA 2020: 293 million ha

New planting year information

Carbon removal factors for newly added data

FAO FRA 2020: https://www.fao.org/3/ca9825en/ca9825en.pdf

HOW CAN THE SDPT BE USED?

SBTN Natural Lands Map

Expediting inspections of timber shipments

Estimating carbon sequestration rates

SBTN Natural Lands Map Documentation: https://sciencebasedtargetsnetwork.org/wp-content/uploads/2023/05/Technical-Guidance-2023-Step3-Land-v0.3-Natural-Lands-Map.pdf

FUTURE PLANS FOR THE SDPT

Keeping SDPT up to date, add new data sources

Incorporate more species-specific data sources

- ‘Likely-species’ attribute

Begin development of SDPT v3.0 in 2024

Image Credit: CIFOR-ICRAF

FOR MORE INFORMATION:

GLOBAL FOREST WATCH

Visit Global Forest Watch

Contact us via email (Jessica.Richter@wri.org)

Africa’s housing needs as an opportunity to driving investment at scale into sustainable forestry

Nick Embden – Gatsby Africa

Caroline Ray - Arup

Thursday 9th November 2023

Africa needs housing

Facts from 2022

Africa's population is ~ 1.4 billion, forecast to grow to ~2.5 billion by 2050

Africa's urban population is ~ 600 million, projected to reach ~ 1.2 billion by 2050

Housing in Kenya

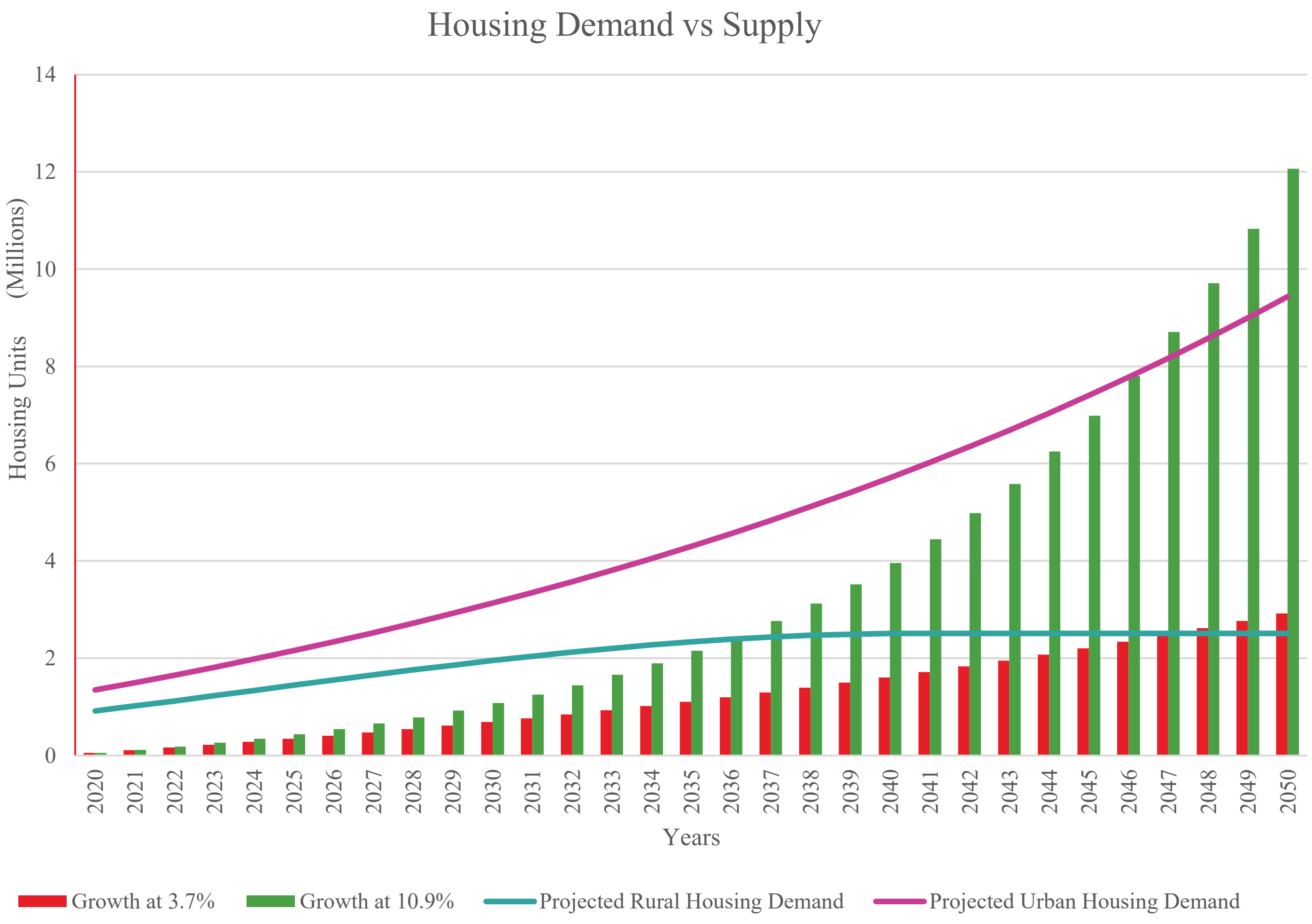
Demand and Supply

Current deficit of 2 million units increasing at over 250,000 units p.a.

In 2022 units were being built at a rate of 50,000 p.a.

Kenya housing supply has been growing at 3.7% p.a.

Housing supply would need to grow at 10.9% p.a. to meet the housing deficit by 2050



How much urban housing?

How many urban apartments in 5-storey buildings?

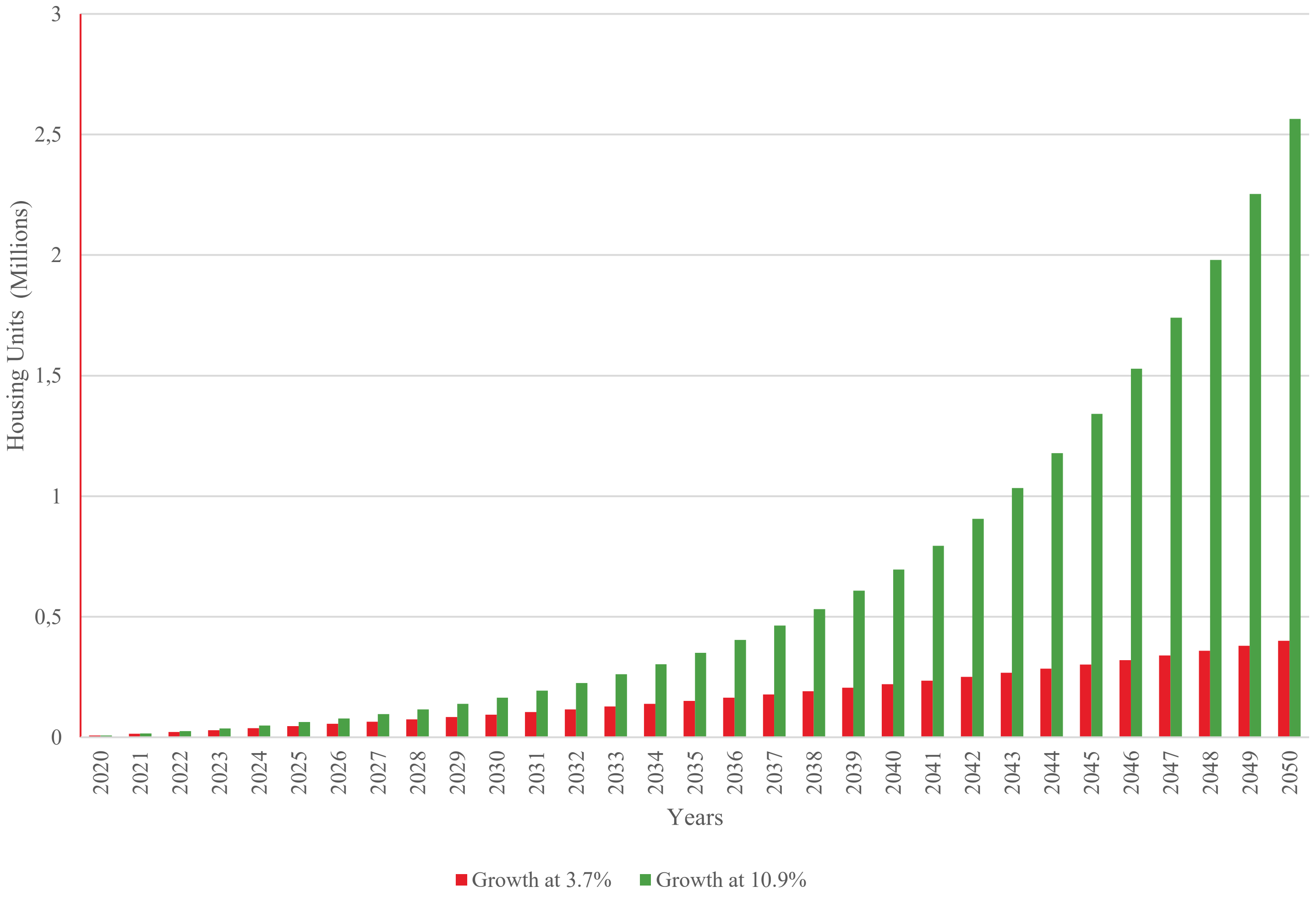
If…
urban housing demand is proportional to the urban population,

50% of the demand is met by apartments in 5-storey buildings,

how many apartments will be needed?

Growth rate of **3.7%** per year
400,000 apartments built by 2050

Growth rate of **10.9%** per year
2,560,000 apartments built by 2050



Use of timber in housing

Opportunities

Wooden floors (sawn timber joists, cassettes, timber boards)

Internal partition frames & walls

Mass Engineered Timber (CLT & Glulam) – columns & floors

Outcomes of adopting timber

Carbon 'saved' through material substitution

Embodied carbon emissions from construction of 5-storey apartments:

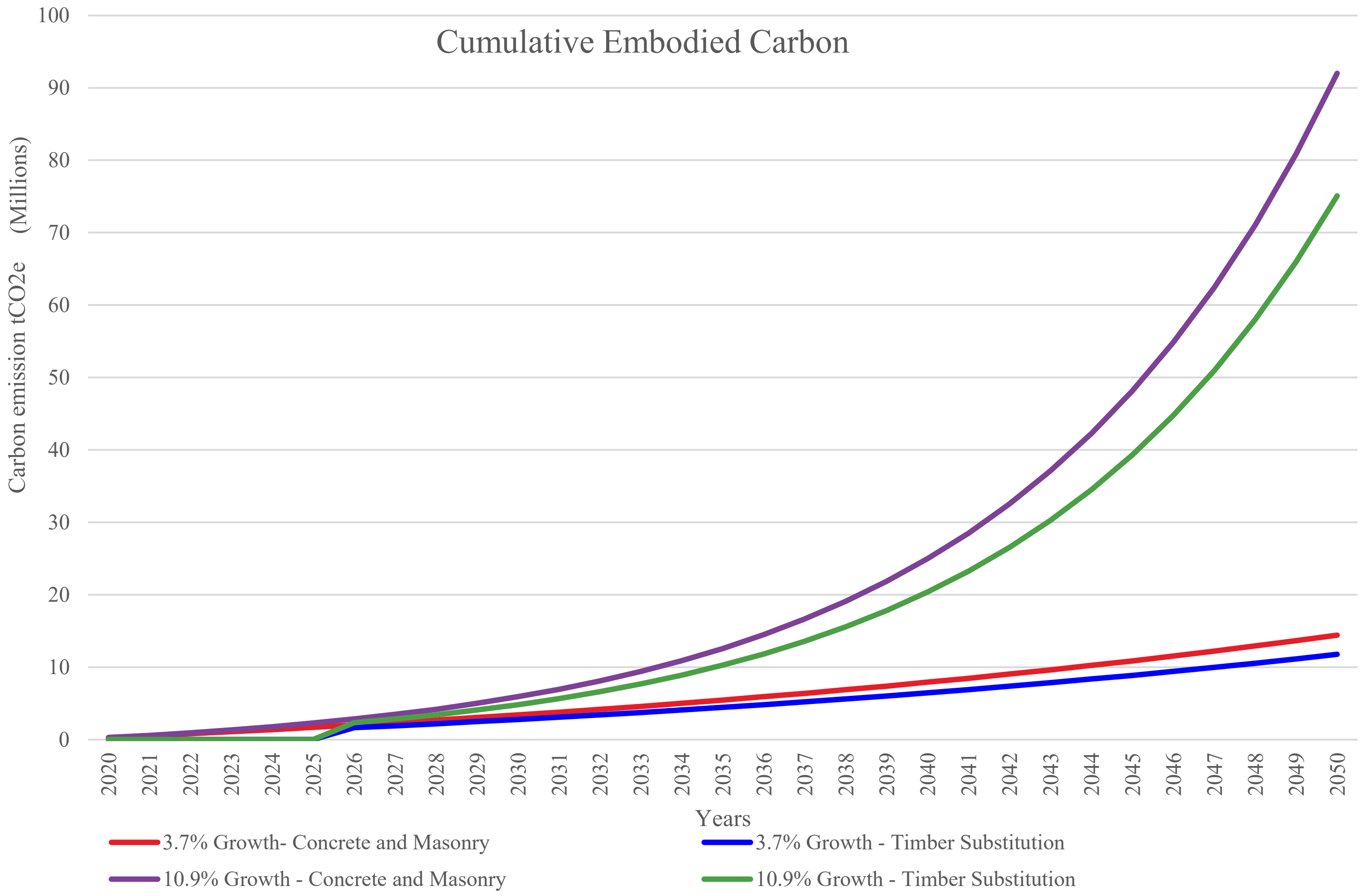
Design options

- Concrete floors and masonry walls
- Sawn timber, plywood floor, concrete topping, internal stud walls

Cumulative carbon saving

Growth at 3.7% **~2.6 million tCO_2e**

Growth at 10.9% **~17.2 million tCO_2e**



Outcomes of adopting timber

Carbon 'saved' through material substitution

Embodied carbon emissions from construction of 5-storey apartments:

Design options

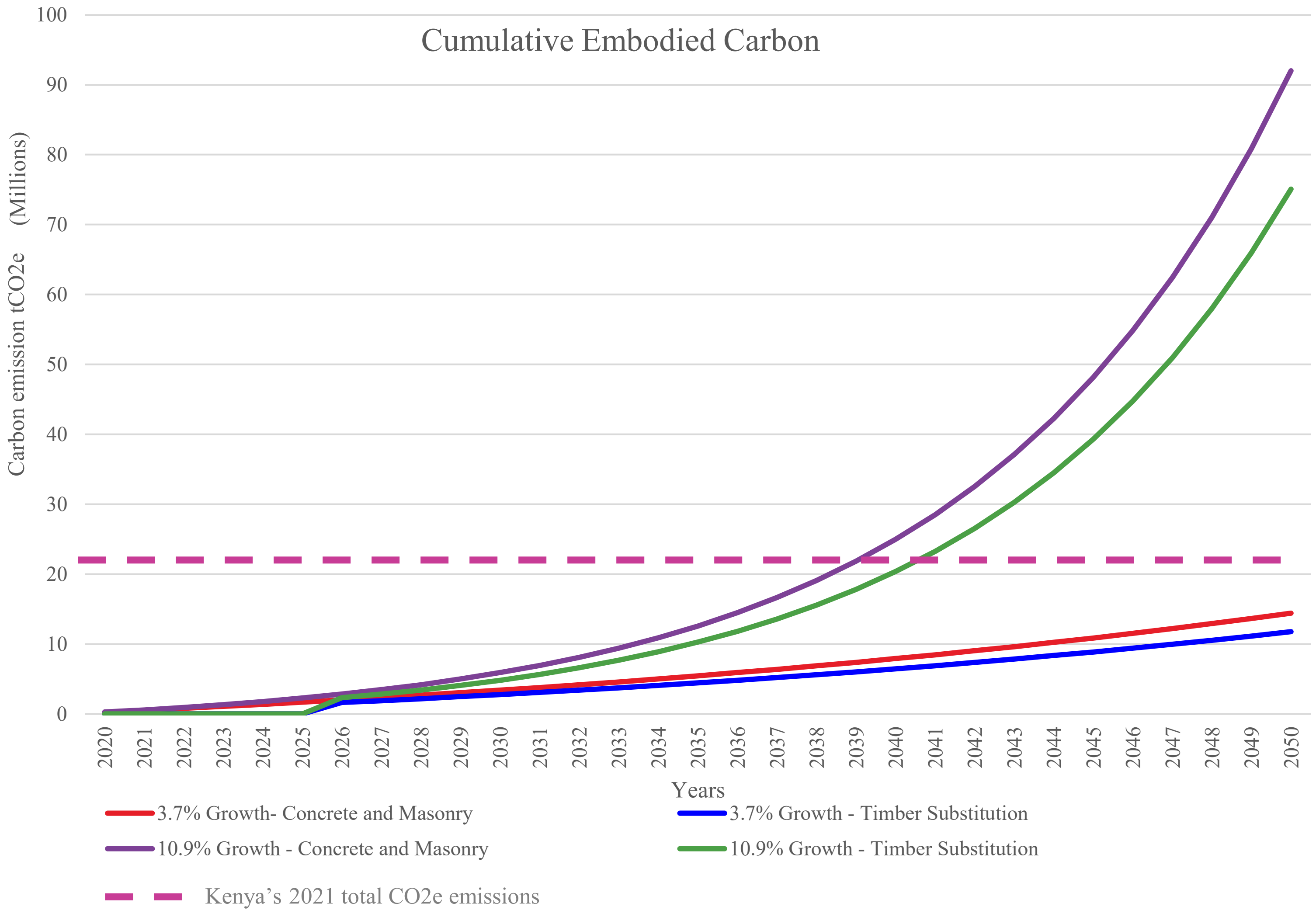
- Concrete floors and masonry walls
- Sawn timber, plywood floor, concrete topping, internal stud walls

Cumulative carbon saving

Growth at 3.7% **~2.6 million tCO2e**
Growth at 10.9% **~17.2 million tCO2e**

Carbon in 2021

Nairobi **~1.96 million tCO2e**
Kenya **~ 22.4 million tCO2e**

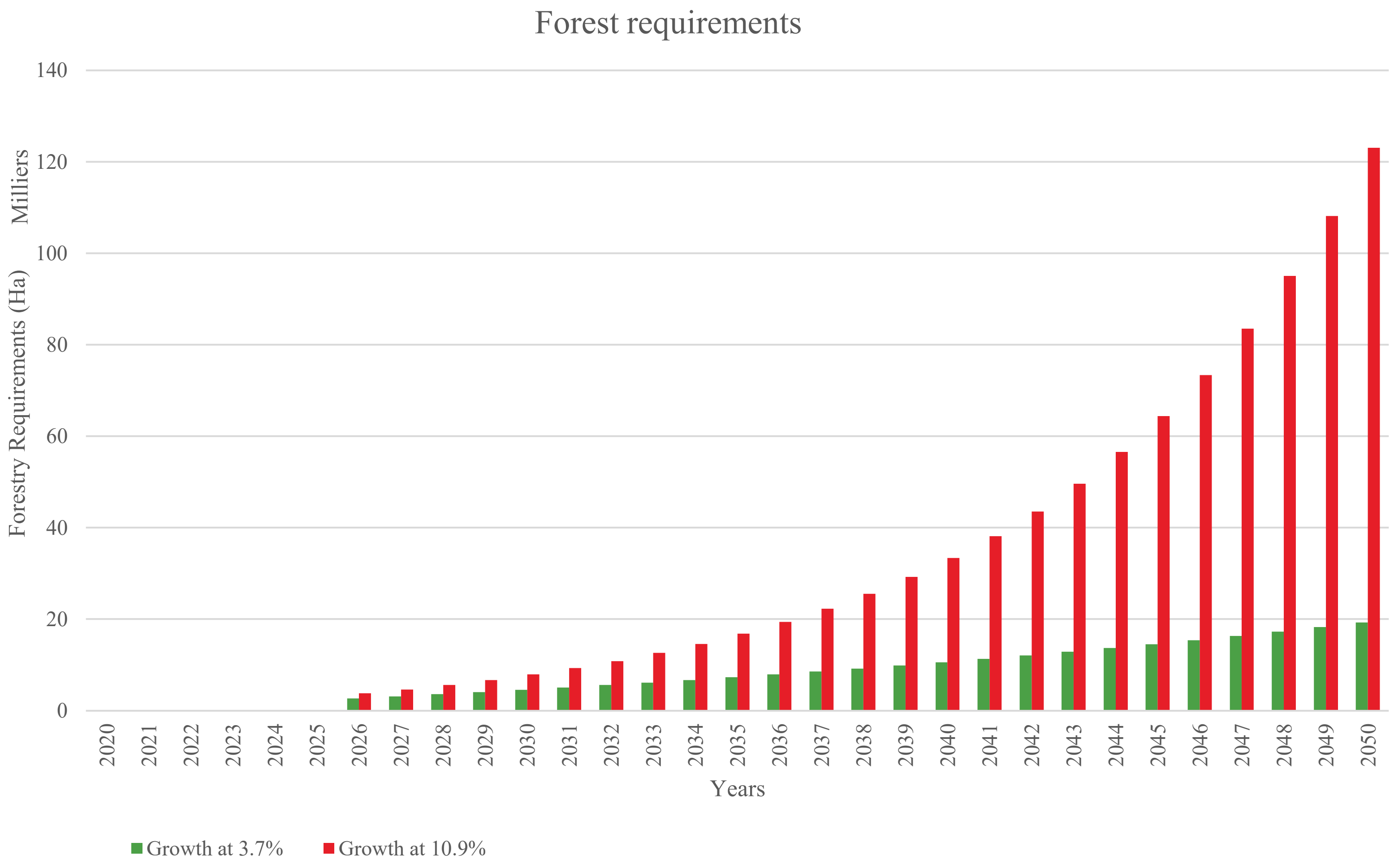


Forest area required

How much forest to supply the timber for this housing?

3.7% growth rate
19,000 ha required

10.9% growth rate
123,000 ha required



Steps to realisation

Factors to consider

Cost

- Cost reducing over time?

