Soil Health and Soil Carbon

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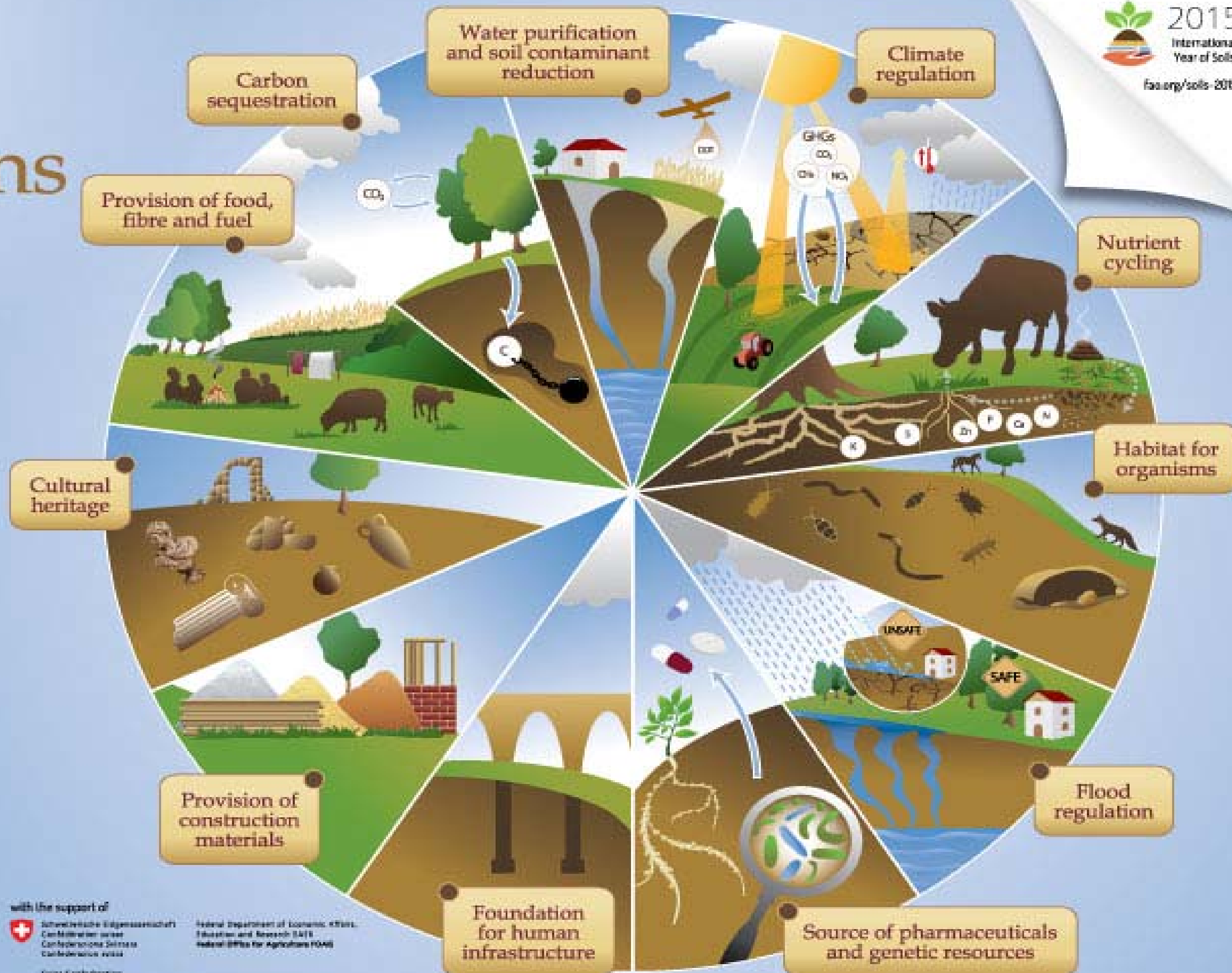
KANSAS STATE
UNIVERSITY

Soil
functions

2015
International Year of Soils
fao.org/soils-2015

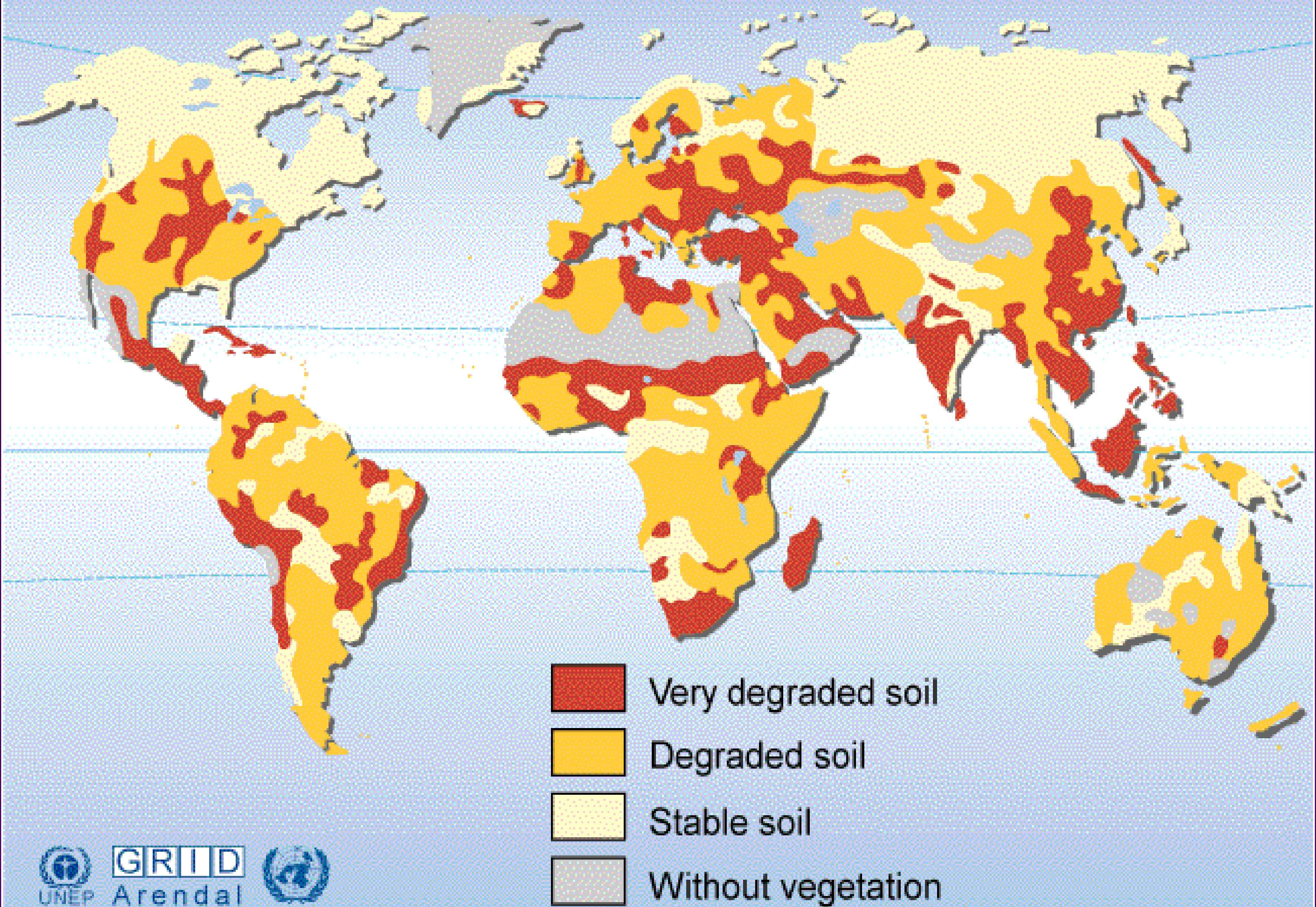
Soils deliver ecosystem services that enable life on Earth



Food and Agriculture Organization of the United Nations

with the support of

Soil degradation



Soil degradation and its impact on other systems (hydrosphere, atmosphere, biosphere)

- Erosion
- Decline in organic matter
- Contamination (local and diffuse)
- Paving
- Compaction
- Loss of biodiversity
- Salinization
- Floods and landslides




Soil loss in 2017

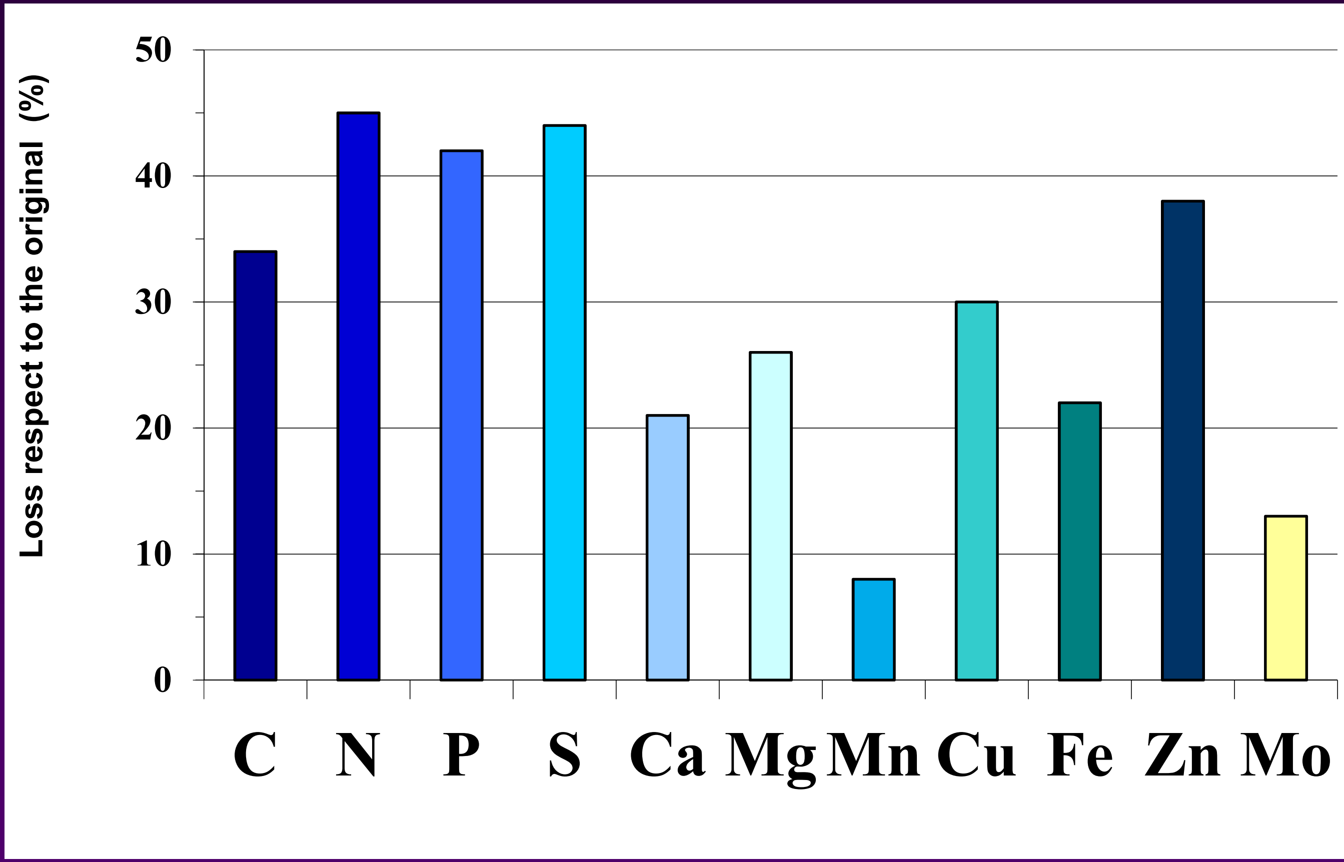
- **National average erosion ~2-5 tons/acre/year**
- **Rate of formation is ~0.1 to 0.5 ton/acre/year**
- **Some regions lose soil at 30-40 tons/acre/yr**
- **In years of severe weather, areas of Iowa suffer losses of 100 tons/acre/yr**
- **One year, thousands of acres in Iowa lost 50 tons/acre <u>in one storm</u>**

