



Effect of mixture and management of a Southern European beech forest on carbon stocks and sinks

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Forest management in a climate change era

INTRODUCTION

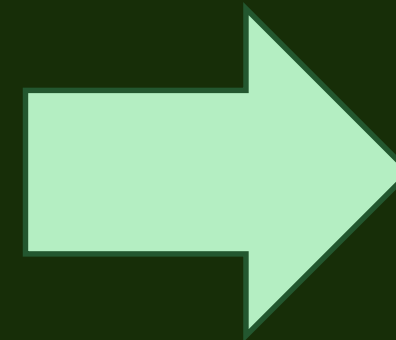
OPPORTUNITIES

Voluntary carbon market

Increased value of forest management

Payment for ecosystem services

Biodiversity
Water regulation
....



CHALLENGES

Effect of management

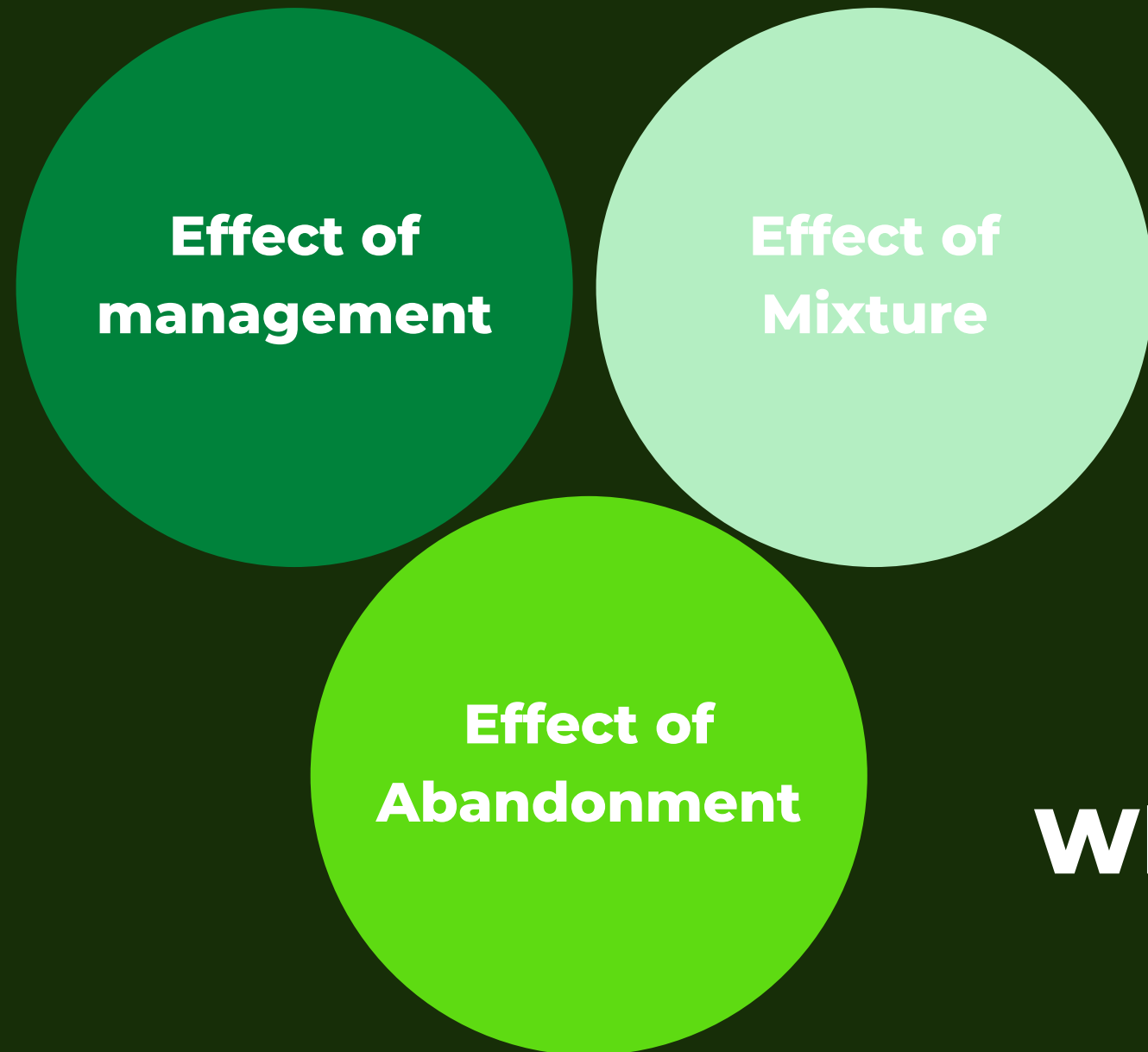
Effect of mixture

Effect of abandonment

Research questions

INTRODUCTION

CHALLENGES



What is the effect of management and mixture on beech C stocks and sinks?

What is the effect of climate change on beech C stocks and sinks?

What is the best management to maximize climate change mitigation?

