CAMBIOSCOP

Carbon management towards low fossil carbon use

Investigation of biopump strategy in France

SHEN Zhou Supervisors: Ligia Barna & Lorie Hamelin & Aras Ahmadi

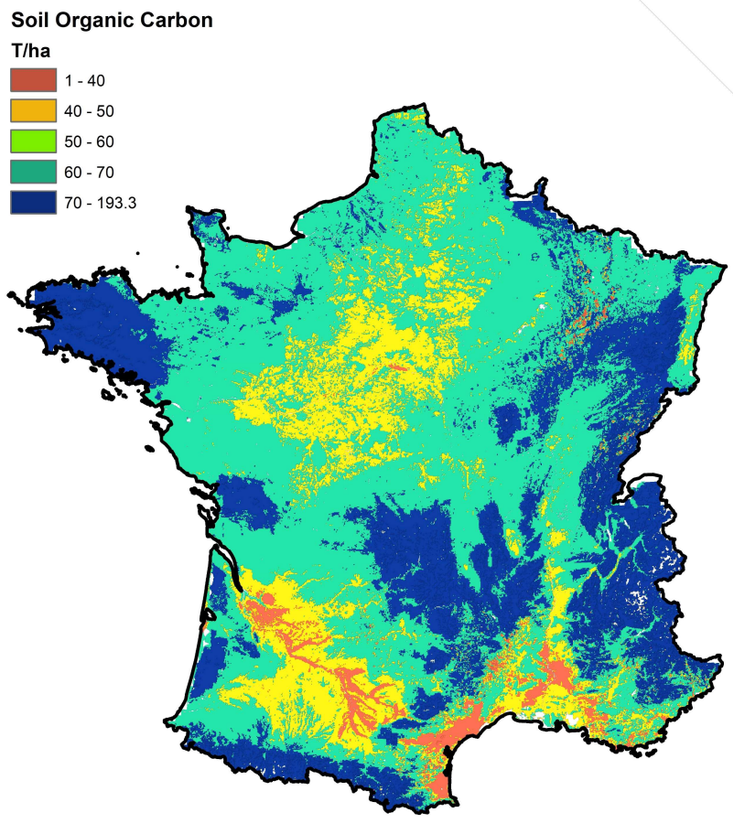
@cambioscop zshen@insa-toulouse.fr

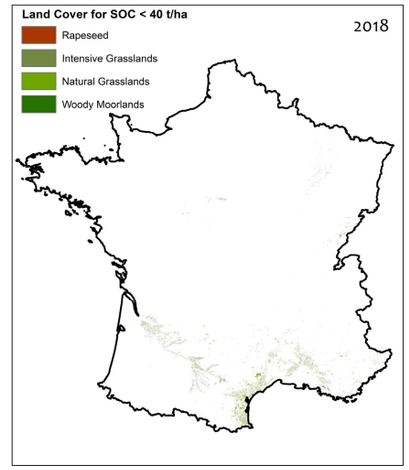
Cambioscop Mid-term Webinar • 28.10.2020

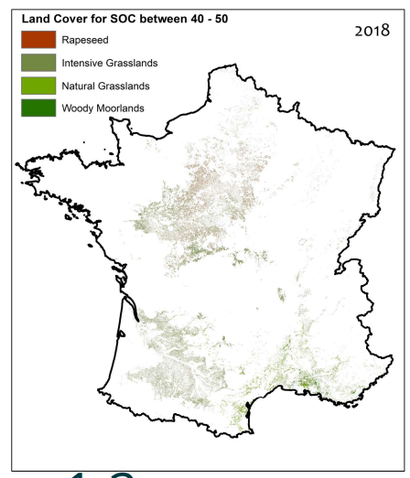
Toulouse Biotechnology Institute
Bio & Chemical Engineering