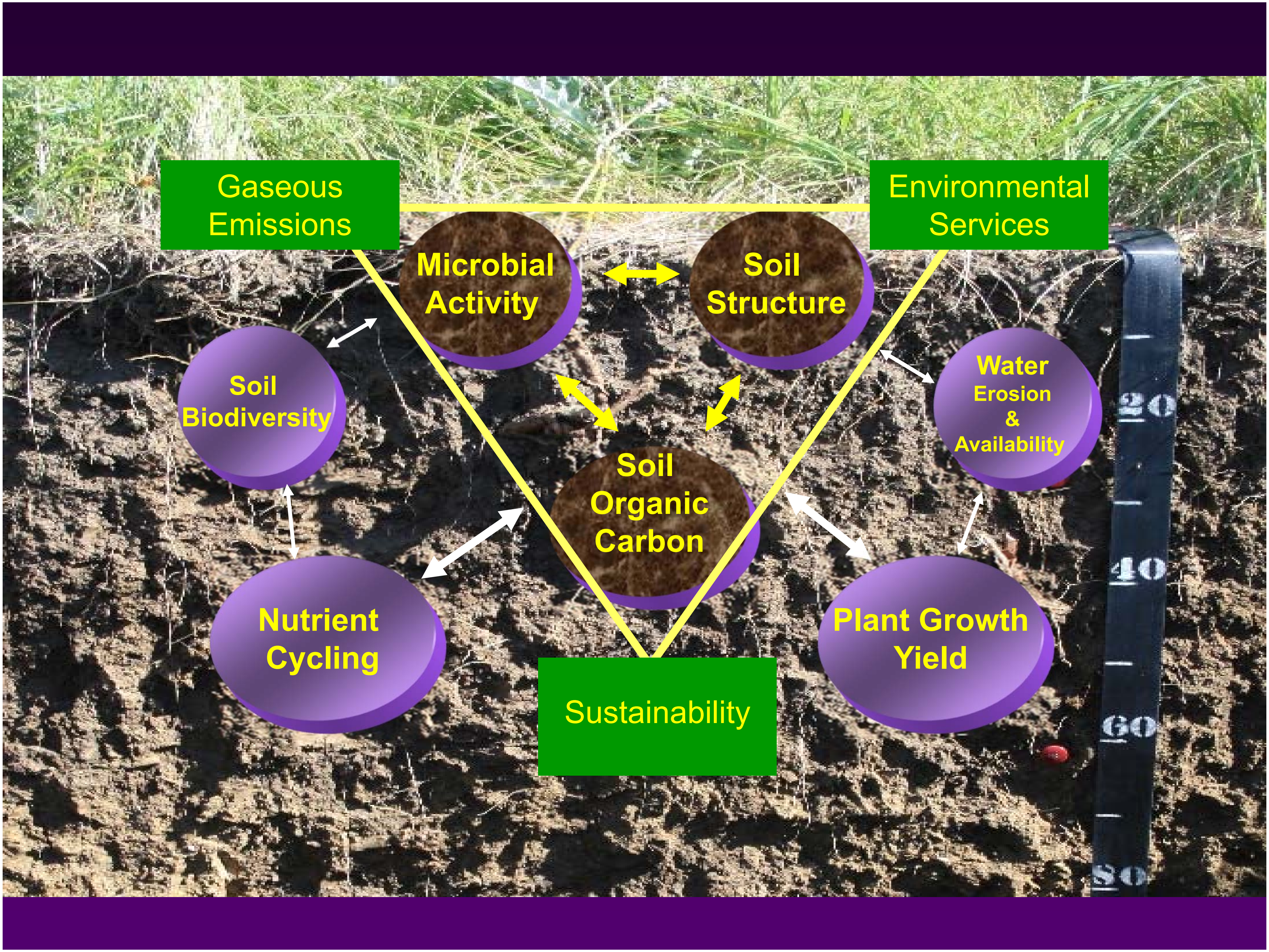
Soil degradation in the Pampean Region of Argentina

Nutrient losses after 80 years of continuous agriculture

Pergamino series — Typic Argiudoll

Source: Andriulo, Galantini y Abrego (1996)





Gaseous Emissions
Environmental Services
Microbial Activity
Soil Structure
Soil Biodiversity
Water Erosion & Availability
Soil Organic Carbon
Nutrient Cycling
Plant Growth Yield
Sustainability
20
40
60
80

Increased Soil Health

- Higher soil organic carbon
- Better soil structure
- Greater microbial activity

- Greater resilience
  - Water
  - Nutrients
- Lower economic risks

- **Less soil degradation**

Inherent soil differences vs differences due to management.

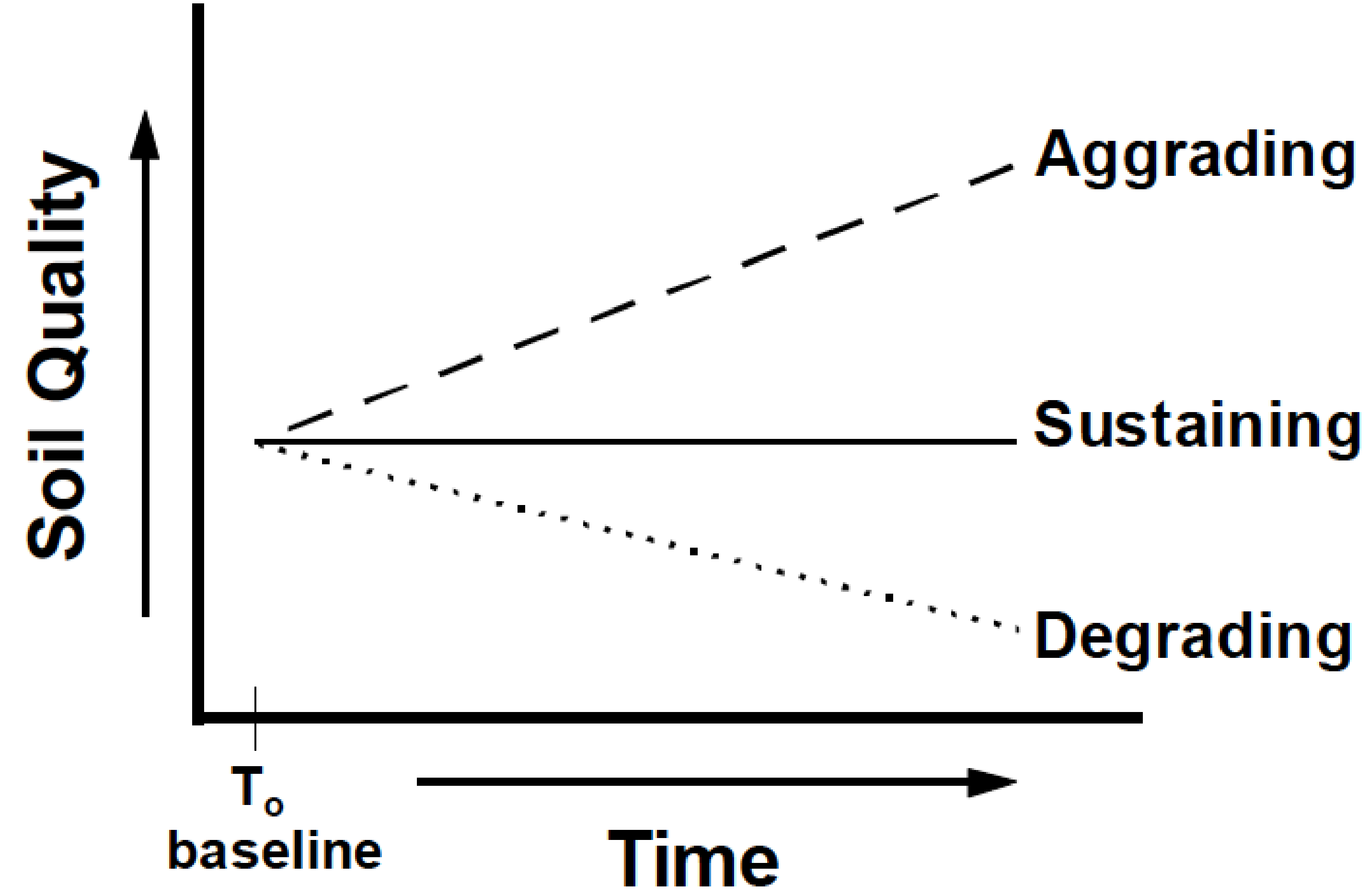


Fig. 2. Conceptualization of dynamic soil quality trends from time zero (T_0). Adapted from Seybold et al., 1998.

Use of "baseline conditions" to assess response of soil to subsequent soil management decisions.

