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History of Soil Survey in Canada 1914–1975

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Preface

This brief history of the development of soil survey in Canada is the result of discussions among members of the Soil Resource Inventory Section of the Soil Research Institute in 1973. We realized that many of the pioneers of soil survey in Canada had retired and that their knowledge must be tapped if we hoped to learn and to record the developments that had led to the present stage of soil survey. The importance of knowing past developments became clear as we sought the bases of our sometimes widely divergent concepts about soil mapping and classification. Therefore we wrote to about 20 pioneer soil surveyors asking them to write notes on their recollections of the early years of soil survey in Canada. The response was excellent.

The first draft of a history of soil survey was assembled from the notes referred to and from published material dating from about 1920. The draft was circulated to contributors of the historical notes and to other pedologists for criticism and suggestions. A second draft was prepared and revised on the basis of suggestions of many pedologists.

We thank the many retired and active pedologists who contributed historical notes, constructive criticism, and editorial suggestions. Special mention for their contribution is due to: R. Baril, the late W. E. Bowser, D. B. Cann, J. H. Day, the late W. A. Ehrlich, C. C. Kelly, L. Farstad, P. G. Lajoie, J. D. Newton, N. R. Richards, J. A. Toogood, G. B. Whiteside, and R. E. Wicklund. The critical comments and suggestions of D. B. Cann, J. G. Ellis, B. Kloosterman, P. G. Lajoie, and A. Leahey were invaluable. The photographs were provided by J. A. Toogood, D. B. Cann, and W. E. Bowser.

Introduction

In 1975, Canadian pedologists could look back on about 60 years of soil survey in Canada. During those years, soil maps of varying scales and degrees of sophistication had been made of most of the settled area of the country and significant forays had been made into the vast northern regions. About 150 pedologists and student assistants were in the field in the summer of 1975 mapping soils from Vancouver Island to Newfoundland and from southern Ontario to the Arctic Islands. A similar number of pedologists and supporting staff were busy with correlation, cartography, soil data management, research, and administration related directly to soil survey. Demand was strong for soil survey information and its interpretation for land use planning purposes. This is in sharp contrast with some periods in the past when financial support for soil survey was withdrawn, and even when soil information was available it was often ignored.

The purpose of this report is to trace the development of soil survey in Canada from its inception to 1975. Although 60 years is a brief span in terms of human history or even of the history of European settlement in Canada, it encompasses more than half the period during which systematic soil surveys have been done anywhere in the world. Major changes have occurred not only in methods of soil survey and systems of mapping but also in concepts of the soil itself. Tracing the evolution of these methods and concepts should help to put in perspective the present stage of development of soil survey in Canada.

First attempts to classify soils (before 1920)

Various surveys by geologists and botanists and expeditions of explorers had provided some information on the nature and distribution of soils in Canada before 1920. The Palliser expedition in 1857 rated the "arid belt" or "Palliser triangle" in the southern plains as unfit for human habitation. However, the triangle is now a major wheat-producing area. Settlers were aware of soil differences and they tended to occupy new land that was similar to the land from which they emigrated. Therefore, it is said that the Scots chose rocky land, the Ukranians chose black soil, and the Dutch chose wet areas. Despite these examples of awareness of soil differences, surveys that focused on the identification and mapping of different kinds of soils did not begin until 1914.

The first soil survey in Canada was undertaken by the Department of Chemistry, Ontario Agricultural College, Guelph, in 1914. G. N. Coffey, formerly of the U.S. Bureau of Soils, advised A. J. Galbraith during the first month of field work. This precedent of strong influence from practices developed in the United States has continued throughout the history of soil survey in Canada. Field work on this initial soil survey of southwestern Ontario was continued each summer until 1920 and the report was published in 1923. The major purpose of the survey was to identify and map the main soil types so that agricultural development and practices could be planned according to the nature of the soils. Other applications of soil survey information were recognized such as location of land suitable for specific uses, planning of roads, basic information for education, and related uses. Undertaking soil surveys to serve practical purposes is another precedent that has been followed to the present time.

The scale of this initial survey is indicated by the fact that all Ontario southwest of Kingston was covered by 1920 in spite of the inexperience of the men involved and of changes of the surveyor-in-charge in the years 1916 and 1918. The classification system of the U.S. Bureau of Soils was used. It was a hierarchical scheme having 3 levels: soil province—based on general features of surficial geology; soil series—somewhat analogous to a geological formation, based on color, origin of material, and weathering; soil type—based on textural divisions within the series. The broad scope of a soil series at that time was indicated by the fact that only nine series were mapped in the entire area surveyed. The series has been a category in most of the systems of classification used throughout the history of soil survey in Canada, both the early field systems and the taxonomic systems. Its meaning has become increasingly specific. Now, the series is the lowest category in the hierarchical system of soil taxonomy. Taxa at the series level, as at other categorical levels, are conceptual. However, series names are commonly used to indicate the major class or combination of classes of soil within mapping units, particularly in the more detailed surveys. Despite the changes in concept and definition of series, most of the series names (Guelph, Haldimand, etc.) used in the initial soil survey are in use today.

Galbraith, who did the first soil mapping in Ontario, brought the idea of soil survey to the Manitoba Agricultural College when he moved from Guelph in 1915 to join the Department of Chemistry. Supported by the Manitoba Department of Agriculture, he carried out road traverses and studied the soils of the southern part of the province in the summers of 1917 and 1918. Unfortunately there is no record of this work as Galbraith died of influenza during the epidemic in 1918.

The only other soil survey activity in Canada before 1920 was the soil (or land) mapping undertaken by the Topographical Survey of the Dominion Department of the Interior in 1919. The purpose of this work, which was curtailed in 1925 and terminated in 1930, was to identify land close to railway lines in Western Canada that would be suitable for agricultural settlement by veterans of World War I. Land was classified according to its suitability for such settlement and the soil was considered as a major factor. Soil sampling and analysis was a part of the program.

The beginning of systematic soil surveys (1920 to early 1930s)

Newly formed departments of soils in faculties of agriculture at the universities in the Prairie Provinces started soil surveys in the twenties, usually with the support of the provincial departments of agriculture and with some limited financial assistance from the federal Department of Agriculture in the latter part of this period. In British Columbia, soil surveys were begun in 1926 by the B.C. Forest Service. The Ontario Agricultural College in Guelph undertook soil surveys of counties in southern Ontario. All the surveys mentioned were undertaken entirely independently in each province and so somewhat different systems of soil classification and mapping developed. Because soil surveys were strictly provincial undertakings during this period, the evolution and development of the program varied from province to province.

Alberta

F. A. Wyatt began mapping the soils of Alberta in 1920 after moving from the Department of Agronomy and Chemistry at the University of Illinois in 1919 to head the new Soils Department of the Faculty of Agriculture, University of Alberta, Edmonton. His initial soil survey project was the delineation of the province into broad soil-climatic zones. The first zone map, completed about 1925, depicted the zone of Brown soils of the semiarid southeast, the Black soils of the central region, and the zone of Gray Wooded soils of the north and west. In the meantime, problems of drought and wind erosion in southern Alberta prompted the launching of a soil survey in the Macleod area in 1921. In 1922, six men using two model T Fords for transportation were involved in that survey under Wyatt's direction. By 1926, more than 3 million ha (*7 million ac*) of southern Alberta had been mapped, mainly on the basis of surface soil texture. However, notes were taken on topography, stoniness, soil color, vegetation, and land use.

Soil samples in the early surveys were taken at arbitrary depths of 0-17 cm (*0-6 2/3 in.*), 17-51 cm (*6 2/3-20 in.*), 51-102 cm (*20-40 in.*) which was the general practice in the United States at that time. The samples were analyzed to determine particle-size distribution, some plant nutrients, and total elemental composition.

The soil surveyors moved from one small-town hotel to another as the survey progressed. Breakfast and dinner were available in Chinese restaurants established when settlements developed soon after the railway line went through. Lunches in the field were sometimes enhanced by fresh milk (Fig. 1) and by the availability of firewood for cooking (Fig. 2). Traveling by car, surveyors examined the soil along the roads and traverses across the virgin plains (Figs. 3 and 4).

Fig. 1 Fresh milk for morning coffee.

A soil survey of the St. Ann sheet west of Edmonton was completed in 1927. There, mapping was based on a numbering system indicating soil zone, series, and type; sampling was on a horizon basis.

The growing demand for new land prompted the Research Council of Alberta to allocate funds in 1928 for exploratory soil surveys in the Peace River area of northern Alberta. The headquarters of these surveys was the Soils Department directed by F. A. Wyatt. Field parties, consisting of a chief, an assistant, a cook, and a packer, made pack horse traverses through bush and muskeg, and mapped the soils from June to September (Figs. 5 and 6). Between 1928 and 1931 more than 8 million ha (*20 million ac*) were mapped on a broad reconnaissance basis, and the soils, terrain, and vegetation were described in reports. The map of the Lesser Slave District (Fig. 7), typical of the maps of those exploratory surveys, shows five classes of soil. These maps and reports were used in selecting land for settlement in the Peace River area in the thirties.

Poor crop yields in the Gray Wooded soil zone were recognized as a problem in the mid twenties and Wyatt set up pot culture work to check for nutrient deficiencies. Legumes were found to respond to superphosphate and later work showed that this was due to the sulfur in the fertilizer. Arrangements were made in 1929 with Ben Flesher to carry out experiments on the Gray Wooded soils on his farm at Breton, southwest of Edmonton. J. D. Newton, a soil microbiologist who joined the Soils Department in 1922 and participated in the early soil surveys, had a major role in the development of the Breton plots, which are still in use today. They demonstrated clearly sulfur deficiency in some Gray Wooded soils as an important soil-crop relationship in central and northern Alberta.

Soils surveys in the Peace River area were discontinued in 1931 due to shrinking budgets. Perhaps some secret sighs of relief were breathed in response to the termination of this era of pack horse surveys and the rough life in the field. The crews were a hardy lot who said goodbye to the comforts of home in early June and returned in late September with vivid memories of hundreds of miles cut through thick forests and heavy muskeg; countless cubic yards of soil excavated to expose profiles; potluck meals concocted from staples of flour, salt, sugar, lard, bacon, beans, and dried fruit, supplemented by local game and berries; camps exposed to the vagaries of the weather; and, most of all, the hungry hordes of mosquitoes and black flies that had pestered them night and day.

Detailed soil surveys of irrigation projects in southern Alberta were started in 1929 in response to the financial problems of the farmers. These surveys continued from 1931 to 1935, a period when all other survey operations in the province had to be abandoned because of the withdrawal of funds.

Saskatchewan

At the request of farmers in drought-stricken southwestern Saskatchewan, the provincial government held a "Better Farming Conference" at Swift Current in 1920. A Royal Commission appointed as a result of that conference recommended that "a reconnaissance soil survey of Saskatchewan be undertaken to outline the various soil areas and classify them as to their suitability for grain growing and stock raising." Thus the Saskatchewan soil survey was formed in response to a call for help from the agricultural community.

R. Hansen, first professor and head of the Department of Soils established in 1919 at the University of Saskatchewan, directed the initial soil survey in southwestern Saskatchewan in 1921. Hansen soon delegated the main responsibility for soil survey to A. H. Joel, a graduate of Michigan State University, who joined the Department in 1922. Joel, who had previous experience in soil survey in the United States, provided dynamic leadership in the development of soil mapping procedures and soil classification in Saskatchewan, and indeed in Canada.

Report No. 1 of the Saskatchewan Soil Survey, published in 1923, included a colored map showing the surface texture of soils in the Moose Jaw area. The report provided information on the physiography, climate, agriculture, and history of the area and included sections on soil types (texture), soil management, and soil composition (physical and chemical data).

