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The Lower Boundary of Selected Mollisols[1]

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ABSTRACT

Thicknesses of three Mollisols (Tama, Elburn, and Drummer series), developed from Wisconsinan-age material in a toposequence in Central Illinois, were considerably greater (18 to 68 cm) when their lower boundaries were determined by the depth of rooting of native perennial big bluestem (*Andropogon gerardi*) than when determined by the lower limit of the solum. A combination of four criteria—structural development, significant clay accumulation, significant clay films, and the presence of completely unleached material—probably gave the best measure of solum thickness of these soils. However, evidence of some clay movement below the solums and the greater depth of rooting of native perennial grass, and also of such crops as corn (*zea mays* L.), suggests that material beneath the solum is important in the behavior, definition, and classification of many of these kinds of soils in the north-central region of the U.S.

Additional Key Words for Indexing: pedon boundary, solum thickness, soil classification, *Andropogon gerardi* rooting.

In order for soils to be studied, classified, and their properties interpreted for various purposes, it is desirable that a basic soil unit [soil individual (11) or pedon (16)] be defined in terms of limits or boundaries. Generally, there has been agreement on the upper limit of soil as the land surface-air interface and on the lateral boundary as other soils, water, rock, etc., but there has not been widespread agreement on the lower limit or boundary of soil.

In soils having developed A and B horizons, a commonly used, but not universally accepted, definition of the lower boundary of soil has been the lower limit of the solum. Many workers (2, 7, 9, 13, 16, 17, 23) agree that the solum includes the genetic or developed A and B horizons and differs from the underlying material in physical, chemical, and biological characteristics. In definitions of the lower boundary of soil based on the thickness of solum, the criteria for determining *significant* alterations of soil parent material (or material in which the soil developed) by soil forming processes are often difficult to apply. The effects of soil forming processes commonly diminish gradually with depth. Some workers (22) have included in soil, *Soil Survey Manual* (17) horizons such as Cca, Csa, and Cl that underlie the solum. Others (17) have included layers beneath the solum that influence the genesis and behavior of soils.

Pedologists have generally recognized the indefinite or vague nature of the lower boundary of many soils (8, 15, 16, 21). In defining the pedon as the basic soil unit (16), the use of the lower limit of common rooting of native perennial plants has been proposed as an alternative to the thickness of the solum as a basis for determining the lower boundary of soil if rooting extends below the solum.

The purpose of this study was to compare the depth and nature of the lower boundary of three Mollisols, occurring in the north-central region of the U.S., based on the thickness of genetic horizons (the solum) and on the depth of common rooting of native perennial plants.

SOILS STUDIED AND METHODS

Three soils, Tama, Elburn, and Drummer, occurring as a toposequence in the local landscape, were sampled in a short (93 m or 305 feet) traverse. The Tama developed in 180 cm (71 inches) of loess on a thin 23-cm (9 inches) layer of outwash underlain by loam till and is moderately well drained. Elburn developed in 142 cm (56 inches) of loess on outwash and is imperfectly (somewhat poorly) drained. The poorly drained Drummer formed in silty material, predominantly loess, 102 cm (40 inches) thick on outwash. Till occurred in the Elburn profile at 254 cm (100 inches) and in the Drummer at 216 cm (85 inches). Tama was sampled on a 2.5% slope, Elburn on a 1% slope, and Drummer on a flat with zero slope. Descriptions of the three soils are summarized in Table 1 using terminology and abbreviations of the *Soil Survey Manual*, Soil Survey Staff, USDA (17). The soils were described and sampled from pits located along the New York Central Railroad about 1.21 km (3/4 miles) northwest of Farmer City, in Dewitt County, Illinois.

In the current national classification system, Soil Survey Staff, USDA (16), Tama, Elburn, and Drummer are classified as Typic Argiudoll, Aquic Argiudoll, and Typic Haplaquoll, respectively. All three soils are in a fine silty, mixed, mesic family although the Tama and Elburn of this study are borderline to a fine-textured family. Classification of the moderately well-drained soil in the Tama series is questionable, largely because of the high clay content (40.0%) in the 15-cm (6 inches) thick B21 horizon and the high B/A and B/C clay ratios. However, the series placement of

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this soil does not in any way affect interpretations and conclusions in this study.