From Karlen et al. 2008

Keys to Future **Systems**

- Focus on Soil Health

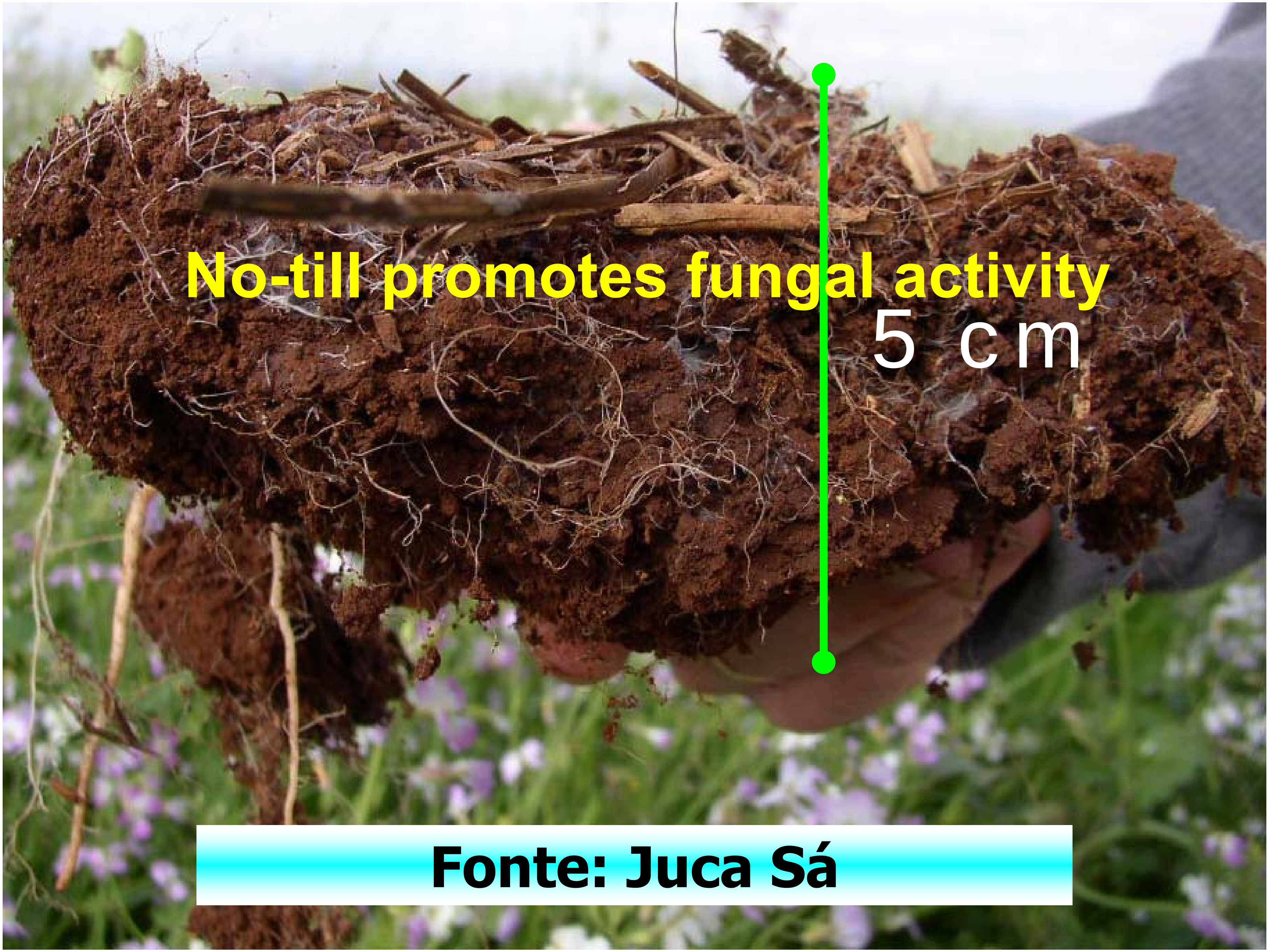
- Intensify Systems:
  - Fertilizer, water and energy management
    - **Efficiency not inputs**
  - Crop rotations

- Diversify Systems:
  - Plant rotation and management

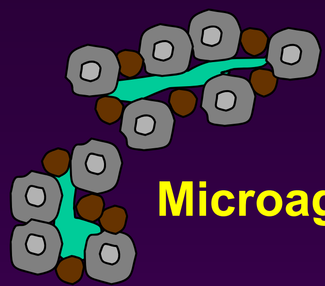
No-Tillage Cropping Systems
Conservation Agriculture

- Restores soil carbon
- Conserves moisture
- Saves fuel
- Saves labor
- Lowers machinery costs
- Reduces erosion
- Improved soil fertility
- Controls weed
- Planting on the best date
- Improves wildlife habitat


6


No-till promotes fungal activity
5 cm
Fonte: Juca Sá

Conceptual diagram of soil aggregate hierarchy



Microaggregate 20-90 and 90-250 µm

Plant and fungal debris

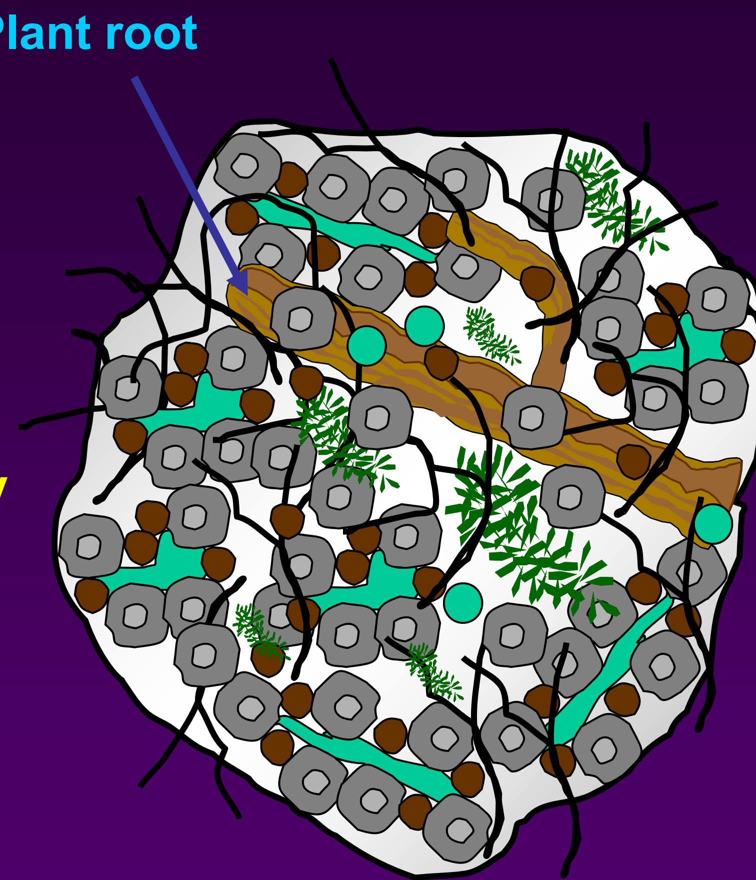
Silt-size microaggregate with microbially derived organomineral associations

Clay microstructures

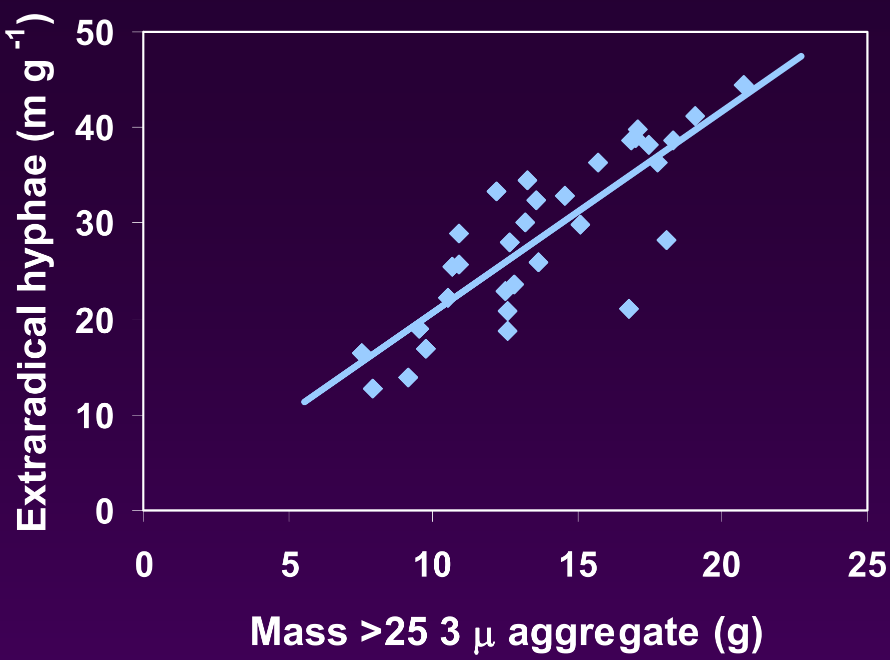
Particulate organic matter colonized by saprophytic fungi

