Restoration Age and Quality Effects on Dynamic Soil Properties at Nachusa Grasslands in Franklin Grove, IL

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Abstract

Land use and management are key factors influencing the quality and function of soil as measured through dynamic soil properties. This study was conducted to quantify the differences in soil quality indicators across a chronosequence of prairie restorations of varying vegetative quality. Prairie restorations were chosen from a 3,100 acre Nature Conservancy site in Franklin Grove, IL known as Nachusa Grasslands, while the dynamic soil properties bulk density, aggregate stability, organic carbon, particulate organic matter (POM), color, and structure, along with texture were analyzed using standard laboratory and field methods. There are some clear trends that can be identified from the laboratory data. Both bulk density and aggregate stability had changes across the different age and quality groups, which also matched expected trends away from those levels in the ag land towards those in the never cultivated plot.

Introduction

Soil is dramatically impacted by land use. Agriculture is one of the primary contributors to the physical destruction of soil. Use of heavy machinery and extensive tillage have lead to lowering levels of soil quality. Indicators of this include a variety of physical, chemical, and biological properties within the soil. Physical indicators of soil quality are also referred to as dynamic soil properties, and change over time along with land use and management. An assortment of these properties were the focus of this project. They include bulk density, commonly related to compaction by machinery, organic carbon content, linked to amount and type of vegetation present, aggregate stability, related to high levels of organic matter and microbial activity, particulate organic matter along with color and structure. Each of these properties were analyzed in only the surface horizon of the soils sampled to capture the area most influenced by land use (Karlen et al., 1997).

Nachusa Grasslands is currently 3,100 acres of remnant and restored tallgrass prairies, owned by the Nature Conservancy, located in Franklin Grove, IL, about an hour and a half west of Chicago. As a natural area, the grasslands are home to more than 700 native plant species, as well as insects, birds, reptiles, and most recently a reestablished herd of bison. Sites have been restored to prairie from agriculture for the last 30 years, and are continuing to be acquired and restored. Plots for this study were organized based on age and quality of the restorations. Quality is assigned by the preserve manager and restoration ecologist at Nachusa based on species abundance and diversity and weed pressure within the plot. Ag fields were given the lowest quality rating, and never cultivated plots the highest, with restorations falling in between. Samples were taken at one representative location within each plot, except where there was enough topographic relief to warrant sampling at summit, backslope, and footslope or toeslope landscape positions. Data was also gathered from remnant and current agricultural sites.

Methods

All methods follow standard field and lab procedures

Field

- Bulk density: collected to about 30 cm at a representative point within each plot
- Aggregate sample collected from 5 points within a 5 m circle of central point to a depth of about 10 cm

Lab

- Bulk density
- Organic carbon measured using Elementar vario Max CN analyzer dry combustion system
- Wet aggregate stability method following Patton et al., 2001
- Particle size analysis using standard pipette method
- Particulate Organic Matter (POM) adapted from Wander et al., 1998

