Soil Organic Carbon Dynamics Beneath Tree Windbreaks in the Russian Steppe and U.S. Great Plains

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INTRODUCTION.

Tree windbreaks represent an attractive multiple-benefit land use through their ability to mitigate climate change by modifying the local microclimate to improve crop growth and by sequestering carbon in the soil and tree biomass. Current climate change literature has many examples of changes in soil organic carbon (SOC) content following changes in management practices. However, basic studies of the specific biogeochemical drivers of these changes are still relatively uncommon. This study was designed to address specific questions regarding tree plantings on former agricultural lands that are a very promising bioenergy system with potential for both bioenergy production and C sequestration. The relationship between C accumulation and climate factors enables the estimation of soil carbon stocks in existing windbreaks and the prediction of potential carbon sequestration in future plantings.

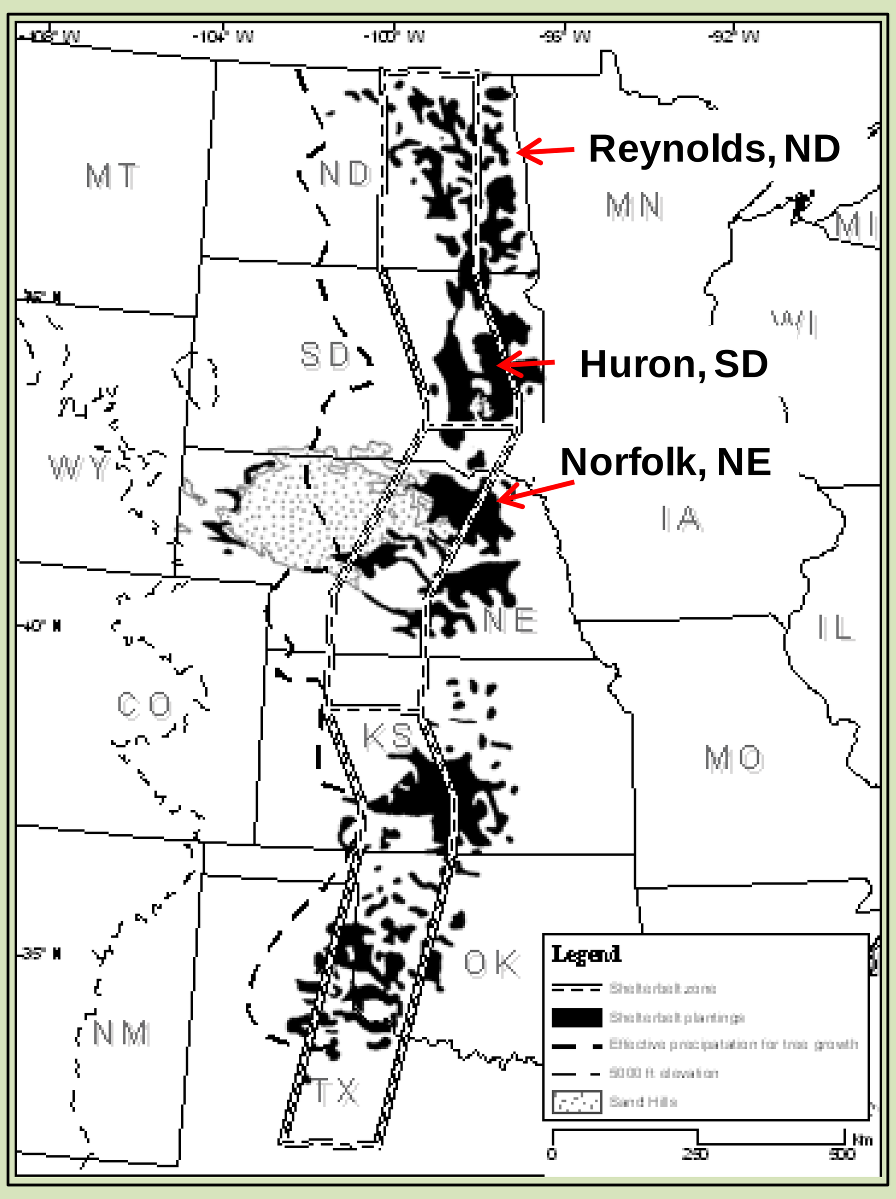
OBJECTIVE.

Determine the soil C sequestration potential of tree planting on marginal or degraded agricultural soils across climatic gradients in the U.S. Great Plains and Russian Central Uplands.

MATERIALS & METHODS

- Six sites identified in U.S. and Russia with range of mean annual temperature (MAT) of 4.4 to 9.6°C, mean annual precipitation (MAP) from 485 to 696 mm, and hydrothermal coefficient (HTC, Selyaninov, 1928) from 1.0 to 1.47.
- Soil samples collected in three parallel transects spaced 4 to 5.5 m apart and approximately the same spacing within transects.
- Three soil samples per sampling point composited by depth, 0-15 and 15-30 cm.
- Soil was air-dried, ground to pass a 2 mm sieve, and roller-milled before SOC determination by dry combustion on a Fison NA 15000 Elemental Analyzer (ThermoQuest Corp., Austin, TX).
- Soil pits and full profile descriptions were prepared for tree, crop, and undisturbed grassland at all locations.

