Labile and Non-Labile Soil Carbon

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Organic Matter

- It is the most important constituent required to rebuild or to maintain soil health.
- When Organic Matter is incorporated into the soil its appearance change as it decompose and progresses through the different carbon pools.
- One of these pools is Labile Carbon: the fraction of soil organic carbon with the most rapid turnover. Labile Carbon is also a major source of nutrients and energy to sustain life in soils and to maintain the condition of soils.
- Another pool is Non-Labile Carbon which is important for the long-term storage of Carbon in soils.
- To obtain these benefits, we must adopt land management practices that are efficient in getting us there.

Benchmarking management

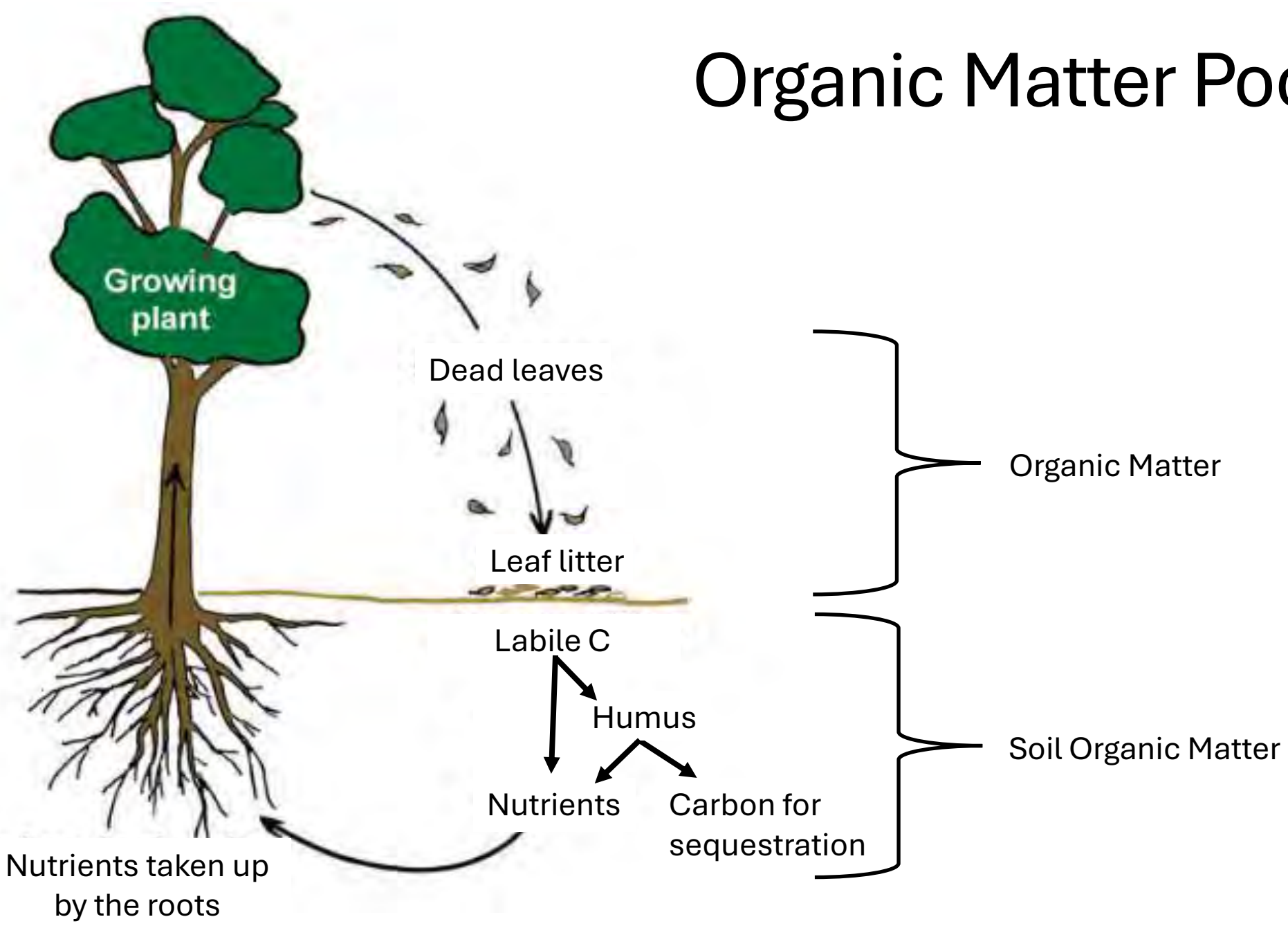
for improving and maintaining soil health