Study Site

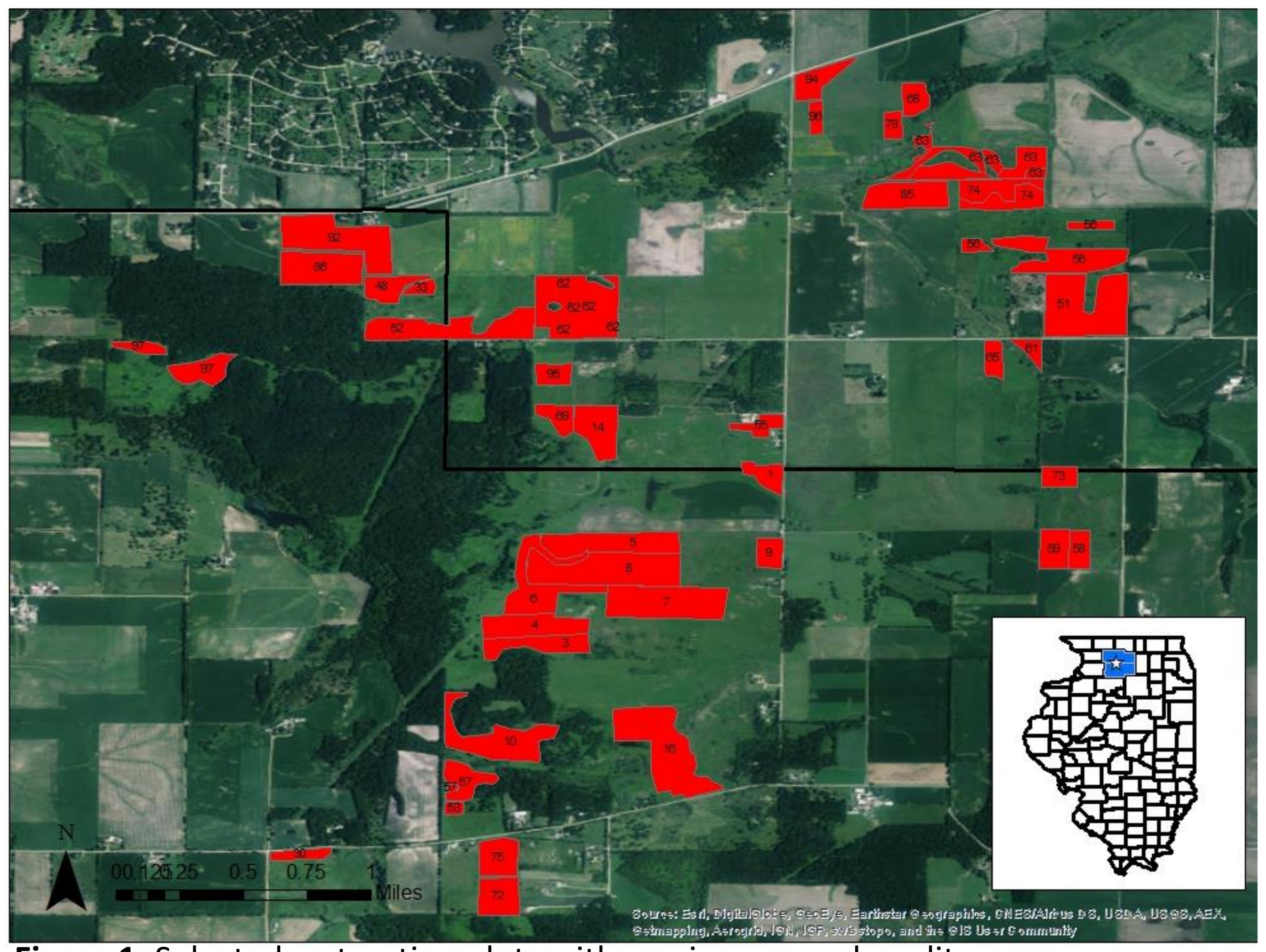

Figure 1. Selected restoration plots with varying age and quality.

Figure 2. Landscape view of typical prairie restoration at Nachusa Grasslands.

