NEGEM

Land-neutral negative emissions through biochar sequestration

16 June 2022
International Conference on Negative CO_2 emissions

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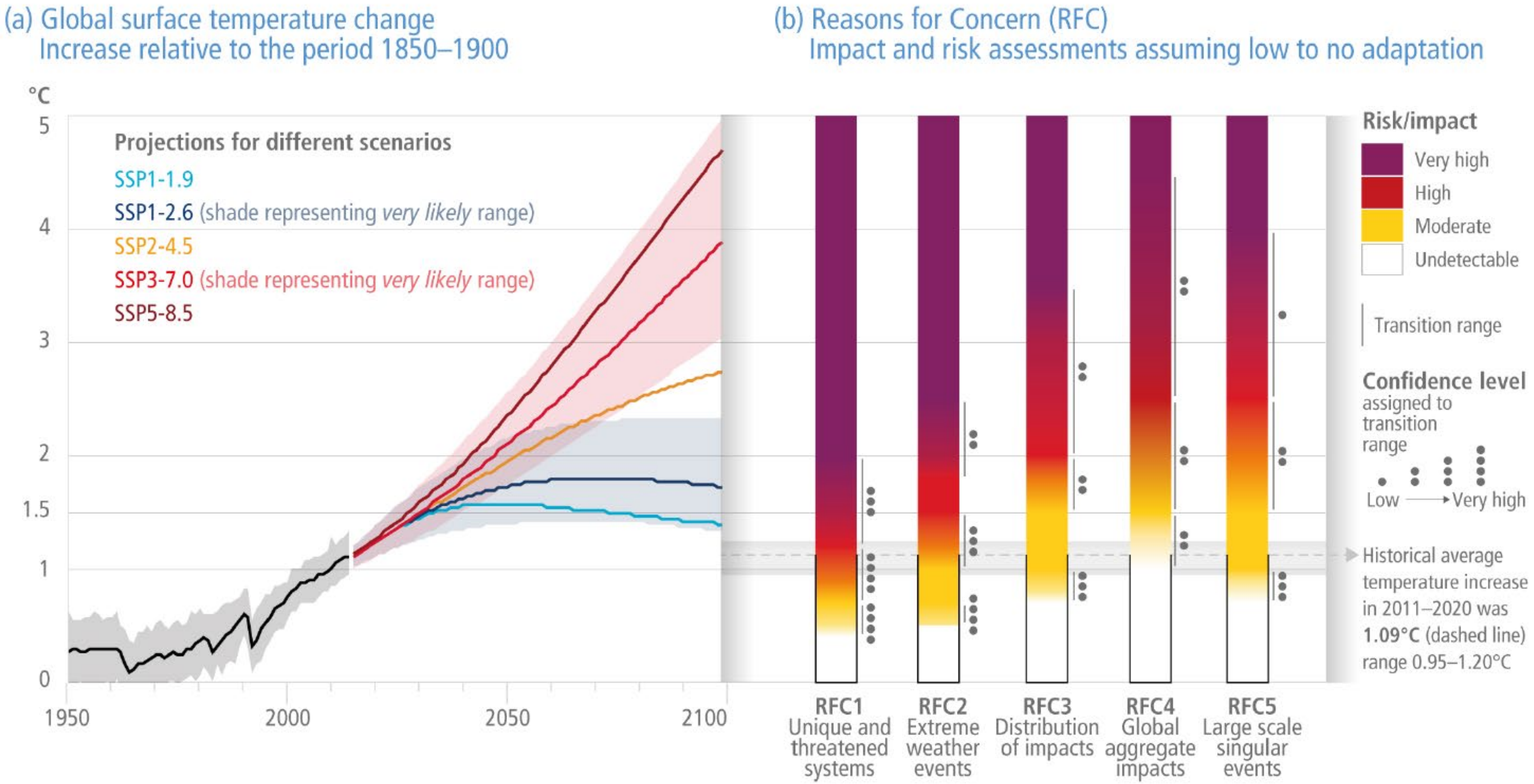
PIK
Potsdam Institute for Climate Impact Research