May 2012



July 2012

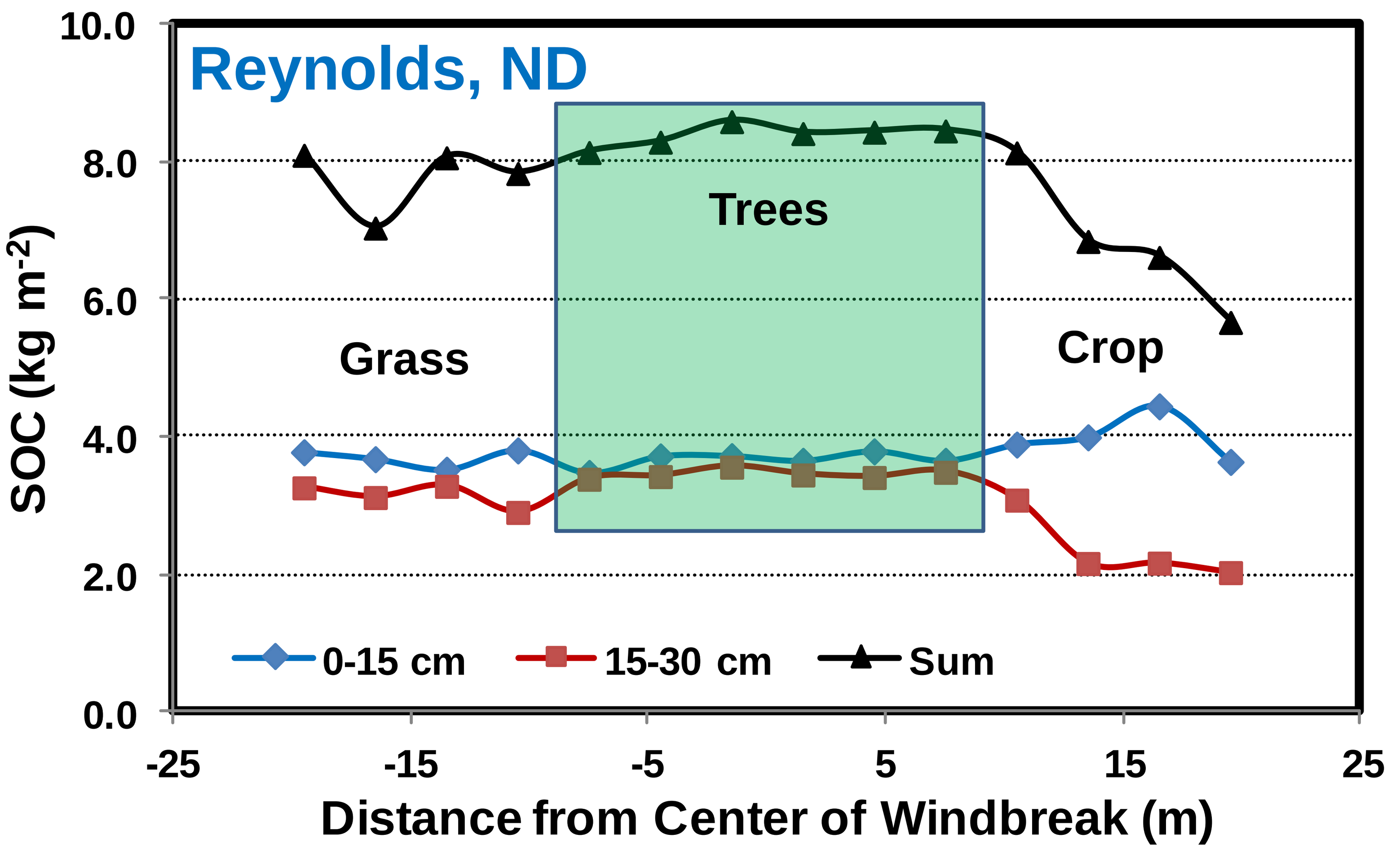
Sampling teams in Russia (above) and South Dakota (below).