Results & Discussion

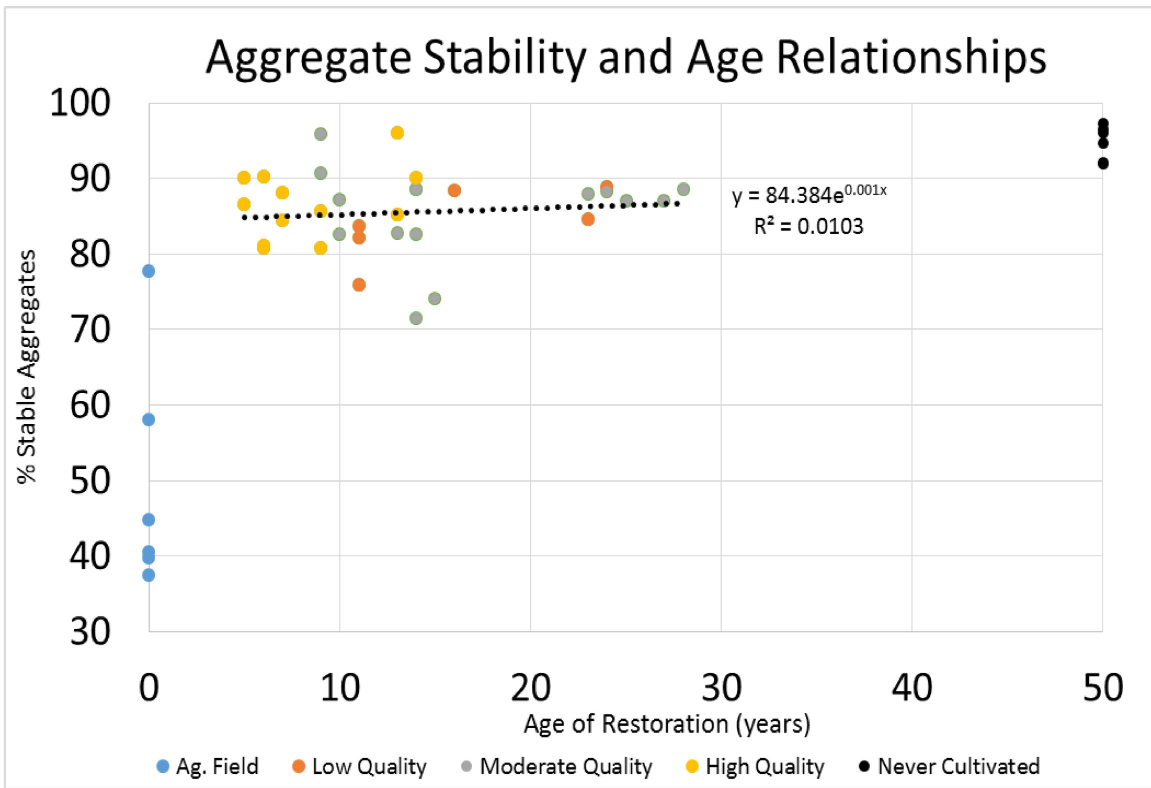

Figure 3. % Stable aggregates of various aged plots, grouped by quality.

Some clear patterns begin to develop across the different properties analyzed when grouped by age or restoration quality. Aggregate stability when rated by restoration age ranges widely, but starts to narrow down towards values that are just outside the range of the never cultivated site. There is also some indication that aggregate stability increases with higher quality restoration. The values slowly increase with restoration quality, and are found within a smaller range of values in high quality restorations, compared to those of lower quality. Very few of the aggregate stability values for the various restorations overlap with the never cultivated plot, but all are greater than majority of the values observed for the agricultural field. Those restorations that do overlap with the never cultivated plot are less than 15 years old, and are of moderate to high quality.

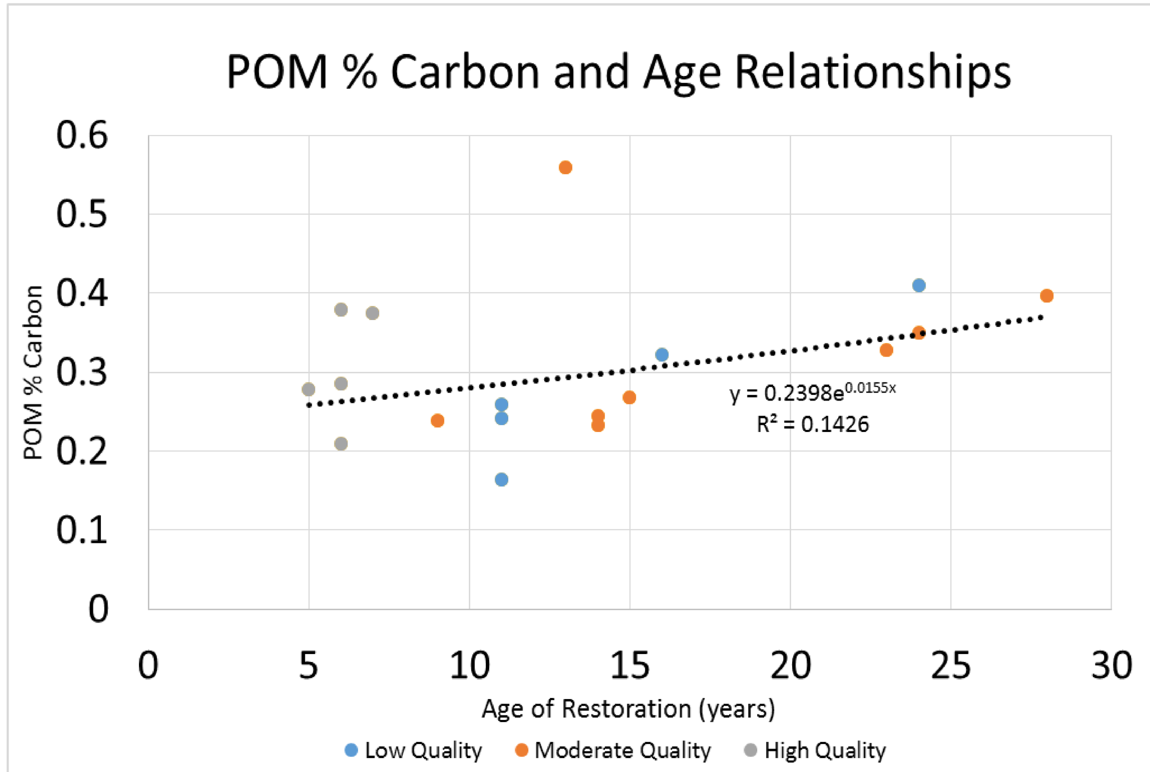

Figure 4. % Carbon of POM of various aged restorations, grouped by quality.