Policy & regulations

- Green construction incentives?
- Standardisation across East Africa

Industry capacity

- Build capacity in processing
- Build capacity in design
- Build capacity in construction

Changing perceptions

- Redefine ‘norm’
- High quality examples
- Demonstration projects

Gatsby Africa

ARUP

Isolation of chemical characterization of biopesticides from *Melia volkensii* against fall armyworm and red flour beetle

Dr. Victor Jaoko
ochiengjaoko@kefri.org

Introduction

- Agriculture; considered backbone of most economies
- Food, employment, foreign earning etc
- About 10,000 insect species attack crops; 10% are major pests e.g. armyworm

Climate change fans spread of pests and threatens plants and crops, new FAO study

- Reduced yield, quality, food security

Fall armyworm (*Spodoptera frugiperda*)

- ‘Coronavirus of agriculture’
- Larvae cause up to 100% yield loss in maize

Red flour beetle (*Tribolium castaneum*)

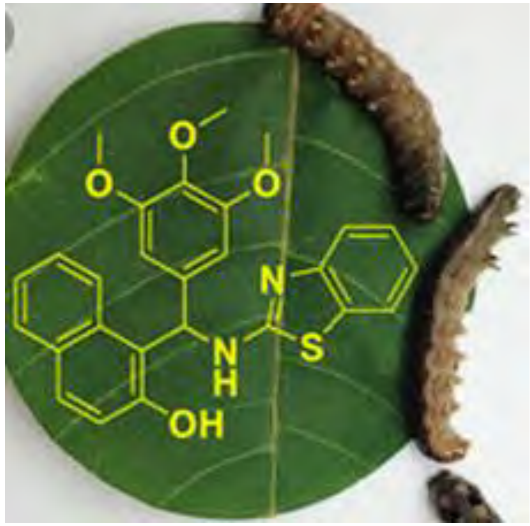
Known as ‘Osama’ in Western Kenya

Synthetic pesticides application

Are used to control insects; sprayed, admixed etc

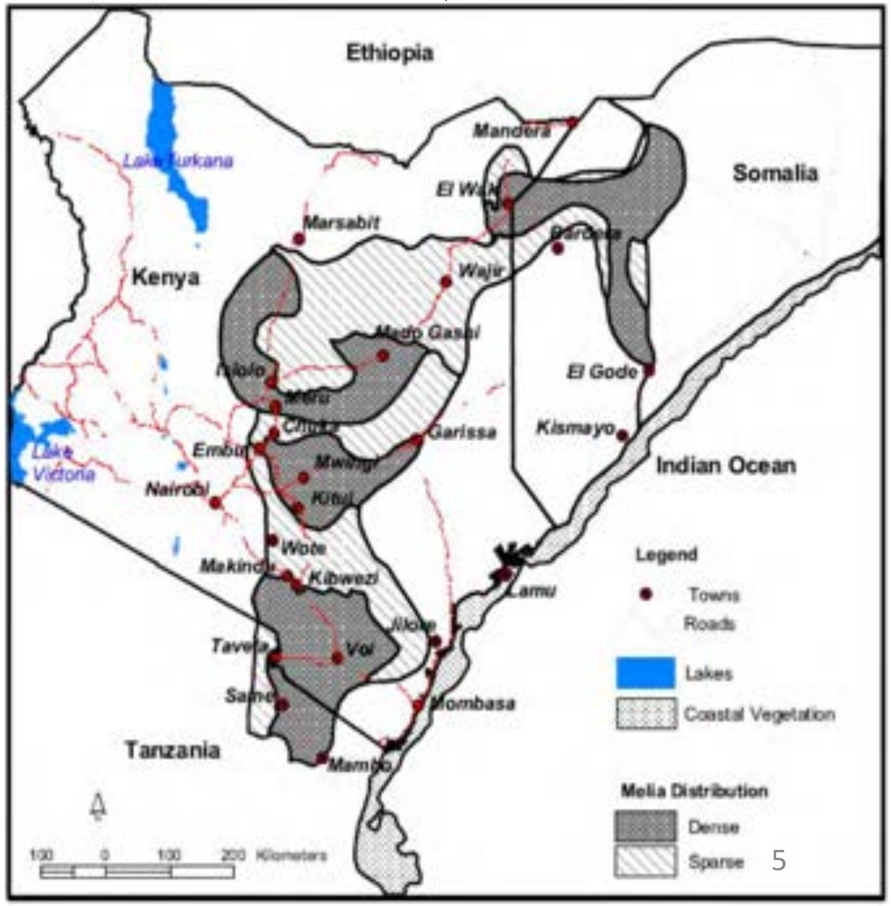
Emergence of botanical pesticides

- Are plant-based
- Alternative to synthetic pesticides?



Melia volkensii

- Indigenous tree; native to drylands of East Africa
- Termite-resistant timber, fodder, agroforestry tree

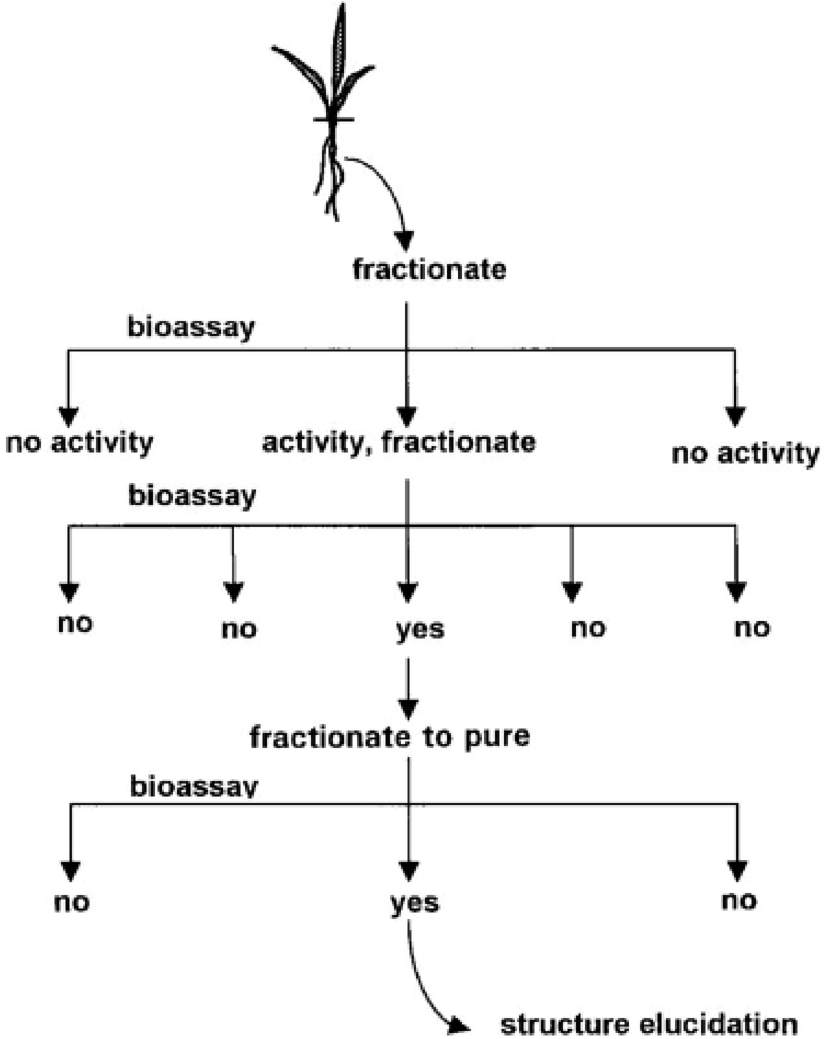


Objectives

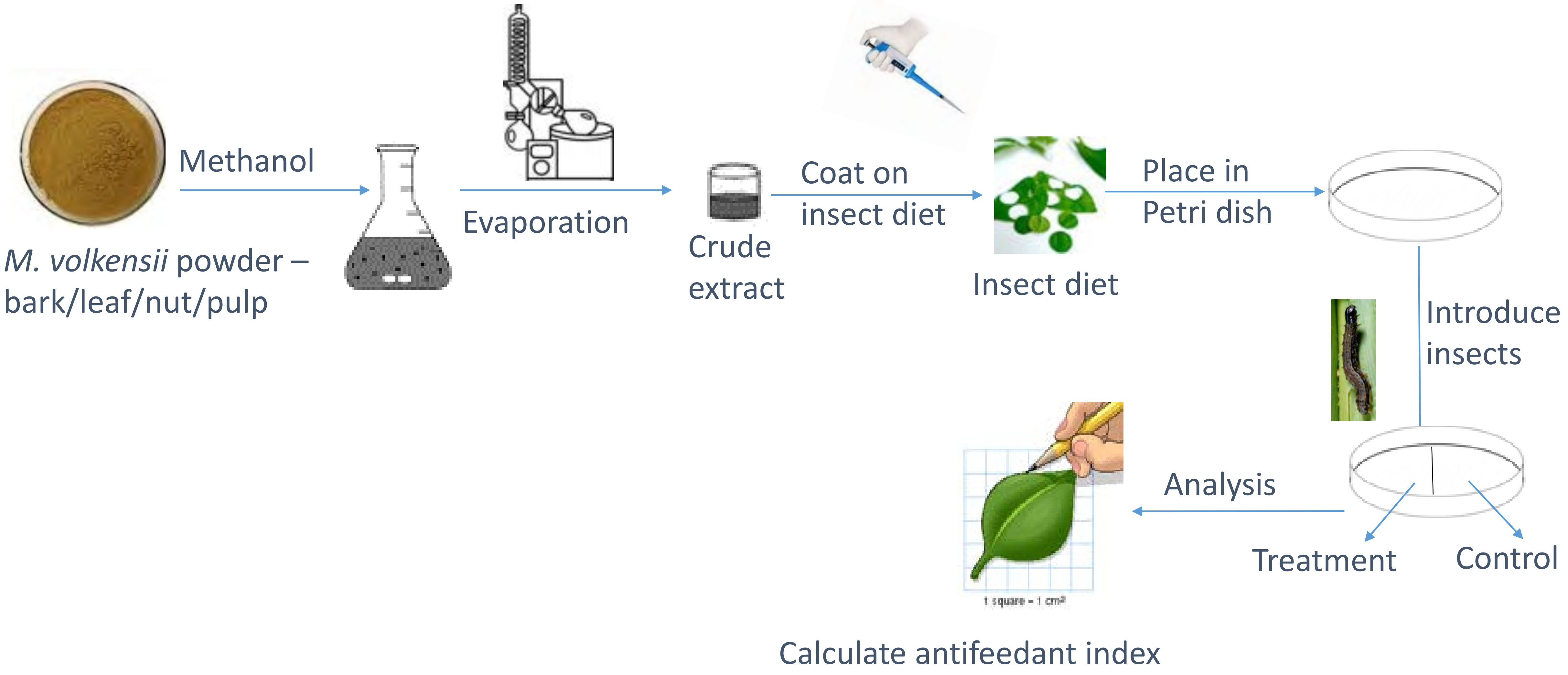
Laboratory testing of *M. volkensii* crude extracts against the insects

Extraction of active compounds from *M. volkensii*

Classical bioactivity-guided isolation

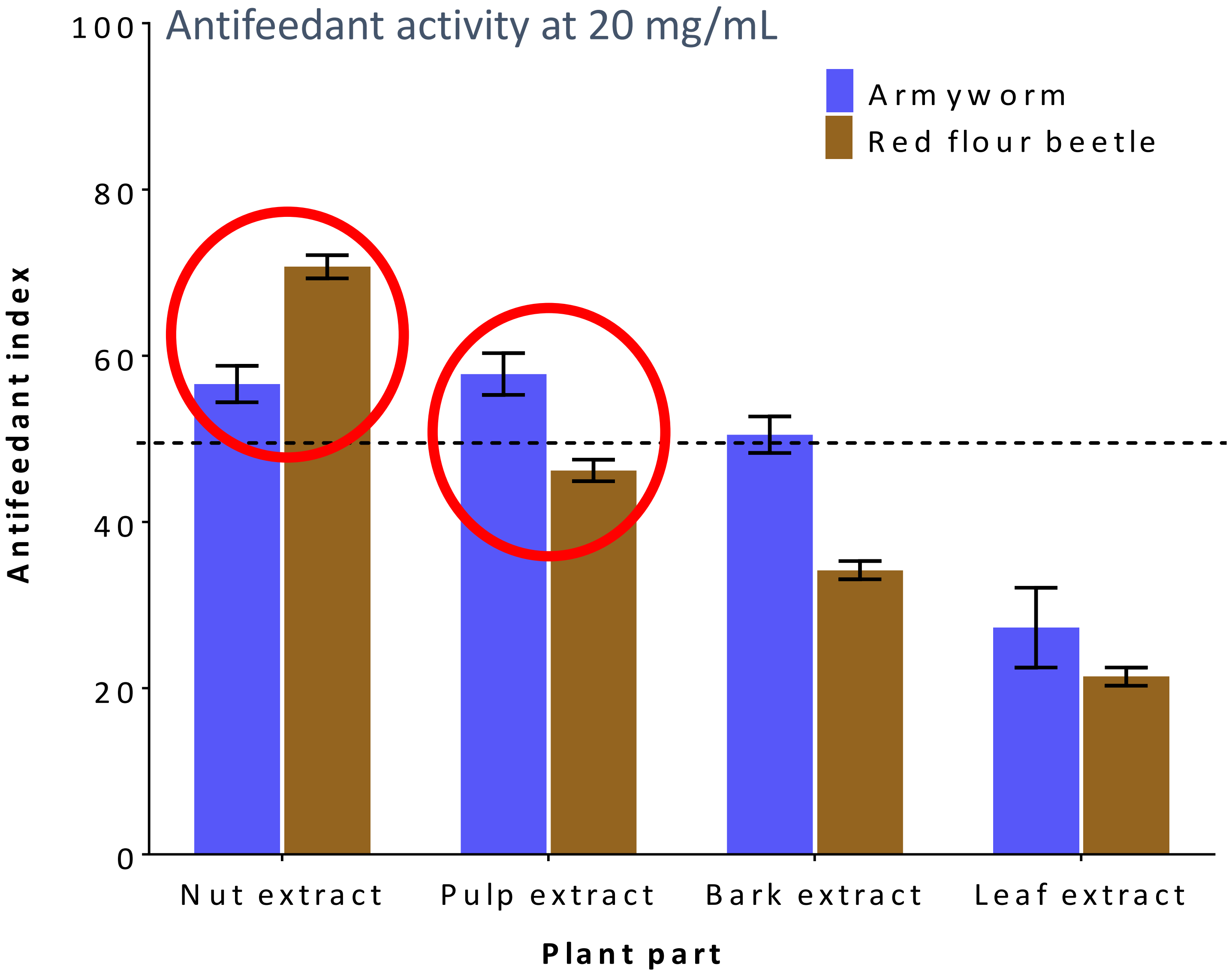


Methodology: Preparation of plant extracts and insect bioassay

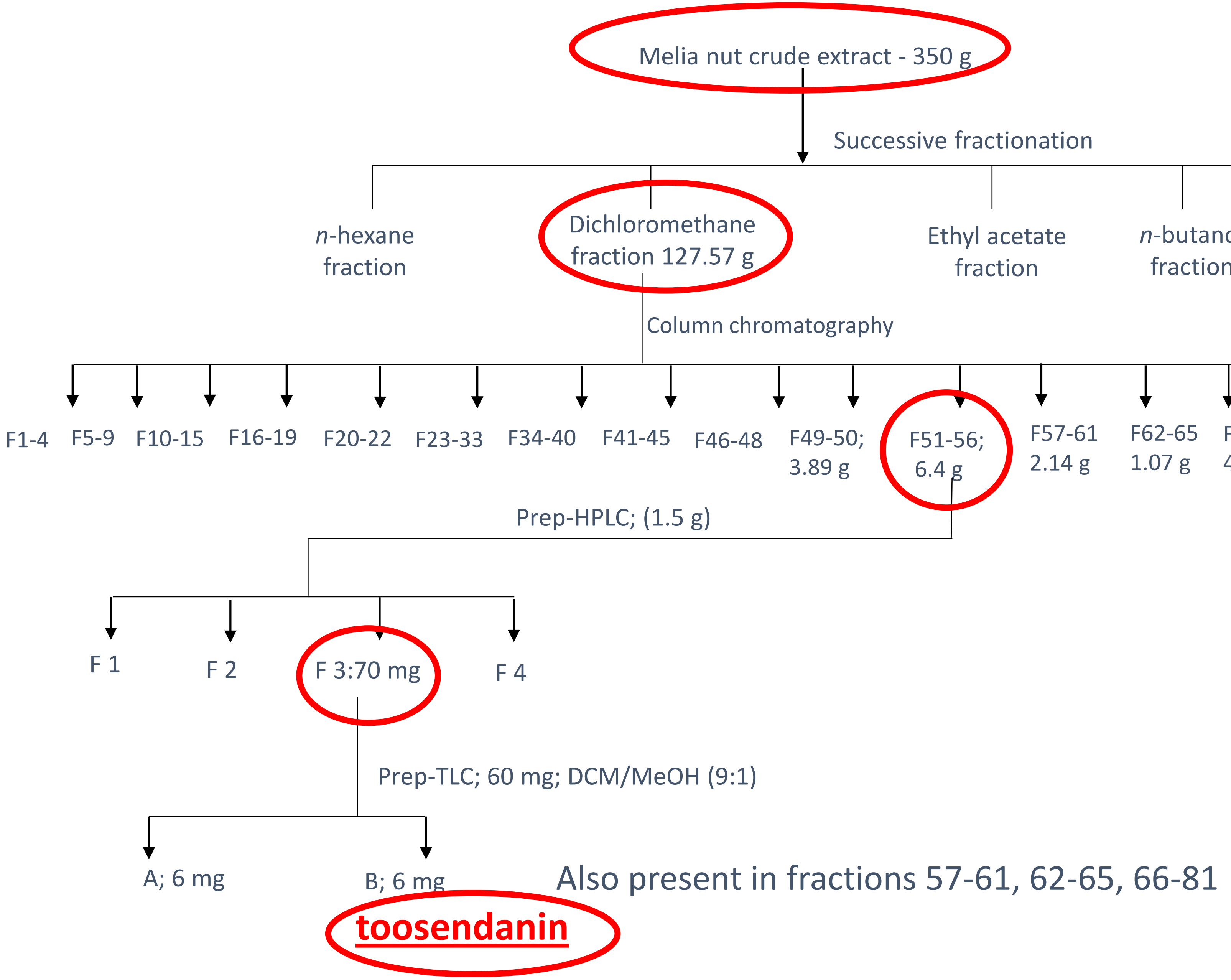


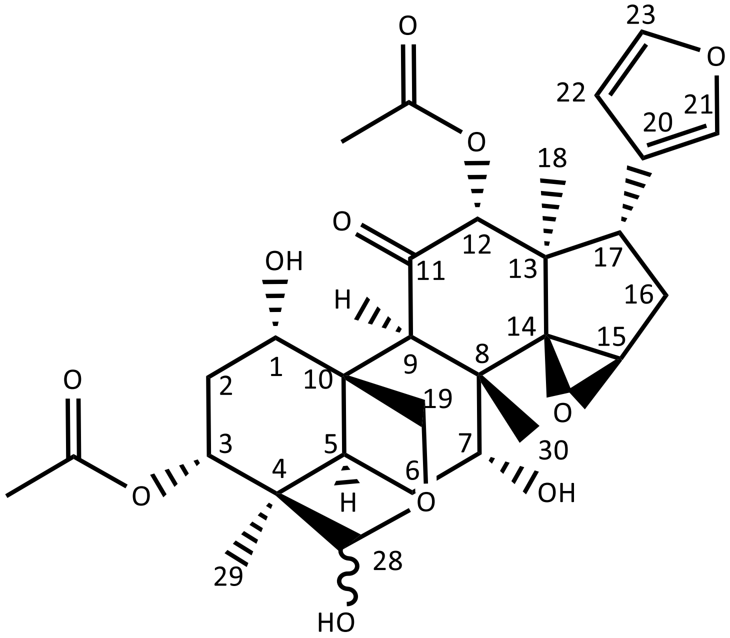
Results: antifeedant activity of crude extracts

- Tested 100, 80, 60, 40, 20 mg/mL
- All plant parts had activity
- Pulp & nut extracts had higher antifeedant activity, ~> 50%
- Pulp & nut - further purification



Complete purification of nut extract





Complete purification of pulp extract

Melia pulp crude extract; 250 g

↓ Fractionation

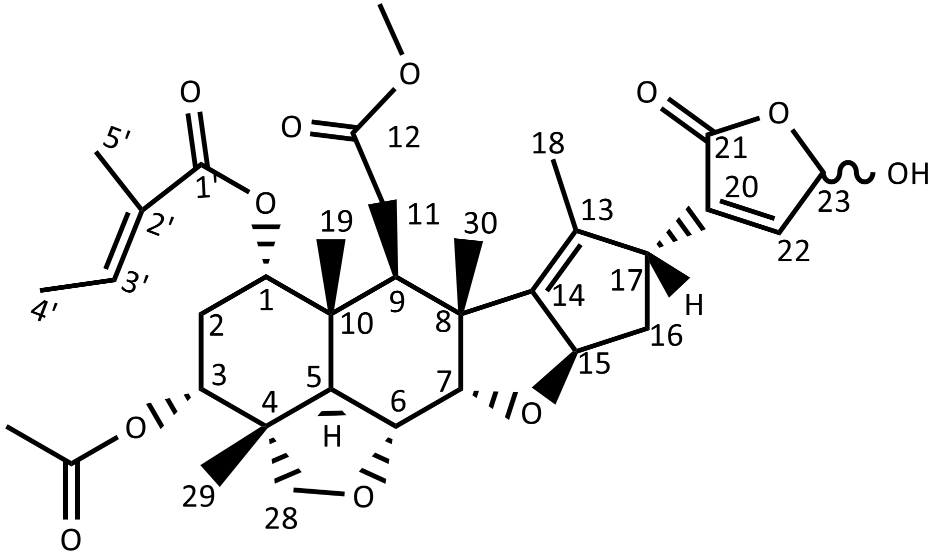
- *n*-hexane fraction
- Dichloromethane fraction; 92.8 g
- Ethyl acetate fraction
- *n*-butanol fraction
- Residue