The soils are in a humid temperate climate with an average annual rainfall of about 89 cm (35 inches), a mean annual temperature of about 12C (53F), and a growing season of about 180 days.

Possible sampling sites were limited to areas on which good stands of native perennial grasses were growing. This confined the study to a railroad right-of-way as this was the only place in central Illinois where native perennials could be located. The native perennial used in this study was big bluestem (*Andropogon gerardi*), and sampling was done when the bluestem was nearly mature in August of 1965.

Three cores 7.6 cm (3 inches) high and 7.6 cm (3 inches) in diameter were taken in major horizons with a Uhland core sampling device for determinations of bulk density, hydraulic conductivity, capillary, noncapillary, and total porosity. Thin sections were ground to 20 μ-thickness. Organic carbon was determined by using a modification of the Walkley-Black wet-oxidation method (19). Calcium carbonate equivalent was determined for all horizons having a pH greater than 7.0 by the gravimetric loss of carbon dioxide method of the U. S. Salinity Laboratory Staff, USDA (18). Cation exchange capacity was determined by a modification of the direct distillation of adsorbed ammonia method of Peech et al. (12). Exchangeable calcium and magnesium were determined by a modification of the method of Barrows and Simpson (1). Exchangeable sodium and potassium were determined with a Coleman Model 21 flame photometer and a Model 6C junior spectrophotometer using a natural gas-oxygen flame. Free iron was determined by the method described by Kilmer (10) as modified for use by the Soil and Water Conservation Research Division, ARS, USDA, Beltsville, Maryland.

Root samples were taken to a depth of 213.4 cm (84 inches) in soil-root monolith trays which were 30.5 cm (12 inches) by 10.2 cm (4 inches) in horizontal cross section using the method of Weaver and Darland (20). The roots were washed, mounted and photographed, oven-dried, and weighed.

RESULTS AND DISCUSSION

Physical properties of the soils determined in the field are given in Table 1, and physical and chemical properties measured in the laboratory are presented in Table 2. Various soil properties determined either in the field or in the laboratory or both were used as criteria for defining and placing the lower boundary of the three Mollisols. Whenever possible, values of properties were graphed, and, in many cases, arbitrary limits of significant alterations of parent material due to soil development were used to estimate the lower boundary of the soils. The results of using the various criteria of soil depth or thickness are summarized in Fig. 2.

Root distribution of big bluestem (*Andropogon gerardi*) is given in Table 3 and rooting patterns with depth in the three soils are shown in Fig. 1.

Soil depth based on structural development and base of solum (A and B horizons) as determined in the field compares very closely with that based on significant clay accumulation, significant clay films, and completely unleached calcium carbonate equivalent found in the laboratory (Fig. 2). Significant clay accumulation in Tama was considered to be greater than the 16.4% clay of the unleached (calcareous) loess of the C1 horizon. Since the upper 142 cm (56 inches) of Elburn were considered as loessial except for some outwash admixture in the lower few inches, significant clay accumulation in it was also referred to the C1 of Tama. The upper 102 cm (40 inches) of Drummer were considered as silty material, predominantly loess, and significant clay accumlation was referred to the C1 of Tama Significant clay accumulation in the B3 horizons of Drummer was considered greater than the 20.5% clay of the calcareous outwash of the IIC1 horizon.

Presence of significant clay films was considered to be the depth to which oriented clay films could be identified in voids, although the amount of these films was small in the B3 horizons of Drummer. The depths of significant clay films in the thin sections correspond to those depths to which patchy clay films, in contrast to only a few, could be identified in the field.

Completely unleached calcium carbonate equivalent of the Tama was considered as that of the calcareous loess of the C1 horizon (17.8%), the presumed parent material of the Tama and of the upper 142 cm of the Elburn and the upper 102 cm of the Drummer. The IIC1, calcareous outwash horizons of Elburn and Drummer with 17.0 and 18.0% calcium