Mycorrhizal hyphe

Pore space; polysaccharides and other amorphous interaggregate binding agents

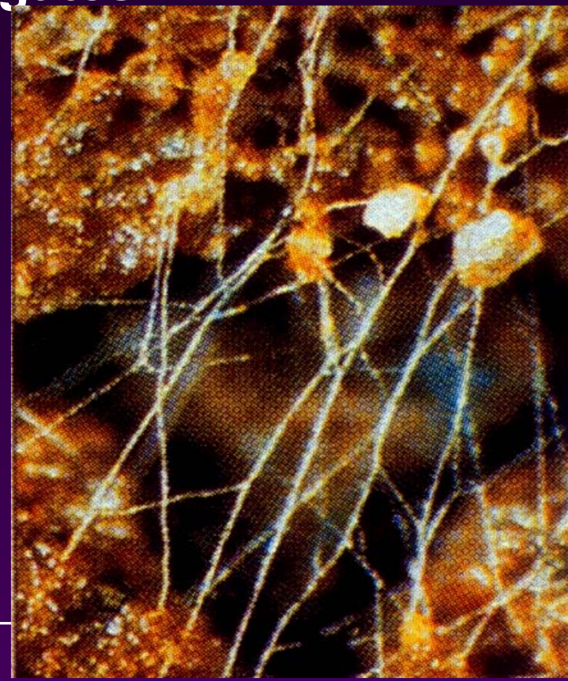


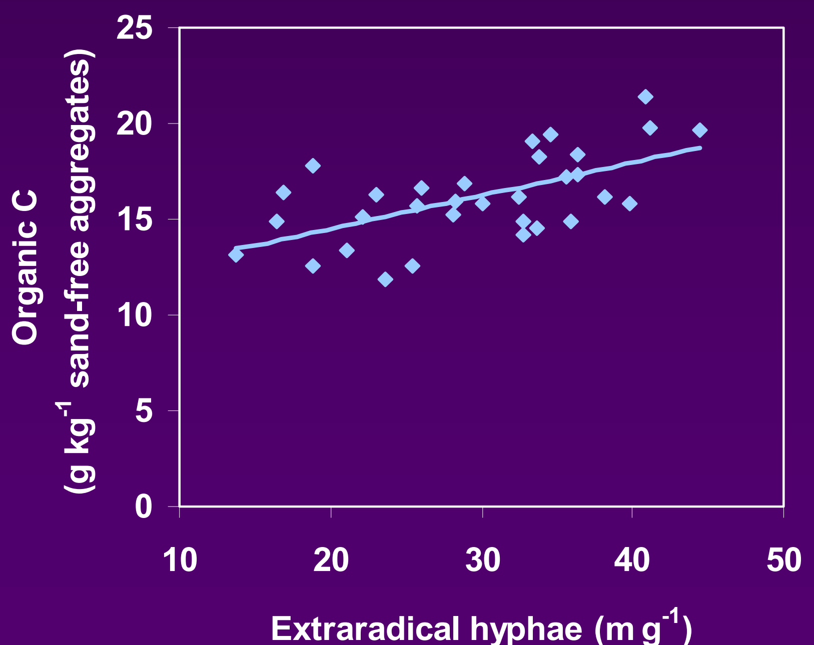
Jastrow & Miller 1997



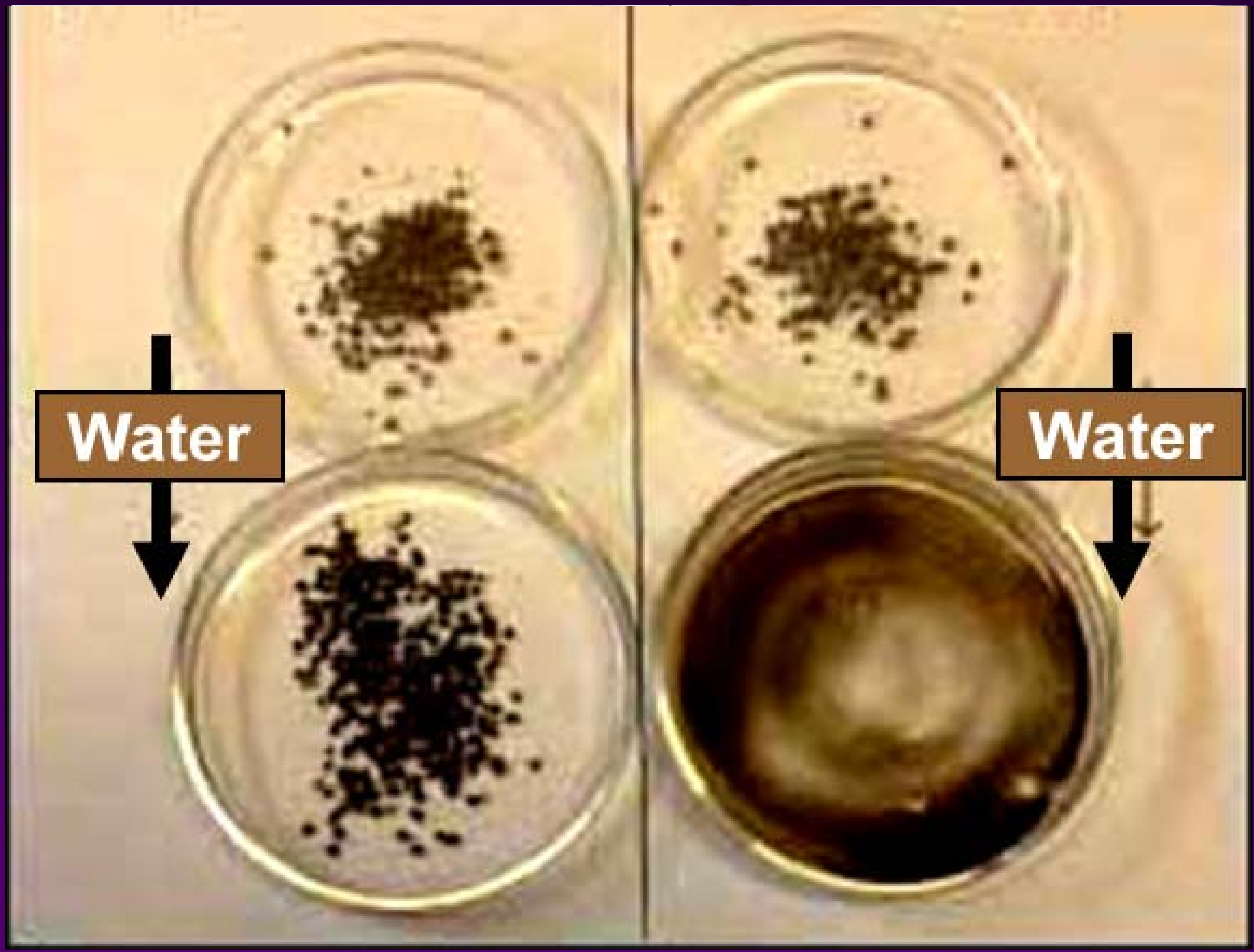
Macroaggregates

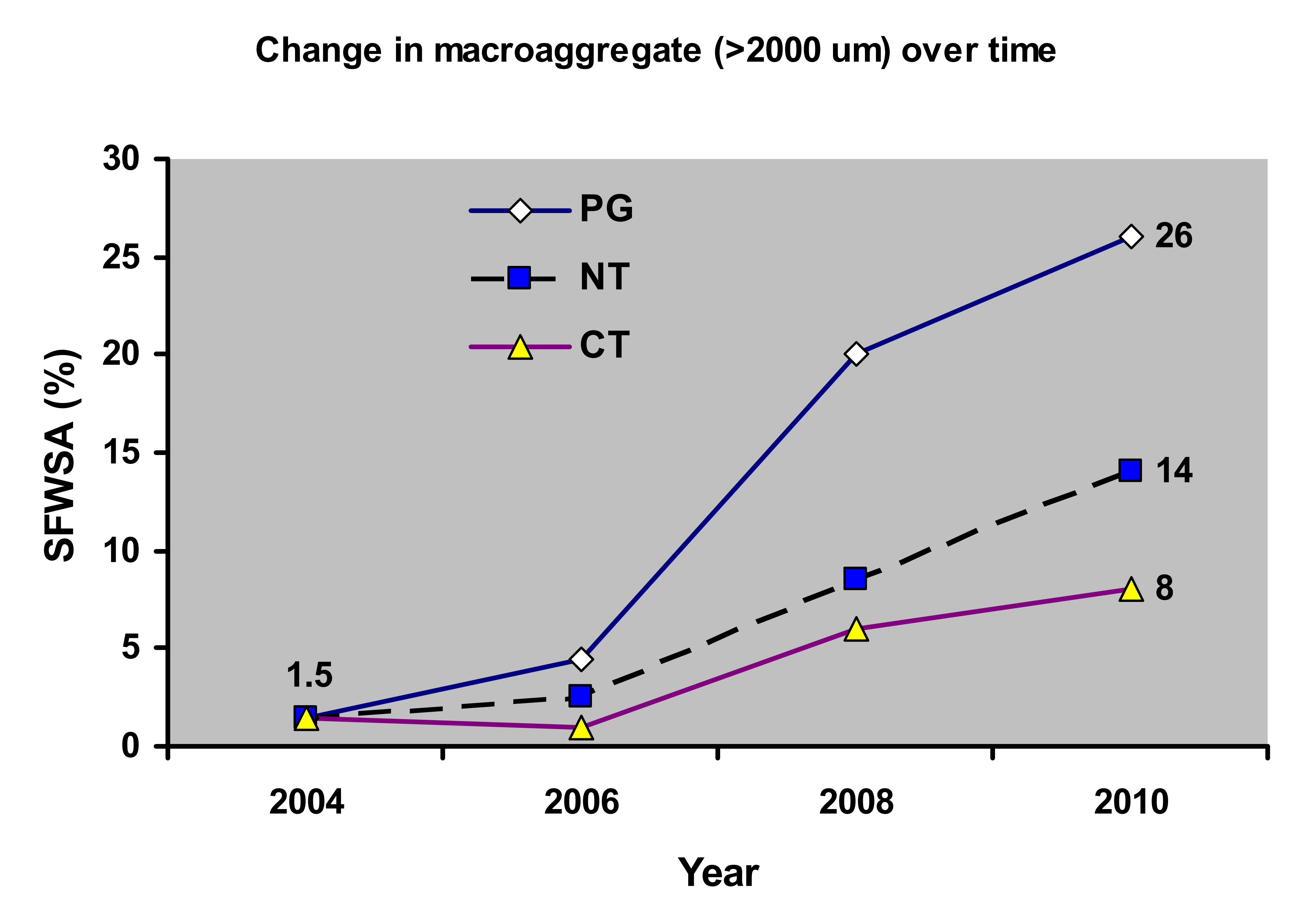
$P < 0.0001$
$r^2 = 0.834$





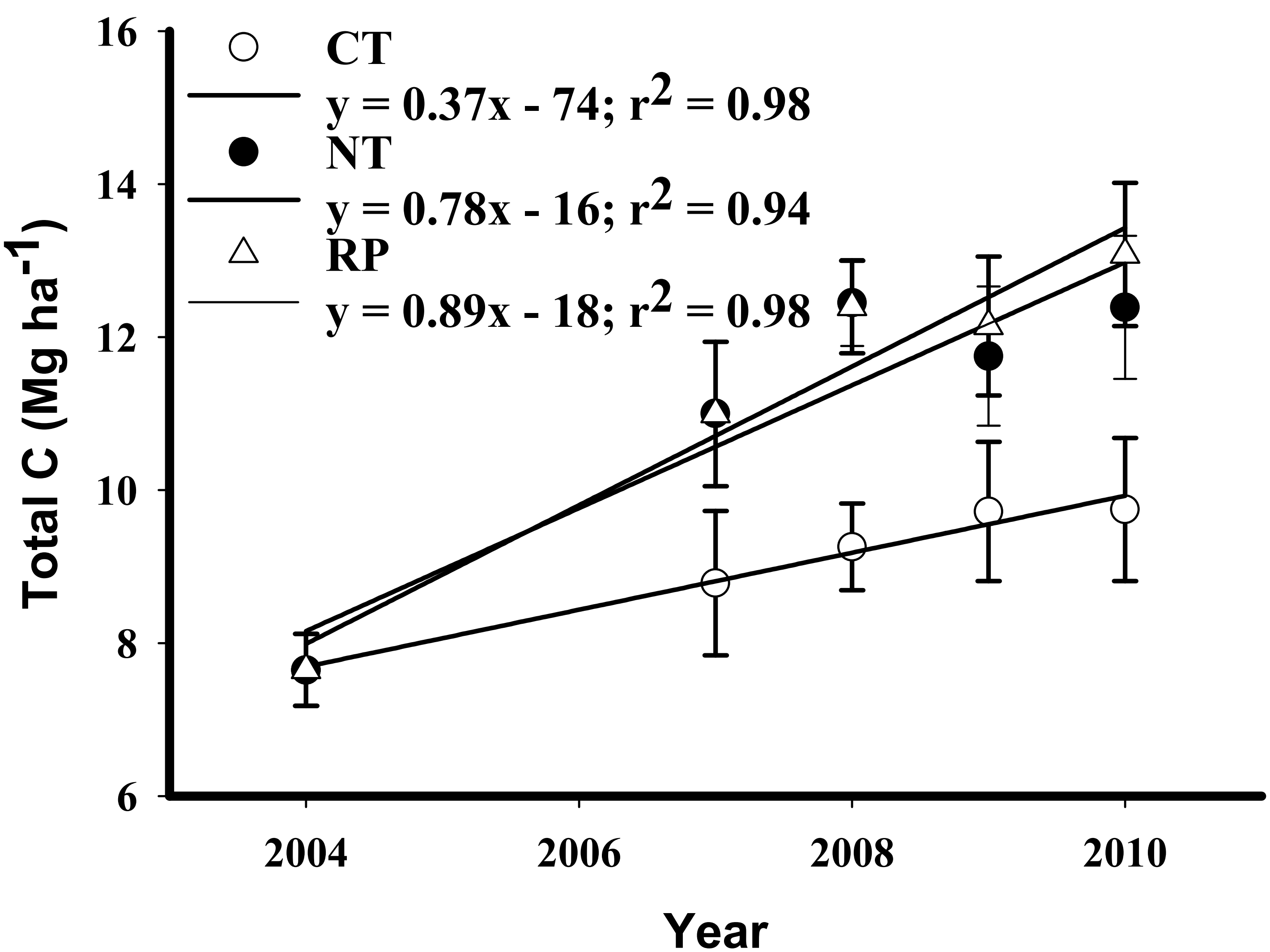
Fungal activity promotes aggregate stability





PG: prairie grass (big bluestem); NT: No-till sorghum; CT: Conventional till sorghum.
SFWSA: sand-free water stable aggregate (Mfombep and Rice 2014)

Ecosystem SOC sequestration rate (0-5 cm)



(Mfombep 2013)