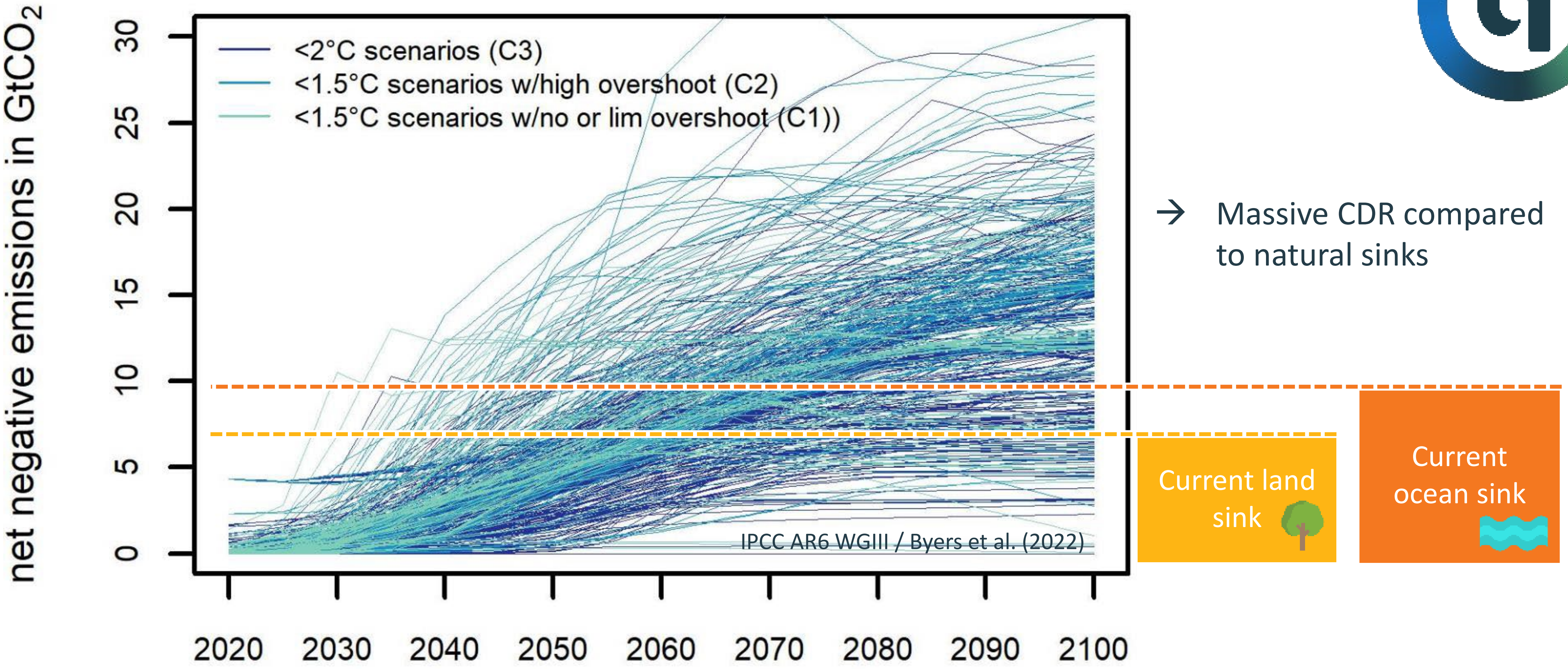
Why do we need climate stabilization?