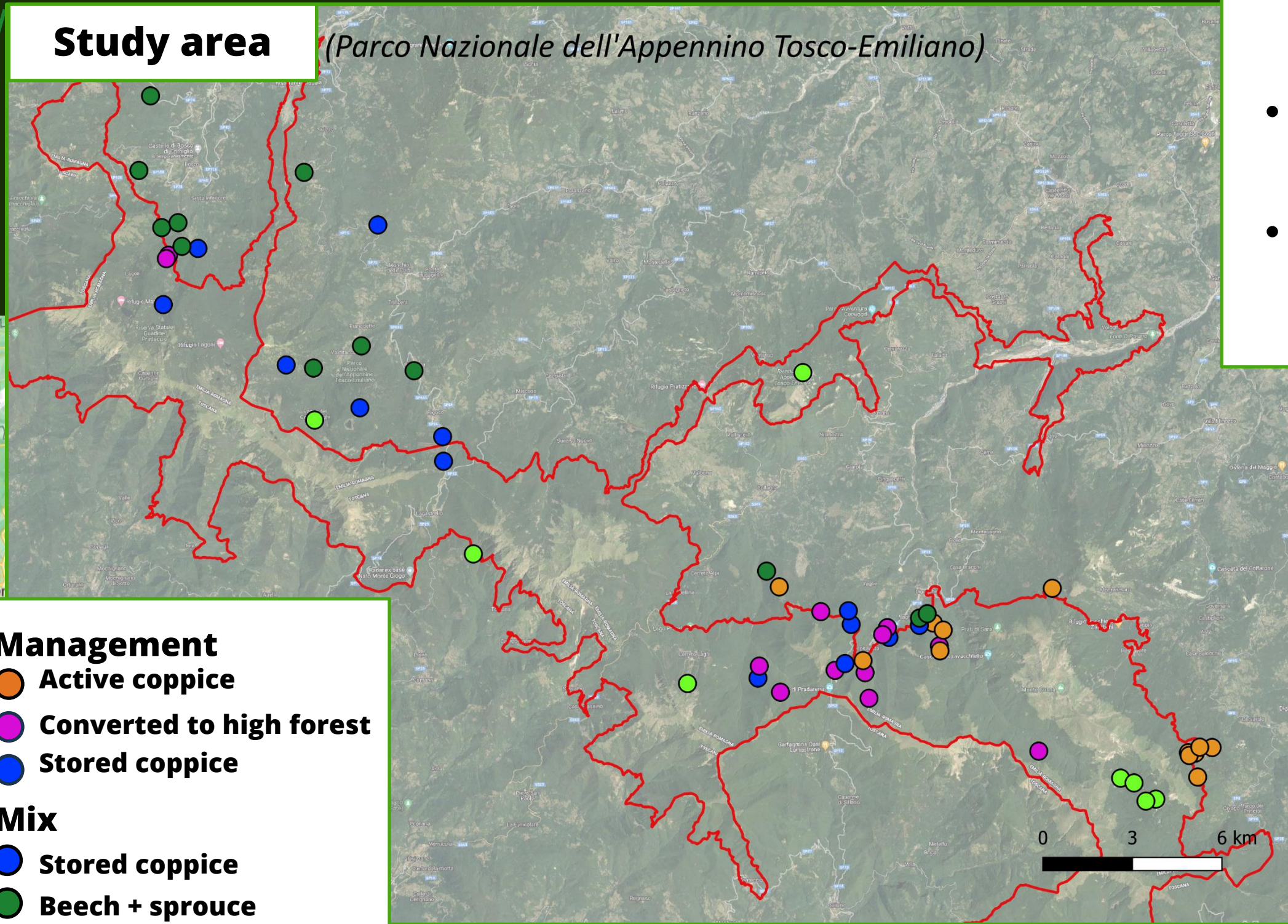
Study area

MATERIAL AND METHODS

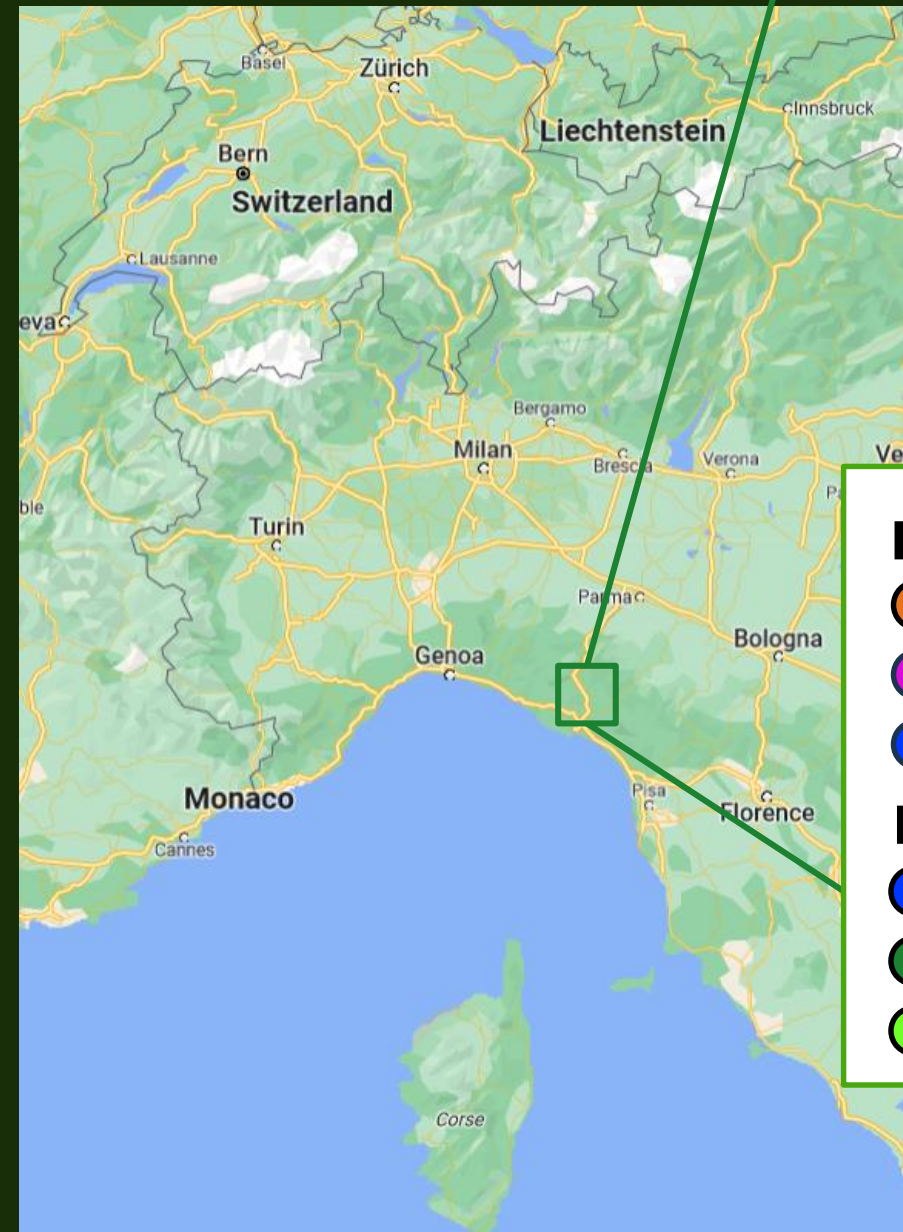
- **<1000 masl**
mixed forests of
broadleaf
- **1000 – 1500 masl**
pure beech
- **>1500 masl**
Spruce

Study area

(Parco Nazionale dell'Appennino Tosco-Emiliano)



- Management**
- **Active coppice**
 - **Converted to high forest**
 - **Stored coppice**
- Mix**
- **Stored coppice**
 - **Beech + spruce**
 - **Beech + broadleaf**



Experimental design

MATERIALS AND METHODS

Effect of management?

Effect of mix?



Coppice converted to high forest



Active coppice



Stored coppice



Stored coppice mix with broadleaf



Stored coppice mixed with spruce

PURE BEECH

Field sampling

MATERIALS AND METHODS

60 sampling plots
(12 replicates x level)

- Diameter
- Density
- Slope
- Exposure

10 beech trees * plot \approx 600 trees

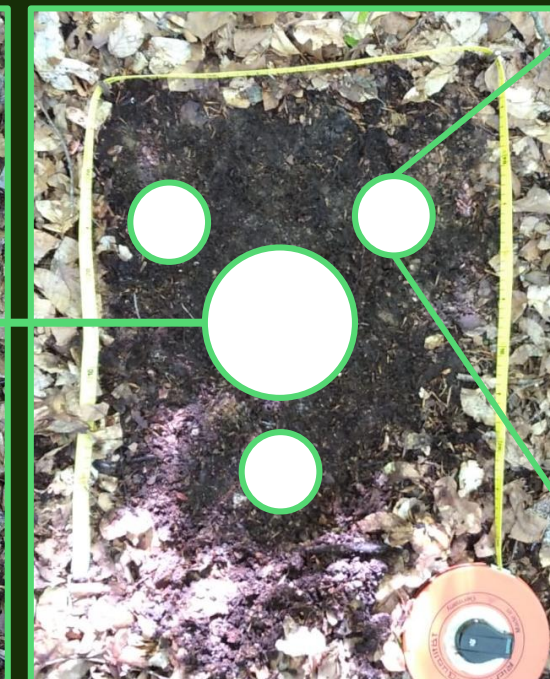
Dendrometric data

- Diameter
- Height
- Crown

2 wooden cores * 10 trees



SOIL: every two trees, at increasing distance from the tree (1,2,3,4,5m)



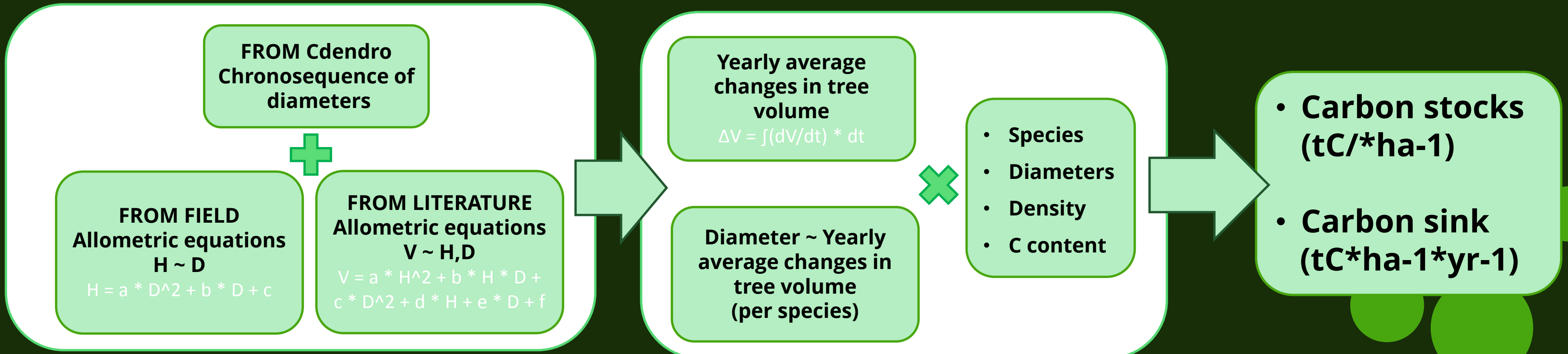
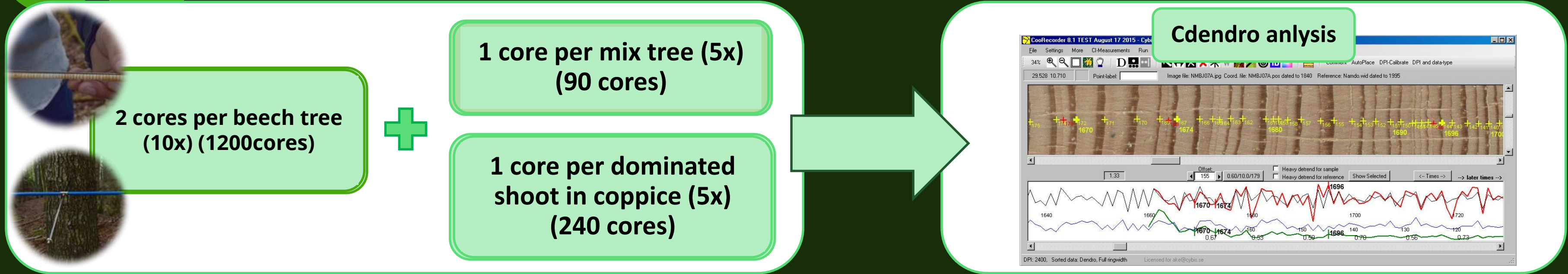
SAMPLES

- Litter
- Soil samples for C - N analysis C/N (0-20cm)
- Bulk density (0-5cm)



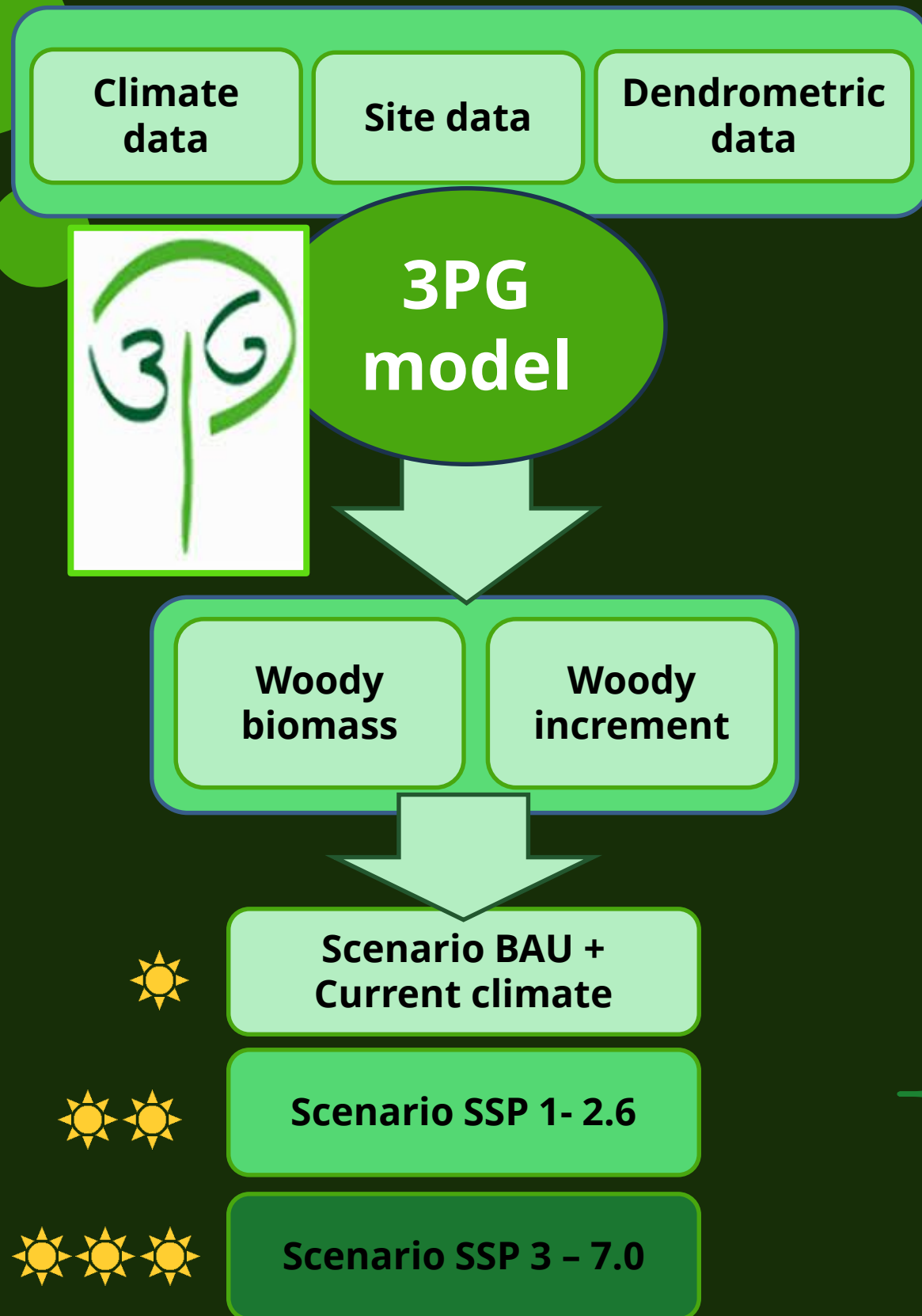
Dendrochronological analysis and stock/sink




