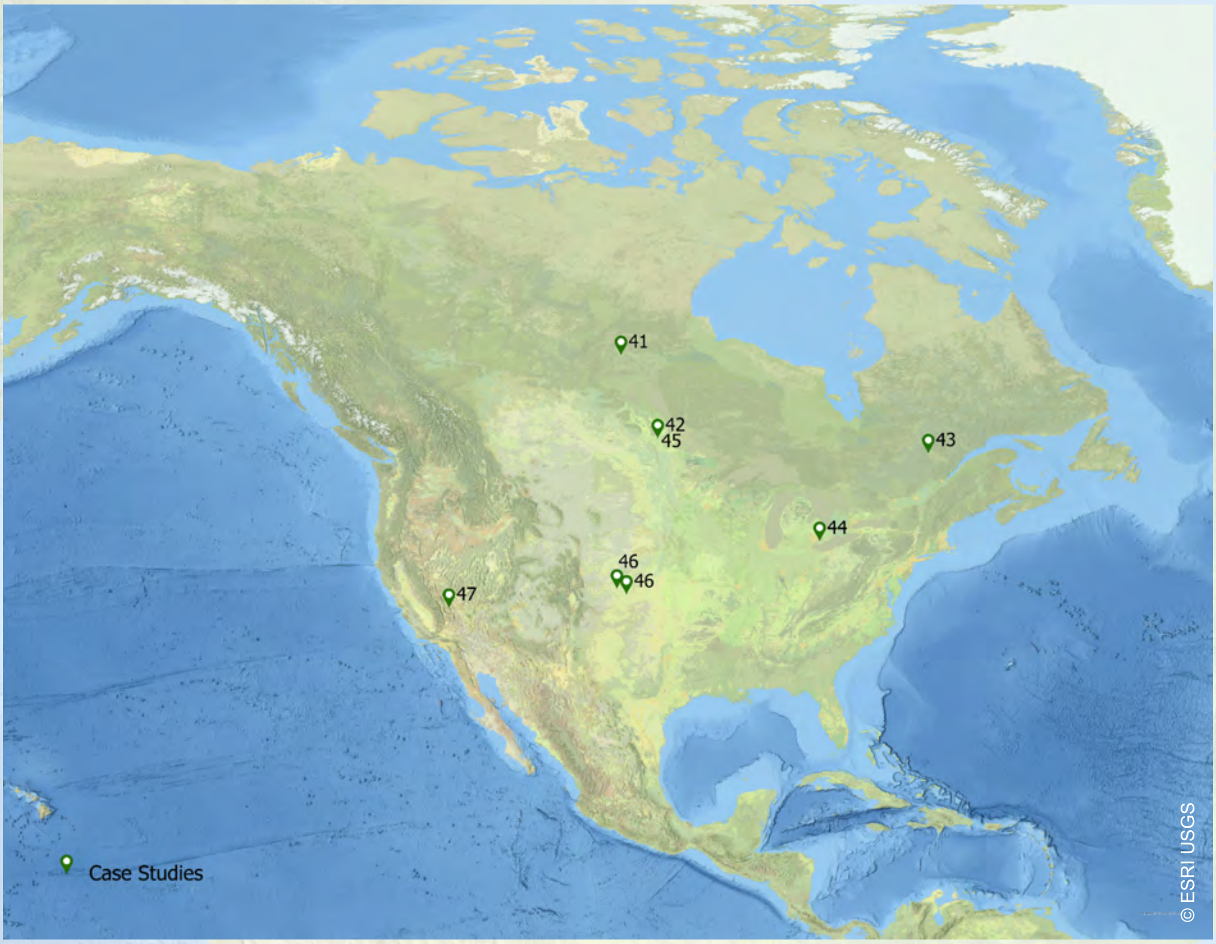
North America



44. Zone Tillage of a Clay Loam in Southwestern Ontario, Canada

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1. Related practices

Zone tillage, No-till

2. Description of the case study

No-till (NT) management can reduce corn (*Zea mays L.*) yields relative to moldboard plow tillage (MP) on fine textured soils in cool humid climates. Zone tillage (ZT) consists of tilling the corn row only and leaving the interrow area uncultivated. Zone tillage increased corn yields relative to NT. In this study, SOC content, bulk density, and penetration resistance were compared both in zone and between zones for the ZT, MP, and NT tillage treatments for a Brookston clay loam soil (Typic Argiaquoll) in southern Ontario, Canada.

This case study was initiated in 1993. The initial treatments included three NT and two MP treatments, which were arranged in a randomized complete block design with four replicates. In 1996, one of the NT treatments was left as NT, while the other two NT treatments were converted into ZT. No soil disturbance occurred in the NT treatment except for planting with a no-till planter. The MP treatment included moldboard plowing to the 15- to 17-cm depth each fall and then secondary cultivation or disking and harrowing in the following spring just before planting. The ZT treatment (ZT) involved a fall tillage operation using a chisel shank and two fluted coulters which were used to cultivate the soil in 21 cm wide zones that were ~15 cm deep (McLaughlin *et al.*, 2008). The corn was planted into the middle of each zone in the following spring. Corn row spacing for all tillage treatments was 76.2 cm, hence MP had 100 percent of the soil surface cultivated, ZT had ~28 percent of the soil surface cultivated and the soil surface was not cultivated at all with NT. During the course of the 3 year rotation, there was one fall tillage operation for ZT (before the corn phase) while the soybean and winter wheat phases of the ZT treatment were under no-till. In contrast, fall tillage was used every year for the 3 crops under MP.

