REPORT

on the

THIRD CONFERENCE OF THE NATIONAL SOIL SURVEY COMMITTEE

Held at

SASKATOON, SASKATCHEWAN

OCTOBER 31 to NOVEMBER 5

1955

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Members of N.S.S.C. Attending the Conference

Mr. H.W.R. Chancey, Experimental Farm, St. John's, Newfoundland
Mr. G.B. Whiteside, Experimental Farm, Charlottetown, P.E.I.
Dr. D.B. Cann, Nova Scotia Agricultural College, Truro, N.S.
Dr. G.R. Smith, " " " " " "
Dr. J.F.G. Millette, University of New Brunswick, Fredericton, N.B.
Prof. August Scott, Department of Agriculture, Ste-Anne de la Pocatiere, Que.
Mr. R. Baril, " " " " " " " "
Dr. W.A. DeLong, Macdonald College, Quebec
Mr. P. Lajoie, " " "
Prof. N.R. Richards, Ontario Agricultural College, Guelph, Ont.
Dr. B. Matthews, " " " " "
Dr. R.E. Wicklund, " " " " "
Mr. L.J. Chapman, Ontario Research Foundation, Toronto, Ont.
Prof. J.H. Ellis, University of Manitoba, Winnipeg, Man.
Dr. W.A. Ehrlich, " " " " "
Prof. J. Mitchell, University of Saskatchewan, Saskatoon, Sask.
Mr. H. Moss, " " " " "
Dr. J.L. Doughty, Soil Research Laboratory, Swift Current, Sask.
Dr. J.D. Newton, University of Alberta, Edmonton, Alta.
Mr. W.E. Bowser, " " " " "
Mr. W. Odynski, " " " " "
Dr. C.A. Rowles, University of British Columbia, Vancouver, B.C.
Mr. L. Farstad, " " " " " "
Mr. C.C. Kelley, Department of Agriculture, Kelowna, B.C.
Dr. H. Atkinson, Science Service, Department of Agriculture, Ottawa
Dr. P.O. Ripley, Experimental Farms Service, Dept. of Agriculture, Ottawa
Dr. A. Leahey, " " " " " " "
Dr. P.C. Stobbe, " " " " " " "

Guests attending the N.S.S.C. Meeting

Dr. Roy W. Simonson, U.S. Soil Survey, U.S.D.A., Beltsville, Maryland, U.S.A.
Mr. August Mailloux, Dept. of Agriculture, Ste. Anne De la Pocatiere, Que.
Dr. C.F. Bentley, University of Alberta, Edmonton, Alta.
Dr. W.L. Hutcheon, University of Saskatchewan, Saskatoon, Sask.
Dr. D.A. Rennie, " " " " "
Mr. J.S. Clayton, " " " " "
Mr. W.K. Janzen, " " " " "
Mr. R.J. St. Arnaud, " " " " "
Mr. A.K. Ballantyne, " " " " "
Mr. J.G. Ellis, " " " " "
Mr. L. Lutwick " " " " "
Mr. W.E. Johnson, Dept. of Agriculture, Regina, Sask.

BUSINESS SESSION

October 31

Dr. A. Leahey, Chairman of the National Soil Survey Committee, opened the conference and welcomed the members and guests. In a brief review of the activities of the National Committee since its establishment in 1945, he pointed out that although this is only the third general conference, the influence of the committee on soil survey work in Canada has been marked. The periodic meetings of all the senior men connected with soil survey work and the frank discussions of mutual problems have greatly aided in obtaining a better appreciation and understanding of each others views. Of perhaps more concrete benefit have been the reports of the various sub-committees on the more specific subjects assigned to them.

He pointed out that some of the members who have been active on sub-committees in the past are no longer with us and their place has been taken by younger men. Some of the sub-committees have pretty well completed their task and they will only need to review their earlier reports and make small changes or adjustments, while other sub-committees have still a great deal of work to do. In addition, some new sub-committees have been established. For these reasons and in order to obtain a more desirable representation, the executive decided to re-organize the personnel of the various sub-committees. After a brief outline of the problems that the sub-committees might consider he asked the various committees to meet separately during the first two days of the conference and then present their reports to the general conference later in the week.

Dr. V. J. Graham, Dean of the Faculty of Agriculture of the University of Saskatchewan, welcomed the National Soil Survey Committee to the University and offered the use of the University facilities to the members. In his welcoming remarks he stressed the importance of our soil resources and of their proper use. He pointed out that as a member of the National Advisory Board on Agricultural Services, he had been able to follow rather closely the aims and accomplishments of the Soil Survey Committee and he hoped the members would be able to continue their useful work during this conference.

Dr. John Mitchell, Head of the Soils Department, warmly welcomed the members to his Department and invited them to visit the various laboratories and to become familiar with the soil research work conducted at Saskatoon.

During the remainder of the day, the sub-committees met in private sessions.

Dr. Roy Simonson, Chief Correlator of the United States Soil Survey, attended the meetings at the invitation of the Chairman. He not only contributed greatly to the general discussions in connection with the sub-committee reports but also presented a discussion of the Fourth Approximation of the United States soil classification scheme which was greatly appreciated by all the members. A summary of Dr. Simonson's talk is given below.

Revision of Soil Classification System in the United States

The last major revision of the comprehensive scheme of soil classification followed in the United States appeared in Soils and Men in 1938. Much has been learned about soils since that time. Furthermore, the 1938 scheme has certain defects that are now apparent. It attempted to put all the geographic bias into the highest category. It omitted many soils of the tropics and frigid zones. It was never completed by the grouping of soil series into classes in higher categories.

The present effort to revise the system in the USA began about 10 years ago with the rather innocent requirement that all soils series descriptions should indicate the great soil group to which the series belonged. This brought to light a number of problems which were considered by committees of our national soil survey conference. Some changes in concepts of great soil groups were consequently made, and these are largely summarized in the symposium on soil classification published in Soil Science Volume 67, No. 2, February, 1949.

After a few years, it was concluded that the whole scheme must be treated as an entity since important changes in the concept of one category affected other categories. More recent efforts to revise the system have therefore dealt with it as a whole. These have gone through a series of approximations, the latest being the Fourth Approximation now under discussion.

The Fourth Approximation consists of seven categories with increasing numbers of classes in each category from top to bottom. Beginning with Category VII as the highest, the numbers of classes in each are approximately 9, 40, 100, 500, 1500, 5,000 and 15,000 in the United States. It seems likely that the number of classes in higher categories would not be greatly increased if additional parts of the world were considered. On the other hand, much greater numbers of classes would be necessary in the lower categories. With the increasing number of classes going from top to bottom in the system, a correspondingly greater number of properties and of degrees of expression of properties are considered. Throughout the higher categories, the Fourth Approximation places more emphasis on B horizons that have earlier systems.

The primary basis for distinguishing classes in Category VII are horizon sequences and major kinds of horizons, the degree of horizonation, and the gross composition of soils. The intent is to place emphasis on features that reflect major genetic processes in soil formation.

In Category VI distinctions between classes are based on degree of horizonation, on the degree of weathering or weatherability, on the kinds of differences between major horizons, and on moisture regimes.

Distinctions between classes in Category V are based on minor horizons and minor horizon differences, as compared to those considered in Categories VI and VII, on horizons extra to the main sequence used to classify a soil, and on temperature regimes.

Distinctions in Category IV are based on degree of overlap in characteristics used to differentiate classes in higher categories. In other words, one class in the category is considered to be the type specimen or central concept for each class in the next higher category. The closely related classes clustering around the one representing the central concept are all thought to be gradational toward soils typical for some other class in Category V. Consequently, there would be one typical or central class and a number of intergrades recognized in Category IV for each class recognized in Category V.

Distinctions between classes in Category III may be based on any of the properties used to differentiate soil series, but is is expected that wider ranges will be allowed within classes. Concepts of Category II, the soil series, and of Category I, the soil type, are unchanged from those defined in the Soil Survey Manual.

Study of the Fourth Approximation will indicate a number of problems still in need of solution. Questions remain on the choice of criteria in Category VII, as for example, the use of clay minerals to distinguish a pair of the classes at that level. The proposed classification of organic soils is a marked departure from earlier efforts and may or may not be the best approach. Recognition of Solonetz soils as a separate class in the highest category has also been questioned. These few problems are simply illustrations; they are not a complete list. We are certainly anxious to have further reactions to the Fourth Approximation, whether those be criticisms of what has been attempted or alternative ways of classifying selected soils.

RWSimonson
5-8-56

November 5

Reports- After the general discussions, the meeting agreed that the sub-committees might review the reports which have been presented in light of the discussions which have taken place. Where desirable, some of the pertinent discussion might be attached separately to the report. It was agreed that all the reports would be issued together in a folder.

Eastern and Western Sections of N.S.S.C. - The Chairman pointed out that there had been some difficulty in bringing all the members together for a national meeting, consequently these meetings had not been held as often as they perhaps should have been held. He suggested that regional meetings might be held by eastern and western groups in alternate years, and that meetings of the entire committee might be held at greater intervals. Such arrangements would be cheaper and; would permit more thorough discussion of regional problems; would make it possible for more of the party chiefs to attend such meetings and it would be more feasible to organize field trips in connection with such meetings. After some discussion the meeting agreed that the suggestion of holding regional meetings is sound, provided that the intervals between the national meetings are not too great. It was also suggested that the regional meetings should operate under the same chairman and secretary and that the regional meetings should not interfere with the activities of the sub-committees or the national committee. A motion in favour of eastern and western regional meetings was approved.

Joint Meetings with Other Soil Scientists - Dr. Ripley suggested that there might be some merit in bringing about closer active association between soil surveyors and other soil scientists. This would tend to bring about closer co-ordination of soil research programs and better use of soil information already obtained. He suggested that this end might be achieved by bringing soil surveyors and other soil scientists, particularly those engaged in soil management studies, together during the regional meetings. At such meetings, each group could hold separate sessions, as well as some joint meetings on problems of mutual interest.

This suggestion was met favourably by members from several provinces who felt that soil information already available has not been used to best advantage and that closer contact between various groups of soil investigators would be valuable. Others suggested that there has not been enough contact locally in the field between soil surveyors and other soil scientists and that more efforts in this connection would be worthwhile.

However, it was pointed out also by some members that the National Soil Survey meetings have been the only occasions when soil surveyors could meet by themselves and discuss their own problems, many of which are of little interest to other soil scientists. For this reason this group should not lose its identity and provisions for separate sessions on soil classification should be safeguarded.

In order to facilitate the arrangement of joint meetings, it was suggested that a National Committee on Soil Management would be desirable and the Chairman and Dr. Ripley were directed to approach the Chairman of the National Advisory Board on Agricultural Services regarding the advisability of creating such a committee.

Collection of Kodachrome Slides and Soil Monoliths - Some discussion on the exchange of soil monoliths and Kodachrome slides took place. It was suggested that the exchange of representative soil monolith, might be arranged between the interested individual soil survey units. The collection of a set of Kodachrome slides representing the major soil profile types in Canada appeared to be more feasible. In this connection, it was suggested that the members send to the secretary good slides of their soils in order to build up a complete set of the different major soil profiles. This set would then be duplicated and made available to the various units.

Appointments to Executive - Dr. J.D. Newton, University of Alberta was appointed as western representative and Prof. Auguste Scott as eastern representative on the executive of the N.S.S.C.

Closing Remarks - Towards the closing of the sessions, Dr. J. Mitchell paid warm tribute to Prof. J.H. Ellis who has retired from the University of Manitoba for his pioneering work and his continued contributions towards the establishment and improvement of soil survey work and soil classification in Canada. In his reply, Prof. Ellis expressed his appreciation for the sentiments expressed and hoped that the younger scientists who are coming along will have the same love for the land that has been ingrained in the older survey men.

Following a vote of thanks to Dr. Mitchell and the college for their hospitality to the group, the meetings adjourned at 1:00 p.m., November 5, 1955.

REPORT AND RECOMMENDATIONS OF THE SUB-COMMITTEE ON PHYSICAL ANALYSES

1. Committee Members:
   Bowser, Chapman, Doughty, Kelley, Mathews, Ripley, Rowles - Chairman.

The Committee would like to acknowledge the valuable help received from Hutcheon and Lajoie and from W.K. Janzen who acted as Secretary.

2. Terms of Reference Given by the N.S.S.C.
   The National Soil Survey Committee requested that the Sub-Committee examine the points listed below.

(a) Review and discuss textural classes and textural triangle, mechanical analysis.
(b) Discussion of other physical analyses that are needed to characterize soils.
(c) Methods of analyses.
(d) Sampling techniques.
(e) Expression of results.

3. Procedure followed by the Sub-Committee

Since this was the first sub-committee appointed by the N.S.S.C. solely for the purpose of studying physical analysis, it was decided that a questionnaire should be prepared and distributed to Canadian Soil Laboratories to provide information relative to:
(a) What physical analyses are being made.
(b) What methods are being used and which ones are recommended.
(c) What Canadian Soil Scientists think should be done with respect to physical analysis of soils relative to Soil Surveys.

The questionnaire prepared and distributed to University and Government Soil Laboratories across Canada is shown below. A copy of the questionnaire was also sent to the National Research Council, Division of Building Research.

QUESTIONNAIRE

INFORMATION REQUIRED BY THE PHYSICAL ANALYSES COMMITTEE OF THE NATIONAL SOIL SURVEY COMMITTEE

1. (a) What soil separate sizes are you presently using? (State limits).

   (b) What soil separate sizes do you recommend for adoption by Canadian Soil Surveys?

(c) What method or methods of mechanical analysis are you using? (Please supply detailed sampling techniques and laboratory procedures where possible.)

(d) What method or methods of sampling and mechanical analysis do you recommend for adoption by Soil Surveys in Canada?

(e) How do you report mechanical analysis results?

(f) What method or methods do you recommend Canadian Soil Surveys should adopt for reporting mechanical analysis results?

(g) What soil textural classes are you using? (If possible give percentage limits of sand, silt, and clay and a copy of the textural triangle you are following).

(h) What soil textural classes and sand, silt and clay limits do you recommend should be adopted by Canadian Soil Surveys? (If possible include a copy of the textural triangle you recommend).

2. (a) What physical analysis other than mechanical analysis do you feel should be adopted by Canadian Soil Surveys to characterize Canadian Soils? (List, giving conditions and reasons for the adoption of each).

(b) What sampling techniques and laboratory methods do you recommend for adoption by Canadian Soil Surveys for the tests listed in 2 (a) above? (Give detailed procedures where possible).

(c) How do you recommend the results of the analysis listed in 2 (a) above should be expressed?

(d) Where applicable, discuss the interpretation of the analyses listed in 2 (a) giving ranges of values such as high, medium, low, etc.

3. What general comments or suggestions do you have for the Physical Analyses Committee?

Response to the questionnaire was most gratifying and ten replies were received in time to be considered by the Sub-Committee. These were summarized by the Chairman and the summaries appear in the final sections of the report.

These summaries were used as the basis for the Sub-Committee's discussions during the past week. The meetings have proved most useful, but the Sub-Committee feels much remains unfinished, and therefore, this report is preliminary in nature and the work should be continued.

4. General Comments

There was rather general agreement that the Sub-Committee should give attention to methods of analysis, and mechanical analysis in particular. In this connection, many references were made to the mechanical analysis results reported for the test samples distributed from Ottawa a short time ago. Numerous people were disturbed by the lack of agreement evident and felt that this should receive attention ahead of all other considerations.

There was also general agreement that greater uniformity in textural classes would be desirable in Canada.

The view was generally expressed that not enough attention was being given physical analysis in Canadian Soil Surveys and that every effort should be made to correct this situation. With this in mind the Sub-Committee makes the following recommendation.

Recommendation No. 1. It is recommended that more emphasis be placed on physical analysis in Canadian Soil Survey operations.

The Sub-Committee would like to acknowledge the useful comments received from Dr. Leggett of the Division of Building Research of the N. R. C. Among other things the Division of Building Research acknowledged the valuable assistance given it by Soil Scientists serving on the engineering committees of the N. R. C. and suggested that it might be useful if Soil Mechanics representatives were included on the physical analysis sub-committee of the N. S. S. C.

The Sub-Committee was in agreement with this thought and makes the following recommendation with respect to it.

Recommendation No. 2. The Sub-Committee recommends that a representative of the Division of Building Research of the N. R. C. be invited to join the Sub-Committee on physical analysis of the N. S. S. C.

Following a general discussion of the work of the Sub-Committee, it was decided that it should stress physical tests considered to be important in soil genesis and soil characterization although other tests which may not now be considered important in this regard could be studied as time permits.

5. Mechanical Analysis, Soil Separates and Texture

(a) Sampling for Mechanical Analysis.

The Committee found that several methods are being followed in sampling soils for mechanical analysis and that two general approaches are used as follows:

(1) To characterize surface soils, mechanical analyses are often carried out on a composite sample obtained by collecting six to ten individual samples and mixing.

(2) To characterize soil profiles, individual samples are collected from each horizon, sometimes from the middle of the horizon and sometimes from the whole depth.

The Committee concluded that more attention should be directed to soil variability and that composite samples were of relatively little value in this regard. With this in mind the following recommendation is made.

Recommendation No. 3. When sampling soil types to characterize their surface texture, sampling should be done in such a way that not only the typical but also the range in mechanical composition is determined and to accomplish this, individual rather than composite samples should be used.

(b) Methods of Mechanical Analysis

The Sub-Committee found that methods of mechanical analysis used in Canadian laboratories vary widely and a summary of these may be found in another section of this report. Both the hydrometer and pipette methods are widely employed, the former being most common in Eastern Canada. No two laboratories were found to use exactly the same procedures or techniques for sample preparation. Very briefly, this situation may be summarized as follows.

Starting in British Columbia, both the pipette and the hydrometer methods are used frequently. The pipette method used is basically that outlined by Kilmer and Alexander, but modified to provide for the use of an extra sample to determine organic matter, soluble material and carbonate free weights for purposes of calculation. Sample preparation for the hydrometer test is similar to that used for the pipette. Effective Hydrometer Depth is calculated according to the method of Day and A. S. T. M. methods are used for calculating results.

In Alberta, after extensive experience and experimentation, the pipette method is recommended basically as outlined by Kilmer and Alexander. However, Toogood and Peters have recommended certain modifications which they have found, shortened the time and improved the results. These modifications include using a mechanical stirrer instead of shaking, using an extra sample to get the weight of sample for calculation, and using different methods of filtering. The method and modifications are reported in detail in the Canadian Journal of Agricultural Science.

In Saskatchewan the pipette method is also used and recommended, basically similar to that of Kilmer and Alexander. However, there is some modification designed primarily to ensure satisfactory dispersion in calcareous soils that are high in organic matter.

Manitoba relies upon the pipette method of analysis with very little variation from the Kilmer and Alexander procedure.

Moving now to Eastern Canada, at the Ontario Agricultural College a pipette procedure is used to some extent for research purposes, and the hydrometer method, modified somewhat to that proposed by Bouyoucos is used extensively on survey samples.

The soil survey laboratories at Ottawa and McDonald College use the Bouyoucos Hydrometer method, and it is also used extensively at Kentville and Truro, N. S.

The Building Research Laboratory of the N. R. C. uses the Hydrometer method as described in the A. S. T. M. procedures.

In view of the wide range of techniques, the Sub-Committee had difficulty in making recommendations with respect to mechanical analysis methods. However, the following are offered for the consideration of the N. S. S. C.

Recommendation No. 4. (1) That for the present, we accept as our basic or standard reference procedure, the pipette method of mechanical analysis as described by Kilmer and Alexander but permitting the following modifications which are similar to those suggested by Toogood and Peters.

(a) That an extra sample be weighed out for the determination of organic matter, soluble matter and moisture free weight of soil for purposes of calculation, thus eliminating the necessity of oven drying the soil that is to be dispersed.

(b) That provision be made to keep the temperature constant during sedimentation by using a constant temperature bath or other means.

(c) That as optional modifications, mechanical stirring may be substituted for over night shaking, hypobromite treatment may be substituted for the hydrogen peroxide treatment for the removal of the organic matter and alternate filtering or centrifuging may be substituted for Chamberlain filters to remove excess water and dissolved materials.

(2) The Committee recommends that, although the Kilmer and Alexander method as proposed does not provide for the removal of carbonates by means of acid treatment; in other than textural determinations, it may and often is desirable to remove carbonates by treating the soil with 2NHC1 and filtering. In this regard it should be pointed out that in the presence of carbonates, H_2O_2 cannot be expected to completely destroy organic matter.

(3) The Committee recommends that the reference soil samples previously tested on a national basis be analyzed again for mechanical composition by as many laboratories as are suitably equipped for carrying out mechanical analysis following the Kilmer and Alexander procedures.

The Committee recommends that the U.S.D.A. Laboratory also be asked to conduct mechanical analysis tests on these samples.

(4) The Committee recommends that the Hydrometer method not be lost sight of as there are undoubtedly cases where results obtained by it are equally satisfactory to those obtained by the pipette method. However, it is suggested that the responsibility for establishing this fact should rest with the person or persons using it. To assist in the evaluation of the Hydrometer method, it is recommended that the samples referred to in Paragraph 3 above be tested by as many co-operating laboratories as possible, using the Hydrometer method as described by Day in the Report of the Committee on physical analyses of the Soil Science Society of America, August 1955 or by the A.S.T.M. method D422-54T 1954.

As a further test of the Hydrometer method, it is recommended that the reference samples be supplied to the Soil Mechanics laboratory of the N.R.C. with a request that mechanical analysis be made using the A.S.T.M. hydrometer procedure.

(c) Expression of Mechanical Analyses Results

The Sub-Committee found that there are several methods used for expressing mechanical analysis results, principally as follows.

(1) Results expressed as percent by weight of oven dry soil, i.e., mineral plus organic material.
(2) Results expressed as percent of the moisture free, organic matter, soluble matter, and carbonate-free soil.

There are soils where the differences in methods of expression may make very little or no difference. However, there are cases where the differences are quite significant. The difficulty will be solved in part if a standard method of mechanical analysis is accepted and with this in view, the Sub-Committee makes the following recommendation with respect to the expression of mechanical analysis results.

Recommendation No. 5

(1) It is recommended that for purposes of textural classification, the percent of sand silt and clay be expressed as percent of the moisture, organic matter and soluble matter free soil.

(The Committee realizes that there are cases where it will be desirable to express the results on the basis of the moisture, organic matter, soluble matter and acid soluble free weight of soil.)

(2) It is recommended that in reporting mechanical analysis results, the percentage of organic matter, soluble matter and carbonates be indicated where such results are appropriate.

(3) With respect to the gravel fraction or mineral particles between two mm. and three inches in diameter, it is recommended that these be collected and weighed separately and reported as a percentage of the air dry weight of the whole soil.