MATERIALS AND METHODS



Modeling scenarios

MATERIALS AND METHODS

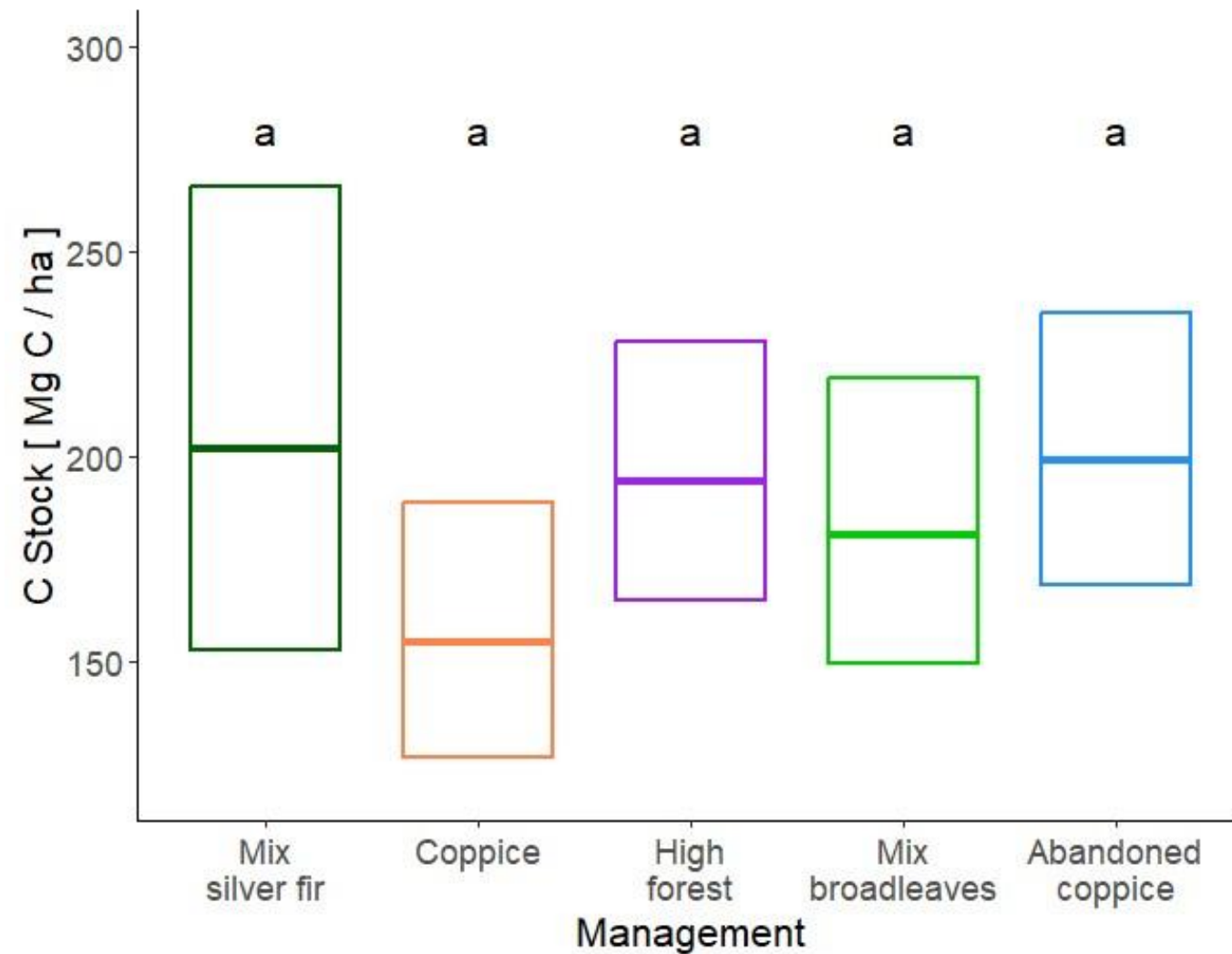


		Management intensity		
		LOW	MEDIUM	HIGH
	ACTIVE COPPICE	- Rotation 45 years - Cut • 95% s/m • 80% b	- Rotation 30 years - Cut • 95% s/m • 80% b	- Rotation 30 years - Cut • 95% s/m • 90% b
	STORED COPPICE	- Rotation 20 years - 2 cut 15% - 1 cut 20%	- Rotation 30 years - Cut • 30% s/m • 10% b	- Rotation 30 years - Cut • 95% s/m • 80% b
	COPPICE CONVERTED TO HIGH FOREST	- Rotation 20 years - Cut 8%	- 30% at 110 y.o. - 100% at 140 y.o.	- 30% at 100 y.o. - 100% at 120 y.o.

Current carbon stocks and sinks in tree

RESULTS biomass

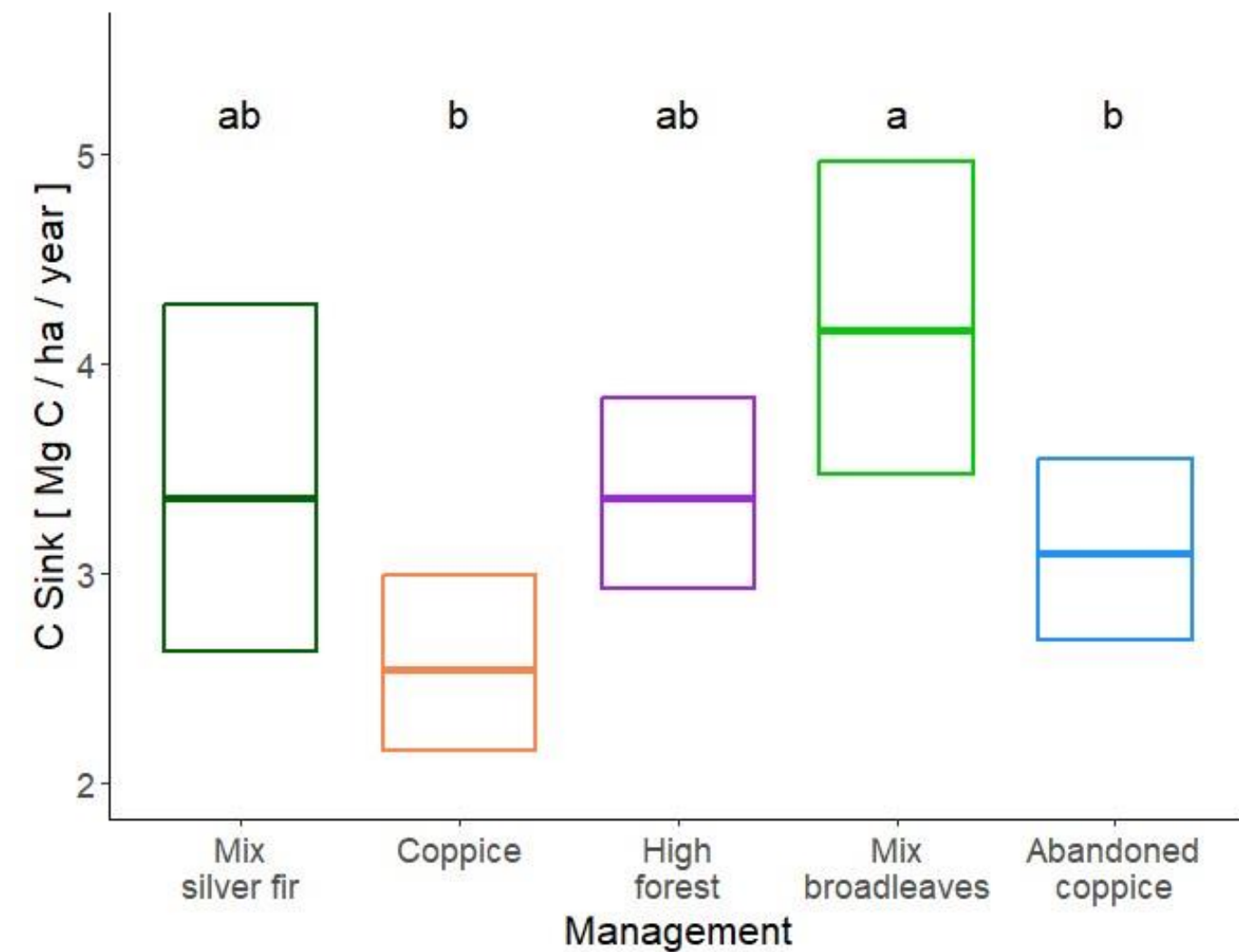
CARBON STOCKS



GLM

Variables: Management ($p=0.345$) + Density ($p+=0.031$) + Age ($p+<0.001$) + Soil OC ($p-=0.014$) + Soil N ($p+=0.050$)