Dichloromethane fraction → Column chromatography EtOAc/Hexane

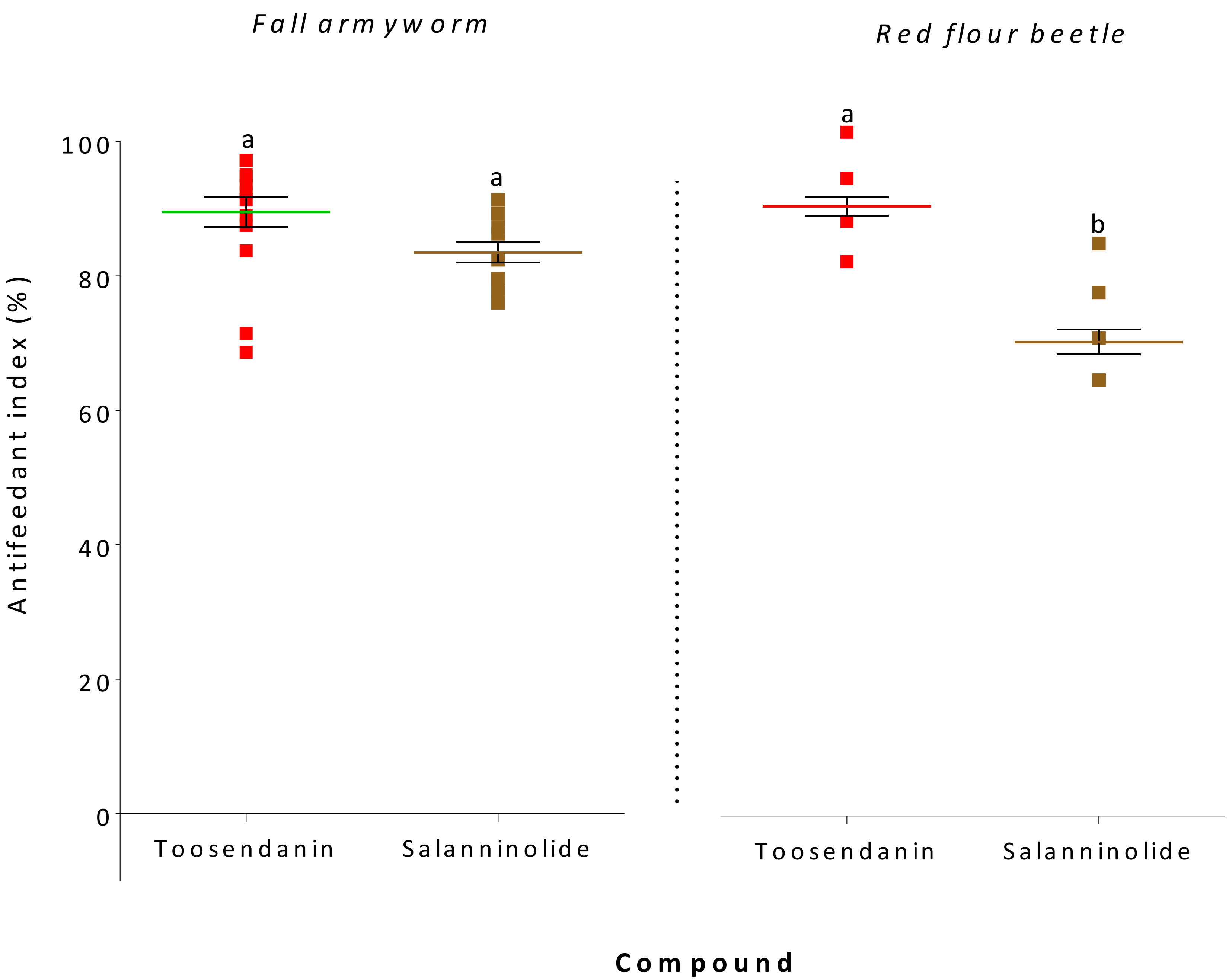
F1-3 | F4-11 | F12-21 | F22-23 | F24-27 | F28-32 | F33-41 | F42-44 | F45-47 | F48-54 | F55-64 9.88 g | F65-75 | F75-85 | F86-95

F55-64 → Re-crystallization in MeOH; (3 g)

<u>Salanninolide</u> 136 mg



Activity of pure compounds against insects



Conclusions

- *Melia volkensii* nut, pulp, bark and leaf extracts have bioactive antifeedant constituents
- 2 pure bioactive compounds isolated could be lead compounds in biopesticide development
- *M. volkensii* extracts do not have knock-down effect on insects
- They possess antifeedant activity, affecting midgut cells of insects and cessation in feeding
- Overall impact is crop protection
- *M. volkensii* could be incorporated in Integrated Pest Management (IPM); reduced pesticide application

THANK YOU

5th International Congress of Planted Forests

Bio-pesticide activity of *Commiphora africana* resin extract against bedbugs

Norman W. Wairagu
Kenya Forestry Research Institute
(KEFRI)

Introduction

- Increased bedbug infestation – adverse health effect

- Growing concern of shortcomings of current control methods

  (Environmental pollution, affect non-target insects & resistance development)

- Natural products - environmental friendly

  - Information on active phytochemicals is scanty

- There is need to characterize these active phytochemicals

Russell *et al*., (2012). *Clinical Microbiology Reviews,* **25**: 164 - 192.

Commiphora africana

- Family: Burseraceae
- English name: African myrrh
- Vernacular name (Taita): Dowe

Ethno-botanical uses:

- Resin – bedbugs, tick controls and wound
- Wood - termite resistant
- Bark- Treatment of snake bite, scorpion sting and leprosy
- Fruits – management of typhoid, fever and stomach problems
- Leaves - toothache and diseases of the gum

Isolated compounds: Coumaric acid, ferulic acid, rutin, isoquercitrin , quercetin, kaempferol and apigenin

Okwute and Ochi (2017). *Journal of Pharmacognosy and Phytochemistry*, **6**: 451 - 454.

Original Research Paper

Natural Product Communications
Volume 17(6): 1–10

DOI: 10.1177/1934578X221106898
journals.sagepub.com/home/npx
SAGE

Repellency and Toxicity of Selected Fractions, Identified Compounds and Blends of *Commiphora africana* Resin Against Bedbugs

Norman W. Wairagu[1,2,*], Benson M. Wachira[3,*], Joseph K. Githiomi[2], Nellie Oduor[2] and Margaret M. Ng'ang'a[1]

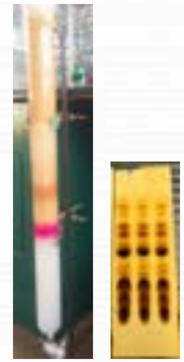
Aim:

Solvent extraction, column separation, spectroscopic characterization and bioassays of isolated compounds and selected blends against bedbugs

Materials and methods

Sample collection

Extraction



Column separation[2]

Spectroscopic analyses

Crude extracts

FRs/Cpds/blends

Bed bug rearing[1]

Bioassays[3]

Data analysis (ANOVA)

[1]Araujo *et al*., (2009). *J. Insect Physiol*., **55**: 1151 - 1157.
[2]Zhang *et al*., (2010). *Journal of separation science*, **33**: 2743 - 2748.
[3]Cynthia *et al*., (2016). *J. Entomol*., **4**: 406 - 418.

Results and Discussion

Table 1: Mean repellency of *C. africana* crude extracts against bedbugs

Treatment	% Mean Repellency ± S.D			
	Exposure time (hours)			
	½	1	6	12
Hexane extract	68.5 ± 5.03^{Ad}	77.5 ± 4.07^{Be}	85.0 ± 5.72^{Cd}	98.5 ± 1.12^{Dd}
CH_2Cl_2 extract	**70.0 ± 6.81^{Ad}**	**82.5 ± 2.08^{Bf}**	**92.0 ± 3.11^{Ce}**	**100.0 ± 0.00^{Dd}**
EtOAc extract	60.0 ± 7.14^{Ac}	67.5 ± 3.02^{Bd}	77.5 ± 5.03^{Cc}	82.5 ± 4.11^{Dc}
MeOH extract	55.0 ± 4.76^{Ab}	57.5 ± 5.33^{Ac}	67.5 ± 7.37^{Bb}	75.0 ± 5.21^{Cb}
H_2O extract	55.0 ± 3.11^{Bb}	50.0 ± 4.74^{Ab}	65.5 ± 5.18^{Cb}	72.5 ± 4.51^{Db}
Neocidol (positive control)	**78.0 ± 3.05^{Ae}**	**80.0 ± 2.56^{Aef}**	**90.0 ± 1.02^{Be}**	**100.0 ± 0.0^{Cd}**
Acetone (blank)	1.5 ± 0.66^{Ca}	0.5 ± 0.08^{Ba}	-0.1 ± 0.05^{Ba}	-0.0 ± 0.01^{Aa}

Means followed by different small and capital letters in a column and row respectively indicate significant difference ($p < 0.05$)

Table 2: Mean LC_{50} of *C. africana* resin crude extracts against bedbugs after 24h exposure

Extracts	Mean LC_{50} concentration (mg/L)	95% Confidence interval
CH_2Cl_2	**11.68[d]**	**8.06 - 14.57**
Hexane	13.58[c]	7.45 - 17.68
EtOAc	16.97[b]	10.71 - 21.71
MeOH	20.88[a]	14.94 - 27.03
H_2O	21.55[a]	15.61 - 25.31
Neocidol	**10.81[d]**	**7.11 – 13.56**

Means followed by different small letters indicate significant difference ($p < 0.05$)

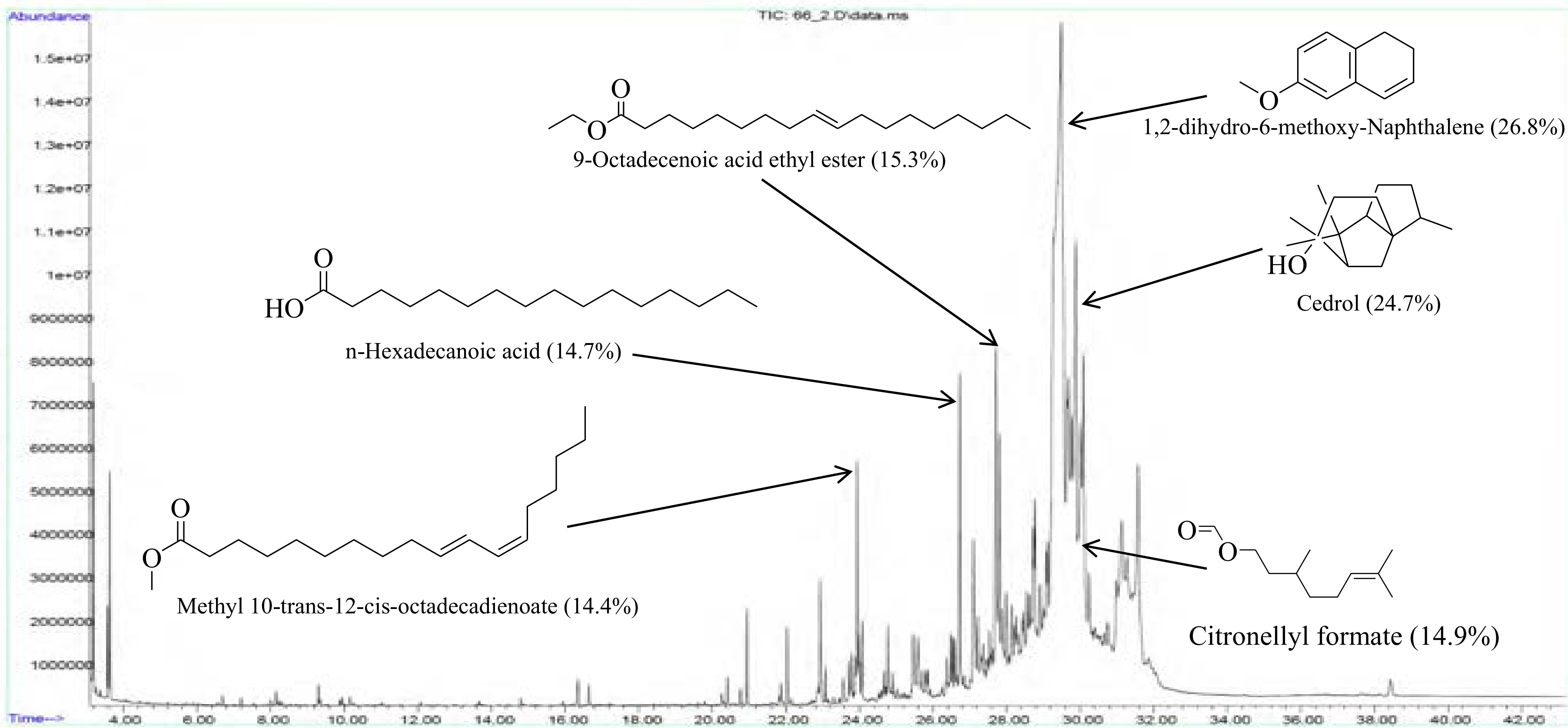
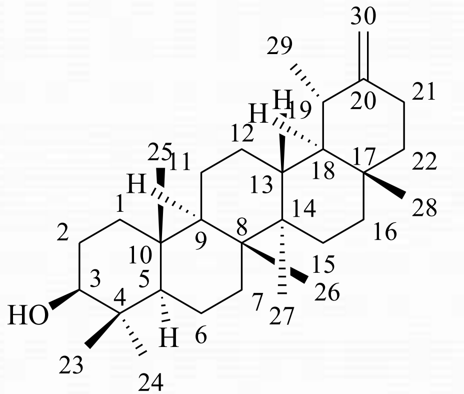


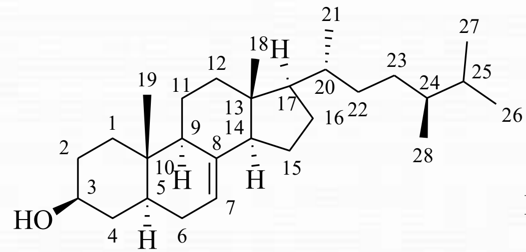
Figure 1: GC-MS spectrum of highly active fraction (FR7)

- Cedrol – Highest mean repellency (80.5%) and toxicity (27.43 mg/L) similar to the +ve control - Neocidol
- Synergistic repellency and toxicity effects were observed on blending studies

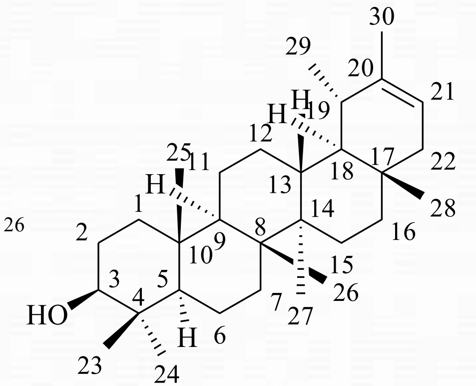
Isolated pure compounds



Taraxasterol
(white crystals)

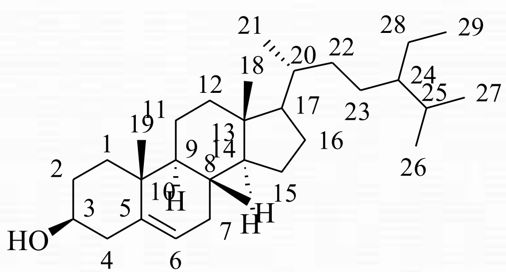


Fungisterol
(White crystals)

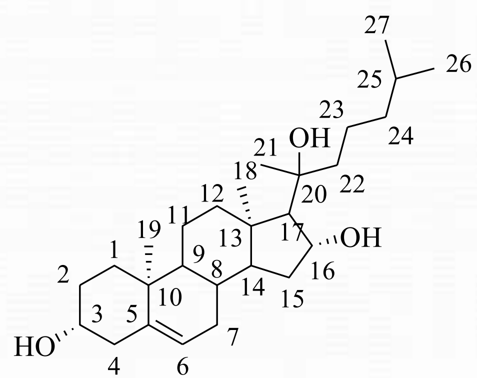


Pseudo-taraxasterol
(white crystals)

Khalilov *et al*., (2003); Chemistry of Natural Compounds, **39**: 285 - 288.
Jassbi *et al*., (2016); Pharmaceutical biology, **54**: 2044 - 2049.



Beta-sitosterol
(white crystals)



Guggulsterol
(White powder)

Chaturvedul and Prakash (2012); International Current Pharmaceutical Journal, **1**: 239 - 242.
Sultana and Jahan (2005). für Naturforschung B, **60**: 1202-1206.

Table 3: Mean Repellency and LC_{50} of bedbugs on treatment with isolated compounds

Compound ID	Mean % Repellency ± SD (1 hr exposure)	LC_{50} mg/L (CI) (24 hrs)
Taraxasterol	65.0 ± 1.9[b]	38.72[d] (33.46 - 45.67)
Pseudo-taraxasterol	65.0 ± 2.8[b]	31.44[c] (27.72 - 35.50)
Beta-sitosterol	70.0 ± 2.1[c]	45.10[e] (39.78 - 51.02)
Fungisterol	**75.0 ± 1.0[d]**	**25.73[b] (22.87 - 33.99)**
Guggulsterol	70.0 ± 1.8[c]	30.37[c] (25.91 - 39.38)
Neocidol	**74.0 ± 1.0[d]**	**9.81[a] (7.11 – 13.56)**
£Solvent	0.0 ± 0.0[a]	-

Conclusions

1. High repellency and mortality demonstrated by DCM extract against bedbugs confirmed the ethno-botanical uses of *C. africana* resin among the Taita

2. a) **Cedrol** had the highest repellency (87.2%) and mortality (LC_{50} = 27.43mg/L) against bedbugs.

b) Five triterpenes were isolated from *C. africana* resin for the first time. **Fungisterol** (95.1% repellency and LC_{50}= 25.73mg/L) was the most potent compound

3. A **six-constituent blend** of 9-Octadecenoic acid ethyl ester + octadecadien-1-ol + **citronellyl formate + cedrol** + hexadecanoic acid + 1,2-dihydro-6-methoxy-naphthalene reported the highest repellency (93.4%) and mortality (LC_{50}=15.06mg/L)

Recommendations

Resource-based survey, conservation and product development

Allometric equations to estimate potential biomass and carbon stocks for on-farm bamboo species in agricultural landscapes of Kenya

John Ngugi Kigomo

Research Scientist/Consultant

Forest Resource Assessment

Justus Mukovi, Nancy Bor, Solomon Kipkoech, Betty Leshaye, Titus Cheruiyot and Margaret Kuria

International Congress on Planted Forests

7-10th November 2023

Introduction

- Bamboos are classified as perennial woody grasses
- Due to fast growth, now priority species for rehabilitation and protection of water catchments/riverbanks
- Widely used as timber substitutes, pulp and paper, fiber and textile, food and beverage & bioenergy
- Bamboo gazetted as cash crop to enhance propagation & sustainable utilization
- Contribution of planted bamboo in climate change mitigation is limited in Kenya

Widely cultivated Bamboo species in Kenya

Species

- ✓ Indigenous (1)
- ✓ Exotic (22)
- ✓ Cultivated (15)
- ✓ Most common (3)