(4) It is recommended that whenever possible, mechanical analysis results should be shown as sumation percentage curves rather than simply as percent of sand, silt and clay.

(d) Soil Separates

The Sub-Committee concluded that the recommendation of the Committee on the chemical and physical analyses made in 1948 should be accepted. This was to the effect in Canada we comply with the U.S.D.A. system of soil separate designation. However, the Sub-Committee wishes to express the view that this system places too much emphasis on the coarse fractions and offers the following recommendations.

Recommendation No. 6

(1) It is recommended that if it is not desired to separate all the sand fractions included in the U.S.D.A. system, the very coarse sand and coarse sand should be combined together and the fine and very fine sand combined together, thus reducing the number of separate classes by two.

(2) The Committee recommends that more attention be directed toward the fine clay and suggests that as more information is obtained, a further division of the clay separate may prove desirable.

(3) With respect to the classification of gravelly soils, it is recommended that the U.S.D.A. procedure be followed as outlined in the Soil Survey Manual.

(e) Textural Classes and Textural Triangle

The Sub-Committee noted that some differences exist with respect to textural classes and textural triangles used in Canada. In some cases different textural class names are used and also the actual limits of classes sometimes differ.

The Committee is of the opinion that greater uniformity would be desirable and with this in mind, makes the following recommendation.

Recommendation No. 7

It is recommended that we follow the U.S.D.A. textural classes and textural triangle as set down in the Soil Survey Manual with, however, the addition of a second clay class - heavy clay, to include all soils which contain 60 percent or more clay.

The Committee would like to express its reluctance to accept the term "heavy clay" and hopes that a more scientifically acceptable term may be found.

6. Physical Analyses Other Than Mechanical Analysis

The Sub-Committee found that there is a great interest in and need for physical analyses other than mechanical to characterize Canadian soils. Apparently, this has come about quickly as the Sub-Committee on chemical and physical analysis in 1948 suggested only three physical tests to assist in the description of soil profiles. These were as follows:

(1) Mechanical analysis
(2) Moisture equivalent
(3) Colour

The present Sub-Committee found that a large number of physical tests were being made or suggested to characterize Canadian soils. Included among these were the following:

(1) Bulk density
(2) Real specific gravity
(3) Total pore space

(4) Macro and micro pore space
(5) Soil-moisture constants at low tensions, e.g., 10, 40, 80 and 100 cm. water tension.
(6) 1/3 atmosphere percentage
(7) Field capacity
(8) Moisture equivalent
(9) Permanent wilting percentage
(10) Atterberg limits (lower, upper and range)
(11) Permeability (hydraulic conductivity)
(12) Colour
(13) Ignition loss
(14) Saturation percentage
(15) Infiltration rate
(16) Water stable aggregates

The Sub-Committee was of the opinion that all these tests as well as others, have their place in characterizing the physical properties of Canadian soils but the Committee felt that it would be unrealistic to suggest that all should be used regularly in connection with soil survey operations. However, the Sub-Committee recommends that they should be kept in mind and carried out as and when facilities and staffs permit.

The Sub-Committee has found considerable difference of opinion as to how soils should be sampled for some of the tests listed above and has found that the methods of conducting the tests vary also.

In some instances, for example, in British Columbia, considerable effort is made to obtain undisturbed soil samples from horizons at specific moisture content for the determination of such things as bulk density, pore-size distribution, hydraulic conductivity and moisture retention at low tensions. In other laboratories, disturbed or bulk samples are used for some of these tests. The Sub-Committee does not feel that it can resolve such differences at this meeting and recommends that the matter be kept under study.

The Sub-Committee would like to emphasize the importance of all the physical tests listed above but would like to draw particular attention to the following as being generally appropriate for the physical characterization of Canadian soils.

(1) Bulk density
(2) Soil moisture constants such as .1 atmosphere percentage, 1/3 atmosphere percentage, moisture equivalent, field capacity and permanent wilting percentage.
(3) Total, macro and micro pore space
(4) Hydraulic conductivity
(5) Atterberg limits.

The Sub-Committee would like to point out that there is a great wealth of literature available regarding methods for conducting these tests and the Committee does not intend to repeat these here. However, a few suggestions may be in order and later sections of this report contain considerable information on the subject.

For estimating Bulk density, a method that is often used is to prepare a flat surface either horizontal or vertical and to press or drive a core sampler or cylinder into the soil, care being taken to see that no compaction or disturbance occurs. The core samples are then taken to the laboratory and the ends trimmed off and the oven dry weight of soil determined. The number of individual core samples required to characterize a soil will vary, but normally it runs from 6 to 10. In soils that show swelling, bulk density results may be effected by the moisture content of the soil at the time of sampling. To minimize this effect it has been found convenient in British Columbia to bring some field soils to a standard moisture content before making bulk density determinations.

A number of techniques are available for determining moisture constants at low moisture tensions and particular attention is directed to the publications of L. A. Richards.

Permanent wilting percentage may be found by the direct method using sunflowers or estimated indirectly using the 15 atmosphere percentage method of Richards or the Dessicator method of determining permanent wilting percentages of soils by Lehane and Staple. (Soil Sc. Vol. 72, No. 26)

Total pore space is usually calculated from the real and bulk density of the soil although it may also be found by displacement of air under vacuum. Undisturbed samples are required for the estimation of macro pore space and the Tension Table apparatus of Leamer and Shaw has been popular in Canada for this determination.

Several methods are available for estimating permeability by means of hydraulic conductivity. Some prefer to use undisturbed soil samples collected from soil horizons, while others find disturbed samples satisfactory. A great deal of literature is available on the subject and the publications of the A. S. T. M. are particularly useful.

The Atterberg limit tests are well known to all and the A. S. T. M. publications are useful in this regard. It should be noted that an improved type of grooving tool is available.

The final discussions of the Sub-Committee dealt with mineralogical analysis and the following recommendation is made on this subject.

Recommendation No. 8

The Sub-Committee on physical analysis recommends that a small committee including representatives from both the chemical and physical analysis Sub-Committees of the N. S. S. C. be established to study, facilitate and co-ordinate the mineralogical characterization of Canadian soils.

GENERAL DISCUSSION OF THE PHYSICAL ANALYSIS SUB-COMMITTEE REPORT AT THE PLENERY SESSION OF THE N. S. S. C.

Leahey - It is rather difficult to appoint a member of a sub-committee who is not a member of the main committee.

Mitchell - I would like to suggest that the Soil Mechanics personnel of the several Soil Mechanics Laboratories in Canada should be invited to become members of the Canadian Soil Science Society.

Bowser - To simplify the presentation of the report, I would suggest that the discussion of additional personnel other than pedologists to committees be deferred till the end of the report.

Ripley - The Sub-Committee's recommendation, re adding Soil Mechanics representatives to the Sub-Committee could be worded so that a member of the Soil and Snow Mechanics Committee of the National Research Council, could be invited to attend Sub-Committee meetings in a purely advisory capacity. (Committee agreed).

Millette - The sampler has a tendency to bias results toward a less gravelly phase, when sampling gravelly soils, by discarding the large particles during sampling. In New Brunswick, two sets of samples are taken of each profile sampled, one set being core samples for physical measurements other than mechanical analyses, and one set for mechanical analyses.

Moss - Some confusion seems to exist in the use of the terms gravel and gravelly. Gravel should be used for classifying particle size, and gravelly should be used as a textural connotation.

Ellis - In Manitoba, the field man takes a number of samples and makes a rough measure of texture by means of the moisture equivalent. Where desired, smaller samples are taken from the bulk sample for mechanical analyses.

Bowser - A modification of the texture triangle was prepared by Mr. John Toogood at the University of Alberta. Toogood's texture triangle is two dimensional instead of three dimensional. Otherwise it is similar to the U.S.D.A. (It was felt that either triangle should be satisfactory, provided the limits are the same).

Millette - Did the Sub-Committee give any thought to ways of speeding up mechanical analyses by the pipette method?

Rowles - The Sub-Committee felt that it should attempt to get approval by the whole committee to establish certain standard methods for mechanical analyses. Where someone wishes to modify a given method, the Committee felt that the onus should rest on the modifier to prove his modified method gives comparable results with the approved method. The Sub-Committee's recommendation on mechanical analysis does provide for some modification to facilitate the speed of analyses.

Smith - The Committee would be on much safer ground to stay with standard methods.

Hutcheon - In Saskatchewan, the pipette method has proved the most satisfactory. The hydrometer method is not reliable for our soils. However, the hydrometer method may have its uses.

Simonson - The U.S.D.A. has done a large number of samples by both methods. The variability of the hydrometer method was as high as 4%, as compared to the pipette method. This variation is considered to be too high, and the U.S.D.A. has gone back to the pipette method.

Stobbe - In the 1953 survey using the 17 standard samples sent out from Ottawa, the Eastern results were reasonably good, using the hydrometer method. In Western Europe, the soil surveys find the hydrometer method gives more reproducible results than the pipette method.

Hutcheon - Is reproducibility of results of any value if the results are wrong?

Rowles - At the University of British Columbia, comparative results by the hydrometer and pipette methods have been very close, where similar preparation and dispersing techniques have been used and appropriate corrections for effective depth of the hydrometer have been utilized in making calculations.

Hutcheon - I would suggest that the lime be left in during mechanical analyses, where the analyses are textural checking, but that lime should be removed for profile analyses.

Erhlich - What dispersing agent should be used in mechanical analyses? The Kilmer-Alexander method uses "Calgon", which is the trade name for sodium hexa-metaphosphate. It was agreed that this dispersing agent should be used.

Ellis - Should all 17 samples be re-done, or should the analyses made on selected samples only? The latter alternative would reduce the amount of work materially.

It was decided that all samples should be tested.

Stobbe - No mechanical analyses results should be released from Ottawa until all results are in. Approved.

Leahey - There is an urgent need for more information on soil moisture relationships to correct the Thornthwaite formula for moisture. This formula is now approximately correct for use up to Latitude 50° north. It should be extended to at least latitude 60° north.

Recommendation - That the report of the Sub-Committee on Physical Analyses be approved.

Carried.

Report of the Sub-Committee

on

Soil Classification

The Committee is very appreciative and thankful for the explanatory review of the 4th Approximation of the U.S. Soil Classification Scheme presented by Dr. Roy Simonson before the N.S.S.C. It is realized that the U.S. organization has worked very hard on this tremendous task, and the Committee feels that we should give them our assistance in any way possible. The Committee suggests that a serious effort should be made in trying to fit all our recognized and defined soils into the U.S. Soil Classification Scheme. The usefulness of the scheme for our purposes can only be determined if it will satisfactorily classify and group all our soils. A satisfactory world classification of soils would be of interest to us in the comparison of our own soils with those occurring in other parts of the world, regardless of whether it is the most logical or practical system to be adopted for the grouping of the Canadian soils for general use in this country.

After due consideration the Sub-Committee reached the opinion that the 4th Approximation of the U.S. System, as it stands, could not best serve our great need for a satisfactory grouping and classification of Canadian soils which would greatly assist in presenting a logical and simplified picture of our soils. Some of the points that influenced the Committee were:

1. The U.S. System is too complicated. In order to take care of soils which are not known to occur and which are not likely to occur in Canada, some classes and criteria were introduced which are of no apparent importance in Canadian soils. It was also pointed out that the U.S. System is too complicated for the average soil scientist to understand. This point, however, was not given very much weight because it was felt that if the classification was otherwise sound and usable it would be worthwhile for the average soil scientist to devote more study to it.

2. In the grouping of soils into progressively higher categories, some soils have been separated at comparatively high categorical levels around which common concepts have been gradually built up through the years in this country. Other soils which differ more significantly according to our concepts are kept together at relatively low categorical levels.

3. The definitions of certain differentiating criteria do not entirely agree with the conceptions, rightly or wrongly, developed and accepted in this country.

4. Certain differentiating criteria used in the scheme have not been studied and used long enough, at least in this country, to test their relevance for grouping purposes. Some of the differentiating criteria which assume considera-

importance in the scheme have not received sufficient attention in the past in the definition of some soils so that consequently we can not classify at the present a number of our soils according to the U.S. Scheme. Such soils will require considerable study and reappraisal before they can be properly classified according to this scheme. However, a reappraisal in light of present knowledge is probably necessary in any event if for no other reason than to obtain a more accurate understanding of our soils.

While considering a classification scheme for Canadian Soils it was first believed that the proper approach would be to define the major kinds of soils (above the family level) which occur in Canada and then group them together into progressively higher categories. However, it was soon realized that the definitions of the different kinds or types of soils would have to be made on approximately the same level of abstraction. In order to accomplish this objective it was found necessary to prepare a tentative overall scheme, based on the general knowledge of all our soils, outlining the different categorical levels. After much discussion and careful consideration of many valuable suggestions the Committee recommends that -

(a) This scheme, as presented and discussed below, be given a thorough trial.

(b) A number of sub-committees be established to define more accurately the different soil classes in the three higher categories and to review, and where necessary, re-define the differentiating criteria.

A serious attempt to place all our soils (series or catenary members) into the appropriate categorical classes will indicate whether or not the scheme fulfills our needs. It will also indicate what changes or adjustments are necessary.

The Committee further suggests that those provinces which to date have not grouped their soil series or equivalent catenary members into soil families (Category III in scheme) should endeavour to do so and define these families in terms of their distinguishing characteristics.

Discussion of the Outline of the Suggested Classification Scheme

The classification scheme is based on our present knowledge of Canadian soils and on the concepts which gradually have been developed regarding their genesis and morphology. It is hoped that the scheme is flexible enough to cover those soils which are likely to occur in Canada but it is definitely not intended to cover the soils of the world. It is recognized that many soils which occur outside of Canada can not be fitted into the proposed scheme.

The proposed outline contains 6 categorical units or levels of abstractions. Although the different categorical units have not been definitely named, Category I corresponds to our present conception of the soil type; II to the soil series or catenary member; III to the soil family (low family-consisting of a group of morphologically related series); IV corresponds closely to the U.S. high family (consists of inter-grades or other major sub-divisions of the great soil groups; V corresponds closely to the present conception of the great soil groups, and VI, the highest category, consists of a number of morphologically and/or genetically related great soil groups. It is hoped that if the principles of this classification scheme are acceptable it will be possible to agree on appropriate names for the different categories. It might be pointed out that this scheme contains one category less than the 4th Approximation of the U.S. Scheme. While seven categorical levels could be conveniently used in some classes (3 & 4), others (1, 2, 5, 6 & 7) do not readily lend themselves to seven categorical sub-divisions.

Category VI

In Category VI the soils have been sub-divided into 7 classes. The soils of each class may be further sub-divided according to the categorical level of abstraction. The sub-divisions in Category VI are based on the major morphological features of the entire profile and not necessarily on the presence or absence of any one horizon, or of any one particular characteristic. The number of groups was arrived at by a critical examination of all the known soils in Canada. It was felt that 7 classes would take care of all Canadian soils; however, this number may be increased or decreased if closer study and a thorough trial of the scheme indicates that this is desirable. The different classes have temporarily been designated by terms which have been in use long enough to have a definite connotation for most soil scientists. While it would have been desirable to add the ending "ic" to all the names in Category VI, no suitable connotative word could be found for class 4. More appropriate names may be decided upon after further study if the classification scheme seems satisfactory.

The seven classes and their differentiating characteristics are given in the attached outline. In view of the high level of abstraction the definitions must be broad enough to include all the soils of the same class in the lower categories. In addition to the more specific soil characteristics, the kinds of profiles in terms of horizons, the conditions under which the soils have formed and the major soil forming processes usually associated with the soils in question also have been indicated in the outline as additional features. It is hoped that these definitions will be sufficient to classify our soils into the respective classes. However, after careful study the various sub-committees may be able to suggest further changes or improvements to these definitions.

Category V

Each of the seven classes of Category VI are sub-divided in Category V into two or more units which are approximately equivalent to the great soil groups in level of abstraction. The criteria used for the sub-divisions in Category V vary from class to class depending on their relevant significance.

The Chernozemic soils (class 1.) are sub-divided in Category V on the basis of color, organic matter and nitrogen content of the A_1 horizon and to a lesser degree on the relative depth of the solum (on similar parent materials). The Brown (1.1), Dark Brown (1.2), and the Black (1.3) soils should conform rather closely to our present concept of these respective great soil groups. The exact definitions of these groups in terms of their differentiating characteristics will be prepared by respective sub-committees appointed for this purpose. These definitions must be broad enough to include all the soils of the respective groups. It may be noted that the "Thin" or "Shallow Black" and the "Degraded Black" soils are not considered as separate units in Cat. V. These soils are treated as sub-unit in Cat. IV.

The Halomorphic or Solonetzic (class 2) soils are sub-divided in Cat. V on the basis of the degree of development of the A_2 and solonetzic B into: Solonetz, Solodized Solonetz and Solod soils. Sub-divisions of these groups according to Zonality are made in Cat. IV. The placement in Cat. V of the Solod soil in which the solonetzic B has disintegrated to a point where it no longer interferes with the water regime may be questioned. Eventually it may be desirable to place these soils in Cat. IV of the Chernozemic or Grey Wooded soils. It is intended that the soils in which the solonetzic or solodic development is very weak will be placed in Cat. IV of Class 1 or 3. The differentiating criteria of the different sub-units will have to be defined more specifically by the respective sub-committees.

The Podzolic soils (Class 3) are sub-divided in Cat. V first, mainly on the nature of the B horizon (and associated characteristics) into: Those soils that in the past have been considered as "podzolic" (clay accumulation dominant in B horizon) and the "podzols" (sesquioxides and/or humus accumulation dominant in B horizon). The "podzolic" soils are further sub-divided into the Grey-Brown Podzolic (3.1) and the Grey-Wooded (3.2) soils, mainly on the nature of the surface horizon (A_1 or mull versus A_0 or moor). The Podzols are sub-divided on the nature of the B horizon into: Humus Podzols (3.3), (humus dominant accumulation product); Ortstein Podzols (3.4), (cemented B with sesquioxides or sesquioxides and humus) and Orterde Podzols (3.5), (friable B horizons with sesquioxides and humus accumulations in B). The sub-divisions suggested for the Podzols differ from those suggested in the U.S. Scheme. In many of our Podzols we lack the information which is required for the U.S. classification.

The sub-division of the Podzolic soils (class 3) would more readily lend itself to seven categorical units than to the six units suggested but unfortunately most of the other classes do not lend themselves to sub-divisions into seven categorical units. The sub-divisions suggested in Category V result in units of about the same level of abstraction as that considered for the great soil groups.

"The Forested Brown Soils" (Class 4), which include all the forest soils with a brown B horizon and without a noticeable A_2 horizon have been sub-divided in Category V into: (a) more or less saturated soils formed from calcareous or strongly basic materials, (4.1) Brown Forest soils (with mull-type of A_1), (4.2) Brown Wooded soils (with A_o and only very thin or no A_1) and (b) acid, unsaturated soils with little or no A_1 horizon formed from resistant non-calcareous materials, (4.3) Brown Podzolic soils (the term "Podzolic" will have to be changed, perhaps to Acid Brown?) and (4.4) Shotty Brown soils. Soils with definite but thin A_2 horizons which formerly were often classified as Brown Podzolic would now be classified as thin Podzols in Category IV under 3.51. The need for a fifth sub-division in Category V for acid and unsaturated brown forest soils with a mull-type of A_1 horizon has not been fully confirmed. In most soils with the latter type of morphology that have been investigated the A_1 development can be associated with human activity (management). Such soils have been classified as Brown Podzolic or Shotty Brown soils with an A_c horizon.

The Regosolic soils (Class 5), soils which lack normal profile development, have been sub-divided in Category V into six groups. The first five groups are closely connected with the nature of the parent material (regolith) which has restricted the development of a genetic profile. They are: Rendzina (5.1), where the dominance of lime has restricted solum development, except for the development of an A_1 and the partial removal of lime from the surface horizons; Regosols (5.2), soils formed on unconsolidated materials in which due to the nature of the material, other than the abundance of lime, or recent exposure, soil development has not taken place; Dry Sands (5.3), soils formed on sand which is resistant to further weathering or on recently deposited (dune) sand; Alluvial soils (5.4), soils formed on recent water deposits which have not been in place long enough for sola to develop; Lithosolic soils (5.5), shallow soils over bed-rock or consisting largely of slightly weathered fragments of rock without marked profile development; Tundra soils (5.6), soils in which the presence of permafrost or the churning action due to permafrost has restricted profile development.

The Gleisolic soils (Class 6) have been sub-divided in Category V as follows:

(a) Those without marked A_2 and B_2 horizons, which include Meadow soils (Wiesenboden), (6.1), soils developed under grass and having a dark A_1 horizon which grades into the underlying gleied layer; Dark Grey Gleisolic soils (6.2), soils developed under forest vegetation having a dark A_1 horizon which is abruptly underlain by gleied layer; Solonchack (6.3) soils, saturated with soluble salts which may encrust on the surface when dry; Peaty glei soils (6.4), soils with a peaty surface (but without a significant A_1 horizon) underlain by gleied layer.

(b) Soils with distinct A_2 and B_2 horizons. Podzolic glei (6.5), strongly acid to very strongly acid, unsaturated soils with strongly gleied A_2 and B_2 horizons. A_2/B_2 boundary indefinite.

Grey-wooded glei (Depression or Bluff Podzol), (6.6), less acid and less unsaturated soils than above with gleied B_2 horizon considerably finer textured than gleied A_2 horizon.

A peaty layer up to 12" thick may occur on the surface of all the gleisolic soils of Category V.

Organic Soils (Class 7). For the present no definite sub-division is suggested for the Organic Soils in Category V. It would seem that the origin or nature of the organic deposit, the degree of its decomposition, the depth of the deposit and the nature of the underlying mineral soil (especially under the shallower deposits) are important criteria to be considered in the classification of these soils. It is suggested that a special committee should further study these soils before definite recommendations are made as to the classification of organic soils.

Category IV

The units of Category IV in the attached outline correspond very closely in level of abstraction to the High families of the U.S. Soil Classification System. These categorical units represent the modal and intergrade concepts of the great soil groups in Category V or they may represent differences in kind of development within the broad concepts of a great soil group. Although it was not the intention to use differences in degree of development, per se, as criteria for sub-divisions in Category IV, the implications of degree of development do enter into some of the sub-divisions more than in others as degree of development is often closely associated with kind of development. The units of Category IV are more specific, i.e., they are based on more specific characteristics, consequently the units must be defined more exactly. In defining these soils it must be kept in mind that any statements made in Categories VI and V must also apply to all the soils of the corresponding class in Category IV.

The various units listed in Category IV of the attached outline are tentative and it is quite likely that after the various sub-committees have had an opportunity to study and define the respective units it may be advisable to drop some of the suggested groupings and add others. However, the suggested categorical units may serve as a basis on which the sub-divisions may be started.