www.toulouse-biotechnology-institute.fr

Carbon vulnerable lands in France

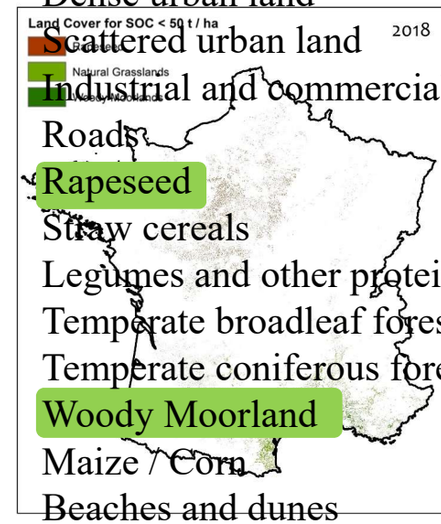




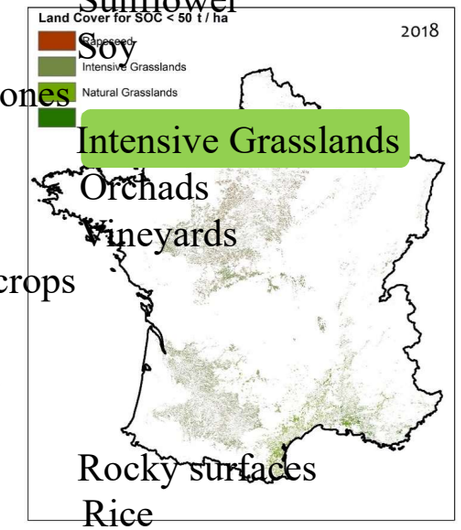


Land use types in France

Dense urban land
Scattered urban land
Industrial and commercial zones
Roads
Rapeseed
Straw cereals
Legumes and other protein crops
Temperate broadleaf forest
Temperate coniferous forest
Woody Moorland
Maize / Corn
Beaches and dunes
Water
Root and tubers



Sunflower
Soy
Intensive Grasslands
Orchads
Vineyards
Rocky surfaces
Rice
Glaciers / snow
Natural Grasslands



Possible land: 11,187 - 24007.4 km^2

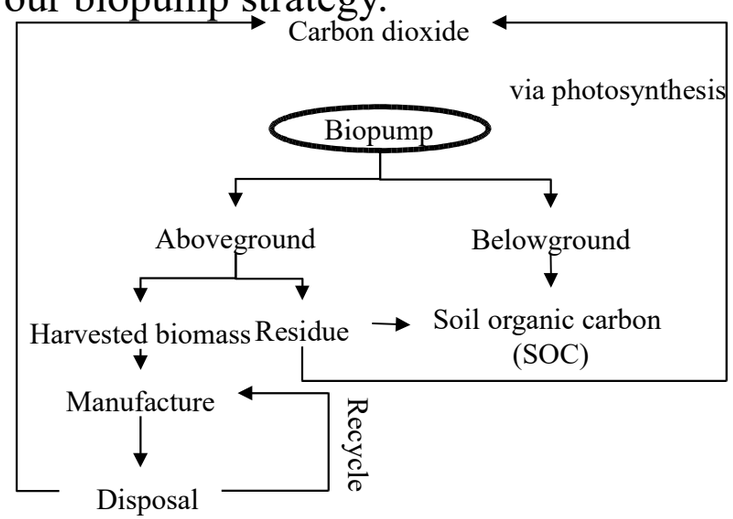
Harmonized World Soil Database v 1.2

1 Inglada, J,**2017**.
SOC: soil organic carbon

Biopump case

Aim: To induce a CO2 removal and transit towards a low fossil carbon economy simultaneously.

1) Build the whole LCA process to evaluate the climate change metigation quantitatively;
2) Which plant is more suitable to grow as biopump in the French carbon vulnerable land;
3) Which product has the best performance here, which parameter plays the key role;
4) For the future, which factor we need to focus if conducting our biopump strategy.