CARBON SINK



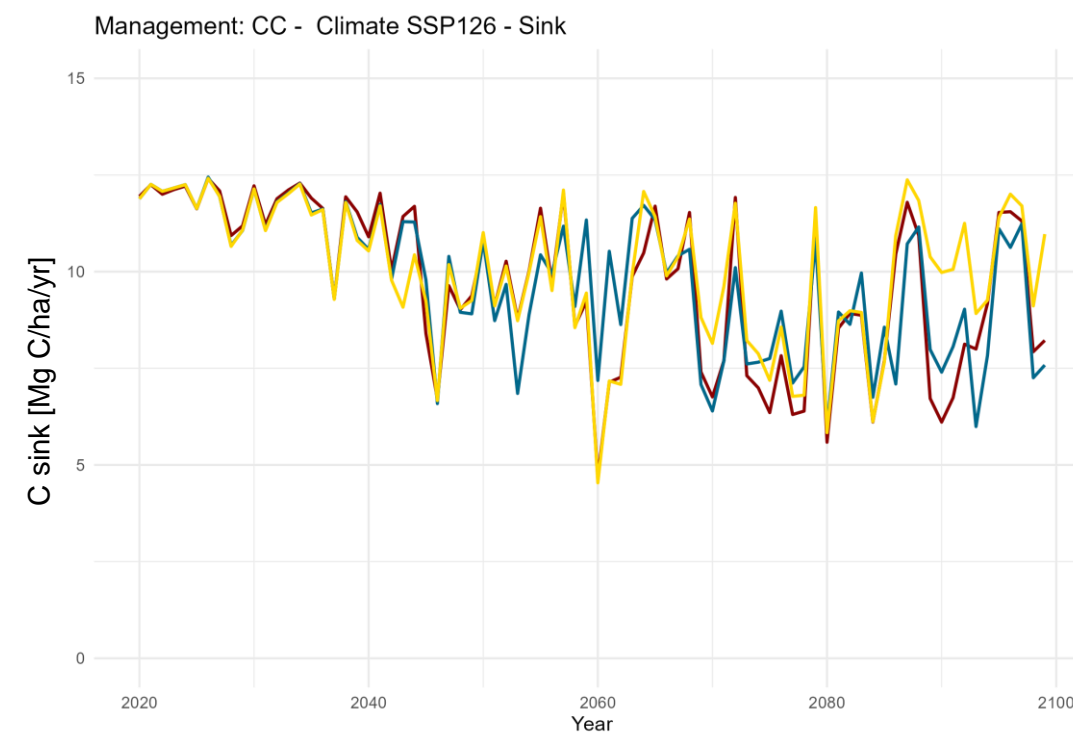
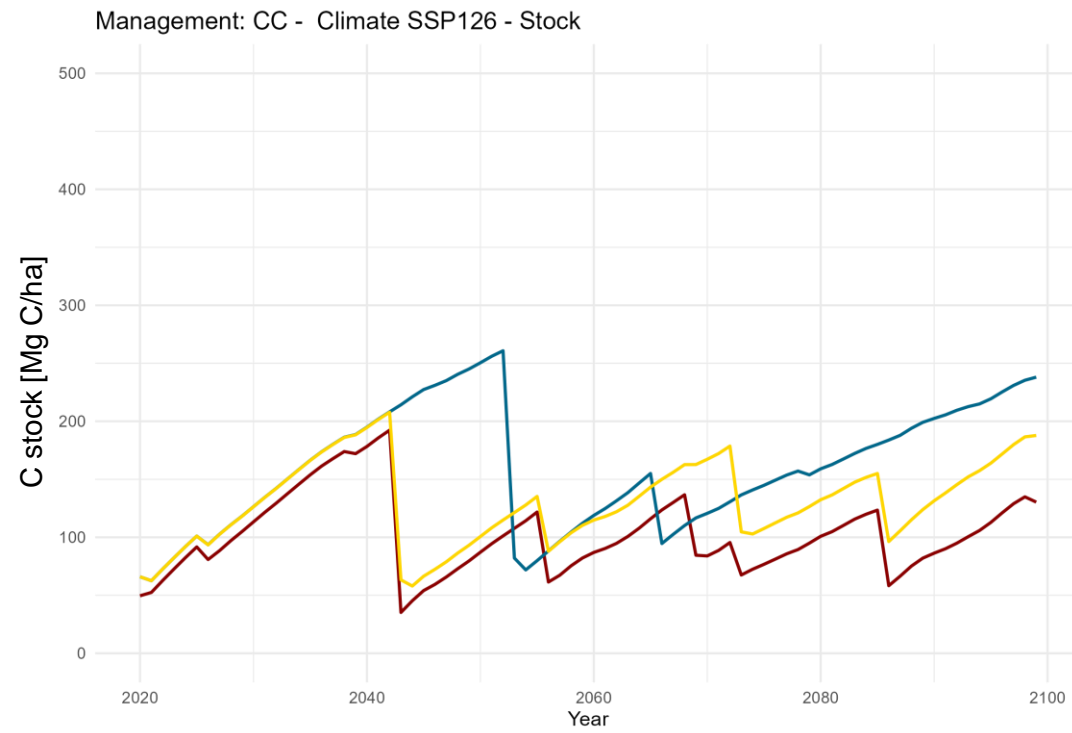
GLM

Variabili: Management ($p=0.002$) + Altitude ($p-=0.174$) + Density ($p+<0.001$) + Age ($p+<0.001$) + Soil OC ($p-=0.018$) + Soil N ($p+=0.055$)

3PG - Future stock and sinks

RESULTS

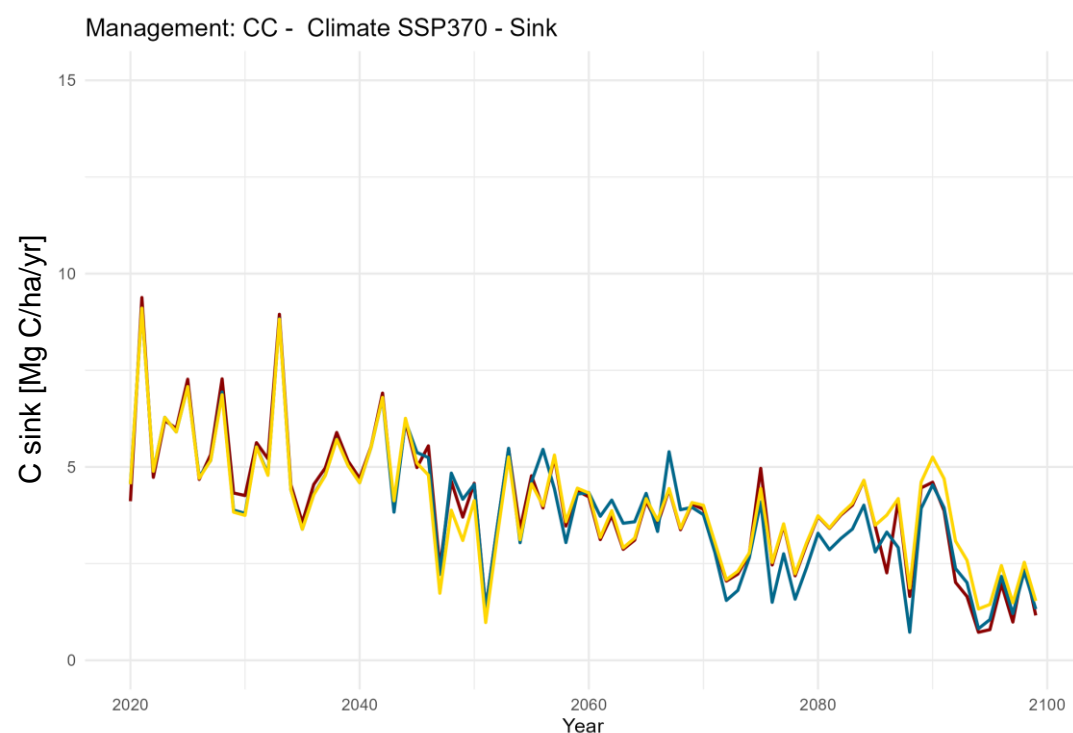
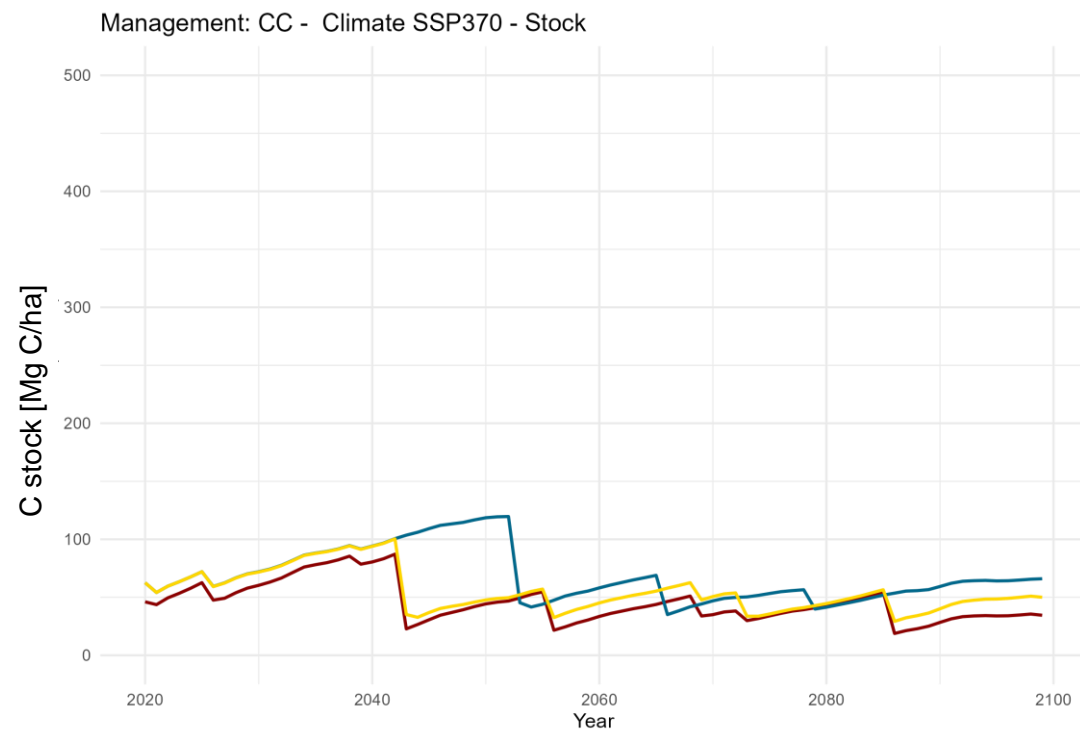
SSP
1.2-6



