# SOIL USE INTENSITY EFFECTS ON SOIL ORGANIC CARBON IN NO-TILL CROP-PASTURE ROTATION SYSTEMS

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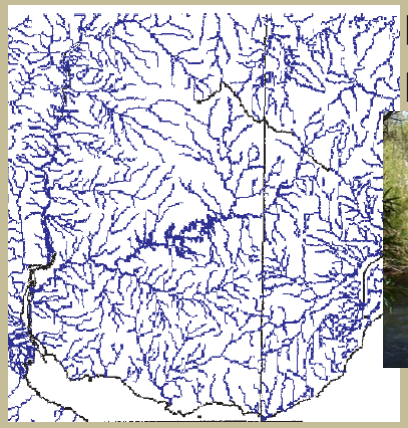
# Intro: Uruguay Location and Climate

- AREA: 176 215 km$^2$.
- Lat. 30-35°S. Long. 53-58°W.
- **Temperate Climate**
  - Annual Rainfall:
    1100mm (±200mm)
    (Similarly distributed)
    (High variability)
  - Mean Temp:
    24°C Summer (± 2°C)
    12°C Winter (± 1.5°C)



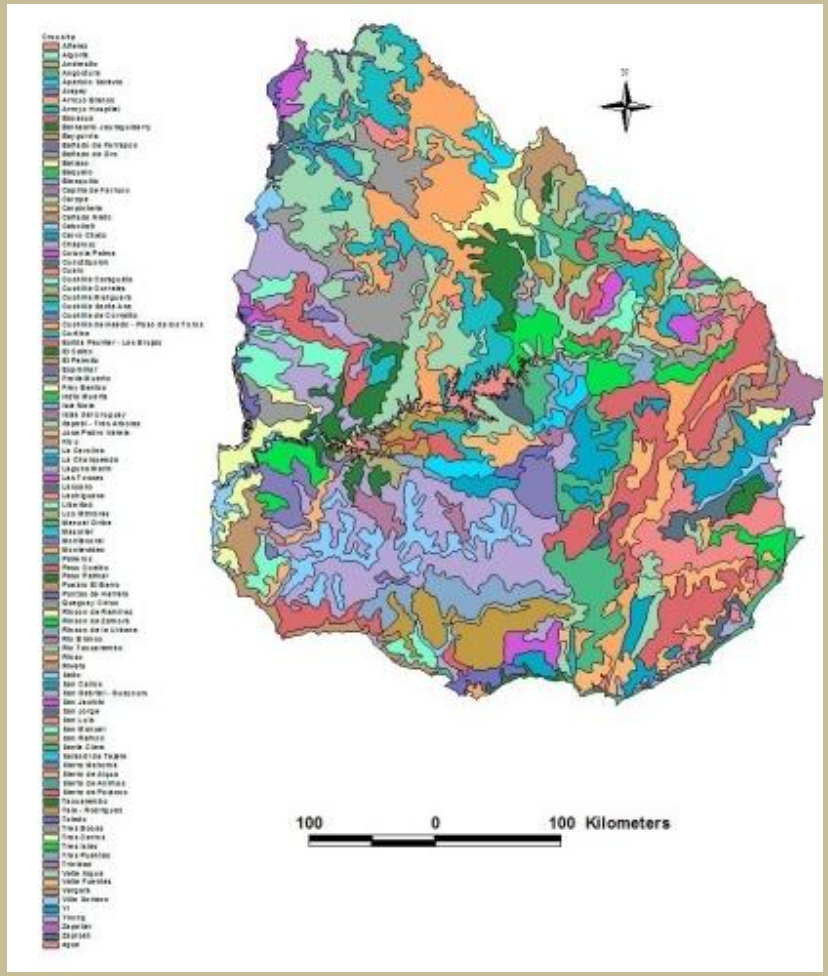



Hydrographic Network

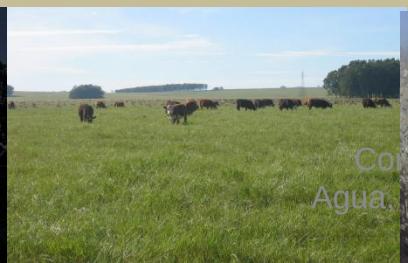
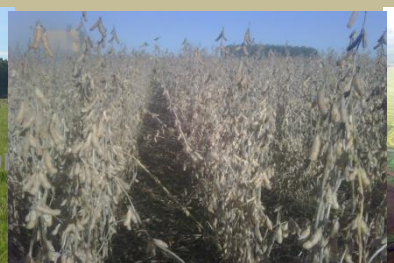
# Intro: Uruguay Ecosystem and Soils

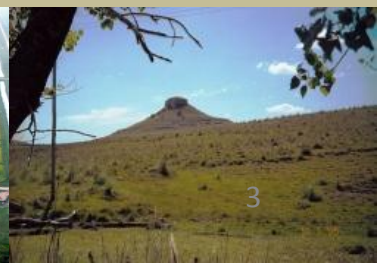
- Ecosystem:
  - Grasslands associated with
  - Riverside shrub forest
- Topography:
  - Rolling Plains
  - Low hills
- Soils (95% agricultural):
  - **Mollisols**
  - **Vertisols**
  - Alfisols
  - Ultisols, Inceptisols,
  - Histosols, Entisols