Biopump literature review

1

Selecting criteria

- SOC increase capacity
- Yield
- Agricultural intensity
- ……

Scoring and ranking

- Perennial plants
- Annual plants

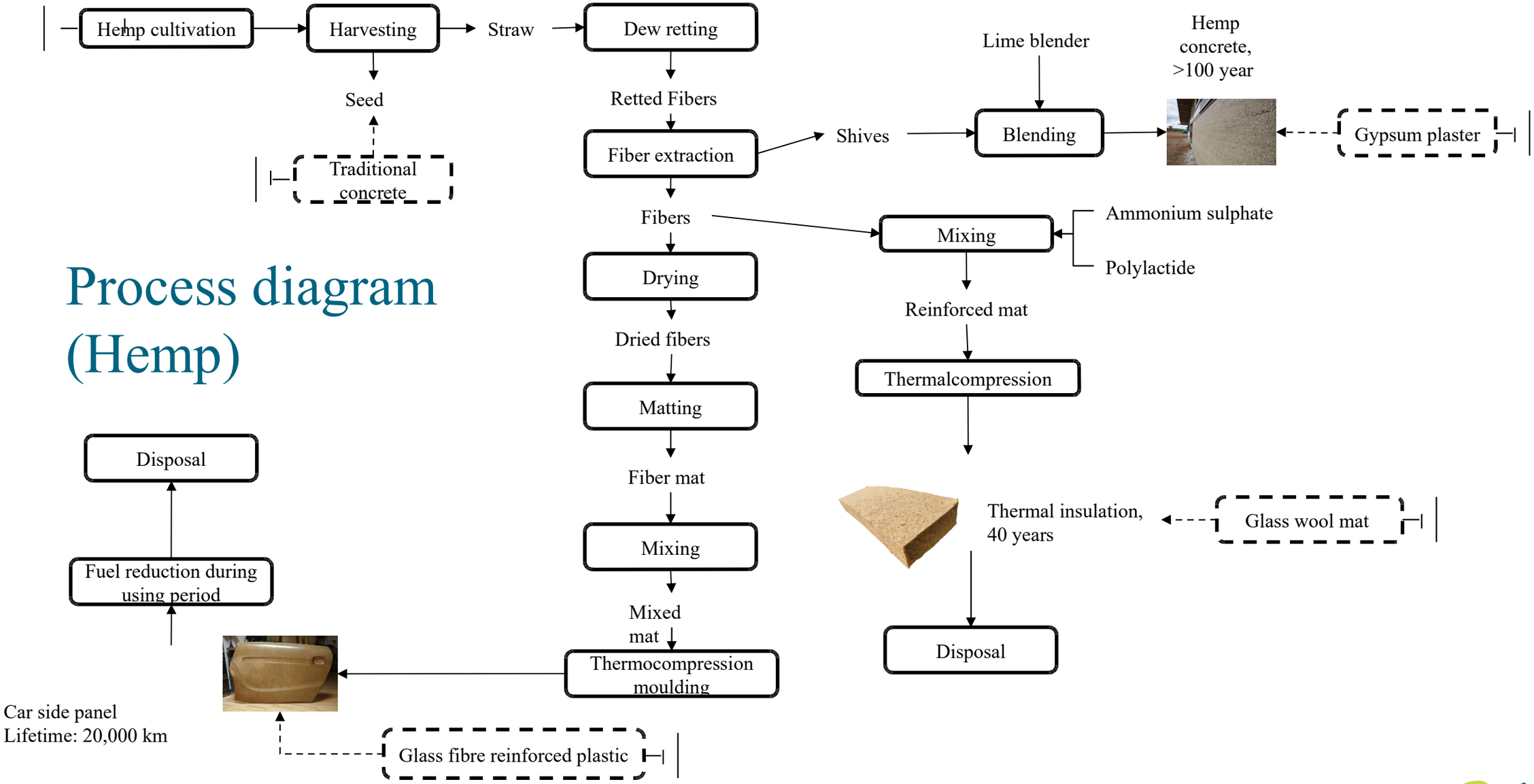
Selected biopumps

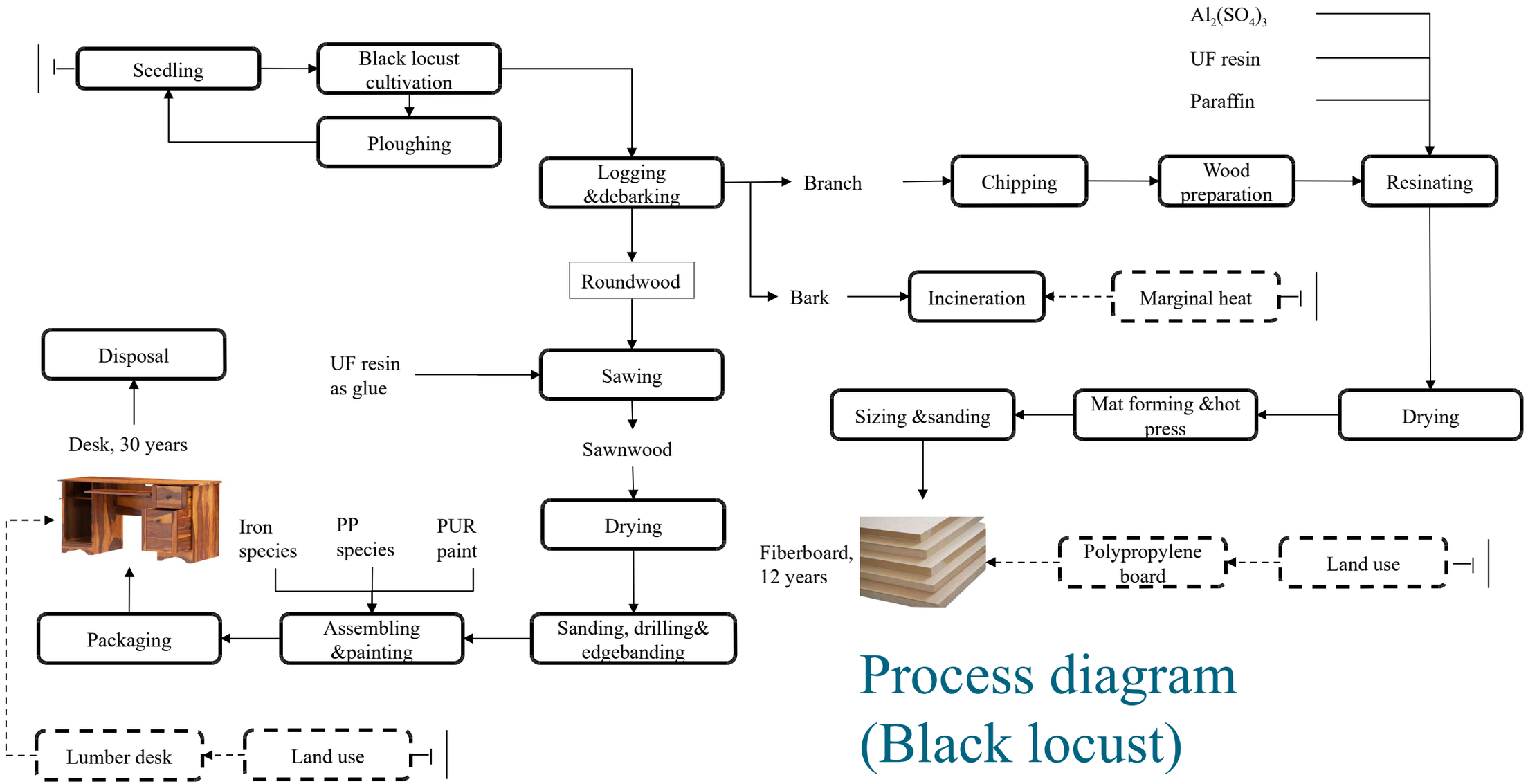
Hemp
Cannabis sativa
Lifetime: annual
Yield: 9.2 t/ha

Black locust
Robinia pseudoacacia
Lifespan: 35 years
Yield: 551 t/ ha at the end

Reference:
1 Ledo, Alicia, et al. (2019)

Process diagram (Hemp)





Process diagram (Black locust)

SOC simulation

Time scale:
105 years, to complete three rotations of black locust

Environmental Modelling and Software 118 (2019) 99–113

Contents lists available at ScienceDirect

Environmental Modelling & Software

journal homepage: www.elsevier.com/locate/envsoft

Modeling soil organic carbon evolution in long-term arable experiments with AMG model [1]

