Biochar from sugarcane residues:

An overview of its sequestration potential in Sao Paulo, Brazil

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Context

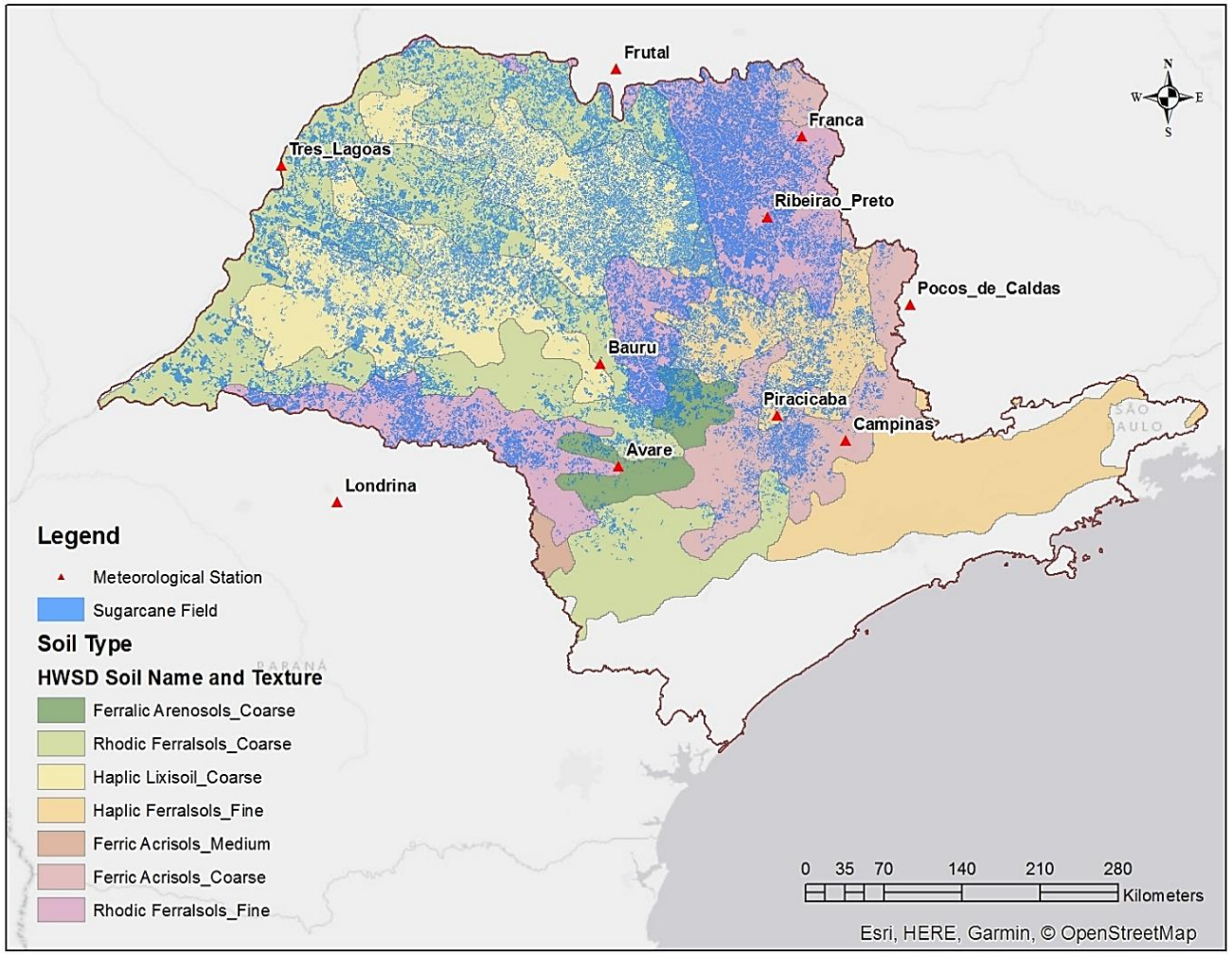
Sugarcane

- The world's largest crop by production quantity
- Brazil → Biggest producer
- Sao Paulo → 55% of Brazilian production
- Residues Available:
  - ≈ 3 t ha^{-1} of trash
  - ≈ 10 t ha^{-1} of bagasse

Biochar (BC)

- Carbon rich material
- Highly recalcitrant
- *"Promising Negative Emission Technology"* IPCC (2018)
- Most properties of sugarcane biochar known

Study Area



- Sugarcane in Sao Paulo: 5.4 Mha
- 10 meteorological stations
- 7 different soil types
- Enough residues to produce 4.2 t biochar ha^{-1} yr^{-1}

How will the BC influence the soil carbon stock?

