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QUANTIFYING THE EFFECT OF GRASSES ON SOIL PHYSICAL QUALITY OF FINE SANDY LOAMS IN PRINCE EDWARD ISLAND

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ABSTRACT
Grasses are considered to be beneficial for soil structure but little quantifiable data is available. The objective of this study was to characterize the soil pore size distribution of a fine sandy loam under long-term perennial grass, compared to an adjacent cultivated area, in Prince Edward Island. Differentiating soil porosity into functional classes important to root growth, based on pore size, indicated that the soil structural form under timothy (*Phleum pratense* L.) was superior than that developed under continuous cultivation. Under timothy, the volume of soil pores > 9 mm were generally greater, over the 8 to 24 cm soil depth, than that present under cultivation.

KEYWORDS
Pore size distribution, macropores, timothy, soil physical condition

INTRODUCTION
Forages can play an important role in the maintenance or improvement of soil structure in the cool, humid climate of eastern Canada (Angers and Carter, 1996). In Prince Edward Island, studies have shown that annual (*Lolium* sp.) and biannual (*Trifolium pratense* L.) forages, undersown in short two year cereal rotations, can increase the stability and organic carbon content of soil microaggregates (< 250 mm diam.), compared to cereals alone (Carter and Kunelius, 1993). Use of cold-hardy perennial grasses, such as timothy (*Phleum pratense* L.), can further improve soil structural stability and organic carbon content (Carter *et al*., 1994). In the latter study, the range of perennial grasses maintained an optimum soil structural form for the loam and sandy loam soils of Prince Edward Island, specifically a stable soil macropore (pores ž 50 mm diam.) volume above 10% of soil volume. Some studies have indicated that differences can occur among forages in their ability to influence soil structural form, especially the ratio of soil macro- to micropores (Mytton *et al*., 1993). In addition, tillage intensity can influence the volume of specific pore sizes, especially large pores, that are of importance for plant growth (Carter, 1988).

Little is known on the influence of grasses on soil structural form, specifically the characteristics of the soil pore volume and distribution of pore size. The objectives of this study were to determine soil porosity under a long-term timothy stand and an adjacent cultivated area, and quantify changes in pore size distribution, specifically the volume of large pores that influence soil aeration, and water transmission and storage.

METHODS
The long-term timothy stand and adjacent cultivated site were located at the Charlottetown Research Centre on a relatively uniform area with < 1% slope. The soil type is a Charlottetown fine sandy loam, an Orthic Humo-Ferric Podzol (Haplorthod) developed on glacial till parent material. Soil particle size distribution is 6%, 30%, and 64% for clay (£ 2 mm), silt (2 to 50 mm) and sand (50 to 2000 mm), respectively. Soil cores (80 mm i.d. by 80 mm) were obtained when the soil was near ‘field capacity’, at four areas at each site, over the 0 to 24 cm soil depth. To obtain a measure of pore size distribution, the cores were saturated in a water bath, then placed on a tension table at tensions of 1, 3, and 6 kPa (using a tension media of glass beads, 30 mm diam.), then transferred to a pressure-plate apparatus and pressures of 33 and 100 kPa applied (Carter, 1988; Topp *et al*., 1993). The above procedure allows calculation of the equivalent pore diameter (EPD) of the smallest pore (in mm) drained at a specific tension or pressure according to the relationship: 300/kPa (Greenland, 1981). Soil cores were oven dried at 105 ½C and weighed to obtain soil dry bulk density.

RESULTS AND DISCUSSION
The soil structural form data revealed that cultivation reduced soil total pore space and also significantly changed pore size distribution (Table 1). The grassland soil had lower bulk densities below the 8 cm soil depth than the cultivated soil, while air-filled porosity (at -6 kPa) was greater. In similar soil types, perennial grasses have been associated with maintaining an equilibrium soil bulk density of approximately 1.3 Mg m^{-3}, and a macroporosity (pores ž 50 mm) above 12% (Carter *et al*., 1994). Generally, a soil bulk density above 1.4 and an air-filled porosity below 10% are considered adverse for root growth in this soil type (Carter, 1988; 1990). Cultivation maintained the structural condition of the surface depth, but lower soil depths were compacted probably as a result of both soil consolidation and vehicular traffic. These soil differences were reflected by the pore size distribution results, which showed that relatively large pores (> 9 mm EPD) decreased in volume under cultivation. The presence of grass roots helped maintain the original soil porosity created by tillage, and evidently, as demonstrated by the pore size distribution data, prevented a collapse of the larger soil pores.

