Patterns of Soil Organic Carbon and Total Nitrogen Distribution in Mesquite Coppice Dunes

Lisa Ebbs and Heather L. Throop

Department of Biology, New Mexico State University, Las Cruces, NM 88003

Introduction

- Woody plant encroachment, the increase in abundance of trees and shrubs in formerly grass-dominated systems, has been observed in semi-arid and arid systems worldwide over the past century.
- Woody plant encroachment jeopardizes grassland biodiversity and threatens the sustainability of livestock grazing in the Chihuahuan Desert. Woody plant encroachment may contribute to the North American carbon (C) sink if woody plants sequester more C than grasses (Schimel et al. 2000). The extent to which woody encroachment acts as a C sink is currently highly uncertain and an area of intense research.
- The effects of woody plant encroachment on soil organic carbon (SOC) and total nitrogen (TN) concentrations in biogeochemical pools relative to *Prosopis velutina* (velvet mesquite) have been explored in the Sonoran Desert, where strong spatial patterns in SOC and TN based on shrub size and subcanopy location exist (Throop & Archer 2008).
- This study examines the effects of *Prosopis glandulosa* (honey mesquite) dunes in the Jornada Basin on biogeochemical pools in the Chihuahuan Desert, which may differ from patterns found in the Sonoran Desert due to the different physiognomy of these two mesquite species.

Figure1: A Chihuahuan Desert grassland (left) and an area of mesquite encroachment in the Chihuahuan Desert (right).

Woody Encroachment in the Jornada Basin

- Significant declines in perennial grass cover and increases in desert shrub cover appear to have occurred in the Jornada Basin starting in the late 1800's (Havstad 2006).
- Coppice dunes form on sandy loams around *P. glandulosa*, when loose particles are carried by the wind and deposited on and around the shrubs.
- It is unknown how the encroachment of *P. glandulosa* into former grasslands affects the amount of C and N stored in the biomass and soils in the Chihuahuan desert.
- Hypothesis 1: Soil bulk density will be greatest in intercanopy areas and decrease toward the center of the coppice dunes due to the compaction of soils in intercanopy areas.
- Hypothesis 2: *Prosopis glandulosa* coppice dunes are "islands of fertility" having greater concentrations of C and N in relation to intercanopy soils due to wind and water erosion, which moves organic matter from intercanopy areas onto dunes.
- Hypothesis 3: SOC and TN will be greatest at the center of the coppice dunes, and will decline radiating out from the center, because wind and water scour organic matter from the surface of intercanopy soils and deposit them within dunes and *P. glandulosa* litter accumulates on the dune over time.
- Hypothesis 4: As the aboveground biomass of *P. glandulosa* increases, the coppice dune around the shrub increases in size, SOC, and TN due to the deposition and accumulation of soil particles and organic matter around the shrub.

Methods

- The study site is located approximately 25 km northeast of Las Cruces, NM, on the USDA-ARS Jornada Experimental Range (JER).
- We selected13 isolated dunes, covering a range of dune sizes present at the field site, for sampling.

Coring Methods

- Approximately 15 soil cores (9 cm depth) were taken from each dune. Cores were from each of four directions based on the orientation of the longest axis, diagonal directions, and intercanopy spaces (Figure 2).
- Each core sample was processed and analyzed for C and N percentages (Costech ECS elemental analyzer).

Bulk Density Methods

- Bulk density of 1/3 of all soil cores was determined based on core mass and volume in order to express SOC and TN on an areal basis.

Aboveground Biomass Sampling Methods

- Aboveground biomass was collected from three 1m2 quadrats in each dune. Biomass was dried and weighed.
- Total aboveground biomass was determined based on the 3m2 sample.

Statistical Analyses

- The absolute distance in meters, from the center of the dunes to each coring position was measured.
- The relative positions from soil cores to the center of each dune was calculated by taking the absolute distance as a proportion of the length of the longest axis of each dune.
- Analysis of variance (ANOVA) and linear regressions exploring SOC, TN, BD, dune size, and coring positions were performed using JMP.