Global and regional risks for increasing levels of global warming



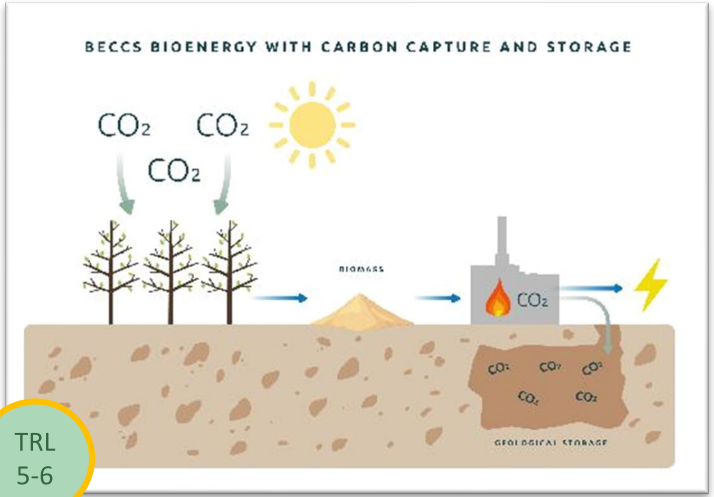
IPCC AR6 WGII

Emission pathways:
CDR projected to be crucial for meeting climate targets

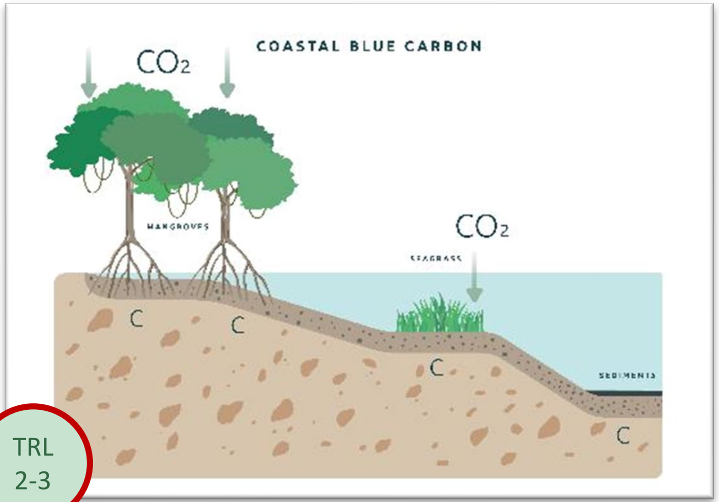


→ Massive CDR compared to natural sinks

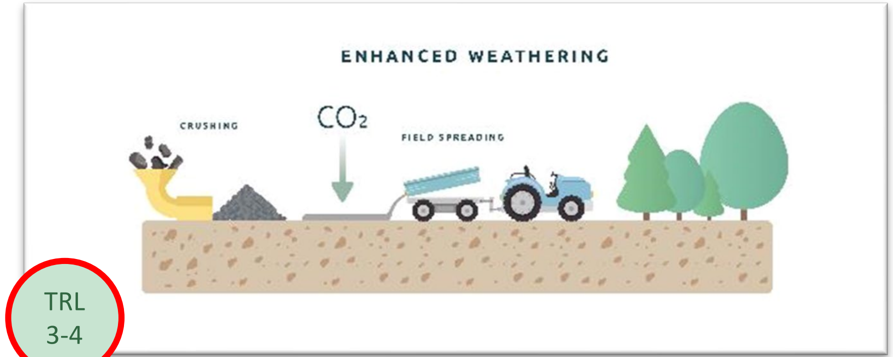
CDR methods of different technology readiness



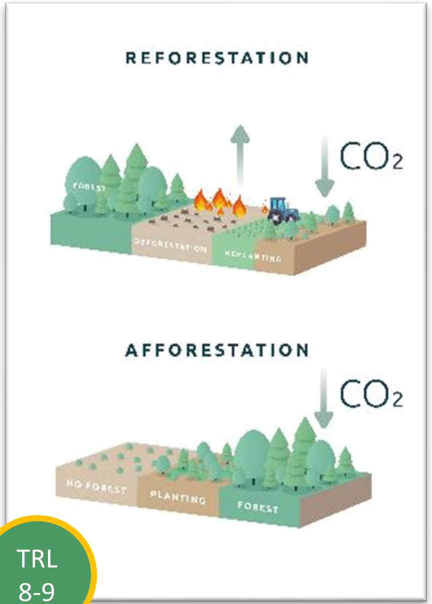
TRL 5-6



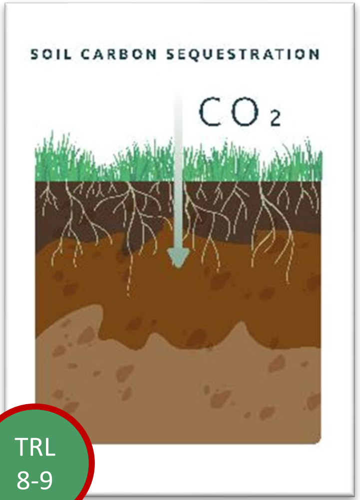
TRL 2-3



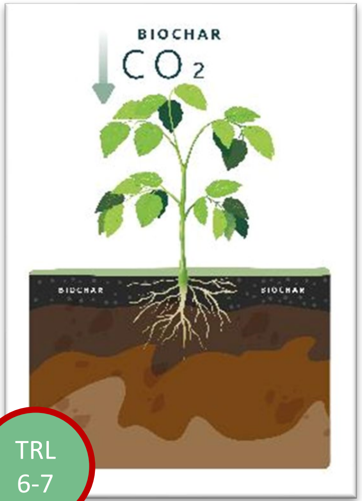
TRL 3-4



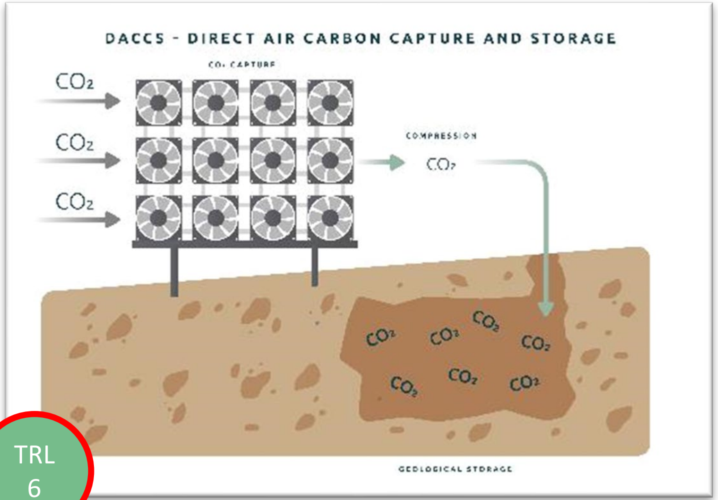
TRL 8-9



TRL 8-9



TRL 6-7



TRL 6

Substantial contribution in IAMs

In a few IAMs

Not yet represented in IAMs

Motivation for evaluating carbon removal potentials of biomass pyrolysis (PyCCS)

Chance for early deployment, due to following features…

- Scalable approach

Photos by H.-P. Schmidt

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Motivation for evaluating carbon removal potentials of biomass pyrolysis (PyCCS)