$$\text{———} = \sum \quad h \; -$$

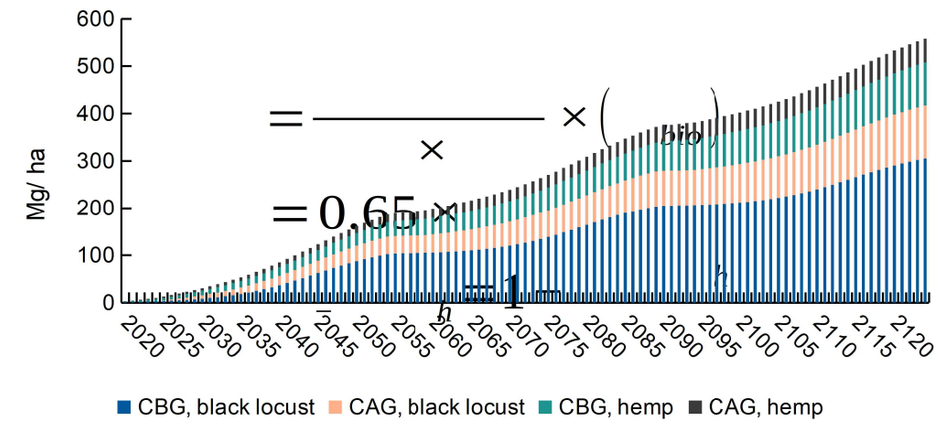
$$= \text{———} \times \left(\quad bio \right)$$

$$= 0{,}65 \times$$

$$\times$$

$$\frac{}{h} = 1 -$$

Accumulated C input of black locust and hemp



Drias

Food and Agriculture Organization of the United Nations

Meteorology

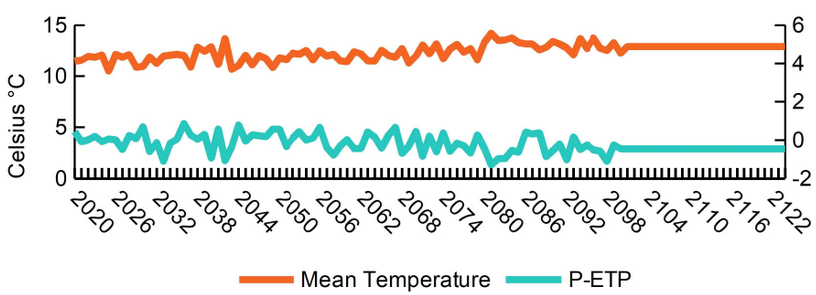


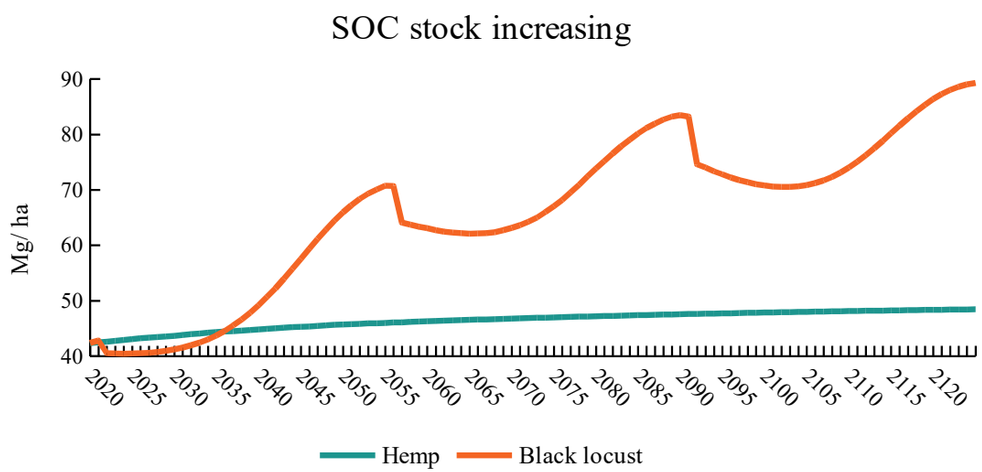
Table Input of AMG, soil characteristics.