How much of the BC will still be there after 100 years?

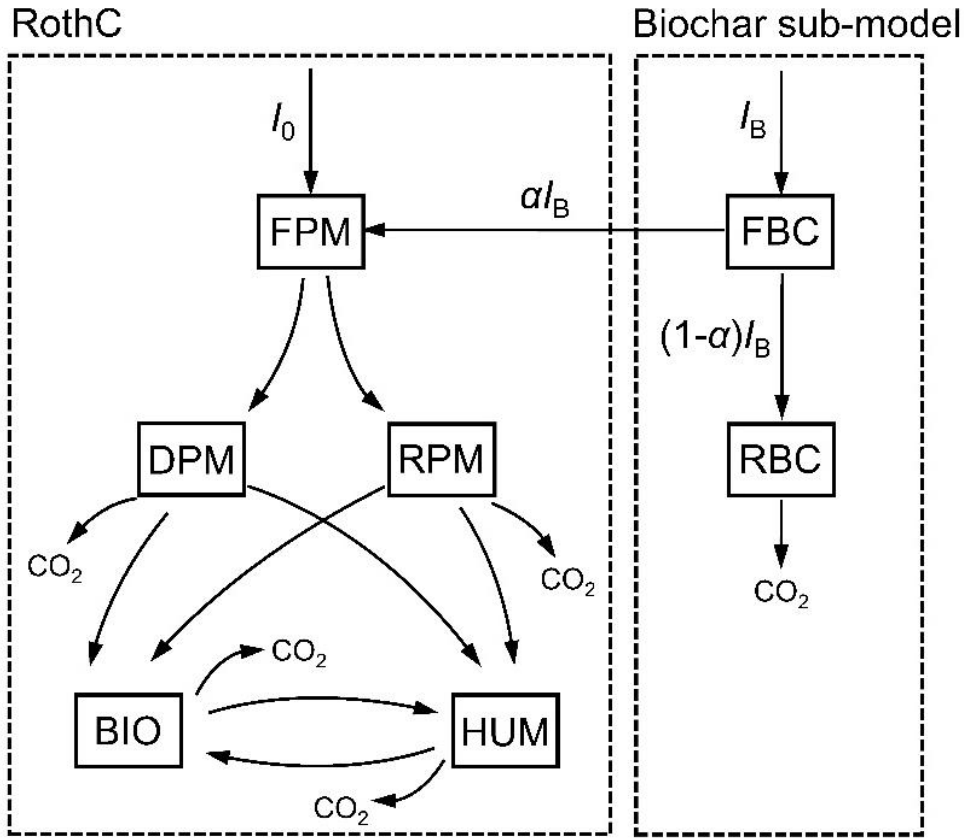
What is the soil carbon stock before any change in management?

RothC and Biochar sub-model

- Used RothC carbon model to set up soil carbon soil before changes in management (values verified with literature)
- Created a RothC biochar sub-model to integrate biochar to the RothC loop and used sugarcane biochar specific properties

Some Sugarcane Residue Biochar Properties

Sugarcane trash biochar (550°C) C content (% dm)	41	%
Sugarcane bagasse biochar (550°C) C content (% dm)	64	%
Bagasse Biochar production Yield (550°C)	31	%
Trash Biochar production Yield (550°C)	34	%
Biochar weight considered labile	3	%
Biochar weight considered recalcitrant	97	%
Sugarcane biochar C lost after 100 years (525°C)	12	%



FPM = fresh plant material
DPM = decomposable PM
RPM = recalcitrant PM
BIO = microbial biomass
HUM = humified organic matter

BC = fresh biochar
RBC = recalcitrant biochar

Does the Biochar sub model works ?