Progress in soil survey can be traced readily from the study of reports published in the twenties. For example, Report No. 3 published in 1925 went beyond surface texture in classifying the soils. "Burn-out areas" were mapped and the origin of the depressions or pits, in what was later

Fig. 2 Wyatt fries the bacon while Newton and Doughty look on. Willow Creek, 1922.

Fig. 3 McAllister, Wyatt, Ward, and Doughty on soil survey with Model T Fords, 1920s.

Fig. 4 Traversing the prairie by Model T.

Fig. 5 Pack horse survey in wooded area.

Fig. 6 Bogged-down pack horse.

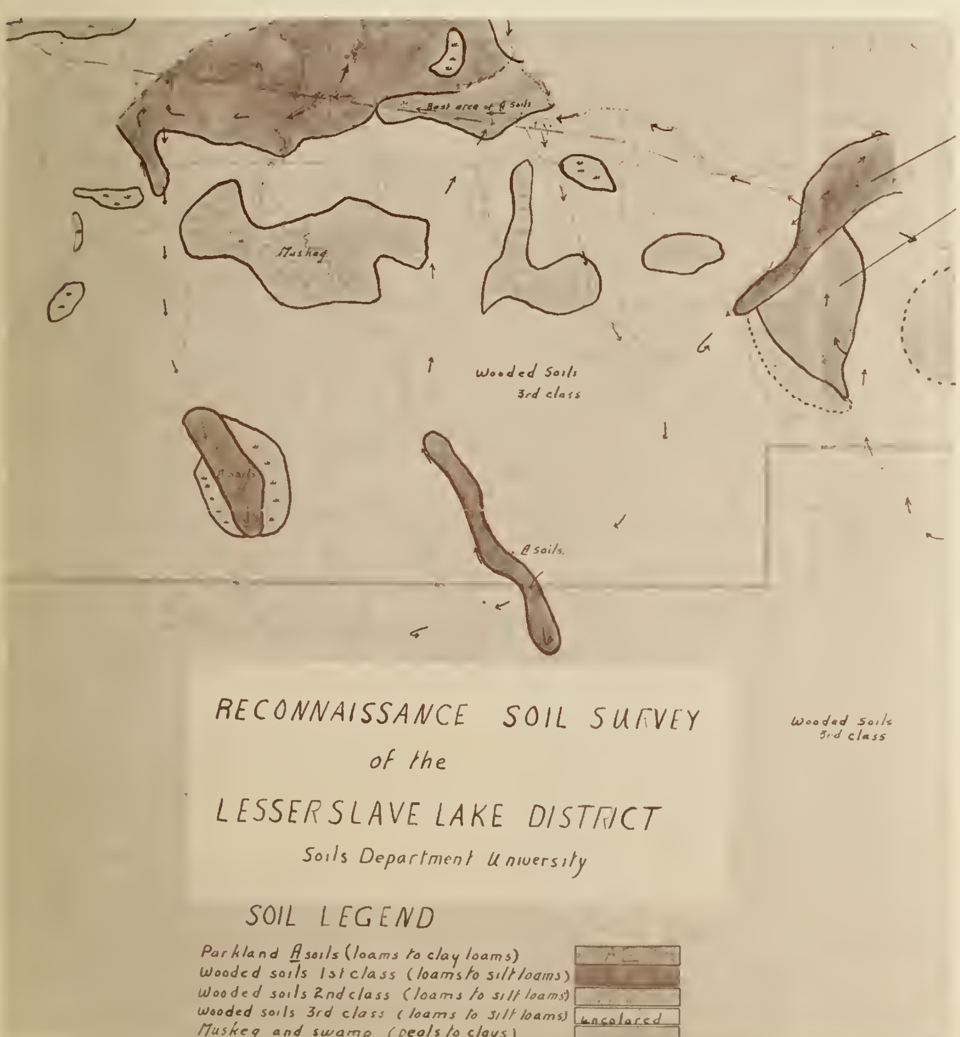


Fig. 7 Reconnaissance soil survey of the Lesser Slave Lake District.

classified as Solonetzic soil, was discussed. The favored hypothesis of origin was that the pits were due to the burning out of sod by prairie fires. Another, the "blow-out" theory, suggested that wind erosion of the surface soil had left the impervious subsoil exposed in the depressions. Rough broken land was another nontextural unit mapped in that survey.

In Report No. 4, 1926, soils were mapped as named series and types (texture); for example, Regina clay. Like Ontario Soil Report No. 1, the series was a mapping unit, not a taxonomic unit, and its range was much wider than that of a series today. Series and types were defined in Report No. 5, also published in 1926, as follows:

"Soils are divided into groups known as series and series are further divided into types. The former corresponds in a general way to genera of plants or animals and the latter to species. Soils of a given series are alike in all essential characteristics except that of texture while soils of the same type are theoretically alike in all characteristics including texture, as are species in a Biological classification. Soil class refers to texture alone, and the various classes are defined by the proportion of clay, silt and sands according to the arbitrary table used by the United States Bureau of Soils. The name of the locality near which the group of soils is first found is usually given to a series, and the type is named by combining the series name with the particular class to which the type belongs."

Report No. 6, 1927, includes a discussion of profile development and mentions soil horizons as well as the concept of a "normal" soil developed "under generally average soil conditions—that is, on smooth, well-drained, medium-textured uplands that have lain undisturbed for a long period of time." The normal profile for the region (Rosetown area) was "the brown to dark brown surface soils and the light gray layer of lime accumulation." This clearly implies the concept of soil zones first mentioned in Report No. 8,

1929. Zones are major belts of soils that reflect the influence of climate and vegetation on soil development. These concepts were further developed in Report No. 9, published in 1931.

Unfortunately the field operations of the soil survey were, for practical purposes, terminated in 1932 due to lack of financial support during the great depression. However, the university staff with the assistance of some graduate students examined and compiled data already obtained and performed the necessary laboratory analysis during the 1932-34 period. This work, representing the first major stage of soil survey development in Saskatchewan, was later published as Soil Survey Report No. 10 by Joel, Mitchell, Edwards, and Moss in 1936. The report and map, on a scale of 1:380 160, covers more than 24 million ha (*60 million ac*) south of Township 48.

Developments in concepts of soil, soil mapping, and classification are evident from the early Saskatchewan soil survey reports. It is clear that the primary aim of the surveys was a practical one—to determine the nature and distribution of soils and to relate soil properties to soil management. In Report No. 12 the soils are grouped from the standpoint of wheat production.

Manitoba

The systematic survey of the soils of Manitoba began in 1927. However, in the summers of 1921 and 1922 C. B. Clevenger of the Chemistry Department was responsible for the mapping of soil texture as a part of an agricultural survey undertaken by the Manitoba Agricultural College. After the completion of that survey in 1922, no further funds were allocated to soil survey until 1926 when the Soils Division of the college undertook the soils aspects of a study, commissioned by the premier, of unused lands in Manitoba.

J. H. Ellis, founder of the Soils Division, began the systematic mapping of the soils of Manitoba in 1927 with a reconnaissance soil survey of an area west of the Red River and extending to the United States boundary. During that initial survey, he developed a system of field classification of soils that has had a major influence on soil classification and mapping in Canada. The system was based on a concept suggested by and discussed with C. C. Nikiforoff of the Russian school of soil science, who was surveying the soils of the Red River Valley on the U.S. side of the border in 1927. In his system Ellis explained:

"Under the Manitoba field classification of soils that evolved, the associated genetic soil types developed on similar material (or geological surface deposits) in the same soil zone were designated as a Soil Association, and the individual associated soils (i.e., Phytomorphic (P) or normally well-drained; Oro-morphic—mountain form—(O) or locally arid shallow profiles due to run-off by reason of elevated or hill crest position; Hydro-morphic (H) or poorly drained; Halo-morphic (Gs) = salinized and (G) = alkalinized soils—recognized by their profile characteristics and reflecting variations in local soil climate and vegetation—together with intergrades, transitional or passage forms, O-P; P-H; H-G) were designated as Soil Associates. The soil associates were then subdivided into textural classes and phases if such more detailed subdivisions were required. The individual soil types or associates that occurred and formed a soil pattern in a given landscape area were thus grouped into soil associations, and the common regional soil characteristics expressed in the regionally normal (Phytomorphic) or well-drained soils of all the various associations (as the result of common regional climate and regional vegetation) provided the criteria for designating the Soil Zone."

The system was considered as an interim one for practical use, to serve until sufficient knowledge of soils was available to permit the development of a scientific classification. Its usefulness as a basis for designating soil mapping units is borne out by the fact that the same basic system is still used in some Canadian provinces as well as in Scotland.

The survey of Manitoba soils came to an abrupt halt in the 1932-34 period due to the withdrawal of federal and provincial funds.

Ontario

The survey of Ontario soils recommenced in 1922 after 2 years without fieldwork. G. N. Ruhnke, who spent the summer of 1922 studying soil survey methods under F. B. Howe of Cornell University, headed the soil survey from 1923. During the twenties "detailed" surveys were made of Kent, Norfolk, Elgin, and Middlesex counties and of the Niagara fruit belt. The method of classification was the same as that of the Preliminary Soil Survey of southwestern Ontario published in 1923, that is, soil provinces, series, and types. As the years progressed increasing attention was paid to the characteristics of the soil profile.

Soil maps (without reports) of these counties were published at a scale of 1:126 720 in the late twenties and early thirties. The legends of these maps provide information on soil series and type, area of each type, color and texture of surface and subsoil, topography and drainage, reaction, land use, and main fertility needs. The narrowing of the range of a soil series is indicated by the fact that about twice as many series were mapped in Middlesex County alone as in all of southern Ontario in the first Ontario soil survey report.

The purpose of these early surveys was clearly and logically tied to agriculture. The work was done by the Ontario Agricultural College in prime agricultural areas. Ruhnke pointed out some of the clear relationships between soil types and soil suitability for specific crops. Dunkirk fine sandy loam (deep phase) was said to be ideal for peach production, and Waterford soil was highly suited to the production of raspberries of superior quality.

British Columbia

The British Columbia Forest Service undertook soil surveys to separate arable land from nonarable land as part of a program to establish permanent forest reserves in which alienation of land would be denied. The first survey was carried out in the central interior in 1926 along the Canadian National Railways line from Fraser Lake to Smithers. The soils were classified according to surface texture, and the slope as measured by the Abney level. Foot traverses were made at 0.8 km (*1/2 mile*) intervals to cruise the timber and examine the soil. These surveys, directed by F. D. Mulholland, were carried out in the environs of Prince George, Sicamous, and the North Thompson Valley between 1927 and 1929. Information from them provided part of the basis of the first sustained yield policy in Canada for forest resources. Lack of financial support from then to the end of 1930 brought about the termination of these surveys.

In 1931 soil surveys were revived in response to a recommendation of the W. Sanford Evans Royal Commission of 1930, which was appointed to investigate the ills of the tree fruit industry in the Okanagan Valley. C. C. Kelley, formerly a district agriculturist, was appointed by the British Columbia Department of Agriculture to carry out the survey from headquarters in

Kelowna. Like many of the pioneer soil surveyors in Canada he had no previous experience in the work. The Experimental Farms Service of the federal Department of Agriculture decided to participate in this program on a fifty-fifty basis and R. H. Spilsbury joined Kelley as the representative of the federal staff.

The first survey in the Okanagan Valley on a scale of 1:4800 was a detailed one of the irrigation districts north of Kelowna. The soils were mapped as series. The survey contributed to the solution of dieback in apples and other tree fruits by showing that these and similar problems were confined to the poorly and somewhat poorly drained soils. Later, the plant physiologists found that boron deficiency caused corky core in apples. In 1935, the demand for detailed soil surveys diminished and reconnaissance surveys of the lower Fraser, Okanagan, and Similkameen valleys were initiated. New kinds of soils were studied and new sequences of soil distribution on mountain slopes were noted.