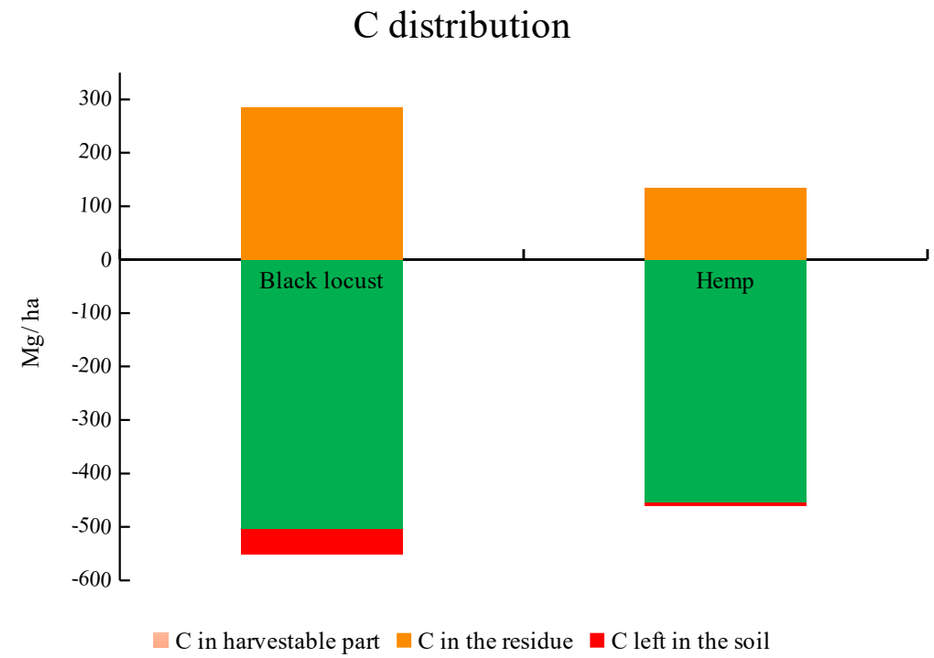
	Measured depth cm	Clay g/kg	CaCO3 g/kg	pH	Bulk density g/ dm³	Coarse fragment %	SOC concentration g/kg	SOC stock Mg/ ha	C/N
Carbon vulnerable land	30	215,97	26,36	6,6	1,4	6,63	10,79	42,35	22,0

1 Clivot, Hugues, et al. "Modeling soil organic carbon evolution in long-term arable experiments with AMG model." Environmental modelling & software 118 (2019): 99-113

tbi Toulouse Biotechnology Institute Bio & Chemical Engineering

SOC simulation





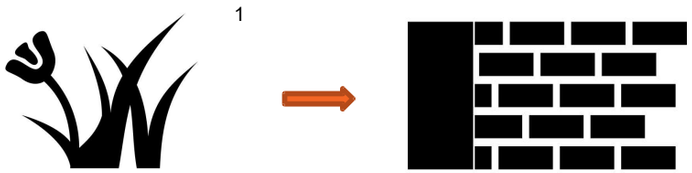
- The SOC increase of black locust is 0.45 Mg/ ha, of hemp is 0.06 Mg/ ha; Black locust could meet the requirement of 0,4%;
- The total SOC increase of black locust is 46. 92 Mg while of hemp is 6.08 Mg in the carbon vulnerable land.

Perspective

- Analyze the LCA result based on the inventory, evaluate the environmental impact of biopump;
- Conducting dynamic LCA to draw the carbon flow with time.

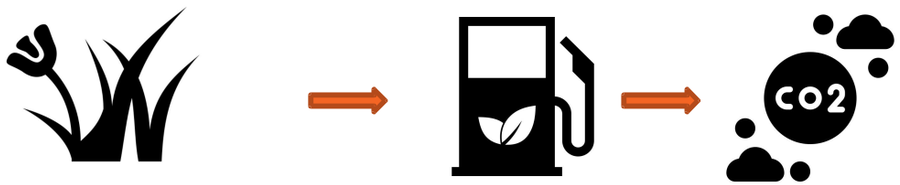
Carbon flows: a simple example of *Miscanthus*