Dendrocalamus asper

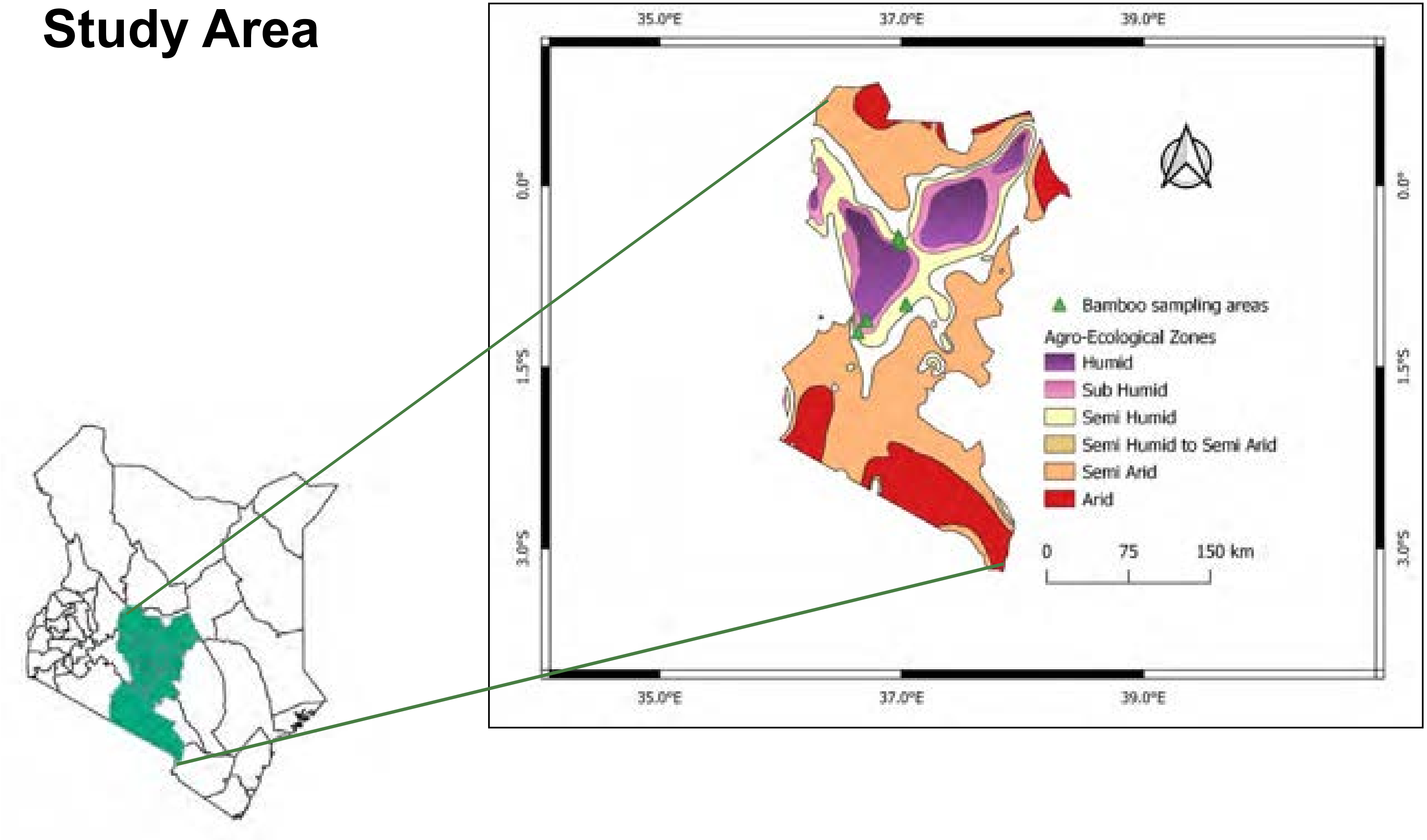
Bambusa vulgaris var. *vittata*

Dendrocalamus giganteus

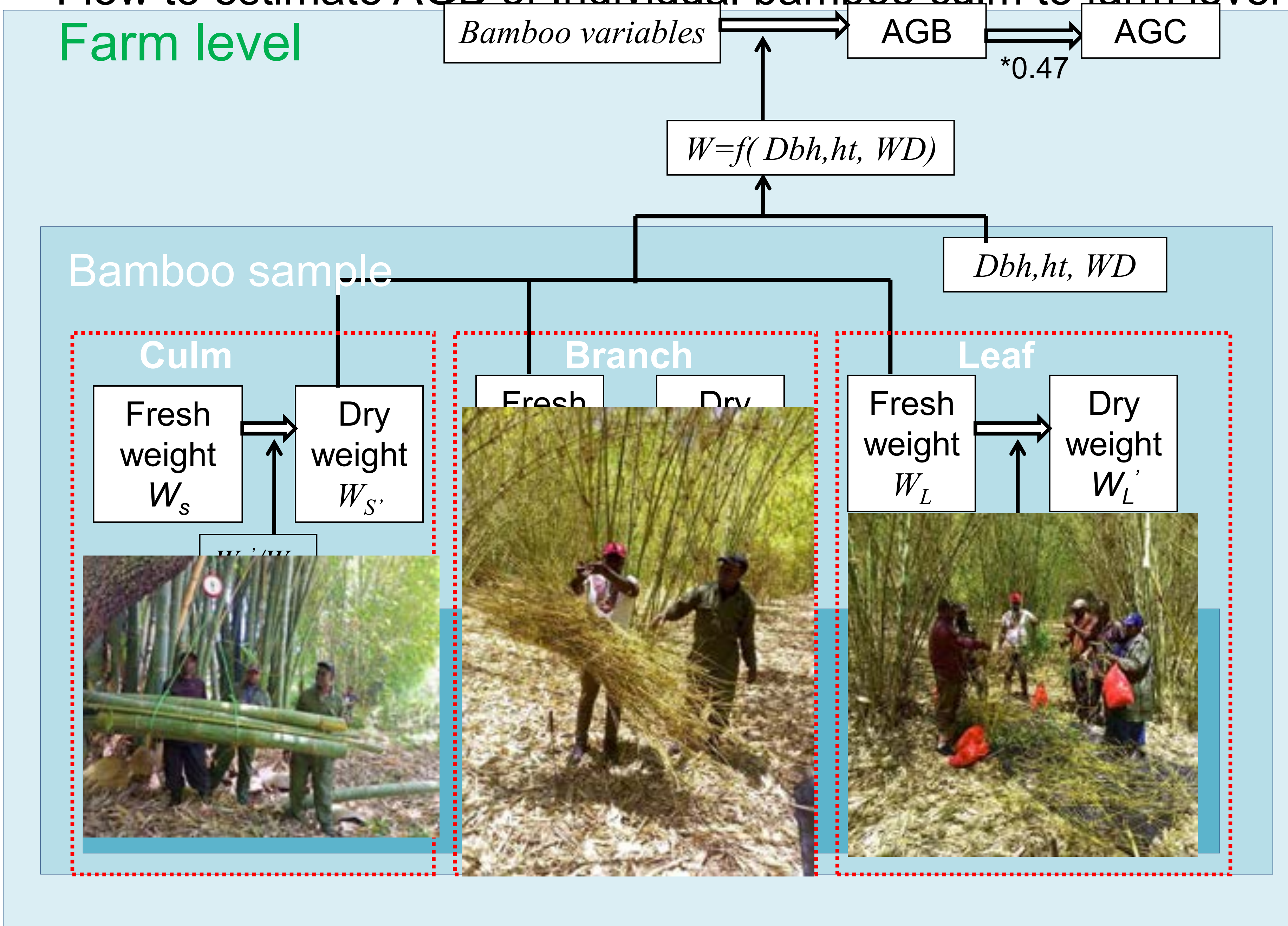
Objective 1: To develop species-specific allometric equations for estimating the aboveground biomass & carbon stock

Objective2: To develop multi-species allometric equations using pooled data of the major bamboo species

Study Area


35.0°E
37.0°E
39.0°E
0.0°
1.5°S
3.0°S
Bamboo sampling areas
Agro-Ecological Zones
Humid
Sub Humid
Semi Humid
Semi Humid to Semi Arid
Semi Arid
Arid
0
75
150 km

Flow to estimate AGB of Individual bamboo culm to farm level



Fitting Models to estimate biomass of various components

1) $Y = a \times dbh^b$
2) $Y = a + b \times dbh^2$
3) $Y = a \times dbh^b \times ht^c$
4) $Y = a \times (ht \times dbh^2)^b$
5) $Y = a \times (WD \times dbh^2 \times ht)^b$
6) $\log(Y) = a + b \times \log(dbh)$
7) $\log(Y) = a + b \times \log(dbh) + c \times \log(ht)$

- Y is the biomass of the culm, branches, leaves, and AGB (kg)
- dbh- diameter at breast height (cm)
- ht - total height (m),
- WD -wood density (g/cm^3)
- a, b and c are coefficients estimated by the regression model

Results

Summary of data characteristics (70% training model; 30% validation

		dbh(cm)		height(m)		Agb(kgs)	
Species	**n**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
B. vulgaris	38	4.71	1.92	7.89	3.17	5.54	5.56
D. asper	32	5.58	2.38	10.64	3.26	9.78	8.53
D. giganteus	43	8.54	4.04	11.99	5.78	14.96	17.13

FITTED EQUATIONS FOR ABOVE GROUND BIOMASS FOR THE THREE BAMBOO SPECIES

Equation	*a*	*b*	*c*	R^2	AIC
$Y = a \times dbh^b$	0.3094	1.8042		0.69712	536.7843
$Y = a + b \times dbh^2$	0.76610	0.18489		0.69401	537.6128
$Y = a \times dbh^b \times ht^c$	0.05944	0.52605	1.67893	0.90485	444.9983
$Y = a \times (ht \times dbh^2)^b$	0.12341	0.69619		0.82720	491.3284
$Y = a \times (WD \times dbh^2 \times ht)^b$	0.11799	0.75302		0.82935	490.3137
$log(Y) = a + b \times log(dbh)$	-1.77677	2.05425		0.99877	90.96754
$log(Y)$					

Conclusions and way forward

- Combination of DBH and height achieved the best performance through high R^2 and AIC
- Log-transformation improved our allometric models
- Wood density did not improve our models
- Allometric equations will help in improved estimates of carbon stocks within farmlands
- Future work is to evaluate applicability of the models in different bamboo agroforestry systems

THANK YOU

THE END

Email: jkigomo@kefri.org, jmukovi@kefri.org

KEFRI: https://www.kefri.org

Carbon sequestration potential of plantation forest in New Zealand: A comparative study

Serajis Salekin[1], Yvette L. Dickinson[1], Mark Bloomberg[2], Dean F. Meason[1]

[1] Scion (New Zealand Forest Research Institute Ltd.), Rotorua, New Zealand
[2] New Zealand School of Forestry, University of Canterbury, Christchurch, New Zealand

The problem

Environment

Climate Change Response (Zero Carbon) Amendment Act 2019

This amendment Act provides a framework by which New Zealand can develop and implement clear and stable climate change policies.

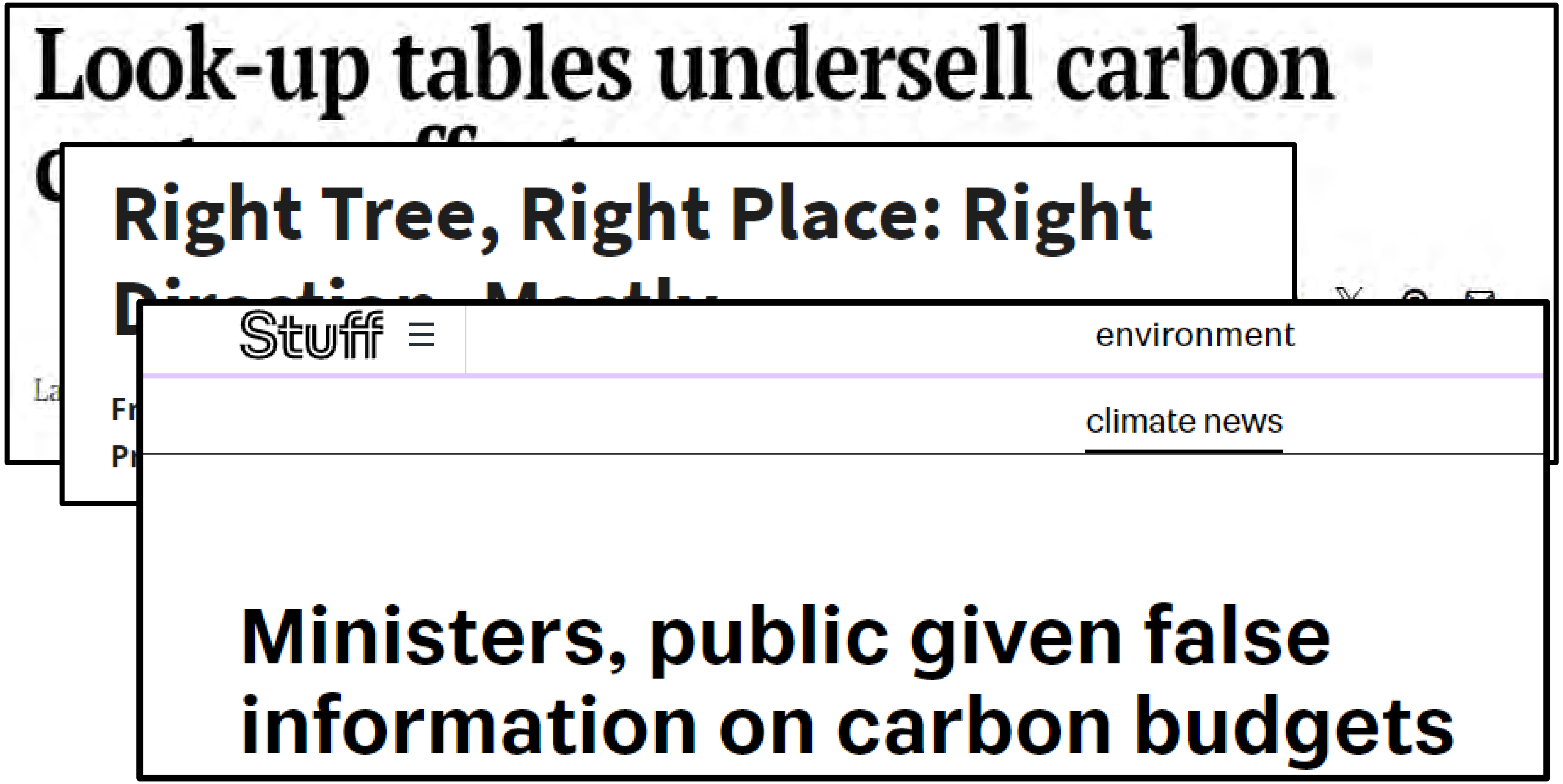
Unprecedented Rainfall in New Zealand Sparks Climate Change Concerns

Heavy Rainfall in Gore District Raises Questions about Climate Change and Preparedness

The problem

- Raised debates and concerns on

“What species?” “Where ?” “How-appropriate management scenario?”



Research aim

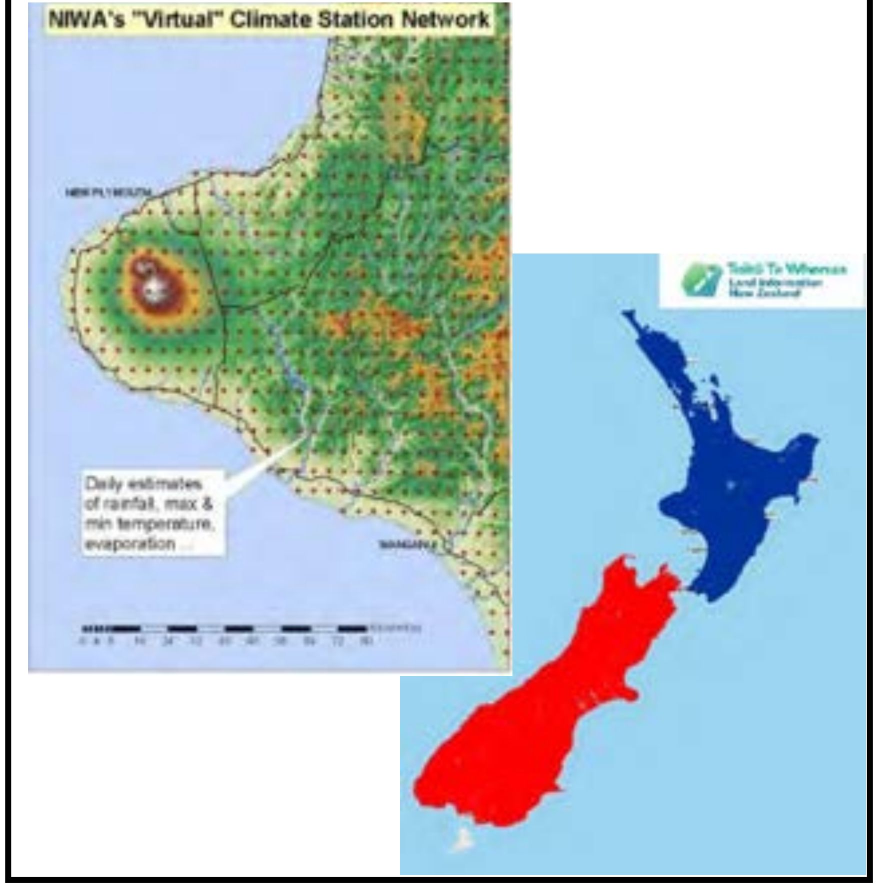
The main aim of this study is to provide realistic comparisons of carbon sequestration rates amongst candidate afforestation species.

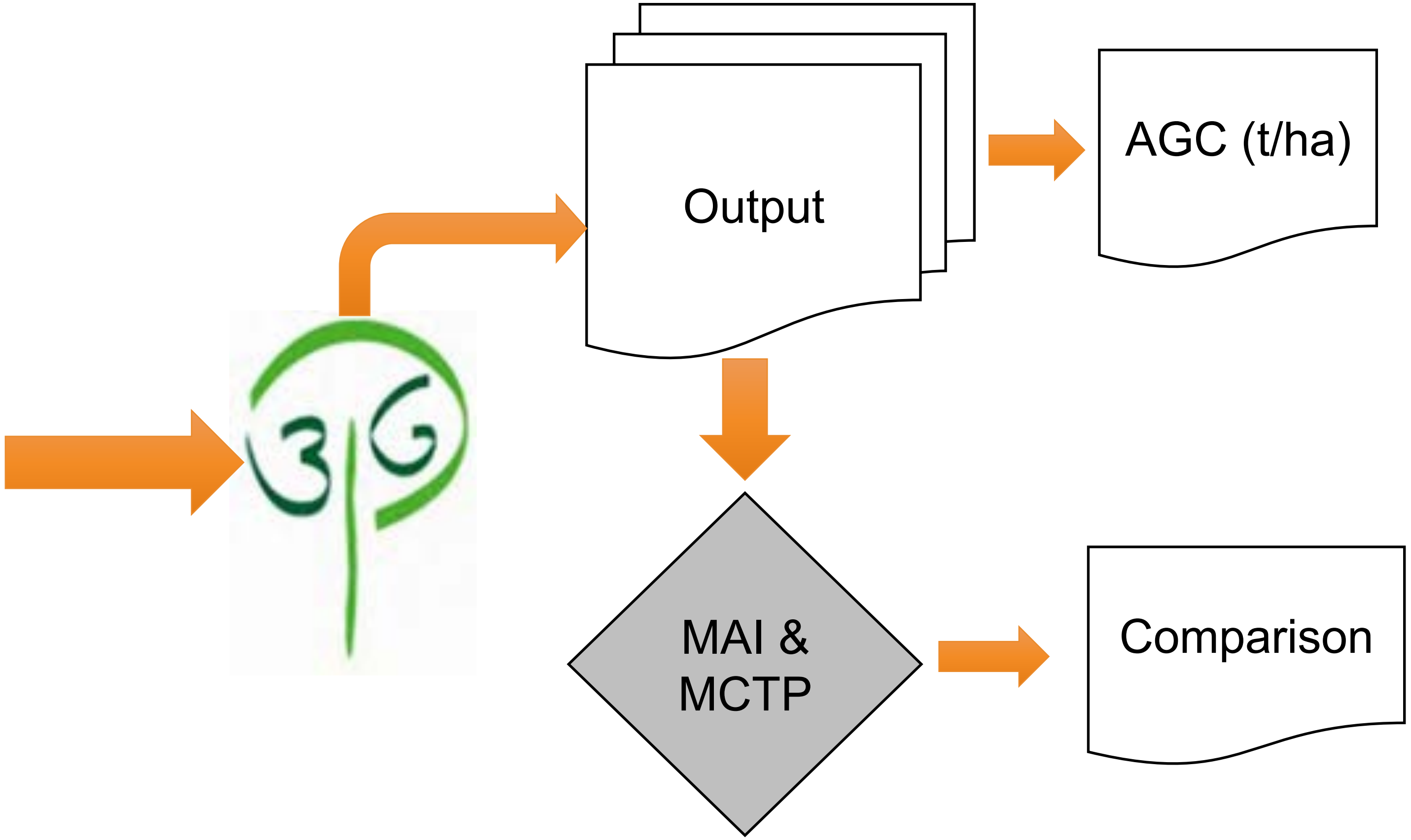
The objective is to use process driven model to quantify and compare the likely carbon sequestration of

- five plantation forest species
- across three contrasting sites with differing site characteristics and
- two silvicultural regimes (+1 regimes for *Pinus radiata* D. Don).

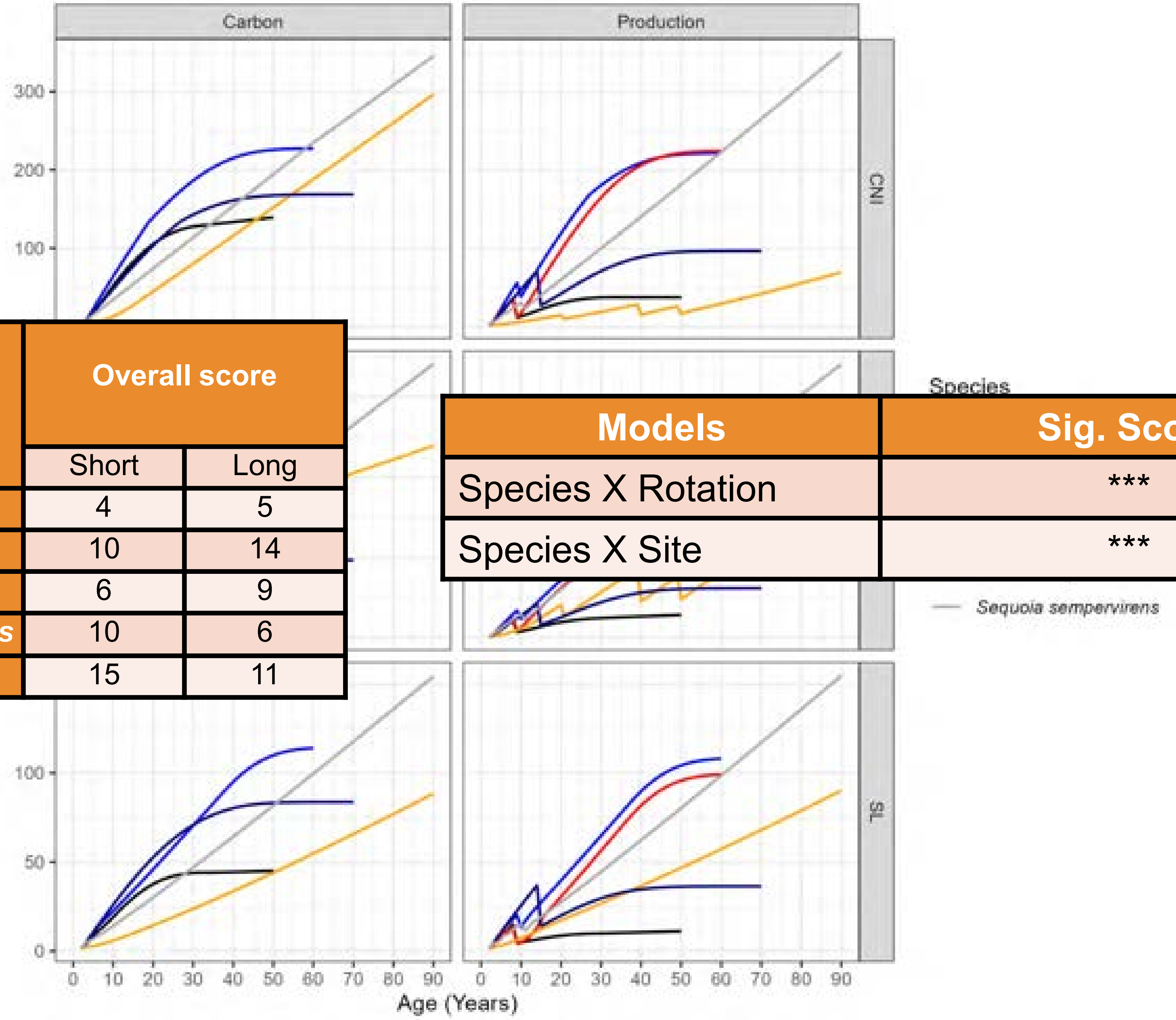
Data & Analysis

Sites	Species	Scenarios
3	5	11 (*P. radiata +1*)





Results



Species	Overall score	
	Short	Long
P. radiata	4	5
E. fastigata	10	14
P. menziesii	6	9
S. sempervirens	10	6
P. totara	15	11

Models	Sig. Score
Species X Rotation	***
Species X Site	***

Discussion & limitations

- Effect of species choice and site
  - *P. radiata* overall generalist
- Effect of species choice and rotation
  - Longer rotation species choice is crucial
  - Influenced by functional traits, e.g., shade tolerance, disturbance resistance etc.
- Uncertain, extreme and frequent climate change anomalies
- Additional life-cycle assessments.

