LONG-TERM SOIL PROFILE ACIDIFICATION: OBVIOUS AND HIDDEN DANGERS

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ABSTRACT

Soil acidification is occurring in the dryland farming region of the Northwest. Historically, soil acidification in the surface foot has been characterized; however, potential acidification of subsoil is unknown. We examined soil acidification for soil profiles (0 to 5 ft) at the R.J. Cook Agronomy Farm (92 ac) for 17 years following conversion from conventional tillage to continuous No-tillage (NT). Surface soil depths (0-12 in) acidified under continuous NT to below 5. Surprisingly, subsoil at depths of 3 to 5 feet were acidified in certain landscape positions prior to conversion to NT. Over 17 years, the acidified subsoil was ameliorated, and subsoil pH increased under NT. Large spatial and temporal variations in soil pH occurred throughout the soil profiles over the course of 17 years of continuous NT. Decreasing leaching of nitrate and bases through more efficient use of water and applied N are major management consideration.

INTRODUCTION

Soil acidification is a major cause of lost farm production throughout the world. Soils of the inland Pacific Northwest were initially near neutral in pH; however, agriculturally driven soil acidification has occurred in the region over time, primarily due to the increased use of N fertilizers. Currently, acidification is an issue of growing concern as more soils are at or below critical pH levels required for optimum yields of small grains and grain legumes. Research has primarily assessed changes in surface (0-12 in) soil pH with little attention to potential acidification of subsoil.

Over the last 40 years, reduced and no-till (NT) production has increase in the inland Pacific Northwest and significantly changed field-scale soil properties and hydrologic processes. As compared to plow-based systems, NT lacks the mechanical mixing of soil and promotes the surface stratification of residues, soil organic matter, immobile nutrients and pH. Furthermore, soil erosion is significantly curtailed under NT as surface runoff decreases and water infiltration increases. In addition, NT is often coupled with deep-band placement of fertilizers including N, a main driver of soil acidification.

In 1998, a long-term NT study was initiated at the Cook Agronomy Farm near Pullman, WA. One objective was to investigate field-scale changes in soil pH throughout the soil profile (0-5 ft) with samples collected in 1998 (initiation of NT), 2008, and 2015 to provide insights into the long-term impact of continuous NT in dryland, wheat-based systems.

METHODS

The research was conducted on a 92 ac field at the Washington State University Cook Agronomy Farm (CAF) near Pullman, WA (Fig. 1), which is also one of 18 USDA Long-Term Agroecological Research (LTAR) network sites. Previous to 1998, the farm produced a mix of small grain and pulse crops under conventional tillage. In 1998, the CAF was converted to continuous NT producing wheat, barley, pulse crops and canola. Nitrogen (N) fertilizer has been primarily deep band applied (3-4 in) since 1999, mostly as ammoniacal forms for all crops with the exception of grain legumes.