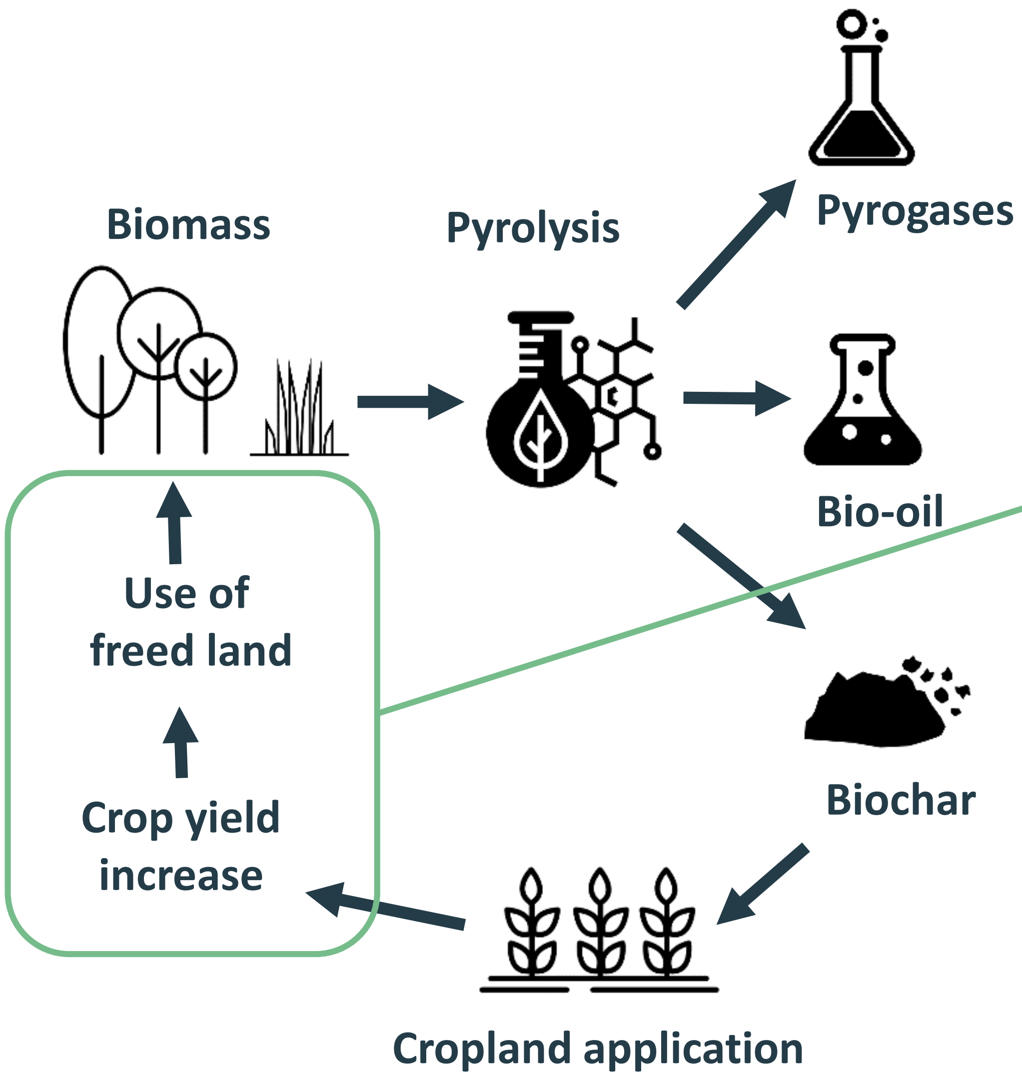
Chance for early deployment, due to following features…

- Scalable approach
- Low-tech options available
- Additional **economic incentive**:

  yield increases with biochar as soil amendment due to enhanced water and nutrient holding capacities

Photos by H.-P. Schmidt

Land- and calorie-neutral PyCCS (pyrogenic carbon capture and storage)



LCN-PyCCS
produces negative emissions without additional pressure on land, while maintaining calorie production.

+ increased water and nutrient holding capacities

+ enhanced climate resilience of soils

+ reduced N2O and CH4 emissions

Co-benefits of LCN-PyCCS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GCB-BIOENERGY WILEY
RESEARCH REVIEW

Biochar in agriculture – A systematic review of 26 global meta-analyses

Hans-Peter Schmidt[1] | Claudia Kammann[2] | Nikolas Hagemann[3,4] | Jens Leifeld[4] | Thomas D. Bucheli[4] | Miguel Angel Sánchez Monedero[5] | Maria Luz Cayuela[5]


Annual Review of Environment and Resources

Land-Management Options for Greenhouse Gas Removal and Their Impacts on Ecosystem Services and the Sustainable Development Goals

Pete Smith,[1] Justin Adams,[2] David J. Beerling,[3] Tim Beringer,[4] Katherine V. Calvin,[5] Sabine Fuss,[6,7] Bronson Griscom,[8] Nikolas Hagemann,[9,10] Claudia Kammann,[11] Florian Kraxner,[12] Jan C. Minx,[6,13] Alexander Popp,[14] Phil Renforth,[15] Jose Luis Vicente Vicente,[6] and Saskia Keesstra[16,17]

LCN-PyCCS
produces negative emissions without additional pressure on land, while maintaining calorie production.