Management Strategies for C Sequestration

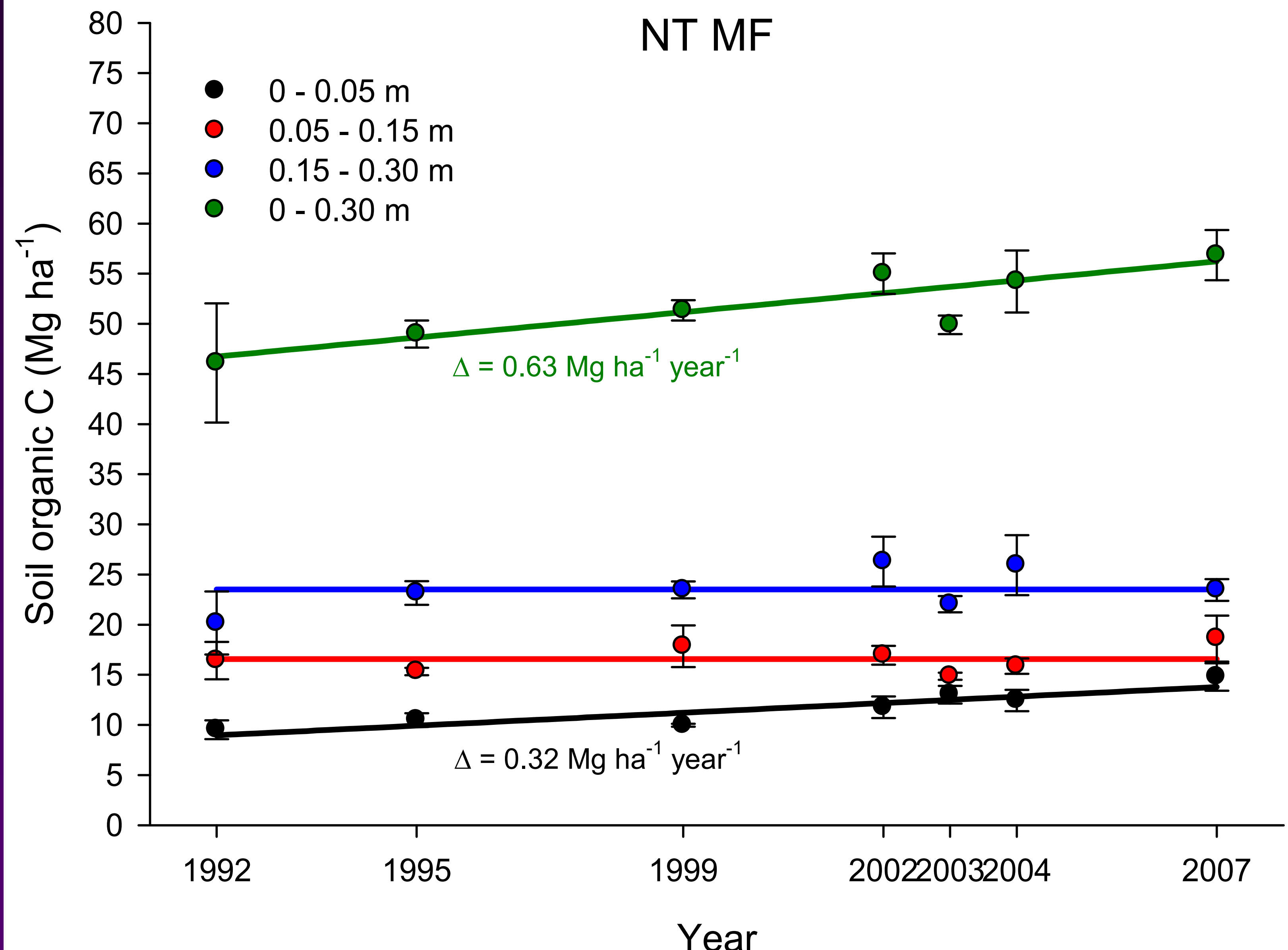
Develop Management Programs that:

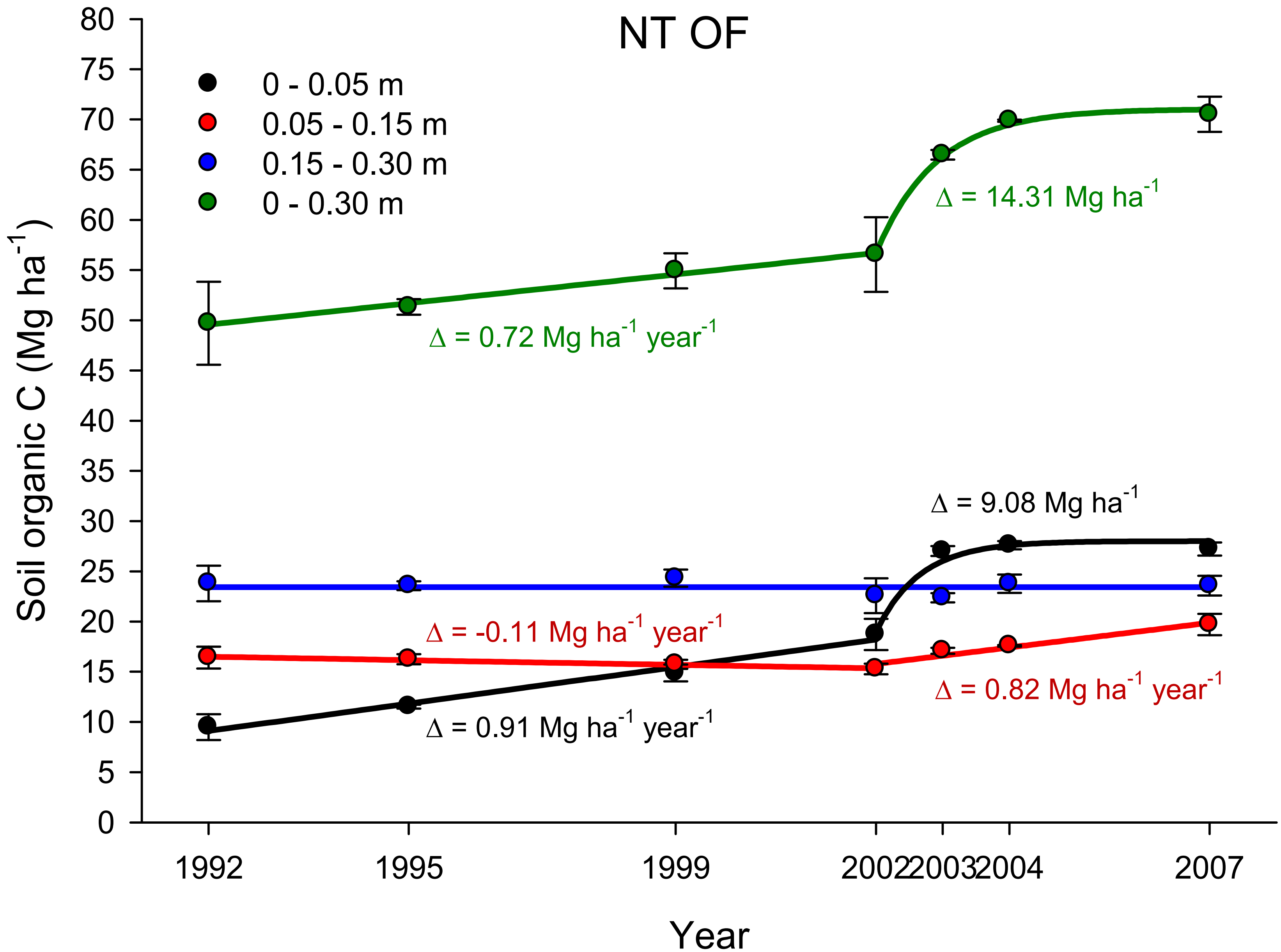
Enhance C Inputs

- **Crop Management**
- **Crop Selection**
- **Crop Rotations**

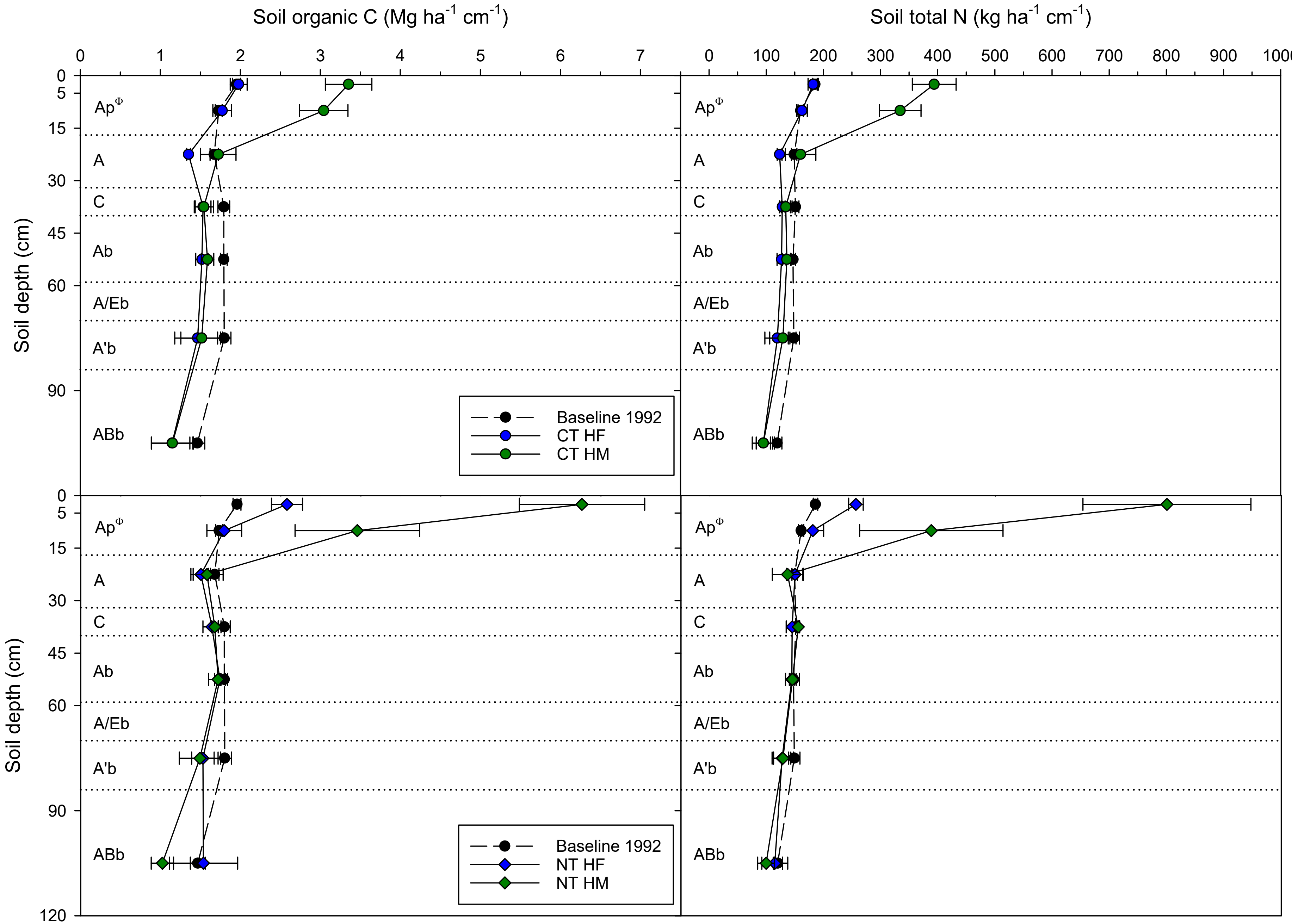
Reduce C losses

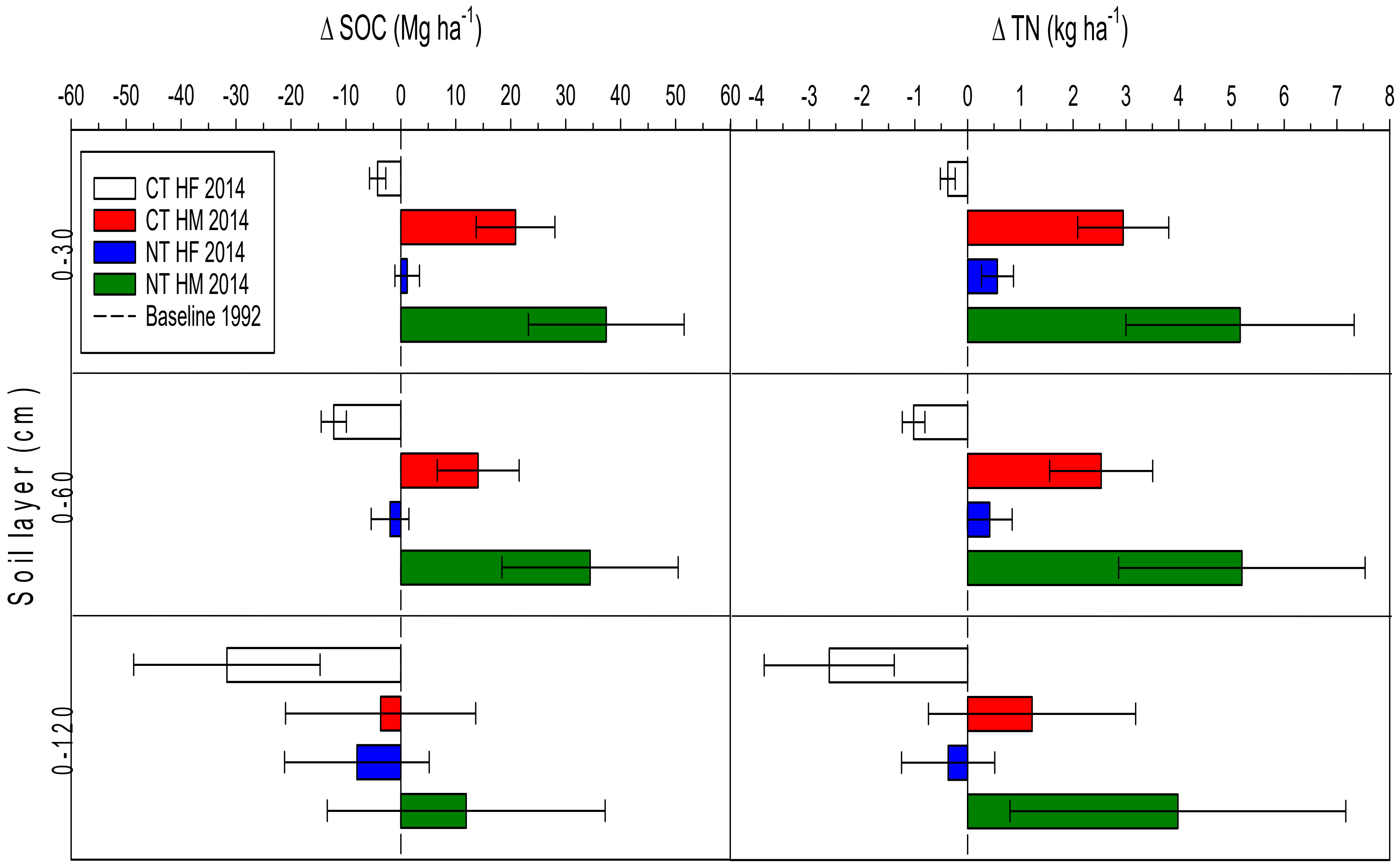
- **Tillage**
- **Fallow Management**


NT MF
Soil organic C (Mg ha-1)
Year
0 - 0.05 m
0.05 - 0.15 m
0.15 - 0.30 m
0 - 0.30 m
Δ = 0.63 Mg ha-1 year-1
Δ = 0.32 Mg ha-1 year-1
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
1992
1995
1999
2002
2003
2004
2007

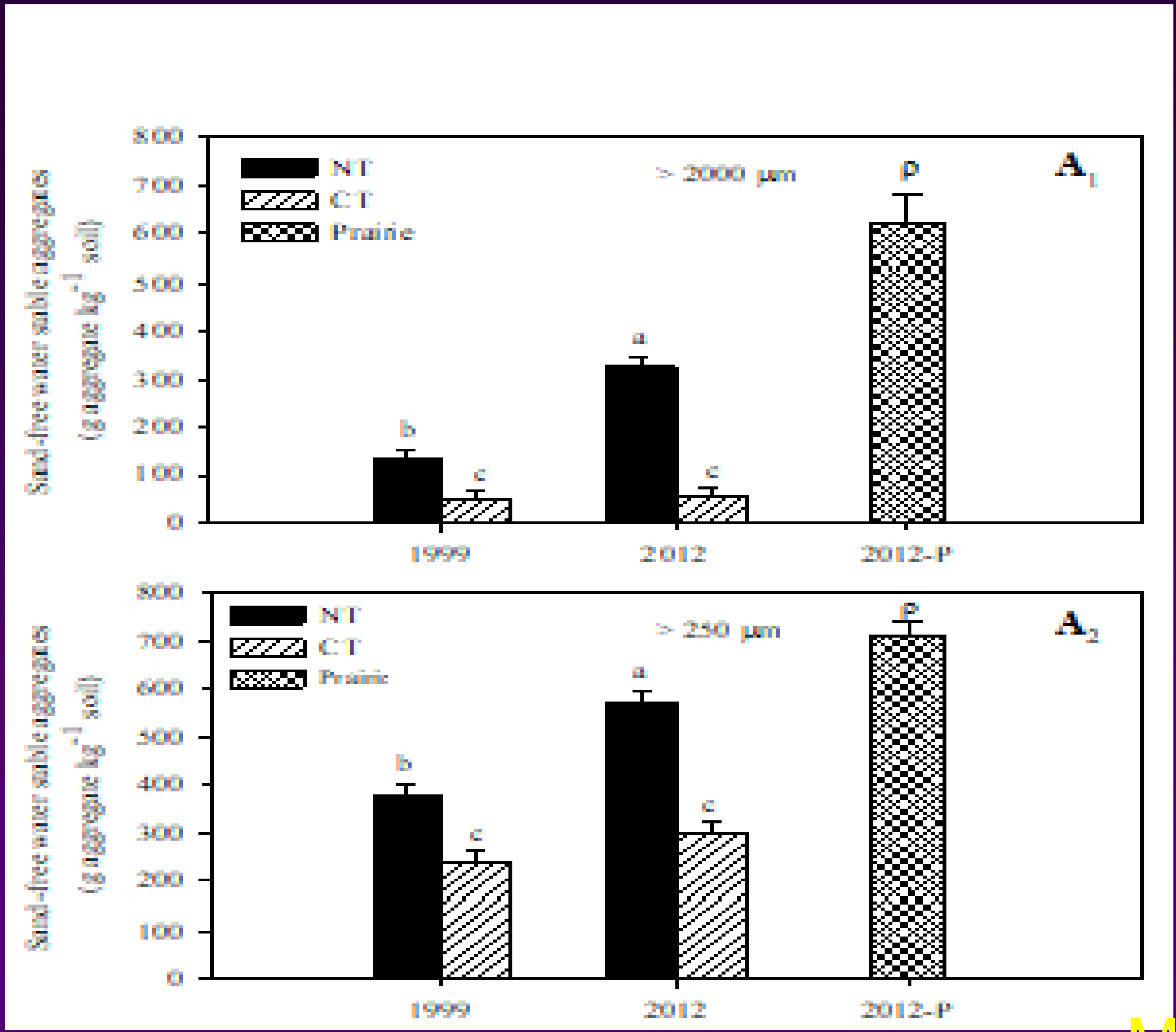

NT OF
0 - 0.05 m
0.05 - 0.15 m
0.15 - 0.30 m
0 - 0.30 m
Δ = 14.31 Mg ha-1
Δ = 0.72 Mg ha-1 year-1
Δ = 9.08 Mg ha-1
Δ = -0.11 Mg ha-1 year-1
Δ = 0.82 Mg ha-1 year-1
Δ = 0.91 Mg ha-1 year-1
Soil organic C (Mg ha-1)
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
1992
1995
1999
2002
2003
2004
2007
Year

SOC and TN stocks.

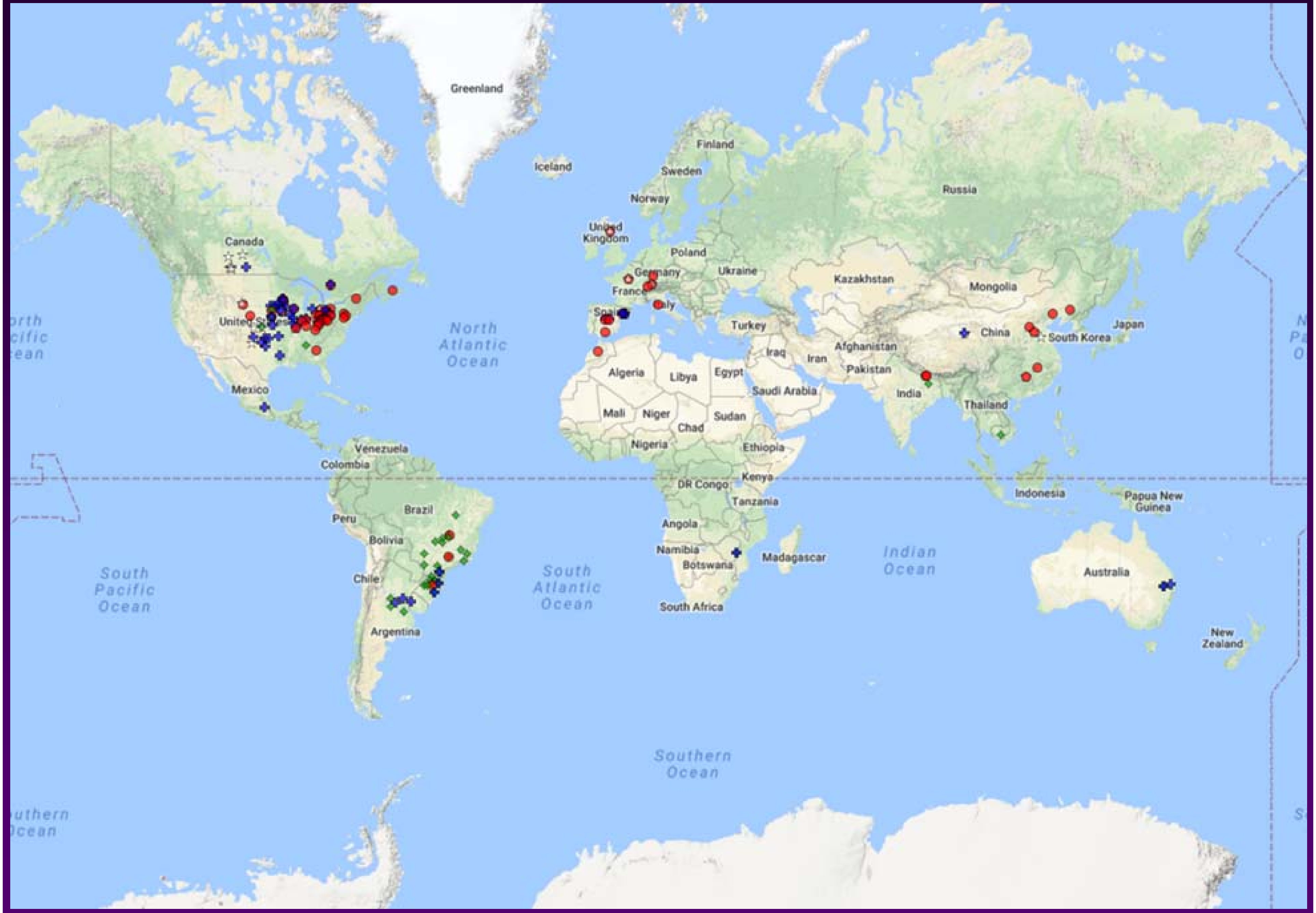



Δ SOC (Mg ha-1)
Δ TN (kg ha-1)
-60 -50 -40 -30 -20 -10 0 10 20 30 40 50 60
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8
CT HF 2014
CT HM 2014
NT HF 2014
NT HM 2014
Baseline 1992
Soil layer (cm)
0-30
0-60
0-120