Quebec

No systematic soil surveys were begun in Quebec before 1934, although R. R. McKibbin had made extensive studies of different types of soil profiles in the province during the late twenties and early thirties. Also during the thirties the Quebec Colonization Department conducted surveys in forested areas to determine the quality of land likely to be open for colonization. These surveys, supervised by forestry engineers, delineated textural classes in particular. Large tracts of land were mapped mainly in Gaspé, Témiscouata, Abitibi, and Temiscamingue counties. However, the maps and soil data have never been published by the Department of Colonization.

Maritime Provinces

Soil surveys were not started in the Maritime Provinces until the mid thirties or later.

Events that influenced soil survey in the twenties

Throughout its history, soil survey in Canada has been influenced strongly by concepts and methodology developed elsewhere in the world. The early leaders of soil survey in Canada: Galbraith, Wyatt, Joel, Ruhnke, and Ellis, were familiar with concepts of soil and methods of soil survey in the United States and they were influenced by them to varying degrees. During the twenties, ideas developed by the great Russian school of soil science were exerting a profound effect on the thinking of North American pedologists. The major concept enunciated by Dokuchaev in about 1870 and developed by other Russian soil scientists was that of soil as a natural body that reflects the influence of climate and vegetation acting through time on surficial geological materials. The 1927 translation by Marbut, head of the U.S. Soil Survey, of a book by Glinka that was published in 1914 in German made the ideas of the Russian school of pedology available to the English-speaking world. There is no doubt that the Russian school influenced the development of soil survey in Canada.

Visits by world authorities on soil classification and mapping stimulated and conveyed new ideas to the pioneer Canadian soil surveyors. The 1925 visit of Marbut stimulated interest in Alberta and Saskatchewan to study soil profiles and the types and arrangements of horizons. After the first International Congress of Soil Science in Washington, D.C., in 1927, Glinka, Marbut, Von Sigmond, Hissink, Waksman, Russell, Ogg, and other distinguished soil scientists visited British Columbia, Alberta, and Saskatchewan. Great efforts were made to provide soil monoliths for display to these visitors (Fig. 8). These monoliths, 2 m (*6 ft*) high and weighing about 113 kg (*250 lb*), are still on display at the Department of Soil Science in Edmonton.

Fig. 8 Leahey and Mather taking monolith for 1927 ISSS tour.

Mapping systems

In the first soil surveys in Canada the soil separations were mainly based on texture. However, increased awareness of soil zones and soil profiles representing natural bodies is evident from soil survey reports published in the mid twenties. Preliminary soil zone maps of Alberta and Saskatchewan were presented by Wyatt and Joel respectively at the first International Congress of Soil Science in 1927. These maps showed broad belts of Brown, Black, and Gray soils. By the late twenties and early thirties the concepts of soils as natural bodies that reflect the influence of climate, vegetation, and relief through time in surficial geological materials were firmly entrenched in Canada. The presence of typical zonal, intrazonal, and azonal soil profiles, such as Brown, Black, Gray Wooded, Gray-Brown Podzolic, Podzol, Solonetz, Solod, and Meadow soils, which approximately corresponded to the Russian great soil groups, were fully recognized in Canada by this time.

Because the soil surveys were conducted in each province independently with only minimal contacts between provinces, the greatest differences occurred in the mapping units and in the vocabulary that was in use. In part this can be related to the detail of surveys. Saskatchewan published their soil maps on the scale of 1:380 160; Alberta mostly on the scale of 1:190 080 (except for the broad reconnaissance of the Peace River area and the detailed irrigation studies); Manitoba on the scale of 1:126 720; and Ontario and British Columbia (except for the detailed orchard studies) on the scale of 1:63 360. Saskatchewan, Ontario, and British Columbia referred to their mapping units as "series" or "types." It is evident that the Saskatchewan mapping unit or series was much broader and more inclusive than the series in Ontario or British Columbia. Alberta had recognized the inherent difficulties in the series designation, and referred to their mapping units by numbers indicating soil zone, nature of parent material, mode of deposition, profile features, and texture. Manitoba, on the other hand, referred to their mapping units as "associations," soils developed on similar parent materials in one particular soil zone, and "associates," members of an association.

Cooperative federal-provincial soil survey program (1934-44)

After a period of relative inactivity, the soil survey program in Canada was revived in the mid thirties as a cooperative program among the federal Department of Agriculture, the universities, and the provincial departments of agriculture. A great deal of credit for this renewed activity must be given to E. S. Archibald, Director of the Experimental Farms Service, through whose determined efforts the federal Department became fully involved in this cooperative program. Later, he was the prime instigator of the concept of a National Soil Survey Committee. In this program the universities provided the headquarters and technical direction in most provinces, whereas the federal Department, and to various degrees the provincial departments of agriculture, provided staff and finances.

The problems of the drought-stricken prairies brought about the revival of soil survey in the west. Soils information was needed as a basis for selecting new land for settlement and for reclaiming wind-eroded land (Figs. 9 and 10). The passage of the Prairie Farm Rehabilitation Act (PFRA) in 1935 made it possible to finance soil survey operations in the problem areas. Through the efforts of Archibald the "Cultural Vote" of the PFRA was assigned to provide most of the finances, and the soils departments of the universities in Edmonton, Saskatoon, and Winnipeg provided the headquarters. The surveys in each province were conducted independently.

At about the same time soil surveys were extended to the other provinces under a special "Cooperative Assistance Vote." At a somewhat later date (in the early forties) all the federal contributions were derived from the administration of the Field Husbandry Division of the Experimental Farms Service, supervised by E. S. Hopkins and later, P. O. Ripley.

Because the work in each province was carried on independently, a brief summary of the progress in each province is presented.

Alberta

Soil surveys were resumed in the fall of 1935 under the general direction of F. A. Wyatt in the southern part of Alberta. The areas designated by the PFRA as requiring assistance included Milk River, Rainy Hills, Sullivan Lake, Lethbridge - Pincher Creek, Blackfoot-Calgary, Rosebud-Banff, and the Wainwright-Vermillion sheets.

In this period the soils were classified and reported by a number system, representing zone, type of parent material, mode of deposition, profile type, and texture. The reports included soil maps on the scale of 1:190 080. In 1938, a soil rating map was added in which the soils were rated according to their suitability for arable agriculture or pasture.

Saskatchewan

The soil survey program in Saskatchewan was resumed in 1935 directed by J. Mitchell; field mapping was the responsibility of H. Moss. During the first 3 or 4 years the work was mainly confined to detailed surveys of irrigable land and severely eroded parts of the drought areas. Most of these surveys were published in Report No. 11. Afterward the surveys were extended to cover all the land south of Township 48, and the soils information on the large area, more than 24 million ha (*60 million ac*) was published in Report No. 12 at a scale of 1:380 160. Some work was also extended to the northern fringe of agricultural settlement.

In Report No. 10 the soil mapping units were series, types, and phases. However, the Saskatchewan pedologists realized that at the scale of mapping used it was impossible to refine the definition of a series to correspond to series mapped elsewhere on a larger scale. In Report No. 12 the mapping units were named in terms of soil zone, association, member (series), type, and phase. This change, particularly in the later surveys, brought the work closer in line with that done in Manitoba. However, some of the series established in the twenties and early thirties included wider ranges than permitted in the Ellis concept of "association," i.e., soils in the same zone, on similar parent materials.

Fig. 9 Dust storm in the thirties.

Fig. 10 The land after the dust storms.

Manitoba

Soil surveys in Manitoba were resumed in 1935 and directed by J. H. Ellis. The work started in the southwestern corner of the province, where drought and soil erosion presented the main problem, and was then extended to the north and east. The soil information was made available locally in a preliminary form although the final reports were not published until the late fifties. They covered southwestern and south-central Manitoba: the Morris, Virden, Carberry, and Winnipeg map sheet areas. The maps were published at a scale of 1:126 720.

There was no basic change in concepts from those reported earlier in the late twenties. The soils were mapped as associations, associates, or types and phases.

British Columbia

During the 1935-36 field seasons in British Columbia, reconnaissance soil surveys at a scale of 1:63 360 were carried out in the Okanagan, Similkameen, and lower Fraser valleys, where intensive agriculture is practiced. Mapping was based on soil zones, series, types, and phases. Preliminary soil mapping was done at Campbell River on Vancouver Island to assist the Forest Service in its tree planting project by designating the location of arable lands.

In 1938 the soil survey worked at Prince George, where agricultural development was limited and where soil information was needed in connection with land settlement. The area was traversed on foot following compass lines at 1.6-3.2 km (*1-2 mile*) intervals. Due to the heavy forest cover, lack of roads, and inadequate base maps, the amount of detail was much less than that obtained in the open agriculturally developed area in southern British Columbia.

The purpose of these early surveys was to classify and map soils, examine their physical and chemical nature, and determine as far as possible their agricultural possibilities. The information also provided an inventory of the soil resources and served as a guide to the consideration of land utilization and to government administrative branches concerned with land and agricultural policies.

In 1938, R. H. Spilsbury resigned as federal soil surveyor to accept a position with the B.C. Forest Service. He was succeeded in 1939 by L. Farstad, who had experience in soil survey in Saskatchewan. Farstad's headquarters were moved from Kelowna to the University of British Columbia in Vancouver in 1941. Cooperative arrangements were developed with the Department of Agronomy. D. G. Laird of that department assisted in the field work in the central interior and the Peace River block.

Soil surveying in the sparsely populated areas of British Columbia in the late thirties and early forties was not only interesting but difficult and often hazardous. Base maps consisted of British Columbia Land Survey (BCLS) and Dominion Land Surveys (DLS) maps supposedly designed to locate lands topographically suitable for agriculture. The soil survey crews followed survey cut lines, compass lines, and game trails. In the spring, sow bears with cubs challenged their right to traverse the terrain and in the fall amorous bull moose had the right of way. The crews traveled by team and wagon, on horse back, by canoe, and on foot. They dined on bannock, beans, bacon, grouse, venison, and berries.

During this period C. C. Kelley worked alone in Kelowna preparing material from previous surveys for publication and carrying out detailed studies of proposals for comparatively small irrigation development projects.

Ontario

In Ontario the soil survey was organized on a cooperative basis among the Experimental Farms Service of the federal Department of Agriculture, the provincial Department of Agriculture, and the Soils Department of the Ontario Agricultural College at Guelph, with G. N. Ruhnke and later F. Morwick in charge of the operation. The surveys were continued on a county basis in southern Ontario, where about 10 counties were completed or started.

In addition, several counties were also surveyed in eastern and central Ontario. In western Ontario, reconnaissance surveys were conducted in the Thunder Bay, Dryden, and Rainy River areas. Preliminary broad reconnaissance surveys were also undertaken in the Clay Belt of northern Ontario. The surveys of soils in the different physiographic and climatic regions of Ontario afforded an excellent opportunity to study the soil types in the widely differing environments of the province.

The mapping units in the county surveys were named in terms of series, type, and phase, whereas the soils in the broader surveys in western and northern sections of the province were mapped on a land type basis in which the main components were described but not necessarily named.

During the soil survey of Carleton County in the early forties, G. A. Hills devised a numerical system for mapping and keying out the soils. The first digit indicated mode of deposition, the second petrographic composition, and the third drainage class. Symbols indicating texture were added. This was an independent development of a system somewhat similar to that used for a decade in Alberta. Challenged by E. S. Hopkins, Chief of the Field Husbandry Division of the Experimental Farms Service at that time, to make their soils information more useful to the crop specialists, Hills and N. R. Richards devised capability ratings of the soils. This was a useful step in the continuing process of improving the interpretation of soil survey information.

Quebec

Quebec soil surveys were started in 1934 on a cooperative federal-provincial basis directed by R. R. McKibbin with headquarters at Macdonald College and with P. C. Stobbe in charge of the surveys. The first survey involved the mapping and classification of organic soils on the

Montreal plain. The soils were classified according to degree of decomposition, depth, and nature of the underlying material. This survey directly resulted in the location and establishment of an Experimental Station on organic soil to improve and promote the production of garden crops for the Montreal market. This was followed by detailed surveys of orchard soils designed to solve some severe problems in the orchard industry. Next, surveys of tobacco soils were undertaken to meet the needs of the expanding flue-cured tobacco industry in Quebec at that time.