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Research questions on LCN-PyCCS

LCN-PyCCS
produces negative emissions without additional pressure on land, while maintaining calorie production.

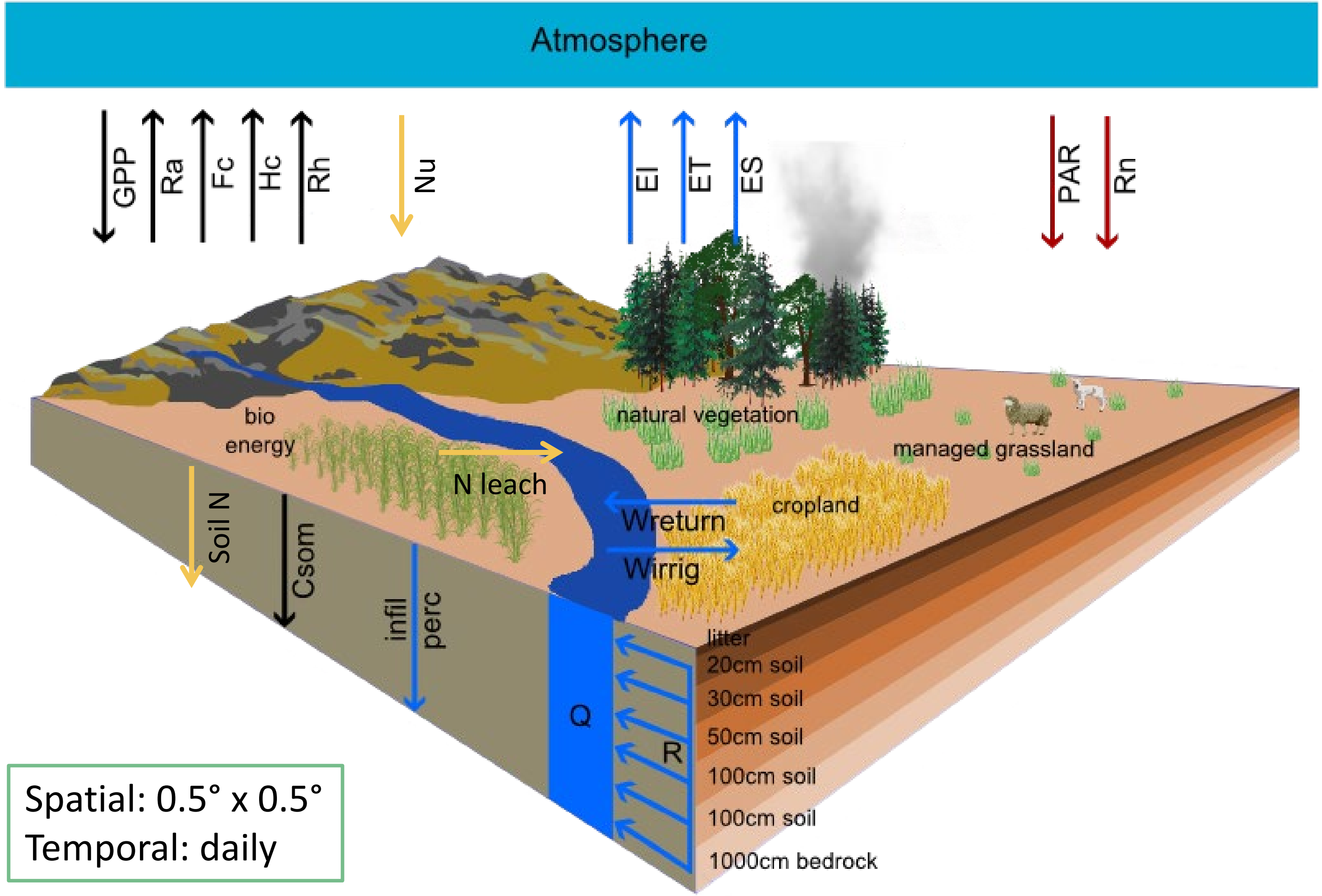
What is the CDR potential of LCN-PyCCS assuming different levels of biochar-mediated yield increases in the tropics?