Scenario 1



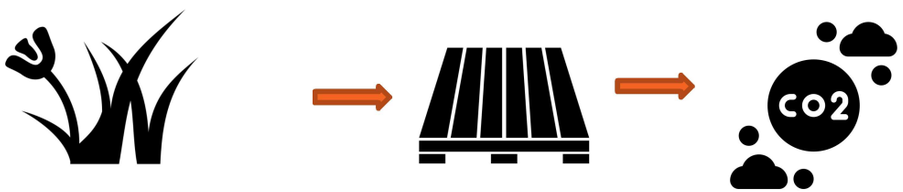
F100L100

Scenario 2



F100L1

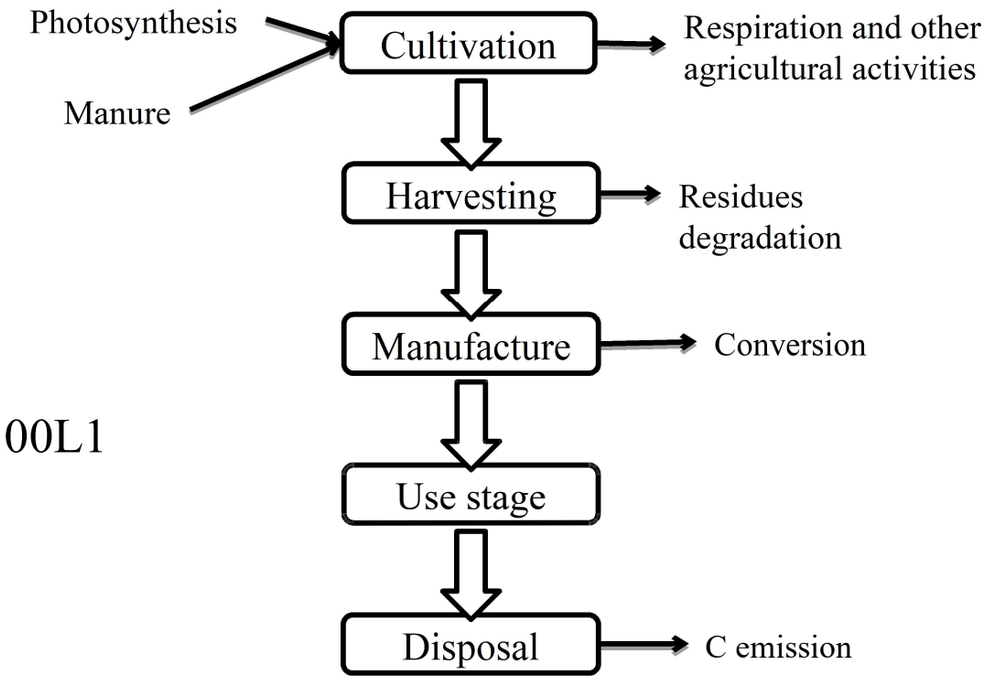
Scenario 3



FxLy/Fx'Ly'

F: biogenic carbon fraction stored in the products
L: product lifetime

Dynamic C flow in 100 years[2]



Reference:
1 Black &whicte irons come from Noun project, https://thenounproject.com/
2 Tiruta-Barna, Ligia, 2016

Carbon flows - a simple example

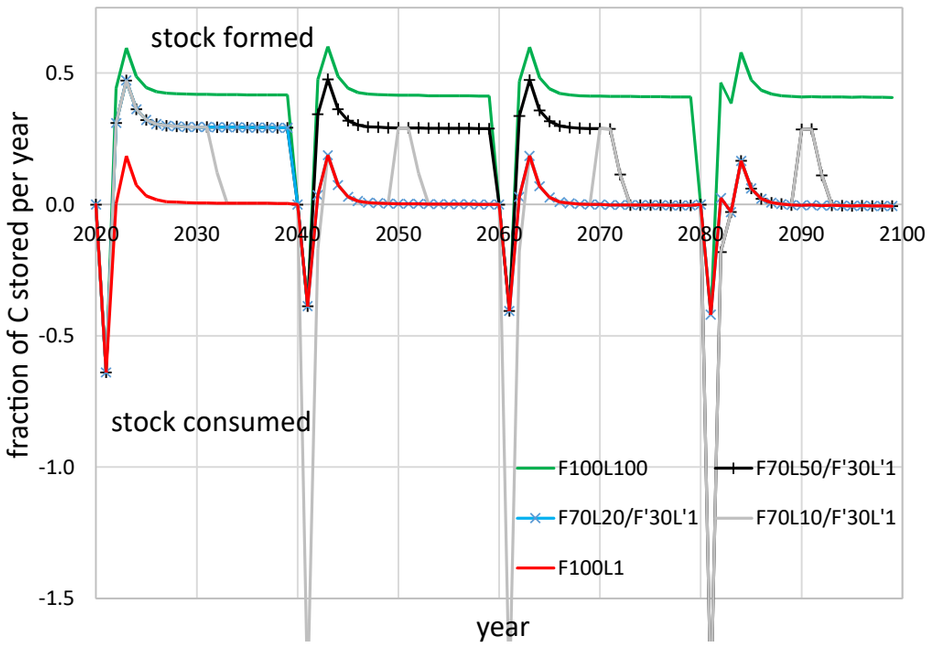


Fig.1 Net CO_2 flows. Results are expressed for miscanthus cultivated on 1 ha marginal land.

