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Proposed revision to Canadian System of Soil Classification: broaden taxonomic criteria for applying LFH horizons to include nonforest soils

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Abstract

In the first edition (1974) of Canadian System of Soil Classification (CSSC), the taxonomic criteria for LFH organic horizons allowed application to any soil and land use developed under imperfectly to well-drained conditions. However, in the third edition (1998) of CSSC, the narrower taxonomic criteria for LFH horizons restricted application to only forest soils. A limited survey was conducted of some soil scientists across Canada to ask them if they had observed LFH horizons in nonforest soils. Distinct LFH horizons were observed across Canada under agriculture such as in no-till fields, tame and native pastures, and in reclaimed soils. They have also been observed in urban areas such as golf courses and grass-recreation fields. LFH horizons could also potentially develop under other nonforest land uses across Canada. Since no-till and native and tame pastures are most dominant in the prairies, the potential for LFH horizons is greatest in this region than elsewhere. However, they may occur anywhere in Canada where accumulation exceeds decomposition of organic material and they contain more than 17% organic carbon by weight or 30% organic matter. Therefore, we propose that the taxonomic criteria for applying LFH horizons be revised and broadened to include nonforest soils and be applicable to any soil order (where relevant) within Canada, and be at the discretion of the field pedologist. It is critical to identify and monitor LFH horizons over time because they are important for soil health, climate change, greenhouse gases, carbon sequestration, nutrient cycling, soil erosion, and hydrology.

Key words: LFH horizons, agricultural soil, surface organic material, plant litter, crop residue, taxonomic criteria

Résumé

Dans sa première édition (1974), le Système canadien de classification des sols (SCCS) appliquait le critère taxonomique des horizons LFH organiques à n'importe quel sol issu d'un drainage allant d'imparfait à excellent. Cependant, dans sa troisième édition (1998), l'application de ce critère aux mêmes horizons était beaucoup plus rigoureuse et se limitait aux sols forestiers. Les auteurs ont interrogé quelques pédologues canadiens pour savoir s'ils avaient observé des horizons LFH hors des sols forestiers. De très nets horizons LFH ont été relevés dans les terres cultivées et les champs non labourés du Canada, ainsi que dans des prairies artificielles ou naturelles et des sols restaurés. Ces horizons ont été observés dans des zones urbaines tels les terrains de golf et les terrains de jeu gazonnés. Il se pourrait aussi que les horizons LFH se développent sur d'autres sortes de terres non boisées au Canada. Puisque les prairies naturelles et artificielles non travaillées prédominent dans les Prairies, cette région est plus que toute autre susceptible d'engendrer des horizons LFH. Quoi qu'il en soit, ces derniers pourraient se retrouver ailleurs au pays, là où la matière organique s'accumule plus qu'elle se décompose. Ces horizons renferment plus de 17 % de leur poids en carbone organique ou 30 % de matière organique. Par conséquent, les auteurs proposent une révision du critère taxonomique appliqué aux horizons LFH pour qu'il englobe les sols non forestiers et que le pédologue puisse l'appliquer à n'importe quel ordre de sol canadien (s'il y a lieu), à sa discrétion. On doit absolument identifier les horizons LFH et en suivre l'évolution, car ils revêtent une grande importance pour la vitalité du sol, le changement climatique, la séquestration du carbone, le recyclage des oligoéléments, l'érosion et de l'hydrologie. [Traduit par la Rédaction]

Mots-clés : horizons LFH, sol agricole, matériel organique superficiel, litière végétale, déchets culturaux, critère taxonomique

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Historical development of criteria for designating LFH horizons

In the first edition of the Canadian System of Soil Classification (CSSC) published in 1974 (Canada Soil Survey Committee 1974), a distinction was made between organic horizons developed under wet conditions (O horizons) and those formed under imperfect or better drainage conditions (LFH horizons). The definition of organic horizons was "Organic horizons may be found at the surface of the mineral soils, or at depth beneath the surface in buried soils, or overlying geologic deposits. They contain more than 30% organic material". LFH horizons were described as "organic layers developed under imperfectly to well-drained conditions" and could be applied to any soils with this specified drainage regime.