As a result of these special surveys, prompted by industry problems, the value of soil surveys was firmly established in Quebec and it was decided to proceed with the general systematic surveys of the province. In 1938 the cooperative arrangement was terminated and the provincial unit moved to Sainte-Anne-de-la-Pocatière. Headed by E. Thèreault and later A. Scott, the provincial unit made a reconnaissance survey of the agricultural soils around the Gaspé Peninsula and later undertook the survey of the soils on the Montreal plain.

The federal unit remained at Macdonald College where Cann and later P. G. Lajoie undertook soil survey in the Eastern Townships of Quebec and in the vicinity of Montreal.

The mapping units were named on the series, type, and phase basis, but the concept of Ellis's soil association was adhered to, enabling the individual series to be grouped as well drained, imperfectly drained, or poorly drained members of an association or catena.

Nova Scotia

Soil surveys in Nova Scotia were started on a cooperative federal-provincial basis in 1934 by G. B. Whiteside under the guidance of L. C. Harlow, with headquarters at the Truro Agricultural College. The first survey covered the Annapolis Valley, where problems in the orchard and gardening industry required more specific soil information. The mapping units were named strictly on a series, type, and phase basis.

In the early forties, the survey was extended to the counties along the north shore of the province. It was there that the concept of Ellis's soil associations was introduced, particularly by R. E. Wicklund, who had been a student of Ellis and who took over the direction of the survey in 1943 when Whiteside left the province.

New Brunswick

The New Brunswick soil survey began in 1938 lead by P. C. Stobbe, who had previous experience in Manitoba with Ellis, as well as in Quebec and New Brunswick. He was succeeded in 1940 by H. Aalund and later by Wicklund. The surveys covered the Fredericton-Gagetown area, where most of the orchards and market gardens in the province were concentrated, and the Woodstock - Grand Falls potato-growing area, where soil erosion had become a serious problem. They were later extended to the counties along the Bay of Fundy and the north shore.

The soils were mapped mainly on the series, type, and phase basis, but the association or catena concept was kept in mind so that the series could be grouped into associations or catenas. Soil associations were mapped in the heavily wooded areas, where it was impossible to separate the individual series.

Prince Edward Island

Soil survey in Prince Edward Island was started in 1943 by G. B. Whiteside who, after being transferred from Nova Scotia, established headquarters at the Experimental Farm at Charlottetown. In cooperation with the provincial Department of Agriculture a reconnaissance survey of the Island was begun and a report covering the entire Island was published in 1950.

Northwest Territories and Yukon

A. Leahey carried out the first soil survey work in the Yukon in 1943 and in the river valleys of the Northwest Territories in 1944. One of the motivating forces behind these surveys was interest in potential land for agriculture in the north.

Need for interprovincial correlation

By 1944 the soil survey program in Canada was well in hand and a total of approximately 50 million ha (*125 million ac*) had been mapped by various types of surveys. The work in each province was carried on independently with only very limited personal contact in the field between the workers in adjacent provinces, particularly during the earlier years of this period. The leaders in each province were responsible for the correlation within their own province. In most provinces soil survey committees were established with representatives from federal and provincial institutions and the universities. These committees reviewed progress and suggested areas to be surveyed and problems to be investigated. Many research programs carried on by the universities and by the experimental stations, although not directly part of the soil survey program, led to a better understanding of the characteristics and genesis of soil types developed in different environments and provided information on the management and productivity of soils that had been mapped.

The initial step toward federal coordination of soil survey came in the late thirties when, for the first time, pedologists were hired as permanent staff of the federal Department of Agriculture. A. Leahey joined the Department in 1936 after surveying in Alberta and completing graduate studies in Wisconsin. Stobbe joined Leahey in 1939. These two men began the task of correlating soil survey in Canada by visiting the provincial soil survey groups, in order to study and discuss methods of soil survey and classification.

It soon became evident that the soil surveys had produced valuable information for use locally in the provinces but that it was difficult to present a national picture of the soil resources in this country.

Some of the problems were:

1. Soil names. Sometimes the same name was used for different soils. In other cases two names were used for the same soil that occurred in two provinces.
2. Nomenclature of mapping units. Some mapping units were named in terms of series but they were in reality associations. In some of the more detailed surveys, series were rather narrowly defined. Consequently the range of properties permitted in series depended on the scale of mapping.
3. Concepts of genetic soil types. The acceptance of the range of properties of Podzolic, Solonetzic, and other soils varied widely.
4. Analytical procedures. Laboratory characterization of samples of soils was done by different procedures in various provinces.

A National Soil Survey Committee was

established in 1940 with representatives from the various participating agencies in each province, to assist in improving and bringing about a greater uniformity in the soil survey program in Canada. Leahey and Stobbe began a long and distinguished period of service as chairman and secretary, respectively, of the Committee. Unfortunately, wartime restrictions prevented the committee from meeting formally until 1945. In the meantime valuable spade work was done by a number of subcommittees that were appointed to deal with the various aspects related to the soil survey program in this country.

National developments in the coordination of soil survey in Canada can be traced from the proceedings of meetings of the National Soil Survey Committee (NSSC) during 1945-60. Actual direction of survey operations, however, remained centered in the provinces. In this section, national developments are considered first, followed by brief summaries of the progress of soil survey in each province.

The first NSSC meeting

Immediately after the Second World War, the National Soil Survey Committee (NSSC) met for the first time in Ottawa (Fig. 12). The week of May 7-11, 1945, was a momentous one in the young history of pedology in Canada as leaders from all provinces assembled to begin discharging the duties of the Committee, namely:

1. To provide greater efficiency in soil survey work by:
   (a) bringing about a greater measure of uniformity between provinces in all phases of soil survey work;
   (b) utilizing the joint experience and efforts of the soil surveyors toward the solution of common problems affecting their field of work;
   (c) providing a clearing house whereby any new developments or improvements in technique in any one province can be made available to all others in this field in Canada.
2. To recommend the location of areas where soil survey work should be done in relation to land settlement or for other purposes.
3. To act as an advisory body on soil survey matters to the parent committee (Canadian Agricultural Services Coordinating Committee).

This was the tangible beginning of a continuing effort to coordinate soil survey work throughout Canada and to develop uniform national systems of soil classification and mapping. Before 1945, soil surveyors of the Prairie Provinces had met periodically to discuss problems of soil classification and mapping, and the soils group of the Canadian Society of Technical Agriculture had provided since 1931 a unifying organization for soil scientists in Canada. However, this was the first time that soil surveyors from British Columbia to Prince Edward Island had met to discuss their work.

Although it is impossible to deduce from the proceedings of the 1945 meeting the personal feelings of the participants, some strong provincial biases must have been evident. After all, soil survey had been under way as a provincial undertaking in some provinces for 25 years. Concepts of soil and methods of soil classification and mapping were far from uniform among the participants. Most of the committee members had wrestled almost individually with the problem of conveying effectively, by means of maps and reports, the complexities, differences, and similarities of the soils in the areas they mapped. In retrospect it seems remarkable that a large measure of agreement was reached on many complicated matters and that a tone of frankness, respect for widely divergent opinions of others, and goodwill was established that has become the tradition of NSSC meetings through the years. Much of the credit for this atmosphere and for the achievements of the Committee through many years is due to chairman Leahey and secretary Stobbe.

The main reports presented and discussed during the 1945 NSSC meeting were:

I Ways and means of utilizing soil survey information—G. N. Ruhnke. The report is still pertinent today because it shows the great potential applicability of soil survey information and the problems of communicating the information effectively.

II Soil classification—P. C. Stobbe. This report is essential reading for anyone interested in the evolution of soil classification in Canada. It points out a fundamental dilemma in soil classification. An ideal classification system must be based on a thorough knowledge of the properties of the whole population of soils to be classified. Yet, as the characterization and mapping of the soils of a nation is begun, the soils must be classified to permit organization and communication of the information obtained. Therefore it follows that a soil classification system must be modified periodically as knowledge of soils expands and as concepts develop. The report suggested a tentative system of field classification of Canadian soils for trial until more information was available. The system had seven categories as follows:

(1) Soil Region—tundra, woodland, or grassland.
(2) Soil Zone—the main subdivision of the Soil Region; the broad belt in which the dominant "normal" soils belong to a great group (zonal great soil group). The Soil Zone was a mapping unit and the zonal great soil group, a taxonomic unit.
(3) Soil Subzone—a subdivision of the Soil Zone based on differences in soils reflecting climatic, vegetative, or parent material differences; for example, Black and Degraded-black.
(4) Association or Catena—the group of soils that are associated together on the same parent material to form a land pattern.
(5) Soil Series, Member, or Associate—the individual soils that make up the association.
(6) Soil Class or Type—a subdivision of Soil Series based on texture.
(7) Soil Phase—a subdivision of mapping units based on external soil characteristics, such as stoniness or topography.

The classes in all categories from soil region to soil phase were real bodies of soil or segments of the landscape that included all of the soil variability within the area designated. The system was not intended to be a scientific or taxonomic one in which the classes were conceptual ones having a defined range of properties. The discussion after the presentation of the report revealed some confusion about taxonomic units as distinguished from soil mapping units, a confusion that still persists to a degree. Another point of contention, mentioned by Kellogg and Stobbe, was the difference in the definition of the soil association in the United States and the Canadian association or catena. It was agreed at the meeting that the term "catena" would be used in Canada for category 4 defined above, except for a transition period; and that the word "association" would be used in the future to designate geographically associated but not necessarily related soils. However, confusion about the use of catena and association persists to the present time and is shown in reports in which the word association is used in the catena sense.

III Land Settlement—F. A. Wyatt. The report covered the applications of soil survey to land settlement and included an estimate of 12.5-16.2 million ha (*31-40 million ac*) of virgin land suitable for settlement.

IV Landscape Terminology—H. Moss. The report summarized methods used by the various provincial soil survey units for indicating physical factors other than soils in the course of soil surveys.

Fig. 11 Correlation tour near the Alberta- Saskatchewan boundary. From left: Leahey, Clayton, Bowser, Moss, Doughty.

Development of consistent standards was urged for the classification of topography, drainage features, erosion, stoniness, and vegetation in soil surveys. Moss pointed out the need for a permanent staff of highly trained pedologists to achieve uniformity of soil survey methods. Kellogg outlined the thinking of the U.S. Soil Survey during the discussion.

V Chemical and Physical Analysis—J. H. Ellis, L. E. Wright, and W. A. DeLong. The report gave a point of view on the purposes of soil analysis. It presented a model of the soil system and its components that might be analyzed and made recommendations on the analyses that should be done in soil survey laboratories. The need was recognized for standardized procedures of sample preparation and analysis.

VI Soil Ratings for Land Classification—L. J. Chapman (for chairman J. Mitchell). The report summarized existing methods of rating soils for agricultural purposes, and considered ways of making climatic and soil survey information more useful in aiding farmers to manage their soils more effectively. E. S. Hopkins presented a follow-up report on "Agronomic Experiments to Determine Crop Adaptation and Fertility Requirements of Soil Types."

VII Maps and Reports—F. F. Morwick. The report dealt with soils, related information, and the potential users of the information. Ways were discussed of presenting the information in maps and reports.

After the meeting field trips in Quebec and Ontario provided an opportunity for pedologists from the west to see some of the soils of Eastern Canada (Fig. 11). No doubt the great tradition among pedologists for heated debate on the genesis and classification of the soil exposed in the pit was maintained and enriched during these tours. Probably some of the western pedologists saw for the first time that their notion of soil zone did not apply as well in Eastern Canada as on the plains. In some of the major agricultural areas of the east, differences in soil properties and development reflected differences in parent material and other physiographic factors more than changes in climatic factors.