3. Context of the case study

Research was conducted on a Brookston clay loam soil located at the Eugene F. Whelan Research Farm, Agriculture and Agri-Food Canada, Woodslee, ON (42°13′ N, 82°44′ W). The average soil texture in the top 15 cm is 28 percent sand, 35 percent silt, and 37 percent clay by weight, and the soil pH ranges from 6.1 to 6.5. The mean annual air temperature and precipitation at the field site are 8.7°C and 827 mm, respectively. Soil erosion and surface runoff are negligible because surface slopes are <1 percent.

4. Possibility of scaling up

Zone tillage could be applied in multiple geographic areas and climatic condition, primary focus for use in areas with fine textured soils and cool, humid climates. The benefits of NT are not consistent across soil type, climate, and landscape. For instance, continuous NT on the cool, humid, fine-textured soils of southwestern Ontario generally reduces corn yields because of excess crop residues, surplus soil water, and lower soil temperatures in the spring, which in turn reduces corn emergence and impairs early corn growth (Drury *et al.*, 1999, 2003; Dwyer *et al.*, 2000; Yang *et al.*, 2008). In addition, continuous NT on fine-textured soils usually leads to increased soil bulk density and soil strength (Drury *et al.*, 2003; López-Fando and Almendros 1995; López-Fando, Dorado and Pardo, 2007), enhanced water and nutrient movement below the root zone (Franzluebbers, Causarano and Norfleet, 2009), decreased air-filled soil porosity and saturated hydraulic conductivity (Pierce, Fortin and Staton, 1992), and increased risk of seedling desiccation due to reopening of the seed planting slot (Drury *et al.*, 1999, 2003).

5. Impact on soil organic carbon stocks

Table 180 shows the additional C storage potential of NT and ZT as compared to the baseline conventional MP treatment on 0-30 layer depth, in the study plot (Canada, Cool temperate moist climate). Soils are Brookston clay loam soil (Typic Argiaquoll in USDA Soil Taxonomy).

Assumptions:

1) CT was in equilibrium so that the quantity of SOC in 2009 was similar to that in the fall of 1993 and the fall of 1996.
2) The impacts of ZT over NT were from the fall of 1996 to the fall of 2009 (13 years)
3) The C sequestration rate for NT was from the fall of 1993 to the fall of 2009 (16 years).
4) The rate of change in SOC sequestration is assumed to be linear over time.
5) The initial SOC for the ZT treatment in the fall of 1996 was assumed to be proportional to the change over the 16 years.

Table 180. Evolution of SOC stocks according to different tillage treatments on the study site at 0-30 cm depth

Baseline C stock (tC/ha)	Additional C storage (tC/ha/yr)	Duration (years)	More information	References
71.7	0	16	Conventional (Moldboard Plow) Treatment	Shi *et al.* (2006); Drury *et al.* (2012, 2006)
	62	13	No-Tillage Treatment	
	673	13	Zone Tillage Treatment	

6. Other benefits of the practice

6.1. Improvement of soil properties

ZT had the lowest bulk density and penetration resistance of the 3 tillage treatments (Shi *et al.*, 2011).

6.2 Minimization of threats to soil functions

Table 181. Soil threats

Soil threats	
Soil erosion	Reduced soil disturbance compared to Moldboard Plow treatment
Nutrient imbalance and cycles	Nutrient mixing occurs MP and in the zone with ZT but nutrient stratification would be expected under NT.
Soil biodiversity loss	Tillage has detrimental impact on earthworm populations when short and long-term NT and ZT were compared in an adjacent tillage study.
Soil compaction	Continuous NT on fine-textured soils usually leads to increased soil bulk density and soil strength, enhanced water and nutrient movement below the root zone, decreased air-filled soil porosity and saturated hydraulic conductivity, and increased risk of seedling desiccation due to reopening of the seed planting slot.

6.3 Mitigation of and adaptation to climate change

Fuel and energy saving benefits: Fuel consumption and related GHG emissions on a per hectare basis was highest for the moldboard plow at 21.6 L/ha, over three times the 6.5 L/ha for the shallow zone till (McLaughlin *et al.*, 2008).

7. Possible increases in greenhouse gas emissions

In two 3-year studies, ZT had significantly lower N_2O emissions than both NT and MP when the N fertilizer was injected at about 10 cm depth (Drury *et al.*, 2006, 2012). In particular, the N_2O emissions under ZT were 38-44 percent lower than MP whereas NT had 17-23 percent lower N_2O emissions than CT (Drury *et al.*, 2006, 2012).

8. Potential barriers for adoption

Table 182. Potential barriers to adoption

Barrier	YES/NO	
Biophysical	Yes	Climatic: ZT benefits best realized in areas with fine textured soils and cool, humid climates, in drier condition, NT benefits seen in drier conditions (Angers *et al.*, 1997)/

Photo

Photo 97. Zone tillage in the fall (September/October) following a July winter wheat harvest in preparation of spring planting of grain corn into the tilled zones in the following May

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