	SYSTEM
1.	Kikuyu pasture; grazed
	Ryegrass/clover pasture; grazed
	Natural grassland or bush
	Permanent grass; hay production (e.g. *E. curvula*)
	No-till annual row crop, legume rotation, residues remain
6.	Sugarcane, not burned, residues remain, green manure every 10 years
7.	Sugarcane, not burned, residues remain, no green manure
	No-till annual cropping; residues remain
9.	Sugarcane, burned, regular OM additions (e.g. chicken litter)
	No-till annual cropping; grain & residues harvested (e.g. maize silage)
	Annual row cropping, conventional tillage (plough & disc), residues remain
12.	Sugarcane, burned, green manure at plant
13.	Sugarcane, burned, no green manure
	Annual row cropping, conventional tillage; residues removed (e.g. maize silage)
	Regular and intensive tillage; little return of residues (typically vegetables)

Most aggrading

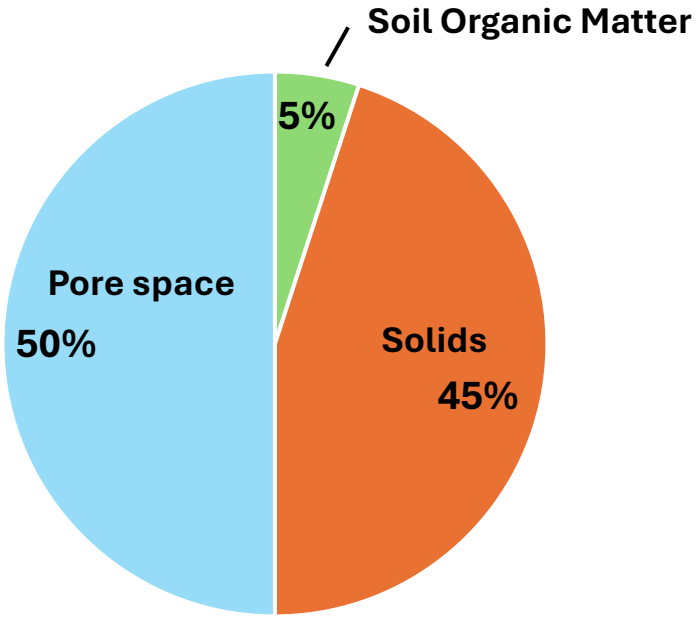
Most degrading

Organic Matter Pools

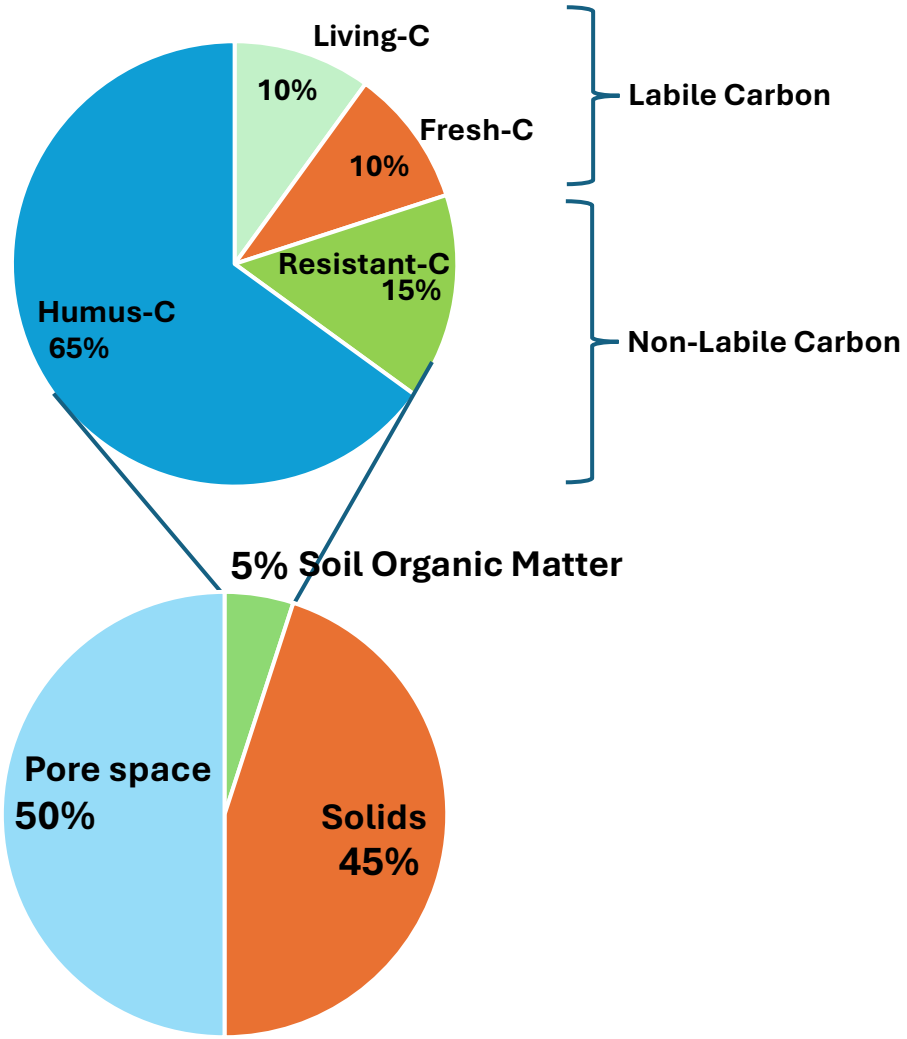


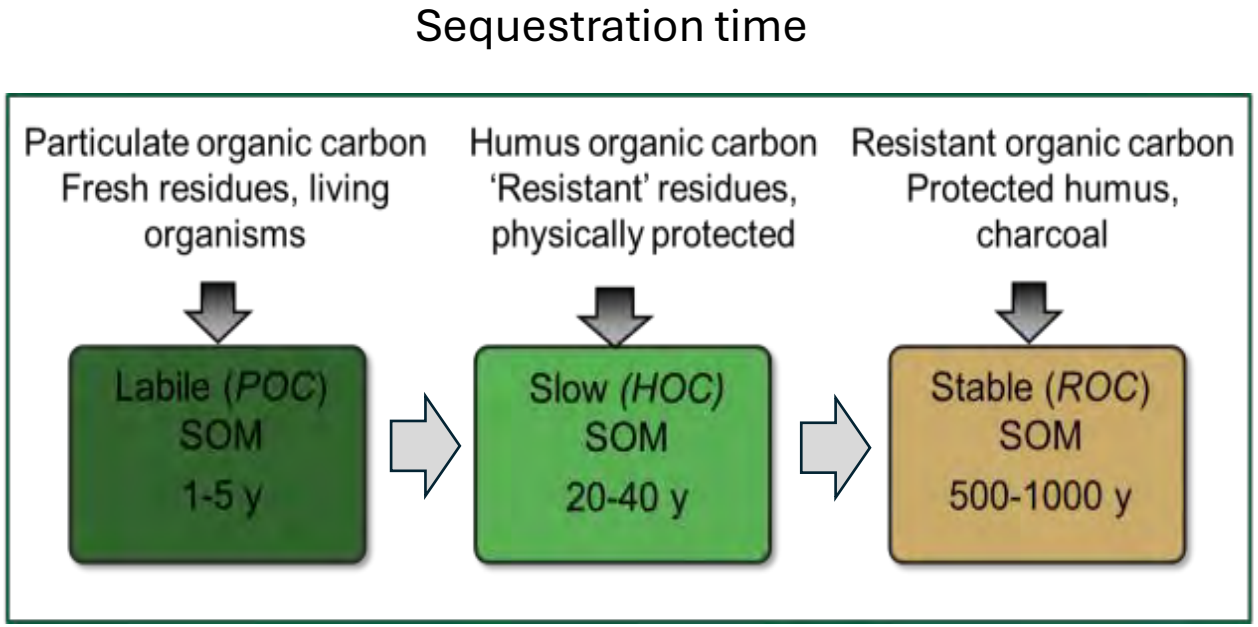
Soil Organic Matter (SOM)