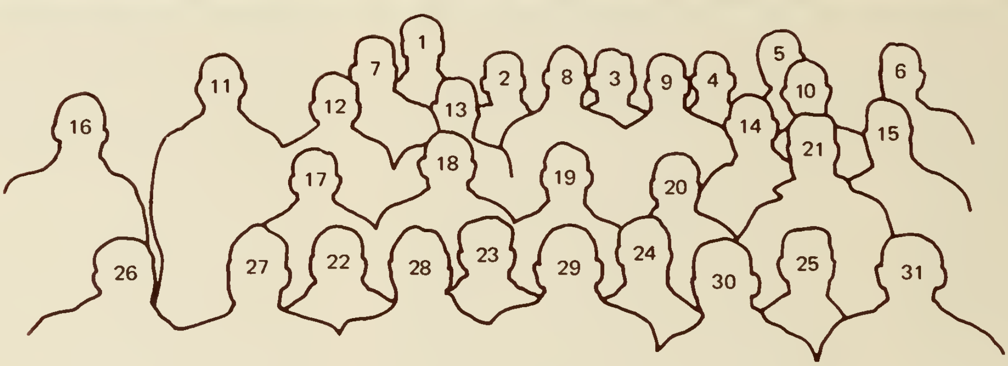
Committee work prior to the 1945 NSSC meeting, the meeting itself, and subsequent visits of Leahey and Stobbe with the survey units throughout the country brought about an increased degree of uniformity of concepts, terminology, and practices in soil survey. Correlation was furthered by joint field and laboratory studies of soils between personnel of adjacent provinces as well as by headquarters staff (Fig. 12). Familiarity with developing ideas and procedures in the United States was maintained through participation of headquarters staff from the U.S. Soil Survey and Canadian pedologists at joint meetings and field correlation studies in Canada and the United States. Laboratory studies on soil characterization and genesis were stimulated by the focus on obtaining a national inventory of soils. In succeeding years it became increasingly possible to develop an overview of the nature of the soil resources of Canada.

Use of the system of field classification outlined in 1945 did not involve major changes in soil survey in many provinces because it was based on Ellis's system that was being used, perhaps with some modifications, in Saskatchewan, Manitoba, Quebec, and the Maritime Provinces. Change was involved, however, in Alberta where a numbering system had been used, in Ontario, and in British Columbia. The soil survey groups in these provinces moved toward using the recommended national system. After 1950, mapping units in reconnaissance soil surveys were generally named in terms of dominant soil series or of two or three series. In Saskatchewan and Manitoba, however, associations were mapped but the component series were not named although they were recognized as associates or kinds of profiles within associations.

Subcommittees of the NSSC on Drainage Terminology and on Landscape Features presented reports at Guelph in 1948. Soil drainage classes were defined by N. R. Richards and his subcommittee in much the same way as they are defined now. The Subcommittee on Landscape Features under Moss stressed the importance of including landform in soil mapping. This subcommittee suggested definitions of major landforms and outlined systems of classifying topography, erosion, stoniness, land use, and vegetation.

The first Canadian taxonomic system

The first Canadian taxonomic system of soil classification was outlined at the third meeting of NSSC held at Saskatoon in 1955. The Subcommittee on Classification headed by Stobbe probably was motivated to proceed with the development of a taxonomic system, rather than continue with the system of field classification presented in 1945, by several factors: (a) knowledge of the soils of Canada had been extended significantly between 1945 and 1955; (b) a taxonomic system probably seemed necessary to order the information on the kinds of profiles known to occur; (c) the United States taxonomic system at that time was not satisfactory and indeed the Soil Conservation Service had begun the development of a new system in 1951. The fourth approximation of the United States system was studied by the subcommittee and considered to be too complicated and too tentative for Canadian needs. It was thought also that it had taken a long time for the users of soil information to



1st NSSC Meeting

1. W.A. Ehrlich
2. P.G. Lajoie
3. L.E. Wright
4. W.A. DeLong
5. H. Aalund
6. R.E. Wicklund
7. A. Scott
8. W. Shaefer
9. W.E. Bowser
10. P.O. Ripley
11. D.G. Laird
12. G.R. Smith
13. H.C. Moss
14. H.J. Atkinson
15. A.L. Willis
16. N.R. Richards
17. G.B. Whiteside
18. F.F. Morwick
19. L.J. Chapman
20. D.B. Cann
21. L.R. Webber
22. J.H. Ellis
23. L. Farstad
24. R. Baril
25. A. Mailloux
26. F.A. Wyatt
27. E.S. Archibald
28. C.E. Kellogg
29. A. Leahey
30. P.C. Stobbe
31. G.N. Ruhnke

Fig. 12 National Soil Survey Committee, 1945.

Fig. 13 Soil survey camp, Peace River area.

understand the terminology of pedology. A shift to the proposed American terminology might have made it difficult to communicate with the users of soil information and therefore their confidence could be lost.

The taxonomic system outlined in 1955, which is the basis of the system used today, had six categoric levels corresponding to order, great group, subgroup, family, series, and type. The orders were named Chernozemic, Halomorphic, Podzolic, Forested Brown, Regosolic, Gleisolic, and Organic. Classes were named and defined in general terms down to the subgroup level.

At the 1955 meeting, reports were presented and discussed on chemical and physical analysis of soils, landscape features, soil drainage terminology, soil ratings, soil structure and consistence, soil horizons, and publications. Through these reports and discussions, the methods and terminology involved in the characterization and mapping of soils became increasingly standardized.

Other NSSC meetings

At the meeting of the Western Section of the NSSC held in Vancouver in 1957, the major topic was classification, with consideration of Solonetzic, Chernozemic, Podzol - Gray Wooded intergrades, and Brown Wooded soils. Some of the diagnostic horizons defined by the U.S. Soil Survey were considered for use in Canada. Other reports dealt with soil analysis.

The Eastern Section of the NSSC met in Ottawa in 1958 and again the major topic was soil classification. In addition to proposals for changes in definition of classes in the upper three categories, there was discussion of the basis of classes at the family level. In hindsight, it appears that the most urgent topic was covered on the last three pages of the proceedings, in which Leahey urged better ways of designating and describing mapping units to convey in a factual and meaningful way the distribution of kinds of soils in the areas of the landscape delineated on soil maps.

The NSSC chairman, Leahey, observed at the meeting of the Western Section of NSSC held in Edmonton in 1958 that most of the committee's efforts since 1955 had been devoted to the development of soil taxonomy. Little progress had been made in a second major objective of integrating soil survey with research in soil fertility and soil management. The meeting considered proposals for improvements in the soil classification system and reports on soil analysis.

The fourth national meeting of the NSSC was held at Guelph in 1960. Revisions were made in the classification system for mineral soil and in horizon designations, and the classification system outlined was accepted for use in Canada. Plans were made for publication of the Canadian system.

Progress of soil survey in the provinces

British Columbia

Until 1949 Kelley worked alone from Kelowna doing detailed soil surveys of small irrigation projects associated with the Veterans' Land Act and starting a reconnaissance survey of the upper Kootenay River valley to estimate the area of potential irrigable land and the water requirement of the soils prior to the construction of the Libby Dam. The province hired additional soil surveyors in 1950 and the increase continued intermittently until 1975. Also, the provincial group provided an extension service to advise farmers on irrigation, drainage, and other soil-related problems. Surveys progressed in the Kettle and Columbia valleys.

The federal group, working from headquarters in Vancouver under L. Farstad, continued surveys in the Peace River area and in central British Columbia at a scale of 1:126 700, and completed the survey of Vancouver Island. During this period, the federal staff grew to four soil surveyors. C. A. Rowles, who had experience in Saskatchewan and Minnesota, contributed to the soil survey program as a member of the Department of Agronomy, University of British Columbia.

Alberta

The Research Council of Alberta recommenced soil survey in 1945 after a lapse of 14 years. In 1948 W. Odynsky, who had worked with the federal group, became head of the Research Council survey group. Odynsky's team surveyed mainly in the Peace River area, working from trailers and using jeeps (Fig. 13). The maps and reports were used by the provincial government as a basis for allocating homestead land. They also gave areal location to the agronomic data being assembled by the agricultural research stations in the area. In 1955, helicopters were used for the first time in Canada for exploratory surveys by the Research Council in northern Alberta. Most of the mapping was done by airphoto interpretation before the fieldwork was started. Landings were made at 8-24 km (*5-15 mile*) intervals to examine the soil and to check the accuracy of airphoto interpretation (Fig. 14). About 4 million ha (*10 million ac*) a year were covered at a scale of 1:760 320.

The federal unit directed by W. E. Bowser continued reconnaissance surveys in southern and central Alberta and detailed surveys of irrigation districts, in particular the St. Mary River development scheme involving 0.2 million ha (*1/2 million ac*). A total of 0.8 million ha (*2 million ac*) were mapped, classified, and rated from poor to excellent for irrigation. This information was used to delineate the areas that could be developed for irrigation and for the planning of distribution structures. From about 1950, series or combinations of series were used as mapping units in reconnaissance soil surveys by provincial and federal groups.

Fig. 14 Soil survey by helicopter, northern Alberta.

Saskatchewan

The broad reconnaissance soil survey of the province continued north of Township 48 and coverage of all the agricultural region was completed in Report No. 13, published in 1950. Mapping of northern Saskatchewan at a scale of 1:760 320 proceeded in the fifties. The mapping units were associations and complexes of great groups and orders. A series of interim reports was made available, but no overall report of the northern surveys has been published. Thus, before 1960 Saskatchewan had essentially completed either broad reconnaissance or exploratory soil surveys of the province. More detailed mapping of the soils of some areas of southern Saskatchewan was in progress. After the death of J. Mitchell in 1955, W. L. Hutcheon became director of the Saskatchewan Soil Survey in 1956.

Manitoba

Mapping of soils of north-central Manitoba at a scale of 1:126 720 proceeded in the 1945-60 period. Exploratory surveys were undertaken in northern and eastern Manitoba. Soil associations as defined by Ellis were the major kind of mapping units until the late fifties, when mapping units in the upper Nelson River area were named in terms of series.

Ontario

Soil surveys of many counties in southern Ontario were completed in the 1945-60 period under the leadership of N. R. Richards and later R. E. Wicklund. Mapping was at a scale of 1:63 360, and series were indicated as the mapping units. Part of the Timiskaming district in northern Ontario was surveyed also.

Quebec

Lajoie, working from headquarters at Macdonald College, completed surveys of many of the counties north of the Ottawa River between Montreal and Ottawa during this period. The counties in the lower St. Lawrence River area and along the north shore of the river between Montreal and Quebec City were mapped by the combined efforts of R. Baril, the federal representative, and the provincial group based at Sainte-Anne-de-la-Pocatière.

The Maritime Provinces

Soil mapping at a scale of 1:126 720 proceeded in New Brunswick supervised by Wicklund, G. J. Millette, and later K. K. Langmaid; in Nova Scotia by Cann, who had worked with Stobbe on the initial soil surveys in Quebec; and in Prince Edward Island by Whiteside. Incidentally, Cann was the only Canadian who had a direct input into the naming of the colors of the Munsell color chart. He visited Washington in 1938 when Kellogg, Thorpe, Nikiforoff, and others were working on an objective system of designating soil colors.

Newfoundland

Soil survey started in Newfoundland in 1944, before it became a province of Canada. The early surveys were done by the Agricultural Division of the Department of Natural Resources. P. E. Murray carried out the first soil survey work initially under the guidance of P. E. Wolfe of Princeton University. The mapping was general in nature and the geological influence was strong. Soil zones and textural classes were indicated. Small areas, of the order of 130 km^2 (*50 sq miles*), with some agricultural potential, were mapped at a scale of about 1:30 000.