In the third edition published in 1998 (Soil Classification Working Group 1998), organic horizons were defined as "occurring in Organic soils and commonly at the surface of mineral soils, may occur at any depth beneath the surface in buried soils or overlying geologic deposits, and contain more than 17% organic C (about 30% or more organic matter) by weight. Two groups of these horizons were recognized: the O horizons (peat materials) and the L, F, and H horizons (folic materials)". The revised definition of LFH horizons was "These organic horizons developed primarily from the accumulation of leaves, twigs, and woody materials with or without a minor component of mosses. They are normally associated with upland forest soils with imperfect drainage or drier". Therefore, the narrower and more restrictive definition in the 1998 and current edition implied that LFH horizons could only be applied to forest soils (i.e., folic materials), but not to nonforest soils such as under agriculture (e.g., conservation tillage, tame and native grasses, horticulture), reclamation, urban, recreation, and other land uses.

The pedological concern that has arisen is that LFH horizons have been observed in the field on nonforest soils such as under agriculture and other land uses, but LFH horizons cannot be applied to these soils because the current taxonomic criteria limit application to only forest soils. Therefore, the taxonomic criteria for applying LFH horizons need to be broadened to include nonforest soils.

Importance of LFH horizons in agricultural systems

The main short-term benefits of plant litter or crop residue include improved crop production (under certain conditions), reduced raindrop impact, greater infiltration and reduced runoff and erosion, reduced crusting and compaction, and moderation in soil moisture (reduced evaporation) and temperature regimes (Lal 2005). The main long-term benefits are increased soil organic carbon pool and nutrient cycling, improved soil quality, reduction in nonpoint source pollution, impact on greenhouse gas emissions, and an increase in soil biodiversity. Greater plant litter on tame and native pastures (Adams et al. 2005), and riparian areas (Fitch et al. 2009), or more crop residues on arable cropland (Turmel et al. 2015; Fu et al. 2021), is also important for soil health.

Recent research on the microbial ecology of grassland leaf litter and crop residues under arable cropping has revealed that surface litter or residue are as "biologically alive as soil" (Mouginot et al. 2014) and "fully fledged microbial ecosystems" (Kerdraon et al. 2019). LFH horizons may also coincide with the detritusphere, which is the part of the soil attached to crop residues and is the most extensive and broad hotspot of microbial life in the soil (Kerdraon et al. 2019). However, increased crop residues under arable cropping such as conservation tillage may have some negative effects on crop production such as a source of fungal pathogens for crops (Kerdraon et al. 2019), nitrogen immobilization, waterlogging, and reduced soil temperatures (Turmel et al. 2015), and may offset possible benefits.

Identifying and monitoring LFH horizons has become extremely important to quantify and qualify soil health, record temporal dynamics in soil as a result of impacts from climate change adaptation/mitigation, carbon sequestration, nutrient cycling, runoff quantity and quality, sustainable agricultural technologies for maintaining the integrity of soil organic matter, and providing a standard set of protocols for measuring accumulation or erosion of surface crop residues. This is especially important in agricultural systems for undertaking detailed intensive monitoring of soil surface accumulations and loss of residues. In addition to long-term monitoring, there will be a need for more detailed assessments on a seasonal basis to record, monitor, and map distribution of surface crop residues (L horizon) as they transform to fibrous (F horizon) and humic materials (H horizon).

Evidence of LFH horizons in nonforest soils across Canada

In British Columbia, LFH horizons were observed in both introduced and native grasslands, and they are usually in areas which were protected from grazing or fire for extended periods of time, which facilitates accumulation of a thatch layer (P. Sanborn, C. Bulmer, B. Wallance, and M. Krzic, personal communication, 2022). These thatch layers have also been observed at golf courses and grass-recreation fields in urban areas (M. Krzic, personal communication, 2022).

In southern Alberta, LFH horizons were observed in no-till fields, native rangeland, and irrigated pastures in Chernozemic soils. LFH horizons from crop residues occurred on a producer's long-term (30+ years) no-till field (Fig. 1*a*) (R. Dunn, personal communication, 2022), and long-term (22 years) no-till research experiment (Fig. 1*b*) (B. Ellert, personal communication, 2022) in the Dark Brown soil zone at Lethbridge in southern Alberta. Crop residue accumulated on the soil surface because of conservation tillage.

LFH horizons from plant litter occurred on native rangeland on the fescue prairie on a Black Chernozem near Stavely in southwestern Alberta (Figs. 2*a* and 2*b*) (B. Adams, personal communication, 2022; J. Dormaar, personal communication, 2022). The accumulation of surface litter occurred over the long term because of light grazing.