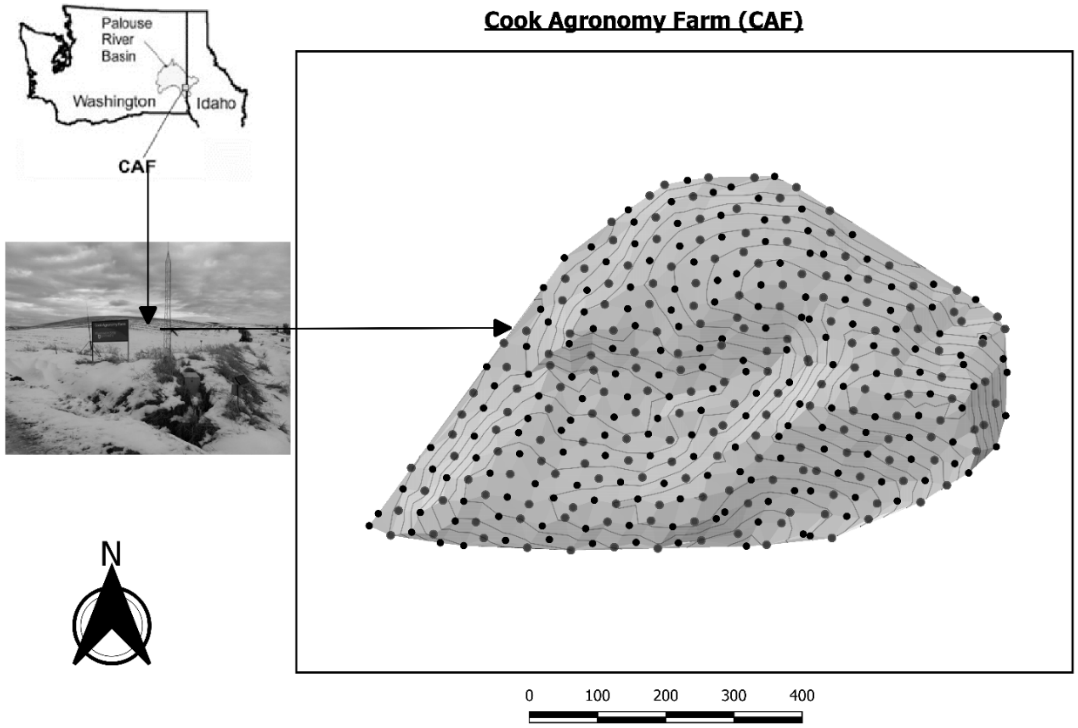

Fig. 1. Sampling points for the 92 ac Cook Agronomy Farm: Black and red dots represent 369 geo-referenced points whereas red dots represent samples (184) used in our study. Contour lines are created at 7 ft (2.5 m) intervals.

One hundred and eighty-four of the 369 geo-referenced sample locations were selected for this study (Fig. 1). Intact soil cores (0 to 5 feet) were collected at alternating points and divided into depth-increments of 0-10 cm (0-4 in), 10-20 cm (4-8 in), 20-30 cm (8-12 in) and then by soil horizon to 150 cm (5 ft). Samples were air-dried at room temperature, passed through a 2-mm sieve and analyzed for soil pH (1:1, soil:water). Analysis of variance was used to assess differences in soil pH over time for 3 soil series (Naff, Palouse, Thatuna). Spatial maps were created using inverse distance squared interpolation at relevant depths.

RESULTS AND DISCUSION

Soil pH in the surface foot (0-30 cm) decreased consistently over time and were below 5 for the surface 4 in (0-10 cm) depth-increment after 17 years (Figs. 2, 3, 4). Contributing factors to stratified soil pH were lack of mechanical mixing with tillage and deep-band placement of applied N fertilizer. Surprisingly, subsoil pH values of below 6 occurred in portions of the field in 1998, indicating that acidification was occurring under conventional tillage in portions of the field (Figs. 2, 5, 6). These locations were primarily in low elevation, bottomland areas where Thatuna soil is more prevalent. In addition, tremendous soil profile variability in pH occurred within a given soil type (Fig. 2). Contributing factors are likely leaching of nitrate-N as driven by field-scale surface run-off, infiltration and subsurface movement under conventional tillage. After initiation of NT, subsoil pH for 2 to 5 ft (60-150 cm) depths increased from 5.5 to over 6.5 from for much of the field (Figs. 2, 5, 6). Increases of subsoil pH under NT were likely driven by greater infiltration of water coupled with greater subsurface movement of nitrate and leaching of bases. Production systems that decrease N and base leaching by increasing water use and N use efficiency should be considered.