How high are potential benefits of substituting assumed BECCS CDR in regard to...

a) nature restoration

b) additional calorie production

Dynamic Vegetation Model LPJmL (Lund-Potsdam-Jena managed Land)



Spatial: 0.5° x 0.5°
Temporal: daily

Carbon

GPP	gross primary production
Ra	autotrophic respiration
Rh	heterotrophic respiration
Hc	harvest
Fc	fire carbon fluxes
Csom	soil organic matter

Nitrogen

Nu	nitrogen uptake
Soil N	soil nitrogen content
N leach	nitrogen leaching

Water

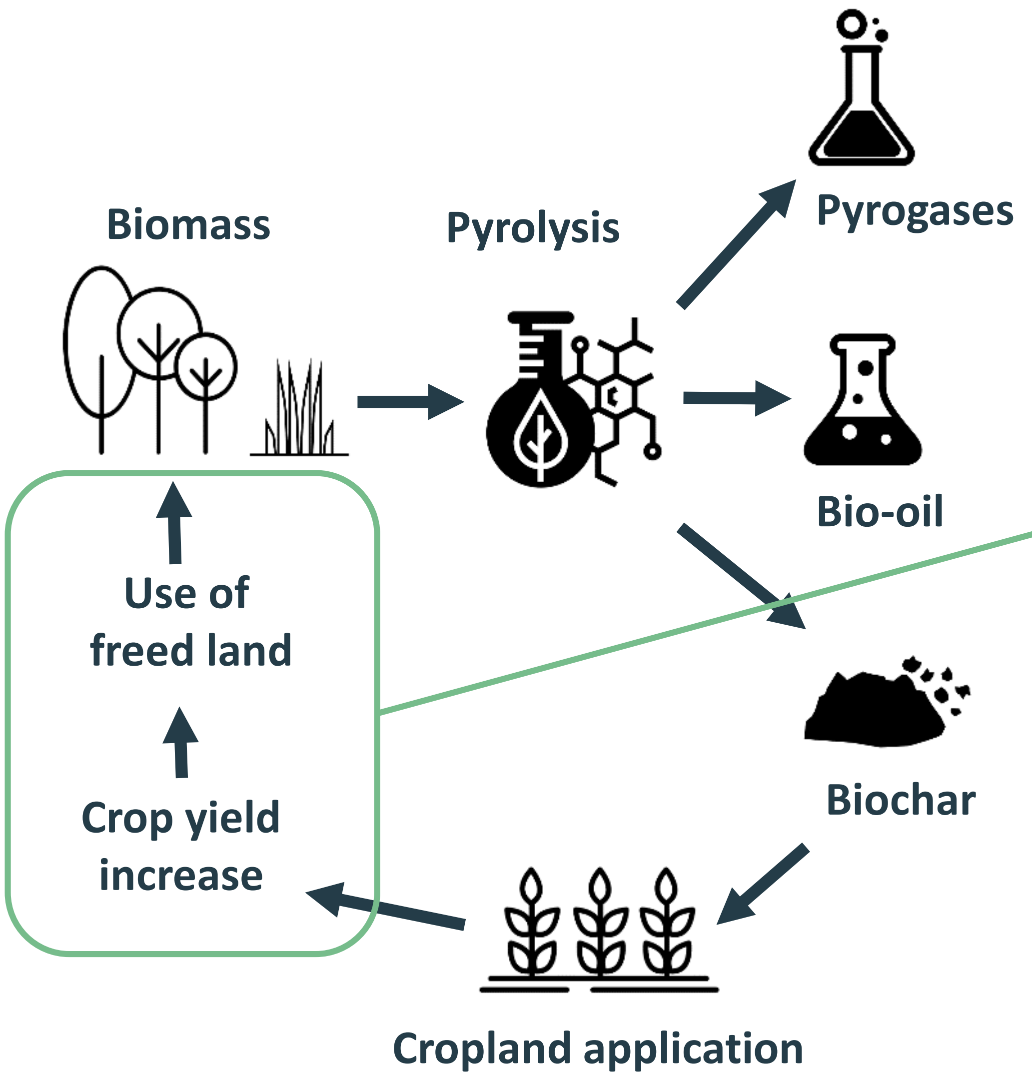
EI	interception
ET	transpiration
ES	evaporation
perc	perculation
infil	infiltration
R	runoff
Wreturn	return flow from irrigation
Wirrig	irrigation water
Q	discharge