ACTIVE COPPICE



SSP
3.7-0



Intensity

— high

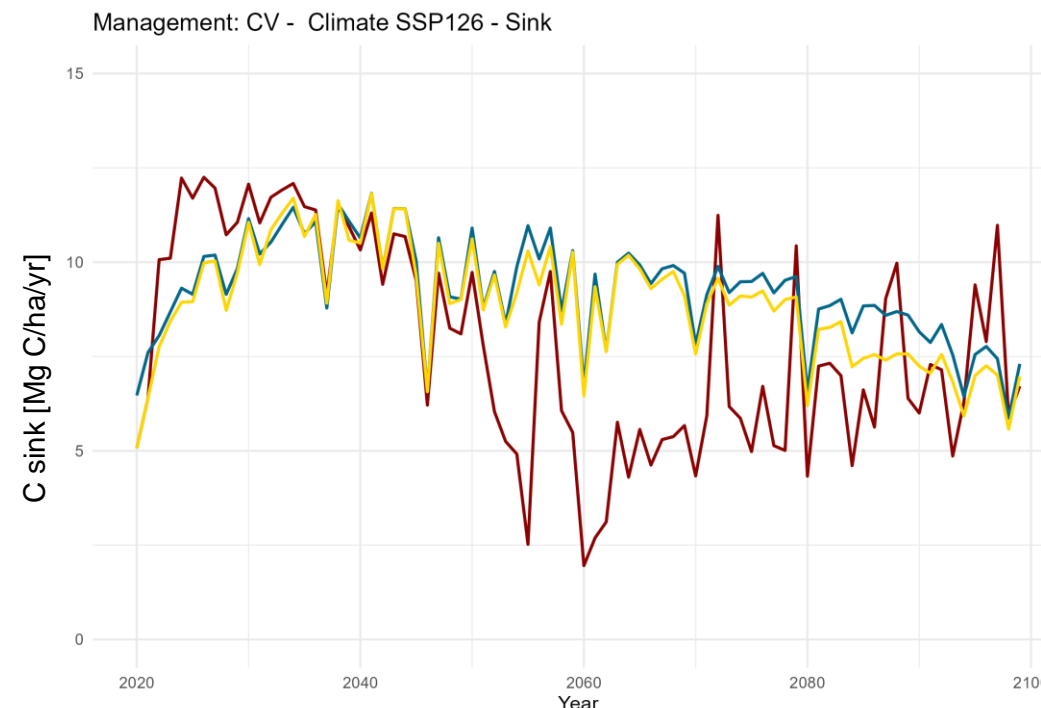
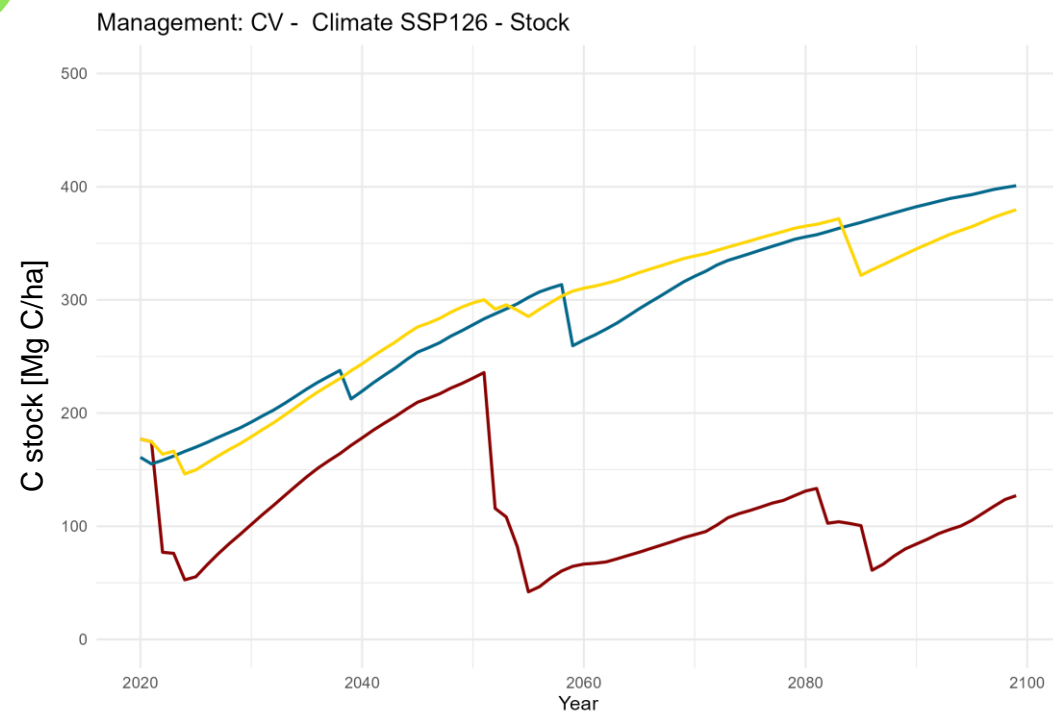
— low

— medium

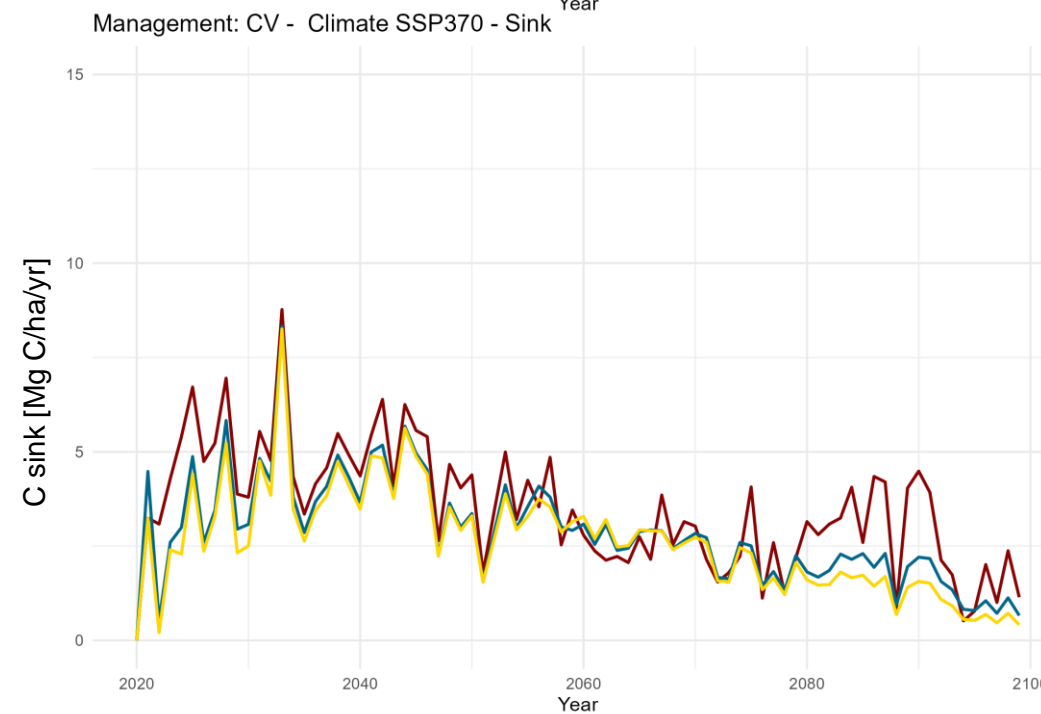
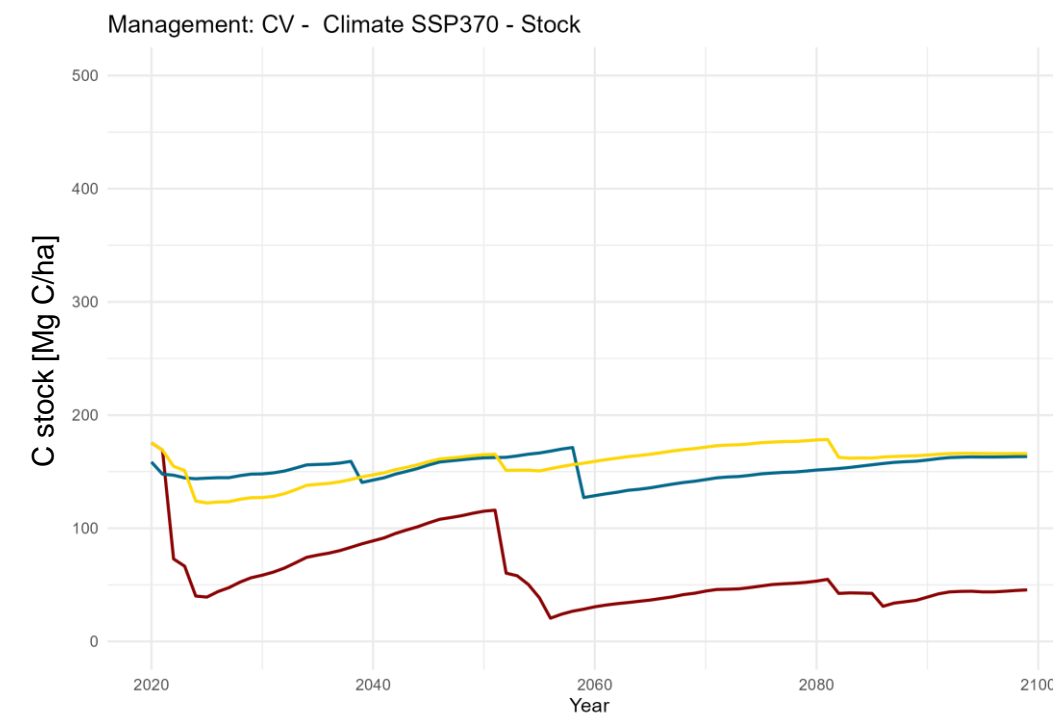
3PG - Future stock and sinks