In order to indicate the kinds of soils that were intended for the different units, tentative connotative names have been used in the scheme. It is realized that many of these names are not satisfactory and some misunderstandings have already been caused by these names. It is hoped that eventually it will be possible to decide on a more appropriate terminology but for the present an involved discussion of the terminology would hinder the consideration of the principles involved.

In order to assist in the clarification of the terminology and of the categorical units suggested in the scheme, the following brief comments are offered:

The term "modal" in Category IV refers to the normal or average soils of a great group, i.e. soils which do not possess special morphological features which are characteristic of other great groups, and to which modifying adjectives (such as used in 1.12 to 1.17, etc.) can not be applied.

The calcareous soils (1.12, 1.22 and 1.32) have the general profile characteristics of the respective groups but due to the calcareous nature of the surface soils they approach the Rendzima soils.

The degrading soils (1.13, 1.23 and 1.33), although still representative of the three respective groups, show definite indications of woodland degradation. It is suggested that the soils formerly considered as Degraded Black, and which covered a very wide range in degree of degradation be divided into two, those which still may be considered as Black soils (1.33) and those which may be considered as weakly developed Grey Wooded soils (3.22).

The solonetzic, solodic and saline or salinized Brown (1.14, 1.15 and 1.16), Dark Brown (1.24, 1.25 and 1.26), Black (1.34, 1.35 and 1.36) and Grey Wooded (3.25 and 3.26) soils are in all respects representative of their respective great groups but in addition show weak solonetzic, solodic or saline characteristics. They should not be confused with Halomorphic or Solonetzic soils of Class 2 in which the solonetzic or solodic developments are very marked and present major problems, nor with the Solonchack soils (6.3). These distinctions should be clearly brought out in the definitions of these categorical units.

The meadow-like or imperfectly drained soils (1.17, 1.27 and 1.37) soils are still considered as members of the three respective groups but are in effect intergrades to the Meadow soils (6.1).

The Solonetz, Solodized Solonetz and Solod soils have been classified in Category IV on the nature of the surface (A_1) soil into brown, dark brown, black and grey sub-units. It is questionable whether a grey (wooded) Solod could be distinguished from a modal grey Wooded soil.

The sub-division of the Grey-Brown Podzolic soils in Category IV is fairly obvious. The weakly developed (3.12) soils represent intergrades to the Brown Forest group and the imperfectly drained (3.13) represent intergrades to the Dark Grey Gleisolic group. The podzolized (3.14) Grey Brown and Grey Wooded (3.27) soils represent those soils in which a weakly developed Podzol has developed in the A horizons of the soils of the respective groups. Those soils in which the podzol development in the upper part of the solum is marked but the lower fine textured B_2 horizon is still sufficiently intact to influence the moisture regime, are classed in the Podzol group (3.5). The need for a Grey-Brown-Grey Wooded intergrade, i.e. Grey-brown podzolic soils with a thin A_1 horizon (3.15), has not yet been fully established.

In the sub-division of the Grey Wooded soils two weakly developed sub-units have been suggested; 3.22 is an intergrade to the Black soils (strongly degraded black) but more like the Grey Wooded than Black, and 3.23 represents the intergrade to the Brown Wooded soils. Whether two subdivisions (3.27 and 3.28) are required for podzolized Grey Wooded soils requires further study and consideration. The 3.27 (podzolized Grey Wooded) sub-grouping has already been mentioned above in connection with 3.14. The 3.28 sub-grouping was suggested for those Grey Wooded soils in which the upper A_2 is appreciably lighter in color and more unsaturated than the lower A_2 without any noticeable incipient B between these two horizons. It was suggested that the upper A_2 is more like the A_2 of Podzol than of Grey-Wooded soils. However, since no scientific data has been produced to date to support this suggestion, this unit might be deleted and the soils in question included with the modal sub-grouping.

The Humus Podzols have not been studied very extensively in Canada, hence the suggested sub-divisions for Category IV, based on the profiles studied to date, are tentative. The sub-divisions have been largely based on the kinds of formations that have been observed under the humus B horizons.

The Ortstein Podzols are tentatively sub-divided on the basis of the nature of the cemented B horizons. The 4.41 sub-grouping is suggested for those podzols with a thin, brittle iron pan (without an appreciable humus B), while 4.42 is suggested for the podzols with the thicker and more massive ortstein, cemented with sesquioxides and humus (usually associated with light textured soils). With the accumulation of more chemical data it may become advisable to sub-divide this unit further in Cat. IV on the basis of the major cementing material. The imperfectly drained ortstein (4.43) soils include some of the soils formerly classified as Ground-Water Podzols. Some of these soils have a B horizon quite high in organic matter and they need to be carefully integrated with 3.12 and 3.13 and defined accordingly.

In the sub-division of the Orterde Podzols, 3.51 is suggested for weakly developed or minimal Podzols (with thin A_2) which may be considered as Brown Podzolic intergrades. A number of soils formerly classed with the

Brown Podzolic soils will fall into this unit. The modal (3.52) soils of the group have a non-cemented and friable B horizon but there are a number of Podzol soils (particularly in Eastern Canada) in which the B horizon is quite firm (3.53) although not cemented. This condition is generally associated with certain parent materials. This suggested division will require further study and it may be more desirable to combine the two units, and to define them accordingly. The imperfectly drained (3.54) podzol is an intergrade to the gleisolic soils. It includes some of the soils formerly classed as Ground-Water Podzols (on sand and gravel), as well, as those referred to in the past as imperfectly drained Podzols.

The 3.55 sub-unit is suggested for the well drained Podzols with an organic B_1 sub-horizon which may be considered as an intergrade to the humus Podzols. The last three suggested sub-divisions 3.56, 3.57 and 3.58 are based on conditions in the lower part of the solum. The first of these (3.56) is designated for those Podzols in which the friable upper solum (A_2 and B_2) is underlain by a very compacted or cemented subsoil, often referred to as fragiopan. While the importance of this marked break in the subsoil is well realized, the differences in intensity or degree of compaction or cementation make it difficult at the present time to define these soils accurately. More investigations are required for the proper definitions if this unit is to be maintained. The Podzols with a clayey lower B (3.57) represent the intergrades to the Grey Wooded and Grey Brown Podzolic soils.

In the Brown Forest and Brown Wooded soils, 4.11 and 4.21, represent the modal soils of the two groups, respectively, and 4.12 and 4.22 the imperfectly drained members or gleisolic intergrades. The 4.13 and 4.23 groupings are intended for the regosolic intergrades and 4.14 and 4.24 for the degraded members of the respective groups, i.e., the Grey-Brown Podzolic and the Grey Wooded intergrades. The Brown Podzolic intergrade (4.15) is intended for those soils in which, due to a dilution of materials, the profile has acquired characteristics intermediate to those of the two groups.

In the Brown Podzolic soils the units 4.31, 4.32 and 4.33 are analagous to 4.11, 4.12 and 4.13 discussed above. A degraded member or Podzol intergrade (4.34) has been suggested but it is questionable whether it will be possible to define a unit intermediate in podzolic degradation between 4.31 and 3.51 and it may be necessary to delete this unit. Two other sub-divisions which were inadvertently omitted in the original scheme have been included in the present outline. 4.35 has been set up for the Brown Podzolic soils which have developed in the upper solum of Grey Brown Podzolic or Grey Wooded soils and in which the finer textured B_2 of the former soil is sufficiently in evidence to influence the moisture regime. 4.36 is suggested for those soils that are underlain by a fragiopan. Any statements made in connection with 3.56 also apply to this unit.

No sub-divisions are at present suggested for the Shotty Brown soils but it is expected that most of the categorical classes suggested for the Brown Podzolic soils will also apply to this group.

Tentatively the following sub-divisions are suggested for the Rendzina soils: 5.11 for the locally arid soils on knolls where a rendzina type rather than the zonal profile has developed. Whether this unit should be expanded in Category IV to separate the Brown, Dark Brown and Black Rendzina types or whether this separation should be made in Category III requires further consideration. 5.12 is suggested for the slightly depressional Rendzina types in which due to an influx of lime normal development has been restricted. These soils need not necessarily be imperfectly drained, hence the term used in the outline may be misleading. The Lithosolic Rendzina (5.13) is suggested for those soils in which the high lime content of the parent material and fragments of the parent rock throughout the soil have brought about the rendzina type of profile. The degraded Rendzina (5.14) is intended for those soils in which there has been some podzolic degradation associated with a partial removal of lime.

The sub-divisions suggested for the Regosols are connected with the nature of the parent materials.

5.21. The regolith or parent material consists of fine textured materials (usually heavy clay) in which little or no profile development (except for A_1 or A_o) has taken place.

5.22 parent material from which the solum has been eroded and no new profile has developed.

5.23. Recently deposited aeolion material other than dune sand.

5.24. Recent colluvial soil materials.

The Lithosols have been sub-divided into: those on calcareous materials (5.31) and those on non-calcareous materials (5.32).

The Dry sands have been sub-divided into recent Dune sands (5.41) and sands strongly resistant to pedologic weathering (5.42).

The Alluvial soils are tentatively sub-divided into those with a moderately developed A(A_o or A_1), (5.51), horizon. Further study may indicate the necessity of further sub-divisions of this unit in Category IV, which would permit the separation of gleisolic intergrades and of those soils in which the easily soluble constituents have been removed from the surface and faint tendencies towards the formation of the zonal soil are noticeable.

The second unit (5.52) presently suggested in the outline applies to the recently deposited materials in which an A horizon has not yet developed.

Tundra soils. The Committee is at the present not in a position to suggest a satisfactory sub-division in Category IV for the Tundra soils.

The Meadow soils have been sub-divided in Category IV into 5 units: 6.11, the normal or modal meadow; 6.12, the calcareous meadow (free lime at the surface and accumulation of lime in glei-like layer); 6.13, the Saline meadow (presence of soluble salts), an intergrade to 6.31; 6.14, degraded meadow, an intergrade to 6.61, and 6.15, peaty meadow - (a thin peaty layer over the A_1 horizon.)

The sub-divisions suggested for the Dark Grey Gleisolic soils are: 6.21, the normal or modal member; 5.22, the degraded member and 5.23, the peaty member.

The Solonchacks have been sub-divided into those with an A_1 horizon (6.31) and those without an A horizon (6.32). The need of a unit for a peaty Solonetz should be given some consideration by the sub-committee. Whether separations on the nature of the dominant salts should be made in Category IV or III should also be considered.

No further sub-divisions in Category IV have been suggested for the peaty glei in the present outline.

The only tentative sub-division in Category IV suggested at the present for the Podzol-glei and Grey-Wooded-glei are: the soils with a peaty surface layer and those without a peaty surface layer.

Category III

The level of abstraction of Category III corresponds very closely to the concepts of the Low Family of the U.S. Soil Classification Scheme. It is expected that when all soil families have been set up for all the soils which have been studied and defined to date there will be at least one, and generally more, soil families for each unit established in Category IV.

The Committee feels that it, as such, can not develop and suggest criteria for the setting up of the various soil families. This grouping will have to be developed on a provincial level with close integration and correlation between adjacent provinces. Some provinces have already proceeded with this project and have grouped all their soils into families, while other provinces have given little attention to this matter to date. The families should essentially consist of a grouping of closely, morphologically related soil series or catenary members. The characteristics involved in the establishment of the family grouping will, in the main, be more associated with the degree or

intensity of development rather than the kind of development. Generally the characteristics involved will be the same as used in the definitions of individual series but with wider ranges permitted in texture, lithology and mode of deposition, thickness of horizons, etc. than in the individual series. It is quite likely that the first attempt at such grouping will not be entirely satisfactory and it may be necessary to regroup the soils several times before satisfactory and logical units are obtained which can be properly defined.

Category II represents the soil series, catenary member or associate. It is essentially the basic unit of the entire classification scheme. Category I represents the soil type or the textural class of the series. As the concepts of these units are well understood the Committee does not offer any further suggestions regarding these at this time.

Sub-Committee

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PRELIMINARY OUTLINE FOR THE CLASSIFICATION OF CANADIAN SOILS

VI ORDER		V Group	IV Sub Group	III Family	II Series	I Type
. CHERNOZEMIC SOILS Soils with chernozemic* A_1 horizons, colored, structured or weakly textured B horizons; lack distinct A_2 horizons, generally Ca sub-horizon present. Moderately well drained* soils developed under grass. Major profile types A_1, B, C, A_1, A-B, C May have weakly developed sub-horizons of (A_2), (B_g), (B_{sa}). Major processes: calcification	on bases of organic matter and colour of A_1, relative depth of solum	.1 Brown	.11 Brown (Modal) .12 calcareous brown .13 degrading b. .14 solonetzic b. .15 solodic b. .16 saline b. .17 meadow-like (imperfectly drained)			
		.2 Dark Brown	.21 Chestnut (Modal) .22 calcareous d.br. .23 degrading " " .24 solonetzic " " .25 solodic " " .26 saline " " .27 meadow-like "			
		.3 Black	.30 Shallow black .31 Black (Modal) .32 calcareous blk. .33 degrading " .34 solonetzic " .35 solodic " .36 saline " .37 meadow-like"			
2. HALOMORPHIC SOILS Soils with A_1 or A_0 surface hor,		1 Solonetz	.11 Brown s. .12 Chestnut s. .13 Black s. .14 Wooded s.			

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VI		V	IV	III	II	I
2. HALOMORPHIC (Cont'd) strongly developed A_2 and with solonetzic* B; developed on saline parent materials Moderately well drained soils developed in arid or sub-humid regions on saline materials or in saline depressions. Profile types A_1, A_2, B, C, A_0, A_1, A_2, B, C, A_0, A_2, B, C. Major processes: desalinezation and leaching.	degree of A_2 and B develop and leaching	.2 Solodized solonetz	.21 Brown s.s. .22 Chestnut s.s. .23 Black s.s. .24 Wooded s.s.			
		.3 Solod	.31 Brown s. .32 Chestnut s. .33 Black s.			
3. PODZOLIC SOILS Soils with (A_2) bleached eluvial horizons and (B_2) illuvial horizons having accumulations of R_2O_3 and/or organic matter or clay (not solonetzic B). Moderately well drained soils of cool regions developed under forest and/or heath. Major profiles: A_1, A_2, B_2, C A_0, A_1, A_2, B, C A_0, A_2, B_2, C	clay accumulation in B	.1 Grey Brown Podzolic (with mull-type A_1)	.11 Grey Brown (Modal) .12 Weak dev. (Brown F.) .13 Imp. drained .14 Podzolized .15 Thin A_1 (Grey Wooded Intergrade)			
		.2 Grey Wooded (with Ao and/or weak A_1)	.21 Grey Wooded (Modal) .22 Dark Grey (Black Intergrade) .23 Brown (Brown wooded Intergrade) .24 Imperfectly drained .25 saline .26 solonetzic .27 podzolized (solum of podzol developing in A_2 of Grey Wooded) .28 ~~podzol-gr. w. (A_2(p) & A_2 (gw)~~ merge brown podzolic – G.W.			

Name used
Podzolized Grey Wooded

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VI	V	IV	III	II	I
3. PODZOLIC SOILS (Cont'd) May have a variety of sub-horizons; Major processes: decalcification and clay movement and/or podzolization. R_2O_3 and Org. Accum.	.3 Humus Podzols	.31 Heath type-Bh underlain by thin Iron pan* and/or oststein. .32 Heath glei podzol intergrade. .33 Depression (glei) type-Bh underlain by bog iron .34 Forest type-Bh over compact till, fragiopan or ortstein .35 Forest type-Bh over orterde .36 - - Bh over permafrost			
	.4 Podzols (ortstein)	.41 Thin iron pan .42 ortstein .43 imperfectly drained with ortstein .44 ortstein over permafrost			
	.5 Podzols (orterde)	.51 Thin A_2 (Brown Podzolic intergrade) .52 Loose friable B (Modal) .53 firm B .54 Imperfectly drained .55 within organic B_1 sub-horizon .56 Underlain by fragiopan .57 Underlain by clay B (G.B. or G.W. Intergrade) .58 Underlain by permafrost			
4. FORESTED BROWN SOILS Soils with an A_1 or Ao horizon over a color and/or structure B (lack distinct elluvial and illuvial horizons. calcareous ...ials-saturated	.1 Brown Forest (with mull-type A_1)	.11 Brown Forest (Modal) .12 Imperfectly drained B.F. .13 Regosolic B.F. .14 Degrading B.F. .15 Brown Podzolic Intergrade			

VI	V	IV	III	II	I
4. FORESTED BROWN SOILS (Cont'd Moderately well drained soils developed under forest Major profiles: Ao, B, C A_1, B, C Major processes: variable mainly weathering of upper horizons but without translocation of R_2O_3, org. matter or clay resulting in weak profile development. from non-calcareous materials unsatura-ted.	.2 Brown Wooded (with Ao or weak A_1)	.21 Brown Wooded (Modal) .22 ~~Imperfectly drained B. W.~~ .23 Regosolic B.W. .24 Degrading B.W. .25 With permafrost			
	.3 Brown Podzolic	.31 Brown Podzolic (Modal) .32 Imperfectly drained .33 Regosolic .34 Podzolized .35 With clayey B .36 Over Fragiopan .37 Over Permafrost			
	.4 Shotty Brown	---			
5. REGOSOLIC SOILS Profile development has been restricted mainly to the development of a surface (A_1 or Ao) due to the nature of the parent material, age, climate or position. Moderately well drained soils, (some Alluvial soils may be poorly drained), developed under various climatic and vegetative conditions. Major profile types: A C; C.	.1 Rendzina (dominated by lime)	.11 Arid .12 Imp. drained .13 Lithosolic .14 Degraded			
	.2 Regosols (Unconsolidated material little weathered due to its nature or recent exposure)	.21 Fine textured materials .22 Eroded soil materials .23 Recent aeolian materials .24 Colluvial			
	.3 Dry Sands (Dominance of resistant materials or recent deposition)	.41 Blow sands .42 Sands resistant to weathering			

VI	V	IV	III	II	I
5. REGOSOLIC SOILS (Cont'd) Major processes: mainly accumulation of organic matter and melanization. Development very weak.	.4 Alluvial soils (Recent deposition)	.51 A C .52 C			
	.5 Lithosols (Dominated by consolidated materials)	.31 Calcareous materials .32 Non-Calcareous materials			
	.6 Tundra (Permafrost and frost churning)	.61 - - - .62 - - -			
6. GLEISOLIC SOILS Soils with peaty (less than 12") or mineral surface high in O.M. or both and dull coloured subsoils (with chroma of 1 or less or not higher than P.M.) and/or with brighter coloured prominent mottles. Poorly drained soils developed under various climatic and vegetative conditions in the presence of high or strongly fluctuating water table. Major profile types: A_1, G, C; A_o, G, C, A_1, A_{2g}, B_g, C; A_o, A_{2g}, [illegible]	.1 Meadow (Wiesenboden)	.11 Meadow .12 Calcareous meadow .13 Saline meadow .14 Degraded " .15 Peaty "			
	.2 Dark Grey gleisolic	.21 Dark grey gleisolic .22 Degraded dk. gr. gl. .23 Peaty dk. gr. gl.			
	.3 Solonchack	.31 A C. .32 C			
	.4 Peaty glei	.61 - - - .62 - - -			
	.5 Podzolic glei	.41 Podz. glei .42 Peaty podz. glei			
	.6 Grey Wood. glei	.51 Grey Wooded glei			

VI	V	IV		III	II	I
7. ORGANIC SOILS Poorly and very poorly drained soils having an organic surface more than 12" thick and underlain by strongly gleied mineral soil. Profile types: O, D Major processes: organic accumulation and gleization.						

* Moderately well drained for this purpose includes imperfectly as well as well drained and some excessively drained soils. It does not include poorly and very poorly drained soils which are treated under Gleisolic and Organic soils.

* Chernozemic A_1 - see definition given by Smith in 4th U.S. approximation.

* Calcification - see definition given in Soils and Men

* Solonetzic B - see definition given by Smith in 4th U.S. approximation.

(If anyone has better definitions to offer - let's have them).

General Discussion

Leahey - It is very useful to be able to discuss the Canadian soils by themselves in individual groups or progressively larger units. Such a scheme assists in presenting a picture of our soil resources.

Stobbe - Will the seven classes suggested in Category VI take care of all the soils we have in Canada? The general consensus of opinion was - Yes.

Millette - There is a need for defining "humus layer".

Moss - In Chernozemic soils there is a need to stress synthesis and accumulation of humus in A_1.

Stobbe - The term calcification includes the formation of humus in A_1.

Odynski - We have to define the terms of reference for each category and segregation.

Stobbe - The suggested sub-committees should review and define each categorical unit within the proposed framework.

Hutcheon - Does brown solonetzic in Category IV, 1.14, differ from Solonetz 2.11.

Stobbe - 1.14 is essentially a Brown soil that is slightly solonetzic, not enough to warrant separation, while 2.11 is a Solonetz in all respects but happens to have a brown surface.

Hutcheon - All Solonetzic soils should be sub-divided in Category V as Halomorphic soils and kept out of Category IV of Chernozemic soils, otherwise one can get into embarrasing situations when teaching.

Leahey - In Category IV of Chernozemic soils A_1 is most significant while in Halomorphic soils A_2 and B_2 are most significant horizon.

Moss - We can fit our soils into the scheme with reservations. First we have to agree amongst ourselves, in a province and in adjacent provinces. Our concepts of Solonetz and Solodized Solonetz has changed. We now like to think of solonetz-like and of Alkali Solonetz. We can distinguish and differentiate between Black and Podzolic Solonetz but can not distinguish between Brown and Dark Brown Solonetz.

Stobbe - Our concepts of the Halomorphic groups has been, rightly or wrongly, based largely on morphology of the solum, rather than on the chemistry.

Ellis - The Solonetz morphology can be defined without references to salts.

Bentley - Questioned the placing of Solonchack soils in the Regosolic class instead of the Halomorphic.

Matthews - Questioned the use of different concepts or criteria for the sub-division of different groups in the same category. He felt the same concepts should be used in the same category for all the soils.

Stobbe - This would be very desirable but unfortunately it appears to be impossible. Each categorical unit has to be sub-divided on the basis of the differentiating criteria which are most relevant for that unit.

Ellis - Can other categorical units be added to Category IV?

Stobbe - Yes. The Scheme is expandable. If we find that provisions have not been made to accommodate certain soils, such provisions can be made.

Mitchell - Is there a climatic implication in the first Category (VI) except for Regosols?

Stobbe - Yes and No. We have tried to avoid zonal or climatic implication but we can not do so entirely. In classifying on strict morphological features we find that certain features are so closely associated with climatic conditions that the two are often inseparable.

Ellis - If we adopt this scheme some of us will have to reorient our thinking and change our concepts, particularly in regard to Rendzinas.