**65%** of the territory remains under natural grasslands used for beef and wool production under grazing




No Fossil Fuels



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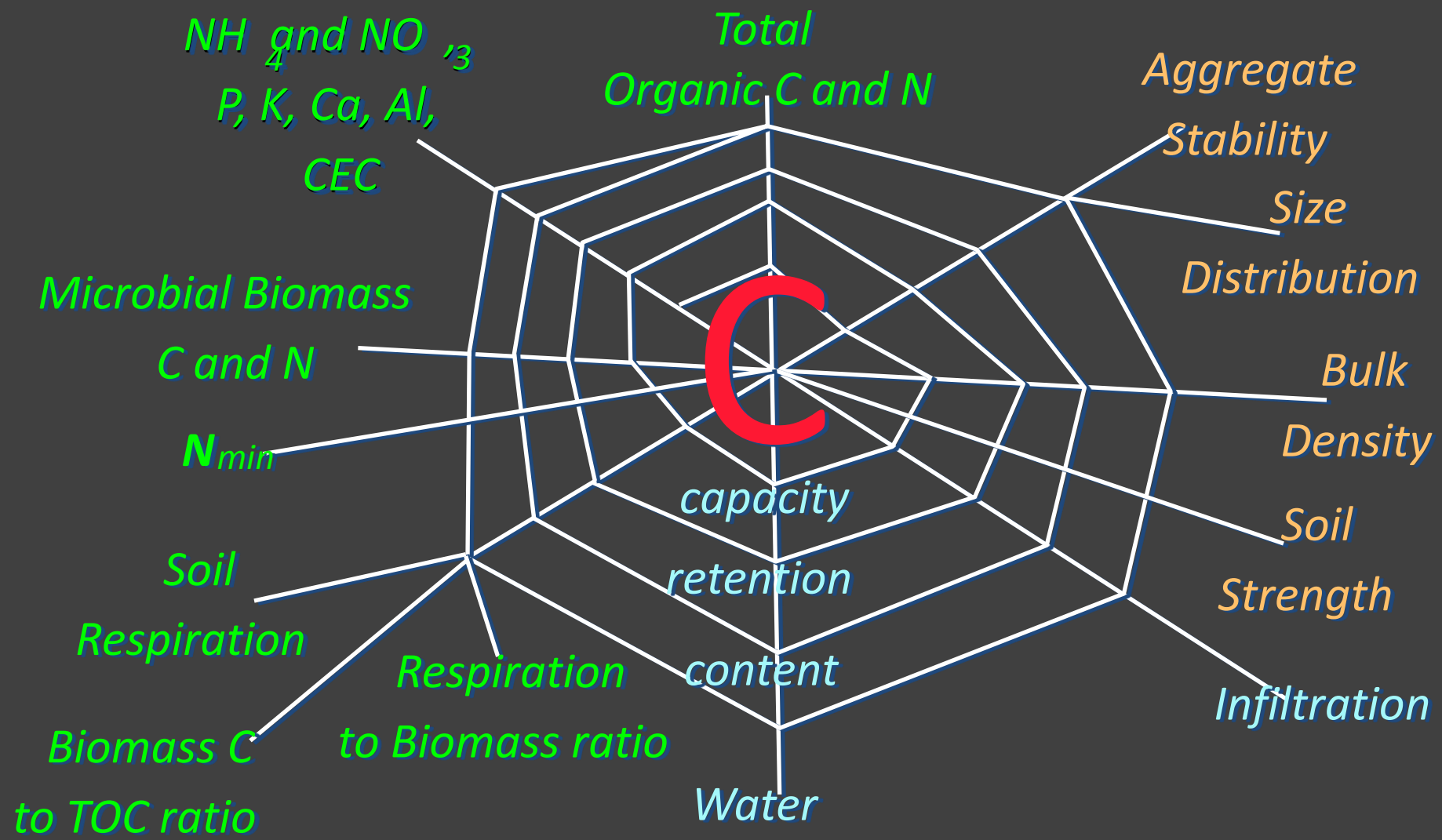
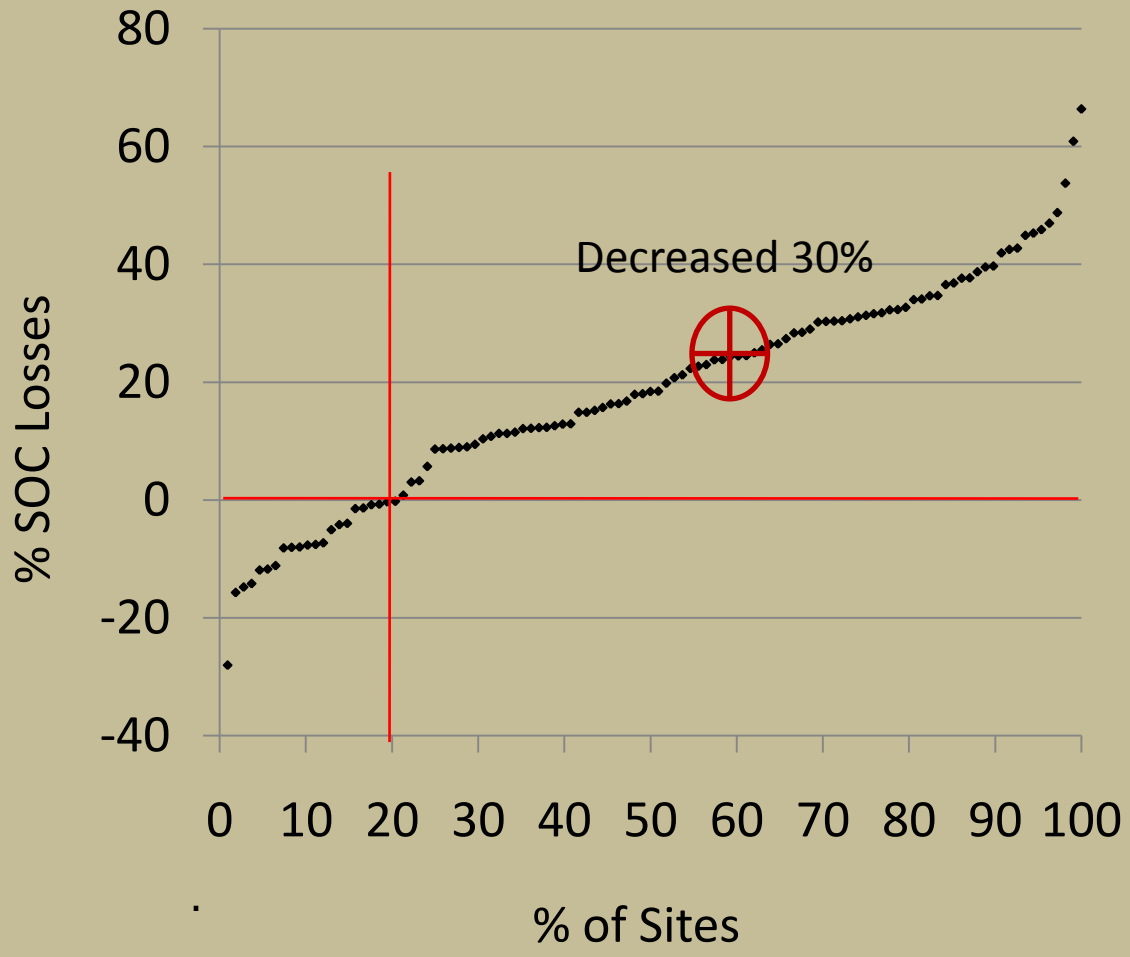
# **Intro: Soil C** as a basis of Soil Quality/Productivity