Conclusions

- We systematically compared carbon sequestration of plantation forests species.
- Carbon sequestration rates by planted forests are site- and species-specific.
- The preferred species, regime and site for carbon sequestration is dependent on the planning horizon.
- The results indicate a broader significance and applicability.
- Our business-as-usual model may not be the best .

www.scionresearch.com

SCION

FORESTS ▪ PRODUCTS ▪ INNOVATION

Prosperity from trees *Mai i te ngahere oranga*

NATIONAL DEVELOPMENT PLAN 2020

EUROPEAN UNION
European Regional Development Fund

INVESTING IN YOUR FUTURE

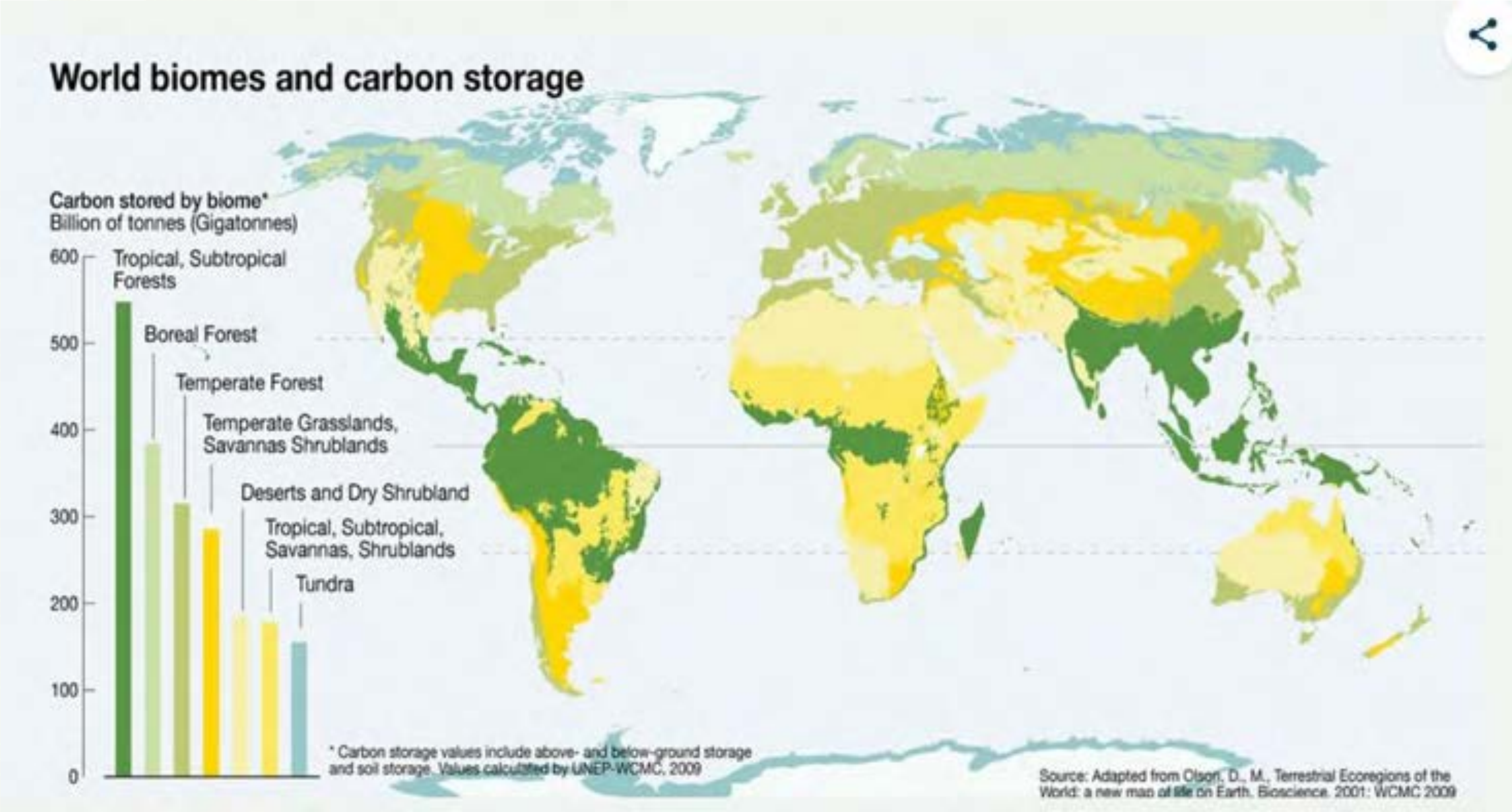
SILAVA

Can prolonged rotation in combination of forest drainage be a solution to increased carbon storage in Scots pine forests on organic soils of hemiboreal region?

Mg.silv. Valters Samariks
Latvian State Forest Research Institute ''SILAVA''

5TH INTERNATIONAL CONGRESS ON PLANTED FORESTS

November 9, 2023


World biomes and carbon storage
Carbon stored by biome*
Billion of tonnes (Gigatonnes)
600
500
400
300
200
100
0
Tropical, Subtropical Forests
Boreal Forest
Temperate Forest
Temperate Grasslands, Savannas Shrublands
Deserts and Dry Shrubland
Tropical, Subtropical, Savannas, Shrublands
Tundra
* Carbon storage values include above- and below-ground storage and soil storage. Values calculated by UNEP-WCMC, 2009
Source: Adapted from Olson, D., M., Terrestrial Ecoregions of the World: a new map of life on Earth. Bioscience. 2001: WCMC 2009

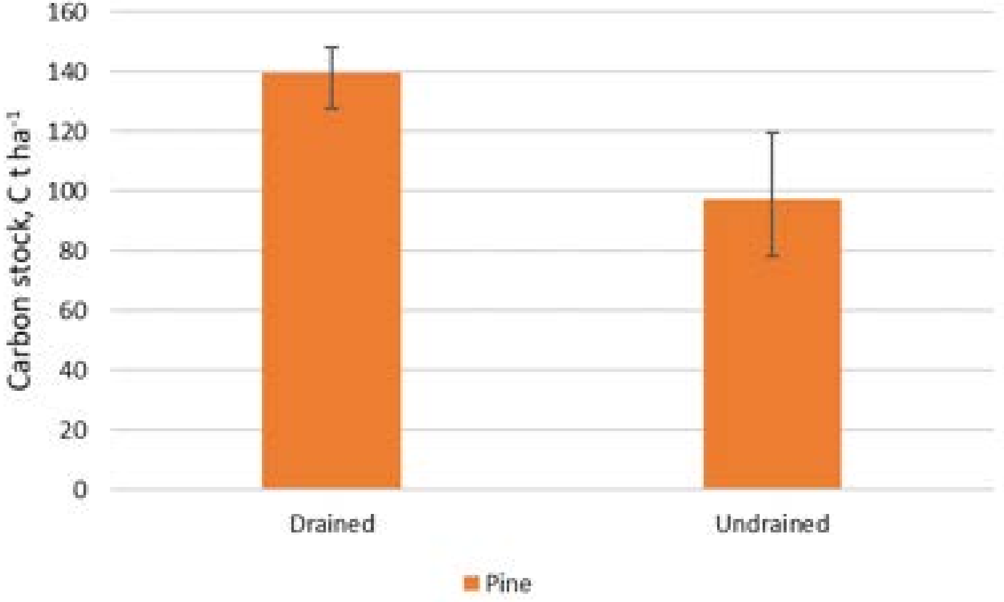
Forest cover ~ **53%**

Most common tree species:

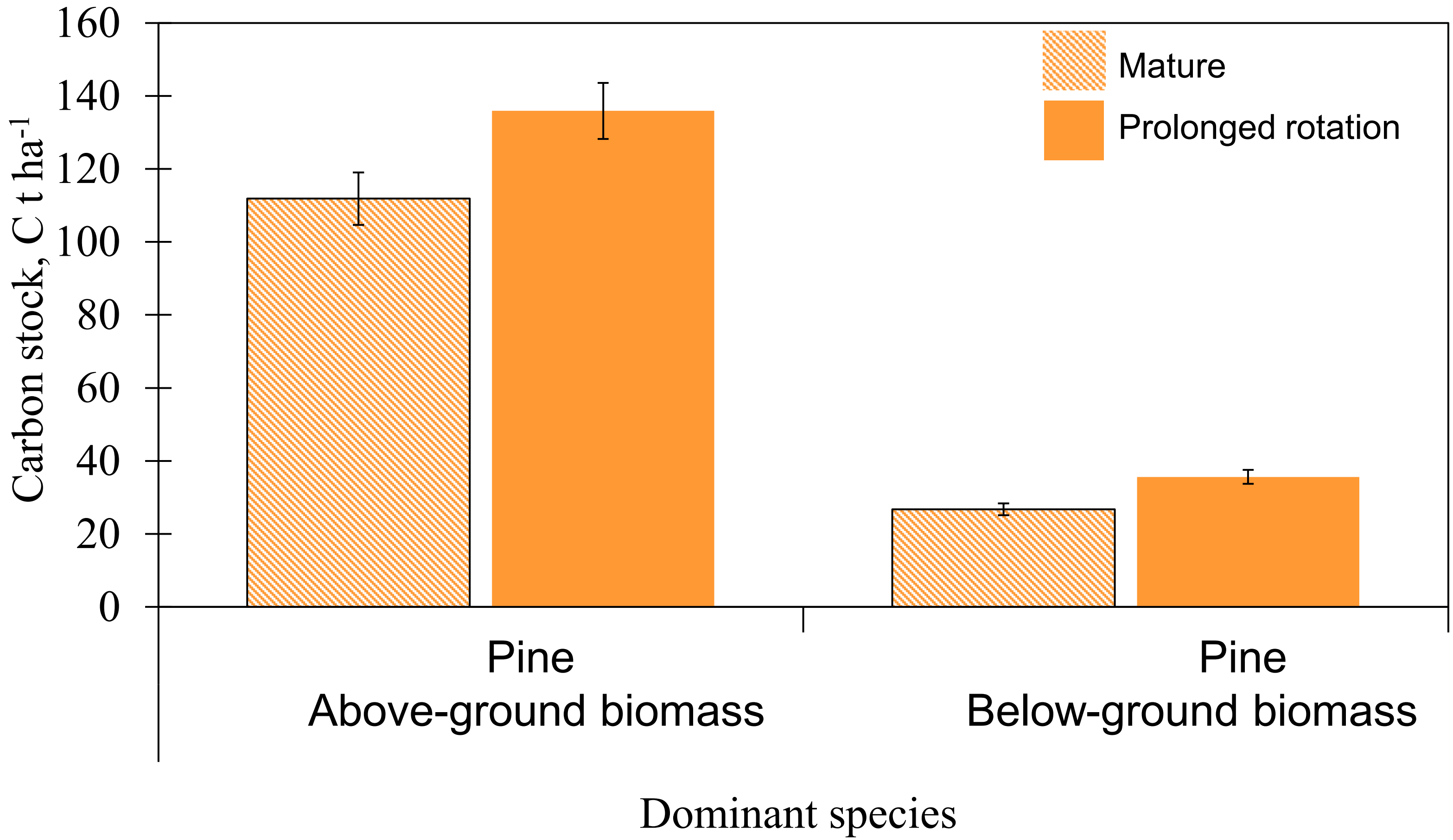
- Scots pine (*Pinus sylvestris*) – 33%
- Birch (*Betula spp*) – 30%
- Norway spruce (*Picea abies*) – 19%

Effect of drainage

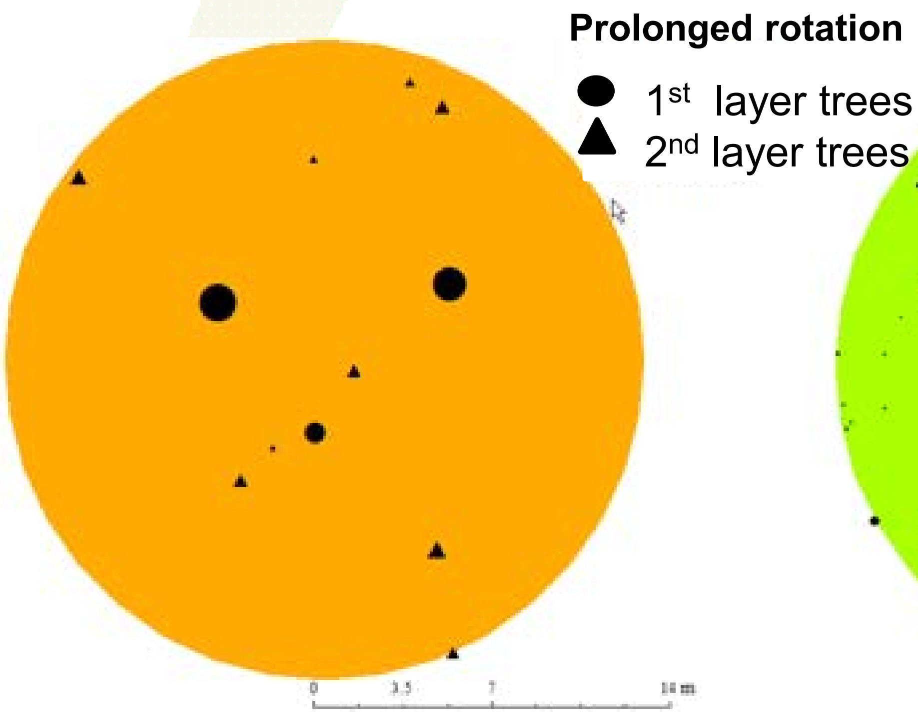
- Globally, 15% of the organic soils are drained, but in Europe even 48% of the organic soils are drained to improve forest growth
- In Latvia most drainage systems has been established in 1960ties

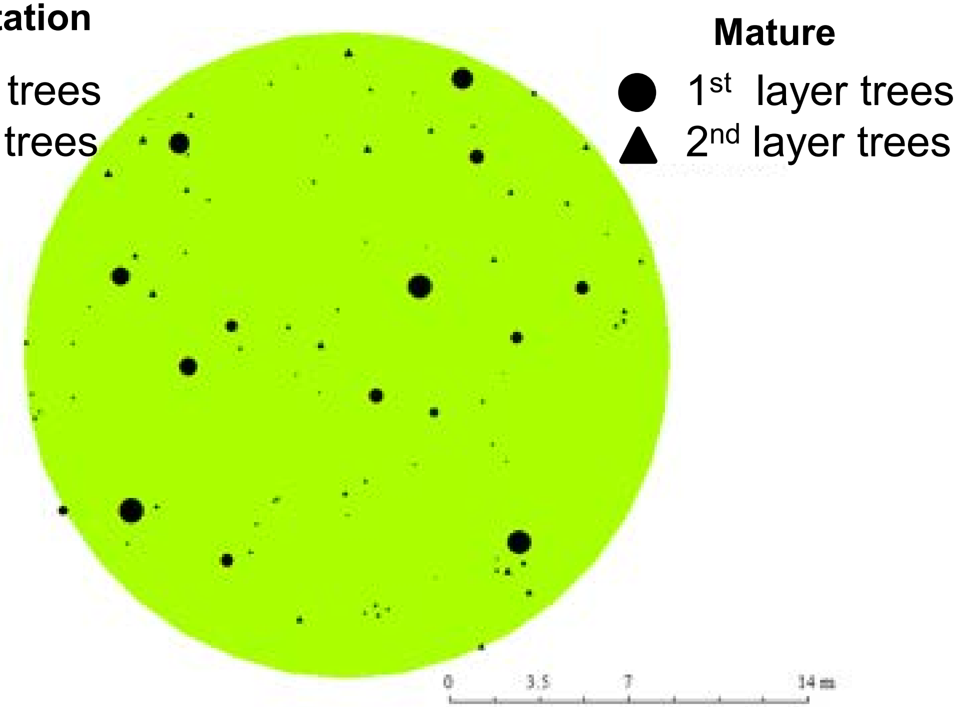


90 vs 160 year rotation?



Visualization of carbon stock



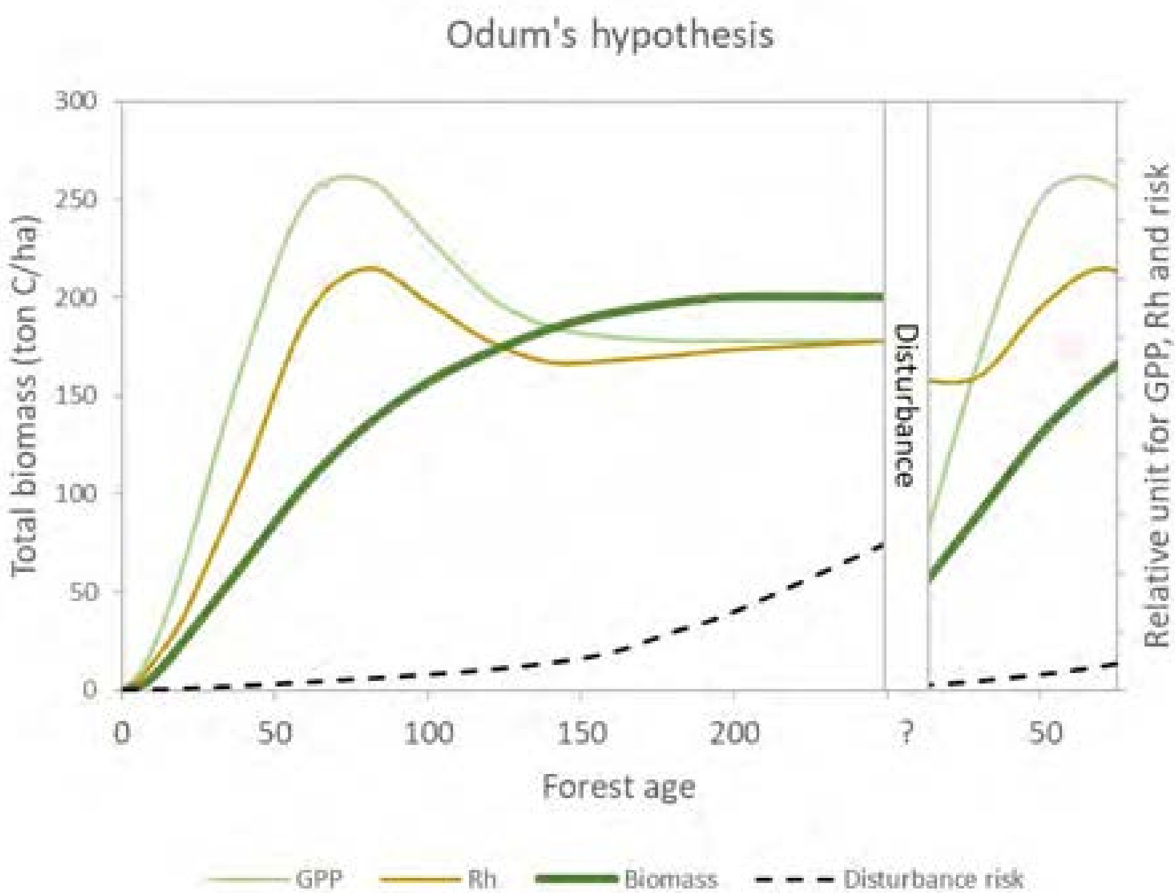


limiting factors for forest carbon:

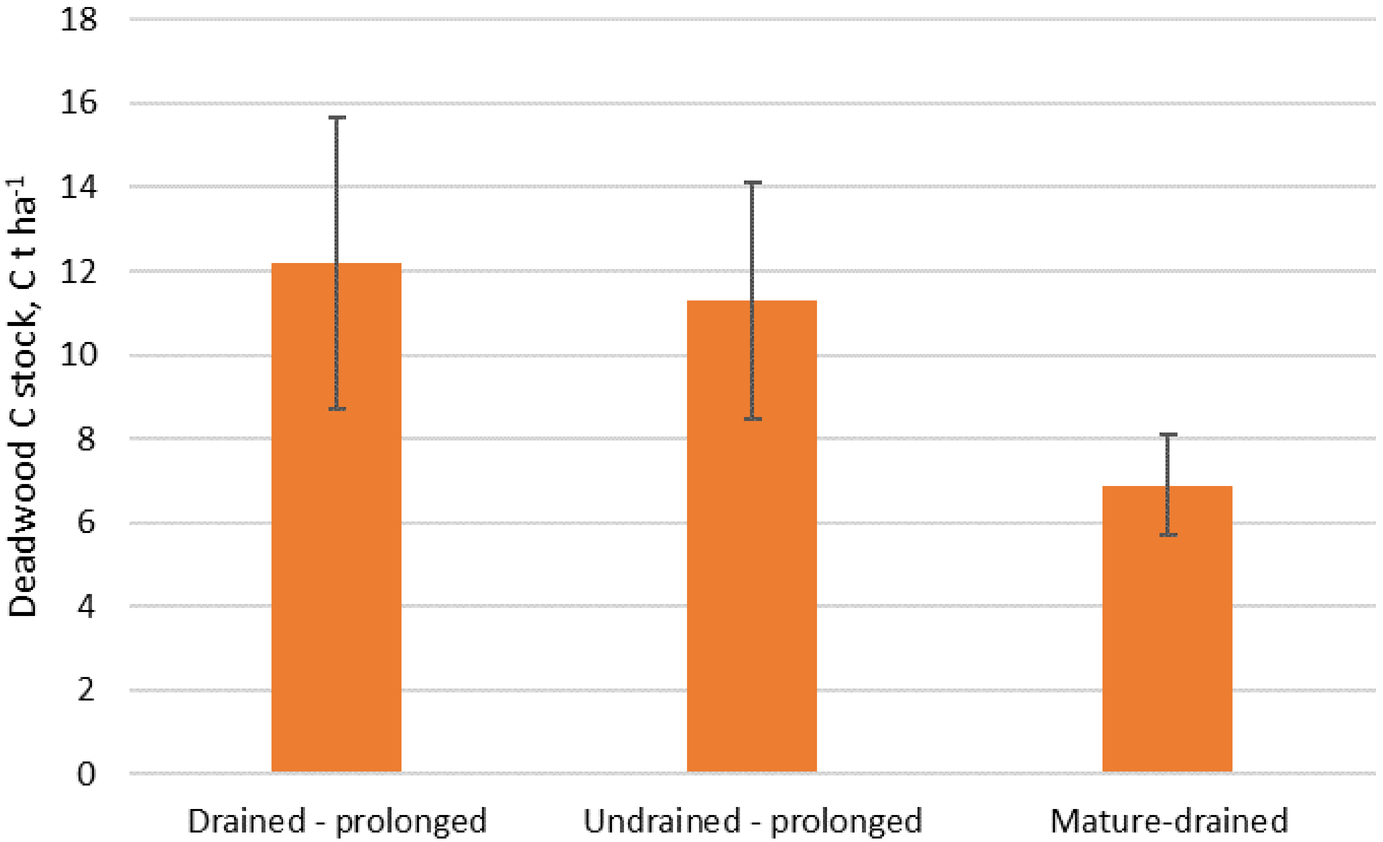
a) specific ecosystem potential to store carbon;

b) forest management;

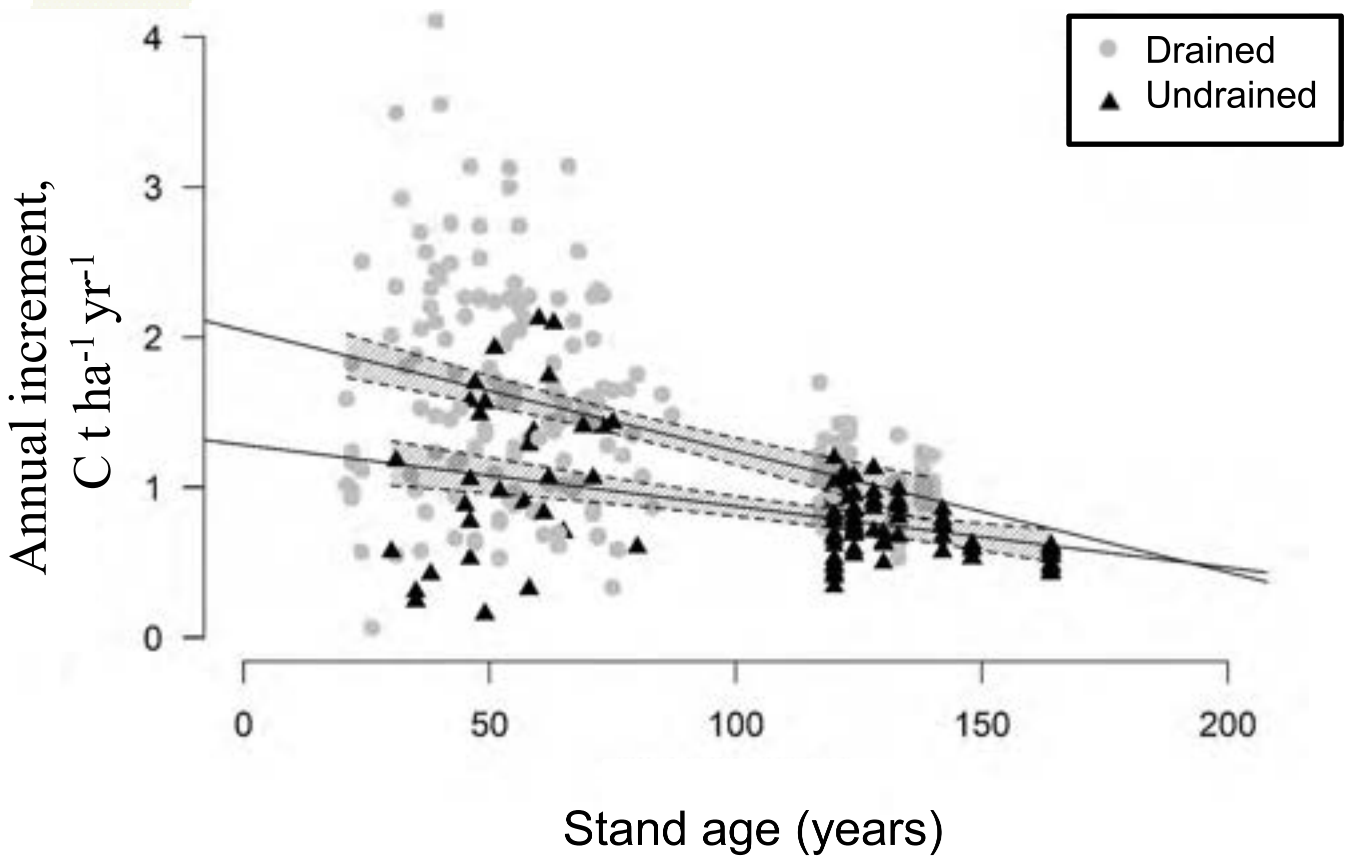
c) natural disturbances



Carbon in deadwood



Annual carbon sequestration



Take-home messages

- Prolonged rotation in combination with site drainage results in improved tree growth and carbon storage.

- Annual carbon sequestration capacity decreases with aging, thus stands with normal rotation period has higher annual carbon sequestration potential.

- Deadwood carbon stock is similar between drained and undrained with prolonged rotation, however lower deadwood amount can be observed in stands with normal rotation period.

NATIONAL DEVELOPMENT PLAN 2020

EUROPEAN UNION
European Regional Development Fund

INVESTING IN YOUR FUTURE

SILAVA

This research was funded by project “Development of a decision support tool integrating information from old-growth semi-natural forest for more comprehensive estimates of carbon balance” (ERDF No. 1.1.1.1/19/A/130).

Thank you for your attention!

Life Cycle Assessment (LCA): new poplar clones allow an environmentally sustainable cultivation

Andrea Deidda, Sara Bergante,
Pier Mario Chiarabaglio, Gaetano Casto,
Corrado Carbonaro, Simonetta Pagliolico.

This is the degree thesis of Dr. Andrea Deidda, obtained at the Architectural Technology group and the LaSTIn (Innovative Technological Systems) laboratory of the Department of Architecture and Design, in collaboration with CREA- Forestry and Wood Centre.

Forestry and Wood Center

DAD Department

DISAT Department

E. Vigolungo SpA Canale (CN)

GOAL OF THE RESEARCH

To apply the LCA methodology to poplar cultivation for plywood production

To evaluate the impact of the use of different poplar clones and cultural models on sustainability of the process

Focus attention on the most impactful phases of the process and identify possibilities for improvement

POPLAR AND ITS CULTIVATION

Poplar is a genus of fast growing species able to produce wood for industry in about 10 years.
Its wood is light and white.

Many clones are available for cultivation:
P. ×canadensis, P. deltoides, P ×generosa…

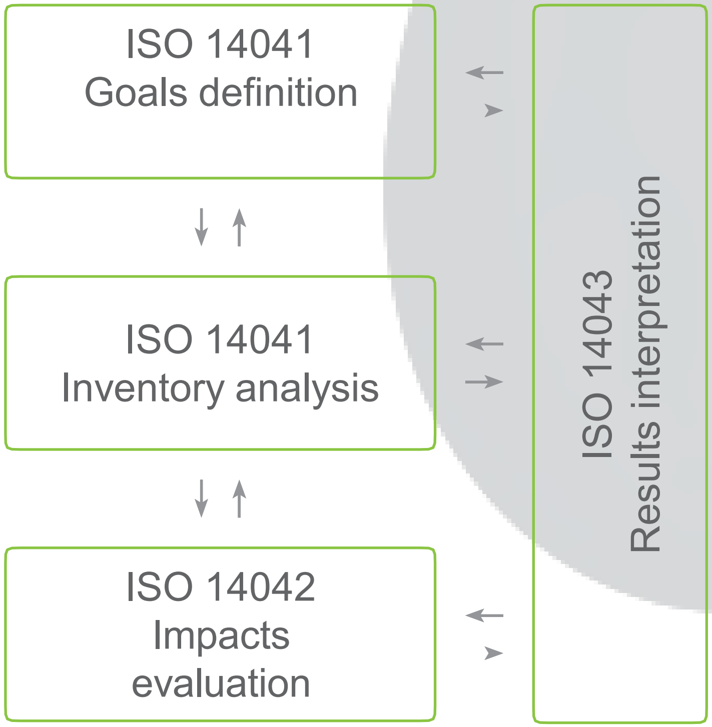
Plywood
OSB
Particle boards
Saw and packaging
Pulp for paper
Chips for energy

Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

LIFE CYCLE ASSESSMENT

Life cycle assessment or LCA is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a commercial product, process, or service.

An LCA study involves a thorough inventory of the energy and materials that are required across the supply chain and value chain of a product, process or service, and calculates the corresponding emissions to the environment.



SimaPro

> Direct experimental data:

- Phase I – Poplar growth: from CREA-Forestry and Wood Center, Casale Monferrato (AL) –Italy
- Phase II – Plywood: E. Vigolungo, Canale (CN) -Italy

> Software for data processing:

SimaPro 8.2.3.0

> Functional unit:

- Phase I – Poplar growth: 1 t of wood
- Phase II - plywood: 1 m^3 of plywood

> Impact categories:

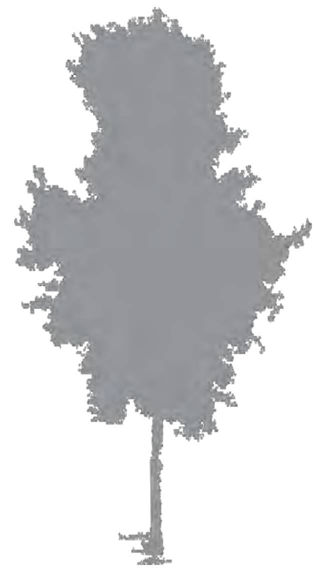
- GWP 100a (EPD 2003, IPCC 2013)
- CED (CED)
- Freshwater Ecotoxicity (ILCD method)
- Water Scarcity (Berger et al 2014)

> Average economic allocation

PHASE I
POPLAR CULTIVATION LIFE CYCLE

Barbatellaio (very high density nursery)
Life cycle: 3 y
Density: 62 500 sprouts/ha

Nursery
Life cycle: 2 y
Density: 7000 trees/ha



Poplar stand
Lyfe cycle: 10 y
Density: 277 trees/ha

Harvest

PHASE I – POPLAR GROWT
3 SCENARIOS

INTENSIVE WITH 'I-214' CLONE

INTENSIVE WITH MSA CLONES

(MSA= Maggior Sostenibilità Ambientale = Greater Environmental Sustainability)

PEFC CERTIFICATE WITH MSA CLONES

iscritti al RNCF al 1980

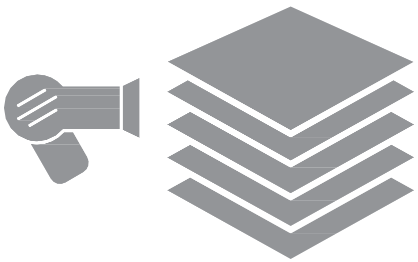
CLONE	Venturia	Ruggini	Bronzatura	Necrosi corticali	Virosi	Afide	
BL Costanzo	**	**	**	**	****	**	Populus ×canadensis
Cappa Bigliona	**	**	**	**	****	**	Populus ×canadensis
Boccalari	*	**	**	**	****	**	Populus ×canadensis
Branagesi	*	***	***	** (?)	****	**	Populus ×canadensis
Gattoni	*	***	**	** (?)	****	**	Populus ×canadensis
Pan	**	**	**	**	****	**	Populus ×canadensis
Adige	*	***	**	**	****	*	Populus ×canadensis
Stella Ostigliese	*	**	***	**	****	**	Populus ×canadensis
302 San Giacomo	*	**	***	** (?)	****	**	Populus ×canadensis
I-154	*****	****	**	*** (?)	*****	**	Populus ×canadensis
I-214	*****	***	**	***	*****	**	Populus ×canadensis
I-262	*****	***	*	*** (?)	*****	**	Populus ×canadensis
I-45/51	*****	***	**	*** (?)	*****	**	Populus ×canadensis
I-455	*****	**	*	*** (?)	*****	**	Populus ×canadensis
NND	*****	***	**	***/****	****	**	Populus ×canadensis
San Martino	****	****	****	****	*	****	Populus ×canadensis
Triplo	****	****	****	***	***	**	Populus ×canadensis
Harvard	*****	*****	*****	**** (?)	*	****	Populus deltoides
Lux	*****	****	*****	*****	**	*****	Populus deltoides
Onda	*****	*****	*****	*****	**	****	Populus deltoides
Bellini	*****	*	***	*	*****	****	Populus ×canadensis
Carpaccio	**	*	***	**	*****	****	Populus ×canadensis
Cima	***	**	****	*	*****	***	Populus ×canadensis
Guardi	*****	**	***	*	*****	**	Populus ×canadensis
Luisa Avanzo	***	*	****	*	*****	***	Populus ×canadensis
Jean Pourtet	*****	****	*****	*	*****	***	Populus nigra

iscritti al RNCF dopo 2011

CLONE	Venturia	Ruggini	Bronzatura	Necrosi corticali	Virosi	Afide	
Imola [(1)] 83.160.029	****	****	*****	****	****	*****	Populus ×canadensis
Orion [(1)] 83.148.041	*****	***	*****	***	*****	***	Populus ×canadensis
Monviso [(1)]	*****	*****	*****	*****	****	****	Populus ×generosa
Pegaso [(1)]	*****	****	*****	*****	***	***	P. nigra x Populus xgenerosa
Sirio	*****	*****	*****	****	*****	***	Populus deltoides × Populus ×canadensis
Aleramo 83.141.020	****	***	*****	****	****	*****	Populus ×canadensis
Diva 83.002.031	****	***	*****	****	****	***	Populus ×canadensis
Moleto 83.190.012	****	****	*****	****	****	*****	Populus ×canadensis
Mombello 84.048.032	****	* Map	*****	****	****	*****	Populus ×canadensis
Moncalvo 83.024.017	****	* Map	*****	****	****	*****	Populus ×canadensis
Senna 83.002.011	****	****	****	****	****	****	Populus ×canadensis
Tucano 84.260.003	****	***	*****	****	****	*****	Populus ×canadensis
Baldo [(1)]	*****	****	*****	****	****	****	Populus ×canadensis
AF2	*****	*****	*****	***	*****	*****	Populus ×canadensis
AF3	*****	****	*****			**	P. nigra x Populus xgenerosa
AF4	*****	****	*****			*****	Populus ×canadensis
AF6	*****	****	****			****	P. nigra x Populus xgenerosa
AF7	*****	****	*****			****	Populus ×canadensis x Populus xgenerosa
AF8	*****	****	*****			****	Populus trichocarpa x Populus xgenerosa
AF9	*****	*****	****			**	P. nigra x Populus xgenerosa
Koster	****??	****	***	***/****	****	****	Populus ×canadensis

PHASE II
PLYWOOD PRODUCTION LIFE CYCLE





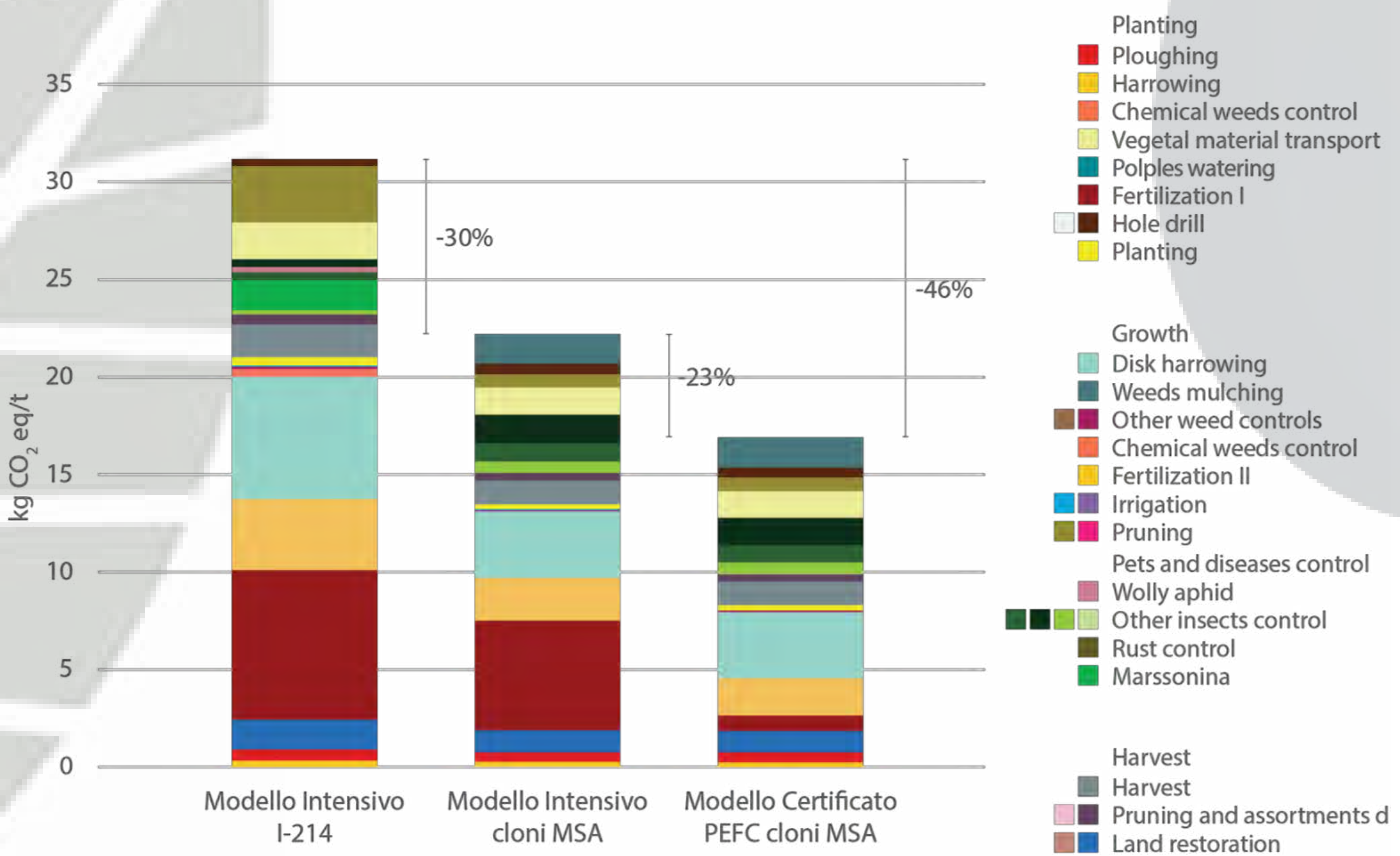

Logs to industry | Logs peeling | Wood sheets drying | Pressing and gluing



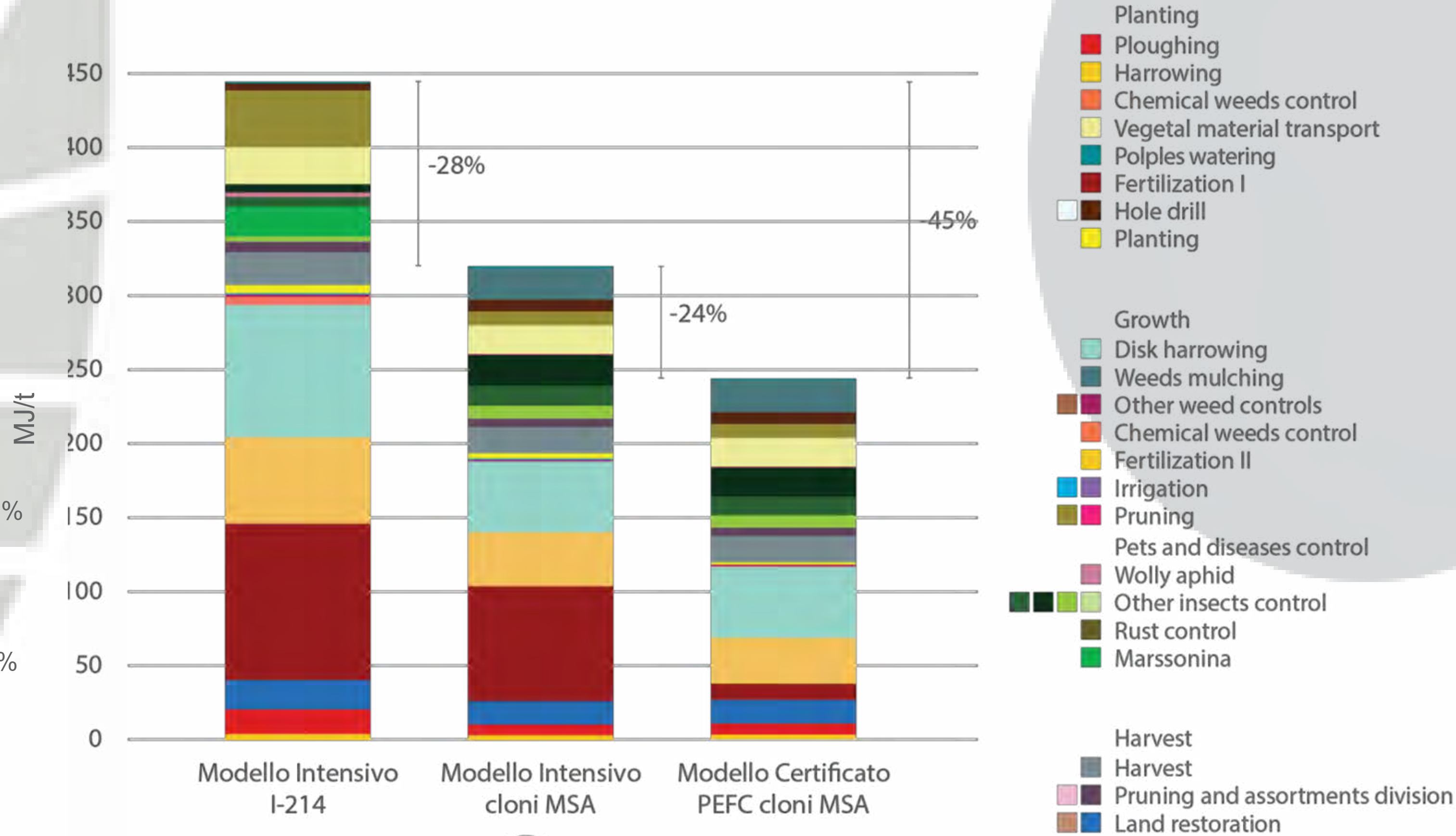

PHASE I – POPLAR GROWT RESULTS

GWP (IPCC 2013 method)