RESULTS

SSP
1.2-6



SSP
3.7-0



STORED COPPICE



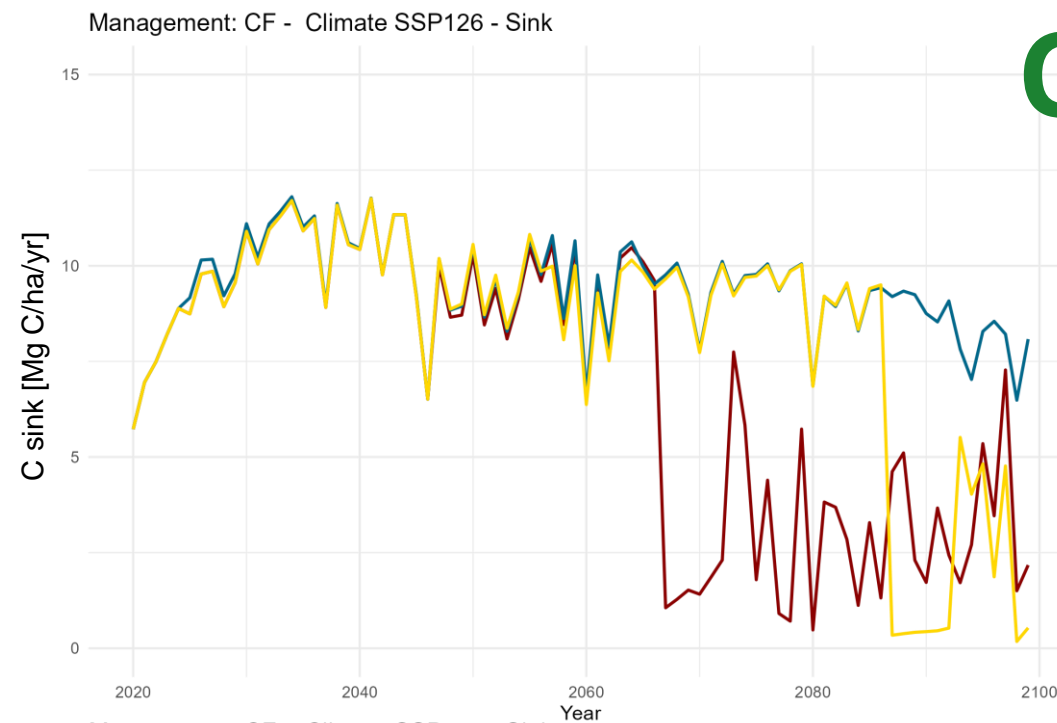
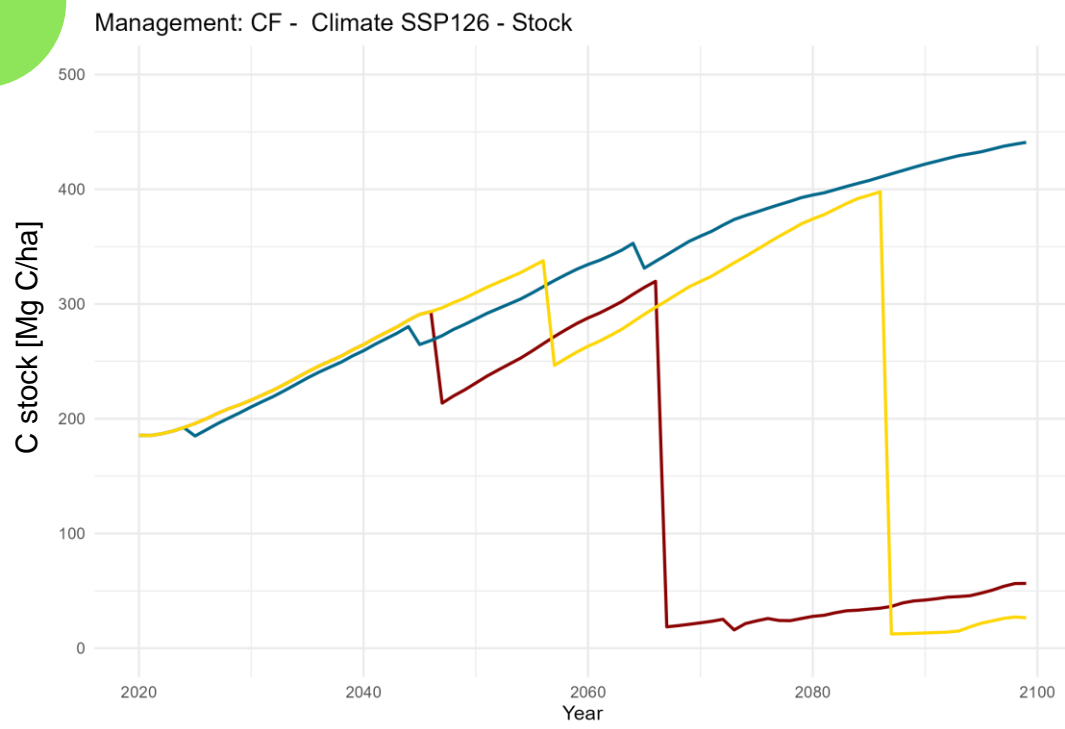
Intensity

- high
- low
- medium

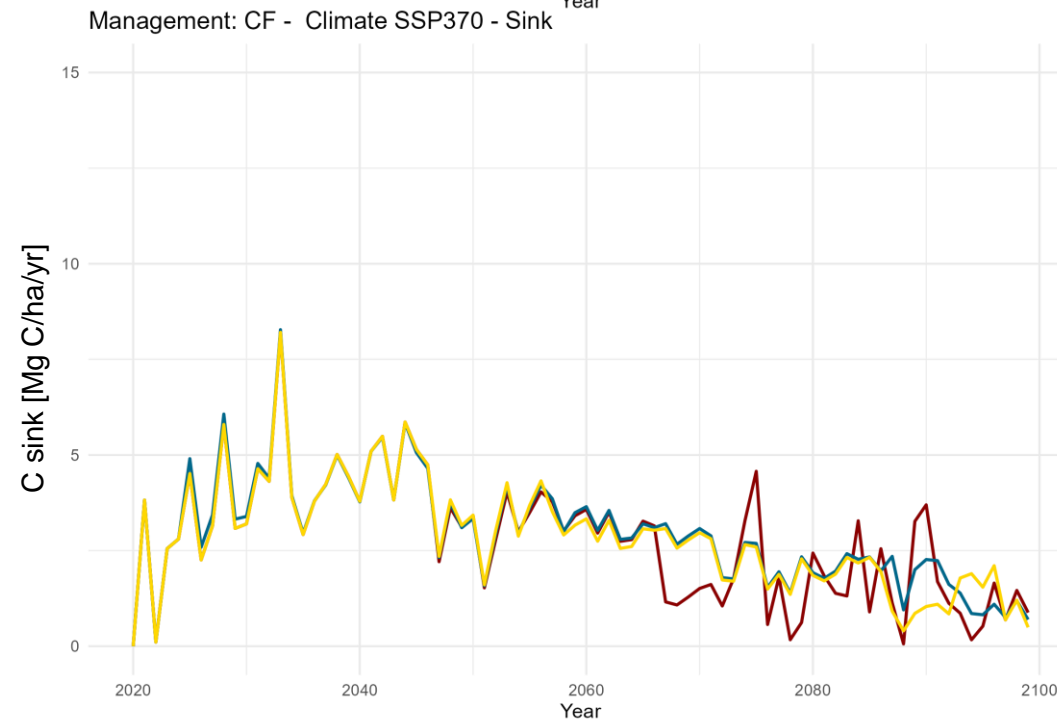
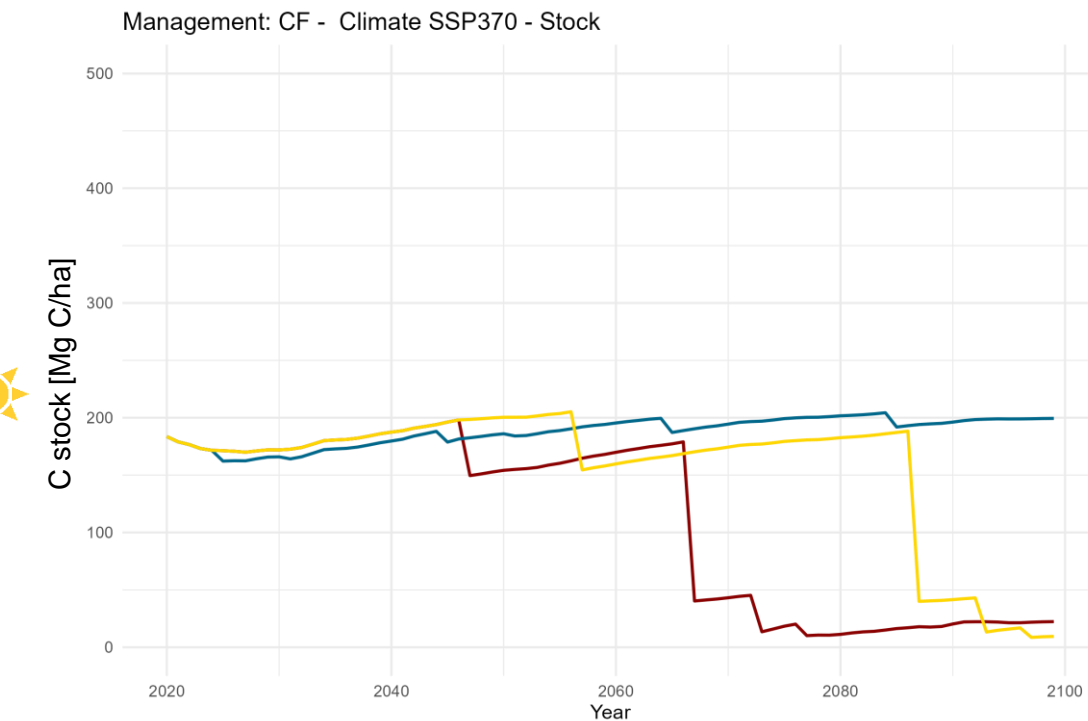
3PG - Future stock and sinks