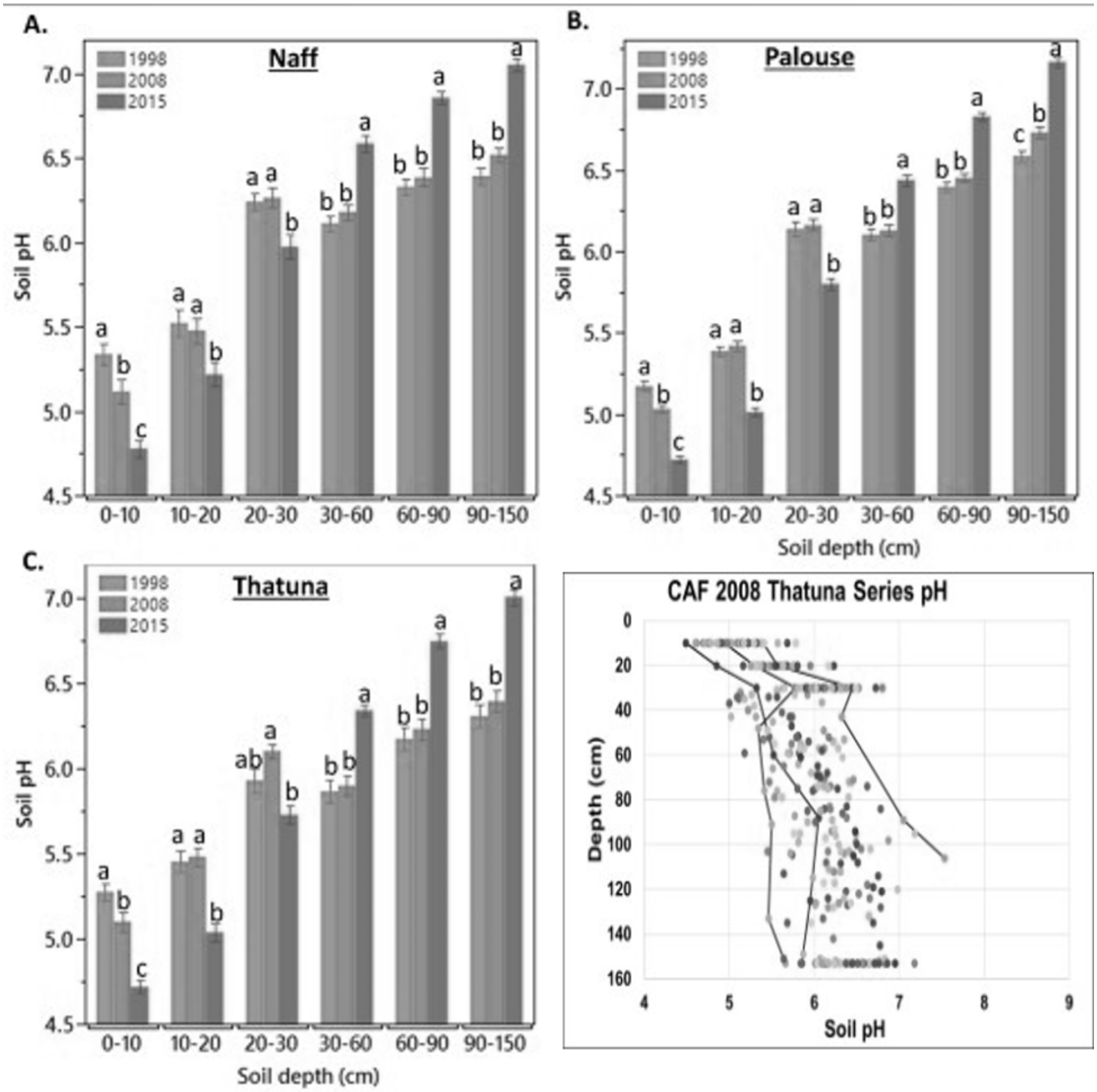

Fig. 2. Soil pH over time (1998, 2008, and 2015) at different soil depths in A. Naff, B. Palouse, and C. Thatuna series soil of Cook Agronomy Farm. Means sharing the same letter in bars within depth are not significantly different at a 5% significance level. Depth distribution of soil pH at points with Thatuna series in 2008.