Table 1—Description of soils

Tama	Elburn	Drummer
Al, 0–33cm., 10YR 2/1–2/2, sil, 3m-fgr, mfr, cs.	Al, 0–30cm., 10YR 2/1, sil 3f-mgr, mfr, cs.	Al, 0–33cm., N 2/ , sicl 3mgr, mfi, cs.
Bl, 33–46cm., 10YR 3/2, sicl, 3m-cgr, mfr, cs.	B1, 30–41cm., 10YR 2/1 & 3/2, sicl, 3m-cgr,mfr,cs.	B21, 33–46cm., 5Y 4/2 & 5/2, sicl, 2fsbk breaking to 3cgr, mfi, cs. 10YR 3/1 & 4/1 clay films.
B21, 46–61cm., 10YR 4/3, hv sicl, 3f-msbk, mfi, cs. 10YR 3/2 discontinuous clay films.	B21, 41–61cm., 10YR 4/2 & 5/2, fid 10YR 5/6 mots, hv sicl, 3f-msbk and abk, mfi, cs. 10YR 4/1 and 3/1 clay films.	B22, 46–58cm., 5Y 5/1 & 5/2, sicl, lmpr breaking to 2f-m abk, mfi, cw. 10YR 3/1 clay films, N 2/ Fe-Mn concretions.
B22, 61–84cm., 10YR 4/3, f1f10YR 5/6 mots, sicl, 1fpr breaking to 2msbk-abk, mfi, gs. 10YR 4/2 clay films.	B22, 61–86cm., 2.5Y 5/2 & 6/2, cf-mp 10YR 5/6 & 5/8 mots, sicl, 2mpr breaking to 2–3abk, mfi, gs. 10YR 4/1 & 3/1 clay films, N 2/ Fe-Mn concretions.	B31, 58–76cm., 5Y 6/1 & 5/2, cl-2p 10YR 5/6–5/8 mots, hv sil, lcpr breaking to 2mabk, mfi, gs. Some 10YR 4/1 & 3/1 clay films, N 2/ Fe-Mn concretions.
B31, 84–112cm., 10YR 5/6–5/8 and 2.5Y 5/2, hv sil, lcpr breaking to lcabk, mfr–mfi, gs. Patchy 10YR 3/1 clay films.	B31, 86–112cm., 5Y 5/2 & 5/1, 2.5Y 6/2 & 10YR 5/6–5/8, li, sicl, lcabk, mfi–mfr, gs. Patchy 10YR 4/1 clay films, 10YR 2/1 root channel fillings, N 2/ Fe-Mn concretions.	B32, 76–102cm., 5Y 5/1, 6/1, & 5/2, m2p 10YR 5/6 & 5/8 mots, sil, lcabk, mfi, gs. Some 10YR 4/1 & 3/1 clay films, N 2/ Fe-Mn concretions.
B32, 112–135cm., 10YR 5/6–5/8 and 2.5Y 6/2, sil, lcabk, mfr, cs, weakly calc. Patchy 10YR 4/1 clay films	B32–IIB32, 112–142cm. 5Y 5/1, 2.5Y 6/2 & 10YR 5/6–5/8, sil, lcabk, mfr, cs, weakly calc. Patchy 10YR 4/1 clay films, 10YR 2/1 root channel fillings,N 2/Fe-Mn concretions. Some sand in lower part.	B32, 76–102cm., 5Y 5/1, 6/1, & 5/2, m2p 10YR 5/6 & 5/8 mots, sil, lcabk, mfi, gs. Some 10YR 4/1 & 3/1 clay films, N 2/ Fe-Mn concretions.
Cl, 135–180cm., 10YR 5/6–5/8 and 2.5Y 6/2, sil, o, mfr, *calc loess*, cs. N 2/ Fe-Mn concretions, pores and some root traces lined with 10YR 3/1 material, few patchy 10YR 4/1 clay films on major fissure faces.	IIC1, 142–193cm., 10YR 5/6 & 2.5Y 6/4, some 5Y 6/1 & 6/2, sl, o, mfr, cs. 10YR 2/1 channel fillings, N 2/ Fe-Mn concretions and few patchy 10YR 4/1 clay films on fissures. *Calc outwash.*	IIB33, 102–127cm., 5Y 6/1 & 5/1, m2p 10YR 5/6 & 5/8 mots, sil with noticeable sand, lcabk, mfi-mfr, gs. Some 10YR 4/1 & 3/1 clay films. *Outwash.*
IIC2, 180–203cm., 10YR 5/6 & 6/4, f1f10YR 5/8 mots, sl, o, mfr, as. Pores and some root traces lined with 10YR 3/1 material, few patchy 10YR 4/1 clay films on few fissure faces. *Calc outwash.*	IIC2, 193–208cm., 2.5Y 5/4, 5Y 6/1, 5GY 5/1, and 10YR 5/4, sl, o, mfr. *Calc outwash.*	IIB34, 127–147cm., 5Y 6/1 & 5/1, m2p 10YR 5/6 & 5/8 mots, sil with noticeable sand, very lcabk, mfr, gs. Patchy 10YR 4/1 clay films. *Weakly calc outwash.*
IIIC3, 203–218cm., 10YR 5/4 and 2.5Y 5/4, 5GY 6/1 and 5YR 6/3 mots, 1, o, mfi. *Calc loam till.*		IIC1, 147–165cm., 5Y 6/1, 5/1 & 5/4, m2p 10YR 5/6 & 5/8 mots, 1, o, mfi, Few 10YR 4/1–3/1 clay films on fissure faces. *Calc outwash.*
Sequence of materials: loess 0 to 180cm. (71 in.); outwash 180cm. to 203cm. (80 in.); loam till 203⁺cm., unoxidized below 368cm. (145 in.).	Sequence of materials: loess 0 to 142cm. (56 in.) with some sand in lower few inches; outwash 142 to 254 cm. (100 in.); unoxidized loam till 254⁺cm.	Sequence of materials: silty material, predominantly loess 0–102cm. (40 in.); outwash 102cm. to 216cm. (85 in.); loam till 216⁺cm., unoxidized below 244cm. (96 in.).