POM Carbon values also change across restoration age and quality. Most of the younger restorations fall within 0.2-0.4% range, while the remaining plots are mainly in that range with a few outliers. Because of this, the various quality types also fall within that middle range, with some mild variation.

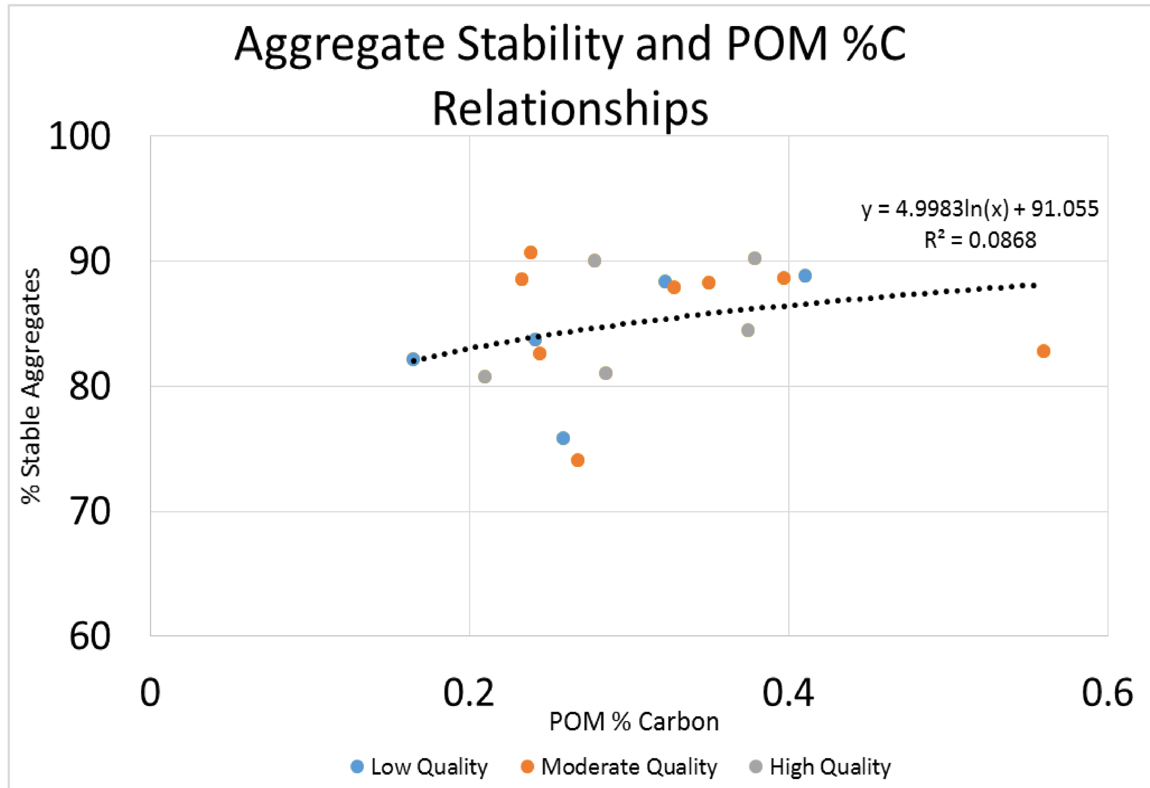

Figure 5. % Stable aggregates as a function of % Carbon of POM, grouped by quality

The relationship between aggregate stability and % POM Carbon is not a distinct one. Almost all of the values for both of these properties fall within a central location. There is no clear indication that % POM Carbon has any influence on % stable aggregates within a given plot. This data is from a small set of data, with two strong outliers removed, so further addition of data points may show a stronger relationship.

Conclusions

One important point to make is that almost all of the young restorations are rated as being high quality, so some of these distributions are skewed in that way. From the observations presented here, it is possible to see some relationships between age and quality and the different observed soil properties, as well as potentially among the properties themselves. These results may indicate, in some cases, that prairie restorations reach a stable condition where the properties analyzed fall slightly below the natural condition.

Acknowledgments

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