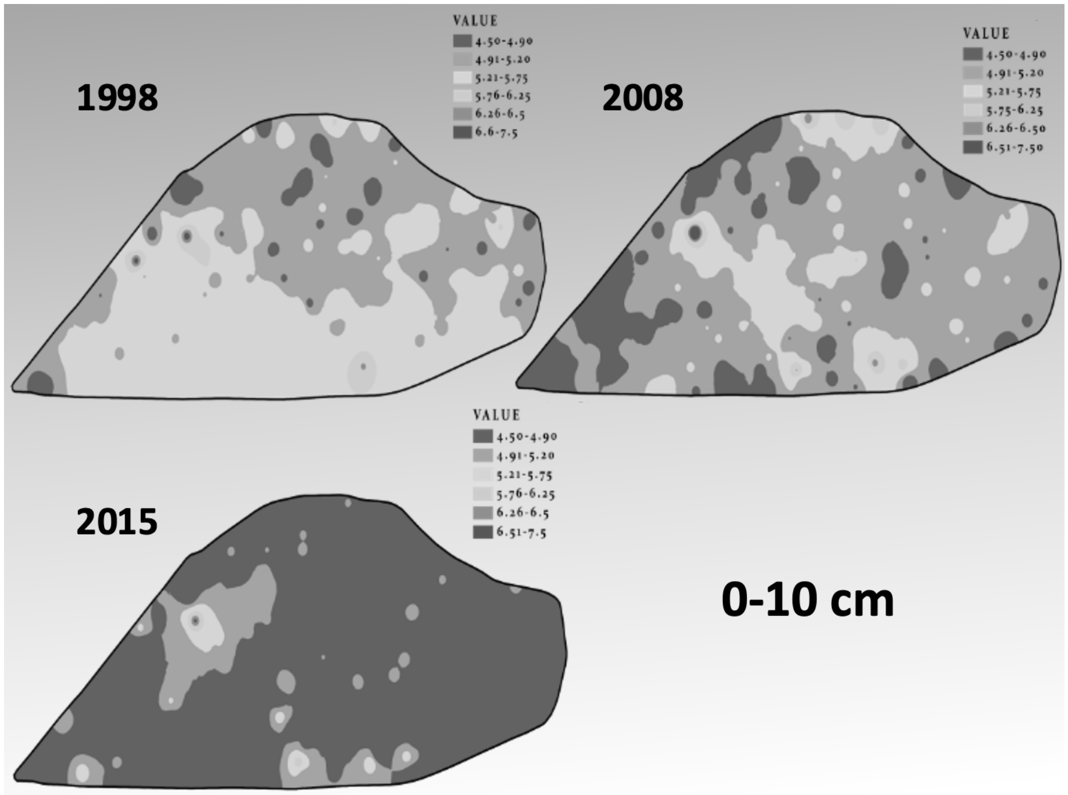

Figure 3. Soil pH in the surface 4 inches (0-10 cm) over the 92 ac Cook Agronomy Farm in 1998, 2008 and 2015.