Stobbe - I think all of us will probably have to change some of our concepts. In the suggested outline Rendzinas will be confined to soils with an A_1 horizon over lime (without a B horizon).

Wicklund - Grey-Brown Podzolic and Grey-Wooded soils can be distinguished in the field on the nature of the A_2. He suggested a limit in the thickness of A_1 and differences in chroma of A_2 might be used as differentiating features.

Moss - Agreed that there might be difficulty in separating Grey-Brown Podzolic and Grey Wooded soils on the A_1 alone.

Odynski - There should be more correlation trips to test the suggested differentiating criteria.

Leahey & Odynski - Pointed out that the Brown Wooded soils generally contain more lime in the upper part of solum than the Brown Forest soils and on degradation form Grey-Wooded soils, whereas the Brown Forest soils form Grey-Brown Podzolic soils.

Lajoie - Pointed out that the word "Podzolic" should be dropped from the Brown Podzolic group and should be replaced by another term.

Leahey - Pointed out that Tundra may be Regosolic or Gleisolic. Most soils in Tundra probably fit best into the Regosolic Category. Permafrost alone is not enough to make a separation at a high level. A considerable percentage of the soils in the Tundra region will fit into other soil groups than the Tundra group.

Mitchell - Do the Solonchacks include salty soils with a high pH?

Stobbe - That has been the intention. Sub-divisions on the basis of pH and kinds of salts present are intended for Category IV.

Stobbe - The Committee is at present not in a position to make any definite recommendation in regard to the classification of the Organic Soils.

Odynski - They should be classified on parent material - vegetation.

Stobbe - This is not always so simple. Many organic soils consist of a number of layers of different materials.

Cann - The decomposition of the organic material is also very important and it is frequently related to the nature of the material.

Leahey - There are over 200,000 square miles of organic soils in Canada and we have not made a thorough study of these soils yet.

Mitchell - Suggested that a special sub-committee should be established for Organic Soils (General Agreement).

Simonson - The U.S. Soil Survey has one man (Dawson) who devotes his entire time to the study of Organic Soils.

Ripley - The grouping at the family level will probably be the grouping that most use will be made of by the Agronomist and therefore this grouping should be developed as soon as possible.

Ehrlich - This will require considerable correlation between provinces.

Stobbe - Supported the idea that there should be more correlation, some can be done by correspondence, some has to be done in the field, and it will require considerable time of the senior men.

Moss - We are seriously understaffed on the National basis.

Ripley - If it is possible to set up new positions we might get more correlators, particularly in the West.

Ehrlich - In Manitoba and Saskatchewan we have not mapped series and often it is impossible to map series. How will this effect the classification scheme?

Stobbe - Where the mapping has been done on an Association or Catena basis, it is taken for granted that the Associations are defined in terms of the component soils (members or associates). In the classification, be it on the family level or in the higher categories, only the components of the different associations can be grouped together and not the associations as a whole. Where the associations have been properly defined in terms of soil components, there should be no difficulty. These units can be classified without actually having been mapped individually.

Richards - What should be our status with regard to this classification in relation to the current reports and pending publications.

Stobbe - I would like to suggest that, although we seem to agree on the general outline of the scheme, its application in published reports should be delayed at least until the various committees have defined the respective categorical units and the various soils have been fitted into their respective places. The question of names has also not been settled yet. The introduction of some of these names into the general literature at this time may cause difficulties if we decide to change them after further study. I believe we should, for the present, publish as we have in the past.

Ellis - In referring back to organic soils stressed the importance of depth of peat in their classification and wondered if 36" would be the proper depth to distinguish between shallow and deep Organic Soils.

Stobbe - According to the scheme, Organic Soils 12" or less in depth will be classified as peaty members of the respective Gleisolic groups. What other depth should be used in the classification of these soils will have to be suggested by the proposed committee.

Newton - Questioned the desirability of mapping series of Organic Soils.

Stobbe - Felt this would have to be done. If we had mapped series more consistently in the past we would know more about the Organic Soils now.

Leahey - Moved and Chancey seconded the acceptance of the Committee's Report, - Carried.

Ellis - Expressed his sincere appreciation to the Committee and its Chairman for the presentation of the report. He felt that the Committee had made real progress.

Matthews - Moved and Richards seconded a vote of thanks to the Chairman of the Committee.

Report of the Sub-Committee on Landscape Features, 1955.

Members: L. J. Chapman; R. E. Wicklund; H. W. R. Chancey; A. Mailloux; H. C. Moss (Chairman).

Introduction

The Sub-Committee, after reviewing the 1948 Report, arrived at the following conclusions:

In the absence of any demands prior to the meeting, it was felt a complete revision of the 1948 Report was not required. This does not mean that the Sub-Committee regards the present classification of landscape features as either final or fully satisfactory. It is rather that other subjects, such as soil classification horizon terminology, and laboratory methods are more important problems at this time.

A few changes in the 1948 Report were agreed upon, notably in connection with the classification of stony conditions. It was decided that an additional class, Stones 5, was required to cover the extreme degree of stoniness encountered. It was also decided to recommend the adoption of the classification of rocky conditions given in the U.S.D.A. Manual. These changes are dealt with in the appropriate section of the revised report.

Finally, it was decided that the Appendix, dealing with land-forms, should be deleted, since it does not represent a complete list of the land forms of Canada.

Hence, for the 1955 report, Section 1 - Land Forms and Topographic classes is virtually unchanged. Section 2 - Erosion and Stoniness, is unchanged except for the revision of stony conditions as mentioned above. Section 3 - Land Use and Vegetative Cover is unchanged.

The bulk of the report is, therefore, the work of the 1948 Sub-Committee which consisted of: L. J. Chapman; R.E. Wicklund; F. F. Morwick; D. G. Laird; W. A. Erhlich, and H. C. Moss, (Chairman).

SECTION 1 -- LAND FORMS AND TOPOGRAPHIC CLASSES

(a) Land Forms:

Since this topic was not discussed in the original report, the recognition of the land form as a basic factor in soil survey work and the preparation of a list of land form features for Canada constitute two important tasks for this Sub-Committee. Topography, geological deposits, drainage, vegetation, land use, stoniness, erosion and the soil profile are ali elements of the land form, and variations in these elements are associated with variations in the earth's surface that characterize the different land forms. Therefore, the recognition of the land forms and their component elements should form the preliminary step in the soil survey of a given area.

Can we define the land form so as to indicate both its nature and origin? In our recent studies, we did not find a clear definition in the literature at our disposal. It was suggested that the land form might be defined as: "A recurrent topographic feature". A land form may be recognized and identified by its form and nature as determined by the pattern of the elements of relief and slope, (topography) and the geological materials of which it is composed; the distinctive features of a land form are the combined result of earth movements, surface forces of denudation and deposition and the time element, acting upon the geological material.

The value of the recognition and study of the land form as a basic factor in soil survey work may be summarized as follows:

1. The modern soil survey cannot be, and indeed should not be, confined to the classification, description and mapping of soil profiles. The experienced pedologist is in a position to make an important contribution to the geography of his region by showing the relationship between the soil and all other natural and cultural features. The relationship between pedology and geography is implied in the terms "soil geography" and "soil landscape". A knowledge of both the soil and the land form is essential to any study involving the proper use of these terms.

2. The major land forms are an expression of the physical geography and the geology of an area. Hence even the preliminary description of a surveyed area in the soil report requires an appreciation of the land forms.

3. In most Canadian soil surveys, several soil series or other units may be recognized as forming related groups of soils (catenas or associations). In many instances, prior knowledge of the land form will suggest the types of soil profiles that are likely to be encountered, and the sites at which they will occur; or in other words, the pattern in which soil types are found.

4. Similarly, a knowledge of a particular land form will often suggest the pattern and range of relief and slope, thus indicating what topographic classes are likely to be encountered in mapping the area.

5. More use is now being made of aerial photographs in soil survey work. The modern methods of air photo interpretation require the interpreter to possess a sound knowledge of land forms and associated geological deposits.

6. The land form is an important aid to the appreciation of the cultural geography of an area, the development of land and other natural resources, the location of railways, roads, towns, etc. Such information is required for the soil report.

In defining land forms, it will be necessary to consult the literature of geography and geomorphology and to become acquainted with standard definitions. In preparing the material for this section, a number of standard texts were consulted, and as requested by the Sub-Committee, these are listed below:

"Elements of Geography (Physical and Cultural)"
Finch and Trewartha, McGraw-Hill 2nd Ed. 1942.

"Geomorphology -- An Introduction to the Study of Landscapes"
Lobeck, McGraw-Hill, 1939.

"New Physical Geography"
Tarr and Von Engelin, MacMillan, Rev. Ed. 1929.

"Outline of Glacial Geology"
Thwaites, - Edwards Bros., 1937.

"The Scenery and Structure of Britain"
Dudley-Stamp.

"The Physical Basis of Geography - Woolridge and Morgan"
Longmans, Green & Co., 1948.

It was felt that Finch and Trewartha represent a good introduction to the concept of the major land forms, particularly from the point of view that is of particular interest to the soil surveyor.

Lobeck and Thwaites are very useful at a later stage when individual types of land forms are being studied and classified. Dudley-Stamp indicates the value of the geomorphological approach to the study of a specific region.

Since the Sub-Committee is dealing with the land form for the first time, particular use has been made of Finch and Trewartha in the following discussion. These authors start with four major land forms -- Plains, Plateaus, Hill Lands and Mountains, leading to a discussion of different types of each major form and the recognition that each type includes surface features of a smaller size. Thus we may proceed from the recognition of the major land form to the local elements that make up a local soil landscape. Conversely, a series of recurrent local features may be recognized as the elements that make up a major land form.

How far should we proceed in the classification of each major land form? Plains, for example, may be classified according to:

(a) climatic conditions - as humid-tropical, semi-arid, etc.
(b) situation - coastal, interior, etc.

(c) geology - plains of sedimentary rocks, glaciated plains, etc.
(d) comparative roughness - relief and slope (topography).

The authors point out that the last classification is particularly useful to the geographer because topography indicates, in part, relative ease of land utilization, drainage, arability, etc. Furthermore, the topographic feature is measurable with some accuracy in terms of relief and slope. Obviously these statements also apply to the work of the soil surveyor or pedologist.

A complete definition of a plain would involve the recognition of all types of classification, so that a portion of Western Canada might be described as an undulating, semi-arid, glaciated interior plain. It is apparent that the information contained in the above definition is required for the soil survey, whether or not the study of the "land form" is consciously used to secure such information. It follows that the recognition of the land form should materially assist the pedologist to obtain a complete picture of a given area and should ensure greater uniformity in the description of natural regions throughout the Dominion.

The value of the land form concept to the soil surveyor is increased if we take into account the materials composing the land form and the forces which have produced the land form as we see it today. The recognition of the materials will enable us to include the various rocks as defined by the geologist and the surface deposits which form the source of soil parent materials. The recognition of the forces involved in the development of the land form is equally important.

Forces originating within the earth tend to cause great and wide-spread differences in surface elevation. Forces originating without the earth tend to wear down the elevations and reduce the surface to a uniform and low grade. The conflict between these two opposing forces has produced the great variety of surface features that characterizes the earth today.

The work of the forces originating outside the earth is most familiar to the soil surveyor. Erosion and deposition are both involved, and these processes are carried on mainly by water, wind and moving ice. The work of these natural agents not only moulds the topography and influences the drainage, but also lays down the surface deposits which form the parent materials of the soil. The effects of climate and vegetation, acting through time, result in the development of the soil profile. The cultural features introduced by man complete the picture of the present landscape. We may introduce the term "soil landscape" to emphasize the specific nature of our work as pedologist, and by so doing, we imply a knowledge and recognition of the land form and its elements.

Since the National Committee accepted the foregoing concept of the land form and its relation to the soil survey, the next step is the compilation of a classified list of land forms occurring in Canada and encountered by Canadian Soil Survey organizations. It was not possible to prepare such a list in time for the meeting, and furthermore the Sub-Committee desired to secure the support of the whole Committee before making specific recommendations. Preliminary lists of land forms were received by the Sub-Committee from British Columbia, Ontario and Saskatchewan. As requested by the general meeting, these will be forwarded to all Canadian soil survey organizations. The various organizations will be asked to add land form features not included in the present list, or if they desire, to submit a complete list of the land forms for their own region. When all the material has been received, it will be compiled for the Proceedings of the second N.S.S.C. meeting and included with the report of the Sub-Committee on Landscape Features.

To assist in carrying out the above programme, the Sub-Committee offers the following suggestions for the study of the land forms of Canada:

1. Preparation of a list of the major and secondary land forms so far encountered in soil survey work. (Major forms refer to Plains, Plateaus, Hill Lands and Mountains, and secondary forms to sub-divisions of these--as till plains, lacustrine plains etc.). The land forms should correspond as far as possible to the types defined by the geographer or geomorphologist. Some land forms, however, cannot be identified by reference to standard text books, and it will undoubtedly be necessary for the pedologist to define these himself. Wherever possible, such definitions should be confirmed by competent authorities.

2. Recognition of the associated surface geological deposits. The deposits recognized as those defined by the geologist, or where the pedologist has had to define them, confirmed by the geologist.

3. Preparation of a key or system of classification wherein the relationship between major and secondary land forms is indicated.

4. A description of each land form to accompany the key, ranging from the larger features to the local elements of the landscape (and including any information on geology, climate, vegetation, topography, drainage, soils, land use, etc. that is deemed essential or desirable).

5. Field studies to modify or extend the original classification of land forms. A study of representative aerial photographs may precede or accompany the field work, in order to identify the air photo pattern of specific land forms. Ultimately, the characteristic air-photo pattern might be written down and added to the description of each land form.

It is suggested that the study of the land forms as outlined above will assist the pedologist in setting up a soil classification and mapping legend for any given area. If this can be done prior to the commencement of the actual survey, the field men will have a clear picture of the physical features of the area, and it will be easier for different parties to achieve uniformity in soil mapping. In addition, a great deal of basic information required for the soil report will have been secured.

(b) Topographic Classes

The topographic factor seems to present some difficult problems. Topography is an element of the land form--in fact, the most important element from the standpoint of recognizing different major land forms. But it is most commonly regarded as a soil phase--an external factor that affects the use of the soil. As a phase, topographic separations are usually made on the basis of slope differences in surface drainage, potential erosion and the use of farm machinery. However, these land use differences are not due to slope alone. The designation of a slope class in relation to drainage or potential erosion is meaningless unless it is applied to a specific soil type. Furthermore, the elements that go to make up the concept of topography--elevation, slope (in range and shape) and aspect are also recognized as elements of a major factor of soil formation.

It is suggested, therefore, that topography be regarded first as part of the land form, and that we associate with each land form characteristic types of topography. The relation of each type of topography to erosion, drainage, etc. would be described in the report for each soil type. But if we can agree that moderately sloping topography can be defined within measurable and recognizable limits, and if we desire to show this class on the map, then it should be shown as a surface feature--an expression of a land form or of a section of a land form, and without regard to accelerated erosion, movement of farm machinery, or whether the external drainage is medium or rapid. Since the soil might be anything between a porous loamy sand and an impervious heavy clay, the topographic class cannot by itself indicate the specific conditions of drainage and erosion or the extent to which various farm implements can be used successfully.

This suggestion does not imply that topographic separations are not related to land use. Flat-depressional topography is associated with varying degrees of poor drainage that directly affect land-use; at the other extreme steepness of slope becomes a limiting factor in the arable use of land, although even here the type of soil and the factors of climate and geology make it impossible to set a universal limit on arability based on steepness of slope alone.

In the most detailed surveys, where all mappable soil differences may be separated and shown on the map, the land form and its characteristic topographic features will, so to speak, be cut into little pieces. Soil type

boundaries will more nearly coincide with slight changes in slope, and the term "slope phase" can be more logically employed. But in reconnaissance mapping, where catenas or even complexes of catenas may form the mapping unit, broader topographic separations will likewise be necessary. The boundaries of these broader separations tend to coincide with catena boundaries, and the type of topography is associated with specific land forms. Thus we may separate rolling morainic, undulating ground morainic, nearly level glacial lacustrine, dune topography etc. The restrictive definition of a single phase cannot be applied to such broad topographic separations, since as with soils, a complex of topographic phases may occur within a soil area shown on the reconnaissance map.

From the standpoint of describing the topographic features of the landscape, the following terms are in common use. These are given as examples and the list is not intended to be complete.

1. Depressional -- Undrained basin.
2. Flat -- Level or nearly level.
3. Sloping -- Single slope, smooth surface.
4. Steep -- Single slope, smooth surface; steeper slopes and greater relief than Sloping type.
5. Undulating -- Complex slopes, irregular surface.
6. Rolling -- Complex slopes, irregular surface, steeper slopes and greater relief than Undulating type.
7. Hilly -- very steep (high relief) single or complex slopes.
8. Dune -- characteristic dune formation.
9. Eroded or rough, broken land, in which only small remnants or none of the original upland surface remain. Includes severely dissected and badland topography.
10. Dissected -- Original surface broken and lowered in places by processes of natural denudation.
11. Morainic -- Undulating to rolling topography with specific features characteristic of glaciated regions. These features include the glacial kettle or basin and the stony glacial knob and ridge. The term "rolling morainic" topography would therefore imply a specific type of rolling surface. (The adoption of morainic as a topographic type introduces the land form and suggests that undulating or rolling lacustrine, undulating aeolian etc. may also warrant consideration).

The main types of topography listed above are partly distinguished from each other by their form or appearance. Some types, however, have the same general form, and must be separated by defining the limits of the percent of slope. Thus, undulating and rolling topography may be hard to separate by description alone, and it would appear that we should establish an arbitrary difference in relief, as measured in percent of slope. If we agree that rolling land is characterized by steeper slopes (greater relief) than undulating land, then a slope limit should be set, above which complex sloping land should be designated as rolling, and below which it should be classed as undulating. Limits or ranges in percent of slope are also required if we desire to subdivide any one type of topography into more than one class. We may decide that uniformity within a major type of topography is not feasible for the whole of Canada, or that it may not even be necessary. We should, however, attempt to reach agreement on the differences in slope that will permit separation of undulating from rolling land, sloping from steep, and sloping from level--depressional.

Classification of Topography for Soil Surveys

It is suggested that for soil survey purposes two main types of topography may be recognized, based upon the surface features:

A - Simple topography, corresponding to the U.S. single slopes.
B - Complex topography, corresponding to the U.S. complex of slopes.

It is further suggested that each of the two types of topography may be divided into three main classes on the basis of differences in % slope.

I.	Depressional to Level	- 0 - 0.5% slopes
II.	Sloping	0.5 - 30% "
III.	Hilly	Over 30% "

Finally a number of sub-classes may be established. A key to the classification is presented below:

A. Simple Topography (Single slope, smooth or regular surface)	B. Complex Topography (Multiple slopes, irregular or rough surface).	Slope
	Depressional to Level	
A_0 - Smooth undrained basin	B_0 Irregular (hummocky) basin	0%
A_1 - Smooth level	B_1 Irregular level	0-0.5%
	Sloping	
A_2 - Smooth very gently sloping	B_2 Irregular very gently sloping	0.5-2.0%
A_3 - Smooth gently sloping	B_3 Irregular gently sloping	2-5%
A_4 - Smooth moderately sloping	B_4 Irregular moderately sloping	6-9%
A_5 - Smooth steeply sloping	B_5 Irregular steeply sloping	10-15%
A_6 Smooth very steeply sloping	B_6 Irregular very steeply sloping	16-30%
	Hilly	
A_7 Smooth hilly	B_7 Irregular (rough)hilly - over	30%

30 - 60

over 60

The letters and numerals serve as a guide to the type, class and sub-class of topography. Thus all A topography denotes single slopes of smooth surface and all.

B. Topography denotes several (or complex) slopes of irregular broken surface. In both types the numerals represent increasing grade or greater relief in passing from 1 to 7. Zero represents the absence of slope.

The foregoing classification of topography was adopted at the 1948 meeting. The Sub-Committee had originally prepared a classification scheme in which descriptive names such as gently undulating, moderately rolling, etc. were defined in terms of percent slope, shape of slope, and frequency of dominant slopes. However, the National Committee could not agree on the basic definitions of undulating and rolling topography, and hence the present classification was prepared and submitted at the 1948 meeting.

Discussions during the 1955 meeting indicated that considerable confusion exists regarding the use of the present classification of topography. So far as the Sub-Committee is concerned, the present classification was intended for those who could not accept proposed definitions of descriptive terms for topography. For those who did use descriptive names the classification units, if acceptable, were to be appended to the descriptive names. In this way everyone would know what a particular survey organization meant by such a term as gently rolling.

To give an example, the following description is adapted from the classification used in Saskatchewan:

Gently rolling topography - irregular surface, formed by recurring pattern of ridges and knolls, intermediate slopes, and level to depressional lower areas. The dominant slopes range from over 5% to 9% and the frequency or number of major ridges per 1/2 mile is 2 or more. This means there are 4 or more dominant slopes per 1/2 mile, and that the length of slope from ridge-crest to lowest land is 220 yards or less (B4 topography in N.S.S.C. classification).

It will be evident that the symbol 'B4' may be used on field sheets to indicate the topographic features described above. However, the soil mapper thinks of such an area as a gently rolling soil landscape, and not merely as an arbitrary separation of slope classes.

To give a more detailed picture of the landscape, gently rolling areas may be subdivided on the basis of low and high frequencies. Thus, gently rolling land with a frequency of 2 may be described as gently rolling topography, of low frequency or widely-spaced ridges. Gently rolling land with a frequency of 4 or more may be described as gently rolling, - high frequency, or closely-spaced, and referred as rough or 'choppy'. These differences may be indicated by using B4.1 and B4.2 to represent the low and high frequency conditions respectively. Where it is not feasible to measure the number of major ridges or slopes per unit distance, the same result may be obtained by defining the frequency in terms of length of dominant slopes. Thus the high-frequency (rough or 'choppy') topography described above will have dominant 6% to 9% slopes of approximately 100 yards or less in length. If the low land consists of ponds or sloughs (glacial kettles) the average length of slope may be considerably shorter, and the landscape will consist of frequent knolls or ridges, short slopes, and local depressions. Such a more detailed classification may be applied to other irregular or 'B' topographies.

In broad reconnaissance mapping it may not be possible to separate all types of topography indicated in the N.S.S.C. classification. Thus a soil landscape may be composed of local areas of gently undulating to gently rolling topography which cannot be shown on the reconnaissance map. Such areas may be shown as a mixed topographic class, and described as mixed gently undulating and gently rolling topography (B_3 and B_4 topography in the N.S.S.C. classification).

