Understory Plants Influence Aggregation And Carbon Storage In a Forested Sandy Soil

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Introduction

Chemical understory control is a common and effective forest plantation management practice in the Lower Coastal Plain of the Southeastern US. Spodosols in this area are notoriously sandy, with low soil organic matter (SOM) content and, historically, little expectation of soil aggregation. Due to low clay content, forest management has been shown to have little effect on increasing total SOM; in fact the little data that exists has suggested that chemical understory control can decrease total SOM in near surface horizons (Shan et al. 2001). Recent investigations on soil aggregation now suggests that there is a surprising amount of aggregation (microaggregation) in these sandy soils, with 50% or more of total SOM held within aggregates (Sarkhot et al. 2007). Soil aggregation can play an important role in carbon accumulation and cycling. In soils without the benefit of clay, root and mycorrhizal hyphae take on added importance in aggregation. Therefore, this study was instituted to investigate the long-term effect of understory control on soil aggregation and on the quantity of carbon incorporated into soil aggregates in the surface horizon of a subtropical extremely sandy soil.

Objectives:

- First, verify that the sonication method for developing an aggregate dispersion energy curve does, in fact, destroy aggregates.
- Second, investigate the long term effects of understory control (WR) on SOM within size fractions in comparison to a control (C);
- Third, investigate the influence of chemical understory control (WR), on soil aggregation within size fractions as a function of aggregate dispersion energy. The results were expected to define what the influence of understory removal was on long-term aggregate formation and carbon incorporation into aggregates.

Methods

Experimental site

- The Gator Nationals Experimental Forest site is located 10-km north of Gainesville, FL. The study is a 2 (tree species) x 4 (treatments) factorial with 3 blocks and soil sampled from two depths (0 to 5-cm and 5 to 10-cm). The 4 treatments (see above), 3 blocks and both depths under Loblolly pine (*Pinus taeda)* were used to address the second objective; while soil from the first depth for the C and WR treatments representing the two most disparate blocks were used to address the third objective .

Block 1 was drier due to a higher elevation relative to a local cypress pond (~30-cm), a variably cemented spodic horizon (due to the higher elevation), and an understory dominated by saw palmetto (*Serenoa repens*) and panicum grasses (*Panicum sp.)*. Block 2 had a more friable spodic horizon, was closer to the edge of a cypress pond making it a more hydric environment, and was dominated by a dense stand of gallberry (*Ilex glabra*).

***Site** located at Gator Nationals Experimental Forest in Alachua county, FL*

http://www.floridacountiesmap.com/alachua_county.shtml

Laboratory methods

- Size fractionation of the soil into 4 size classes was accomplished through dry sieving (Sarkhot et al. 2000). The size fractions were 2mm to 250-µm, 250 to 150-µm, 150-53µm, and <53µm.
- The method of Sarkhot et al. (2007) was employed to develop aggregate dispersion energy curves and to measure the aggregate organic matter (AOM) at different dispersion energies. Loss-on-Ignition was used to measure SOM, which is an appropriate method for these quartzic sandy soils.
- Soil carbon mineralization was measured with the NaOH trap method (Anderson, 1982). For each of three larger size fractions, two samples were mineralized in duplicate. The first sample was the whole soil fraction; the second sample has sonicated at ~12000 J to remove approximately 50% of the AOM held in low energy aggregates. The CO_2 evolved from the three larger size fractions was measured after 60 d of incubation when samples were held at 35^0 C and field capacity.
- Data were log transformed when necessary for statistical analysis by ANOVA for the factorial designee described above. Differences were deemed significant at $p<0.05$.

Control 1 (C): Saw Palmetto dominant

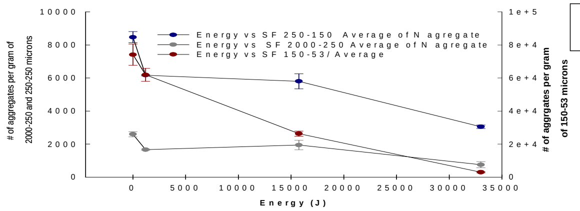
Control 2 (C): Gallbery dominant

Weed Removal

Fertilized and weed control

Fertilized and No Weed Control

Figure 1.- Number of Aggregates per gram of Fraction in different energy levels



Breaking down the aggregates in each Size Fraction

0 Joules in 2000-250 µm SF

350 Joules in 2000-250µm SF

12000 Joules in 2000-250 µm

15000 Joules in 2000-250 µm SF

Figure 2- LOI% for whole soil by treatment for the 0-10cm depth

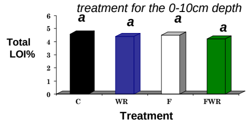


Figure 3- Significant difference between %LOI and soil depth

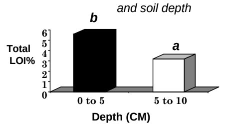


Figure 4- Significant difference between %LOI and Block – Wet (b) vs dry (a) sites