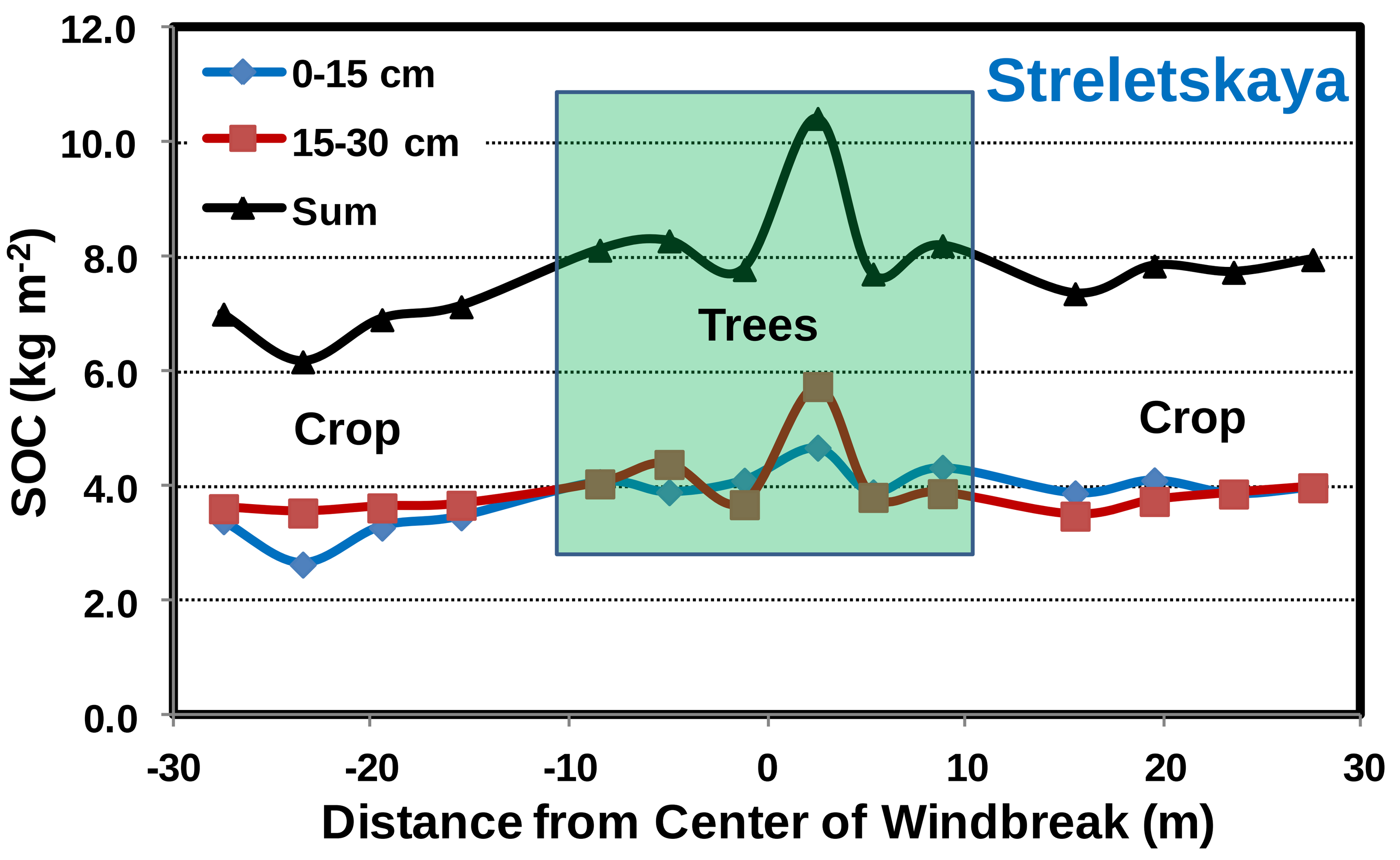
Site	MAT	MAP	HTC	Site	MAT	MAP	HTC
Reynolds	4.4°C	528 mm	1.41	Streletskaya	5.3°C	585 mm	1.23
Huron	7.7	582	1.31	Yamskaya	5.6	535	1.10
Norfolk	9.6	696	1.47	Kamennaya	5.8	485	1.0