Total of the cultivation cycle



CED Non Renewable, fossil (CED)



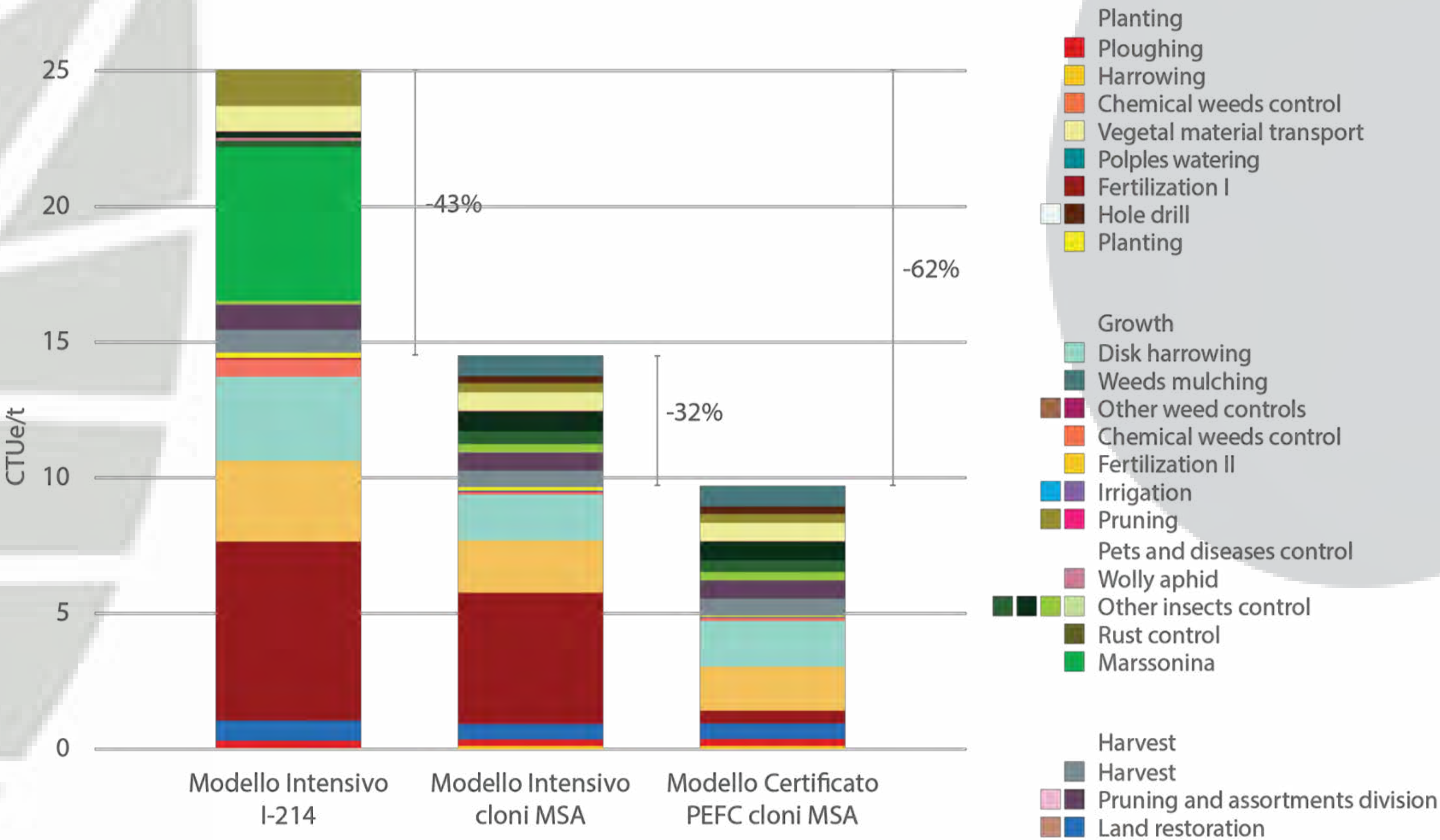
N fertilization:
From I-214 to MSA= -38%
From I-214 to PEFC Cert. = -14%

Basic fertilization:
From I-214 to MSA -26%
From I-214 to PEFC Cert = -85%

Primary energy content
CO_2 emission

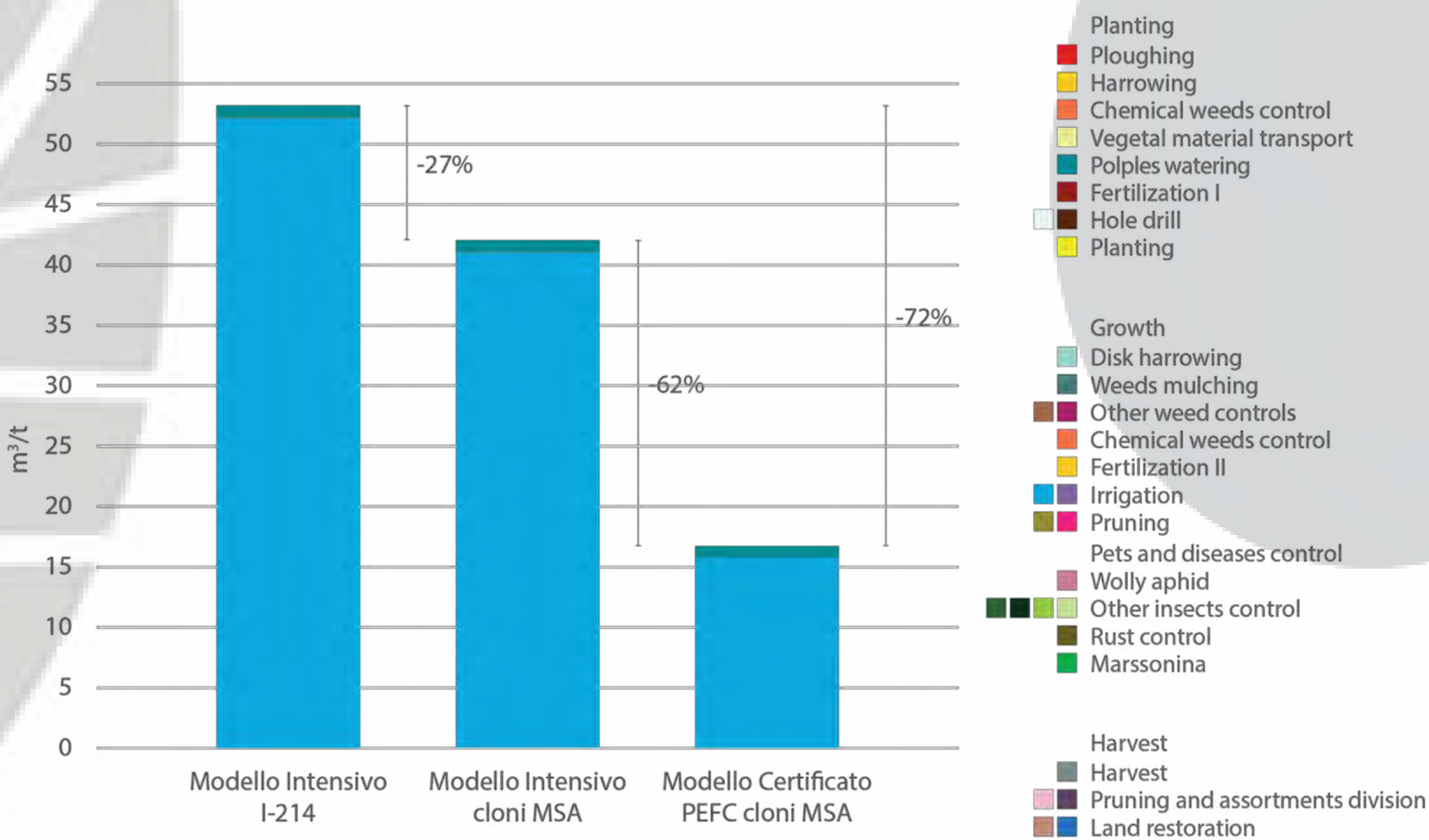
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Freshwater Ecotoxicity (metodo ILCD)



Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

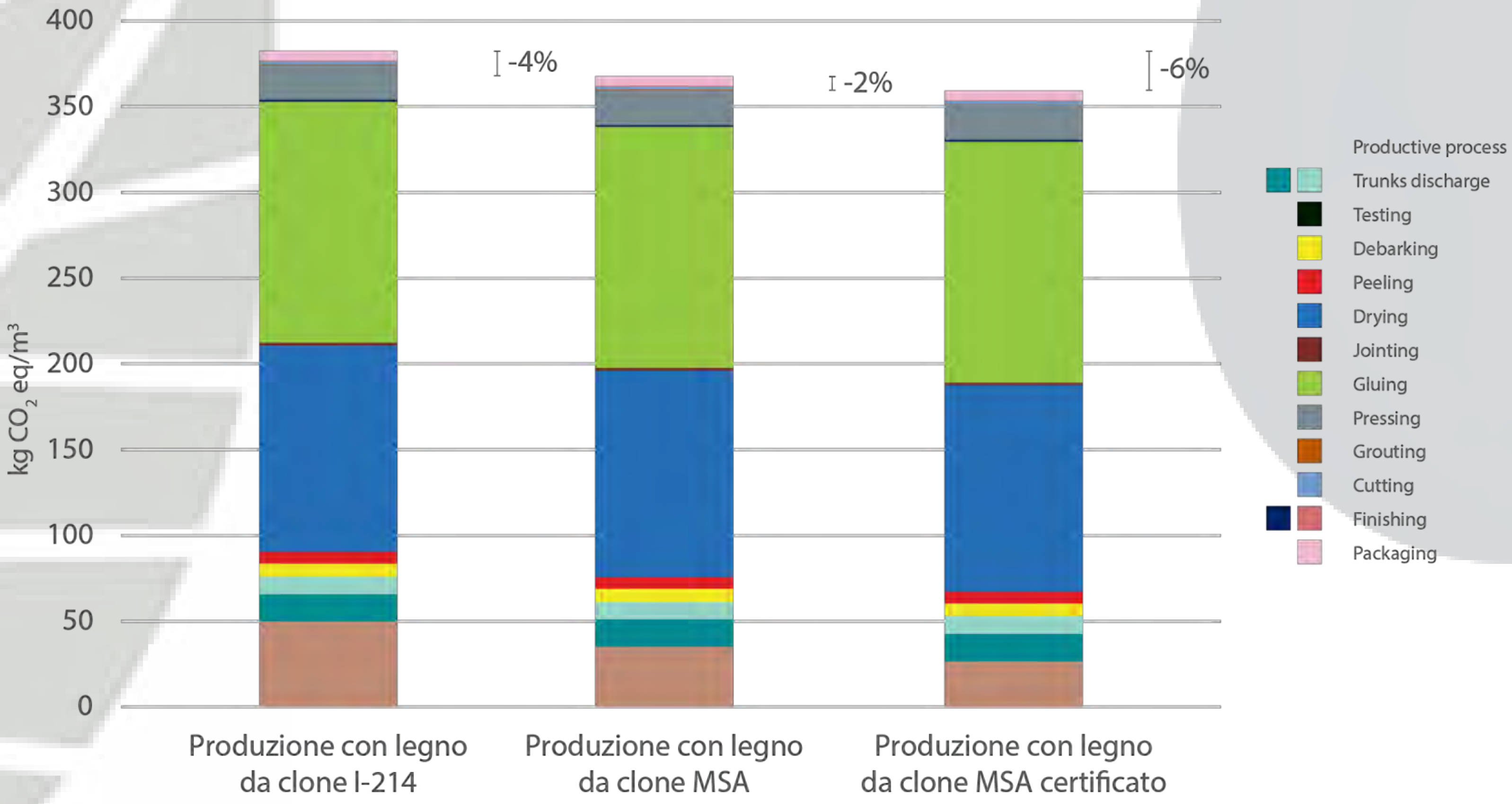
Water Scarcity (Berger et al. 2014)



Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

PHASE II – PLYWOOD RESULTS

GWP 100a (EPD 2003 method)

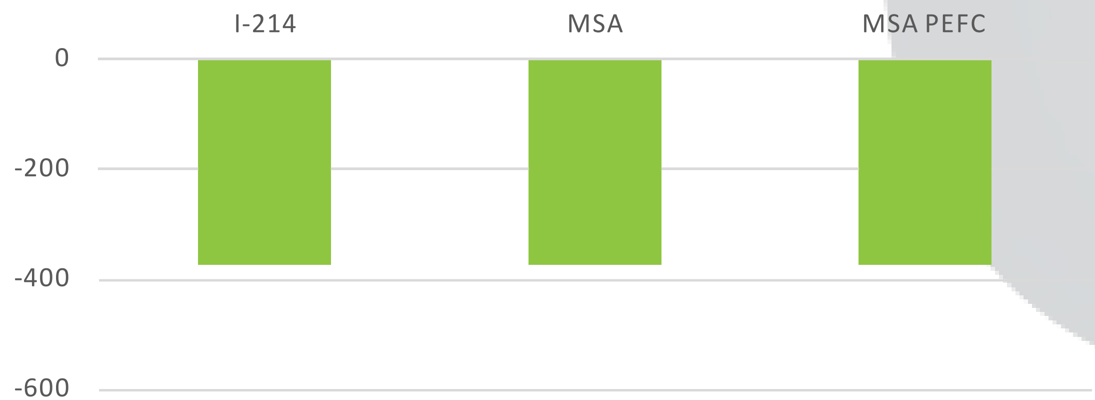


NET CARBON SEQUESTRATION

1 m^3 of poplar plywood seizes

743 kg/m^3 di CO_2

The absorption balance is positive!!



-362 kg/m^3 di CO_2

-376,3 kg/m^3 di CO_2

-383,66 kg/m^3 di CO_2

Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

TAKE HOME MESSAGE

> From 'I-214' to MSA:
GWP: -30% CED: -28%
MSA with PEFC: GWP: -23%
CED: -24%

> From 'I-214' to MSA :
Water ecotoxycity: -43%
MSA with PEFC :
Water ecotoxycity: -32%

> From 'I-214' to MSA :
Water Scarcity: -27%
MSA with PEFC :
Water Scarcity: -62%.

> PEFC has irrelevant effect :
GWP: -3%
CED: -2%

> MSA improve due to the high volume of logs

> Carbon sequestration > emission kg CO2 eq

> The gluing phase impacts il 40% on GWP and on CED.
Reducing of 20%:
GWP: -8%
CED: -6%.
Bio-adhesives: GWP: -9%
CED: -39%

Thank you for the attention!

Sara Bergante

Council for Agricultural Research and Analysis of Agricultural Economics

Centre for Forestry and Wood

Casale Monferrato – Italy

sara.bergante@crea.gov.it

www.crea.gov.it

LAND LIFE COMPANY

Modelling carbon capture by line-seeded reforestation sites in Australia

Take away:

Large-scale reforestation efforts on degraded areas are necessary in Australia *because of :*

climate change, fire, droughts

previous land clearing and subsequent degradation

The voluntary carbon offset market is willing to fund *nature-based reforestation efforts.*

Locally accurate carbon capture forecasts are critical *for decisionmaking*

This study shows that ***with a dedicated model****,* ***locally accurate C capture forecasts are feasible***

Data availability, -collection and -sharing *are crucial in this process*

LAND LIFE

CSIRO

THE UNIVERSITY OF MELBOURNE

CASSINIA ENVIRONMENTAL

LAND LIFE COMPANY

Challenge: to forecast carbon capture of degraded sites in Australia reforested by line-seeding

LAND LIFE COMPANY

Brief introduction to Land Life

forest and nature restoration of degraded areas

Data- and Technology driven

	Ground-Based	Drone	Satellite
Collection Methods	 1 to 40 years → <2 m	 1 to 10 years → 2-5 m	 10 to 40 years → >5 m
Data Collected	 • Species, height & vigor • Geotagging with precision GNSS	 • Orthomosaics, Digital Terrain Models, Biomass, tree counts, health & vigor • Utilizes NDVI, LiDAR	 • Monitor for anomalies such as fire, logging & overgrazing • CO2 flux recordings

FastTrack - carbon capture forecasting model to inform Land Life's global reforestation activities

Locally accurate

NFI filters

Locally accurate parameters

Site Productivity Assessments

Reflects our planting choices

Specific for planting design

Mixed species modelling

Fully accountable

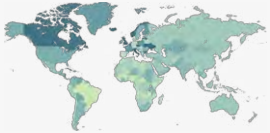
CCPRs

Science Admin

Carbon Modelling App

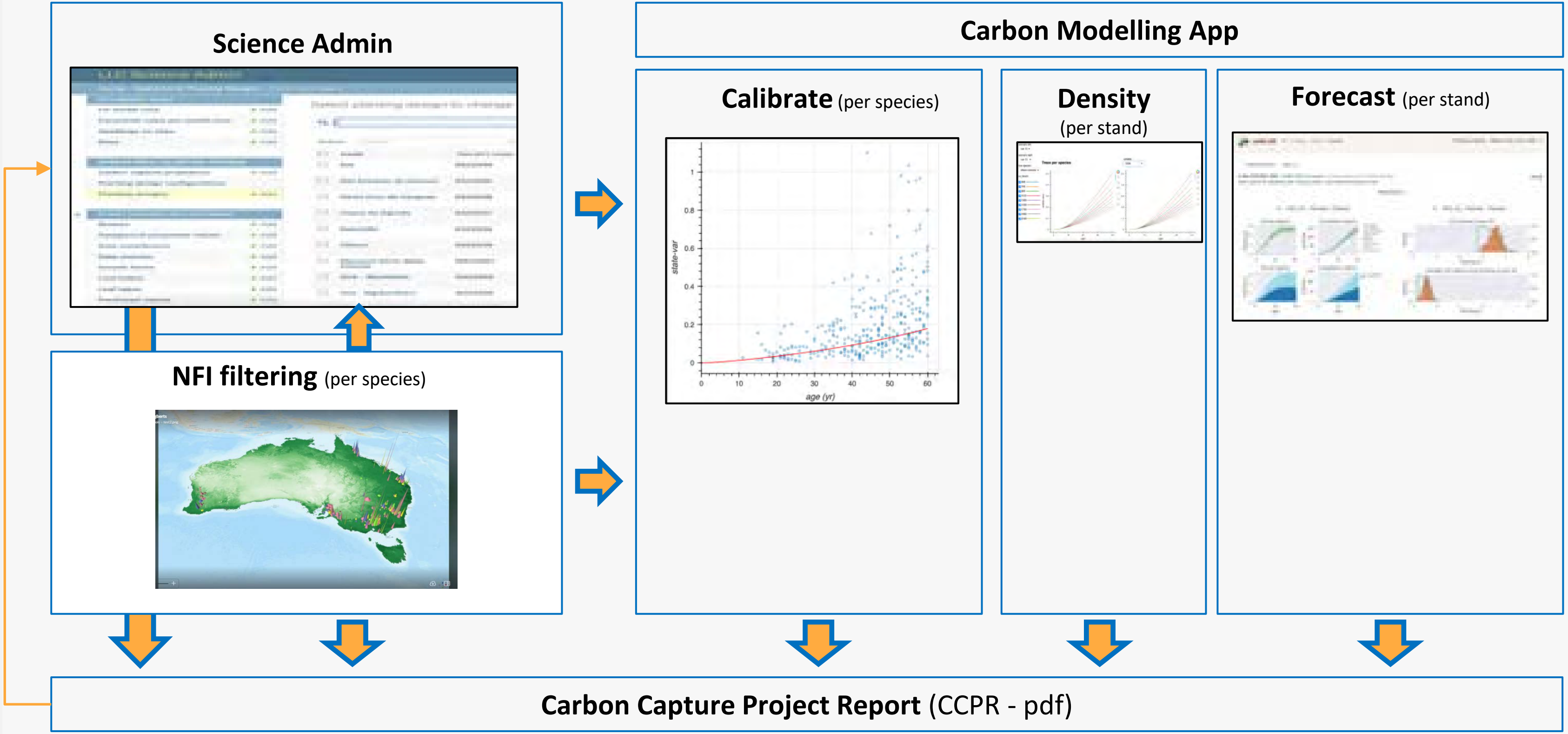
Globally applicable

Consistent method over all geographies, ***with local modification***



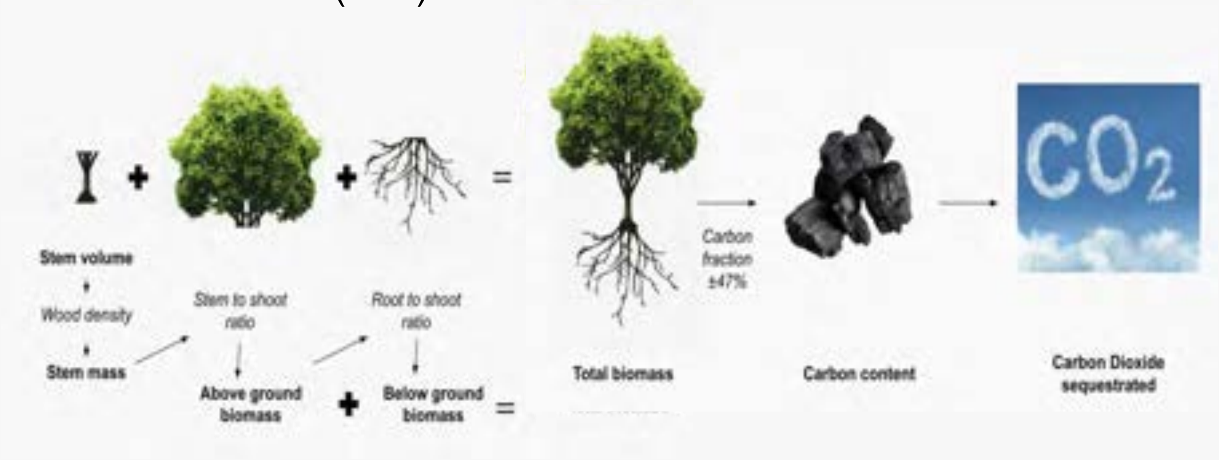
LAND LIFE COMPANY

Determine locally accurate growth parameter values for each species to run FastTrack with, and document every step