Validation challenging

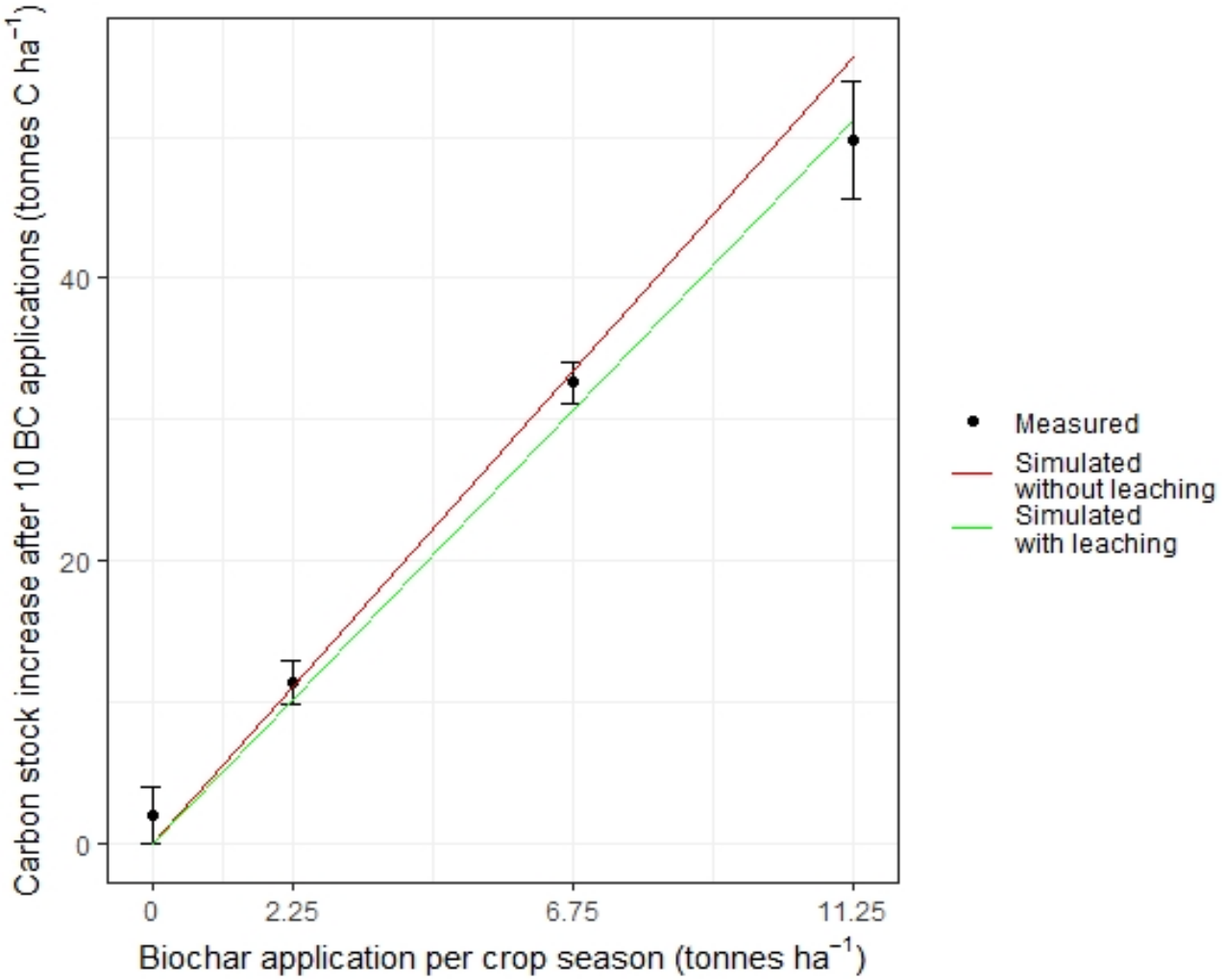
- Data scarcity
- No field experiments with sugarcane
- Very few with successive BC addition

Best available data used:

- Wheat-maize rotation in China
- Successive rice straw BC after each crop season at different rates
- Soil carbon was measured after 5 years

Biochar vertical movement in soil

- Introduces errors in field experiments with limited depth of sampling
- Does not reduce the C sequestration potential
- We simulated a leaching of 5.2 % of biochar per year based on the sand content of the soil (from the literature)