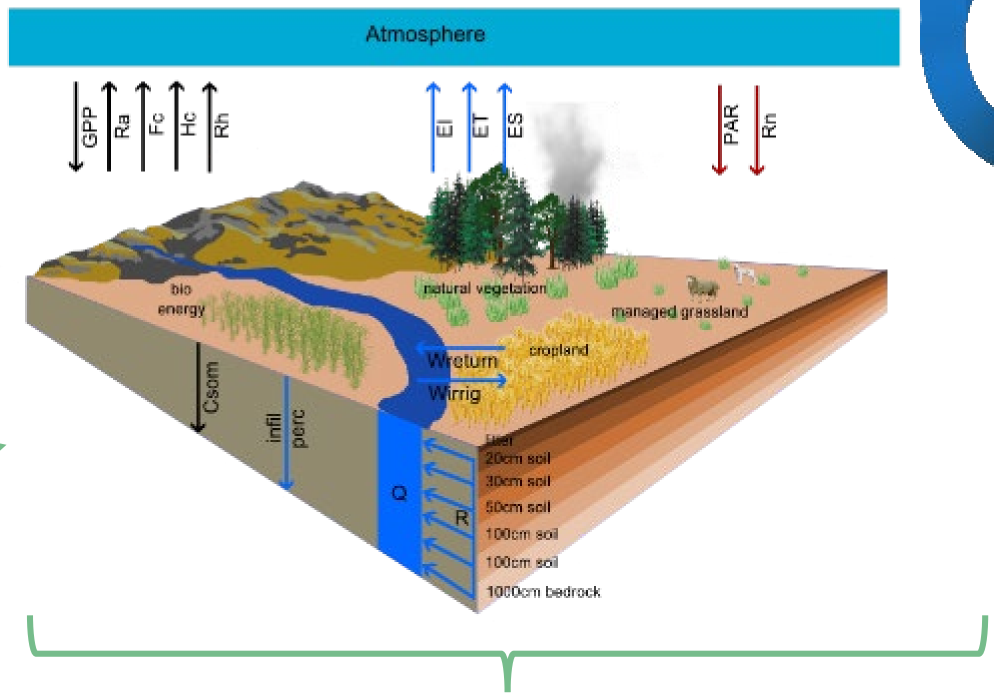
Energy

PAR	photosynthetic active radiation
Rn	net radiation

Schaphoff et al. (2018)

Land- and calorie-neutral PyCCS (pyrogenic carbon capture and storage)