- SOM occupy only a small fraction of the total soil volume, but it is extremely important to
  - sustain soil life as a source nutrients and energy and
  - to sustain or improve the condition of soils
- SOM consists of
  - living plant and animal tissue and
  - dead material in various stages of decomposition



Carbon fractions in soil





Decomposition of Organic Matter

Pyrolysis

Soil Organic Matter

The Living
Roots, mycorrhizae, bacteria, etc. (Biomass)
LABILE CARBON

The Recently Dead
Crop residues, organisms, animals, manures, etc.
LABILE CARBON

The Very Dead
Dead tissue not recognisable
NON-LABILE CARBON

HUMIC SUBSTANCES

NON-HUMIC SUBSTANCES
Biochar or Charcoal

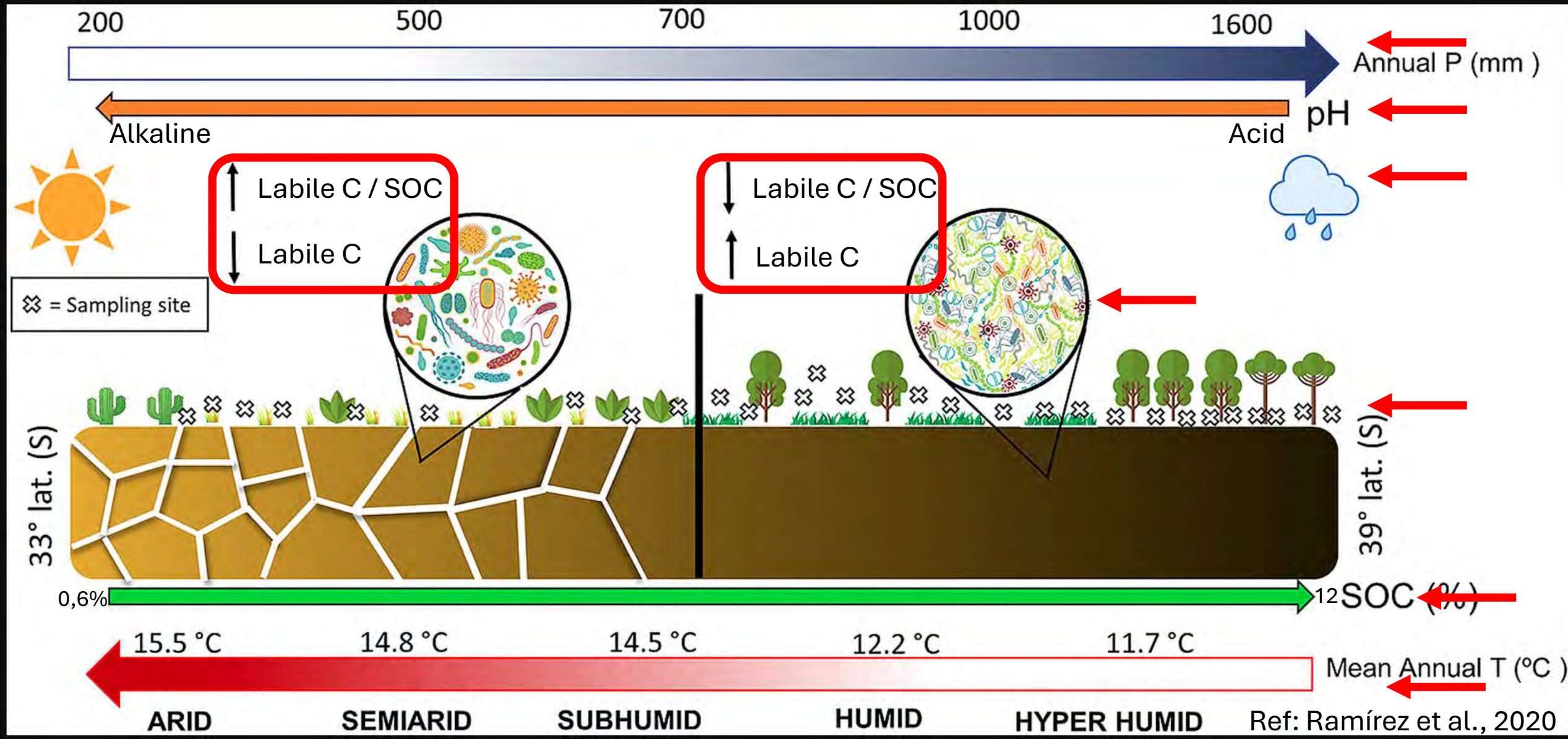
HUMIN

HUMIC ACIDS

FULVIC ACIDS

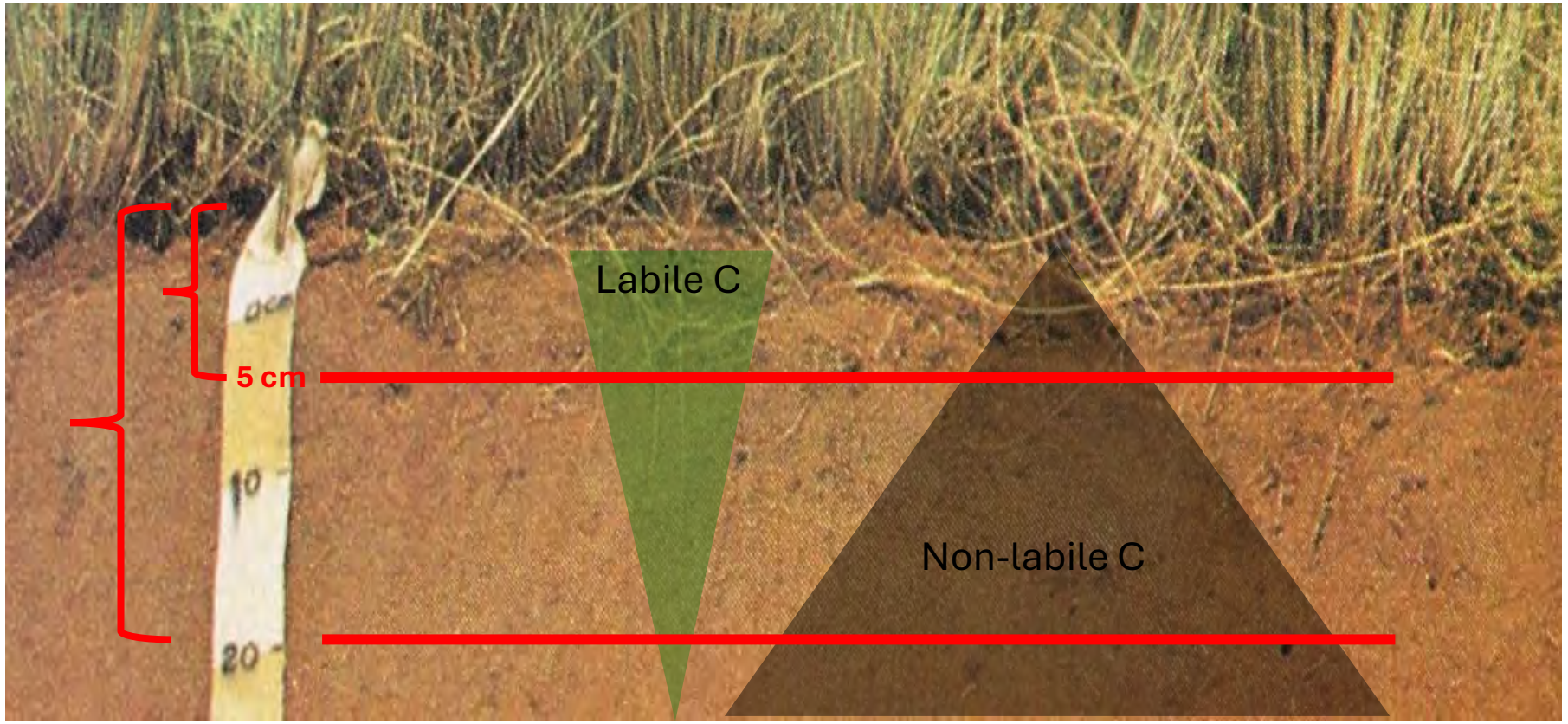
Factors affecting the Development, Duration and Quantification of Labile Carbon