LFH horizons occurred on an irrigated pasture near Brooks, in southern Alberta (Figs. 3*a* and 3*b*) (R. McNeil, personal com-

Fig. 1. (*a*) LFH horizons from accumulation of crop residues on a producer's long-term (30+ years) no-till field (Image credit: R. Dunn), and (*b*) long-term (22 years) no-till research experiment (Image credit: B. Ellert, © Her Majesty the Queen in Right of Canada, represented by the Minister of Agriculture and Agri-Food, 2021) in the Dark Brown soil zone at Lethbridge in southern Alberta. [Colour online]

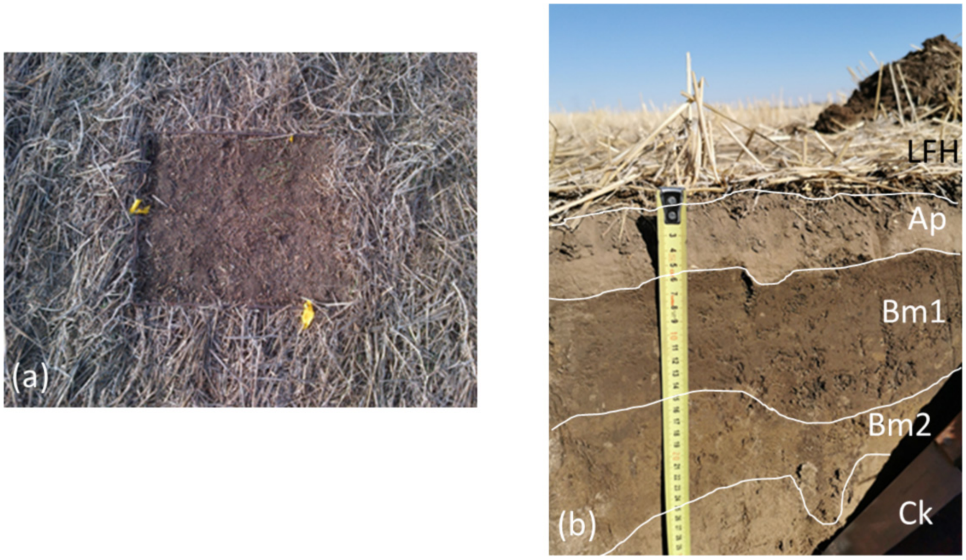
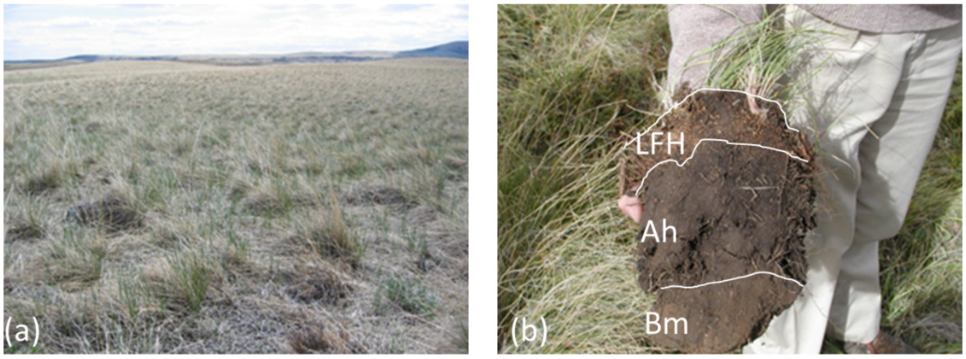


Fig. 2. (*a*) Landscape and (*b*) soil profile on fescue native prairie on a Black Chernozem soil near Stavely in southwestern Alberta showing LFH horizon from accumulation of surface litter (Image credit: B. Adams and J. Dormaar). [Colour online]



munication, 2022). The soil is a mixture of Brown Chernozem and Solonetzic orders. This modified pasture (mixture of native and tame forages) was flood-irrigated for 40–60 years. There were 46 pedon investigations in this community pasture, and an LF (sometimes LF used with the thinnest horizons) or LFH was consistently recognized at all sites. The thickness of these horizons varied from 2 to 7 cm, had an average thickness of 3.6 cm, and 24 of the 46 locations had ≥4 cm of LFH. An appreciable nonmineral (organic) surface build-up occurred due to irrigated pasture production with significant carryover or biomass return. If the production was hayed, or if grazing utilization rates were high, surface material would not accumulate. In addition, grazing managers are following strategies and practices used in the Brown Soil Zone (most manuals are targeted for nonirrigated). For example, a common practice is to use 50% biomass annually and allow the remainder to become litter and ultimately soil, which contributed to LFH development. In central Alberta, LFH horizons also occurred on an Orthic Gray Luvisol on introduced grasses at the Breton plots in central Alberta with an LH overlying an Ap horizon (Fig. 4*a*) (K. Dlusskiy, personal communication, 2022).

