# Differences in Soil Organic Carbon in Landscapes in Cropland, Restored Grassland, and Native Grassland in the Northern Great Plains

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## Abstract

We recently sampled over 1200 sites in seven sampling areas across five states in the northern Great Plains. The sampling sites were located across various landscape positions on cultivated crop land, restored grasslands (including CRP land) and native grasslands. Soil organic carbon (SOC) was determined for the upper 30 cm of the soil at each site. Landscape positions were categorized into summit, shoulder, backslope, footslope, and toeslope positions. We also created categories of undulating uplands and lowlands for sites where landscape positions were not clearly defined but the sampling sites were at positions high or low in the landscape relative to the standard landscape position categories. Differences in SOC between the landscape positions were observed but, in most cases, high SOC variability precluded determining significant differences between SOC levels among the landscape positions.


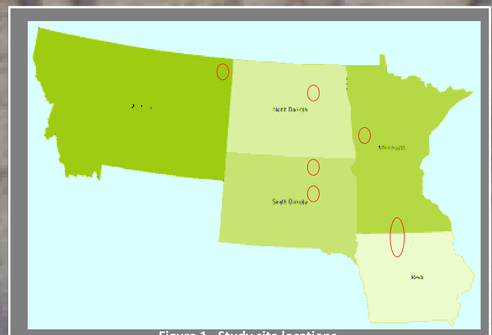


Figure 1. Study site locations.

## Sampling Locations

**Sampling regions are in northeastern Montana, central North Dakota, east-central North Dakota, north-central South Dakota, central South Dakota, western Minnesota, south-central Minnesota, and north-central Iowa (Table 1). These areas were selected in conjunction with previous long-term wetland studies conducted by the U.S. Geological Survey. The sites give a good representation of the Prairie Pothole Region of the United States.**

## Methods

**At sampling locations, five soil samples were taken with a hand probe. The top 0-15 cm and bottom 15-30 cm portions of the sample were composited in separate bags. Results indicate a composite of the samples and are reported as 0-30 cm. After the samples were collected, notes were taken to record vegetation, landscape position, GPS coordinates, and other unique characteristics about the sampling location (Figure 2).**

| Landscape Position | Land Management Type: Cultivated | Restored Grasslands | Native Grasslands |
|---|---|---|---|
| | kg C $m^{-2}$ $yr^{-1}$ 30 $cm^{-1}$ | | |
| Undulating Upland | 5.49§ | 2.22 (1.02‡) | 5.68 (0.77‡) |
| Summit | 4.29§ | 5.06 (1.63‡) | 6.11 (3.71‡) |
| Shoulder | 4.35 (0.90‡) | 4.81 (1.99‡) | 5.73 (0.98‡) |
| Back Slope | 4.03 (1.58‡) | 5.00 (1.78‡) | 6.21 (1.88‡) |
| Foot Slope | 2.96 (1.12‡) | 7.20 (2.67‡) | 6.69 (3.03‡) |
| Toe Slope | 5.04 (1.82‡) | 8.26§ | 7.22§ |
| Undulating Lowland | 4.17§ | NA† | NA† |

Table 1. Average soil organic carbon values for landscape positions in northeastern Montana under three land management practices.
† NA – Data not available.
‡ Standard deviation for landscape position values.
§Not enough data to calculate standard deviation.

| Landscape Position | Land Management Type: Cultivated Cropland | Restored Grasslands† | Native Grasslands |
|---|---|---|---|
| | kg C $m^{-2}$ 30 $cm^{-1}$ | | |
| Undulating Upland | 6.75 (1.43) | 5.01 (1.48) | 8.17 (1.73) |
| Summit | NA‡ | NA‡ | NA‡ |
| Shoulder | NA‡ | 4.75 (1.37) | 10.24 |
| Back Slope | 7.96 (0.97) | 6.07 (2.24) | 8.04 (2.20) |
| Foot Slope | NA‡ | 6.87 (2.30) | 8.67 (3.69) |
| Toe Slope | NA‡ | 4.62 (2.69) | NA‡ |
| Undulating Lowland | NA‡ | 4.84 (1.77) | 7.62 (1.12) |