Tab'e 2—Physical and chemical properties of Tama, Elburn, and Drummer soils

Horizon	Depth		2mm	Sand 2-.05mm	Silt .05-.002mm	Clay <.002mm	Bulk density	pH	$CaCO_3$ equiv.	Org. carbon	Free iron (Fe_2O_3)	CEC	Exchangeable cations				Base sat.
													Ca	Mg	K	Na	
	cm	inches	%				g/cm³		%			meq/100g	meq/100g				%
								Tama Silt Loam									
A1	0-33	(0-13)	—	2.8	71.9	25.3	1.05	5.9	—	2.4	1.3	23.3	13.1	4.3	0.3	0.1	76
B1	33-46	(13-18)	—	2.6	64.2	32.9	—	5.7	—	1.8	1.4	24.4	12.0	5.8	0.3	0.1	74
B21	46-61	(18-24)	—	1.6	58.4	40.0	1.24	5.5	—	1.0	1.4	30.2	15.2	8.5	0.4	0.1	80
B22	61-84	(24-33)	—	1.4	64.2	33.6	—	5.6	—	0.4	2.0	25.7	13.4	7.8	0.4	0.2	85
B31	84-112	(33-44)	—	1.3	74.6	24.1	1.42	7.3	2.8	0.3	2.0	18.0	11.4	5.9	0.3	0.2	98
B32	112-135	(44-53)	—	1.5	80.1	18.4	—	8.2	11.8	0.1	1.4	13.6	10.4	6.0	0.2	0.2	100
C1	135-180	(53-71)	—	3.1	80.5	16.4	1.52	8.1	17.8	0.1	1.5	11.7	10.2	6.9	0.2	0.1	100
IIC2	180-203	(71-80)	11.6	53.7	35.5	10.8	—	8.2	16.8	0.1	1.2	5.7	6.0	3.9	0.1	0.1	100
IIIC3	203-218	(80-86)	10.5	31.2	48.5	20.3	1.82	8.3	21.7	0.1	1.1	7.2	20.9	3.6	0.2	0.1	100
								Elburn Silt Loam									
A1	0-30	(0-12)	—	6.7	69.6	23.6	1.16	6.0	—	3.1	1.0	26.1	15.8	4.6	0.3	0.1	80
B1	30-41	(12-16)	—	4.9	66.7	28.5	—	6.0	—	1.5	1.2	23.4	13.0	6.2	0.3	0.1	84
B21	41-61	(16-24)	—	2.3	59.0	37.0	1.26	6.1	—	0.8	1.0	30.9	16.9	9.8	0.5	0.2	88
B22	61-86	(24-34)	—	1.6	63.7	34.4	—	6.9	—	0.3	1.9	26.9	15.8	9.8	0.4	0.2	98
B31	86-112	(34-44)	—	2.9	68.5	28.6	1.42	7.7	1.6	0.2	2.0	22.6	14.2	8.6	0.4	0.2	100
B32-IIB32	112-142	(44-56)	—	14.5	65.4	20.1	1.51	8.1	3.6	0.2	1.8	14.0	11.4	5.0	0.3	0.2	100
IIC1	142-193	(56-76)	27.1	59.6	31.4	9.0	1.82	8.4	17.0	0.1	1.6	4.5	7.8	2.1	0.2	0.2	100
IIC2	193-208	(76-82)	—	68.9	24.2	6.9	—	8.3	20.5	0.1	0.7	2.4	14.1	1.2	0.1	0.1	100
								Drummer Silty Clay Loam									
A1	0-33	(0-13)	—	11.7	54.0	34.3	1.17	6.2	—	2.7	0.9	34.8	22.0	8.2	0.1	0.1	87
B21	33-46	(13-18)	—	8.7	58.2	33.0	—	6.9	—	0.8	0.9	27.2	16.0	8.8	0.4	0.2	93
B22	46-58	(18-23)	—	5.4	60.1	34.6	1.33	7.0	—	0.4	0.9	27.9	16.4	9.3	0.4	0.2	94
B31	58-76	(23-30)	—	9.9	63.6	26.5	—	7.5	1.8	0.3	1.4	21.1	13.0	7.3	0.4	0.2	99
B32	76-102	(30-40)	—	6.6	70.8	22.7	1.46	7.7	2.5	0.2	1.7	16.8	11.2	6.1	0.4	0.2	100
IIB33	102-127	(40-50)	—	21.7	55.2	23.1	1.56	8.0	3.5	0.1	1.8	13.2	9.8	5.4	0.3	0.2	100
IIB34	127-147	(50-58)	3.1	21.0	57.7	21.3	1.64	8.2	10.6	0.1	1.9	9.4	9.3	5.4	0.2	0.2	100
IIC1	147-165	(58-65)	9.7	38.7	40.8	20.5	1.63	8.2	18.0	0.1	1.8	5.8	20.5	2.7	0.1	0.2	100