LFH horizons were observed in grasslands in Alberta at various ages after reclamation (A. Naeth, personal communication, 2022). Well-developed LF and some evidence of H horizons were also observed on reclaimed sites on nonforest soils (L. Leskiw, personal communication, 2022). They developed in a few years where small trees are planted and there are plentiful shrubs. LFH horizons also occurred on Anthropogenic (Fusco Spolic Anthroposol) nonforest soils (Fig. 4*b*) in the Athabasca oil sands region on peat-mineral mix over tailings sand (K. Dlusskiy, personal communication, 2022).

In Saskatchewan, surface residue layers ranging from 1 to 2 cm in the drier regions and ≥8 cm in Black and Dark Gray soil zones were observed under long-term no till, and thatch layers have also been observed under forages (J. Schoenau,

Fig. 3. (*a*) Landscape and (*b*) soil profile (Orthic Brown Chernozem) on an irrigated pasture (mix of introduced and native species) near Brooks in southern Alberta showing LFH horizon from accumulation of surface litter (Image credit: R. McNeil). [Colour online]

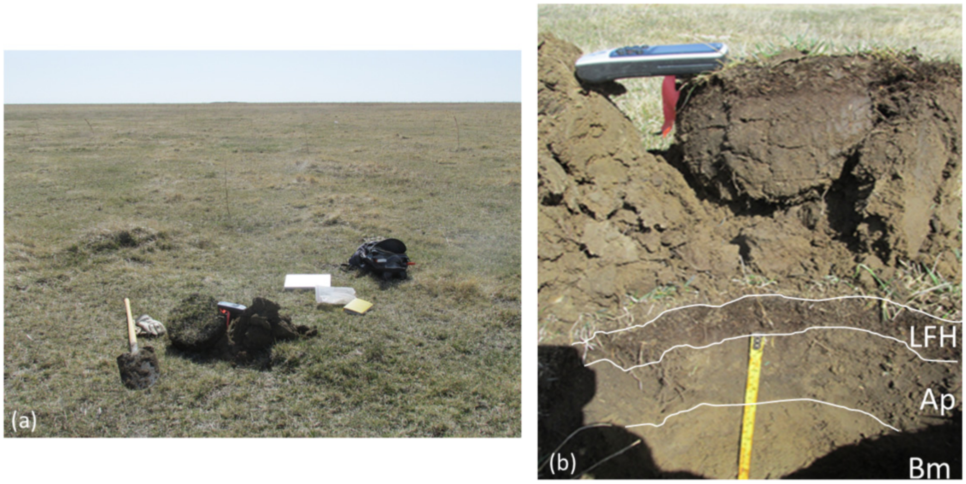
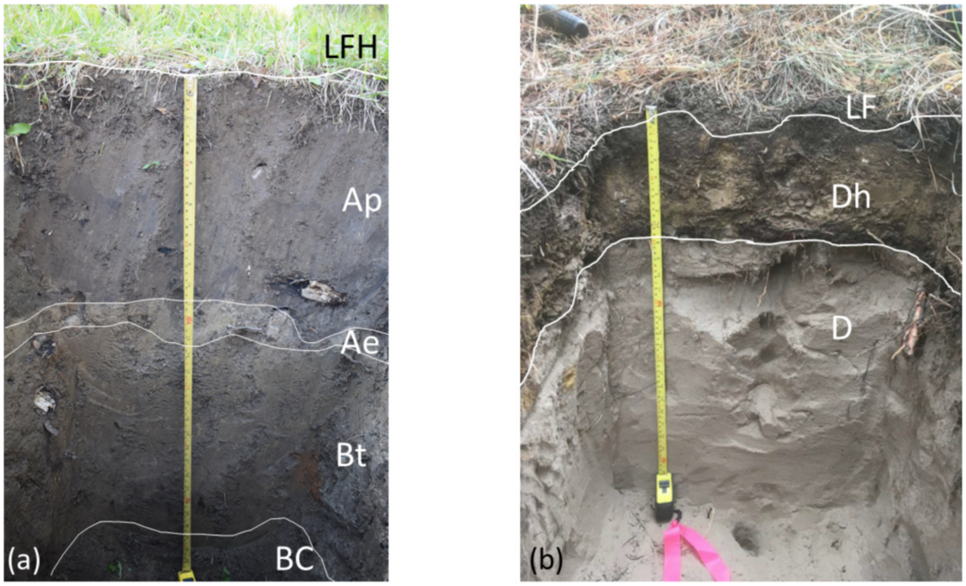