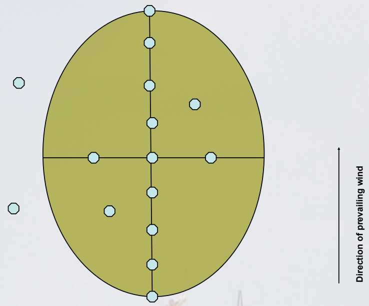

Fig. 2 : Relative positions for soil core samples taken from within and around 13 dunes in the JER. For each dune there were 13 soil cores on dunes and 2 interdune locations.

Bulk Density Results

- Intercanopy soils had greater bulk density than within dune soils ($P < 0.0001$).
- Bulk density increased slightly with increased distance from the center of coppice dunes (Figure 3).

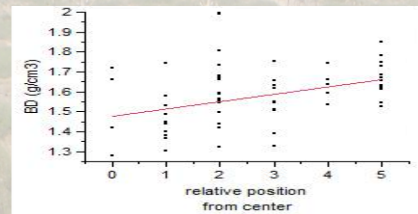

Figure3: Relationship between bulk Density (g/cm³) and relative position. Distance outward from center of dune increases with increased position: 0 represents center and 5 represents intercanopy areas between dunes (R^2: 0.158).

Aboveground Biomass Results

- There was a strong positive relationship between dune area and total aboveground biomass (Figure 4).

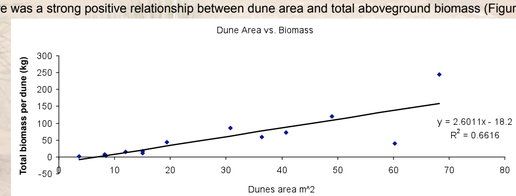

Figure4: Relationship between aboveground biomass and area of *P. glandulosa* coppice dunes.

SOC and TN Results

Absolute Distance

Absolute distance of soil samples had no effect on SOC or TN present in the soil across dunes.

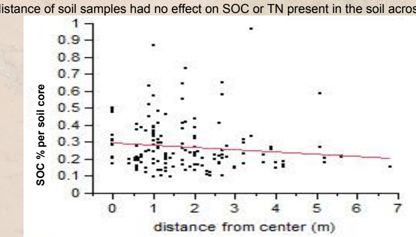

Fig 5: SOC has no relationship with the absolute distance of soil cores, in meters, from centers of dunes(R^2: 0.016).

Relative Position

- Intercanopy soil samples had lower levels of SOC and TN than within-dune soils ($P = 0.0003$, and $P = 0.0004$, respectively).
- SOC and TN decreased slightly with increasing relative distance from the dune center (Figures 6 and 7).

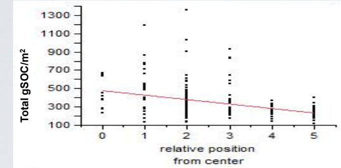

Figure 6: Relationship between relative position and SOC, with 0 representing the center of the dune and 5 representing intercanopy areas.(R^2 = 0.13).

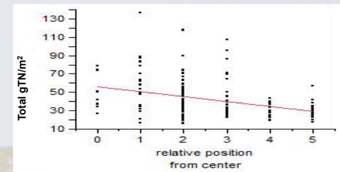

Figure 7: Relationship between relative position and TN, with 0 representing the center of the dune and 5 representing intercanopy areas (R^2 = 0.14).

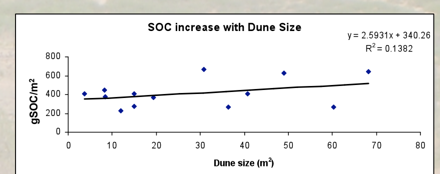

Figure 8: There was a weak relationship between increasing dune size and an increase in SOC (R2 = 0.14).

In Progress

- We have collected deeper soil core samples from the centers of coppice dunes: from surface to 10cm, 10 cm to 20 cm and 20 cm to 30 cm depths. We will use these to test how C and N values vary with depth within dunes.
- We will use models of C and N vs. coppice dune area to estimate total above and belowground C and N pools in areas where coppice dunes are present.

Figure 9: The West Well site on the JER displaying evidence of dune establishment in a former grassland.

Literature Cited

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