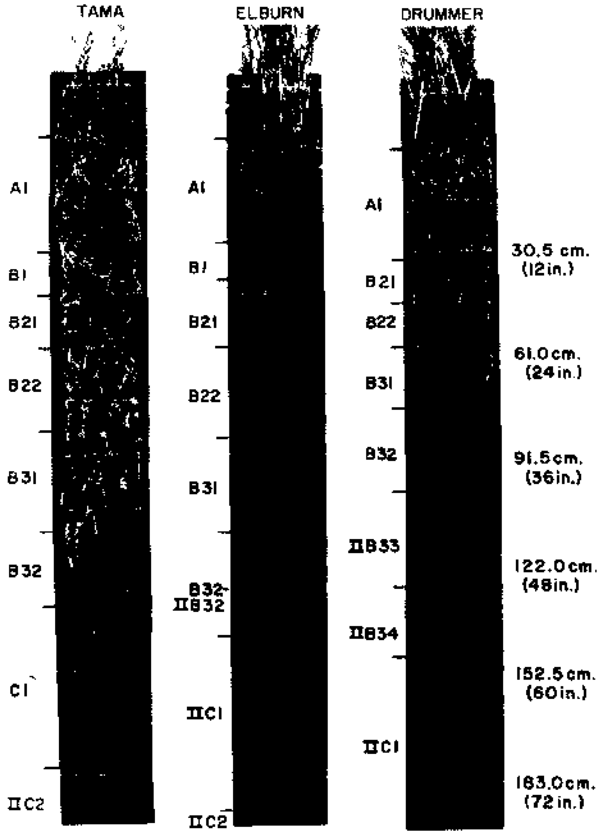

Fig. 1—Root distribution of big bluestem (*Andropogon gerardi*) in Tama, Elburn, and Drummer soils.