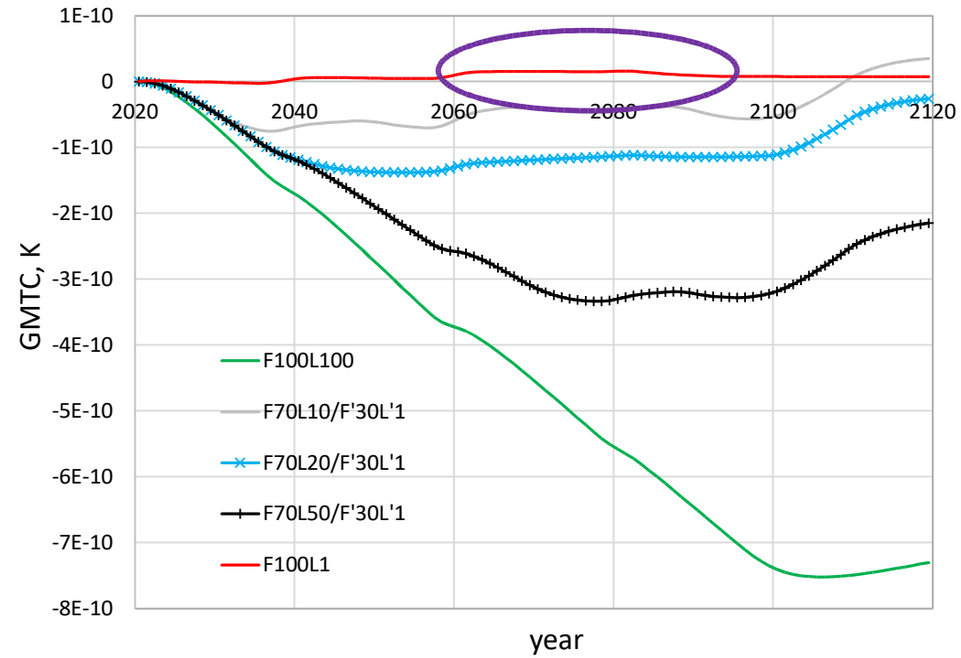


Fig.2 The global mean temperature change GMTC(K). Results are expressed for miscanthus cultivated on 1 ha marginal land.

- CO_2 emission peaks are due to agriculture operations at the rotation time (20 y) and no product fabrication at this moment
- The net CO_2 emission till 2100 varies from -3.63 to -1143.71 Mg CO_2 /ha between F100L1 and F100L100.
- If placed in the climate context (2050 – 2100), product with 1 year lifetime won't contribute to the climate mitigation.
- To maximize the reduction of the mean temperature change, the lifetime should be as long as possible.

Thanks for your attention

zshen@insa-toulouse.fr

@cambioscop

CAMBIOSCOP

Carbon management towards low fossil carbon use

https://cambioscop.cnrs.fr/

Reference

Inglada, Jordi, et al. "Operational high resolution land cover map production at the country scale using satellite image time series." *Remote Sensing* 9.1 (2017): 95.

Ledo, Alicia, et al. "A global, empirical, harmonised dataset of soil organic carbon changes under perennial crops." Scientific data 6.1 (2019): 1-7.

Clivot, Hugues, et al. "Modeling soil organic carbon evolution in long-term arable experiments with AMG model." Environmental modelling & software 118 (2019): 99-113.

Minasny, Budiman, et al. "Soil carbon 4 per mille." Geoderma 292 (2017): 59-86.

Black &whicte irons in this ppt come from Noun project, https://thenounproject.com/

Tiruta-Barna, Ligia, et al. "Framework and computational tool for the consideration of time dependency in Life Cycle Inventory: proof of concept." Journal of Cleaner Production 116 (2016): 198-206.