

Organic Carbon Stocks in Relation to Grass, Mesquite, and Land Use In the Desert Grassland

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Introduction

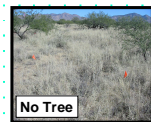
Organic carbon stocks in the soil and plant mass are typically greater in areas with large mesquite trees than open grasslands, but the influences of grass cover, mesquite size, time since mesquite death, and land-use on this carbon-mesquite pattern are largely unknown.

Research Questions

1. Do soil organic carbon (SOC) and $\delta^{13}\text{C}$ differ beneath grass and bare ground?
2. Do SOC and $\delta^{13}\text{C}$ differ beneath old, new, killed (40 y), no tree locations?
3. Does total organic carbon (SOC + wood mass) differ among land uses that removed trees in the past 70 y?

Study Design

Soil samples from 4 depths, 6 locations, 4 mesquite types, in 3 land use areas on the Santa Rita Experimental Range, AZ, USA (Tables 1 and 2). Five samples per mesquite occupation type per study location, and study site served as the replicate. Reporting [SOC] as mg/cm^3 in <2 mm size, adjusted for bulk density. Allometric relations for mesquite carbon and area weighting by mesquite type were used to estimate carbon stocks among land use types.



| Type of Mesquite Occupation | Study Locations |
|--|-----------------|
| Old Tree Largest stem >15 cm basal diameter | 4 |
| New Tree Largest stem 6-10 cm basal diameter | 6 |
| Killed Tree Herbicide 1960-2, largest stem >15 cm basal diameter | 2 |
| No Tree > 5 m from tree canopy | 6 |

Table 2. Cover of mesquite types in 3 land use treatments.

| Land Use Type | Percent Cover of Mesquite Type (SE) | | | |
|--------------------------------------|-------------------------------------|---------------|--------------|----------------|
| | Old Tree | New Tree | Killed Tree | No Tree |
| 1935 Cut (All Trees Cut) | 3.4 (0.9) | 13.8 (0.8) | 0.0 (0.0) | 82.8 (1.3) |
| 1960's Herbicide (~1/2 trees killed) | 8.9 (2.1) | 9.2 (5.7) | 4.4 (1.0) | 77.4 (11.9) |
| No Tree Removal | 14.8 (1.9) | 7.9 (3.6) | 0.0 (0.0) | 77.3 (7.8) |

Results: Question 1

SOC and $\delta^{13}\text{C}$ did not differ between grass and bare areas (Table 2). Apparently, the presence of grass is too ephemeral to differ from the background values, which is consistent with estimates of <5 y grass longevity.

Results: Question 2

SOC differed among mesquite types near the soil surface and $\delta^{13}\text{C}$ differed slightly deeper (Table 2 and Figure 1). SOC was greatest under Old Trees to 7.5 cm depth, but not deeper. $\delta^{13}\text{C}$ was more negative under Old Trees to 20 cm depth, but not below. These results suggest that within 40 y of tree death, virtually all SOC accumulated beneath large mesquite is respired, and that even large mesquite are recent occupants in this former C_4 grassland.

Results: Question 3

Focusing on 0-10 cm soil depth where SOC differed among mesquite types, the organic carbon stocks (SOC + mesquite wood) were about 1.3 Mg ha^{-1} greater in No Removal treatment areas than 1935 Cut areas, and 0.7 Mg ha^{-1} than 1960 Herbicide areas (Figure 2). Differences in carbon stocks among land use types were largely driven by the proportion of land area with Old Trees because they have ~56% more SOC than other mesquite types.

These results suggest that the decline in carbon stocks following old tree removal will only partially be replaced within 70 y by wood accumulation because the re-accumulation of SOC will take much longer.

Table 2. Probabilities (p-values) of no differences in SOC and $\delta^{13}\text{C}$ among mesquite types, presence of grass, and their interaction at 4 soil depths.

| Main Effects | Soil Depth (cm) | | | | | | | |
|------------------|-----------------|-----------------------|-------|-----------------------|------|-----------------------|------|-----------------------|
| | 2.5 | | 7.5 | | 20 | | 40 | |
| | SOC | $\delta^{13}\text{C}$ | SOC | $\delta^{13}\text{C}$ | SOC | $\delta^{13}\text{C}$ | SOC | $\delta^{13}\text{C}$ |
| Mesquite Type | <0.01 | <0.01 | <0.01 | <0.01 | 0.16 | <0.01 | 0.08 | 0.12 |
| Grass Presence | 0.85 | 0.93 | 0.10 | 0.08 | 0.47 | 0.24 | 0.31 | 0.58 |
| Mesquite x Grass | 0.66 | 0.98 | 0.45 | 0.80 | 0.87 | 0.75 | 0.17 | 0.27 |

Figure 1. SOC and $\delta^{13}\text{C}$ in relation to mesquite type and soil depth.

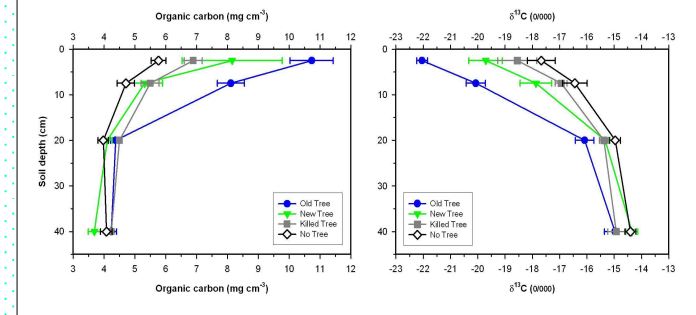
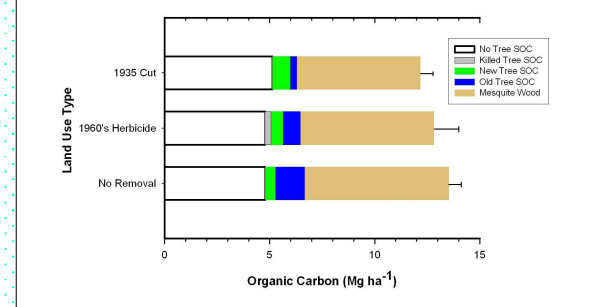


Figure 2. Amount and sources of organic C among land use types.



Acknowledgments

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