Federal soil surveyors began work in Newfoundland in 1950, just a year after the territory became a province. Millette and H. W. R. Chancey did broad reconnaissance surveys and mapped soil zones, series, and types in the early fifties. From 1950 to 1952, Chancey participated in the Newfoundland Fisheries Surveys for the Department of Agriculture. These surveys were designed to obtain information on the potential for agriculture of the land around outlying fishing villages. The soils information reported is general in nature, but the surveys gave Chancey a broad knowledge of the soils of Newfoundland. Reconnaissance surveys were conducted on the Avalon Peninsula.

North of 60° N

Soil investigations begun in the Yukon and Northwest Territories in 1943 by Leahey were continued by Leahey and J. H. Day. Soils along the Hay River and the Mackenzie highway were studied and a mimeographed report of the survey was issued in 1953. Day, working out of headquarters in Ottawa, carried out broad reconnaissance soil surveys of more than 0.8 million ha (*2 million ac*) in the Slave River Lowlands of the Northwest Territories and more than 0.2 million ha (*1/2 million ac*) in the Takhini and Dezadeash river valleys and Whitehorse area of the Yukon. The survey of the northern part of the Slave River Lowlands involved the first systematic mapping in Canada of soils with permafrost.

Area covered by soil surveys

By 1953, the total area covered by systematic reconnaissance soil surveys in Canada was reported by the Field Husbandry, Soils and Agricultural Engineering Division of the Department of Agriculture as follows: thousands of hectares (*acres*):

Newfoundland	190 (*470*)
P.E.I.	566 (*1398*)
N.S.	2962 (*7313*)
N.B.	2929 (*7232*)
Quebec	4647 (*11 483*)
Ontario	7489 (*18 505*)
Manitoba	7211 (*17 819*)
Saskatchewan	27 490 (*67 928*)
Alberta	18 843 (*46 561*)
B.C.	3859 (*9537*)
Total	76 186 (*188 246*)

These values did not include areas covered in some of the early surveys in which only soil texture was mapped. Coverage was greatest in Saskatchewan and Alberta, probably as a result of several factors: the small scale of surveys in much of the area (1:380 000 or 1:190 000), the interest in soil survey due to wind erosion problems and the search for new land, and the relative ease of access on the prairies compared with forested areas. The area covered at that time is impressive; it includes most of the arable land but less than one-tenth of the land area of Canada.

Land use concerns and soil survey (1960-75)

Some of the main events related to soil survey during this period were: participation in the Canada Land Inventory program; the formation of a Soil Resource Inventory Section at the Soil Research Institute, Ottawa, to aid in correlating and otherwise supporting the national soil survey program including the inventory and interpretation aspects; increased public awareness during the latter part of the period of the limited area of prime agricultural land in Canada and of the irreversible utilization of this land for other purposes; vastly increased support for soil and land inventories in some of the provinces; and participation by soil survey personnel in multidisciplinary surveys such as possible pipeline corridors in the Arctic, urban fringe areas, and parks.

In the late fifties and early sixties, soil survey was a program of rather low priority in many supporting departments, but by the mid seventies it was in great demand and support was substantial in spite of austerity. The doubts about soil survey at the beginning of the period were due to several factors. There was surplus production of agricultural products in Canada and farmland was still being abandoned, particularly in Eastern Canada. Although specialists had known otherwise since the thirties, it was generally accepted that good land was abundant in Canada and that production of a crop could be shifted from a recently urbanized area to the hinterland without problems. The apparent preoccupation of the National Soil Survey Committee with taxonomy was a source of concern to potential users of soil survey information, who felt that soil survey had become an end in itself rather than a means to the end of better planning in the use of land. This criticism was not really justified because leaders of soil survey in Canada had been acutely aware of the importance of this from the outset. In fact Leahey, Stobbe, and others could mentally transform a soil map into a series of interpretive maps for purposes such as production of cereals, production of specialty crops, productivity under forest, and suitability for suburban development, and they frequently made these interpretations. However, the practical applications were perhaps taken too much for granted and not adequately publicized.

The change in recognition of soil survey came about as a result of the public awakening to the problems of pollution and the wonders of the natural environment. Faith in the land and the renewing forces of nature began to replace the blind faith in technology, gadgetry, and the magic of the metropolis that had captivated so many Canadians who had emerged from a rural environment to become button-pushing urban dwellers in one generation. The Canada Land Inventory with its focus on the capability of the land for various potential uses contributed to the change.

Soil Survey Committee activities

Meetings of the National Soil Survey Committee were held in 1963, 1965, 1968, 1970, 1973, and 1974. The main event of the 1963 meeting in Winnipeg was the passing of the following resolution: "That the National Soil Survey Committee, through its membership in each province and with the cooperation of the federal ARDA administration in each province, develop an agricultural soil capability classification for Canadian soils and establish an inventory of agricultural soil capability for the settled areas of Canada in which soil surveys have been completed, with as much precision as possible within the next two years." In this way the soil survey made a basic commitment to the Canada Land Inventory program. In addition, refinements were made in the classification system and reports were presented on other topics pertinent to soil characterization and mapping.

The 1965 NSSC meeting in Quebec City brought about further refinements in the Canadian system of soil taxonomy and considered a report by R. Baril on the soil family category. W. A. Ehrlich presented for the first time a taxonomic system for organic soils. The system had been developed in close cooperation with personnel of the Soil Conservation Service of the United States. Reports were presented on soil survey reports and maps, on soil analysis, and on the Canada Land Inventory program. This was the last meeting of NSSC at which Leahey, chairman since 1940, presided.

The major topic of the 1968 NSSC meeting in Edmonton, under the chairmanship of Ehrlich, was soil taxonomy. All categories from order to type were covered and criteria for soil phases were outlined. After many years of discussion, the former Podzolic order was subdivided into Luvisolic (clay movement) and Podzolic (organic - Al, Fe accumulation) orders. Several new topics were considered: international soil correlation—J. S. Clayton tabulated approximate equivalents in the Canadian and United States systems and in the Food and Agriculture Organization of the United Nations (FAO) world soil map legend; B. Bernier defined and classified forest humus forms; A. O. Ridley reported on crop yield assessments; S. Pawluk on engineering interpretations of soil survey, and M. Jurdant on biophysical land classification. In an appendix to the proceedings of the meeting, Day summarized the terminology used in describing soils. This terminology and the revised taxonomic system were the basis of the first published version in 1970 of *The System of Soil Classification for Canada*. Publication of the Canadian system of soil taxonomy was the culmination of 30 years of work toward that end, led by P. C. Stobbe, who retired in 1969.

Under the chairmanship of Ehrlich, the 1970 meeting of the Canada (formerly National) Soil Survey Committee (CSSC) in Ottawa dealt primarily with matters other than soil taxonomy. Reports were presented on many subjects pertinent to soil survey: correlation, engineering interpretations, crop yield assessments, biophysical land classification, remote sensing, and other topics. A special session with discussion leaders from several agencies concerned with soil and land was held to discuss the organization and objectives of soil survey in Canada. Members of CSSC and some foresters in attendance thought that a central agency responsible for all soil survey in Canada was required to avoid the proliferation of uncoordinated soil survey groups in several agencies. The need was indicated for improved correlation and interpretation of soil survey.

The 1973 CSSC meeting, with J. S. Clark as chairman, was held in Saskatoon. Again the focus was on matters other than soil taxonomy, although reports were presented on most of the soil orders and some changes were made. Interpretations of soil survey information was a major topic with reports on provincial soil and interpretation maps, soil degradation, and soil interpretations. A report was presented on the computerized soil information system, CanSIS, under development. Progress was made on the development of a system of landform classification, a topic that had been considered at nearly all meetings since 1945. Pedologists with experience in northern surveys reported on a proposed new order, the Cryosolic order, for soils having permafrost within l m of the surface. The proposal was accepted for trial.

The 1974 CSSC meeting in Ottawa focused on the development of goals for the soil survey program in the light of growing awareness of limited productive land resources in Canada, and the fact that the Canada Land Inventory program was nearing completion. Talks were presented by officials of the agencies involved on relationships of soil survey to land planning, agriculture, urban planning, environmental impact, recreation planning, and interagency inventories. Regional soil survey programs were discussed and priorities were established. A report on soil correlation was presented and discussed. Subcommittees of CSSC were revised and new ones were established with the emphasis on interpretations of soil survey.

The Canada Land Inventory

The Canada Land Inventory (CLI) program began in 1963 under the terms of the Agricultural Development and Rehabilitation Act (ARDA). The program involved an interpretive classification of the occupied area, about 20% of Canada. Capability of the land for agriculture, forestry, recreation, and wildlife was evaluated and capability maps at a scale of 1:250 000 were prepared. The CSSC had a major input into the development of the capability classification for agriculture. Both provincially and federally employed soil surveyors had major roles in training and supervising new staff employed by CLI to do the capability mapping and in participating in the mapping themselves. Many areas for which recent soil survey information was available did not require further fieldwork. Capability ratings could be made from the existing information.

The CLI program detracted from the systematic soil survey but it did focus attention on the limited areas of land in Canada with a high capability for the production of field crops, and on land as a valuable natural resource. The program was almost completed by 1975. During its course it had been under three departments: Agriculture, Regional Economic Expansion, and finally Environment.

National correlation and coordination of soil survey

Correlation of soil survey on a national basis began in the late thirties, when Leahey and Stobbe were in Ottawa with the Department of Agriculture. However, correlation was only one of their many functions, and as the field of soil survey expanded after the war, it became impossible for one or the other of them even to visit each survey unit every year. The need for improved correlation and coordination of soil survey was pointed out at several NSSC meetings and in 1964 Ehrlich and Cann were appointed as western and eastern correlators respectively, working from Ottawa. This was the first time that there had been pedologists whose primary function was soil correlation. After Leahey's retirement in 1966, Ehrlich became coordinator of pedology on the Research Branch executive and Day replaced Ehrlich as western correlator. In 1967 J. S. Clayton, who had long experience in soil survey in Saskatchewan, moved to Ottawa and soon became immersed in the compilation of a comprehensive publication on the soils of Canada, the compilation and presentation of soil climatic data, and other synthesizing tasks. Among them was major participation in the compilation of the Canadian section of the FAO world soil map and report, a project supported by Leahey, as chairman of CSSC, in 1964. This involved extensive correlation studies with representative pedologists from the USA, Mexico, Argentina, FAO in Rome, and senior pedologists in Canada.

When Clayton arrived in 1967, a Soil Resource Inventory Section was started in the Soil Research Institute (SRI) at Ottawa to aid in coordinating and supporting soil survey on a national basis. The Section was developed by J. S. Clark, director of the SRI since 1969, and chairman of CSSC since 1971. In 1975 it involved three correlators, who were frequently diverted to tasks other than correlation, two pedologists involved in the development of a computerized soil data bank, and four others whose primary roles were agronomic and engineering interpretations of soil survey information, application of remote sensing to land use evaluation, and soil classification and genesis. Land evaluation for agriculture, a concept involving the synthesis of pedological, landform, climatic, agronomic, and economic data with a view to predicting yields of various crops under given management of specific tracts of land, was a new program of high priority in the Resource Inventory Section in 1975.

Associated with the development of the Soil Resource Inventory Section was a change in the administration of federal soil survey units in the provinces. For many years, most of the units were administered through the local research stations of the Department. In 1974, however, these units joined those at Edmonton, Guelph, and Truro in being administered by the SRI, Ottawa, whose director became the chairman of CSSC at the suggestion of Ehrlich.

Centralization of the administration of soil survey and the development of a supporting coordination and research staff at the SRI, Ottawa, did not detract from the strong provincial flavor of soil survey. The essential close cooperation among federal, provincial, and university personnel concerned with soil survey remains. Developments in the provinces and northern territories in the 1960-75 period are summarized.