Table 2. Average soil organic carbon values for landscape positions sampled in northeastern North Dakota under three management practices. The numbers in parentheses are the standard deviation for the landscape position values. Values without standard deviations did not have enough data to calculate a standard deviation.
† LSD comparing the restored grasslands management type is significantly different than the other management types.
‡ NA – Not Available

| Landscape Position | Land Management Type: Cultivated Cropland | Restored Grasslands | Native Grasslands |
|---|---|---|---|
| | kg C $m^{-2}$ 30 $cm^{-1}$ | | |
| Undulating Upland | NA† | 7.27 (1.14) | 8.87 (1.72) |
| Summit | NA† | 6.70 | NA† |
| Shoulder | 5.92 (1.16) | 6.75 (1.39) | 7.99 (1.71) |
| Back | 7.75 (1.62) | 7.03 (0.87) | 8.24 (1.52) |
| Foot | NA† | 8.58 (1.97) | 12.09 (2.60) |
| Toe | 9.29 | 7.44 (0.55) | NA† |
| Undulating Lowland | NA† | NA† | NA† |

Table 3. North-central average soil organic carbon for landscape positions (0-30 cm). The numbers in parentheses are the standard deviation for the landscape position values. Values without standard deviations did not have enough data to calculate a standard deviation.

† NA – Not Available

| Landscape Position | Land Management Type: Cultivated Cropland | Restored Grasslands | Native Grasslands |
|---|---|---|---|
| | kg C $m^{-2}$ 30 $cm^{-1}$ | | |
| Undulating Upland | 6.14 (1.52) | 7.33 (1.53) | 8.46 (1.05) |
| Summit | NA† | NA† | 9.05 (0.99) |
| Shoulder | 6.37 (1.98) | 6.98 (1.45) | 8.38 (1.18) |
| Back Slope | 6.62 (1.03) | 7.46 (1.41) | 8.07 (0.67) |
| Foot Slope | 9.8 (0.17) | 7.87 (1.39) | 9.19 (1.01) |
| Toe Slope | 9.63 (0.36) | 8.35 (0.74) | NA† |
| Undulating Lowland | NA† | NA† | NA† |

Table 11. Average soil organic carbon values for landscape positions sampled in central South Dakota under three land management practices. The numbers in parentheses are the standard deviation for the landscape position values. Values without standard deviations did not have enough data to calculate a standard deviation.

† NA – Not Available

| Landscape Position | Land Management Type: Cultivated Cropland | Restored Grasslands | Native Grasslands |
|---|---|---|---|
| | kg C $m^{-2}$ 30 $cm^{-1}$ | | |
| Undulating Upland | 10.35 (2.37) | 9.37 (1.81) | 8.62 (2.07) |
| Summit | NA† | 9.31 | 8.50 (1.44) |
| Shoulder | NA† | 9.17 (1.75) | 7.91 (2.23) |
| Back Slope | 7.85 (2.47) | 8.96 (1.94) | 8.99 (1.71) |
| Foot Slope | NA† | 9.39 (2.07) | 9.32 (1.08) |
| Toe Slope | NA† | NA† | NA† |
| Undulating Lowland | NA† | 8.09 | NA† |

Table 13. Average soil organic carbon values for landscape positions sampled in western Minnesota under three land management practices. The numbers in parentheses are the standard deviation for the landscape position values. Values without standard deviations did not have enough data to calculate a standard deviation.

† NA – Not Available

| Landscape Position | Land Management Type: Cultivated Cropland | Restored Grasslands | Native Grasslands‡ |
|---|---|---|---|
| | kg C $m^{-2}$ 30 $cm^{-1}$ | | |
| Undulating Upland | 10.41 (2.59) | 10.33 (1.42) | 12.38 (1.26) |
| Summit | NA† | NA† | NA† |
| Shoulder | 8.16 (1.80) | 8.01 (1.69) | 9.86 (1.10) |
| Back Slope | 9.12 (1.53) | 8.35 (1.93) | 10.48 (1.25) |
| Foot Slope | 10.08 (1.84) | 10.19 (1.74) | 11.46 (0.68) |
| Toe Slope | NA† | 11.22 (1.93) | NA† |
| Undulating Lowland | NA† | 9.66 (1.78) | 13.21 (031) |

Table 15. Average soil organic carbon values for landscape positions sampled in north-central Iowa under three land management practices in north-central Iowa and southern Minnesota. The numbers in parentheses are the standard deviation for the landscape position values. Values without standard deviations did not have enough data to calculate a standard deviation.

† NA – Not Available
‡ Significantly different

## Soil Tests

**Samples were analyzed for volumetric moisture %, and bulk density was determined. Organic carbon was determined using a high-temperature combustion method by the NDSU Soil and Water Environmental Laboratory and is reported as carbon mass.**

## Results and Summary

**In general the average SOC levels would start at high levels in the undulating uplands, decrease at the shoulder and backslope positions, and start to increase at the foot, toe, and undulating lowland positions. There were many instances where no data was gathered on certain landscape positions because at those sampling locations they were not representative of the landscape.**

**We expected to see higher SOC levels in the lower landscape positions due to erosion effects in natural and cultivated systems.**


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