- Region / Climate
- Temperature
- Water availability
- Slope
- Texture
- Parent material
- Soil pH
- Land use
- Land management for production
- Sampling depth
- Biological activity
- Acidification
- Salinity
- Sodicity



- SOC = Total Soil Organic Carbon
- Labile C / SOC = Carbon ratio

Effect of Sampling Depth on Quantification of Carbon Pools



Summary of Factors affecting Labile Carbon

Labile carbon decrease with an increase in:

- Temperature
- Sampling depth
- pH
- Alleviation (higher position in the landscape)

Labile carbon increase with an increase in:

- Rainfall
- Clay content
- Organic matter
- Decomposers of organic matter

Land management

Effect of Land Management on Soil Carbon

Long term storage of Carbon in soil or Carbon sequestration

- Labile C can be used to gauge the impact of a recent change in land use on SOM. However, to benefit from carbon sequestration and carbon credits we should be looking at a stable form of carbon.
- About 2 500 years ago, farmers in the Amazon improved their soils with charcoal to depths > 1m. Portuguese settlers named this *terra preta*, or “black earth.”

Routes to obtain stable C for long term storage

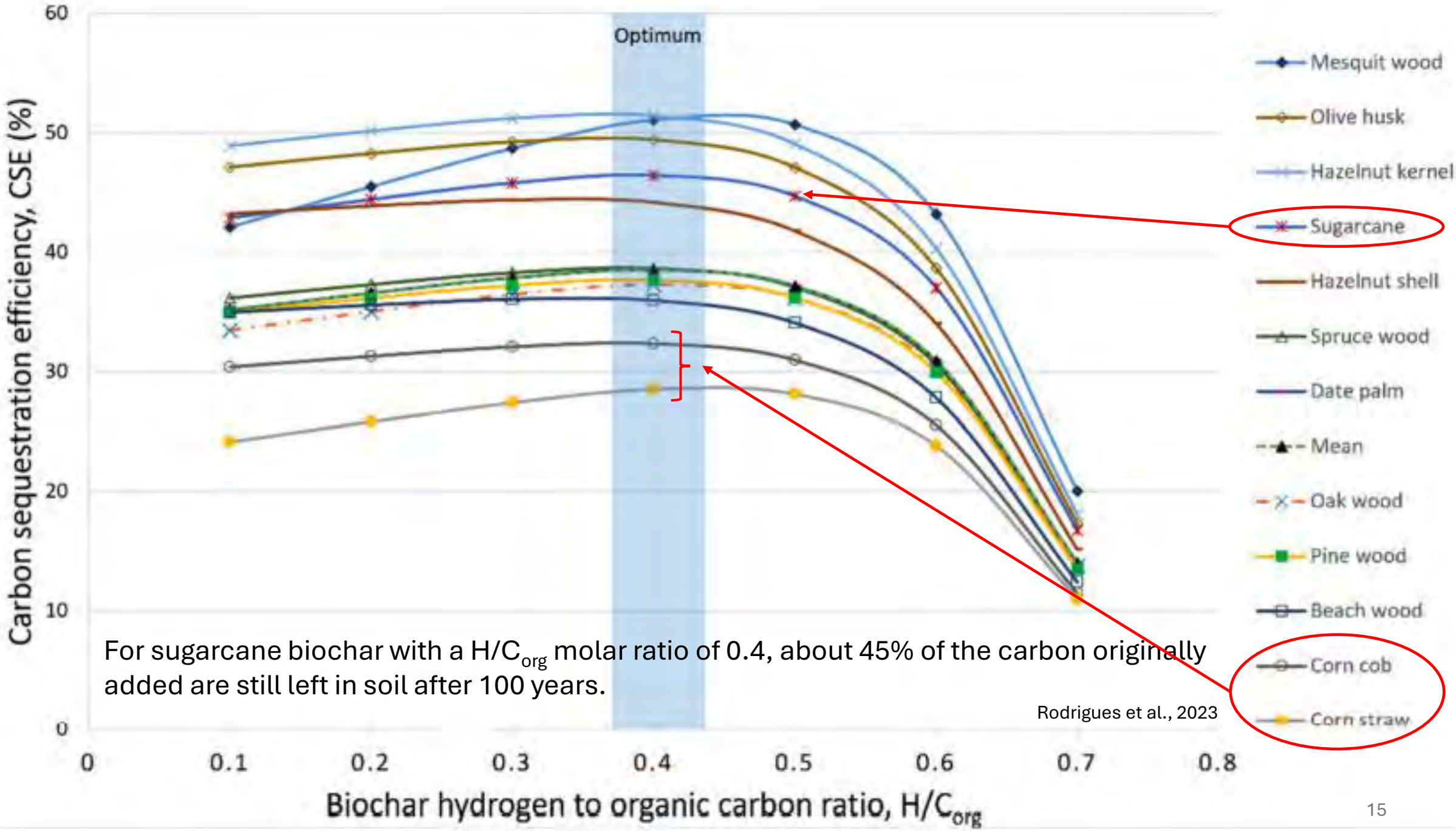
- **Natural process:** Plant residue decompose to produce various C pools with different sequestration times. E.g. Dissolved OM (minutes to days), Labile C (2-50 yrs), Humus (10s-100s yrs) and Biochar (100s-1000s yrs).

Dry humic acid

- **Anthropogenic process:** This refers to converting organics into charcoal (biochar) after partial extraction of the energy (heat and oils) through pyrolysis. Sequestration potential of C as biochar can range from about 100s to 1000s of years.

Charcoal

- **Question:** Can sugarcane be used as a source of biochar?



For sugarcane biochar with a H/C$_{org}$ molar ratio of 0.4, about 45% of the carbon originally added are still left in soil after 100 years.

Rodrigues et al., 2023

Improving soil C for long-term storage

An alternative method of C sequestration
Long-term storage of C above ground

- Plants plants are required that will grow very old. Examples are: Welwitschia >3000 years, Redwoods trees >2000 years, Pine trees 100 – 1000 years, Eucalyptus trees 250 years, Wattle trees 15-30 years.