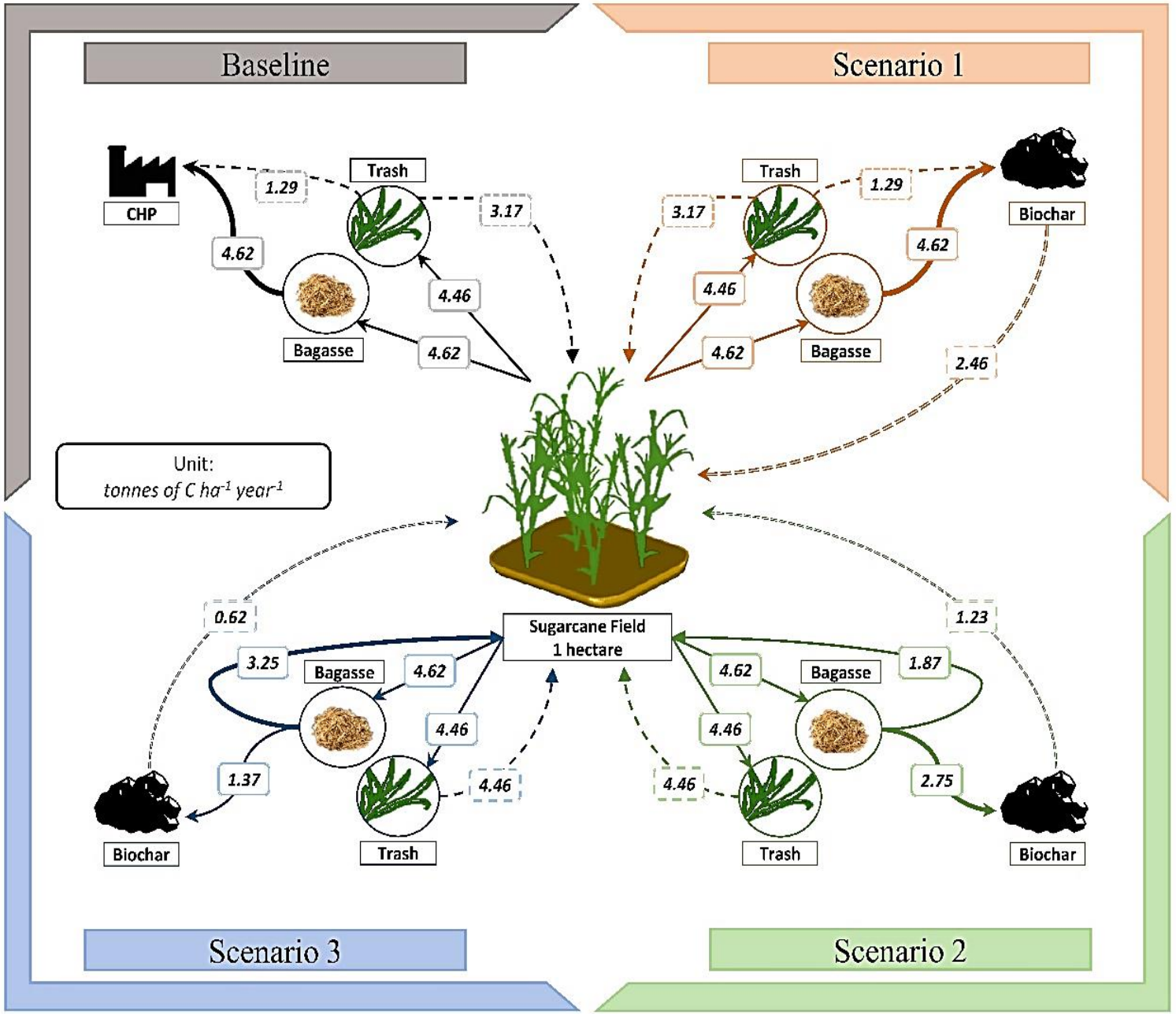
Scenarios

1. Baseline
   - Optimal trash blanketing for weed control
   - Available residues sent to combined heat and power plant

2. Full biochar application
   - Optimal trash blanketing
   - Available residue for BC production

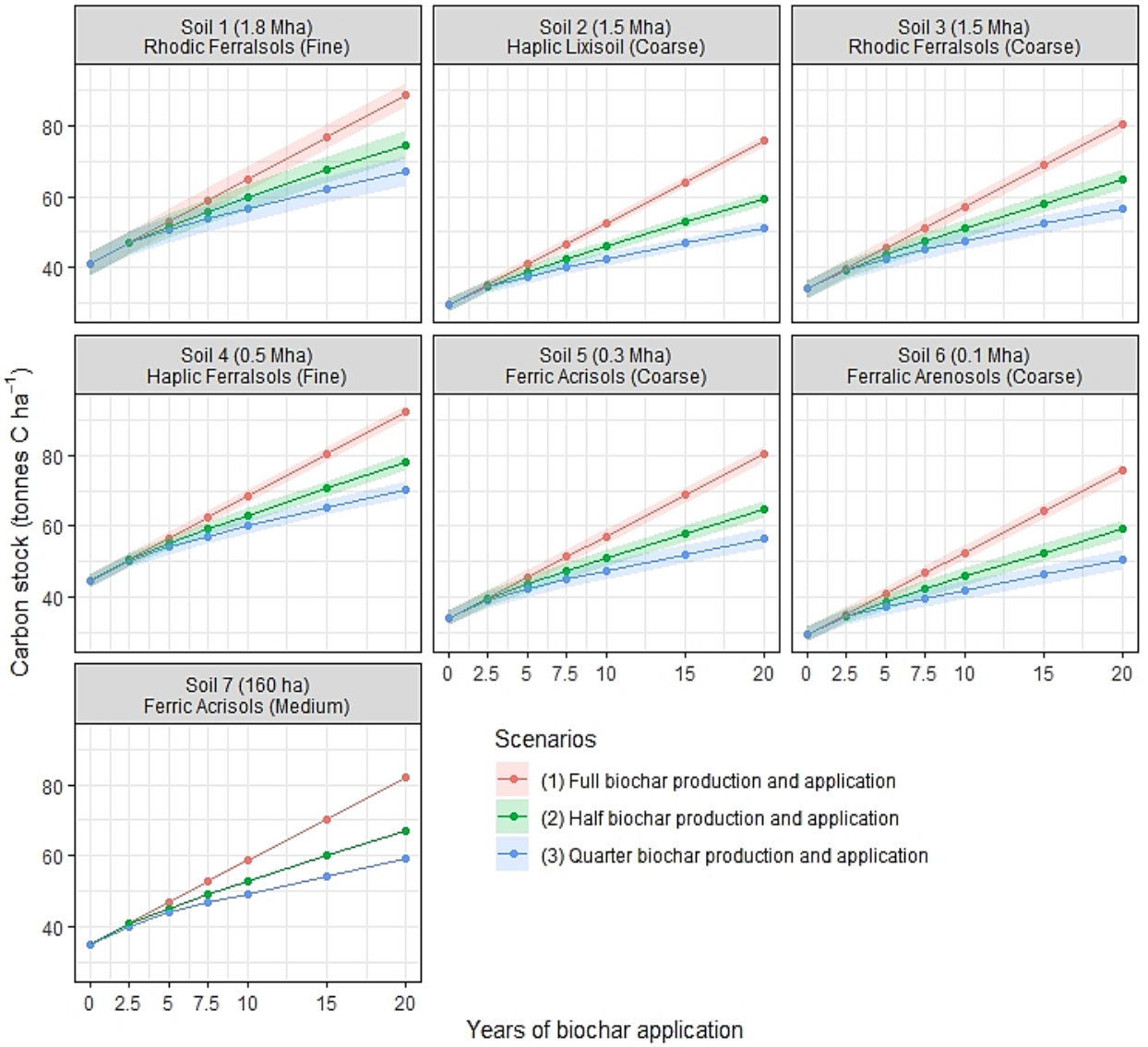
3. Half biochar application
   - Optimal trash blanketing
   - ½ available residue for BC production
   - ½ available residue as mulch

4. Quarter biochar application
   - Optimal trash blanketing
   - ¼ available residue for BC production
   - ¾ available residue as mulch