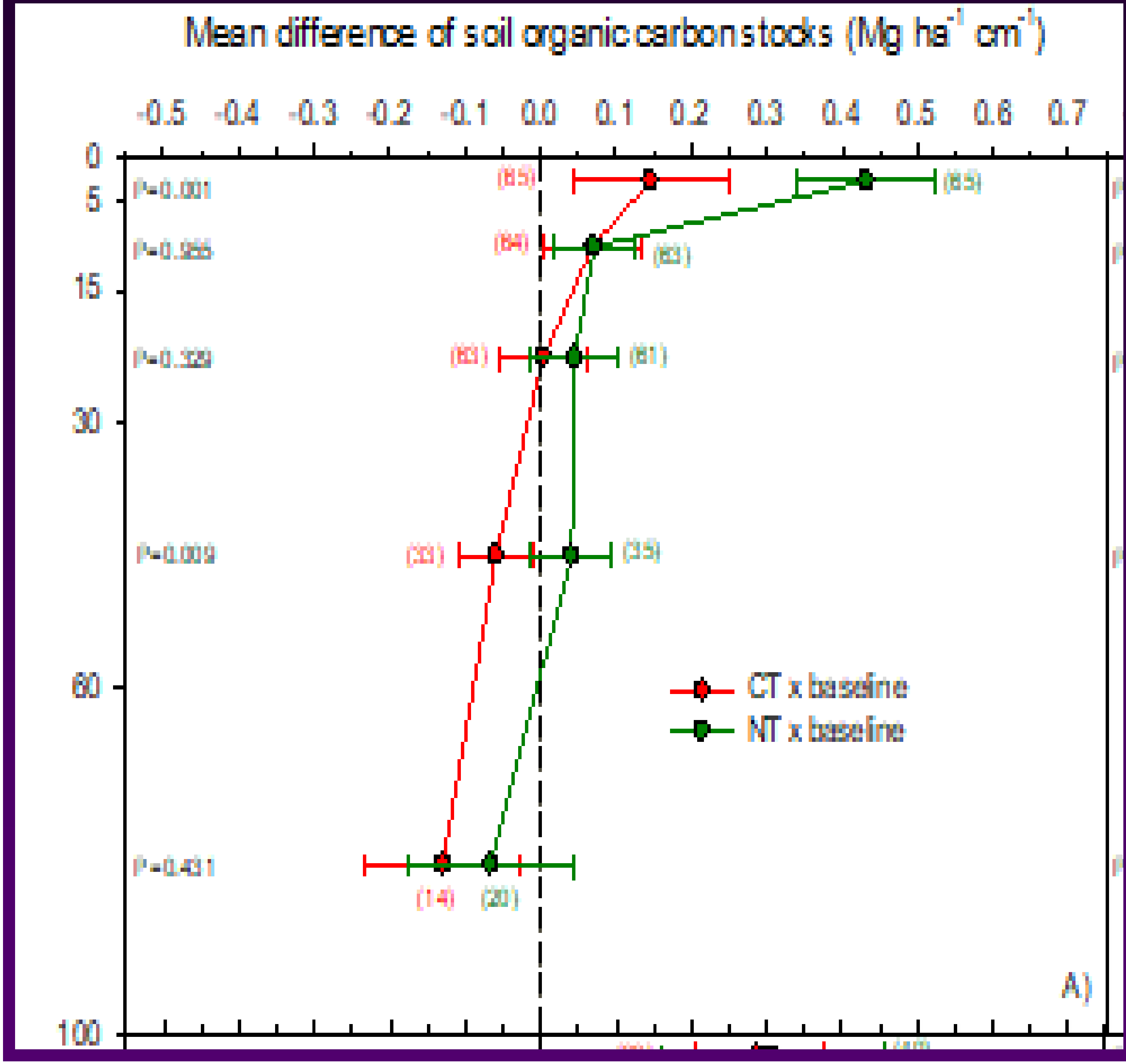
Water stable aggregates between 10 and 22 yrs of management



Mika et al.

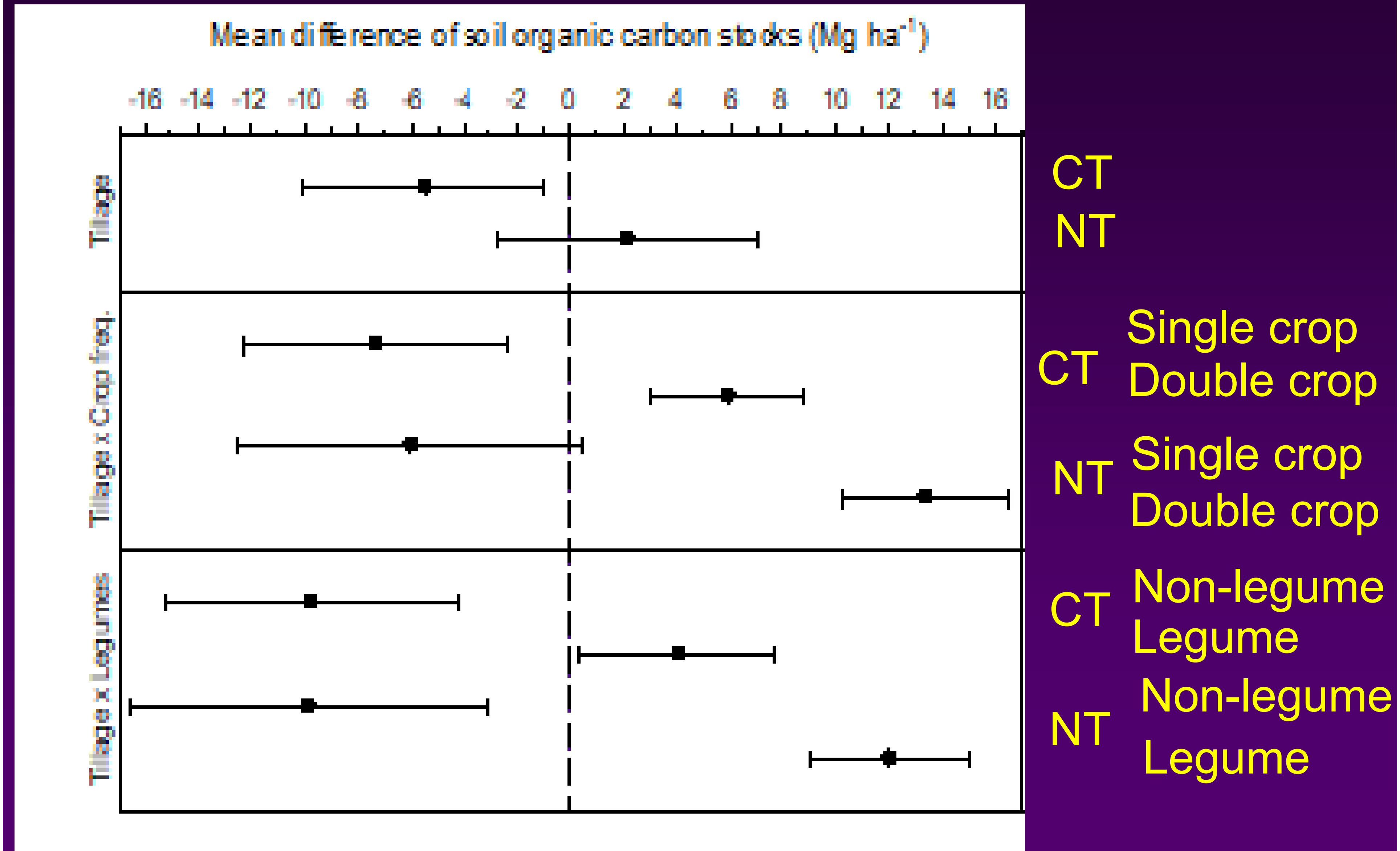


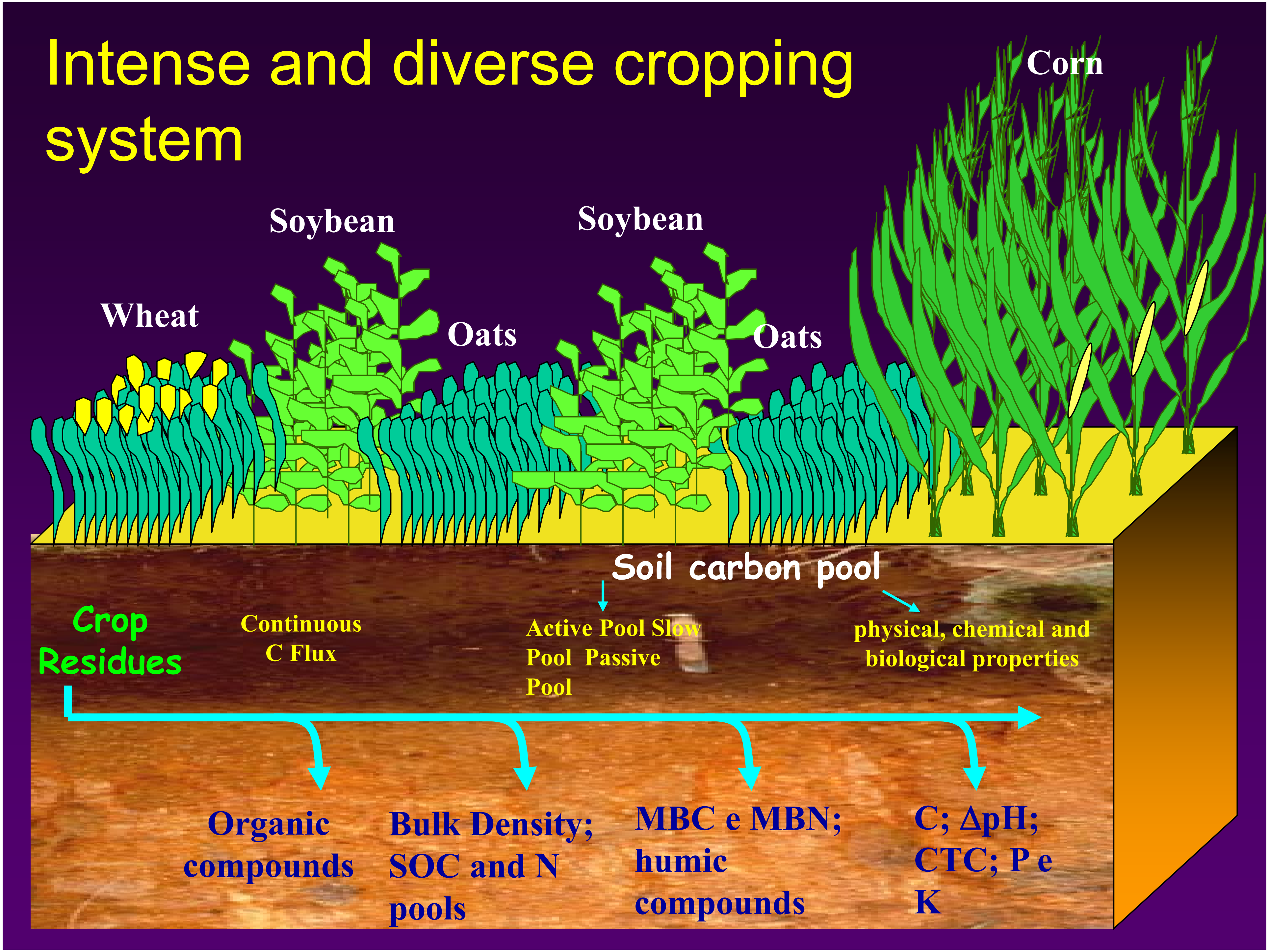
Greenland
Iceland
Finland
Sweden
Norway
Russia
United Kingdom
Poland
Canada
Germany
Ukraine
Kazakhstan
Mongolia
France
Italy
Spain
United States
Turkey
China
Japan
South Korea
North Atlantic Ocean
Iraq
Iran
Afghanistan
Pakistan
Algeria
Libya
Egypt
India
Mexico
Saudi Arabia
Thailand
Mali
Niger
Sudan
Chad
Nigeria
Ethiopia
Venezuela
Colombia
Kenya
DR Congo
Tanzania
Indonesia
Papua New Guinea
Brazil
Peru
Angola
Bolivia
Namibia
Botswana
Madagascar
Indian Ocean
Australia
South Pacific Ocean
South Atlantic Ocean
Chile
South Africa
Argentina
New Zealand
Southern Ocean