Fig. 4. (*a*) Soil profile of an Orthic Gray Luvisol at Breton plots in central Alberta showing LFH horizons from accumulation of litter and (*b*) LFH horizon on reclaimed soil (Fusco Spolic Anthroposol—dystric phase) in the Athabasca oil sands region of northern Alberta which is a peat-mineral mix on tailings sand (Image credit: K. Dlusskiy). [Colour online]



personal communication, 2022). Thin layers of plant residues indicative of LFH horizons occurred in both native and tame pastures and in cropped fields (D. Pennock and A. Bedard-Haughn, personal communication, 2022). In cropland, the adoption of no-till has certainly led to the buildup of crop residues in various states of decomposition. In grasslands, the thatch layer may be several cm thick, and can be thicker where the soil surface is moist as in foot-slopes or adjacent to wetlands.

In Manitoba, substantial and environmentally significant accumulations of thatch layers were observed in a variety of nonforested situations (D. Flaten, personal communication, 2022). The first example is on the conservation tillage portion of the "Twin Watersheds" model watersheds at South Tobacco Creek, where greater losses of runoff P from conservation tillage than conventional tillage were attributed to release of water-soluble P from crop residues after freeze-thaw cycles (Liu et al. 2014*a*). The second example was on the perennial forage portion of another paired-watershed study where the runoff losses of P during snowmelt were much greater from the perennial forage area, compared to a fertilized, conventionally tilled, annual crop area (Liu et al. 2014*b*). The third example was riparian areas where little, if any, benefit for nutrient interception was found in vegetated buffers (Sheppard et al. 2006; Kieta et al. 2018). Although the focus of these studies was not on LFH horizons, crop residues and LFH horizons may play a very important role in runoff (Liu and Lobb 2021) and losses of nutrients (Elliott 2013) in the snowmelt dominated runoff of Manitoba and the Canadian prairies. One of the challenges of classifying LFH horizons for nonforest soils is due to the spatial and temporal effects of management practices on this type of classification (D. Flaten, personal communication, 2022). For example, two neighboring fields might be classified differently based on management, even though their pedogenesis is similar, and the classification for a field might change over a period of a few to several years, depending on the tillage and cropping system.

Other soil scientists in Manitoba have observed LFH horizons in imperfectly drained soils, under minimum till, and in pasture and forage land (P. Haluschak, personal communication, 2022). In contrast, others reported that LFH horizons are extremely uncommon on agriculture land, but occasionally may be found in woodland grazing and natural grazing land (R. Wu, personal communication, 2022).

In Ontario, some soil scientists have not personally observed LFH horizons on nonforest soils (D. Saurette, personal communication, 2022). Crop rotations under no-till in Ontario are generally corn-soy-wheat rotations, and residue accumulation is not appreciable. With the increased use of cover crops and incorporation of cereals as cover crops, more accumulation of residue may occur in the future. However, a couple of scenarios exist where this horizon could have been omitted from the classification. The first scenario may have occurred in pasture or forage fields, where there is typically a thatch layer (2–4 cm) that develops, but is ignored during formal description and classification. The second scenario may occur with specialty crops such as ginseng production in SW Ontario, where a thick layer of mulch (4–5 cm of cereal straw) is artificially added to the soil surface. Typically, these fields are not included in soil surveys, but in the 3–4 year period of crop growth, there may be a significant mulch cover at the surface.

Other soil scientists in Ontario have never personally observed an LFH in typical nonforest soils, but suggest that it might occur under long-term, continuous no-till with crops such as corn (B. VandenBygaart and R. Heck, personal communication, 2022). Tillage in Ontario can often still involve plowing or tandem disking, which can bury much of the residue, which would not favor LFH formation.