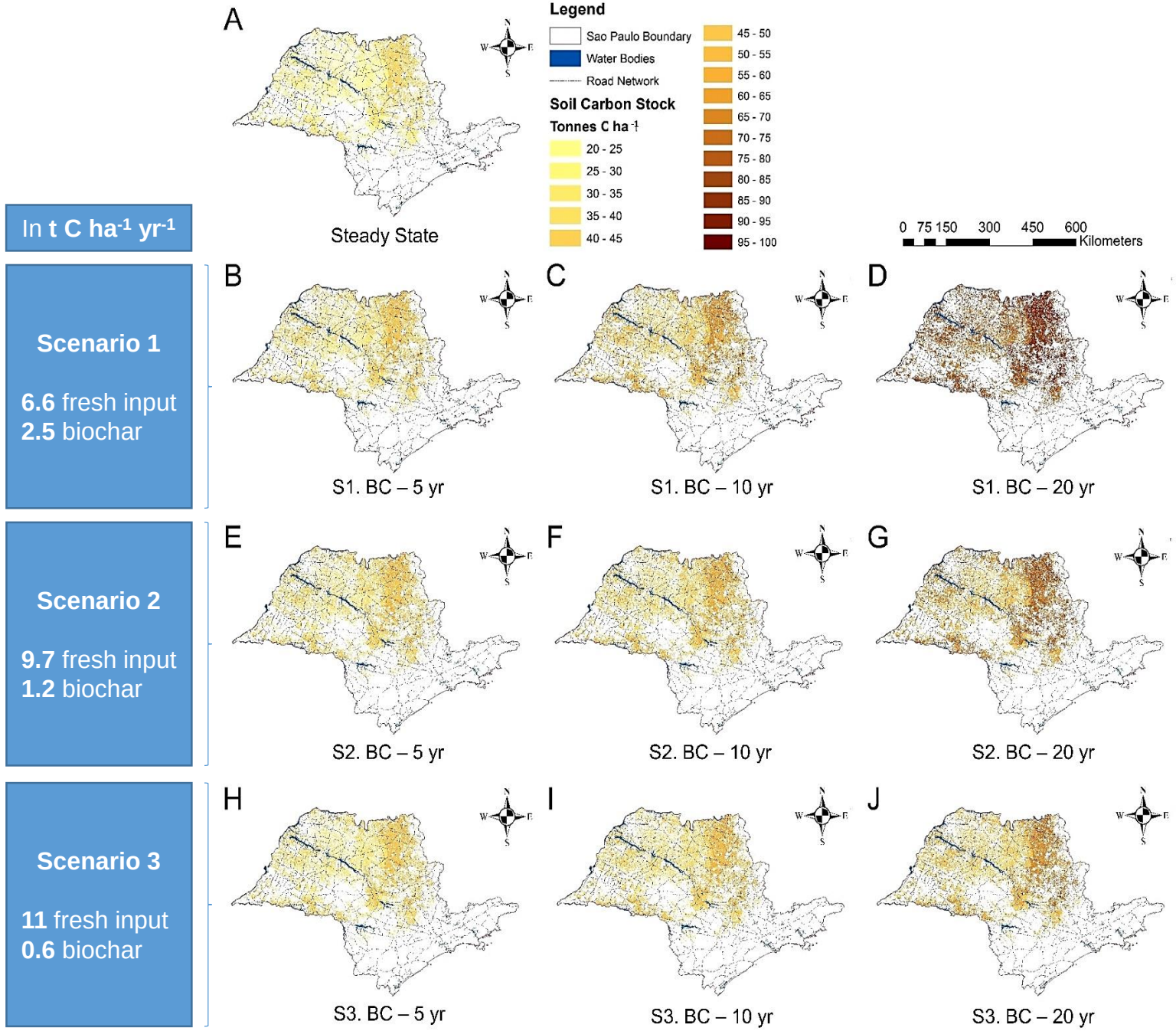
Model results (1)

- The consistently lower C stock at 10 and 20 yr for Scenarios 2 and 3 reflects the results shown in the map
- The C accumulation rate decreases over time for both Scenarios 2 and 3 as a new SOC content equilibrium is reached, following the increased addition of fresh organic matter.
- The overall higher soil C stocks in Soils 1 and 4 are due to their higher clay contents.



Model results (2)

- Model results presented after inverse distance weighted interpolation of the meteorological data
- Scenario 1: steady increase in the SOC (soil organic carbon) stock due to the incremental addition of biochar.
- Scenarios 2 and 3: similar SOC increase in the first 5 yr after biochar application but a lower soil C stock increase after 10 and 20 yr as compared to Scenario 1.
- The lower SOC increase at 10 and 20 yr of S2 and S2 compared to S1 indicates that the soils' C pools reach new equilibria, while the biochar added in S1 is subject to much slower mineralization.