British Columbia

Apart from the CLI program, which involved most of the soil surveyors in British Columbia as well as in the other provinces, the major event of significance to soil survey was the passing of Bill 42 in 1973. This legislation was designed to prevent the use of good farmland for other purposes in the lower mainland and Vancouver Island. The CLI agricultural capability maps at a scale of 1:250 000 were not adequate to assess the suitability for agriculture of small tracts of land. Thus, soil surveyors and others were required to evaluate specific sites. The focus on land brought about the establishment of an Environmental Land Use Committee (ELUC), and the hiring of many pedologists and ecologists by the province. In 1975, about 20 provincial pedologists and foresters were mapping soils and terrain in British Columbia. The role of the federal staff changed from that of carrying out the basic soil inventory work to correlation and supporting research.

During the 1960-75 period two of the pioneer soil surveyors retired, C. C. Kelley in 1966 and L. Farstad in 1975. They were replaced by P. N. Sprout and T. M. Lord as heads of the provincial and federal soil survey units respectively. A. Schori became head of the provincial unit in 1974 when Sprout moved to Victoria with the ELUC Secretariat.

Alberta

The Alberta Research soil survey group expanded markedly in the latter part of the 1960-75 period and undertook a number of projects in addition to aiding in the completion of the CLI mapping. The formation of an Alberta Institute of Pedology patterned after the Saskatchewan Institute formed previously was an important event in 1969. The Institute gave formal recognition of the cooperative arrangements that had existed for years among federal, provincial, and university pedologists. It also provided an agency that could accept contracts to carry out soil surveys. Notable examples of such contracts were those from the Parks Branch of Indian and Northern Affairs to provide the soils input to a survey of National Parks in the mountains.

As in British Columbia, this period saw the retirement of soil survey leaders, W. E. Bowser in 1968 and W. Odynsky in 1969. They were replaced as federal and provincial unit heads by T. W. Peters and J. D. Lindsay respectively. In 1974, W. W. Pettapiece became federal unit head when Peters decided to devote full time to the compilation of crop yield data in relation to soils.

Saskatchewan

Completion of the CLI mapping and standard soil surveys of areas of southern Saskatchewan at a scale of 1:126 700 were the major activities during this period. The establishment of the Saskatchewan Institute of Pedology, the first of its kind in Canada, was a notable event in 1965. The Institute established formal links among the federal, provincial, and university pedologists in the province. The Institute undertook surveys of Prince Albert Park and the Liard River valley, N.W.T., during the latter part of the period.

Senior soil surveyors H. C. Moss and J. S. Clayton retired during the 1960-75 period. Moss, who led the Saskatchewan soil survey for many years, retired from the federal unit in 1959 but continued at the University until 1969. He was succeeded as federal unit head by J. S. Clayton, who transferred to the Soil Research Institute, Ottawa, in 1967 and retired in 1972. D. F. Acton became the new unit head. D. A. Rennie became Director of the Saskatchewan Institute of Pedology in 1965 after the death of W. L. Hutcheon. J. G. Ellis was named as provincial correlator.

Manitoba

In Manitoba, CLI mapping and the systematic soil survey of the southern part of the province were the major activities. The Manitoba soil survey participated in a major program of carrying out a small-scale inventory of northern Manitoba beginning in 1974.

When Ehrlich transferred to Ottawa in 1963, H. Hortie became soil survey head for a few years. Hortie was succeeded by R. E. Smith when he accepted a position with ARDA.

Ontario

Soil survey activities included completion of the CLI mapping, mapping of organic soils in southern Ontario, and a detailed survey of Waterloo County. The provincial soil survey staff dwindled to zero in the early seventies and was reestablished in 1974 as concern increased about depletion of the area of prime agricultural land in the province.

R. E. Wicklund retired as federal unit head in 1970 after a long career in soil survey, and he was succeeded by C. J. Acton.

Quebec

In Quebec, the provincial unit under A. Mailloux moved headquarters from Sainte-Anne-de-la-Pocatière to Quebec City. CLI mapping was the major activity throughout most of the 1960-75 period. The federal soil survey unit ceased to exist when P. G. Lajoie moved to Ottawa in 1963 to work on the CLI program under ARDA and R. Baril moved to Laval University in 1962. A federal soil survey group was reestablished in 1975 with headquarters at Laval University. The unit was a part of the Quebec Institute of Pedology established in 1974 under G. A. Bourbeau. Like Saskatchewan and Alberta, the Institute formally united provincial, university, and federal pedologists as a team with M. Tabi and R. Marcoux as provincial and federal leaders respectively.

The Maritime Provinces

CLI mapping was also a major activity during the period in New Brunswick and Nova Scotia. In addition, resurveys were done at a scale of 1:63 360 of some counties in Nova Scotia, and the systematic soil survey of New Brunswick continued. In 1970 a soil survey of Prince Edward Island at a scale of 1:20 000 was started as a part of the Regional Economic Expansion supported Development Plan for the Island. J. I. MacDougall was head of that survey, which was almost completed in 1975. He was replaced as Nova Scotia head by J. L. Nowland until Nowland moved to Ottawa as correlator in 1972. In 1975 the soil surveys of the Maritime Provinces and Newfoundland were united under a unit head based at the newly established Atlantic Provinces Soils Institute in Truro. G. J. Beke was named the first head of that unit.

After the retirement in 1975 of K. K. Langmaid, longtime soil survey head and conservationist in New Brunswick, C. Wang became the federal soil survey leader.

Newfoundland

The first modern soil survey report of an area in Newfoundland was published in 1970. CLI mapping and the systematic basic soil survey proceeded during the period. The province committed additional staff and funds to soil survey in 1972 and a broad coverage of the province was undertaken in 1975. P. K. Heringa, who moved to Newfoundland from the Alberta Soil Survey in 1963, was the soil survey head.

Northwest Territories and Yukon

During the early years of the period, J. H. Day did reconnaissance soil surveys of the Slave River Delta, Liard River valley, and the upper Mackenzie River area. For a few years following this work, soil survey activities in the north were terminated. However, by 1968, interest in the ranching possibilities of the Slave River Lowland prompted a more detailed resurvey of the area.

By 1970, planning for a possible natural gas pipeline down the Mackenzie Valley lead to an interdisciplinary terrain survey of the Valley. Soil surveyors cooperated with geologists and ecologists in carrying out the survey over a 3-year period. Following this, C. Tarnocai of the Manitoba Soil Survey continued to work on similar interdisciplinary surveys of arctic islands along a potential pipeline route. Thus during this period, information on soils of the Canadian north increased greatly.

Area covered by soil surveys to 1975

Survey type[1]	B.C.	Alta.	Sask.	Man.	Ont.	Que.	N.B.	N.S.	P.E.I.	Nfld.	N.W.T. and Y.T.
					Millions of hectares (*acres*)						
Reconn.	51.80	19.42	28.32	19.02	14.97	7.28	4.86	5.26	-	1.21	3.64
	(*128*)	(*48*)	(*70*)	(*47*)	(*37*)	(*18*)	(*12*)	(*13*)	-	(*3*)	(*9*)
Detailed	0.4	0.4	0.2	0.2	0.8	-	-	-	0.61	-	-
	(*1*)	(*1*)	(*0.5*)	(*0.5*)	(*2*)	-	-	-	(*1.5*)	-	-
Exploratory	2.63	42.49	10.93	12.55	5.67	42.90	-	-	-	3.24	40
	(*6.5*)	(*105*)	(*27*)	(*31*)	(*14*)	(*106*)	-	-	-	(*8*)	(*99*)

[1] *Reconnaissance at scales of 1:50 000 to 1:200 000; detailed at scales greater than 1:50 000, and exploratory at scales less than 1:200 000*

In addition to the areas tabulated, some areas have been resurveyed and the Canada Land Inventory had covered a total of about 202 million ha (*500 million ac*). By 1975 about 35% of the land areas of Canada had been covered by soil surveys, about half of this at exploratory scales, and about 22% of the land area had been rated in the CLI system.

Other surveys related to soil survey

Many kinds of surface-of-the-earth surveys related in varying degrees to soil survey have been done during the 60-year history of soil survey in Canada. For example, surficial and bedrock geology surveys provide vital information on the nature and origin of soil parent materials. For many years, J. A. Allen, head of the Department of Geology at the University of Alberta, visited areas where soil surveys were under way and wrote a section of the report on the geology of the area. Similar cooperative arrangements were made from time to time with geologists in other provinces. Currently, the Department of Land Resource Science at the University of Guelph houses both pedologists concerned with soil survey and geologists. Close cooperation between geologists and pedologists can undoubtedly be of mutual benefit.

Similarly, examples exist of cooperation between pedologists and other specialists: botanists, ecologists, foresters, hydrologists, and engineers. These cooperative arrangements in surveys have generally proved to be broadening to the participants and to result in a better portrayal of the nature of the soil resources than could be obtained by a pedologist working in isolation.

In addition to cases of interdisciplinary inputs into regular soil surveys, there have been attempts to achieve the basic aims of soil survey by different methods. For example, G. A. Hills departed from the mapping practices used in soil survey and developed a system of classifying and mapping land based on physiography. Within the physiographic framework, particular sites were considered in terms of three potential features consisting of relief, pore distribution patterns, and potentially effective chemical elements that governed the three "available features" of ecoclimate regime, soil moisture regime, and nutrient regime. This system is the basis of forest site classification and evaluation in Ontario.

In 1967, the National Committee on Forest Land recommended the initiation of pilot projects to test a proposed reconnaissance land classification system, *The Biophysical Land Classification System*. The purpose of the system was to classify rapidly and at a small scale land areas for which very little basic information was available. The system that evolved after pilot studies in British Columbia, Manitoba, Quebec, Nova Scotia, and Newfoundland was a hierarchical one with five levels:

Land Region—based on regional vegetation and physiographic pattern
Land District—based on the pattern of geology, geomorphology, and vegetation chronosequence
Land System—based on recurring patterns of landform, soils, and vegetation
Land Type—based on fairly homogeneous combinations of soil and chronosequence of vegetation
Land Phase—based on the stage of vegetation when surveyed.

The system was used in a number of modified forms by forestry groups in several provinces. It provided a hierarchical framework for designating land mapping units at various scales.

Surveys of the Mackenzie Valley and the arctic islands carried out in the seventies for purposes of evaluating possible pipeline routes have been done by interdisciplinary teams involving geologists, ecologists, and pedologists usually led by a geologist. The mapping system indicated origin and nature of surficial material, topography, drainage, dominant soils (subgroup), and vegetation.

The increased involvement of soil surveyors in terrain surveys including several kinds of specialists has resulted in increased emphasis on attributes of land other than soils in several soil survey units. Developments to 1975 did not indicate clearly the probable lasting effect of these changes on soil survey procedures.

Soil survey as a part of soil science in Canada

From its inception, soil survey has been a major and vital force in the development of soil science in Canada. The first activity of many of the departments of soil science at universities was soil survey. Most of the heads of these departments have been either soil surveyors or pedologists with some experience in soil survey. This afforded students exposure to the teaching of professors who knew soil survey, who were fascinated by pedology as a part of natural science, and who believed in the applicability of soil survey information to problems of land use and management. Students added to their knowledge of soils by working on soil survey as a summer job thereby obtaining a firsthand experience of the complexities of soils, and the relationships between soils and the growth of agricultural and forest crops. Research projects on soil characterization and classification have served as the basis of numerous theses of graduate students in soils. The furtherance of soil survey has become linked closely with teaching and research in departments of soil science because of this association.

Nearly all the soil research in Canada is linked in some way to soil survey. An example of this is the relationship noted in Alberta between Gray Wooded soils and the response of crops to sulfur, which led to the establishment of the Breton plots by Wyatt and Newton. Research on the nature of soil acidity was prompted in part by the observation that crops grown on Concretionary Brown soils in British Columbia did not respond to liming, although the apparent degree of base saturation of the soils was low. In a broader sense, results of soil research have little relevance unless the nature of the samples and the area represented by the samples are known.