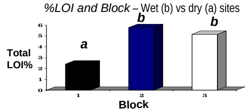
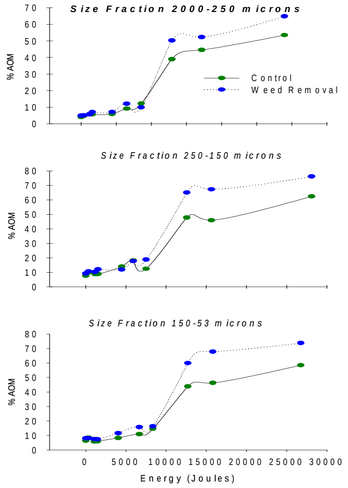


Figure 5- % AOM as a % of Total AOM



Caption - Weed Removal has an overall higher % of Aggregate Organic Matter located on the higher stability or higher energy levels across all Size Fractions

Figure 6.- Drier (Block 1) vs Wetter site (Block 2)

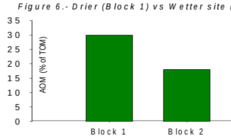
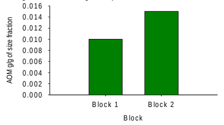


Figure 7.- AOM in grams per size fractionfor both study blocks



Preliminary Data

Figure 8- Carbon respired by size fraction

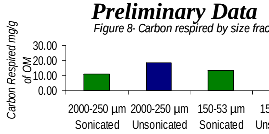
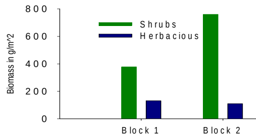


Figure 9.- Biomass of Herbacious and Shrubs in Control Blocks



Results

Sonication was effective in dispersing aggregates over the energy ranged tested for the 2-mm to 250-µm and 150 to 53-µm. The 250 to 150 µm size fraction still had a significant number of aggregates present at the highest dispersion energy applied. While the SOM content of this fraction was low, the higher energy aggregates maybe worth investigating for their carbon sequestration potential (Objective 1).

- ✓ Smaller size fractions had a larger number of aggregates (Objective 1). The number of aggregates per g of fraction was ranked 150 to 53-µm > 250 to 150-µm > 2000 to 250-m (Figure 1). Aggregates were observed to consistently contain mycorrhizal hyphae. Other materials observed among the aggregates were fecal pellets and root epidermis (Figure 1a).
- ✓ Treatments (C, WR, F, FWR) did not differ in total SOM 18 y after treatments were imposed (Figure 2 ; Objective 2). The 0 to 5 cm depth contained about 2x more SOM than the 5 to 10 cm depth (Figure 3; Objective 2); and blocks 2 and 3 had more total SOM than block 1 (Figure 4; Objective 2).
- ✓ WR increased the AOM when expressed as % of total SOM (%AOM; Objective 3). WR > C in the 2000 to 250-µm and 150 to 53-µm size fractions (Figure 5).
- ✓ Block 1 had more %AOM than Block 2 (Figure 6; Objective 3); while Block 2 had more AOM (µg g^{-1} fraction) than Block 1 (Figure 7; Objective 3). Figure 9 (courtesy of E. Jokela, Univ of Florida) showed that Block 2 had far more understory biomass in shrubs than Block 1.
- ✓ WR enhanced the total amount of AOM (µg g^{-1}) in aggregates (Objective 3). AOM (ug g^{-1}) was greater under the influence of WR than C in <u>all</u> size fractions (Figure 5).
- ✓ AOM in high energy aggregates plus particulate OM (left after sonication with > 12000 J) had approximately half the mineralization rate g^{-1} C than total SOM (no sonication), showing a greater degree of protection for AOM in high dispersion energy aggregates (Preliminary investigation resulting from Objective 3, Figure 8).

Discussion

<u>Verification of Methodology</u>: Microscopic evidence verified that sonication was dispersing soil aggregates, therefore the method was deemed useful for the purpose for which is was employed. The reason for higher aggregate stability in the 250 to 150-µm, and the dispersion energy required for total aggregate dispersion, needs to be explored both for mechanism of stability and potential for C sequestration.

<u>Influence of WR on soil aggregation within size fractions as a function of aggregate dispersion energy</u>:

- ✓ The increase in the %AOM and AOM (µg g^{-1} fraction) accompanying the removal of the understory was unexpected given the literature that suggests WR could decrease total SOM.
- ✓ Fungi are known to increase the occurrence of cementing agents used to form aggregates and to participate in aggregation (Lai, 2002). Understory control is known to produce a 4x and 7x increase in loblolly pine fine roots and hyphal length in similar soils (Sylvia and Jarfster, 1997; Figure 5).
- ✓ The greatest differences in %AOM and AOM (µg g^{-1} fraction) was seen in the aggregates of high dispersion energy and high energy aggregates provided more protection from decomposition.
- ✓ While total SOM did not change, the amount of protected SOM increased when understory was removed and when pine roots and mycorrhizae dominated. Preliminary estimates are that this difference in management can increase high energy AOM by ~30 to 50%, increasing the total SOM that is better protected from decomposition by ~15 to 20%. Small site changes (Block 1 vs Block 2) have the potential to influence the total SOM and the amount of AOM.