In Quebec, some soil scientists have not personally observed LFH horizons on nonforest soils, but the closest situation would be the thatch forming on undisturbed (old/native) grassland soils (M. Chantigny, personal communication, 2022). Other soil scientists have never seen LFH horizons on nonforest soils (C. Bossé and L. Grenon, personal communication, 2022).

In New Brunswick, there was generally no LFH horizon under potato and pasture which are the dominant agricultural practices (L.-P. Comeau and S. Hann, personal communication, 2022). For the other harvested crops, the combine machine normally leaves a thin layer of grinded residues on the top of the soil. However, no-till is not a common practice, and this thin layer of residue is incorporated into the soil. Potato production requires relatively deep tillage and high hills. However, LF horizons were observed on pasture sites that were forested before conversion. These horizons were typically thin and were underlain by an Ap horizon. There were also acidic-barrens ecosystems that can have well-developed LFH horizons. In Nova Scotia, some soil scientists have not personally seen LFH horizons in nonforest soils (K. Keys, personal communication, 2022). However, some urban and horticultural sites may have the potential to develop LFH horizons if they are not disturbed over many decades. Also, the limited number of reclamation sites seen were too "young" to have LFH horizon development.

Stuart Veith, a pedologist with USDA-NRCS, has also observed surface organic horizons on irrigated Mollisols along the lower Milk River in Montana. He designated this layer as an Oe (hemic/moderately decomposed) horizon (S. Veith, personal communication, 2021). In contrast to Canada, surface organic horizons in the U.S. Soil Taxonomy can only be defined as O horizons, and there are no LFH horizons (Soil Survey Staff 1999).

Evidence from soil scientists across Canada suggests that crop residues and LFH horizons have a high potential to develop under conservation tillage such as no-till. No-till systems are dominant in the prairies, where large farm sizes and erosion-prone soils enhance the environmental and financial benefits of low-impact, one-pass seeding (Statistics Canada 2018). In the 2006 Census of Agriculture in Canada (Statistics Canada 2006*a*), 7 427 908 ha of cropland retained crop residues on the surface, and the percentage was greatest for the prairie provinces (85.4%) (Alberta, Saskatchewan, Manitoba), followed by eastern (Ontario, Quebec) Canada (13.4%), British Columbia (0.7%), and then the Maritimes (0.5%). There were 13 480 815 ha of cropland under no-till or zero-till seeding in 2006. The greatest percentage was in the prairies (92.6%), followed by eastern Canada (7.1%), British Columbia (0.3%), and then the Maritimes (0.1%). Therefore, there is a greater potential for crop residues and LFH horizons to develop under no-till in the prairies (dominated by Chernozemic order) than elsewhere in Canada. The lack of crop residues under no-till in eastern Canada and the Maritimes may also be partially due to the greater populations of earthworms that may be present in these more humid soils. Crop residues remaining after harvest are incorporated quickly into the soil by earthworms, which is analogous to incorporation from plowing or disking. Earthworms are generally more common in humid than arid regions (Jenny 1980).

Evidence from soil scientists across Canada suggests that thatch layers and LFH horizons have a high potential to develop under tame or native grasses, and this land use is also most prevalent in the prairies. In the 2006 Census of Agriculture in Canada (Statistics Canada 2006*b*), there were 3 928 388 ha of tame or seeded pasture in Canada. The highest percentage was in the prairies (80.9%), followed by eastern Canada (11.5%), British Columbia (6.3%), and then the Maritimes (1.4%). There were 15 441 601 ha of natural land for pasture in 2006. The greatest percentage was in the prairies (85.8%), followed by British Columbia (9.7%), eastern Canada (3.9%), and then the Maritimes (0.5%). Therefore, there is a greater potential for thatch layers and LFH horizons to develop under tame or native grasses in the prairies than elsewhere in Canada.

Since the authors have experience with soils of the Canadian prairies, the possible application of LFH horizons to the

Chernozemic, Solonetzic, Vertisolic, and Regosolic orders occurring on agricultural soils is described below and in Table 1. However, LFH horizons may also occur on nonforest soils for other soil orders found across Canada.

The accumulation rate for the LFH horizon is highest for the Chernozemic order than the other three soil orders because of high crop yields and greater return of residues (Table 1). LFH horizons for Chernozems are widespread and common for no-till fields in Canada, especially over the long-term (>20 years). They occur on rangelands if surface accumulation exceeds decomposition over the long-term. These horizons are not spatially extensive on irrigated pastures, but LFH accumulation may occur over the long-term.