Change in C relative to a baseline.

Mean differences of soil organic carbon stocks in agricultural soils according to tillage system (a, b), crop frequency (c, d), and use of legumes (e, f) as compared pretreatment baselines in the cumulative 0-100 cm soil layer





Intense and diverse cropping system
Corn
Soybean
Soybean
Wheat
Oats
Oats
Soil carbon pool
Crop Residues
Continuous C Flux
Active Pool Slow Pool Passive Pool
physical, chemical and biological properties
Organic compounds
Bulk Density; SOC and N pools
MBC e MBN; humic compounds
C; ΔpH; CTC; P e K

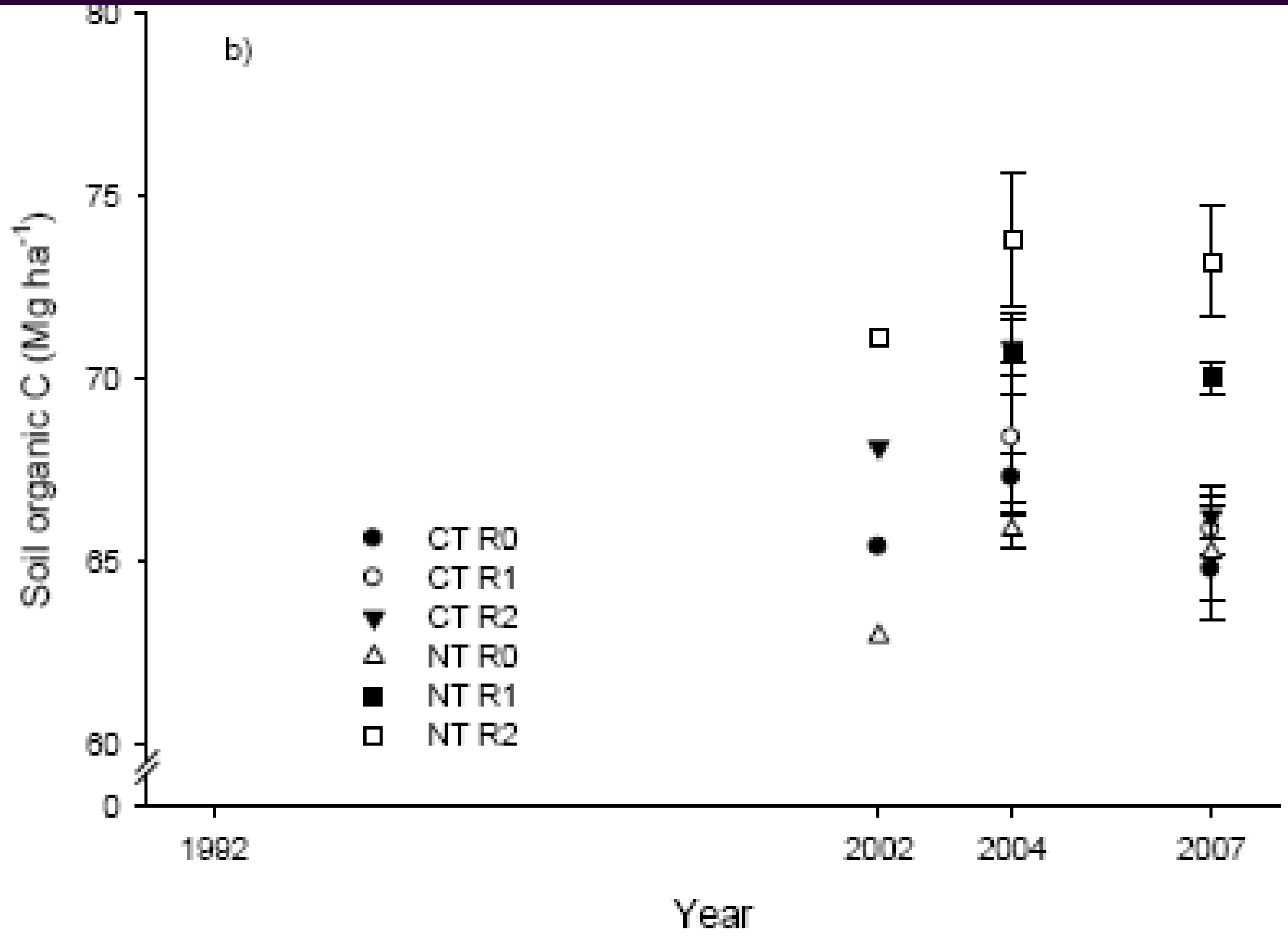
Oxisol

Table 2.4. Average annual aboveground carbon input to the soil between 1985 and 2007 as affected by no-tillage (NT), conventional tillage (CT), and crop rotations (R0 and R2).

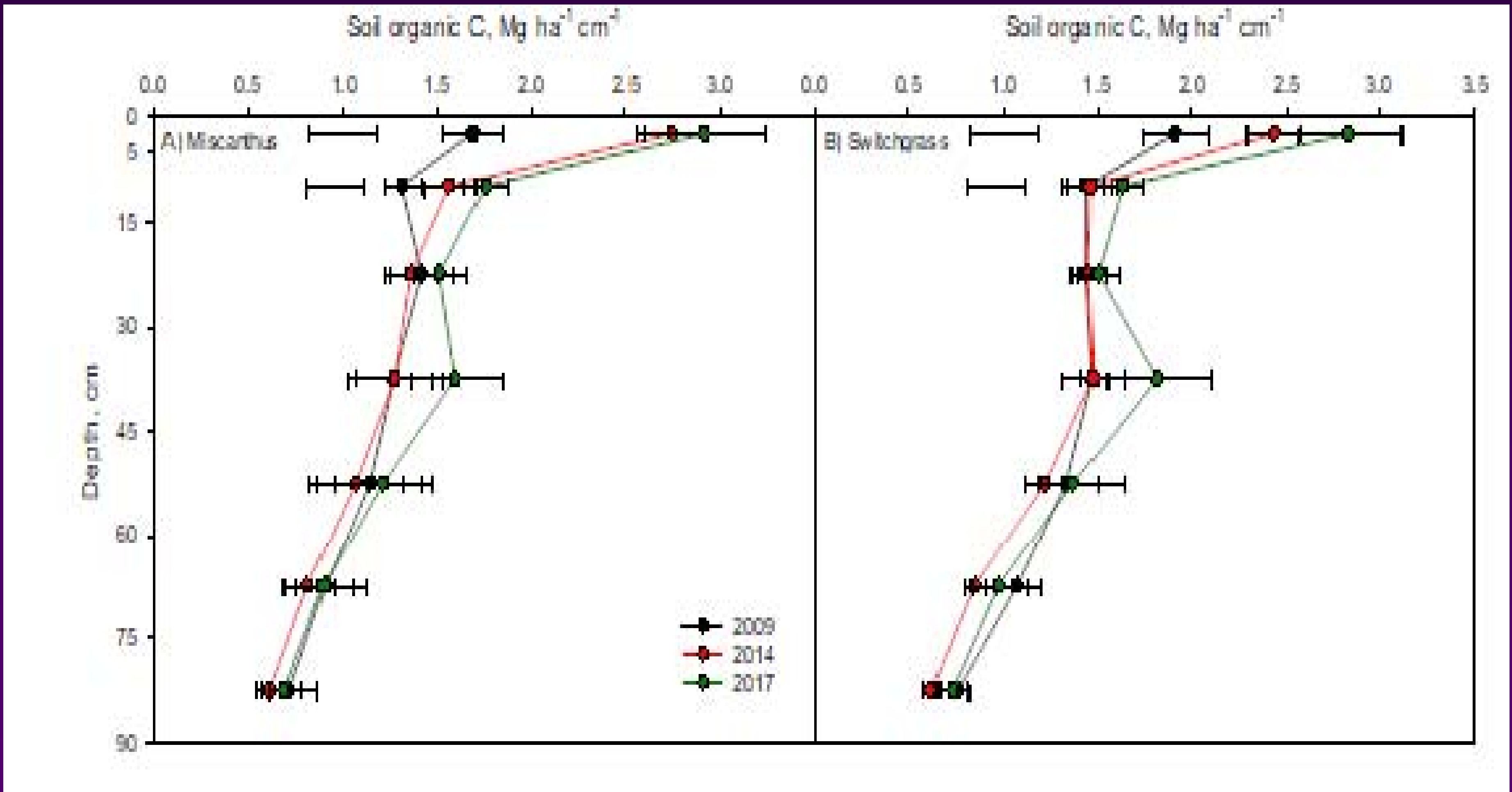
Source	CT R0	CT R1	CT R2	NT R0	NT R1	NT R2
	------------------------------------- Mg ha^{-1} y^{-1} -------------------------------------					
Soybean	2.36	2.87	2.53	2.57	2.57	2.80
Wheat	1.23	1.73	1.43	1.34	2.00	1.58
Oat	-	2.21	2.12	-	2.63	2.46
Corn	-	-	3.84	-	-	4.68
Oat+Vetch	-	-	2.61	-	-	2.94
Radish	-	-	1.51	-	-	1.51
Total	3.59	4.84	5.31	3.91	4.88	6.05

[1] Means with different letters between nitrogen sources within corn or total C inputs are significantly different (Tukey test, P<0.05). R0: soybean/wheat; R1: soybean/wheat/soybean/oat; R2: soybean/oat/soybean/oat+vetch/corn/radish/wheat.

Capítulo 2 – Resultados e discussão



Perennials
Miscanthus and Switchgrass

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