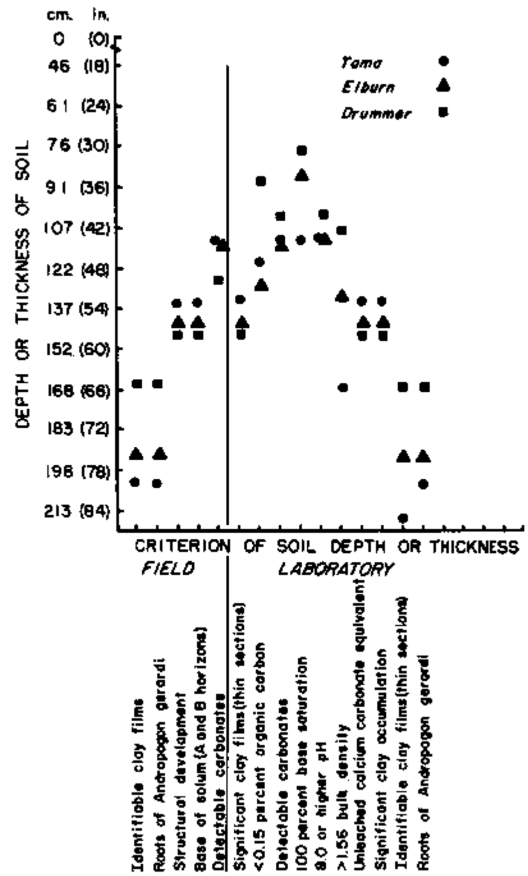

Fig. 2—Thickness of three Mollisols based on soil properties and depth of root penetration of native big bluestem (*Andropogon gerardi*).

carbonate equivalents, respectively, were considered as completely unleached.

Small amounts (< 3%) of carbonates were detectable considerably higher in the profiles by laboratory methods than by field methods (Tables 1 and 2). However, because of possible errors in the laboratory method, calcium carbonate equivalents of less than 3% were disregarded. Using values greater than 3%, carbonates were found at shallower depth by laboratory methods only in the Drummer. Development of weak structure and some clay films of a patchy nature occurs in these soils during and before complete removal of carbonates. Weakly calcareous or only partially leached B3 horizons with appreciable development of structure and clay films are common in many other soils developed in Wisconsinan-age materials. Because the development of structure andclay films in the partially leached B3 horizons of this study is d efinite and significant, depth to detectable carbonates is not a suitable criterion for determining the lower boundary of these soils.

In weakly to moderately developed soils formed in originally calcareous material, high pH (8 or more) and high base saturation (100%) occur at relatively shallow depths because of only partial leaching and removal of bases. These two soil properties are not good criteria for placing the lower boundary of these soils because they occur in horizons having significant structure, clay film, and clay accumulation development. Also, in many soils, such as those of this study, plant root activities extend to considerably greater depths.

Organic carbon decreased gradually with depth in the three soils until a value of about 0.15% was attained. Because further decreases with depth were not apparent, this value was selected as indicating the depth of significant organic matter accumulation.

Maximum depth to which a few clay films could be identified in the field (Table 1) and from thin sections correlated very well with depth of root penetration of big bluestem observed in the field and in the laboratory. This is reasonable because clay movement in the lower horizons followed root channels. Depths to which clay films could be identified were considerably greater in all three soils than depths to which amounts of clay films present were judged to be significant. A few clay films were observed in thin sections in Tama below the depth of rooting of big bluestem at the time of sampling. These clay films were associated with root traces of previous seasons.

An arbitrary bulk density value of 1.56 g per cm^3 was used in placing the lower soil boundary. Bulk density was not a good criterion for determining this boundary in these soils. Bulk density increased gradually with depth, and there was no sharp break indicating a boundary between developed soil and unaltered material. In Tama and Elburn soils, greatest change in bulk density occurred between loess and underlying till or outwash.