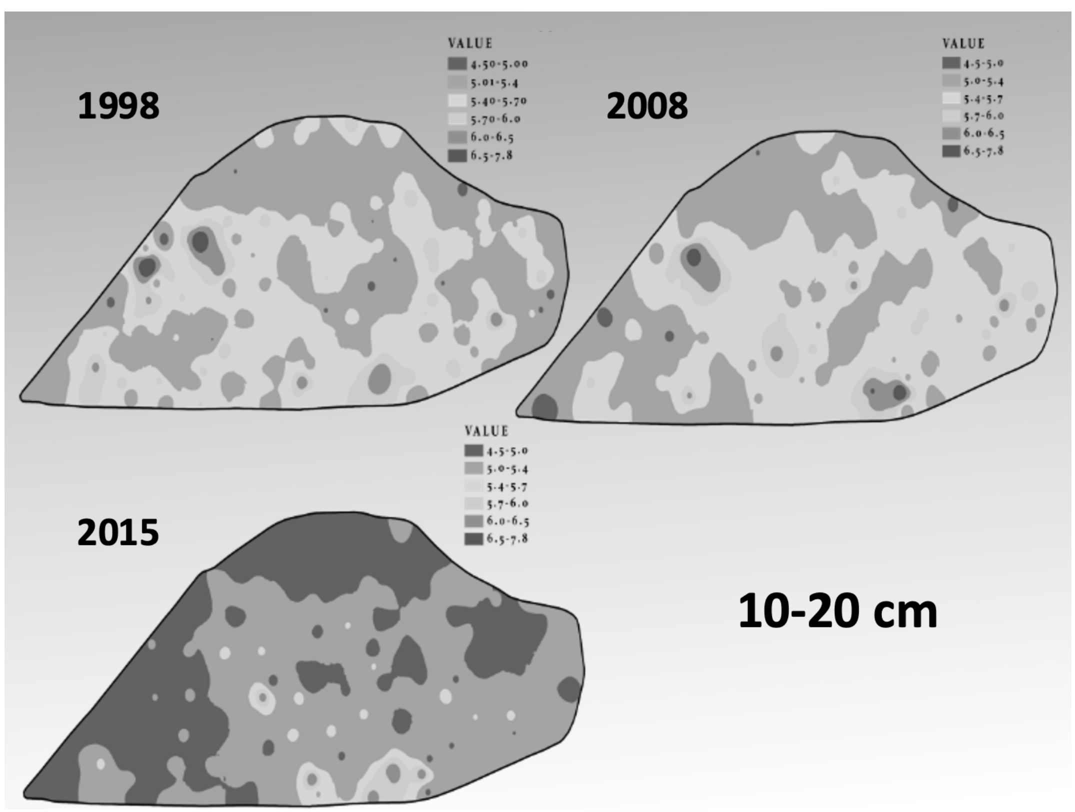

Figure 4. Soil pH in the surface 4-8 inches (10-20 cm) over the 92 ac Cook Agronomy Farm in 1998, 2008 and 2015.