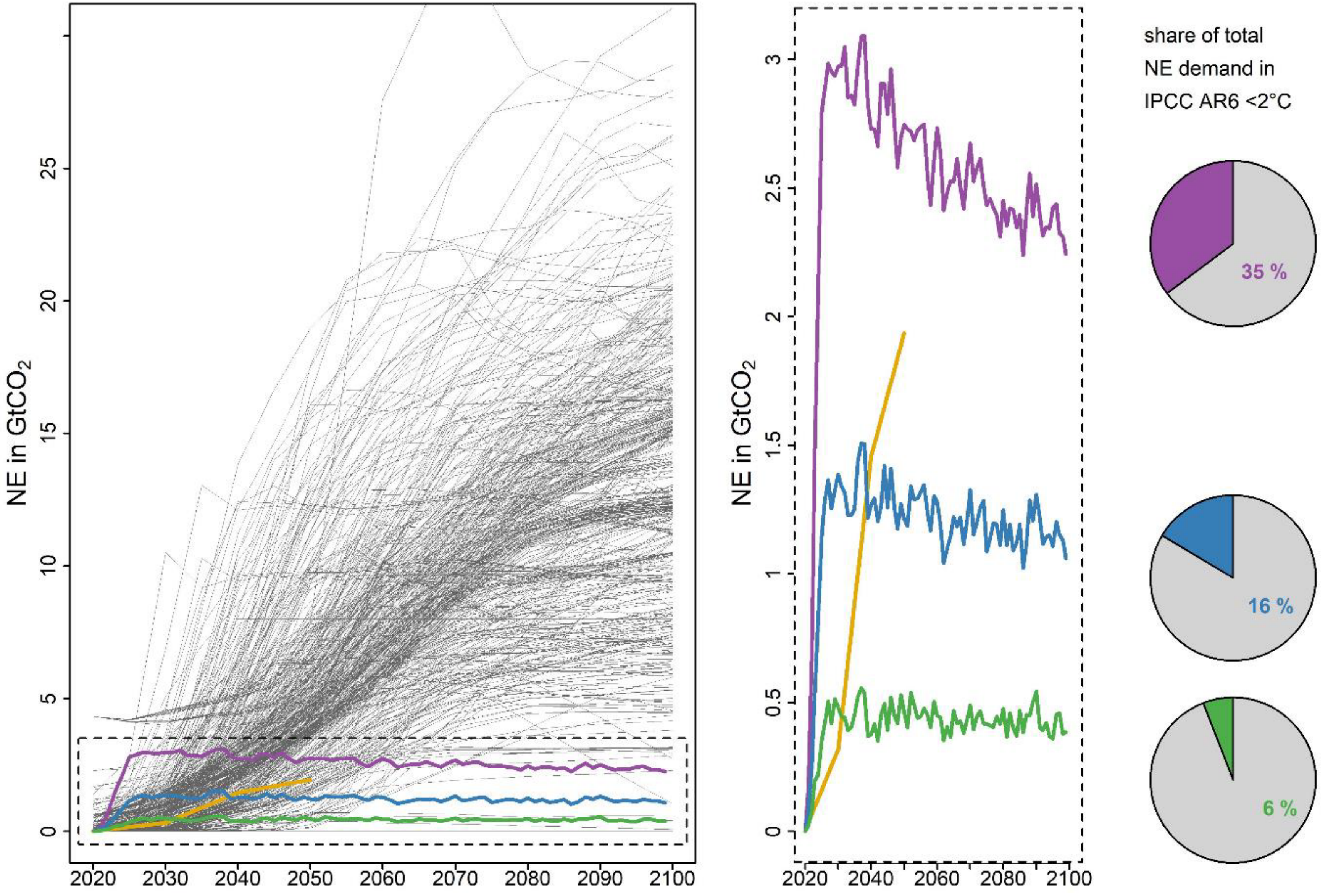


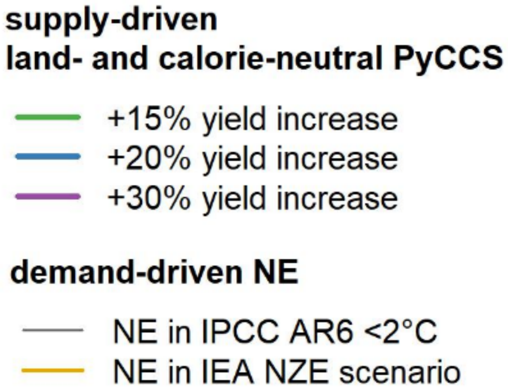


With higher yield increases
→ larger extent of land dedicated to PyCCS
→ higher biomass production
→ higher NE potential

NE **without** pressure on land or food production

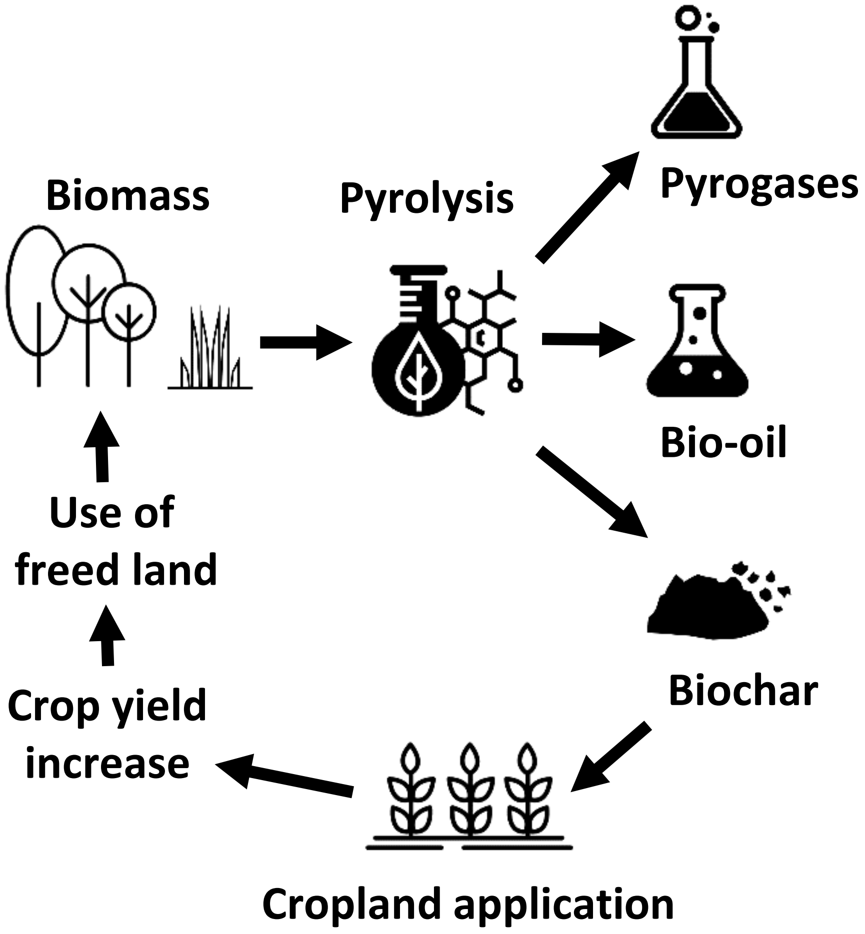
CDR potentials of LCN-PyCCS





Werner et al. 2022, Earth's future (under review)

LCN-PyCCS providing CDR and releasing land use pressure



Sequestration potential	BECCS substitution: Nature restoration		BECCS substitution: Additional calorie production	
	low	high	low	high
Yield increase = 15%				
$GtCO_2$	Mha		% additional production	
0.44	19	14	3.3	2.7
Yield increase = 20%				
1.23	47	34	8.8	6.6
Yield increase = 30%				
2.62	96	69	15.7	11.3

C capture efficiencies

Dashed line: extent of Africa's 10 largest national parks

Conclusions

CDR co-benefits (i.e. yield increases in LCN-PyCCS) are worth considering for the assessment of ...

(1) negative emission potentials and
(2) the additional benefits in areas like nutrition and biosphere protection

Research and practice should aim for developing the best biochar application achievable under field-specific conditions to maximize the potential.

LCN-PyCCS may contribute to climate stabilization without further pressures on land resources and food security.

Substituting CDR from BECCS as assumed in future projections might even release some pressure on nature protection and food provision.

These results call for...

1. Integrating biochar-mediated yield increases in scenario development

2. Representing biochar-mediated processes (i.e. liming, porosity, retention) in dynamic global vegetation models

3. Developing elaborate models/databases on residue and waste use – large-scale deployment of PyCCS should not rely on purpose-grown biomass

Potsdam Institute for Climate Impact Research

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Thank you!

Project Partners

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