Another example is that of a long, smooth, 10% slope, broken by local mounds or knolls with irregular 3% slopes. On a reconnaissance map the whole area may be described as a mixed steeply sloping - gently undulating landscape, and represented by A_5/B_3 - a dominant smooth, steeply sloping topography broken by local areas of irregular (gently undulating) topography. It is suggested that mixed topographic classes as outlined above might be referred to as compound topography. It will be obvious that in detailed soil mapping, the component units of compound topographies would be described and shown separately on the map.

SECTION 2 -- EROSION AND STONINESS

(a) Erosion.

Reference to the original sub-committee report (Proceedings of the N.S.S.C. 1945) indicates that accelerated erosion is not mapped in all provinces, although the problem of erosion on individual soil types is presumably discussed in the soil report. The increasing severity of erosion in many parts of Canada and the greater public recognition of this problem suggests that the Soil Survey should be equipped to classify and map accelerated erosion when required. The decision as to whether erosion classes shall be shown on published maps must be made by the individual regional survey organizations. It is suggested, however, that a method of classifying and indicating various degrees of erosion on field sheets or maps should be agreed upon. In this way the survey organizations desiring to record the occurrence of erosion as an aid to writing the report or to provide useful information on individual farms, will have a standard method to follow. The method may also be useful in the

event that the Soil Survey is requested to make a special map of eroded soils. It is suggested that in classifying erosion, the soil surveyor should take account of the following conditions.

1. Two types of erosion should be recognized and treated separately:

   (a) Normal or geological erosion--characteristic of the land form under natural conditions; and
   (b) Accelerated erosion - erosion greater than the normal geological type, and generally due either directly or indirectly to the activities of man.

2. As suggested by Dr. Kellogg at the first meeting, the soil surveyor should distinguish between the susceptibility of the soil to erode, and the degree of erosion that has actually occurred as it affects the nature and productivity of the soil.

3. Generally speaking, accelerated erosion should be shown on the map only when it is severe enough to warrant a change in land use recommendations. Indications of slight erosion may be shown on the field map, to assist in writing up the soil type for the report and as useful information of local conditions.

4. It was pointed out at the meeting that the soil mapper should exercise care in placing erosion symbols on the field map. If he is engaged in mapping erosion classes in a detailed survey he will be able to establish a boundary for any mappable erosion class. However, where erosion is not mapped but only indicated on field sheets, there exists the problem of dealing with small scattered areas of severe or very severe erosion. If symbols representing these conditions are placed on a field sheet or map, the impression given is that the whole field, quarter section, or farm is affected. The actual area affected by serious erosion is thus greatly exaggerated. Hence the interpretation of field map symbols should be left to the soil survey staff. It was suggested that special symbols might be added to the standard symbols to indicate proportion of area affected by erosion.

In discussing the classification of wind and water erosion at the meeting, the majority of opinion favoured the adoption of a modification of the U.S. Soil Conservation Survey system, whereby erosion is defined in terms of the soil removed. It was decided, however, that the terms proposed should be regarded as a general guide or aid to classification, and that the decision to describe a particular soil area as severely eroded must be the responsibility of the competent soil surveyor who is familiar with the type of soil.

An alternative approach suggested that in classifying erosion, emphasis should be placed upon the profile horizons that remain, rather than upon the material removed. This was proposed because it is upon the soil that remains that crops have to be grown or erosion control methods applied. The experience of one survey organization also showed that the attempt to estimate percentage removal of the A horizon is impracticable where complex topographic conditions are associated with variations in the thickness of profile horizons. However, the designation of slight to very severe erosion by standard symbols will achieve reasonable uniformity in the description of erosion conditions across Canada, irrespective of the methods used to define each class.

The proposed classifications of accelerated wind and water erosion and deposition are given below. The classification is applicable to well developed profiles whose A horizons are of greater thickness than the ordinary cultivated surface layer. Weakly developed profiles such as those associated with recent alluvial deposits will require special treatment in order to estimate what part of the soil has been removed. Similarly soils with very thin A horizons will have to be classified separately. For such conditions the judgment and knowledge of the respective soil survey staffs must be used to establish the class of erosion.

Water Erosion

Sheet Erosion -- Sheet erosion refers to the periodic removal of the soil in relatively thin sheets, or in rills which are usually obliterated by cultivation.

W_1 - Slight erosion. Less than 25% of original A horizon removed. ✓
W_2 - Moderate erosion 25% to 50% " " " " "
W_3 - Severe erosion 75% to 100% " " " " " and subsoil eroded in places.
W_4 - Very severe erosion--all of the A horizon removed and subsoil and parent material eroded.

Gully Erosion -- Gully erosion refers to accelerated erosion caused by the concentration of run-off water in channels that cannot be obliterated by tillage methods alone. Both size (width and depth) and frequency of gullies must be considered from a land use standpoint.

E_1 - Shallow occasional gullies--may be crossed by farm implements and occur over 100 feet apart. ✓
E_2 - Shallow frequent gullies--may be crossed by farm implements but occur less than 100 feet apart.
E_3 - Deep occasional gullies--cannot be crossed by farm implements. Change of land use indicated.
E_4 - Deep frequent gullies--cannot be crossed by farm implements. Change of land use indicated.

Accumulation of Eroded Materials

+- Recent accumulations less than 12" thick, resulting from accelerated erosion, and not including normal flood plain deposits. ✓
1 + 2 + etc. -- Thickness of accumulations in feet

Wind Erosion

D_1- Slight erosion. Less than 25% of original A horizon removed. ✓
D_2- Moderate erosion. 25% to 50% " " " " "
D_3- Severe erosion. 75% to 100% " " " " "
D_4- Very severe erosion. All of the A horizon removed and subsoil and parent material eroded.

Special Symbols

(4)- Blow-pit removal. Number indicates depth in feet.
5- Recent dune or dune-like accumulation. Number indicates height in feet.
- Hummocky - area of mixed removal and accumulation.

(b) Classification of Stony and Rocky Land ✓

The 1948 classification of stony fragments was abolished at the 1955 meeting, and the U.S.D.A. classification of coarse fragments was adopted.*

The 1948 classification of stony land was modified to permit the inclusion of class Stones 5. This class was required to cover such features as boulder pavements, in which the land is essentially paved with stones and arable agriculture is impossible. The revised classification is given below.

Stones 1 - slightly stony land - some stones, which offer only slight to no hindrance to cultivation.
Stones 2 - Moderately stony land - enough stones to cause some interference with cultivation.
Stones 3 - Very stony land - sufficient stones to constitute a serious handicap to cultivation, some clearing required.
Stones 4 - Exceedingly stony land - sufficient stones to prevent cultivation until considerable clearing is done.
Stones 5 - Excessively stony land - too stony to permit any cultivation (boulder or stone pavement).

* Soil Survey Staff, U.S.D.A., Soil Survey Manual. Agric. Handbook No. 18, 1951, page 214, Table 3.

It was also agreed that Table 4 (page 220) of the U.S.D.A. Soil Survey Manual should be used to obtain the relationship between size and spacings of stones, area covered in percent, and cubic yards of stones. The objective is to see to what extent the stony classes can be defined in terms of measurable quantities of stones.

At the 1955 meeting it was further agreed that the classes or rockiness given in the Manual (pages 220-221) should be adopted by Canadian soil survey organizations. It was decided, however, that the agricultural significance and description of classes of rockiness should be determined by each regional organization. It will be noted that the classes of rockiness are comparable to those of stony land.

Table 2 - Names used for coarse fragments in soils[1]

Shape and kind of fragments	Size and name of fragments		
	Up to 3 inches in diameter	3 to 10 inches in diameter	More than 10 inches in diameter
Rounded and subrounded fragments (all kinds of rock).	Gravelly	Cobbly	Stony (or bouldery)[2]
Irregularly shaped angular fragments:			
Chert......................	Cherty	Coarse	Stony
Other than Chert	(Angular) gravelly	Angular cobbly[3]	Do.
	Up to 6 inches in length	6 to 15 inches in length	More than 15 inches in length
Thin, flat fragments:			
Thin, flat sandstone, lime-stone, and schist.	Channery	Flaggy	Stony
Slate	Slaty	"	"
Shale	Shaly	"	"

[1]The individual classes are not always differentiating characteristics of mapping units.

[2]Bouldery is sometimes used where stones are larger than 24 inches.

[3]Formerly called "stony".

SECTION 3 - LAND USE AND VEGETATIVE COVER

Classification of vegetative cover as used in Canadian Soil Surveys was presented at the 1st Conference of the National Soil Survey Committee (1945) under "Report of the Sub-Committee on Landscape Terminology". Following that conference the study was extended to include "land use" and the surveyors in the various Provinces were asked to report changes or developments in respect to "Land Use and Vegetative Cover" for the 1948 conference.

In order to harmonize the statements from the various Provinces each was requested to report its practices under six headings. These reports are summarized as follows:

1. LAND USE AND VEGETATIVE COVER FEATURES RECORDED ON SOIL SURVEY FIELD SHEETS

On Prince Edward Island and in Quebec land use and vegetative cover features are not recorded on field sheets of a reconnaissance survey except in a general way. Such, when obtained, are written up in the survey report. Marsh and forested areas are shown on the base maps used on Prince Edward Island and in Ontario.

Present land use is not mapped in detailed reconnaissance surveys in Ontario but is described in series descriptions. Erosion-land use surveys for conservation studies involve present land use.

In conducting a reconnaissance survey in Manitoba, land use notations appear on field sheets as:

Cultivated (Estimated acreage in percent)
Non-arable (Estimated acreage in percent)
Abandoned
Wooded
Meadow
Swamp
Urban

In the case of a detailed survey the above are noted with the first two groupings broken down into fallow, kind of crop, pasture (sown or native) and waste.

Features shown on field sheets in Saskatchewan:

Agricultural land use - cultivated, cropped, seeded to forage, native pasture and hay, abandoned, irrigated.
Vegetative cover - grass, shrub, trees and combinations.
Special features - waste land, urban.

Also standard map symbols for marsh, water, etc. land use and vegetative features are recorded in part on field sheets of broad reconnaissance surveys while more complete use is made only in a more detailed soil or special surveys.

Following are land use features recorded in Alberta:

Cultivated or non-cultivated
Native pasture
Wooded
Timber land
Bogs

At the same time vegetative cover is noted in field write-up books but very little on field sheets. A short vegetative survey is made and samples of dominant species collected for identification. In the northern part of the Province cover is mapped and graded according to ease of clearing.

While information is placed on the field sheets in British Columbia and some appears in the field note books, the greater portion of such data is placed on the aerial photographs in the field.

Land Use in B.C.

Cultivated - land use partly expressed in terms of type of farming.
- mixed cropping practice as where dairying or mixed farming is dominant.
- cereals.
- seed production - grass, clover or alfalfa.
- tree fruits, small fruits , etc.
- land clearing in progress - careful notation is made as to the apparent productive power of each mapped soil type based on crops being grown.

Range - in native pasture or grassland.
Wooded
Bog
Waste

Vegetative Cover - dominant trees, shrubs, grasses, etc.

Forested - virgin, logged, burned, ease of clearing, etc.
Parkland -
Range or grassland
Muskeg - sedge, meadow, sphagnum - deep or shallow, floating.

2. EXTENT TO WHICH PLANT SPECIES OR COMMUNITIES ARE USED TO INDICATE SOIL FEATURES

On Prince Edward Island plant species are not used as indicators of soil features. Value considered to be questionable in a Province where 83% of land is farmed and practically all forest cover is second growth. A detailed study of herbaceous plants and indigenous grasses may provide useful information but is not possible in a reconnaissance survey.

Have been unable in New Brunswick to establish any definite relation between soil morphology and variations in vegetation. Plant species are, however, used to indicate drainage conditions and to some extent as indicators of light textured soils. For instance, where Jack Pine occurs in abundance light textured soils may be expected, while Black Spruce and Tamarack indicate poor drainage. Notes taken on vegetation are included in the soil type description.

The Forest Service in New Brunswick is making forest cover maps for the entire Province and it is hoped to superimpose the soil boundaries to determine the relation if any between soil and dominant vegetation.

In Quebec plant species or communities are not used to indicate soil features - simply to record plant species and associations in the different soil types. Tree species noted particularly as lands are predominantly forested. It is believed that relationship between soil and crop production requires detailed studies which cannot be made during initial work of soil survey.

In county surveys throughout Ontario many plant species are used as indications of nature of soil. The Provincial Forestry Department is making surveys in Northern Ontario using tree species as indicated on aerial photographs and through ground examination at specific points thereby correlating tree species with soil.

In Manitoba plant species are not used to indicate soil features but a survey of common plant species and their distribution by landscape areas is made. Some plant species are indicative of soil conditions but with altered drainage the plant species may not indicate the character of the soil.

In Saskatchewan plant species have been shown on detailed soil maps of proposed irrigation areas to tie in with saline, solonetzic and well drained land and to secure a record of vegetation prior to irrigation. In broader irrigation surveys of large areas, recently conducted, this detail has not been possible. The identification of particular plants or associations in the field assists the surveyor by suggesting the presence of associated soil profiles; hence plant cover should be observed even when it cannot be mapped. Co-operative studies of research pasture areas by ecologists and pedologists have been mutually beneficial and it is hoped that this work can be extended to other areas.

The Saskatchewan soil report contains descriptions of the location and characteristics of the major plant formations and their respective sections; also plant associations representing saline, sandy, meadow and bog soils, etc. Lists of key species covering the above separations are also given and these are established by competent botanists. The vegetative cover of uncultivated land is mentioned briefly.

Plant species or communities to indicate soil features are used as much as possible in Alberta--where any native cover is left or where there is a recognizable dominant species or association. Believe that more could be done, in Alberta in this connection--useful in indicating where not to divide as well as where to divide.

In British Columbia changes in dominant type of vegetation are watched carefully and provide excellent aid, in many areas for recognizing soil changes. With the information available at present one, however, cannot rely entirely on this. Anticipating some valuable information in this connection through the work of R.H. Spilsbury, a soil specialist with the Forestry Department. He is studying native vegetation as an aid for determination of forest sites. In addition, during the summer of 1947 a Provincial botanist made an ecological study of the Rocky Mountain Trench from the border to Golden. This study was combined with a reconnaissance soil survey of the area. Upon completion of these studies a more effective use of data on vegetation should be possible.

3. TO WHAT EXTENT WILL LAND USE AND VEGETATIVE FEATURES APPEAR ON PUBLISHED MAPS? (Please indicate whether on the soil map or on special purpose maps.)

On Prince Edward Island a tentative broad land-use map has been included in the report, also one indicating the major soil area problems. A land-use and crop distribution map as a basis for erosion study has been attempted.

In New Brunswick reconnaissance maps indicate the cultivated and wooded areas.

Land use and vegetative features do not appear on the Quebec soil maps but to cover such information crop adaptation and land use capability maps are published. The soils are rated in regard to their suitability for general farm crops--good, fair, poor, etc. The soils are grouped on basis of rating which at present is only tentative.

In Ontario land use and vegetative features are not indicated on soil map but are shown on special purpose maps, e.g., Hope Township Soil Erosion-Land Use Survey.

Manitoba does not include land use or vegetative features with exception of meadow and swamp on the soil maps. Instead, included in the report, in addition to soil map, are the following: Land classification map, landscape area map, contour map, table re estimated suitability of the soils for various purposes, statistics on past and present land use and a table of the common plant species and their distribution by landscape areas.

In Saskatchewan land use and vegetative cover will not appear on the ordinary soil map but may appear on special maps (irrigation, erosion, settlement areas). These features are also important when detailed land inspections or individual farm surveys are required. While such maps may not be published in the ordinary sense, they are reproduced in limited quantities for some particular department or service. A sketch map of the native vegetation has also been published in one of the Saskatchewan Soil Survey reports.

In Alberta land use and vegetative features, except bogs (sedge and peat) do not appear on soil maps--are considered to be transient factors. A cultivation map is published which, while of little permanent value, gives an overall picture of land use.

Land use and vegetative features, except for the various types of muskegs, do not appear on the published soil maps in British Columbia. While special maps involving land use and vegetation have not been prepared in the past, it should be pointed out that the Land Utilization Survey is giving major attention to this aspect of surveying and mapping. Land Use maps will doubtless appear at an early date.

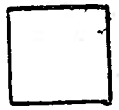
4. LIST SYMBOLS, WITH DEFINITIONS, USED TO RECORD LAND USE AND VEGETATIVE COVER ON FIELD SHEETS AND PUBLISHED MAPS.

For erosion survey map, following symbols were used on Prince Edward Island:

W - woodland
P_n - natural grasslands
P_1 - improved or rotational pasture land
T_1 - crop land, grain
T_2 - roots
T_3 - potatoes
T_4 - hay

In New Brunswick and Quebec symbols are not used to record land use or vegetative cover.

In Ontario:


crop land


pasture land


woodland


idle land

Ref. Hope Township Map.

In Manitoba the estimated agricultural rating is the only feature for which symbols are used. These go on the field sheets of the reconnaissance survey.

Following used on Saskatchewan Soil Survey Field Sheets:

LAND USE AND VEGETATION--SYMBOLS FOR FIELD SHEETS

K - cultivated land.
KG - " seeded to pasture or hay (forage) crops.
KA - Abandoned cultivated land.
P - Pasture land, fenced and grazed. If necessary indicate dominant vegetative cover as PG - grass, PSc - scrub, PSc-G - Mixed grass-scrub, etc.

G - Native grassland.
Sc - Scrub, small trees, bushes, shrubs, etc.
T - Treed or Wooded land (Ta - aspen etc. to indicate dominant species if required)

I - Irrigated Land (Ig - irrigated market garden).
H - Native hayland.
U - urban land (not mapped as soil area) - golf course, airport, village or town limits, etc.

Wx - Waste land, no present agricultural or forest use (bare salt flats, barren shale outcrops, wet marshy areas with non-edible vegetation, very severely eroded land).

If required on field sheets and particularly for soil sample sheets, more detailed information may be given:

Ta - aspen, Tb - black poplar, Tc - bush, Td - black spruce, Ts - White spruce, Tp - jack pine, T_l - lodge-pole, Tt - tamarack, Tw - willows, To - scrub-oak, Wd - weeds, gw - greasewood, bj - blue joint, wb - wild barley, gm - gunweed.

Above have been used in irrigation and northern surveys. Obviously many additions are possible. The species of trees listed are indicators of the aspen grove and mixed wood section of the Boreal forest. The weeds and

other plants are indicators of varying conditions of drainage and salinity. In surveys of unsettled northern areas, the classification of trees as merchantable timber, posts, fuel, might be indicated by the addition of numbers indicating diameter.

In Alberta with the exception of surveys of wooded areas, very little vegetative cover data go on the field sheets.

Tree Cover symbols in Alberta:

T_1- fairly open; T_2- light to medium tree cover.
T_3- medium to heavy tree cover; T_4- timber, dense stands of spruce and pine, poplar over 18".

Symbols on field sheets covering cultivation - Alberta

Cp1 - 1/4 cultivated per 1/4 sec.
Cp2 - 1/2 " " " "
Cp3 - 3/4 " " " "
C - over 140 acres.
AC - abandoned cultivation.
Irr - irrigated cultivation.

Cultivation refers to land once plowed and still used whether in cultivated crops or in hays.

British Columbia land use symbols:

K - cultivated
Ab - abandoned cultivated land.
Gs - grassland - undifferentiated.
T - trees - with symbols to indicate dominant species and size.
 - muskeg, spagnum type.
\M/ - muskeg, meadow type.
I - irrigated.

In Ontario following terms used for farm planning surveys:

P - permanent pasture
F - protected wood lot
Fp - pastured wood lot
H - farmstead
L1 - row crop
L2 - spring grain
L3 - fall grain
L4 - rotated pasture
Lf - fallow

Descriptive terms covering vegetation as used in Manitoba are illustrated in "Soils of Manitoba", p.32 and South Central Report, p.134. Terms covering suitability of land use presented in "South Central Report", p.51 and statistical data of past and present land use in the same report on pages 111 to 115.

Descriptive Terms used in Saskatchewan:

Short grass prairie - short grass vegetation.
Mixed prairie - mixed short and medium-tall grasses.
Parkland Prairie - mixed grassland and groves of trees and shrubs.
Dense or thick parkland - trees predominate over grass-presumed to be forest invasion of original grassland.
Forest - cover as defined by Halliday "A Forest Classification of Canada", with the exception of the Aspen Grove section which is covered under Parkland Prairie.

Descriptive Terms used in Alberta:

Parkland - deciduous trees, tall grass and shrubs.
Open parkland - more grass than trees (thick black zone).
Tall grass plains - (chestnut soil zone); semi-arid plains.
Short " " - semi-arid plains.
Wooded - green and fire killed.
Prairies - open spots in wooded areas.
Sedge peat - self-explanatory
Moss peat - " "
Grease wood flat - used in semi-arid zone - loosely used to infer a somewhat saline soil.

6. SUGGESTIONS WITH REGARD TO STANDARDIZATION OF LAND USE AND VEGETATIVE COVER MAPPING ACROSS CANADA.

From Prince Edward Island:

1. Identification and mapping of plant societies of shrubs, grasses, etc. should aid materially in correlating soil series with crop suitability. This type of mapping would, however, call for a detailed soil survey and the advisory services of a qualified ecologist.

2. Favour the simple feature map for reconnaissance surveys.

From New Brunswick:

1. Mapping of land use and vegetative cover is scarcely justified in the Maritime Provinces. There appears to be little relation between variations in soil morphology and variations in vegetation since the climax vegetation has

in the majority of cases been of a fairly uniform type.

From Ontario:

1. Agricultural and potential agricultural areas of primary concern.

2. Purpose of survey must be defined. Units of mapping must fit purpose.

3. Vegetative cover is mapped by other scientific groups. The work of these different agencies should be correlated.

From Manitoba:

1. Vegetative cover - a general classification containing all aspects of vegetative features across the continent would be too cumbersome. Using grassland, forest and tundra as a starting point, each Province will have to define the transitional belts as they occur.

2. Land use is too intimately bound with its economic status to be standardized across Canada. However, some degree of uniformity can be attained by estimating suitability of soil associations for various purposes.

3. The eight land use classes in "Natural Principles of Land Use" by Graham tend to serve as a basis for land use principles.

From Saskatchewan:

1. Not sure that we should be concerned with standardizing land use and vegetative cover features across Canada.

2. Emphasize that the soil surveyor should note land use and vegetation and apply observations to his main task of knowing his soils and their uses. He should be prepared to show these features on field sheets and special maps. A general outline of a classification and some definitions are required - actual symbols need not be standardized.

From Alberta:

1. Information received relative to present land use is more or less incidental, while that pertaining to recommended land use has been confined primarily to facts relative to soil conservation.

2. Do not see much possibility of standardizing across Canada; more uniformity, however, appears possible on a regional basis.

