

## **Short Term Effect of Breaking and Cultivation on Properties of a an Oxbow Landscape.**

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### **ABSTRACT**

Changes in soil quality over the first six years of cultivation were studied for an Oxbow landscape dominated by Black Chernozems. Bulk density at shoulder, footslope and level landforms was found to increase by 15 - 20% from 1985 to 1988 and by 3 - 4% from 1988 to 1991. Similarly, organic carbon concentration declined by 17 - 37% and 0 - 10%, respectively, over the same periods. These results demonstrate that cultivation of virgin land has an almost immediate impact on soil quality. <sup>137</sup>Cesium measurements indicated that appreciable soil erosion has not occurred in this landscape since cultivation began.

### **INTRODUCTION**

The impact of cultivation on soil properties has been widely studied in Saskatchewan. The usual method for evaluating changes in soil quality has been to compare a soil cultivated for a known length of time with a nearby uncultivated (virgin) soil (Newton et al, 1945; Martel and Paul, 1974; Tiessen et al, 1982; Gregorich and Anderson, 1985). These studies have demonstrated that cultivation significantly increases bulk density and reduces organic carbon (C) concentration (i.e. % by weight) in the surface layer over periods of 15 - 90 years, contributing to an increased potential for soil erosion. However, less attention has been directed to changes in soil quality during the initial years of cultivation, probably due to a relative scarcity of recently broken land. The objectives of this study were to monitor the short term changes in soil quality arising from the breaking and subsequent cultivation of a landscape and to determine whether erosion had occurred during this period.

### **MATERIALS AND METHODS**

The area selected for this study is situated on the Termuende Animal Science research farm located approximately 10 km east of Lanigan, Saskatchewan near the boundary of the Black and Dark Brown soil zones. The local area is dominated by Black Chernozemic soils (Oxbow association) developed on glacial till and characterized by hummocky terrain with slope gradients of 2 - 3%. This field was vegetated by grasses, shrubs and aspen until 1985 when it was cleared, broken and brought into continuous cereal crop production.

A transect consisting of 60 sites spaced five metres apart and representing all landscape positions was established and sampled prior to breaking. Landform elements were later classified according to the system developed by Pennock et al (1987) and placed into one of three categories: shoulders (upper slopes), footslopes (lower slopes) and level sites. Detailed profile descriptions were recorded for each site.

0 - 15 cm core samples were air dried and weighed to determine bulk densities, then were ground to pass through a 2 mm sieve. Organic C content (% by weight) was determined using the modified Mebius procedure (Nelson and Sommers, 1982). <sup>137</sup>Cesium was determined by gamma spectroscopy (de Jong et al, 1982) and expressed in units of becquerels per square metre (Bq m<sup>-2</sup>). The transect was resampled in 1988 and 1991 and the same determinations made for the 0 - 15 cm samples.

## RESULTS AND DISCUSSION

Results are summarized in Table 1. Mean bulk densities of shoulder, footslope and level soils increased by 15, 19 and 20%, respectively, during the first three years of cultivation. Although bulk densities continued to rise in all three landforms from 1988 to 1991, these increases were less significant. These data indicate that cultivation can have an immediate impact on soil physical conditions at all positions in the landscape. Tiessen et al (1982), however, found no difference in bulk density between a native Orthic Black Chernozem and an adjacent site which had been cultivated for four years.

Mean organic C concentrations of shoulder, footslope and level soils exhibited highly significant decreases of 17, 37 and 19%, respectively, from 1985 to 1988. However, the decline from 1988 to 1991 was not as evident. Although level soils experienced a significant 10% decrease over this period, footslope and shoulder soils showed no change in organic C concentration. As with bulk density, these results show that the greatest effect of cultivation on soil organic matter occurred immediately after the field was broken. Newton et al (1945) reported similar decreases of 10, 14 and 27% (relative to adjacent virgin soils) for three sites in the Black soil zone cultivated for five, four and nine years, respectively. Table 1 also shows a steady decrease in the standard deviation at all landforms from 1985 to 1991, suggesting that cultivation has made organic C concentration less variable over time. The initial, rapid decline in organic C concentration can be attributed to favourable mineralization conditions created at the time of breaking, particularly in footslope soils which tend to have higher moisture contents. (Anderson, 1990).

It is important to note that no actual loss of organic C has occurred in six years of cultivation. If organic C is expressed in terms of mass per unit area (% organic C X bulk density X sampling depth), the total amount of C has remained fairly constant because the increase in bulk density has balanced the decline in organic C concentration. The observed decrease in organic C concentration thus implies a change in the quality (i.e. mineralizability), rather than quantity, of soil organic matter. If it is assumed

Table 1. Mean bulk density, organic C and  $^{137}\text{Cs}$  values for soils in three landscape positions sampled in three different years.

	Shoulder Complex (n=18)			Footslope Complex (n=22)			Level Complex (n=20)		
	1985 <sup>a</sup>	1988	1991	1985	1988	1991	1985	1988	1991
Bulk density (Mg m <sup>-3</sup> )	1.01 <sup>1</sup> (0.06) <sup>2</sup>	1.16*** (0.07)	1.19 (0.11)	0.96 (0.09)	1.14*** (0.14)	1.20* (0.12)	0.94 (0.11)	1.15*** (0.16)	1.20 (0.08)
Organic C (%)	4.6 (1.0)	3.8** (0.7)	3.7 (0.7)	6.2 (1.7)	3.9*** (1.1)	4.0 (0.7)	4.8 (1.0)	3.9*** (0.8)	3.5** (0.6)
$^{137}\text{Cs}$ (Bq m <sup>-2</sup> )	2553 (500)	2355 (1193)	2293 (548)	3005 (1494)	2423 (1117)	2734 (780)	2559 (719)	2451 (843)	2548 (854)

<sup>1</sup> mean<sup>2</sup> (standard deviation)

\* significant at P&lt;0.1

\*\* significant at P&lt;0.05

\*\*\* significant at P&lt;0.001

<sup>a</sup> Paired samples t-test used to determine differences between 1988 and 1985 and between 1991 and 1988.

that bulk densities are stabilizing more quickly than mineralization rates, net losses of organic C may begin to occur in the near future.

<sup>137</sup>Cesium is a stable isotope which adheres strongly to soil particles, consequently, its movement within a landscape is closely linked to physical processes which move soil (Ritchie and McHenry, 1989). Thus, <sup>137</sup>Cs measurements can determine if soil redistribution has occurred within a landscape (e.g. from upper to lower slope positions). As shown in Table 1, <sup>137</sup>Cs levels exhibited some temporal variability (possibly due to different standardizations of the <sup>137</sup>Cs detecting equipment) but generally remained constant over time in each landform complex, indicating that the processes of soil erosion and deposition have not yet occurred in this landscape. This supports the above observation that net organic C levels have remained constant and is consistent with the findings of Gregorich and Anderson (1985) who noted that erosion losses of C on upper slope soils in the first 20 years of cultivation were minor compared with mineralization losses.

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