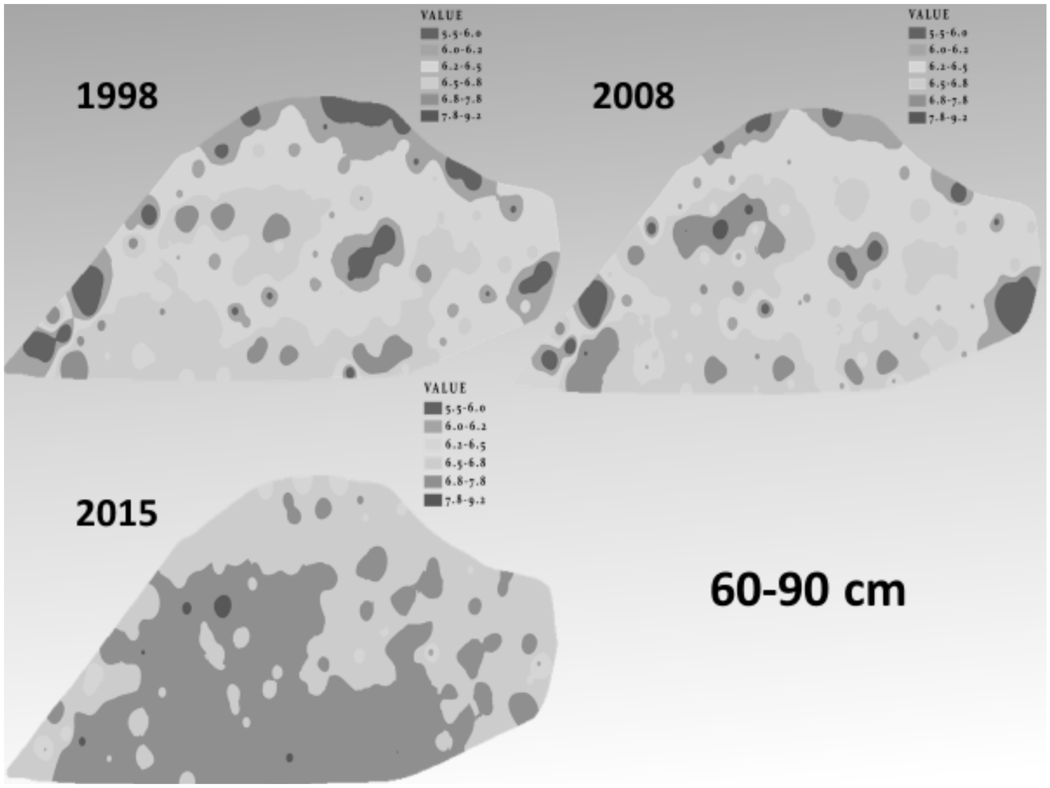

Figure 5. Soil pH in the subsurface 2-3 feet (60-90 cm) over the 92 ac Cook Agronomy Farm in 1998, 2008 and 2015.

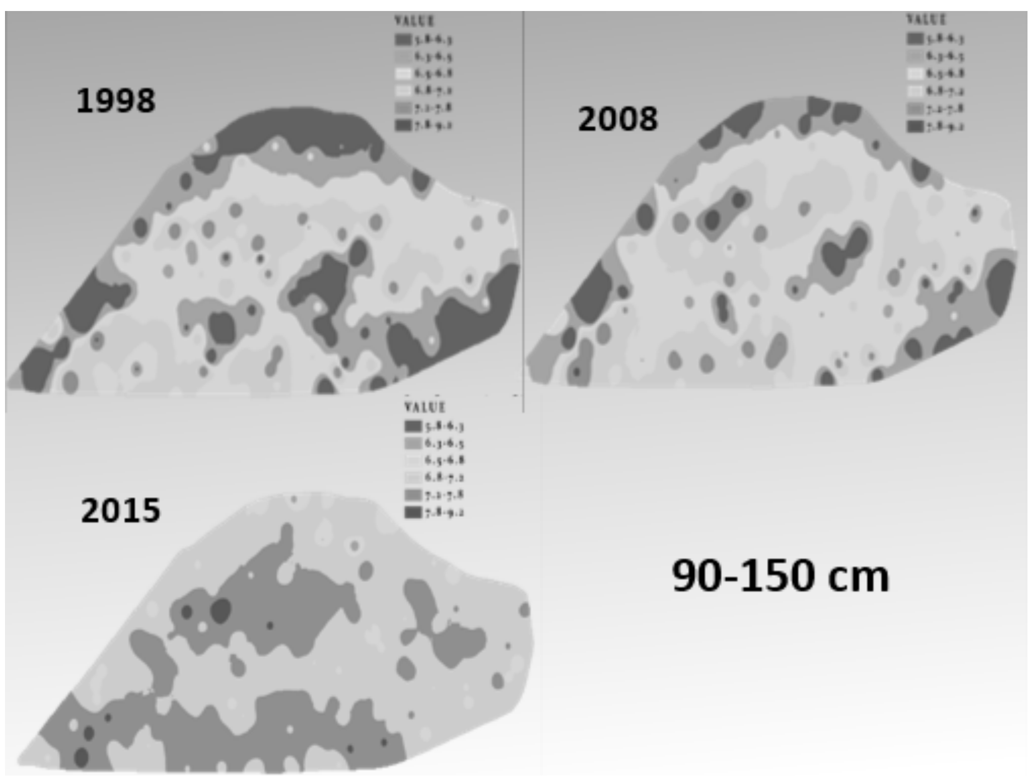

Figure 6. Soil pH in the subsurface 3-5 feet (90-150 cm) over the 92 ac Cook Agronomy Farm in 1998, 2008 and 2015.