For the Solonetzic order, the accumulation rate of LFH is low because of low to moderate crop yields and reduced residue accumulation. LFH horizons for Solonetz may occur in no-till fields with improved surface organic matter and hardpan management. LFH accumulation on Solonetzic soils is uncommon on rangeland and irrigated pastures, and has been observed in some pastures at Vauxhall and Lonesome Lake, Alberta.

For the Vertisolic order, LFH accumulation rate is variable as soil churning can bury LFH horizons. LFH horizons for Vertisols are uncommon in no-till fields, but may occur in clay basins such as at Regina, Saskatchewan, Drumheller, Alberta, and the Red River Valley, Manitoba. LFH horizons are uncommon on rangeland, but have been observed near Acadia Valley, Alberta, and Marengo, Saskatchewan. LFH horizons are uncommon for Vertisols on irrigated pastures, but may occur near Seven Persons and Stirling in southern Alberta.

The rate of LFH accumulation is low for the Regosolic order because of poor crop production. Regosolic soils in no-till fields may occur on eroded knolls, hillsides, and dunes, and the buildup of LFH horizon is predicted as uncommon to rare. LFH horizons are not expected for Regosols on rangeland and irrigated pastures, as these latter soils have slope and other serious limitations to organic material accumulation on the soil surface.

Reporting of LFH horizons in soil journals

Published papers on forest soils (Podzols, Luvisols, and Brunisols) in Canada generally report the depth and properties of LFH horizons (Beke and McKeague 1984; Whitson et al. 2005). Papers on rangeland soils (mainly Chernozemic and Solonetzic) sometimes report % ground cover and mass of surface litter or LFH horizons, but not the depth and properties (Naeth et al. 1991; Willms et al. 2002). In contrast, papers on agricultural soils in Canada rarely or never report surface organic horizons. The reporting of LFH horizons for agricultural soils in soil survey reports may have sporadically occurred for rangeland soils, but likely not for conservation tillage and tame pastures. The "glory years" of soil survey in Canada were from 1940 to mid-1990s, and the mid-1990s and 2010 saw declining activity in new field surveys (Anderson and Smith 2011). Conservation tillage in Canada was not adopted until the late 1970s (Awada et al. 2014). Therefore, many soil surveys were likely conducted prior to conservation tillage when LFH horizons were absent.

The paucity of papers for agricultural soils that recognize and report surface organic horizons is likely due to three factors. First, the current taxonomic criteria for LFH horizons limit application to only forest soils and not agricultural soils. Second, most researchers sample by depth and not by horizon, and any surface organic material is generally removed or ignored during sampling, or the surface organic material is included in the surface soil sample. Third, LFH horizons in agricultural soils are transient and change rapidly through the season and between years, and have a wide range in depth over small areas depending on the cultivation methods from intensive cultivation to grassland. This is in contrast to LFH horizons in forest soils that are generally very stable and long-term. As a result, LFH horizons on agricultural soils were usually not included in the field description in soil survey reports or journal publications.

Ignoring the LFH horizon in nonforest soils has contributed to knowledge gaps about the role of these organic horizons, the interaction between organic and mineral horizons, and the influence of agricultural management on LFH horizons. In addition, reporting on surface residue is even more imperative and essential now with increasing pressures and impacts observed from climate change and erosion leading to organic carbon losses.

Classifying LFH soil horizons based on management

A soil horizon in CSSC (Soil Classification Working Group 1998) is defined as "a layer of mineral or organic soil material approximately parallel to the land surface that has characteristics altered by processes of soil formation. It differs from adjacent horizons in properties such as color, structure, texture, and consistence and in chemical, biological, or mineralogical composition". The differentiation of the horizons within the soil profile in CSSC is categorized by "soil-forming processes" (Canadian Society of Soil Science 2020) such as additions, removals, transfers or translocations of materials, and transformations (Simonson 1959). Some of these major processes include decalcification (Brunisols), melanization (Chernozems), gleying (Gleysols), eluviation/illuviation (Luvisols), paludization (Organic soils), podzolization (Podzols), solonization/solodization (Solonetzic), and pedoturbation (Vertisols). However, none of these processes explicitly define accumulation of above-ground plant material on the soil surface as crop residues or plant litter.