***from Doran et al., 1993***

# **Intro:** Relative SOC content in Uruguayan Soils under cropping




**Morón et al. 2011**



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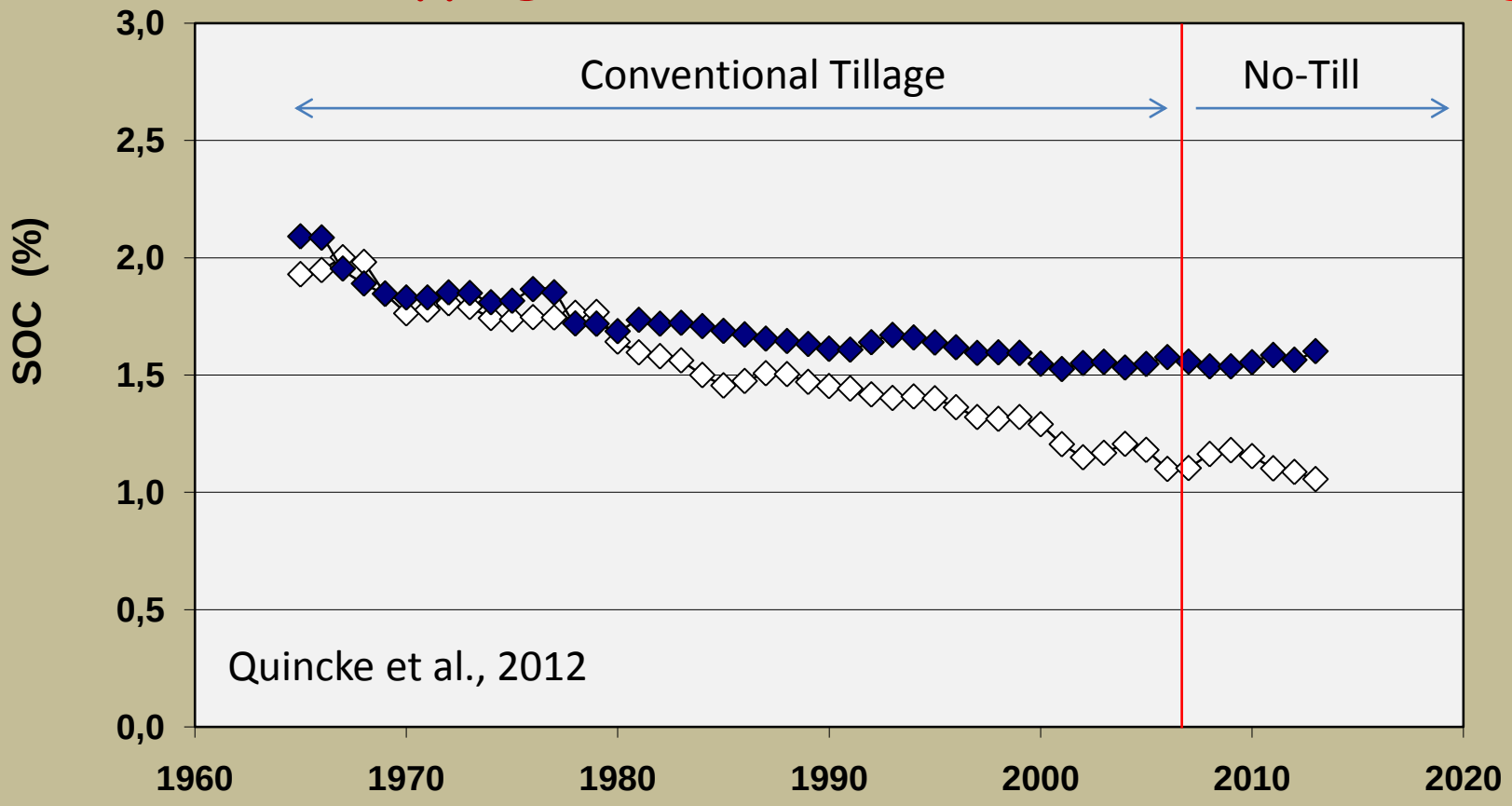
# INTRO: What did we lern from our old term experiments?

## Continuous Cropping decreased SOC in Conventional Tillage




Continuous Cropping (N-P)

Continuous Cropping (Without N-P)



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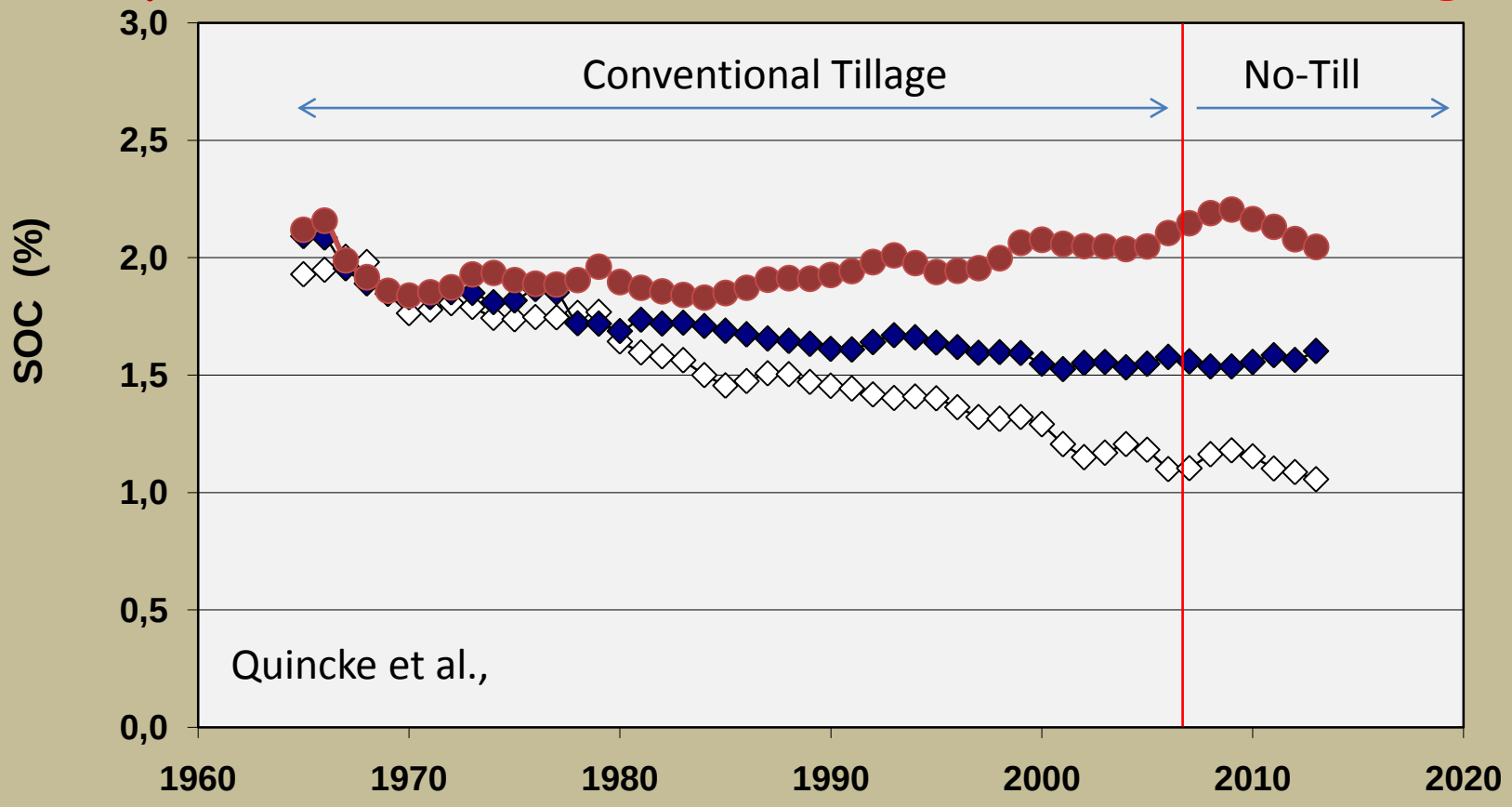
# INTRO: What did we lern from our old term experiments?