RESULTS

SSP
1.2-6



SSP
3.7-0



CONVERTED TO HIGH FOREST



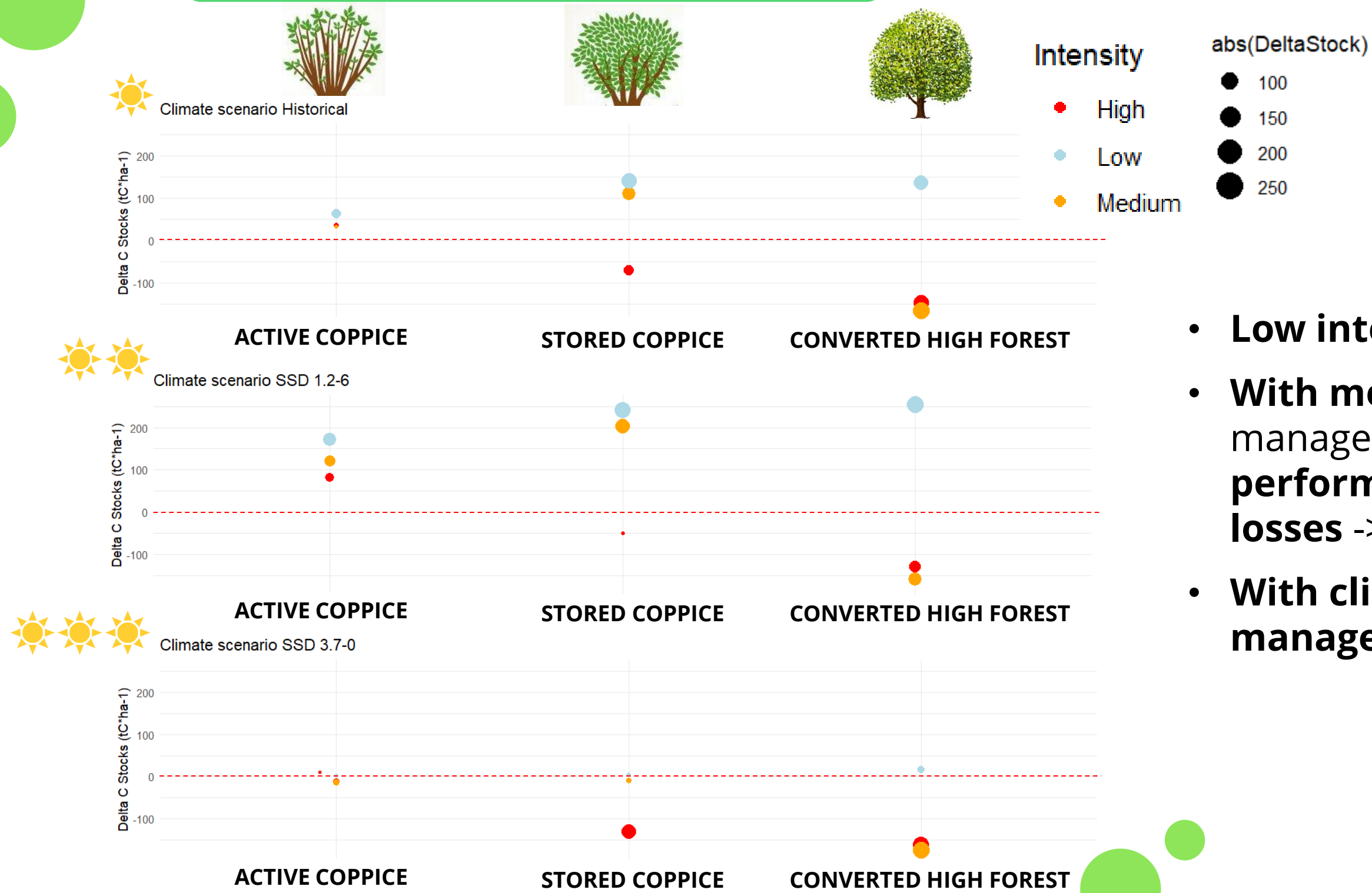
Intensity

- high
- low
- medium

Climate mitigation effects

RESULTS

EFFECT OF MANAGEMENT

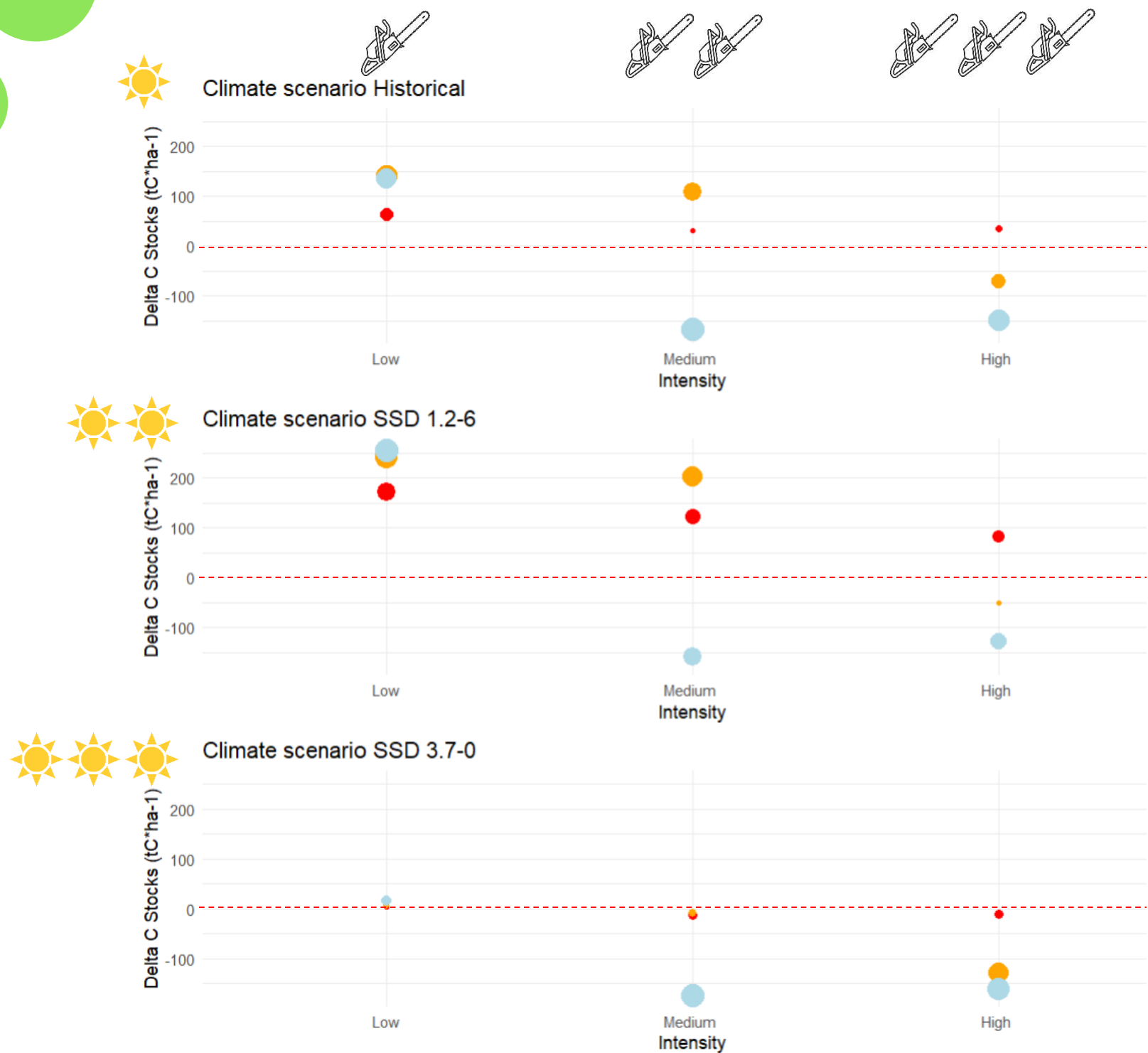


- **Low intensity best performance**
- **With medium and high intensity management active coppice is the best performing, high forest has the highest losses -> problem of products**
- **With climate change the effect of management is less pronounced**

Climate mitigation effects

RESULTS

EFFECT OF INTENSITY



Treatment

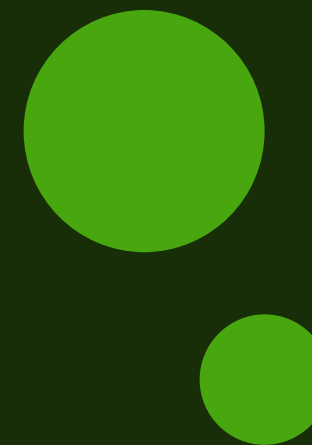
- ACTIVE COPPICE
- STORED COPPICE
- CONVERTED HIGH FOREST

abs(DeltaStock)

- 100
- 150
- 200
- 250

- **Active coppice** less influenced by intensity
- **High forest** highest decrease in ΔC stocks with increasing intensity
- **In climate scenario SSD 3.7-0 forests lose the climate mitigation effect**

Take home message



TODAY

- No effect of management or mix on **STOCKS**
- Mix with broadleaves better than active coppice and stored coppice for **SINKS**

TOMORROW

Effect of Climate change

- **SSD 1.2 - 6** -> Apennines refuge for beech, **better performance** with climate optimum
- **SSD 3.7 - 0** -> High impact on productivity, we **lose the climate mitigation effect**

Best management in a climate change perspective

- Lower intensity preserve the stocks
- Active coppice has the lower losses in a climate change perspective with utilization
- **With more intense climate change, differences between management intensities flatten out**

CHANGE OF PERSPECTIVE

- High forest is seen as a better management option than coppice -> for climate regulation only if the intensity is low (tree selection) – IF NOT we need to focus on the products' fate
- In a climate change perspective, in the PNATE, can we think about intensive management with attention to the fate of wood products and assisted migration ?