Priming effect - Exploring the sensitivity

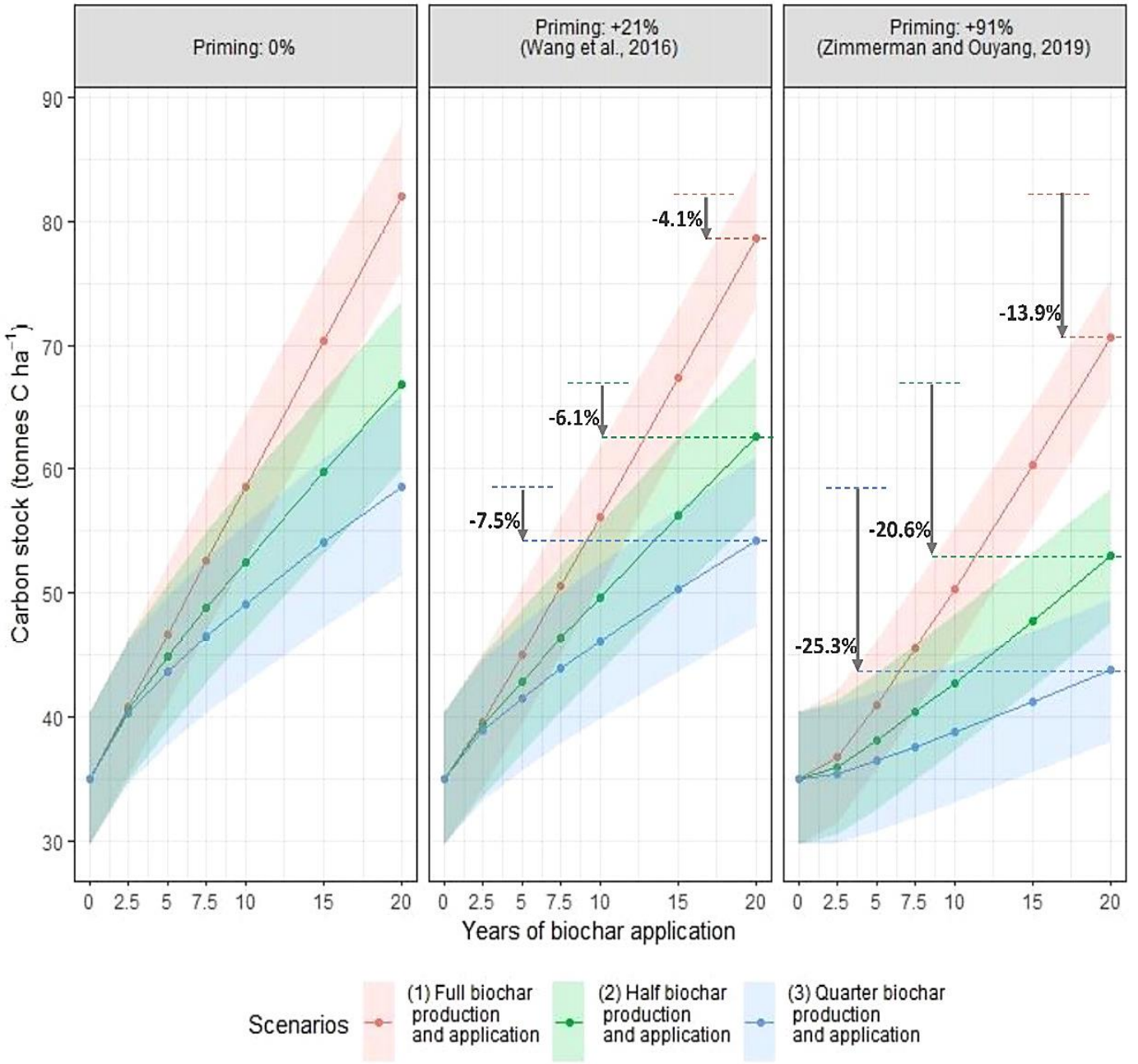
How much?

- 21% from a recent meta-analysis (on sandy soils)
- 91% based on increased sucrose turnover with sugarcane bagasse biochar in an incubation experiment with a simulated soil – an extreme example.