Discussion

Reference to the original Sub-Committee Report and to the foregoing summarized reports indicates that land use and vegetative cover features are recorded and presented in a number of ways but in no instance are they shown on ordinary soil maps. Such information is, however, placed on detailed soil maps in some of the Provinces, when surveying proposed irrigation areas. A number of correspondents report that special land use and vegetative cover maps are prepared which may be an end in themselves or serve as a supplement to the soil map and used for special purposes such as erosion, conservation, drainage or irrigation studies.

1. Objective accepted

It appears obvious that the method of finally presenting the data must be determined by the specific purpose of the undertaking and the unit of mapping. If this principle is kept clearly in mind the procedure should automatically standardize itself.

Regardless of ultimate method of presenting the material considerable data are being accumulated on survey field sheets and in some instances recorded only in field note books. For each regional survey organization it would appear desirable to have a more or less uniform system of classifying and recording such information on survey field sheets, particularly since the soil surveyor may at times be called upon to prepare a special map of an area for local requirements. There is an historical value in having a record of land use and vegetative cover for a given area at time of survey. Subsequent changes in these features can thus be more readily appraised by reference to the original conditions. Such records are particularly useful for "dry" land that is to be irrigated, and for virgin areas that may be settled and cultivated.

The most obvious classification of variations in land use is separation into cultivated, pasture, wooded, waste, urban, etc. How far we should proceed in finer separations is an open question, but the following does not appear unreasonable.

Cultivated:
- Grain farming (cereals)
- Pasture or hay (forage)
- Orchard
- Small fruits
- Irrigated farming
- Truck crops
- Tobacco etc.

Non-cultivated:
- Native grassland or range
- Wooded
- Abandoned
- Waste
- Urban

If desired, kinds of crops or specific land use may be indicated -- as wheat, clover, fallow, etc. Usually, however, such terms would not be permanent, since a different crop might be grown next season. The recognition of specific land use conditions is of some value as information to be noted when sampling the soil.

It is assumed that any land use or vegetative conditions shown on field mapping sheets will be indicated by appropriate symbols defined by the soil survey staff.

In respect to vegetative cover, all surveyors are in agreement that tundra, forest and grassland provide for major separations. This might readily be extended to include parkland (mixed forest and grass). Under forest provision should be made for recording predominant species and size of same, also whether virgin, logged, burned, etc. In respect to grassland ecological divisions such as short grass and tall grass prairies, etc. should be noted. Also local plant associations such as those associated with dune sands, saline areas, natural meadows, bogs, etc. should be carefully noted.

Difference of opinion exists as to the merit in the use of vegetative cover to indicate soil features. Even those surveyors using such data do not rely entirely on them but use them as an aid in spotting soil changes. Doubtless certain vegetative groups, particularly those associated with drainage conditions bogs, saline soils, etc. are quite valuable aids; beyond this, however, there may be some doubt unless we happen to be ecologists as well as soil surveyors.

All correspondents report that at least some data on present land use and the dominant vegetation, particularly in forested areas are recorded. How far one should go in recording details in this regard would appear to depend on the physiography of the region under survey and the specific purpose of said survey. Comprehensive detail would doubtless require the aid of a trained ecologist.

In any event, however, the soil surveyor should endeavour to report carefully on the plant associations which are recognized by ecologists as being significant of specific soil conditions. Even to do this effectively may necessitate at the outset a special study involving the integration of vegetative associations with soil types.

It is suggested that much valuable information could be secured through detailed soil and ecological studies carried out by pedologists and ecologists working in co-operation. As an example, ecological studies of special research areas within P.F.R.A. Community Pastures have been correlated with detailed soil surveys. The relationship between certain plant associations and types of soil formation was established. In addition, both ecologists and soil scientists became better acquainted with each other's field of work.

Finally, the growing use of aerial photography in soil survey work introduces the problems of recognizing vegetative cover on air photos, and of relating it to the soil. The important point is the extent to which vegetative cover is significant to the soil survey. In regions where the significance is apparent, the soil survey staff should seek the assistance of competent ecologists.

General Discussion of Report on Landscape Features

The remainder of the discussion is summarized below.

Stobbe suggested that stony classes be adopted as given in the Manual

Leahey agreed, providing the U.S. agricultural implications were omitted.

It was finally agreed to use Stones 0 to 5 in the manner used in the 1948 report, but with a modification of the Stones 4 class to remove the statement that this land is non-arable.

Richards moved that the classification of coarse fragments given on page 214 of the Manual be adopted. Seconded by Bentley and carried by the Committee.

Moss suggested deletion of Appendix since it is headed 'List of Land Forms for Canada', but represents only three provinces. He also suggested that the 1948 classifications of erosion and topography be retained.

Millette suggested that the land form features were difficult to apply in reconnaissance surveys, but were applicable in detailed surveys.

Chancey suggested that a percentage slope be indicated to typify each land form; he felt there was at present too much personal interpretation.

Bentley asked how many regional groups were using the U.S.A. classification of topography. (Three groups signified this). Bentley stated N.S.S.C. system was being used in Western Canada and in B.C.

Bowser suggested more agreement was required. Like Chancey, he felt the Landscape Committee had not given definite enough qualifications for topographic classes.

Wicklund stated that it was difficult to use the N.S.S.C. classification in Ontario.

Leahey felt that the Sub-Committee had provided precise definitions.

Millette suggested that the Sub-Committee add descriptive or qualitative terms to the present system.

Moss pointed out that this was precisely what the 1948 Sub-Committee had attempted, but that the Committee had rejected it. The present system was therefore devised to avoid the use of descriptive terms by those who could not agree on their definition. In Saskatchewan at least all topographic classes were defined by descriptive terms, and the N.S.S.C. symbols were used merely to identify each topographic class.

Leahey suggested that the Sub-Committee carry on, and that the Chairman send in the classification of topography used in Saskatchewan, and secure reaction of other provinces.

REPORT OF THE SUB-COMMITTEE ON CHEMICAL ANALYSIS OF THE NATIONAL SOIL SURVEY COMMITTEE

It is generally recognized that the chemical analysis of soil samples is necessary in order to provide the soil surveyor with information required to supplement his field observations in the mapping and classification of soils. The main task of the sub-committee on chemical analysis was interpreted to be a study of laboratory determinations which would serve to characterize our soils. Recommendations relative to the information that should be obtained, the methods that should be used, and the manner in which results should be expressed, were expected to be forthcoming. The deliberations of the sub-committee have centered largely around these points, though other aspects of the general situation also received consideration.

Information that Should be Obtained

A considerable amount of information on the chemical composition of soil profiles in various parts of Canada has been published. Most of it is contained in the Soil Survey Reports of the provinces but some is found in papers published by Canadian workers. There are undoubtedly many analyses tabulated and filed in different laboratories where this work is conducted, though such information is available only locally. The committee reviewed a summary showing, by provinces, the number of profiles for which some analytical results are available and the analyses made in the different laboratories. Reports on very few profiles are available from some provinces, and on a large number from others. The kinds of analyses reported vary not only from province to province, but also from year to year in the same laboratory. In view of the fact that the information in the published Soil Survey Reports is of interest not only to the workers and others in the province which compiles the report but also to surveyors throughout Canada and more particularly to University teachers whose students come from several provinces, the committee believes that steps should be taken to remove this lack of uniformity in the results presented.

Very careful consideration was given to the determinations that should be made in order that the information forthcoming would be of greatest benefit to the greatest number of soil scientists in Canada. The committee recommends that, for the purpose of obtaining results for inclusion in published Soil Survey Reports, the following determinations be made on selected soil profiles:

(a) Soil reaction - pH
(b) Total nitrogen
(c) Total organic carbon or organic matter
(d) Inorganic carbon where free carbonates are present
(e) Total calcium, magnesium, potassium, and phosphorus

(f) Cation exchange capacity
(g) Exchangeable cations on all non-calcareous horizons as follows:

   (1) Calcium, magnesium and potassium
   (11) Hydrogen, sodium, and manganese only where desired

(h) Conductivity where desired

Furthermore, in the case of profiles subject to considerable leaching, the following additional determinations be made:

(a) Silicon, iron, and aluminum
(b) Titanium, manganese, sodium, and sulphur only where desired

It is recognized that determinations such as total phosphorus and total potassium will contribute little, if anything, to an understanding of soil-forming processes. Nevertheless, information on these constituents is of considerable interest in view of their importance as plant foods.

Methods

Following the 1948 Meeting of the National Soil Survey Committee, a project was initiated with the objective of ascertaining how close or how diverse were the results obtained in the provincial and federal laboratories when a common set of soil samples was subjected to the methods of analysis commonly used as routine procedures on soil survey samples. Seventeen reference soil samples, representing a wide range in texture, reaction, and organic matter content as well as various horizons, were prepared in such a way as to ensure uniformity of the material in each case as far as possible. Small samples were then distributed to ten co-operating laboratories, one of which was that of the U. S. D. A. Division of Soils and Irrigation. The results were compiled and distributed in August 1953. In view of the fact that the methods used were very diverse, wide variations in results were to be expected and in fact did occur in many cases, particularly with the exchangeable cations and cation exchange capacity. On the other hand, fairly close agreement was obtained in the case of a few determinations, notably pH values. Nevertheless, this project has pointed very definitely to the fact that there is need to get some uniformity in the methods used in the various laboratories examining soil survey samples in Canada if the published results are to serve as a basis of comparison of our soils between provinces.

The committee recommends that a collaborative study of certain methods be undertaken at once, under the direction of the chairman of the sub-committee on chemical analysis. As the difficulties with one method become straightened out, other methods will be considered. It has been agreed by the committee that the first methods to be so examined will be those for total nitrogen and cation exchange capacity. Each laboratory will be asked to submit the details of the methods now in use. These will be studied and a uniform procedure outlined and distributed with the instruction that the details be followed exactly. Collaborators will be encouraged to suggest minor modifications where deemed desirable. After each set of results is returned and examined, new instructions will be prepared and submitted to collaborative study until, finally a satisfactory procedure acceptable to all laboratories will be evolved. The reference samples which each laboratory should now have are to be used. In cases where the supply of any sample is low, more is available from Ottawa where a stock supply is held.

In connection with chemical methods, there appears to be a need to have one individual available to co-ordinate the analytical work of the laboratories examining soil survey samples, to study and recommend reliable and uniform procedures for all laboratories, to develop or modify procedures based on new analytical techniques, and to serve as an adviser and consultant to the analysts concerned. It is believed that this would effect a considerable improvement in the quality and quantity of results obtained.

Expression of Results

For some time there has been a difference of opinion among soil chemists with regard to the method of expressing the results of soil analysis. This has been particularly true in the case of the mineral constituents of the whole soil. It has been customary to express these as oxides for two reasons: (1) It facilitates the comparison of results with those for rock analysis which are usually expressed in this manner; (2) It is convenient to add together the values for loss on ignition and the oxides of the elements as a measure of the accuracy of the analysis. Ideally, they add up to 100 per cent. On the other hand, results for exchangeable cations are reported in terms of the element.

There appears to be a trend in recent years, in agricultural work in general, to express results as the element rather than as the oxide. This is particularly noticeable in the case of fertilizer analysis where the use of P_2O_5 and K_2O has become strongly established. At least one provincial soil survey laboratory has consistently expressed results as the element. The committee has agreed to change the recommendation made in the 1948 report with respect to this point and now recommends as follows: that the results of all analyses, except those for soluble salts, should be given in terms of the amount of the element itself while those for analyses for water-soluble salts should be expressed as cations and anions in terms of per cent in case of salts in soils, and as p. p. m. for irrigation and drainage waters.

The opinion was expressed that the recommendation that "all results should be expressed on the basis of the moisture-free soil" was not sufficiently specific. The committee recommends that "dried at 105° C." be added.

Mineralogical Studies:

The place of mineralogical studies in a soil classification program was reviewed by the committee. At the 1948 Meetings of the National Soil Survey Committee, it was agreed that studies of the nature of the clay minerals were required for the solution of many of our soil problems. Since that time, a well-equipped soil mineralogy laboratory has been developed in the Soil Chemistry Unit at Ottawa. During the past four or five years, samples representing approximately 25 profiles, all from Western Canada, have been examined in that laboratory. In some cases, e. g. a group of profiles from Manitoba, the results on the clay fraction failed to contribute information hoped for. This has perhaps served to warn us that the answers to all our problems may not be found in a greater knowledge of the clay mineral content of our soils.

The mineralogical study of soils is not confined to an examination of the clay fraction. Important information with reference to soil-forming processes can be obtained from a study of the sand fractions and some evidence has been forthcoming to that effect from a number of projects at various centers. It is quite clear that there is an interest in all our provinces in soil mineralogical studies. It is a subject of interest not only to chemists but also to those working in soil physics.

It is the opinion of the sub-committee on chemical analysis that all available information pertaining to the mineralogy of Canadian soils should be carefully reviewed before any extensive program of analysis is undertaken. It is recommended that this be done by a small group of not more than three persons, selected jointly by the chairmen of the committees on chemical and physical analyses. The study by such a group should be very thorough. Their report and recommendations, if any, should be forwarded to the chairmen of the two sub-committees as well as to the chairman of the National Soil Survey Committee. These three should take whatever action is deemed necessary to further our knowledge on a sound basis.

There are a number of sources of information. A few papers have been published on the subject and a few graduate students' theses have been prepared. Reports also have been prepared on certain investigations, particularly in the laboratory at Ottawa, and copies of these can be made available. Possibly some information can be obtained from those who have studied pleistocene deposits. All such sources should be explored and carefully studied in order to determine if we are yet in a position to recommend an extensive program of mineralogical analysis.

Sampling

The committee discussed the question of adequate sampling of profiles in order to characterize a specific soil series. Fear was expressed that the analysis of a single profile at a single point was inadequate and the results would not show the characteristics of that soil correctly. The possibility of compositing horizon samples from a number of sites, with a view to reducing analytical work and yet getting results which would more nearly represent the average composition of a series than would a single profile, was considered but rejected by the committee. No specific recommendation on sampling is being made. However, the suggestion is put forward that when there are extensive areas of the same soil series, the field men consider the advisability of sampling at more than one site.

Research Projects

In the course of our deliberations, a number of subjects were discussed, any one of which might form the basis of a graduate thesis in soil science. Again, no specific recommendation is made but those directing the work of graduate students are urged to give consideration to projects in soil genesis or soil classification.

Respectfully submitted,

Sub-committee on chemical analysis

W. A. DeLong
J. H. Ellis
J. Mitchell

J. D. Newton
N. R. Richards
A. Scott

G. R. Smith
G. B. Whiteside
H. J. Atkinson (Chairman)

November, 1955.

RECOMMENDATIONS OF THE SUB-COMMITTEE ON CHEMICAL ANALYSIS ADOPTED BY THE NATIONAL SOIL SURVEY COMMITTEE, NOVEMBER 4, 1955.

The following recommendations of the sub-committee on chemical analysis were adopted by the National Soil Survey Committee:

1. That the following determinations on selected soil profiles be made for publications in Soil Survey Reports:

   (a) Soil reaction - pH
   (b) Total nitrogen
   (c) Total organic carbon or organic matter
   (d) Inorganic carbon where free carbonates are present
   (e) Total calcium, magnesium, potassium, and phosphorus
   (f) Cation exchange capacity
   (g) Exchangeable cations on all non-calcareous horizons as follows:

      (i) Calcium, magnesium and potassium
      (ii) Hydrogen, manganese, and sodium only where desired

   (h) Conductivity where desired

   And, in the case of profiles subject to considerable leaching, the following additional determinations be made:

      (i) Silicon, iron, and aluminum
      (ii) Titanium, manganese, sodium, and sulphur only where desired

2. That a collaborative study of certain methods be undertaken at once and that the first methods so examined be those for total nitrogen and cation exchange capacity.

3. That the results of all analyses, except those for soluble salts, should be given in terms of the amount of the element itself while those for the analyses for water-soluble salts should be expressed as cations and anions in terms of per cent in case of salts in soils and as p. p. m. for irrigation and drainage waters; and that all results should be expressed on the basis of the moisture-free soil dried at 105° C.

4. That all available information pertaining to the mineralogy of Canadian soils should be carefully reviewed, before any extensive program of analysis is undertaken, by a small group of not more than three persons

selected jointly by the chairmen of the committees on chemical and physical analyses.

5. That a well-trained chemist be made available at the Ottawa laboratories to co-ordinate the analytical work on soil survey samples, to study and recommend reliable and uniform procedures for all laboratories, to develop or modify procedures based on new analytical techniques and to act as adviser and consultant to the analysts in the provincial laboratories.

In support of the last recommendation (5), the following information and observations are presented:

In 1951-52, seventeen reference soil samples were analyzed in the provincial soil survey laboratories, as well as in the soil chemistry laboratories of the Chemistry Division at Ottawa, for various constituents by the methods commonly in use in each. The results were summarized in 1953 and they showed a degree of variation which is quite disturbing. For example, six laboratories reported results for cation exchange capacity ranging from 18 to 35 m. e., for organic matter from 3.0 to 4.5 per cent, and for total phosphorus from 0.07 to 0.15 per cent P, on a single sample. In the opinion of the committee on chemical analysis, this points very definitely to the fact that there is an urgent need to get some uniformity in the methods used in the various laboratories examining soil survey samples in Canada if the published results are to have real meaning and are to serve as a basis of comparison of our soils between provinces.

There is a further need, in connection with methods of analysis, to keep abreast of the development of new techniques. A case in point is the tremendous development, within the last three years, of the versenes as analytical reagents. Their correct use can lead to a great saving of time, but experience has shown that much study is needed before a reliable procedure for soil analysis can be developed. Such studies should not be left to the individual small laboratory.

These two needs can be largely met by the appointment of a chemist as specified in the recommendation. It would be an economical move in that it would save a great deal of the time of the individual analysts, time now spent in seeking to improve techniques or adopt new ones, time spent in making analyses by procedures which could be greatly shortened by making use of newer analytical information. This saving of time is very important in view of a previous recommendation of the committee on chemical anlysis with regard to the determinations to be made on selected soil samples, determinations which are not now being made in several of the laboratories but which, in the opinion of the committee, are necessary to characterize the soils more fully and to supply the necessary information for comparison between regions both within Canada and outside. Furthermore, the data would be more reliable due to the adoption of more uniform procedures which have been thoroughly tested before being adopted for routine work.

SUMMARY OF THE DISCUSSION OF THE REPORT OF THE SUBCOMMITTEE ON CHEMICAL ANALYSIS

Prof. Hutcheon - raised the question of having the degree of accuracy stated when standard methods are set up.

Dr. Matthews - inquired if some methods would have to differ with different soils.

Dr. Ehrlich - believed this would be particularly true with cation exchange methods when dealing with acid and calcareous soils.

Mr. Odynsky - stated that, in averaging results from profiles in the gray-wooded region, a large spread in values was obtained, even in the case of pH.

Dr. Doughty - indicated it was necessary to understand the degree of refinement in relation to interpreting results. When pH values are expressed to two places of decimals, the last figure has little if any significance.

Dr. Stobbe - wondered whether a series should be sampled so as to establish a range in values or should be sampled according to the central concept of that series. To establish a range, many more analyses would need to be done than had been published in the past. Laboratory data should be used as a guide in making field separations and changes should be made in the origin al field classification if the laboratory results indicated such were necessary.

Dr. Simonson - stated that in the United States, there were about six laboratories doing anlysis of soil survey samples. The analyses performed might be divided into three classes: (1) To characterize the soil. Determinations were usually pH, C, N, exchange capacity, mechanical analysis, carbonates, salts, and bulk density, by standard methods. Two profiles are usually sampled to represent the central concept of the type. (2) To provide immediate aids to mapping problems. Determinations might include texture and salinity. (3) To study the genesis of the soil. Determinations would be made as required to support a hypothesis.

Dr. Leahey - felt it would be necessary to decide whether to do many analyses on a few profiles or a few analyses on a larger number of profiles.

Prof. Ellis - indicated that the number of profiles necessary to obtain a range around a modal concept might vary. He wondered about the value of compositing a number of horizon samples from a single large pit.

Dr. Millette - wondered whether, in sampling a horizon, one should sample the whole depth of horizon or only the central part.

Dr. Simonsom - stated that, in the United States, they had analyzed both the whole horizon and the horizon fractionated by depth, but had reached the same interpretation of results with regard to the whole profile.

Dr. Leahey - thought the subcommittee should endeavour to draw up an acceptable procedure for taking profile samples so that this technique might become more uniform.

Prof. Richards - suggested that, when the provincial laboratories are asked to submit the details of various methods of analysis in the proposed collaborative investigation, they might also be asked to submit the details of the procedure they use in collecting samples.

Dr. Millette - wondered if the determinations listed in the first recommendation should be made by all laboratories before methods have been standardized.

Dr. Smith - suggested that the A.O.A.C. methods be followed in the meantime.

Mr. Bowser - inquired why total Ca, Mg, K, and P were included.

Dr. Atkinson - indicated that several members of the subcommittee had requested these determinations. It was recognized that information on potassium and phosphorus was of interest mainly because of their importance as plant foods.

Dr. Stobbe - asked if the analyses were to be made on the total soil or on the clay fraction.

Dr. Atkinson - stated that the subcommittee had agreed that the analyses should be made on the whole soil.

Dr. Millette - asked if consideration had been given to having the results expressed on a bulk density basis.

Dr. Atkinson - stated that the subcommittee had discussed this point but had no recommendation at present.

Dr. Leahey - suggested that results might be reported on a weight basis and also on a bulk density basis.

COMMITTEE REPORT ON SOIL DRAINAGE TERMINOLOGY

The sub-committee on Soil Drainage Terminology was instructed to review the 1948 report and make necessary revisions. Comments on the 1948 report were solicited from all soil survey workers in Canada. This present report contains the revisions considered necessary.

Natural Soil Drainage

Natural soil drainage refers to the rate and extent of removal of water from the soil profile in relation to the additions. This removal of water may be by percolation through the soil or by evaporation and transpiration from the soil surface. Additions may be by rainfall, irrigation or seepage.

As a soil condition, drainage refers to the rate and extent of removal of water from soil as well as the amount remaining in the soil at field capacity. Soil drainage, therefore, is a function of total rainfall, or irrigation, temperature, texture, permeability, and water-holding capacity.

Ordinarily in soil descriptions, a statement of the general soil drainage is sufficient. For certain other interpretations, other moisture criteria are required. Permeability measurements are essential in considering artificial drainage of soils or in making irrigation recommendations.

The natural drainage condition existing in a soil is the result of the combined effect of surface water loss, percolation (which is determined by permeability), water holding capacity, the level of the ground water table either permanent or perched, as well as climate particularly total rainfall and temperature. Although the frequency and duration of periods when the soil is free of saturation or partial saturation can be measured, the field surveyor must estimate them by inference. He actually determines drainage by observing the effects of drainage or the lack of it.