The CSSC was also influenced by Jenny's five state factors of soil formation (Canadian Society of Soil Science 2020). The five factors of soil formation include: (1) climate, (2) organisms, (3) topography, (4) parent material, and (5) time. Yaalon and Yaron (1966) proposed that the human-induced changes in soil-forming processes should be considered as a sixth factor. In contrast, Dror et al. (2022) suggested that direct and indirect anthropogenic activity has become the most influential factor currently affecting each of the five original soil-forming factors, and that human impacts should not be a

Table 1. Presence of surface organic horizon associated with selected soil orders and agricultural land types.

Soil orders	LFH accumulation	LFH presence by land type		
	Rate	No-till (NT)	Rangeland	Irrigated pasture
Chernozemic	High	Widespread and common in Canada, especially over long term (>20 years)	Occurs if surface organic accumulation exceeds decomposition over the long term	Land type is not spatially extensive, but LFH accumulation is noted for time frames >20 years
Solonetzic	Low	Can occur, as NT improves surface organic matter and hardpan management	Uncommon to have LFH accumulation	Uncommon land type, but LFH accumulation has been documented in AB pastures at Vauxhall and Lonesome Lake
Vertisolic	Variable; soil churning can bury LFH	Infrequent land type except in clay basins (Regina, Drumheller)	Uncommon land type, but occurs near Acadia Valley AB and Marengo SK	Rare land type, but may occur in Seven Persons and Stirling areas of AB
Regosolic	Low	Uncommon land type, except in eroded knolls, hillsides and dunes	Rare to have LFH accumulation	Uncommon to rare, as Regosolic soils have slope or other serious limitations to irrigation.

sixth factor, but actually a major (and often dominant) control on all five of these original soil forming factors.

Despite the fact that soil taxonomic systems are designed to be resilient and unaffected by short-term soil change, over the past 50 years (a time period historically seen as "'short-term"' within pedology), soils have been modified dramatically by human activity, resulting in different classifications at a variety of levels (Veenstra and Burras 2012). These changes are likely due to many factors including erosion, tillage, fertilization, tile drainage, and other agricultural practices. Through agricultural land use, humans are accelerating soil formation and transformation to a depth of 100 cm or more (Veenstra and Burras 2015). In addition, the proposed Anthroposolic order for CSSC is based on human-caused disturbances to soils, and these soils can occur on agricultural landscapes if the disturbance goes beyond typical tillage that can be accounted for with the "p" suffix in the CSSC (Naeth et al. 2012). Therefore, the increasing effect of humans on soil genesis over time suggests that classifying soil LFH horizons based on human-caused management practices (e.g., agriculture) is justified.

Proposed revision to CSSC for LFH horizons

Two options could be considered: (1) to re-establish the terminology for applying LFH horizons defined in CSSC (1974) or (2) to broaden the existing 1998 taxonomic criteria for when to apply LFH horizons to include forest and nonforest soils. If the 1998 taxonomic criteria for applying LFH horizons are revised, we propose the following revision: "The LFH organic horizons are developed where surface plant residue accumulation exceeds decomposition (1) in upland forest and natural uncultivated ecosystems (i.e., leaves, stems, twigs, woody materials, minor amounts of mosses, grasses, etc.); or (2) in agricultural ecosystems (i.e., leaves, stems, and roots from grasses and forbs and other crops, including orchards and vineyards; and harvested plant residues such as straw, chaff, leaves, stems, husks, etc.); or (3) in other upland scenarios such as reclamation, recreation, and urban land uses (i.e., various accumulated organic residues). Upland soils are associated with imperfect drainage or drier conditions. Inclusion of the LFH horizons will depend on the discretion of the field pedologist or researcher with respect to the purpose of the survey or scientific study, and the scale and degree of precision required across the landscape". In addition, possible use of lowercase suffixes for LFH horizons that describe humus form classification (mor, moder, and mull) should be considered in any revision to LFH criteria (Fox and Tarnocai 2011).

In the 1974 edition of CSSC, the diagrammatic horizon patterns in various soil orders recognize that an Ap horizon can be present under cultivated conditions. However, the presence of LFH is not indicated in the diagrammatic pattern of horizons as being applicable over the Ap. In the 1998 edition, the presence of an Ap is usually indicated in the text, but not in the diagrammatic pattern of horizons. We propose that possible LFH horizon designations overlying Ah and Ap horizons be officially recognized in both the diagrammatic pattern of horizons in figures and in the text for use over both Ah and Ap horizons.

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