Simulation approach

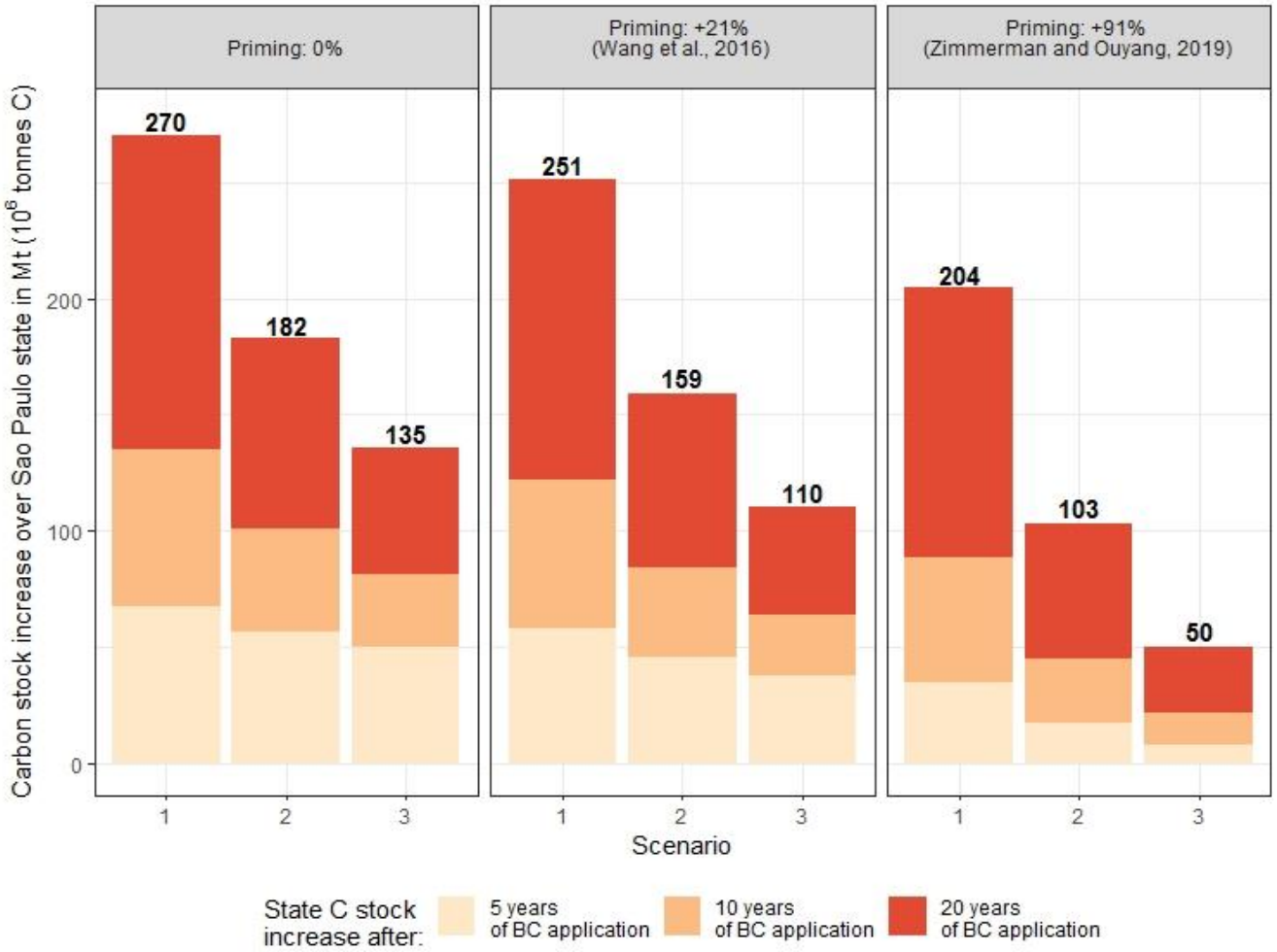
- By increasing the RothC decomposition rate constants

A biochar-induced positive priming effect could impair the C sequestration potential of the practice. However, the net SOC balance with biochar addition remains positive.



Effect of Priming on Carbon Stock Increase over 20 years and negative CO_2 emissions

- Applied to all of Sao Paulo State
- Possible negative CO_2 emissions range by a factor of about five from 9.1 Mt CO_2e yr^{-1} (S3, with 91% priming) to 50 Mt of CO_2e yr^{-1} (S1 with priming)
- These represent 6 to 31% of the State's CO_2e emissions in 2016.
- The most likely central estimate is 29 Mt CO_2e yr^{-1} [S2 21% priming], representing 18% of the State's CO_2e emissions in 2016
- This is 5 ± 0.9 t CO_2e yr^{-1} ha^{-1}



Scenarios:
(1) Full biochar production and application
(2) Half biochar production and application
(3) Quarter biochar production and application

Thank You

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