## Crop-Pasture rotations maintained SOC in Conv. Tillage



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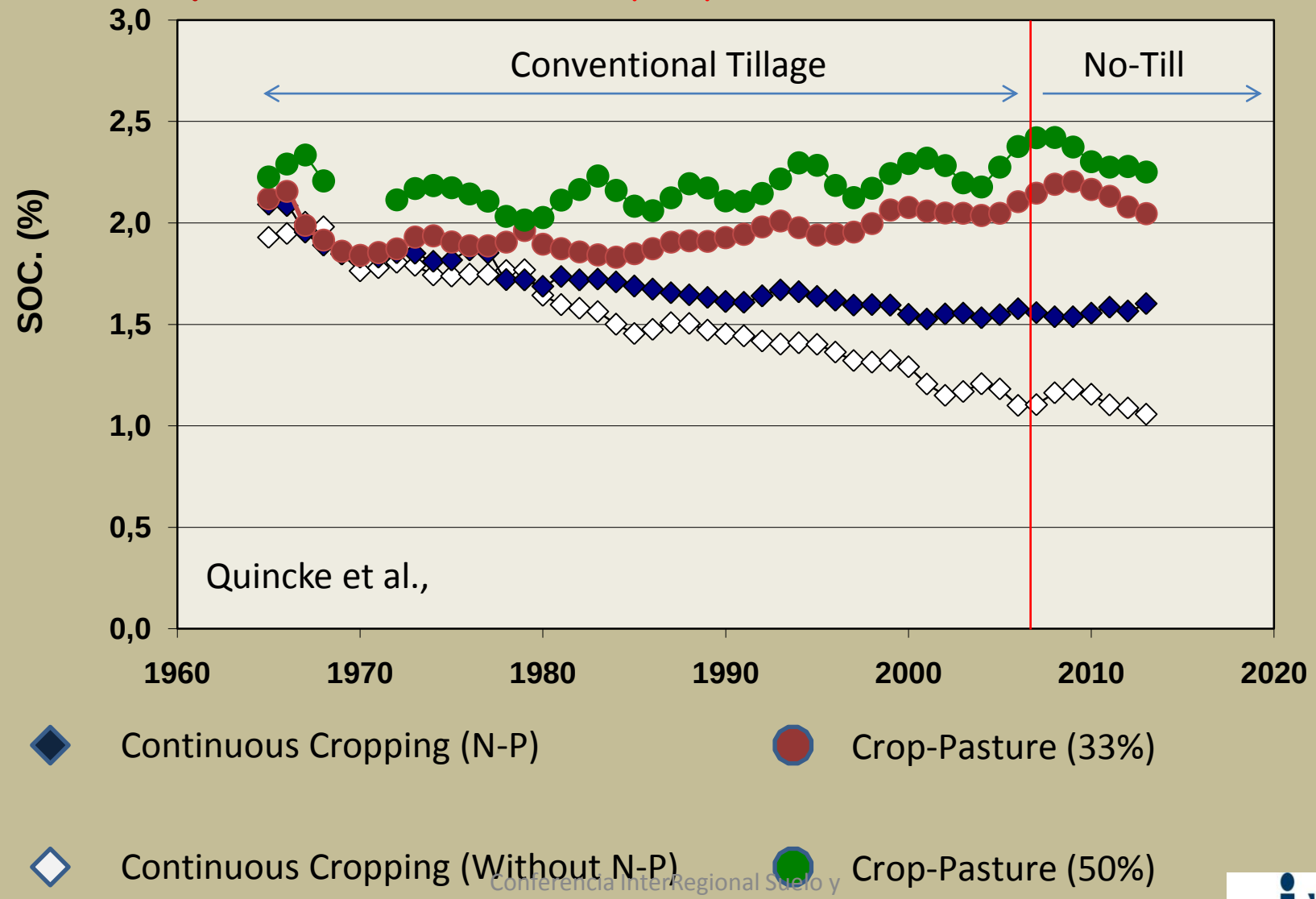
# INTRO: What did we lern from our old term experiments?