FastTrack - based on IPCC – Tier 2 approach to calculate carbon capture

CAI * WD * BEFD * (1+R) * CF * 44/12 = CO2



Determine parameters
- site & species specific
- only species specific

mixed-species forests

+ crown competition

+ mortality

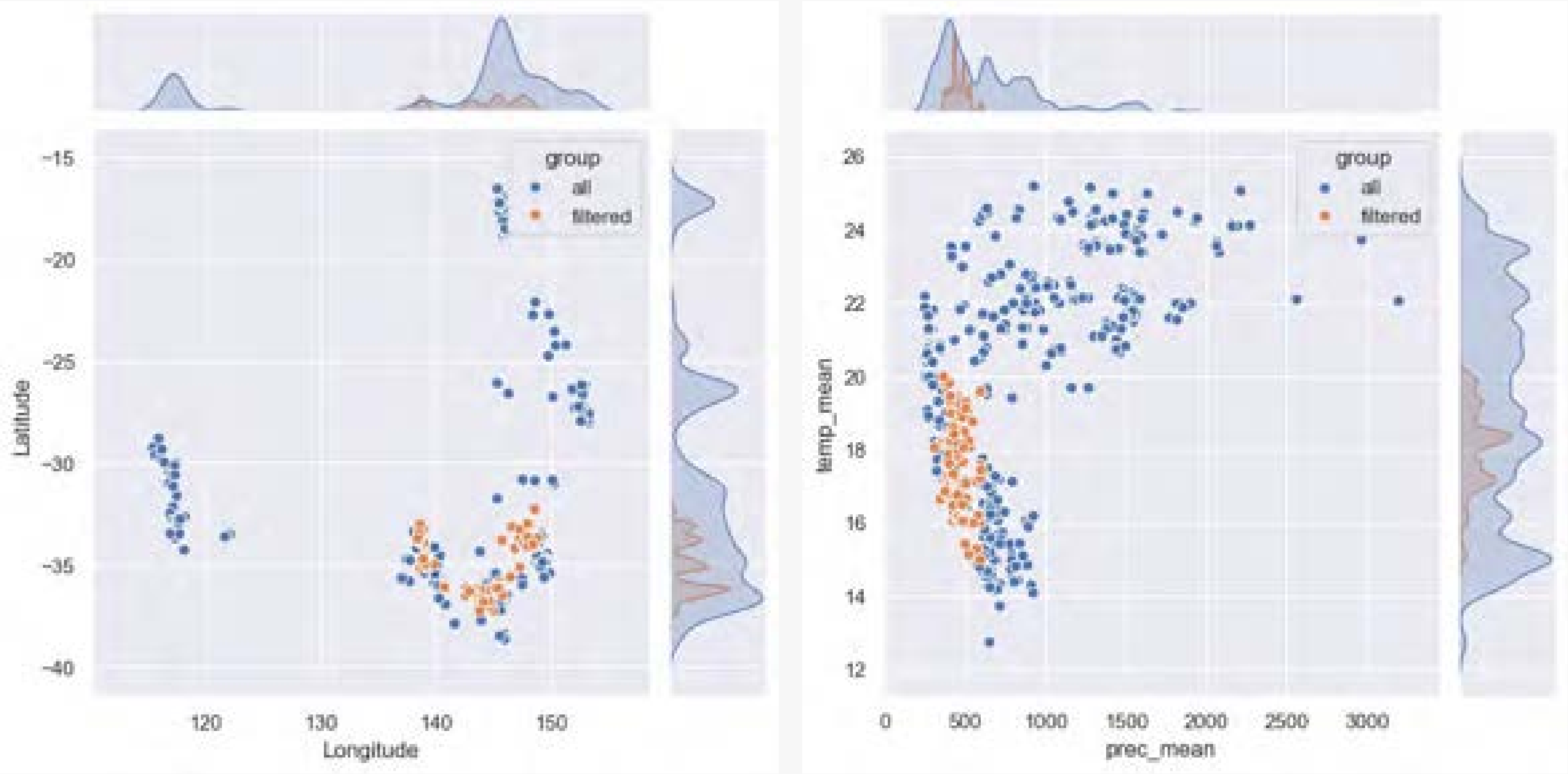
Parameter	Unit	Parameter description
BEFD	kg DM/kg DM	Biomass expansion factors
CF	kgC/kgDM	Carbon fraction
fMrt	yr-1	fraction mortality
MxCAI	m3/ha/yr	maximum current annual increment
MxRdsCr	M	maximum crown radius
MxRRdsCr	yr-1	Maximam relative crown radius increment
R	kg DM / kg DM	Root fraction
WD	kg DM / m3	Wood Density

LAND LIFE COMPANY

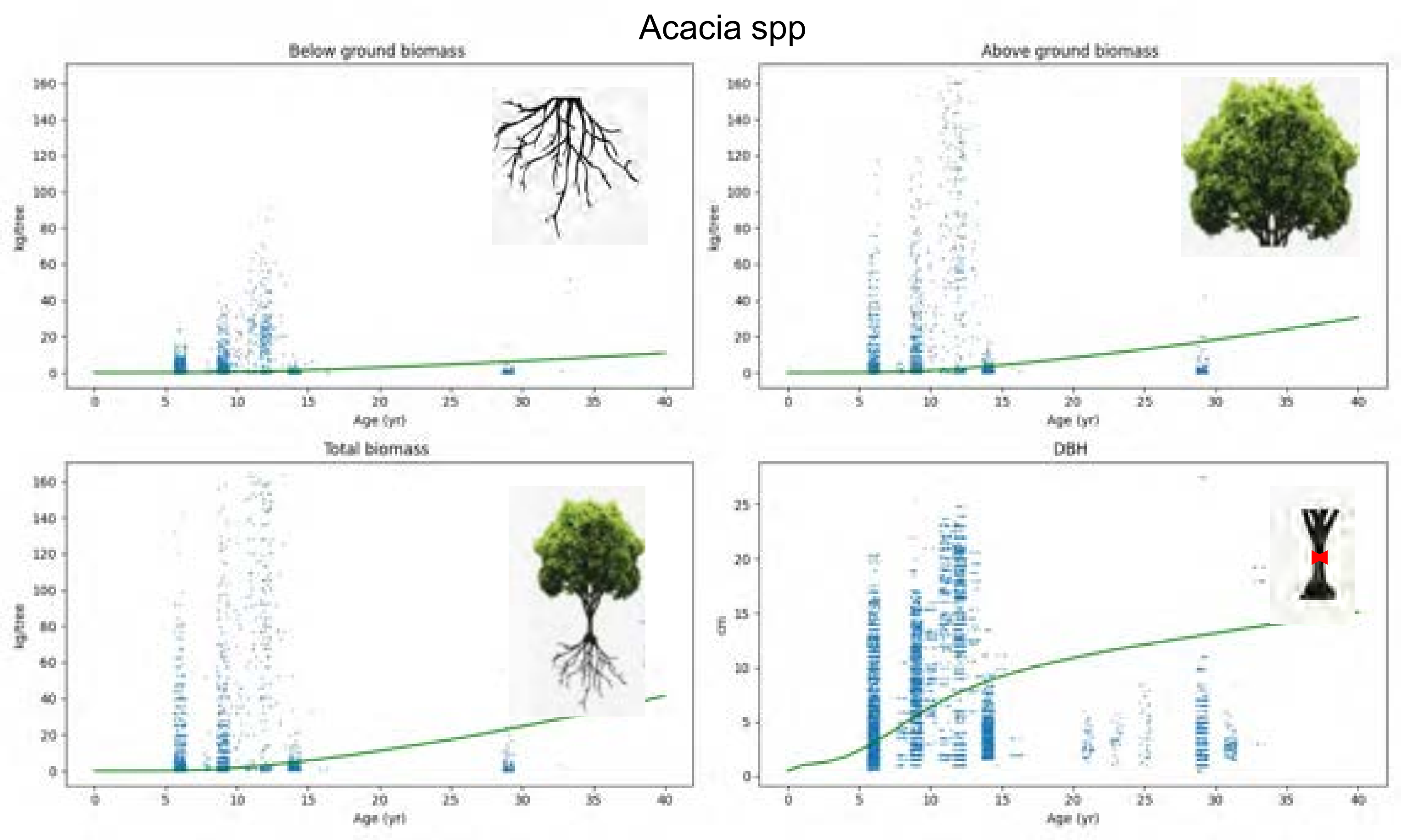
Calibration data. Australian National Forest Inventory: StemDiameterDatabase

LAND LIFE COMPANY

Filtering of SDD data representative for the planting site

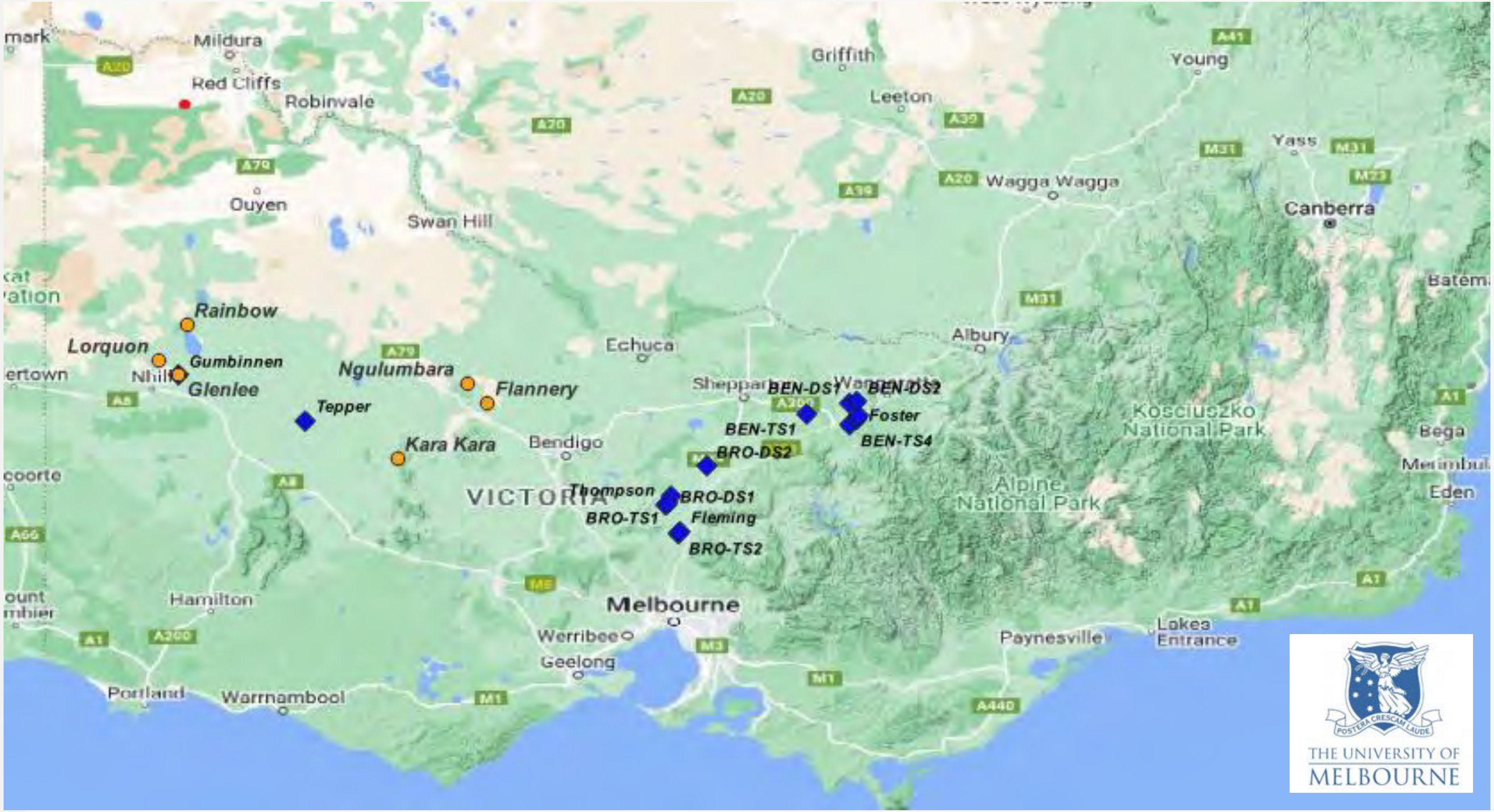


Calibration: determine site & species specific parameters based on SDD data



LAND LIFE COMPANY

Independent validation data. Site Productivity Analyses (SPA)

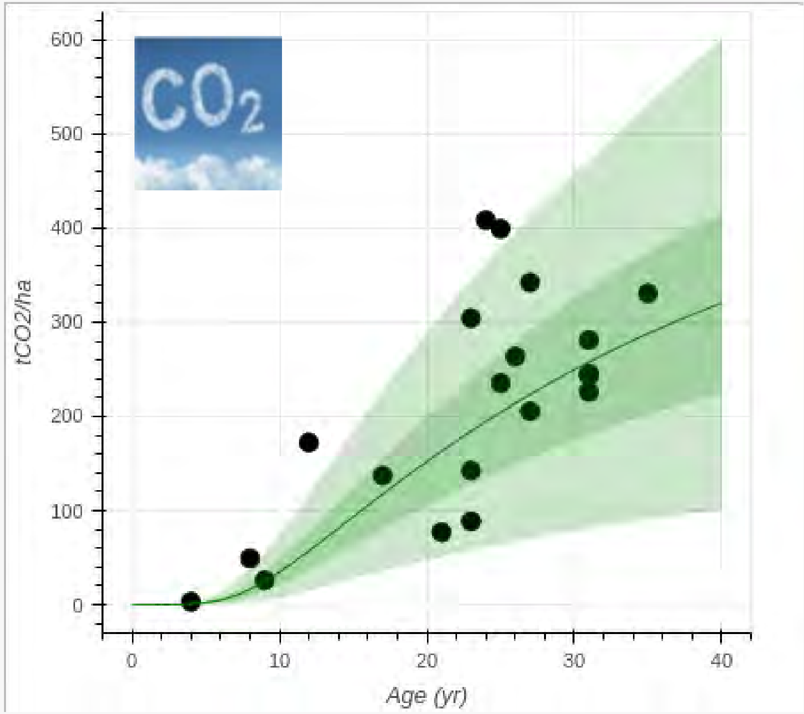


THE UNIVERSITY OF MELBOURNE

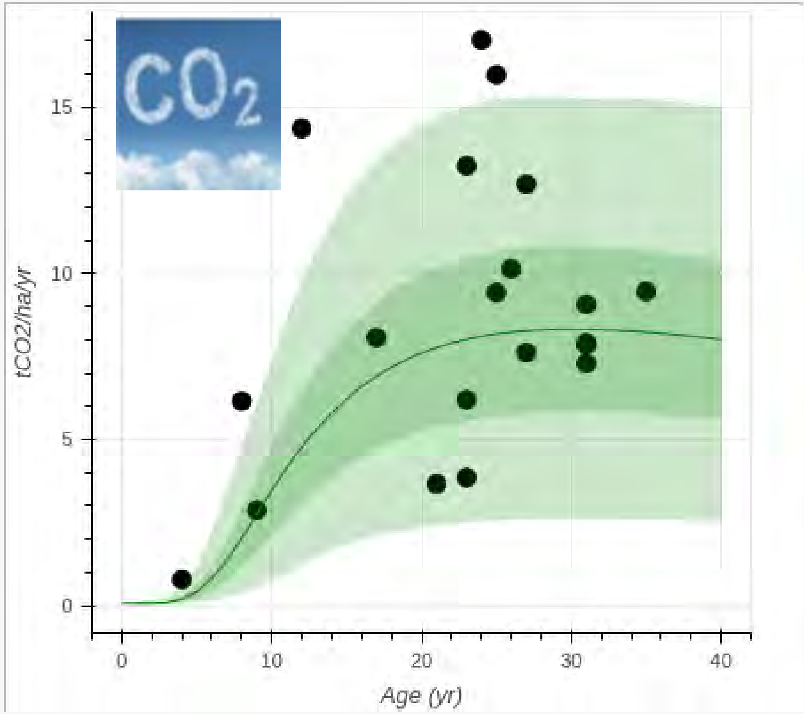
LAND LIFE COMPANY

Validation: compare model with SPA data of mixed species line-seeded planting. Not used in the calibration process.

stock



rate of change

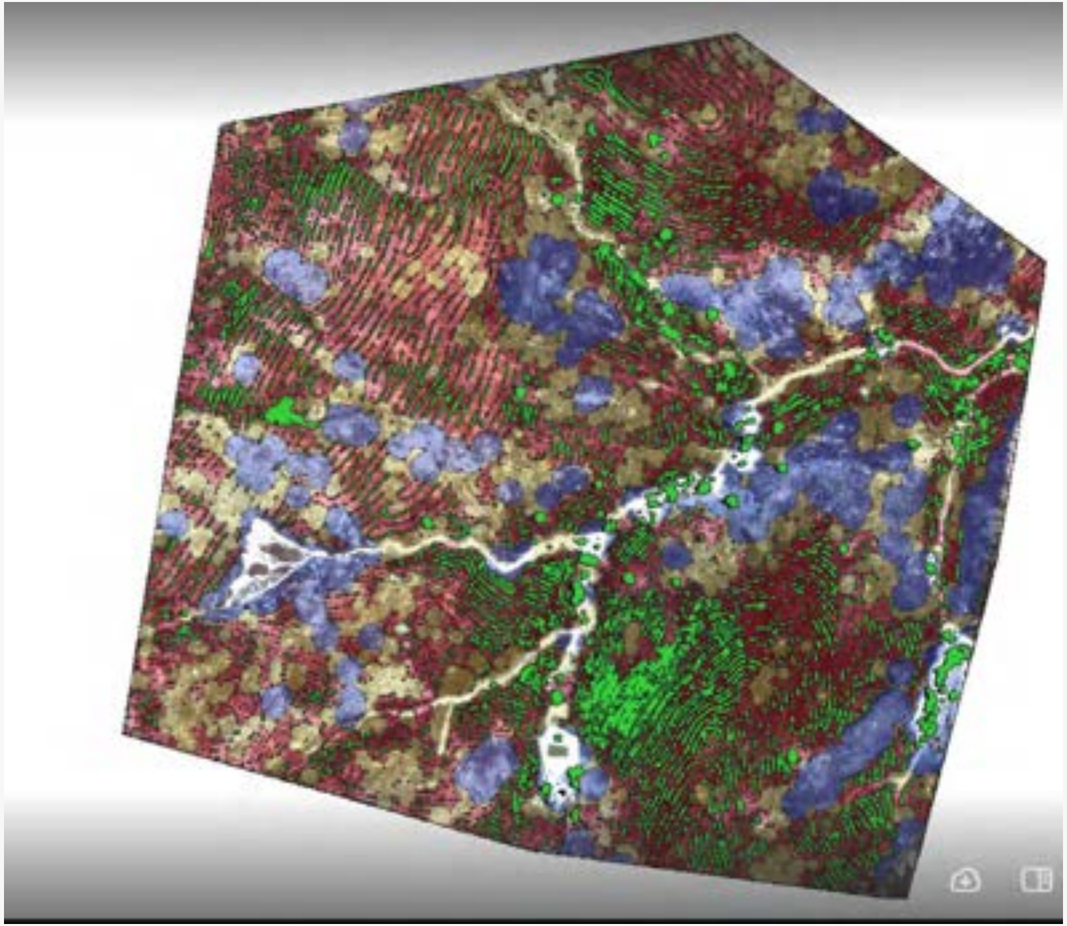


LAND LIFE COMPANY

For which part of the planting area CO2 capture curves valid?

Assess fraction of area with

- ***high growth rate***
- ***medium growth rate***
- ***low growth rate***



Key messages:

Climate change, fire and droughts require large-scale reforestation efforts on degraded areas in Australia

Nature-based, mixed-species reforestation efforts can be funded by the carbon offset market

Locally accurate carbon capture forecasts are critical for decisionmaking by funders and land owners

This study shows that accurate carbon capture forecasts are feasible with a dedicated model

Data availability, collection and sharing are crucial in this process

LAND LIFE COMPANY

Thank you!!

LAND LIFE

Arnout Asjes, Remi Borelle, Hielke Heida, Ysbrand Galama, Josephine Haas, Marco van der Heijden, Helena Lindorff, Veronica Nooijen, Jeroen van der Veen, Quinten Versmissen,

THE UNIVERSITY OF MELBOURNE

Lauren Bennett
Anna Karopoulos
Rodney Keenan

CSIRO

Jacqui England,
Keryn Paul

CASSINIA ENVIRONMENTAL

Patrick Byrne
Paul Dettman