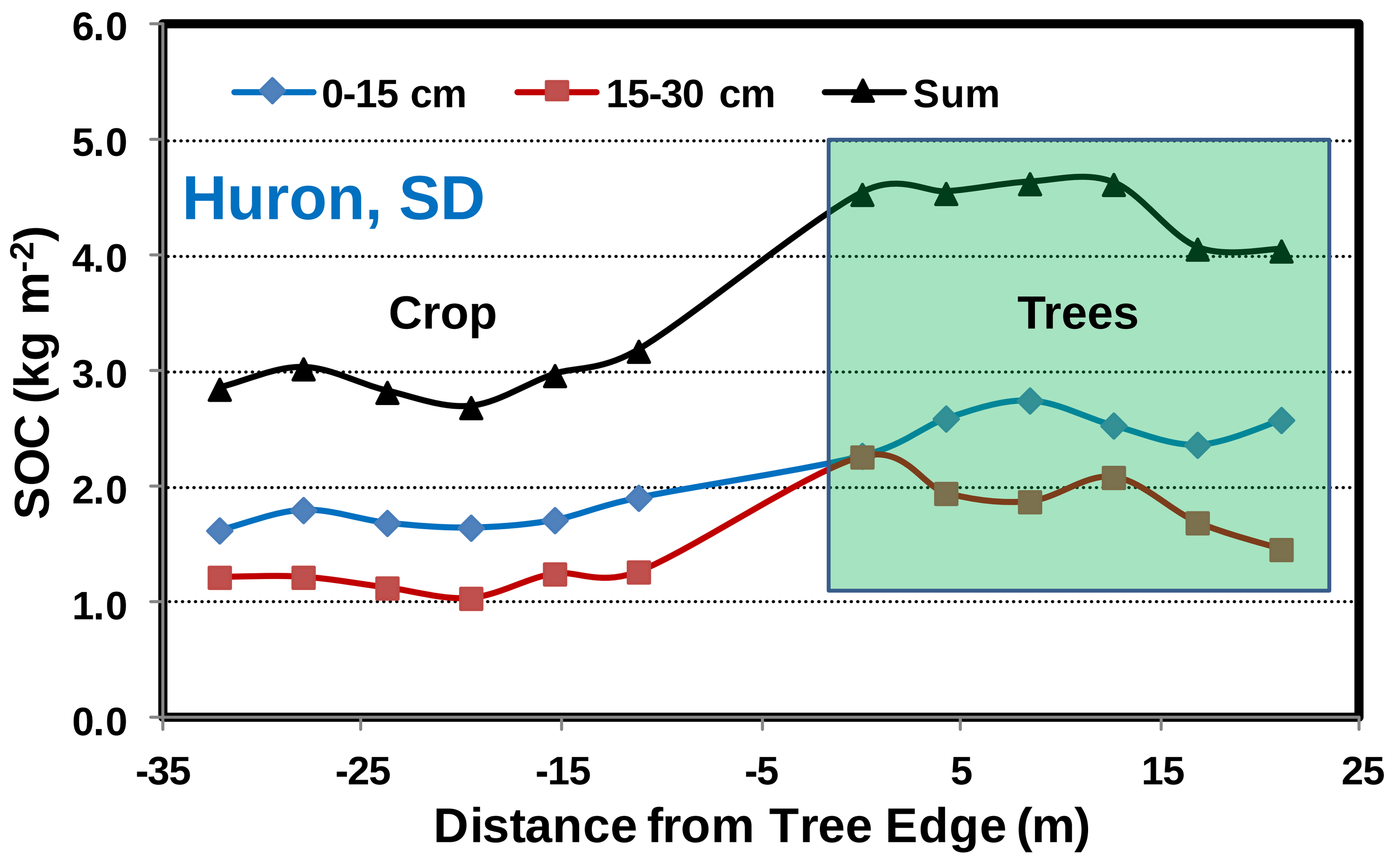
Site	Soil Texture	Trees (age)	Crops (length of cultivation)
Reynolds	loam	Green ash (*Fraxinus pennsylvanica*) Redcedar (*Juniperus virginiana*) (53 yrs)	Wheat (*Triticum aestivum*, L.), corn (*Zea mays*, L.), soybean (*Glycine max* (L.) Merr.), & sunflower (*Helianthus annuus*) (~110 yrs)
Huron	loam	Green ash (19 yrs)	Corn, soybean, & grain sorghum (*Sorghum bicolor* (L.) Moench) (21 yrs)
Norfolk	loamy sand	Siberian elm (*Ulmus pumila*, L.) Mulberry (*Morus rubra*, L.) Cottonwood (*Populus deltoides*) (70 yrs)	Corn, soybean, wheat, & alfalfa (*Medicago sativa*, L.) (~120 yrs)
Streletskaya	loam	Black poplar (*Populus nigra*) Silver birch (*Betula pendula*) (55 yrs)	Wheat (140 yrs)
Yamskaya	loam	Box elder (*Acer negundo*) (57 yrs)	Wheat, corn, & soybean (140 yrs)
Kamennaya	clay loam	English oak (*Quercus robur*) Balsam poplar (*Populus balsamifera*) (57 yrs)	Wheat & sunflower (140-150 yrs)