**Pastures impacts** on SOC were proportional **to its time** in rotation



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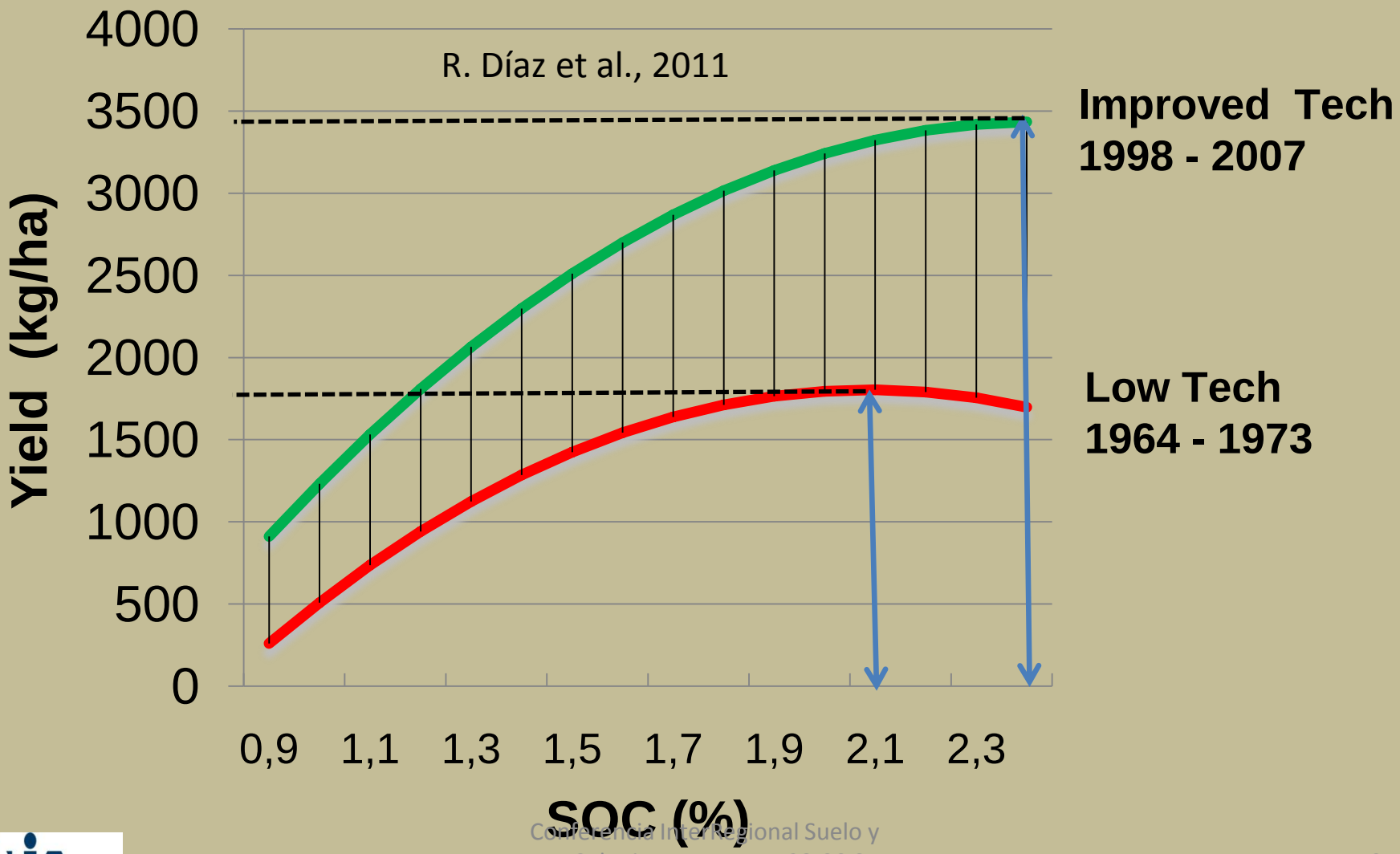
# Intro: Soil organic C content impact on wheat productivity



# The hypothesis (1994):

- Matching **no-till** technology and **crop-pasture rotations** may allow **sustainable agricultural intensification** systems in type III and IV USDA soil use capacity classes covered by natural grasslands.



# Objective

- Evaluate **soil use intensity** impacts on **soil organic C** content in **forage crop** based and **grain crop** based **rotations** under **no-till**.


# M&M: Treatments

## No-Till Soil Use Intensities for FORAGE (1995):

| SOIL USE INTENSITY | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | Yr6 |
|---|---|---|---|---|---|---|
| Continuous Cropping | Oat - Sudangrass | Ryegrass-Foxtail Millet | | | | |
| Crop-Pasture Rotation (Short: 2-2) | Oat - Sudangrass | Ryegrass-Foxtail Millet | Pasture | Pasture | | |
| Crop-Pasture Rotation (Long: 2-4) | Oat - Sudangrass | Ryegrass-Foxtail Millet | Pasture | Pasture | Pasture | Pasture |
| Permanent Improved Pasture | Pasture | Pasture | Pasture | Pasture | | |

# M&M: Treatments

## No-Till Soil Use Intensities for GRAIN (2005):

| SOIL USE INTENSITY | Yr1 | Yr2 | Yr3 | Yr4 | Yr5 | Yr6 |
|---|---|---|---|---|---|---|
| Continuous Cropping | Sorghum - Oat | Soybean- Wheat | | | | |
| Crop-Pasture Rotation (Short: 2-2) | Oat- Sorghum | Oat - Soybean | Wheat/ Pasture | Pasture | | |
| Crop-Pasture Rotation (Long: 2-4) | Oat- Sorghum | Oat - Soybean | Wheat/ Pasture | Pasture | Pasture | Pasture |
| Permanent Improved Pasture | Pasture | Pasture | Pasture | Pasture | | |

# M&M: Experiment highligths

- Field Scale (72 ha, 3 ha plots)
  - Direct Grazing with animals.
  - Use of Commercial Equipment & management
- All phases of the rotation are present each yr.
- No synchronic reps.
- Undergraded soils under Natural Grasslands
- No-Till

# M&M: Soils at the experiment


- NSCS-USDA Soil Taxonomy (Uruguay Site 13)

  - Abruptic Argiaquolls (in the Summit and shoulder)

  - Oxiaquic Vertic Argiudolls (in the back and foot slope)

# M&M: Soil Sampling and Analysis


- Sampling every year.
- Depths:
  - 0-5 cm, 5-15 cm, 15-30 cm
- 12 georefrenced sites/paddock.
- 3 Topographic positions/paddock
- .4 sites/topographic position.
- 10 composited samples/site (10-m radio) .
- C-POM (physical fractionation) .
- Total C and N: Dry combustion LECOR CN-2000.

# RESULTS:

## SOC (0-15-cm) and fractions content in different No-Till systems for **Forage** production (10 yr.)

(Carbone et al., 2010)

| | Soil Use Intensity† | | | | |
|---|---|---|---|---|---|
| | Continuous Cropping | Crop-Pasture (Short) | Crop-Pasture (Long) | Permanent Improved Pasture | Native Grassland Reference |
| SOC Fractions | (Mg C $ha^{-1}$) | | | | |
| **Total C (<2000 µm)** | **30.0 d** | **35.8 b** | **34.5 b** | **39.1 a** | **40.1 a** |
| **C-POM (2000-200 µm)** | **4.6 c** | **5.7 bc** | **5.8 b** | **6.8 b** | **8.7 a** |
| **C-POM (200-53 µm)** | **3.3 c** | **3.6 bc** | **3.9 ab** | **4.4 a** | **4.3 a** |
| **No-C-POM (< 53 µm)** | **22.1 c** | **26.5 ab** | **25.0 b** | **27.8 a** | **27.1 a** |