Distribution of free iron, although given in Table 2, did not correlate well with clay distribution in these soils, and was not

Table 3—Root distribution of big bluestem (*Andropogon gerardi*) in Tama, Elburn, and Drummer soils

Horizon	Depth		Root weights from 10 by 30 cm trays with depth: Total in horizon	Root weights from 10 by 30 cm trays with depth: Per 2.54 cm	Proportion in horizon
	cm	inches	g	g	%
			Tama Silt Loam		
A1	0–33	(0–13)	39.254	3.020	75.4
B1	33–46	(13–18)	4.440	0.888	8.5
B21	46–61	(18–24)	2.849	0.475	5.5
B22	61–84	(24–33)	2.488	0.276	4.8
B31	84–112	(33–44)	1.591	0.145	3.1
B32	112–135	(44–53)	0.880	0.098	1.7
C1	135–180	(53–71)	0.486	0.027	0.9
IIC2	180–203	(71–80)	0.030	0.003	0.1
IIIC3	203–218	(80–86)	—	—	—
		Total	52.018		
			Elburn Silt Loam		
A1	0–30	(0–12)	40.303	3.359	70.0
B1	30–41	(12–16)	4.093	1.023	7.1
B21	41–61	(16–24)	5.101	0.638	8.9
B22	61–86	(24–34)	5.030	0.503	8.7
B31	86–112	(34–44)	2.316	0.232	4.0
B32-IIB32	112–142	(44–56)	0.602	0.060	1.1
IIC1	142–193	(56–76)	0.140	0.007	0.2
IIC2	193–208	(76–82)	—	—	—
		Total	57.585		
			Drummer Silty Clay Loam		
A1	0–33	(0–13)	36.780	2.829	76.3
B21	33–46	(13–18)	4.983	0.997	10.3
B22	46–58	(18–23)	2.286	0.457	4.7
B31	58–76	(23–30)	1.889	0.270	3.9
B32	76–102	(30–40)	1.543	0.154	3.2
IIB33	102–127	(40–50)	0.525	0.052	1.1
IIB34	127–147	(50–58)	0.187	0.023	0.4
IIC1	147–165	(58–65)	0.018	0.002	0.1
		Total	48.211		

used to place lower boundaries. Alteration of primary forms of iron has occurred to considerable depths in these soils. Depth to unoxidized material was 368 cm (145 inches) in Tama, 2:4 cm (100 inches) in Elburn, and 244 cm (96 inches) in Drummer (Table 1).

From variations in thickness or depth of soil as measured by various soil properties and the lower limit of rooting of native prairie grass (Fig. 2), it is evident that the lower boundary of these kinds of soil is not sharp and its definition and placement depends on the criterion used. Thicknesses of these Mollisols based on the extent of rooting of big bluestem, the predominant native perennial plant, are considerably greater than those based on soil properties commonly used to determine solum thickness.

Thickness based largely on structural development, significant clay accumulation and clay films, and depth to completely unleached material may give the best average solum thickness for these soils. But evidence of some clay movement below these depths, present in the form of clay films in root channels and pores, and the depth of rooting of native perennial prairie grass would indicate that using solum thickness only may not be sufficient depth to consider in characterizing and classifying these soils. Several studies (3, 4, 5) also indicate that common crops such as corn often root deeper than the solum in moderately developed soils formed in Wisconsinan-age materials, and that the material beneath the solum is important to the behavior of many of these soils.

A soil such as Drummer, having a cambic horizon, can be placed in the order category of the present classification system on properties of the upper 25 cm (10 inches). In the suborder to family categories, properties of an arbitrary control section between 25 cm and 102 cm (40 inches) are also involved in the placement. In the series category, certain genetically altered layers (diagnostic horizons) are considered below the arbitrary control section if they extend below 1 m, and the regolith is also more than 1 m thick.

From the standpoint of common rooting of native perennial plants, it seems a depth greater than 102 cm (40 inches) should be used for a soil such as Drummer in the family category and in the series category, regardless of whether the diagnostic horizons end above or below a depth of 1 m.

As previously mentioned, the placement of the lower boundary of a soil on the basis of the thickness of the solum involves judgment of significance of alterations of soil materials by soil-forming processes. Many studies (6, 14) indicate that transformations and/or translocations of soil constituents such as phosphorus often extend to depths below the base of the more or less standard solum. In the soils of this study, oxidation of iron has taken place to depths ranging from 93 cm (38 inches) to 233 cm (92 inches) greater than the base of the solums. Changes such as these have significance to soil genesis and should not be disregarded because of arbitrary depth limits of soil.

Placement of the lower boundary of pedons of many soils, on the basis of solum thickness, or the use of an arbitrary soil thickness in the classification system as shallow as 102 cm (40 inches), may often be too thin to include lower lying layers which are important to rooting and growth of native perennial plants and also many farm crops.

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