Thank you for the attention!



NEXT STEPS:

- **Implement modeling on MIX**
- **Calculate C stocks including soil stocks**

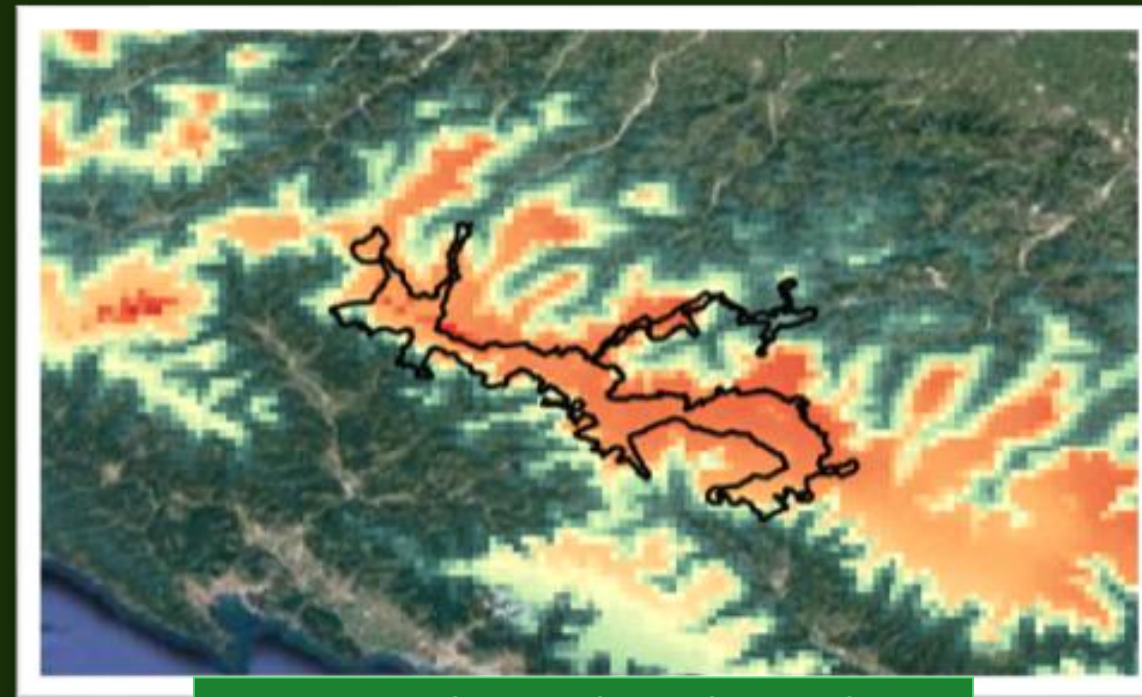


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PNATE

RESULTS – SDM

SSD 1.2-6 2040 - 2070

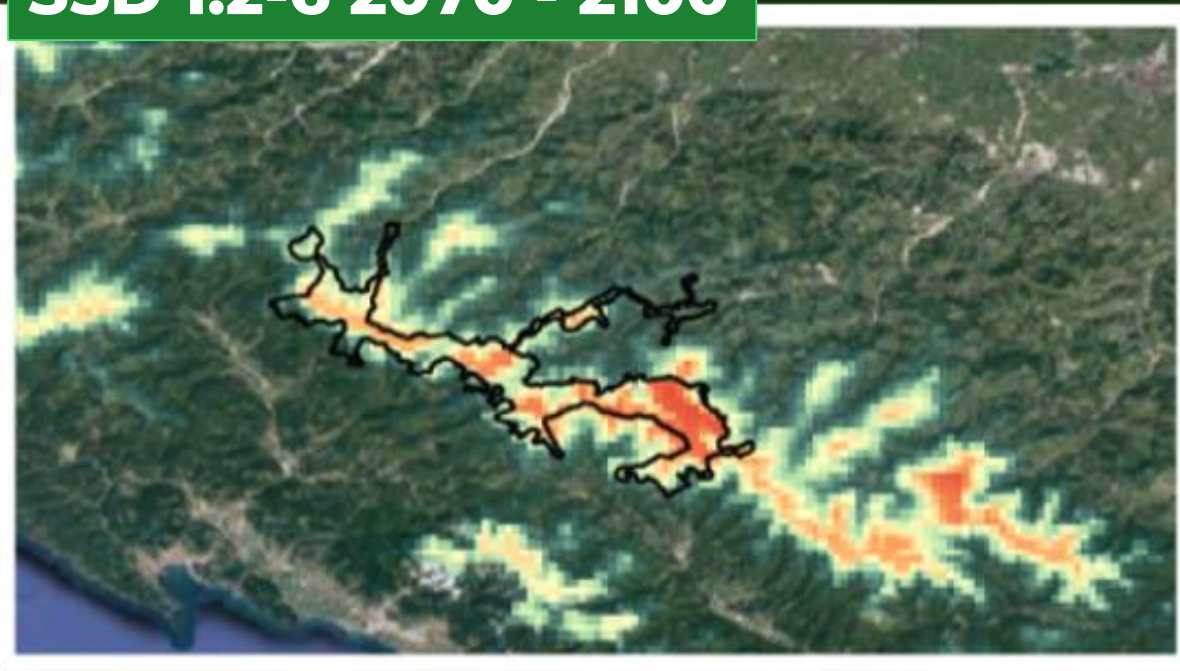


Potential distribution

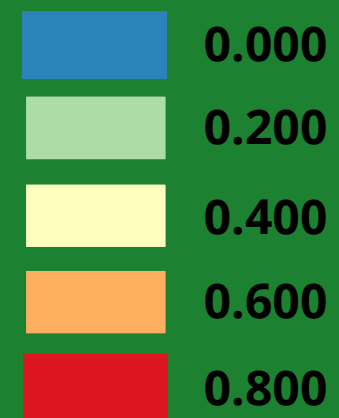
SSD 3.7-0 2040 - 2070



SSD 1.2-6 2070 - 2100



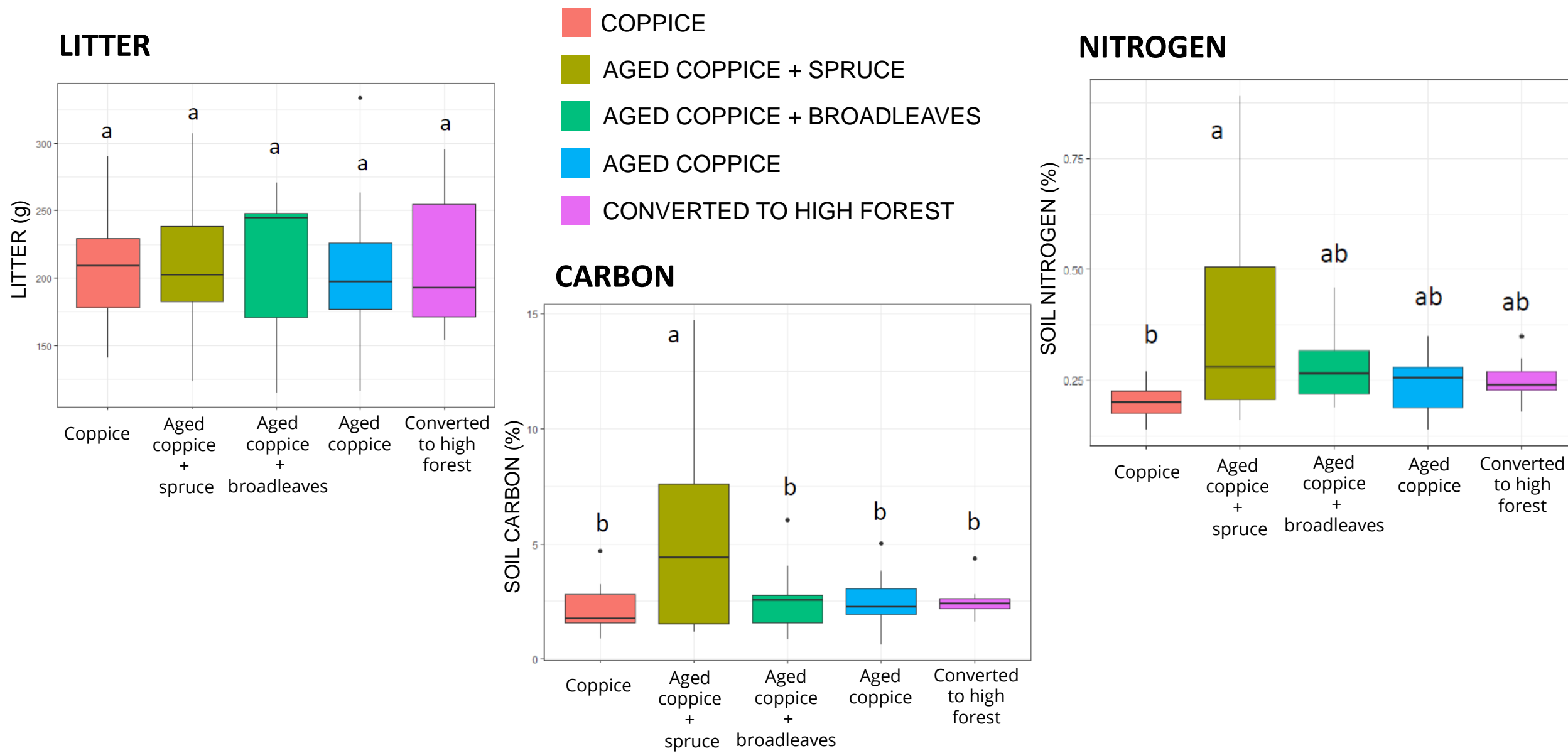
Fagus sylvatica



SSD 3.7-0 2070 - 2100



RESULTS – Soil carbon and nitrogen content



No effect on soil carbon content or litter accumulation

Lower N content in coppice