**No SOC differences** were observed between **Improved Pastures** and **Native Grasslands**

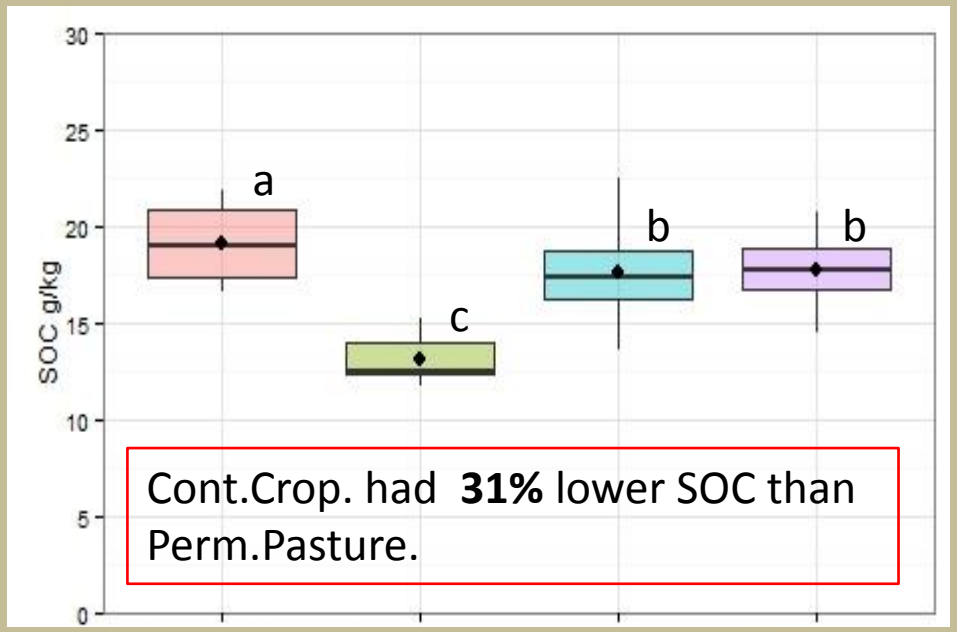
**Continuous Cropping** had **23%** lower SOC and **29%** lower C-POM than Permanent Pasture.

**Crop-Pasture** rotations had **10%** lower SOC and **15%** lower C-POM than Permanent Pasture.

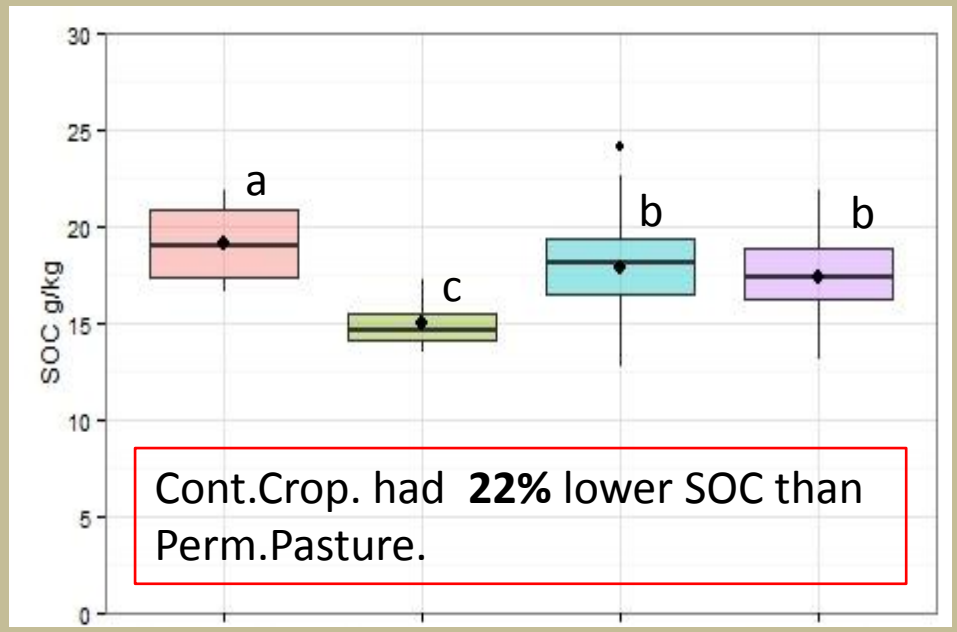
# RESULTS:

## Soil Use Intensity impacts on SOC (**0-15 cm**) in forage and grain crop based rotation systems (20 yrs)

**FORAGE** CROPS BASED




**GRAIN** CROPS BASED

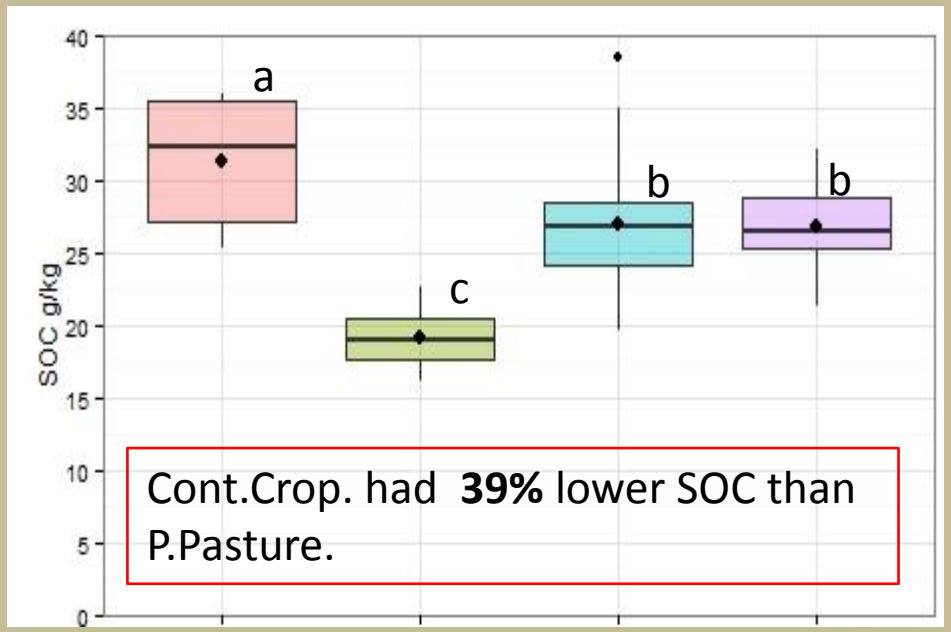



**Crop-Pasture** Rotations had 8% lower SOC than Permanent Pasture but significant higher SOC than continuous cropping; particularly in **forage systems**