The definitions of the soil drainage classes are based, therefore, (1) on morphological characteristics that infer the natural drainage, and (2) on direct observations of water table levels, pools of surface water, periods of soil saturation after water additions.

In the 1948 report, separate drainage criteria were described for forested and grassland soils. On the basis of the information available to the present committee, it was agreed that one set of criteria could apply equally well to forested and grassland soils.

It is recommended that the following drainage classes be recognized. Various combinations of run-off permeability, rainfall, seepage or evaporation result in different soil morphology.

1. Rapidly drained

These soils are free of mottling throughout the profile. Many of the soils are regosols or regosolic. The moisture content of such soils seldom exceeds the field capacity in any horizon except during or immediately after water additions.

2. Well drained

These soils are free of mottling in A and B horizons but may be mottled in the C horizon or below depths of several feet. The horizons may be brownish, yellowish, greyish or reddish. Moisture content does not normally exceed field capacity in any horizon (except possibly the C) for a large part of the year. They are commonly of intermediate texture although coarse and fine textured soils may be well drained.

3. Moderately well drained

These soils are mottled in the lower B horizon and in the C horizon. The A_2 horizon of fine textured soils may be mottled. In medium textured soils a slight mottled A_2 horizon may occur due to a perched water table.

Moisture content exceeds the field capacity of the B and C horizons for appreciable but not large part of the time.

4. Imperfectly drained

In these soils, mottling occurs in the A_2 horizon and in the B and C horizons. The colours are less brilliant.

Moisture content exceeds field capacity of B and C horizons for large part of the time. These soils may have a slowly permeable layer, high water table, additions through seepage or combinations of these.

5. Poorly drained

These soils are mottled immediately below the A_o or A_1 horizon. They are light to dark gray on the surface.

Moisture content exceeds field capacity in all horizons for appreciable part of the time. The water table is at or near the surface for a considerable part of the time.

6. Very poorly drained

These soils have a grey gley layer immediately below a mucky or peat surface horizon. Mottling may be present but at depth in the profile.

Moisture content exceeds field capacity in all horizons most of the time.

The committee recognizes that certain soils are well drained above but poorly drained below due to a moving water table. Also some soils are poorly drained in the surface (peaty layer) and well drained below. Modification in the above definitions may be necessary to classify these soils but the committee can make no recommendation at the present time.

Run-off

The 1948 Committee set up run-off classes. Run-off is affected by several factors other than soil e.g. vegetative cover, slope, and storm characteristics. Run-off therefore must be assessed for each site and is deduced from a number of observations outside the soil profile. Erosion classes based on amounts of soil removed have been defined by the landscape perminology committee.

It is recommended therefore than run-off should not be included within the scope of this committee.

Internal Drainage

Internal soil drainage has been used to refer to the rate of movement of water through the soil profile. It is in fact dependent on the permeability of the soil horizons. It is recommended that the classification of internal drainage be dropped entirely and permeability classes set up.

Permeability

The permeability of soil is the property of a soil to transmit water or air. The permeability and the infiltration rate, which is an integral part, are most important in predicting the moisture regime of soils when artificially drained or irrigated. Generally the percolation rate of a soil is determined by the least permeable horizon in the solum or immediately below it. It is proposed, therefore, that the permeability class of a given soil be determined on the basis of the least permeable horizon.

It is recommended that permeability measurements on the horizons of the major kinds of soils in each region be made (1) to establish mathematical definitions of permeability classes and (2) to discover observable features, if any, that can be used to estimate permeability in the field.

ALTERED MOISTURE CHARACTERISTICS

Altered drainage refers to drainage conditions that are different from those under which the soil profile developed. Such alteration can occur through artificial drainage, irrigation or by natural deepening of stream channels or filling of depressions, or clearing.

In most instances, time has been insufficient for the altered drainage to cause morphological changes in the profile. The classification of altered drainage, therefore, is based on direct observation of ground water level, frequency and duration of soil saturation.

Altered drainage can be described in the same relative terms as used for natural drainage. Altered drainage should not be used as a criterion in the taxonomic classification although it may be a factor in a land use classification.

Name of Sub-Committee

During the preparation of this report, it was evident that soil drainage could not be discussed without consideration of other moisture characteristics such as field capacity, available water, percolation, etc.

It is recommended, therefore, that the committee be renamed as the Soil Moisture Committee.

D.B. Cann
A. Scott
W. Odynsky
B.C. Matthews, Chairman.

Discussion at the Plenary Session

The Report of the Soil Drainage Committee - reported by Dr. Mathews

Mathews - 1) Reported a new committee composed of Cann, Scott and Odynsky.
2) Read a definition of soil drainage classes
3) Recommended that:
(a) 1948 definitions of drainage be used.
(b) land use interpretation be deleted
(c) accept drainage classes for grassland and forested soils under 6 classes
(d) run off classes be handled by the Landscape committee
(e) the need for permeability classes
(f) use of field capacity factor
(g) the committee be renamed the Soil Moisture Committee.

Ellis - pointed out the effect of wet and dry cycles on soils and another condition where deep profiles occurred in wet areas adject to thin profiles on drier sites

Bowser - disagreed with the term drainage and suggested the use of the term drainability

Mathews - suggested that only the water in the profile affects the morphological features.

Leahey - suggested considering permeability

Mathews - suggested it was a factor because it controls water movement.

Bowser - indicated that a soil could be classified as well drained but on irrigating becomes poorly drained.

Millette - stated drainage is seen in the soil profile

Mathews - suggested that permeability could not be defined on the basis of drainage.

Leahey - suggested that all soils could be periodically wet

Mathews - suggested the length of time a soil was wet was the factor

Ellis - suggested that poor drainage does not necessarily give a deeper A and pointed out that poor drainage could give a shallow A_1.

Millette - suggested eliminating the portion about thickening the A_1 from the definition.

Ehrlich - suggested there was a thickening of the A in grassland slopes down the slope

Stobbe - suggested that the committee's opinion were based on the general rule but he added there are always exceptions. He stated that this does not take care of all moisture relationships such as seepage water, which is very important in forest soils and in drainage projects; nor does it handle cases where subsoils were excessively drained and gleization occurred on the surface, as in the case of some heath soils which may be well drained below the A_2. He suggested it is a question of whether the gleization occurs from the top or bottom and added that the above conditions had to be taken care of. He suggested there were 3 types of water: 1) running 2) aerated 3) stagnant and stated that the Europeans had lots of seepage water.

Cann - suggested handling this as a sub-class

Mathews - suggested that all horizons well drained except G.

Odynsky - stated that drainage leaves its impression on the profile.

Stobbe - pointed out that a Canadian fragipan is caused by infiltration when the soil is dry.

Odynsky - queried if these classes would not fit in.

Stobbe - suggested it worked from the bottom up, the soil being saturated and then an upward movement occurs. This, he stated, was the case in black and forest soils, but he was not certain in the Brown but he stated they were periodically wet not from the bottom but from the top.

Mathews - suggested that the moisture content was greater than field capacity in the B and C horizons part of the time.

Newton - suggested a soil could be temporarily poorly drained; for example, when solodized solonetz pits are filled with water.

Farstad - suggested that a soil could have different water contents and develop different profiles.

Ellis - asked what was the evidence being used for poor drainage, was it iron or gleization?

Mathews - stated it was iron and added he did not like the term gleization.

Ellis - suggested that in some soils there may be little evidence of iron in poor drainage. He suggested that soils are locally arid and locally humid, depending on the area.

Mathews - stated he had to accept grassland drainage

Clayton - stated that in solonetzic soils there is evidence of salts and gypsum, he added that with a rise of water gave an upward movement of salts; in some arid conditions a concentration of salts is accepted as inferring the drainage conditions.

Ehrlich - added plus calcium carbonates

Stobbe - suggested there are drainage conditions for each major soil type. For example salts only apply to saline grassland soils. He suggested the need for drainage classes for each major group; for example, a grey-brown podzolic soil could not be poorly drained

Mathews - queried if morphological characteristics were described by the 6 classes

Plenary Session agreed that morphology is recognized in the 6 classes.

Ellis - suggested there may be 1 class above normal, several below, and what is normal for a site may not be normal for the region.

Stobbe - stated there were features for different classes but this does not cover all conditions. There are cases where the morphology does not agree with the condition.

Millette - suggested adding to the definition "and other evidence of morphological drainage"

Recommended -
** 1) the classes and description be accepted - carried by Session
2) Terminology - substitute moisture
a) Very low moisture
b) low moisture
c) medium moisture
d) moderate moisture
e) high moisture
f) very high moisture

refers to retention

** It was agreed that the old names in the 1948 report be used except that excessive be changed to rapid and add 1 more class, moderately well drained.

3) That permeability on each horizon be made. - not voted on-
** 4) Moved by Stobbe that run off classes should not be set up.
Agreed by Session

Stobbe - What about seepage?

Mathews - suggested this is not a final report

Leahey - suggested for now just indicate seepage and non-seepage water.

Stobbe - indicated the method in which water is removed depends on many things.

** Recommended that the committee could study seepage and put their findings if any, in the final report.

Report of Committee on Soil Ratings

In the 1945 and 1948 reports it was pointed out that there were two general methods of rating soils as to their relative suitability for the production of crops, i.e. that of Storie[1], which is based on soil characteristics and that proposed by Ableiter[2] of the U.S. Soil Survey based on yield history.

The Committee wishes to again emphasize the importance of including some form of rating or grouping in soil survey reports. The ratings or groupings used should be presented in such a form as to be readily usable by farmers, assessors or appraisers, agronomists and others.

A rating is in part an interpretation of soil survey data. The matter of interpreting soil survey information to the layman and professional is of concern to everyone connected with soil surveys. The job of the soil surveyor is not complete with the issuance of a map and report. He must also encourage the use of the information gathered in the course of the survey.

It is considered essential that soil surveyors continue to be alert in discovering and pointing out agronomic or other problems associated with the soils of an area.

There has been some attempt to carry out fertility and management studies as a follow up program to the findings of the soil survey. We would recommend that such a follow up program be considerably expanded.

While the responsibility of preparing a rating may rest on the soil surveyor, he may profitable seek the opinions of others in completing the rating of soils in an area.

Assessors, Agricultural Representatives, Horticulturists, Agronomists, Agricultural Economists and any others who have a special knowledge of the lands of the area and their suitability for various crops are among those who might offer information useful in determining ratings. Through enlisting such assistance the soil surveyor is also providing himself with an opportunity for explaining and interpreting his work as well as promoting its fullest use.

The promotion of sound land use is an important objective of the soil survey. This objective is steadily becoming of greater importance with growing populations, and the increasing encroachment of industrial and other urban development on agricultural lands. This objective should be kept in mind when considering possible uses to which soil ratings may ultimately be put.

1. R.L. Storie, Bulletin 556, University of California, Berkeley.
2. U.S.D.A. Manual of Soil Survey, 1951.

Since the last meeting of the National Soil Survey Committee a system of rating soils for irrigation development in Western Canada has been proposed by W.E. Bowser and H.C. Moss. A full description of this system may be found in the following paper:

Bowser, W.E. and H.C. Moss, A Soil Rating and Classification for Irrigation Lands in Western Canada. Sci. Agr. 30. p. 165. 1950.

Members of the Sub-Committee

W.A. DeLong, Macdonald College
C.C. Kelley, Kelowna
P.O. Ripley, Ottawa
J. Mitchell, Saskatoon.

Discussion at Plenary Session on Soil Ratings - reported by Dr. Mitchell

Leahey - stated that there was one phase which was not covered namely the response to management, and suggested that this was not taken care of in the rating factor.

Ellis - stated that management had been used by placing a symbol to which it can be raised in brackets. It has been given 2 ratings. He added that in U.S. reports 2 ratings for management are used.

Leahey - wondered if ratings should be by the kinds of crop that can be grown on a soil.

Moss - suggested that a more organized effort be made to acquire agronomic data. He stated that early surveyors had been forced by other groups to say something about agricultural use. He indicated that we still lack actual data.

Ripley - suggested that soil ratings were the responsibility of various groups of soil workers. He recognized that Moss had suggested more concentrated action but he felt that this was not quite true and stated that the Federal Government works with the Provincial and University organizations and uses soil data from reports and studies made of fertility and physical conditions. He suggested that the time has come for a National Committee to follow up these studies. He indicated 2 points for a follow up programme.

(1) start with soil types; for example, if it is a physical problem, then start at this level. He suggested working through the illustration stations and said a study would be made of Grey Wooded Soils - this he added might be too broad and there may be need of a more specific problem.

(2) could study irregularities within soils, for example try to relate the results that cannot be reproduced on soils 100 yards apart on the same farm.

He stated that this work should be expanded.

Moss - stated that he wanted to make it clear than when he indicated no plan he referred to the Soil Rating. He added that in the Assessment Commission the research economist has spent considerable time gathering yield data.

Simonson - appreciated the problem of rating specific soils and suggested making an agricultural rating at some management level. These ratings would have a life expectancy of 10 years because of technical changes. He stated that in dealing with specific parcels of land more land classification is necessary; for example, whether an area is irrigable or not depends on other properties such as where should the ditches go, salts, relationship of the whole area, etc. He suggested that if you carry too much on the soil rating you could break its back.

Newton - suggested that you cannot always predict where the alkali is going.

Leahey - stated that there was a tendency to put too much of a load on the soil surveyor and wondered where his (the soil surveyor) effectiveness ceased.

Hutcheon - suggested that the ratings are comparative and that the soil surveyor is in the best position to assess this comparison between soils. He added this would take care of Ellis' and Simonsons' objections.

Millette - suggested use be made of the illustration stations, they can supply economic details and suggested that the rating would be better based on economic terms than on yield data.

Odynsky - suggested taking the typical management and using its potential in terms of better management and not following the management of the typical farmer. He suggested projecting the ratings in areas where there was not sufficient management and yield data.

Stobbe - suggested that the soil surveyor should indicate the potential as he sees it, it could be placed in the report. He said we need to get the potential of our natural resources, for example, Dark Grey Gleisolic Soils have a potential and added should it be placed in the report.

Leahey - suggested that this prospective could also apply to management.

Mitchell - suggested that part of the soil survey activity should include the matter of selling maps and reports to the general public, to the agricultural representatives in an area, and to other technical people. He suggested that we have to give the soil surveyor time to do this.

Kelley - stated he found his appropriations larger by co-operating with other interprovincial departments.

Leahey - stated a lot has been done but we still owe a duty to the general public.

Recorder: Jim Ellis.

REPORT OF SUB-COMMITTEE

ON

SOIL STRUCTURE AND SOIL CONSISTENCE

(November 1955)

The report on Soil Structure and Soil Consistence accepted by the National Soil Survey Committee at Saskatoon in November 1955 consists of a slightly revised form of the Soil Structure Classification adopted at Guelph in 1948 and a Soil Consistence Classification as presented in the 1951 U.S. Soil Survey Manual.

SOIL STRUCTURE

Soil structure is the arrangement of primary and secondary particles into aggregates with certain structural patterns. These aggregates are separated from adjoining aggregates by thin films or by forces thought to be wholly internal.

A natural soil aggregate is called a "ped" and should not be confused with (1) a clod, formed as a result of some disturbance and will break down from alternate wetting and drying, (2) a fragment, formed by a rupture of a soil mass across natural surfaces of weakness, or (3) a concretion formed by local concentrations of compounds that irreversibly cement the soil grains together.

Soil structure is classified on the basis of shape, character and size of the aggregates. For classification purposes, these features are respectively designated as type, kind and ~~species~~ class. The type of structure is distinguished by the main shape of the aggregates. The kind of structure within the principal types is indicated by the character of the faces and edges of the aggregates. Finally, the species is distinguished on the basis of size.

types
class
Grade

Grade of structure is the degree of distinctness of aggregation and expresses the differential between cohesion within the aggregates and adhesion between the aggregates. In field practise, grade is evaluated mainly by noting the durability of the aggregates and the proportions between aggregated and unaggregated material that results when displaced or gently crushed. Grade of structure varies with moisture content of the soil and should be described at relevant moistures. If the moisture content is unstated, descriptions of grade refer to a condition obtained throughout the range of dry to moderately moist. Terms for grade of structure are as follows:

0. Structureless:
   - A. Single-grain structure -- Loose, incoherent mass of individual particles as in sands.
   - B. Amorphous (massive) structure -- A coherent soil mass showing no evidence of any distinct arrangement of soil particles. Occurs in puddled soils and in soils of clay texture.

Structure Classification

Type	Kind	Species	mm
1. Cube-like Structure-- Soil aggregates are approximately equally developed along the three axes.	A. Granular Structure-- More spherical than six faced, usually somewhat rough.	Fine granular	<2
		Medium granular	2-5
		Coarse granular	5-10
	B. Subangular blocky-- faces sub-rectangular, vertices mostly oblique, or sub-rounded.	Fine subangular blocky	<10
		Medium subangular blocky	10-20
		Coarse subangular blocky	20-50
		Very coarse subangular blocky	>50
	C. Blocky-- Faces rectangular and flattened, vertices sharply angular.	Fine blocky	<10
		Medium blocky	10-20
		Coarse blocky	20-50
		Very coarse blocky	>50
2. Prism-like Structure-- Soil aggregates are predominantly developed along the vertical axis.	A. Prismatic structure-- Vertical faces well defined, and edges are sharp.	Fine prismatic	<20
		Medium prismatic	20-50
		Coarse prismatic	50-100
		Very coarse prismatic	>100
	B. Columnar structure-- Vertical edges near top of columns are not sharp. (Columns may be flat-topped, round-topped or irregular.)	Fine columnar	<20
		Coarse columnar	20-50
		Coarse columnar	50-100
		Very coarse columnar	>100
3. Plate-like Structure-- Soil aggregates are predominantly developed along the two horizontal axes.	A. Platy structure-- Horizontal planes more or less developed.	Fine platy	<2
		Medium platy	2-5
		Coarse platy	>5

1. Weak: The degree of aggregation characterized by poorly formed indistinct aggregates that are barely observable in place. When disturbed, soil material that has this grade of structure breaks into a mixture of few entire aggregates, many broken aggregates and much unaggregated material. If necessary for comparison, this grade may be subdivided into very weak or moderately weak.

2. Moderate: That grade of structure characterized by well-formed distinct aggregates that are moderately durable and evident, but not distinct in undisturbed soil. Soil material of this grade, when disturbed, breaks down into a mixture of many distinct aggregates, some broken aggregates and little unaggregated material.

3. Strong: That grade of structure characterized by durable aggregates that are quite evident in displaced soil, that adhere to one another weakly, and that withstand displacement and become separated when the soil is disturbed. When removed from the profile, soil material of this grade is very largely of entire aggregates and includes a few broken fragments and unaggregated material. If necessary for comparison the grade may be subdivided into moderately strong and very strong.

Miscellaneous Structures

Crumb
Structure: Spheriodal, very porous (granular aggregates are relatively non-porous).
Fine crumb <2 mm
Medium crumb 2-5 mm
Coarse crumb >5 mm

Fragmental
Structure: Irregular-shaped structure with sharp angular sides and corners, often found in leached and Solonetzic soils. (Species may be described in the manner described under blocky.)

Shotty: May be used as an adjective for angular structure where the aggregated material is well rounded and nearly spherical in shape.

Many soils have mixed structures in a single horizon and where these occur the separate components may be indicated in the following manner:- columnar and sub-angular blocky, granular and platy, etc. In the parent material of soils, the amorphous material with structural shapes may be designated as pseudo-fragmental, pseudo-platy, etc.

Pseudo for Pm.

Geological Terms*

Stratum: A unit of sediments that separates more or less readily from overlying and underlying units.

Stratum
Layer: A unit with stratification planes that are more than one centimeter apart.

Bed

Crossbedded

Lamina: A unit with stratification planes less than one centimeter apart.

cross-laminated

Stratified: Laid in beds or layers.

Stratification: Arrangement in layers or beds. It arises from variations in color, texture, dimension of particles and composition.

SOIL CONSISTENCE*

Soil consistence comprises the attributes of soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture. Every soil material has consistence irrespective of whether the mass be large or small, in a natural condition or greatly disturbed, aggregated or structureless, moist or dry. Although consistence and structure are interrelated, structure deals with the shape, size, and definition of natural aggregates that result from variations in the forces of attraction within a soil mass, whereas consistence deals with the strength and nature of such forces themselves.

The terminology for consistence includes separate terms for description at three standard moisture contents (dry, moist, and wet). If moisture conditions are not stated in using any consistence term, the moisture condition is that under which the particular term is defined. Thus friable used without statement of the moisture content specifies friable when moist; likewise, hard used alone means hard when dry, and plastic means plastic when wet. If a term is used to describe consistence at some moisture content other than the standard condition under which the term is defined, a statement of the moisture condition is essential. Usually it is unnecessary to describe consistence at all three standard moisture conditions. The consistence when moist is commonly the most significant, and a soil description with this omitted can hardly be regarded as complete; the consistence when dry is generally useful but may be irrelevant in descriptions of soil materials that are never dry; and the consistence when wet is unessential in the description of many soils but extremely important in some.

Moist is the standard thus list to moist terms only unless otherwise indicated

* W.H. Twenhofel. 1939. Principles of Sedimentation. 1st Edition, p. 494.

* Section on Soil Consistence is taken from The U.S. Soil Survey Manual. 1951 p. 231-234.

Although evaluation of consistence involves some disturbance, unless otherwise stated, descriptions of consistence customarily refer to that of soil from undisturbed horizons. In addition, descriptions of consistence under moist or wet conditions carry an implication that disturbance causes little modification of consistence or that the original consistence can be almost restored by pressing the material together. Where such an implication is misleading, as in compacted layers, the consistence both before and after disturbance may require separate description. Then, too, compound consistences occur, as in a loose mass of hard granules. In a detailed description of soils having compound structure, the consistence of the mass as a whole and of its parts should be stated.

A number of terms, including brittle, crumbly, dense, elastic, fluffy,[1] mealy, mellow, spongy, stiff, tight, tough, and some others, which have often been used in descriptions of consistence, are not here defined. These are all common words of well-known meanings. Some are indispensable for describing unusual conditions not covered by other terms. They are useful in nontechnical descriptions where a little accuracy may be sacrificed to use a term familiar to lay readers. Whenever needed, these or other terms for consistence not defined in this Manual should be employed with meanings as given in standard dictionaries.

The terms used in soil descriptions for consistence follow:

I. Consistence When Wet

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in

Consistence when wet is determined at or slightly above field capacity.

A. Stickiness -- Stickiness is the quality of adhesion to other objects. For field evaluation of stickiness, soil material is pressed between thumb and finger and its adherence noted. Degrees of stickiness are described as follows:

0. Nonsticky: After release of pressure, practically no soil material adheres to thumb or finger.

1. Slightly sticky: After pressure, soil material adheres to both thumb and finger but comes off one or the other rather cleanly. It is not appreciably stretched when the digits are separated.