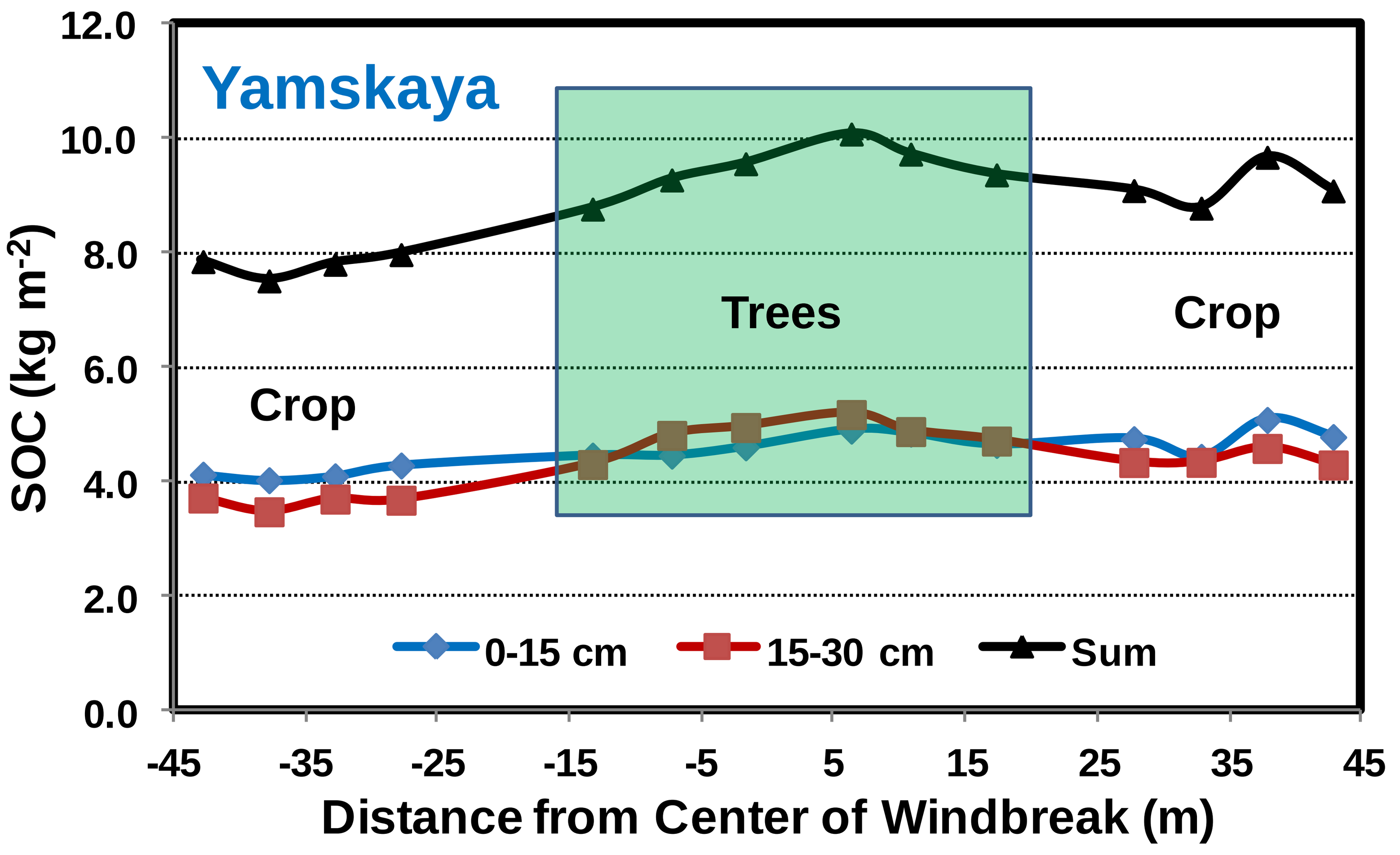
152-15
2813

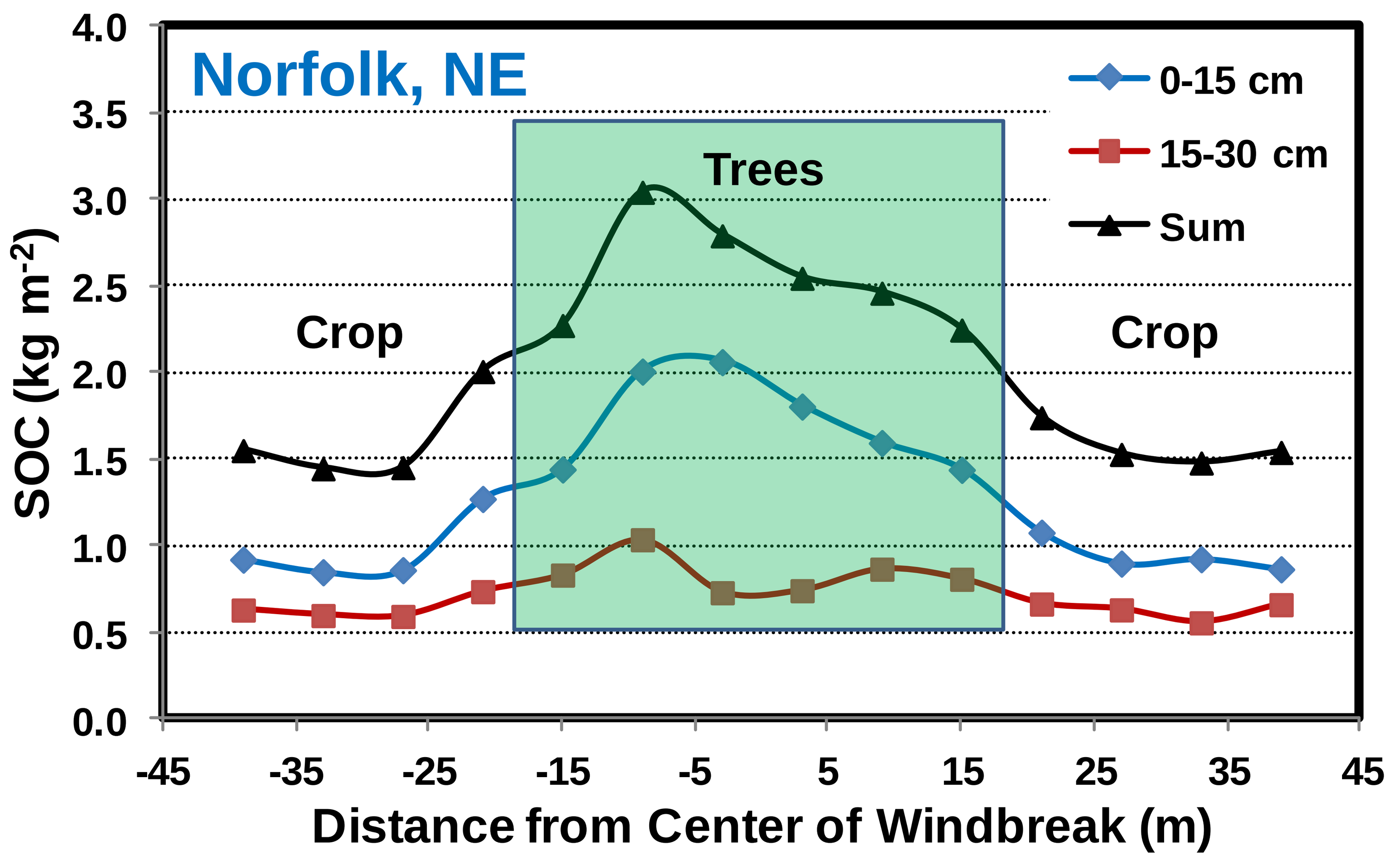
RESULTS

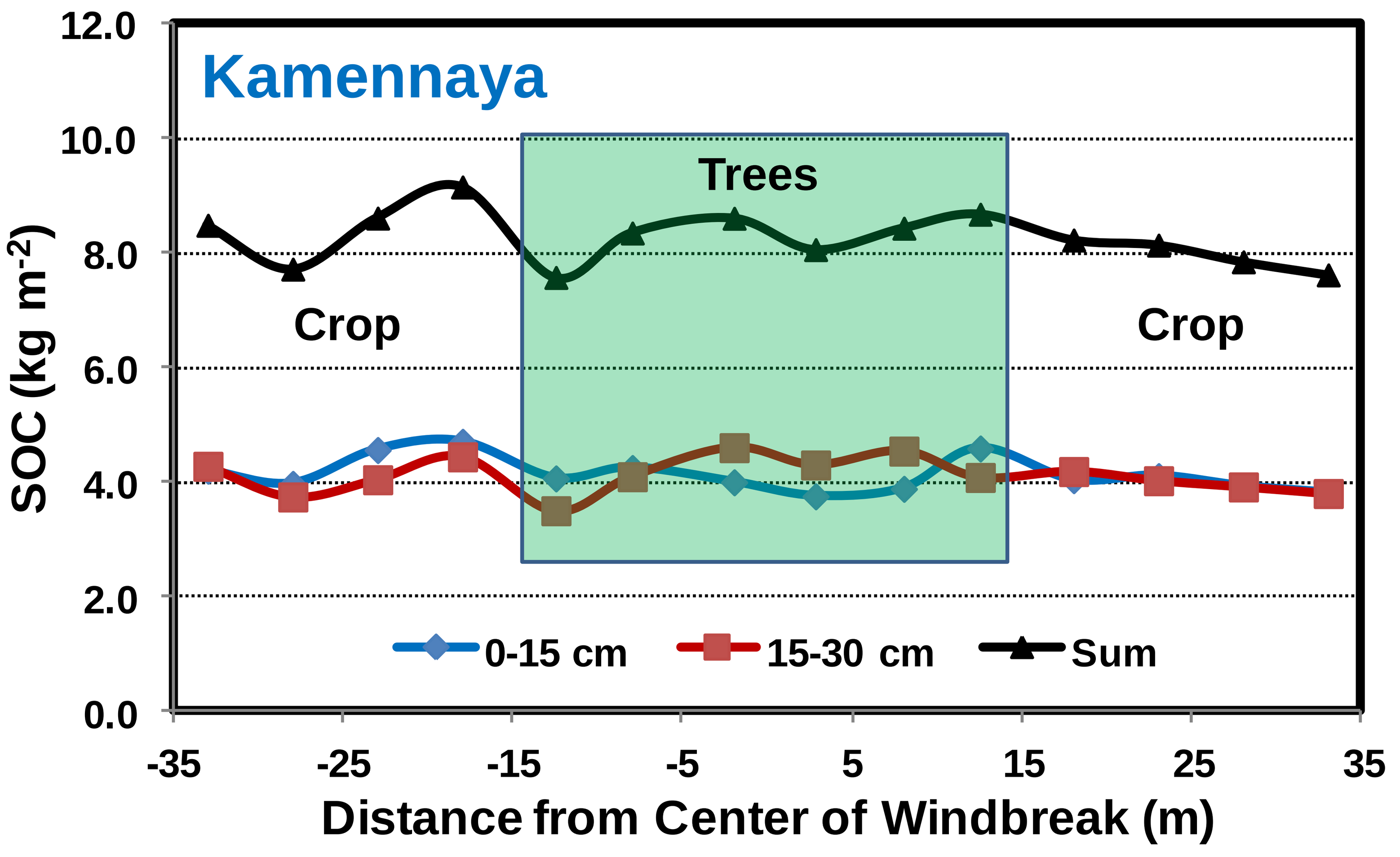




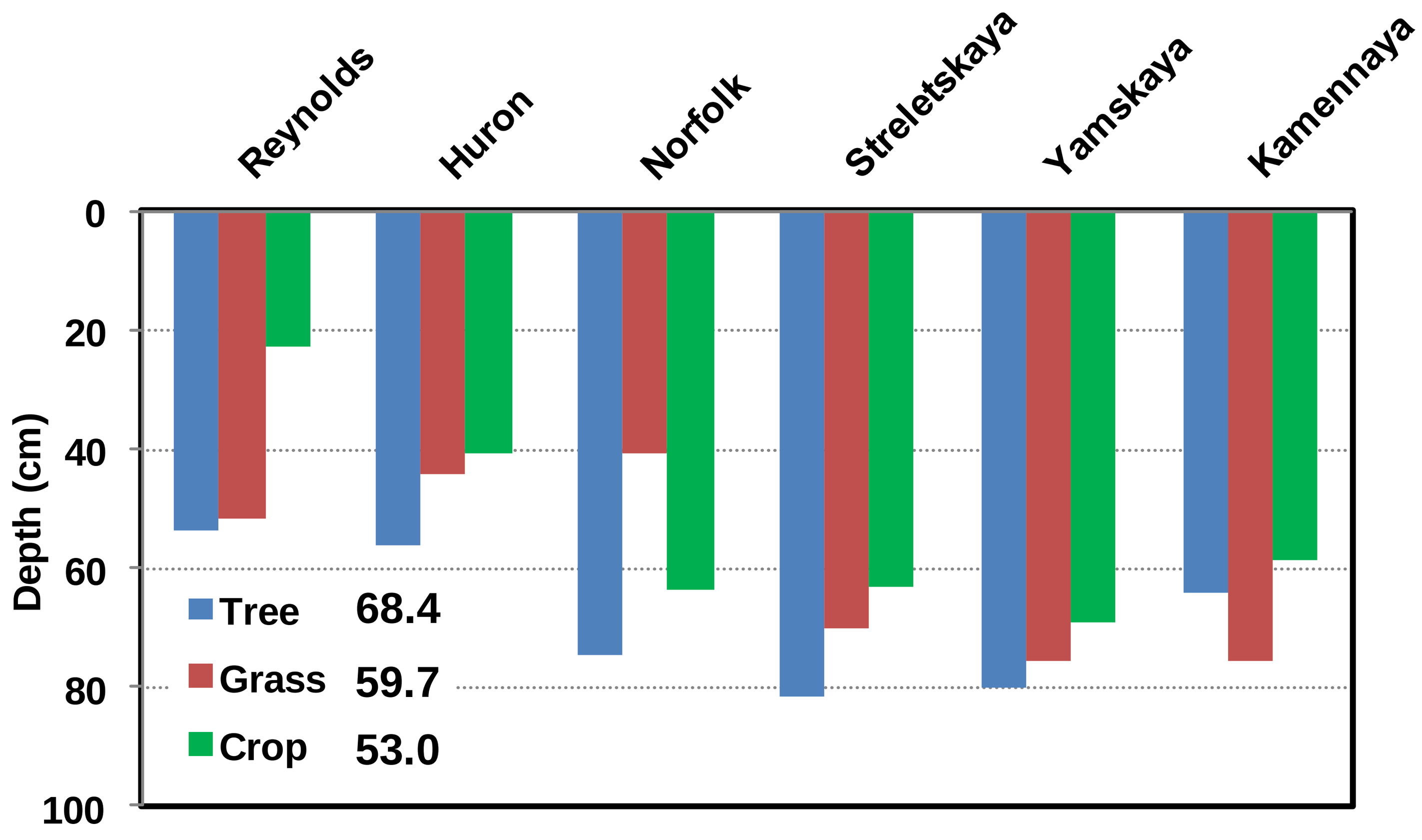




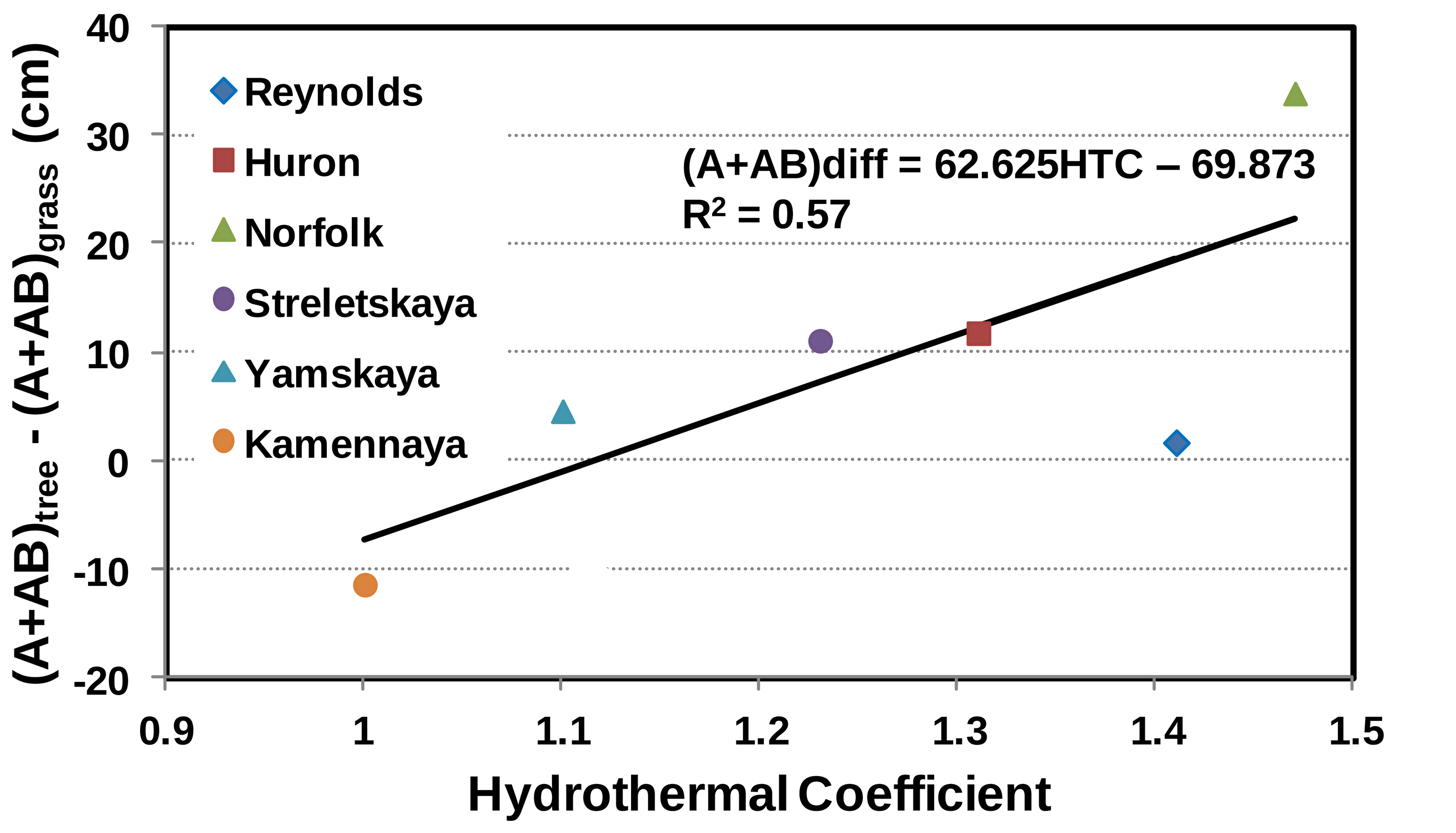




Depth of Topsoil Thickness (A + AB Horizons)



Difference of humus profile thickness in soils under tree plantings and uncultivated grassland soils vs. hydrothermal coefficient (HTC)



HTC = 10R/Σt, where R - precipitation in millimeters for the period with temperatures above 10° C, Σt - the sum of temperatures in degrees Celsius for the same period. (Selyaninov, 1928).

CONCLUSIONS

- For 0-30 cm surface layer, SOC content beneath trees ranged from 2.5% less than to 62.6% greater than adjacent cropped fields (average 22.4% increase).
- Depth of the SOC-enriched surface horizon was strongly correlated with the HTC.
- Stable isotope and POXC analyses underway to further elucidate SOC dynamics.

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