Pore size distribution is a useful concept for describing soil porosity in terms of their function for plant growth (Greenland, 1981). Pores of 300 to 50 mm (EPD) represent ‘water transmission’ pores, that allow water to freely drain through the soil, while pores of about 0.5 to 50 mm (EPD) represent ‘large water storage’ pores that retain water that is easily obtainable by plant roots. In addition, pores > 300 mm (EPD) accommodate entry of plant roots and movement of air. Pore volume > 9 mm, which has important implications for root growth as indicated above, changed significantly with land use in this study, from 17.0% in timothy to 10.3% in cultivation at the 8 to 16 cm soil depth, and from 11.8% to 6.4% at the lower 16 to 24 cm soil depth. This indicates that the organization, maintenance, and stability of soil porosity attributes , that are important for root growth and crop productivity, were superior under grass than cultivated conditions. The results suggest that the soil structural form of sandy loam Podzols in Prince Edward Island could be enhanced by regular use of grasses within crop rotations.

REFERENCES
Angers, D.A. and M.R. Carter. 1996. Aggregation and organic matter storage in cool, humid agricultural soils. Pages 193-211 *in* M.R. Carter and B.A. Stewart, eds. Structure and organic matter storage in agricultural soils. CRC/Lewis, Boca Raton, Florida.

Carter, M.R. 1988. Temporal variability of soil macroporosity in a fine sandy loam under mouldboard ploughing and direct drilling. Soil Tillage Res. **12:** 37-51.

Carter, M.R. 1990. Relative measures of soil bulk density to characterize compaction in tillage studies on fine sandy loams. Can. J. Soil Sci. **70:** 425-433.

Carter, M.R. and H.T. Kunelius. 1993. Effect of undersowing barley with annual ryegrasses or red clover on soil structure in a barley-soybean rotation. Agric. Ecosystems Environ. **43:** 245-254.

Carter, M.R., D.A. Angers and H.T. Kunelius. 1994. Soil structural form and stability, and organic matter under cool-season perennial grasses. Soil Sci. Soc. Am. J. **58:** 1194-1199.

Greenland, D.J. 1981. Soil management and soil degradation. J. Soil Sci. **32:** 301-322.

Mytton, L.R., A. Cresswell and P. Colbourn. 1993. Improvement in soil structure associated with white clover. Grass Forage Sci. **48:** 84-90.

Topp, G.C., Y.T. Galganov, B.C. Ball and M.R. Carter. 1993. Soil water desorption curves. Pages 569-579 *in* M.R. Carter, ed. Soil sampling and methods of analysis. Lewis Publishers, Boca Raton, Florida.

Table 1

Soil bulk density, pore size distribution, and air-filled porosity in a fine sandy loam under long-term grass, compared to an adjacent cultivated soil

Soil depth (cm)	Bulk density ($Mg\ m^{-3}$)	Pore size distribution (EPD diam., µm) as percent of soil volume						Air-filled porosity at -6 kPa (%)
		> 300	300-100	100-50	50-9	9-3	< 3	
Long-term grass								
0-8	1.25	2.8	4.2	3.9	3.9	2.0	33.4	10.9
8-16	1.28*	3.0*	3.8	5.4*	4.8*	2.2	29.4	12.2*
16-24	1.30*	0.7	5.1*	2.1	3.9*	2.4	30.2	7.9*
Cultivated								
0-8	1.29	2.5	5.2	4.0	2.4	2.7	32.1	11.7
8-16	1.35	1.0	3.6	2.7	3.0	2.0	34.0	7.3
16-24	1.50	0.5	2.0	2.0	1.9	2.2	32.9	4.5

* Significantly ($p < 0.05$) different from cultivated area according to unpaired *t* test