Effect of technological advances on soil survey

It is common knowledge that advances in science and developments in instrumentation and analytical techniques have expedited laboratory investigations that are essential for the characterization and classification of soils. Perhaps less commonly recognized are other technological developments that have affected the accuracy and efficiency of field and cartographic operations in soil survey. Some of these developments are discussed briefly in the following sections.

Base maps and aerial photographs

In the early years of soil survey, good base maps were not available for most of the areas to be surveyed. Usually the soil surveyors had to either prepare their own base maps or correct old and often inaccurate plans or maps. After the war in the forties, the Topographic Survey of the Department of Mines and Resources embarked on a program of aerial photo mapping of Canada. This not only provided the soil surveyors with more accurate base maps but also made available to them aerial photographs on which soil areas could be delineated more accurately than previously. In addition, soil surveyors learned the skills of photo interpretation, enabling them to improve the prediction of the kind of soil that would occur in a given position and hence to reduce the number of digs to check the nature of the soil. Photo interpretation has been particularly useful in the less accessible areas, such as mountainous, forested, and northern regions. The use of aerial photos has increased the accuracy, efficiency, and economy of soil survey operations.

More recent developments of a similar nature are the availability of color and infrared photography for some areas, and satellite imagery of the earth's surface. All of these developments proved useful in some soil survey operations and their potential has probably not yet been fully utilized.

Mode of transportation

Soil survey operations have been influenced greatly by the mode of transportation available. During the early surveys, cars and small trucks were the principal means of transportation in developed and easily accessible areas. Considerable walking was done, particularly on detailed surveys. Bicycles were sometimes used when cars were unavailable. In the more inaccessible areas of Alberta, horseback pack trains were the means of transportation in the late twenties. Boats and canoes were used extensively during exploratory surveys in the Yukon and Northwest Territories and to a lesser extent in British Columbia and New Brunswick. Handcars on railroad tracks helped operations in northern Manitoba along the Hudson Bay line. After the war, four-wheel-drive jeeps and landrovers with power winches were used extensively, particularly in rough terrain.

Helicopters were first put to great advantage in soil surveys of northern Alberta by J. D. Lindsay in 1955. The inaccessible areas of forest and muskeg were covered rapidly and effectively after preliminary photo interpretations. Helicopters have also facilitated soil survey in British Columbia, Saskatchewan, Manitoba, Newfoundland, and in the north. Fixed wing aircraft have been used in inaccessible areas to obtain a rapid appraisal of the land, to assess the need for further studies, and to transport supplies to survey camps. Modern means of transportation and aerial photography have made it possible to obtain at least a rough assessment of the land and soil resources of much of the country that would have otherwise been inaccessible.

Other advances

Other technological advances have assisted pedologists in the field. The Munsell color chart modified for use in describing soils through the U.S. Soil Survey has had a major impact on the uniformity and accuracy of recording soil color. Hand and power augers have aided soil surveyors in the essential examination of the soil profile. However, better excavation equipment remains one of the primary needs of Canadian soil surveyors, particularly in areas of stony and indurated soils. Numerous field tests such as that for the fiber content of Organic soils and the coding forms developed for soil descriptions have contributed to the uniformity of characterization of soils.

Soil cartography

This section deals primarily with soil cartography in Ottawa although soil maps are prepared also by the Alberta Research Council, the Quebec Department of Agriculture, and recently the B.C. Environmental Land Use Secretariat.

The earliest soil maps compiled by the pioneer pedologists in Canada were drafted and prepared for printing by the Department of Interior. This department was abolished in 1931 and thereafter the drafting was supervised by the Department of Mines and Technical Surveys. During the depression, there was a hiatus in soil map production until 1935 or 1936. Mr. Nixon, a draftsman employed by the Experimental Farms Service, assisted by student draftsmen, prepared soil maps under the supervision of the chief cartographer, Department of Mines and Technical Surveys, from 1936 until his death in 1944.

In 1945, Mines and Technical Surveys could no longer accommodate the Experimental Farms Service draftsmen and E. S. Archibald arranged space for them in the Agricultural Engineering Building at the Central Experimental Farm. Gus Beaudoin joined the staff in 1945 and arranged for equipping the new drafting office. Harry Nicol, formerly a draftsman with Mines and Technical Surveys, became chief cartographer at the Experimental Farm in 1946. Drafting of soil maps at the Experimental Farm began in 1946, with a staff of two. Beaudoin became chief cartographer after the death of Nicol, J. G. (Mick) Roberts was named head in 1965 after the death of Beaudoin, and J. H. Day is currently in charge of soil survey operations including cartography.

In the early fifties, the cartography staff was enlarged in response to the expanded soil survey program. By 1963, the staff totaled eight but the start of the Canada Land Inventory program that year brought about a rapid expansion in staff and map production. The concurrent expansion in staff and change to new drafting techniques and cartographic processes lent an air of excitement and involvement to the Cartography Unit. During the period 1965-74, the Unit drafted and prepared for publication soil capability sector maps as follows: 208 agriculture, 187 forestry, 197 recreation, 193 wildlife–ungulates, 182 wildlife–waterfowl. In addition, 48 provincial summary and special maps were prepared. Of the 1038 map manuscripts received, 736 have been completed and printed.

As the CLI program nears completion, the cartography staff is decreasing from a maximum of about 60. Some of the staff have been transferred from CLI to Agriculture Canada funding. The backlog of soil maps resulting from the CLI program is now being processed. Increased soil survey activity throughout the country has resulted in a need for an expanded cartography service in Agriculture Canada. Soil map publication data tabulated below show the variability and the total output throughout the half century.

Approximate number of soil maps published

	1920-1929	1930-1939	1940-1944	1945-1949	1950-1954	1955-1959	1960-1964	1965-1969	1970-1974
B.C.		1		2	1	2	4		7
Alta.	3	5	4	1	3	2	10	2	8
Sask.	8	2	5		1	1	1	3	2
Man.		1	4		1	5	4	1	7
Ont.	3	3	2	4	7	7	12	3	2
Que.		2	13	2	6	3	8	7	2
N.B.			2		2		1		
N.S.			1	1	3	2	6	2	1
P.E.I.			1					1	1
Nfld.									1
Y.T.-N.W.T.					1		1	2	2
Total	14	14	32	10	25	22	47	21	33

by film printing negatives and zinc printing plates.

Evolution of soil cartography has been dramatic in the 30 years since Nicol and Beaudoin set up the work at the Central Experimental Farm.

New techniques were introduced when possible. For example, pagra (aluminum cored paper) was treated with lacquer and sanded to roughen the surface before topographic and soil information was blue keeled down (like carbon paper but erasable). Then lines were followed with pen and ink on the corrected map manuscripts. Captions were typeset either by the Queen's Printer or by hand from stock type; in some cases hand printing was used. Although the pagra stock was an improvement over vandyke paper, high accuracy was still unattainable. In the uncontrolled environment, even pagra stretched and rubber cement lost its grip so that symbols shifted.

Further technical developments have continued since the fifties. About 1952, better quality type set on bible stock paper was available from commercial printers. This text was pasted down by draftsmen. In the early sixties, text printed on positive strip film was introduced. Drafting procedure changed from blue-keeled compilation followed by inking, to scribing on coated plastic. Among the new materials introduced were acetates, peelcoats, and duplicating film. In 1973, further technical developments permitted the computer storage of soil map information. A small computer controller and digitizing tables are in operation. All soil maps are simultaneously scribed and digitized during the normal drafting process in order to store the map data in digital form. The stored information is used to prepare interpretative maps by computer.

Major changes in materials, techniques, and processes have taken place during the 50-year history of soil cartography in Canada. In the thirties, when the production of new soil maps was suspended, the bases used were existing maps, some of good quality, others rough. The few photogrammetric bases that existed were compiled from oblique stereoscopic photographs, a ready source of error. Material prepared from ground survey varied in quality. All lettering was done by hand. The draft was photographed and color separation negatives were produced by a process that involved beeswax and soot. Copper and zinc plates were prepared by etching in acid. The methods of reproduction relied on wet vandyke paper and large errors in scale through stretching were incurred.

Immediately after the war in 1945, Nicol and Beaudoin continued the drafting work with similar materials. Map bases were drawn from available sources. Usually the unstable vandyke prints of MTS maps were used. When these were not available, base maps were compiled by using standard tables of latitude, longitude, and distance; and by drawing curved lines of latitude using templates and railroad curves. All work was produced by pen and ink. Copper plates became obsolete and were replaced

Future of soil survey in Canada

The history of soil survey in Canada prompts a brief look at the future. If the past is any indication, clearly the future will bring changes in priorities depending on the relative urgencies of problems related to land and soil. These changes will, no doubt, affect the extent and the sources of support received for soil survey and related activities. Advances in science and technology, both in Canada and elsewhere and the nature of the problems under study will influence concepts and methodology. Because the nature of future needs cannot be foreseen, it is essential that leaders of soil survey be attuned to current requirements for soil information and to possible improved ways of obtaining and making available that information.

Planning for the future of soil survey in Canada will probably include the following considerations:

1. Although we have a useful broad picture of the soil resources of Canada, much more soil information is required as a basis of planning the effective use of these resources. Most of the settled areas of the country have been covered by some type of soil survey, and numerous forays have been made into the hinterland. However, many of the early reconnaissance soil surveys of the settled area were at small scales, mainly from 1:380 160 to 1:126 790 and most of the surveys of the northern fringe have been at much smaller scales. These surveys were useful in providing general information on soil resources and as a basis for regional planning. They do not, however, provide information of sufficient detail for local land use planning. It must be recognized also that many of the older surveys, particularly those made before 1950, are out of date. Furthermore, the maps and reports for many of the early surveys are now out of print, at a time when the demand for soil information is greater than ever. Many areas will have to be resurveyed using current techniques to furnish the required soil information to a growing variety of users of soil surveys.
2. Greater application of soil survey information to land use planning and to the solution of problems will be essential in the future. Concern about application of the information probably will have a major influence on soil survey techniques and operations in numerous cases. Standard soil surveys will continue to meet a range of needs but in cases of specific concerns such as the suitability of areas for agricultural development, parks, suburban development, rural centers that depend on septic tanks, and pipeline corridors, particular kinds of information will have to be collected according to the primary purpose of the survey. The requirement for more specific interpretation of standard soil survey information will require that some pedologists specialize in this aspect of pedology. However, a high level of competence in mapping and classification will remain basic.
3. Interest in the soil resources of Canada has led a number of agencies to become involved in soil studies. In addition, other agencies work in closely related fields such as ecology, surficial geology, and the use of land. Problems concerning the soil resource are often best tackled by a multidisciplinary approach. An interagency committee concerned with surveys of the earth's surface and interpretation of the data could do much to foster and to coordinate these studies. The recently formed Canada Committee on Ecological Biophysical Land Classification may succeed in fulfilling this essential role.
4. An enormous amount of information has already been collected on the soils of Canada: site characteristics, geography, soil properties, productivity, and allied matters. The potential of the computerized soil data bank, CanSIS, to store, order, rearrange, and display this information will be tested in the years ahead. A system of this kind is essential to a comprehensive land evaluation program.
5. The need will remain to maintain a delicate balance between centralization to provide uniformity and coordination, and regionalization to aid in meeting particular regional needs, and to encourage the trial of new concepts and methods. The best possible balance is more likely to be attained if periodic objective evaluations of concepts and procedures related to soil survey are considered as an essential part of the planning process.
6. Maintenance, in current and future soil surveyors, of the enthusiasm, dedication to their profession, individuality, adaptability, and cooperative spirit of the best of their predecessors will be a primary objective. The increasing public interest in the soil is at least partially due to the sound development of a cooperative federal, provincial, and university organization to classify, map, and interpret the soil resources of Canada.

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