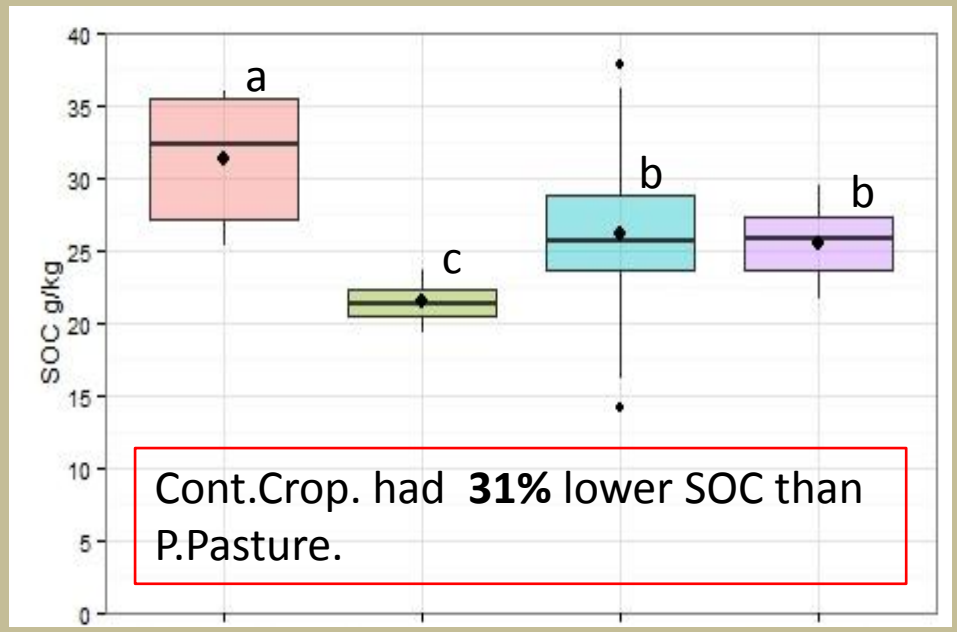
# RESULTS:

## Soil Use Intensity impacts on SOC (**0-5 cm**) in forage and grain crop based rotation systems (20 yrs)

**FORAGE** CROPS BASED

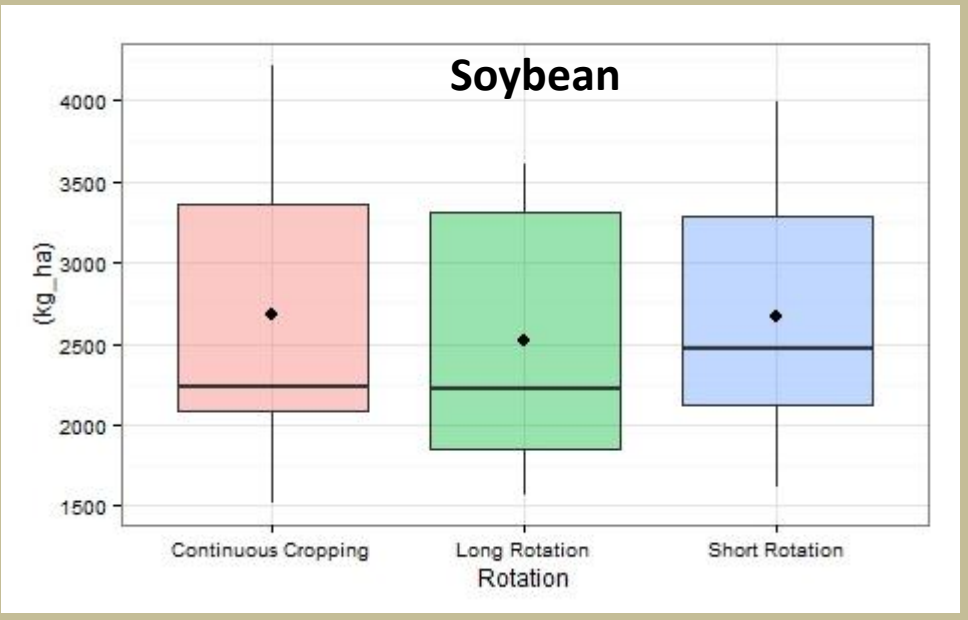


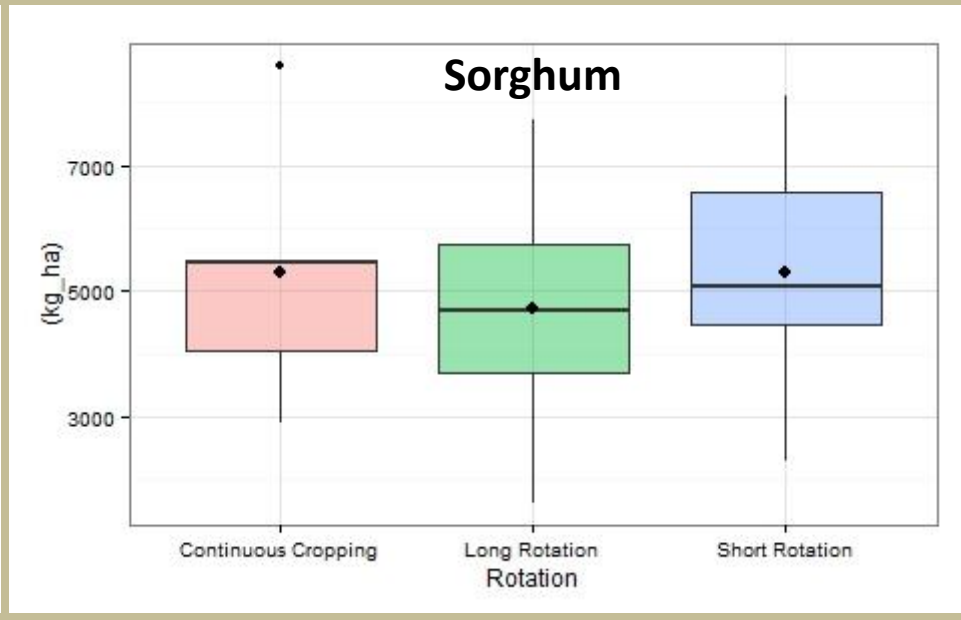

**GRAIN** CROPS BASED

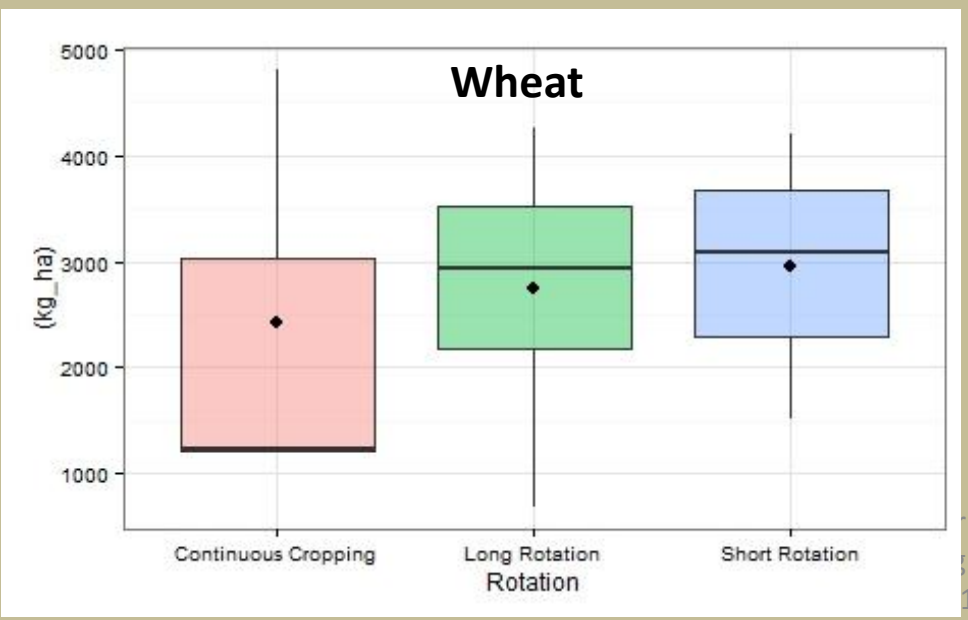



Crop Pasture Rotations had 15% lower SOC than P.Pasture.

# Results: Crops Yields



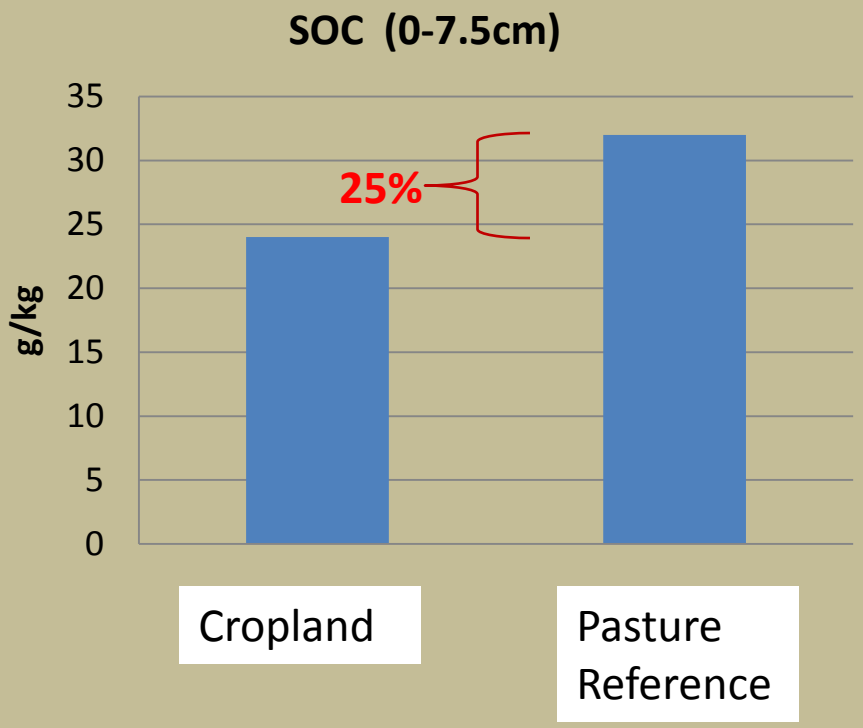



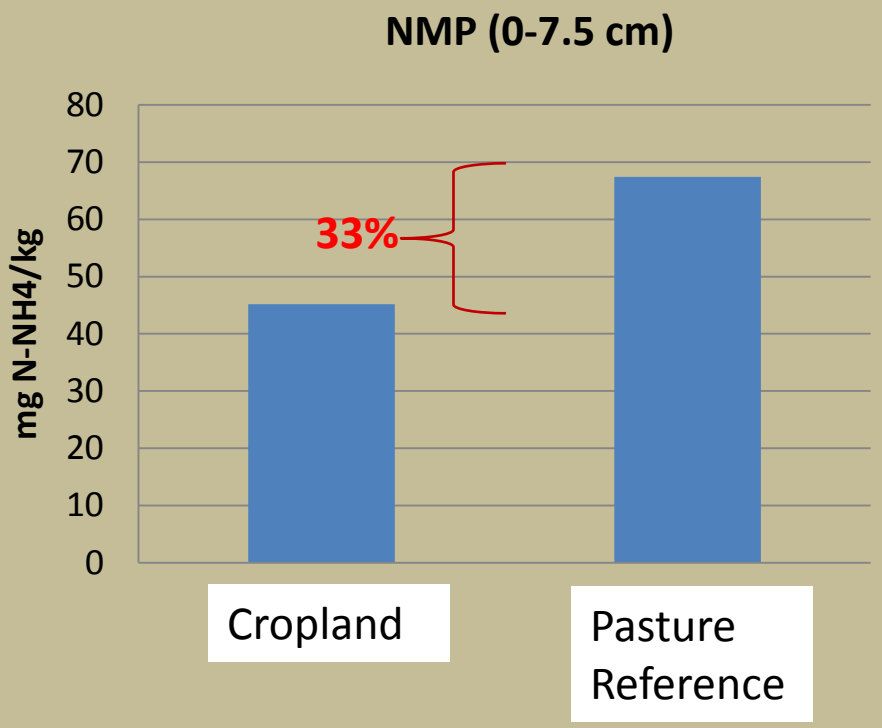

**Similar Crop Yields** between rotation systems.

**Grain** cropping rotations may have contributed to increase residues related to forage cropping rotations and then SOC.

The major contributions to SOC conservation was related to **perennial pastures**.

# Commercial Fields with similar undisturbed soils after 5 yrs of continuous Soybean-Wheat-Soybean under No-Till




N=6. (Quincke and Pérez-Gomar, up)

# Conclusions

1. Continuous cropping significantly reduces SOC in undisturbed soils incorporated to agriculture under no-till, and this impact is higher in intensive forage systems.
2. Even under no-till and integrated with pasture rotations, cropping systems reduced SOC compared with permanent pastures.
3. For undisturbed Mollisols incorporated to cropping systems, like those prevalent in Eastern Uruguay, rotating with perennial pastures is critical to mitigate SOC losses during cropping phases of the rotation.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# THANKS