2. Sticky: After pressure, soil material adheres to both thumb and finger and tends to stretch somewhat and pull apart rather than pulling free from either digit.

[1] As used in describing soils, fluffy denotes a combination of loose to very friable consistence and low bulk density.

3. Very sticky: After pressure, soil material adheres strongly to both thumb and forefinger and is decidedly stretched when they are separated.

B. Plasticity -- Plasticity is the ability to change shape continuously under the influence of an applied stress and to retain the impressed shape on removal of the stress. For field determination of plasticity, roll the soil material between thumb and finger and observe whether or not a wire or thin rod of soil can be formed. If helpful to the reader of particular descriptions, state the range of moisture content within which plasticity continues, as plastic when slightly moist or wetter, plastic when moderately moist or wetter, and plastic only when wet, or as plastic within a wide, medium, or narrow range of moisture content. Express degree of resistance to deformation at or slightly above field capacity as follows:

0. Nonplastic: No wire is formable.

1. Slightly plastic: Wire formable but soil mass easily deformable.

2. Plastic: Wire formable and moderate pressure required for deformation of the soil mass.

3. Very plastic: Wire formable and much pressure required for deformation of the soil mass.

II. Consistence When Moist

Consistence when moist is determined at a moisture content approximately midway between air dry and field capacity. At this moisture content most soil materials exhibit a form of consistence characterized by (a) tendency to break into smaller masses rather than into powder, (b) some deformation prior to rupture, (c) absence of brittleness, and (d) ability of the material after disturbance to cohere again when pressed together. The resistance decreases with moisture content, and accuracy of field descriptions of this consistence is limited by the accuracy of estimating moisture content. To evaluate this consistence, select and attempt to crush in the hand a mass that appears slightly moist.

0. Loose: Noncoherent.

1. Very friable: Soil material crushed under very gentle pressure but coheres when pressed together.

2. Friable: Soil material crushes easily under gentle to moderate pressure between thumb and forefinger, and coheres when pressed together.

3. Firm: Soil material crushes under moderate pressure between thumb and forefinger but resistance is distinctly noticeable.

4. Very firm: Soil material crushes under strong pressure; barely crushable between thumb and forefinger.

5. Extremely firm: Soil material crushes only under very strong pressure; cannot be crushed between thumb and forefinger and must be broken apart bit by bit.

The term compact denotes a combination of firm consistence and close packing or arrangement of particles and should be used only in this sense. It can be given degrees by use of "very" and "extremely".

III. Consistence When Dry

The consistence of soil materials when dry is characterized by rigidity, brittleness, maximum resistance to pressure, more or less tendency to crush to a powder or to fragments with rather sharp edges, and inability of crushed material to cohere again when pressed together. To evaluate, select an air-dry mass and break in the hand.

0. Loose: Noncoherent.

1. Soft: Soil mass is very weakly coherent and fragile; breaks to powder or individual grains under very slight pressure.

2. Slightly hard: Weakly resistant to pressure; easily broken between thumb and forefinger.

3. Hard: Moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.

4. Very hard: Very resistant to pressure; can be broken in the hands only with difficulty; not breakable between thumb and forefinger.

5. Extremely hard: Extremely resistant to pressure; cannot be broken in the hands.

IV. Cementation

Cementation of soil material refers to a brittle hard consistence caused by some cementing substance other than clay minerals, such as calcium carbonate, silica, or oxides or salts of iron and aluminum. Typically the cementation is altered little if any by moistening; the hardness and brittleness persist in the wet condition. Semireversible cements, which generally resist moistening but soften under prolonged wetting, occur in some soils and give

rise to soil layers having a cementation that is pronounced when dry but very weak when wet. Some layers cemented with calcium carbonate soften somewhat with wetting. Unless stated to the contrary, descriptions of cementation imply that the condition is altered little if any by wetting. If the cementation is greatly altered by moistening, it should be so stated. Cementation may be either continuous or discontinuous within a given horizon.

1. Weakly cemented: Cemented mass is brittle and hard but can be broken in the hands.

2. Strongly cemented: Cemented mass is brittle and harder than can be broken in the hand but is easily broken with a hammer.

3. Indurated: Very strongly cemented; brittle, does not soften under prolonged wetting, and is so extremely hard that for breakage a sharp blow with a hammer is required; hammer generally rings as a result of the blow.

Sub-Committee:
P. G. Lajoie
G. B. Whiteside
J. L. Doughty
Chairman, W. A. Ehrlich

WAE/RMcL

REPORT ON STRUCTURE AND CONSISTENCE

Reported by Dr. Ehrlich

Discussion on Soil Structure:

Ehrlich - Questioned the use of the term "cloddy" and stated he was not in favor of the term. He stated that clods are an expression of tilth and not as a result of soil-forming processes and asked if it should be used in the technical sense.

Moss - Stated that cloddy structure occurs in heavy soils and at depth. He said the term suggested irregular shaped aggregates and asked what term could take its place.

Ehrlich - Suggested the terms prismatic or nuciform depending on its general form.

Moss - Expressed disagreement with the use of these terms.

Ehrlich - Questioned if the structure occurred anywhere else.

Bentley - Suggested that they did not occur in Manitoba but occurred in Alberta.

Stobbe - Queried if they were massive when wet and wondered if they were characteristic of a massive soil when dry.

Clayton - Stated they were characteristic of the so-called self-swallowing clays and wondered what Simonson's views were.

Simonson - Stated that these soils have a granular surface and are loose blocky below or structureless.

Moss - Stated that nuciform means "nut-like" and referred to the U.S. Soil Survey terminology of blocky and sub-angular.

Wicklund - Wondered if blocky could include cloddy.

Ehrlich - Read the description for blocky as defined in the U.S. Soil Survey Manual.

Ellis - Stated that clay derived from some shales gave rise to nodular and hard granular structure.

Ehrlich - Suggested that the term nuciform be called sub-angular blocky. ......This was agreed by Plenary Session Audience...... He stated that this would remove the use of the term nutty.

Kelley - Suggested cloddy would not fit into sub-angular blocky.

Stobbe - Suggested dropping the term nuciform which means nut shape.

Wicklund - Asked how the "B" horizon of a Podzol would be described.

Bowser - Moved that irregular blocky be used for the term cloddy. This was seconded by Moss.

Stobbe - Stated a preference for the term sub-angular blocky.

Bentley - Disagreed with the motion made by Bowser and suggested that cloddy does not fit blocky but fits the term sub-angular blocky.

- .....Session decided to use sub-angular blocky instead of.... irregular blocky.

Lajoie - Stated polyhedral would be preferred in Quebec.

Ehrlich - Suggested that we should not depart from our present definition.

Discussion on Description of Fragments in Parent Material:

Ehrlich - Exhibited a sample of amorphous fragmental till caused by pressure of overriding ice.

Moss - Suggested it was like Flint's flaky structure.

Lajoie - Suggested the term pseudo-fragmental.

Stobbe - Suggested using the U.S. Soil Survey terms and stated that these forms may be due to the nature of the parent material.

Ehrlich - Stated this is not due to kind of parent material but formed as a result of pressure.

Matthews - Suggested they refer to it as structure whether it is caused by nature of the parent material or by other means.

Simonson - Suggested we refer to it in notes on the profile. He stated there was no definite agreement on this question by the U.S. survey personnel.

Ehrlich - Stated the U.S. Soil Survey does not recognize fragments and clods as peds.

Moss - Referred to platy kinds of soil. He suggested the use of words like laminated, varved, pseudo, etc.

Bowser - Stated we did not want interim terms and suggested the use of pseudo as described by Lajoie.

Ellis - Queried the use of the term shotty.

Farstad - Stated he did not like the term shotty.

Ehrlich - Suggested that the shot-like aggregates in the profiles exhibited by Farstad and Odynsky are concretions and added that U.S. Soil Survey Manual makes no reference to shot structure.

Leahey - Stated that shot is hard and granular and added that the B.C. survey has priority on this term.

Chancey - Suggested that shotty be used for concretions.

Kelley - Stated that shot identifies "A" horizons and is not concretionary.

Stobbe - Suggested that shot is a specific form of granular and suggested shot-like be used to indicate strongly developed granular structure.

Odynsky - Suggested if they are concretions to say concretions and not shot.

Lajoie - Suggested shot-like meant granular.

Ehrlich - Stated that shot differentiates from granular as granular differentiates from crumb.

Stobbe - Repeated his discussion on shot-like and discussed previous remarks on this topic.

Moss - Suggested that shot-like granular could be used.

Odynsky - Stated that many people think that shot means concretions.

Farstad - Stated he had concretions that are shot-like.

Simonson - Suggested granular-strong.

Farstad - Asked for terminology to stress concretions.

Bowser - Moved that shot as a specific structure be used as an adjective. This was seconded by Farstad.

Ellis - Suggested that if granular were used then use it as a modifier for example shotty-granular.

Moss - Suggested using shotty concretions and shotty granular.

Discussion on Geological Structures:

Ehrlich - Read some definitions for geological structures taken from "Principles of Sedimentation" by Twenhofel.

Ellis - Queried about the structures in parent material of soils such as till.

Ehrlich - Stated these could be referred to as pseudo-types, such as pseudo-fragmental.

Ellis - Suggested that fragmental may be geological.

Lajoie - Queried if stratification was a change in texture.

Ehrlich - Usually.

Ouellette - Queried varved clays.

Lajoie - Suggested you state things as you see them.

Stobbe - Varved clays are referred to as banded clays.

Millette - Stated that he had written a thesis on wind blown versus water-laid deposits and suggested that these were layers of uniform textures and wondered what to call them.

Lajoie - Suggested they be called layers.

Millette - Suggested using a term and defining it.

Ehrlich - Stated that stratification is generally due to a difference in texture.

Odynsky - Suggested setting up terms using beds.

Ehrlich - Stated layers and beds are the same.

Odynsky - Stated that a bed is the same as strata; and added that a layer is thinner and a varve is the thinnest.

Ehrlich - Suggested using a personal interpretation so that others could understand.

Farstad - Asked about the definition of varved.

Ehrlich - Said it is stratification as a result of seasonal changes.

Discussion on Soil Consistence:

Wicklund - Suggested that the term friable by itself meant moderately friable.

Lajoie - Suggested deleting the word moderately.

.....The Plenary session agreed to use slight instead..... of friable.

Hutcheon - Asked how many people could make these separations and what application do the separations apply. He suggested the use of 3 separations.

Moss - Suggested we were not relating structure and consistence. He stated that a prism may go to a flat-top block which breaks easily or hard and the pressure required refers to consistence.

Hutcheon - Suggested that consistence is a property of the structure not of the soil. He suggested that the consistence of soil could not be evaluated.

Stobbe - Expressed disagreement and suggested that there can be a friable soil composed of hard peds. He added, soils could have a hard "B" with hard peds.

Hutcheon - Suggested that columns could be differentiated in soils and the columns could break to clods and crush to powder. Pressure, he added, is required to break the structure and suggested a limit of 3 classes for consistence. He asked if consistence gave any genetic information about morphology.

Stobbe - Suggested that after the information has been gathered it could be placed into three classes but now there was a need for five classes. He felt that five classes would be easier to apply in the field and suggested that if only three classes were used there may be overlapping because of over emphasis.

Moss - Stated that there should be uniformity between workers and doubts that there could be because, the method of determining consistence was strength and this varied between people. He added that there is no measurement for consistence.

Millette - Suggested that the consistence classes were too variable when use is made of six classes plus the human factor.

Stobbe - Suggested the need for five classes for the present.

Hutcheon - Suggested when describing pressure that a soil could be firm if moist and might be very firm when dry.

Ellis - Referred to the terms friable, firm and hard.

Ehrlich - Asked the group if they were in agreement with the consistence terminology as it appeared in the U.S. Manual.

Moss - Said it was too complex.

Hutcheon - Wondered if a worker could duplicate his consistence ratings.

Matthews - Stated he would like to support Hutcheon's dry-moist-wet concept, and added that the moisture content should be known.

Ehrlich - Defined dry, moderately moist, moist and wet from the 1948 report.

Matthews - Asked how would you determine moderately moist.

Ehrlich - Read from the report.

Bentley - Suggested using the same classification and fewer subdivisions.

Hutcheon - Stated that he would support the classification of consistence if it were reproducible.

Lajoie - Stated the need for five classes for differentiation.

Odynsky - Suggested that two units be taken out of the classification.

Farstad - Preferred to include five units in the classification.

Odynsky - Stated that after very hard, a person could not differentiate consistence.

Bowser - Suggested subdividing by adjectives and suggested 1948 terms and modifying them.

Moss - Suggested using the terms soft, firm and hard plus modifiers.

Ehrlich - Suggested the term firm for moist or moderately moist conditions.

Hutcheon - Suggested that moisture could not be estimated in the field.

Ehrlich - Stated that there are no instruments used in the field to determine moisture and thus would have to estimate the moisture content as described in the 1948 report.

Hutcheon - Questioned its application.

Ehrlich - Suggested the use of the terms dry, moderately moist, moist and wet. The term soft would apply to dry soils.

Ripley - Suggested the term friable would apply to dry soils.

Moss - Suggested that the terms soft, firm and hard indicated pressure.

Millette - Suggested that five terms could be used with less error and indicated that three terms would be too restricted.

Simonson - Stated that the determination of consistence is difficult and he favoured the use of fewer terms but said that the U.S. Survey personnel are able to obtain about 85 percent reproducible results with present classification.

Bentley - Stated that the soil could be plastic, sticky, dry and moist, and suggested that four consistence terms be used instead of six. He referred to the U.S. Manual containing six classes.

Ehrlich - Agreed that six classes were too many.

Ripley - Indicated that the terms soft, hard, firm were better than the term friable.

Ehrlich - Suggested the use of an adjective and omit the term friable.

Leahey - Stated that many reports came to his office containing the terms very hard and very sticky; he added that one report contains wet consistence while another indicates dry consistence. He suggested that moisture conditions be indicated when reporting consistence.

Ehrlich - Suggested that field workers report the consistence at one of the four moisture levels listed in the 1948 report.

Leahey - Suggested that here was the problem that needed some research.

Ehrlich - Indicated he had 14 types of structure which could be examined for consistence.

Millette - Queried the use of the term dense in regards to ground moraine which had 35-37% pore space.

Bentley - Indicated that the U.S. use the term compact for Millette's dense.

Ehrlich - Indicated that the group had three options:

(1) Keep the 1948 classification;
(2) Revise the 1948 classification;
(3) Adopt the U.S. classification.

......Group favoured the third option--Seconded........ by Farstad.

Recorded by - J.G. Ellis.

RMcL

PRELIMINARY REPORT OF SOIL HORIZON COMMITTEE

DISCUSSION

The following is a summary of some of the discussion that took place at the plenary session of the National Soil Survey Meeting on the Soil Horizon Sub-Committee Report. It is presented as a preamble to the body of the report for purposes of explanation. It is felt that such a preamble is desirable since

(1) this was the first report of a soil horizon committee
(2) some of the suggestions in the report deviate materially from the present accepted practice and
(3) this is a preliminary report.

The Committee first asked the question, "What is the purpose of defining and separating soil horizons?" They suggested the following reasons:

(1) It is a basis for classification.
(2) It is a means of showing relationships.
(3) It is an application of our present state of knowledge.
(4) It is our interpretation of the genetic processes that have been operative.
(5) It is a stimulant to further research.

Some additional reasons suggested by the meeting were:

(1) It is to bring order out of chaos.
(2) It is to indicate a specific position in the profile.
(3) It makes it possible for pedologists to convey to others our interpretation of a profile.

The second question asked by the Committee was, "What is the definition of a master horizon?" They suggested two definitions:

(1) The "zone" wherein a common pedological process is operative.
(2) Any horizon that is significant in characterizing a soil group at a fairly high level of abstraction. (e.g. Group VI of classification committee's proposal.)

The discussion on this question indicated that the term "master" had never been formally applied. Possibly a better term might have been a characterization horizon, and as such A, B and C and several subdivisions of these would qualify. It was suggested that they must be sufficiently characteristic to be recognized, and to satisfactorily differentiate soils.

It was suggested that A, B and C, as such, were difficult to determine and that generally they were recognized by the attributes of one of their subdivisions; that is A_1 or A_2 is recognized, not A. We think in terms, not of A, B and C, but as an A group or a B group of horizons.

This lead to the question, "What broad definition can be given to embrace our present concept of A, B and C?" The only suggestion offered was that A was the zone of maximum weathering, B the zone of less intense weathering and C the relatively unweathered portion.

It was recognized that soils could not generally be mapped by the surveyor on the intensity of weathering and that other factors, such as accumulation, eluviation, etc., were the distinguishing characteristics used by the mapper.

The discussion at the plenary session then turned to the use of subscripts of A, B, and C. A comparison was given by the committee of the numerical subscripts as presently used and suggested as an alternative the adoption of a symbolic letter subscript. It was pointed out that the meaning of the present numerical subscripts varied with position. For example, 2 after the A has a different connotation than 2 after the B. Likewise, a number used in the second position has a different connotation than when it is used in the first position. It was also apparent that the second numeral was being given a specific connotation. From the discussion and from the reports submitted by the survey units to the committee, it appeared that we were not only at variance in horizon nomenclature usage, but also that we had locally attached specific meaning to the second numeral subdivision.

In discussing the use of letter subscripts it was stated that it would tend to make surveyors guess unnecessarily. Conversely it was stated that mappers would be more hesitant and only use subscripts when sure of their interpretation. It was also suggested that competence to classify presupposes that a specific subscript can be given.

REPORT

The plenary session of the National Soil Survey Committee

(a) agreed to accept on a trial basis the idea of symbolic letter subscripts as proposed by the soil horizon sub-committee.

(b) requested the above sub-committee to compile a list of suggested symbols, and to circulate these to the members of the committee.

(c) requested the survey units to give this proposed system of horizon designation a fair trial during the summer of 1956.

The following subscripts to be used with A, B and C are suggested; others may be found necessary.

c - cultivated layer.

h - a dark mineral horizon dominantly characterized by the presence of humus. The most prominent example is the chernozemic A, written Ah. In the humus podzol the designation Bh would be used.

e - a light colored horizon that is the result of eluviation.

The most prominent example is the podzol A, written Ae.

ir - A colored horizon characterized by a comparatively high iron content. Usually considered as an illuvial horizon. The iron podzol is an example, written Bir.

The example of a horizon high in iron, but weathered more or less in situ is another question. Might it be Air if in the horizon of maximum weathering?

t - An illuviated horizon with accumulated clay and indicated by the presence of clay skins. The solonetzic B is an example, written Bt.

g - A gleyed horizon - indicated by grey colors or red or yellow blotches. The weisenboden B is an example, written Bg. It could also be used with A.

xca- Is the lime accumulation horizon.

xsa- Salt accumulation horizon.

xcs- Gypsum accumulation horizon.

xNo decision was reached as to whether these should be used with the B or the C. From the definition of C, (namely, little or no weathering), it might seem more logical to use them with the B, as Bca or Bsa. Ca rather than Co_3 is suggested because it has common usage and the 3 introduces an offset type.

m - An induration horizon. It is suggested that it be used in combination with another subscript, for example, a clay pan would be Btm and ortstein - Birm.

Note: Horizons of orterde might be designated Birh - is there a better suggestion?

u - this is a convenience subscript when an unconforming layer occurs within the solum and would be written for example, Btu.

r - As a subscript of C or B - if consolidated rock.

In addition to the above the following capital symbols are suggested:

O - this to replace the former A_{oo} and A_o.

D - a layer underlying C or B that is different from the material from which the solum is formed.

If any of these principal horizons require subdivision, they should be divided by the use of added numeral subscripts, e.g. Ahl and Ah2. However, these are to be used in a numerical sequence only. It is suggested that these are mapping conveniences and should not appear in a report. For example, if it is necessary to report two divisions of Ah, it might appear:

Ah 0" - 6" - very dark grey
Ah 6" - 9" - dark grey

or

Ah 0" - 9" - the top 6 inches is very dark grey.

This grades to dark grey in the lower portion. Is there any difficulty with the first example?

The transition zone, for example, between A & B (old A_3 B_1) would be reported as A. B. or if necessary B. A.

The following are examples of some type profiles:

Chernozem - Antler loam
Page 42 - Alberta Red Deer Bull.

Ah - 0 - 8"
Ah - 8" - 13"
B - 13 - 23
B - 23 - 27
Bca 27" - 36"
C - 36" →

Solodized Solonetz-
Wetaskawin L.
Page 46 - Alta Red Deer Bull.

Ah - 0 - 9"
Ahe - 9" - 11"
Ae - 11 - 13"
Bt - 13 - 19
Bt - 19 - 23
Bcs 23 - 30"
Cca sa - 30 →

Podzol - St. Fransis S. L.
Page 48 - Quebec Stafford etc Bull.

O & Ah - 0 - 2
Ae 2 - 4
Bh 4 - 12
B 12 - 30
C 30" →
D

Grey Wooded Braeburn L.
Page 36 - Alta Rycroft etc. Bull.

O - 1 1/2 - O
Ah - 0 - 1/2
Ae - 1/2 - 5
AB - 5 - 7
Bt - 7 - 13
B - 13" - 33"
Bca 33 - 39
C - 39 →

Depression Podzol
Page 171 - Saskatchewan #13 Bull.

0 - 2 - 0
Ah - 0 - 1
Ae - 1 - 10
Bg - 10 - 25
BCg - 25 →

Dark Grey Gleisolic
New Brunswick - Woodstock Bull.

0 - 2 - 0
Ah - 0 - 4
Bg - 4 - 12"
C - 12" →

Alluvium High Prairie SiL.
Page 104 & 67 Alberta High Prairie Bull.

Ah - 0 - 4
Ah - 4 - 12
C - 12 - 19
Cg - 19 →

It is to be noted that in the above examples B is in some instances used without subscripts. This, in part, corresponds to the S. in the proposed U.S.D.A. system. It may, for example, contain more clay than C but this is due primarily to weathering in situ.

It is the hope of the Soil Horizon Committee that the survey units give this a fair trial. Modifications and additions are solicitated.

Respectfully submitted,
Soil Horizon Sub-Committee of N.S.S.C.

R. Baril
J.F.G. Millette
Earl Bowser, Chairman.

REPORT OF THE SUBCOMMITTEE ON PUBLICATIONS

Committee - G.R. Smith (Chairman),
L. Farstad,
J.D. Newton,
N.R. Richards

A marked improvement has been noted in many Canadian Soil Survey reports which have been published since our 1948 meeting and this is a sign of progress.

The most striking improvements have been noted in the following sections:

(a) General description of the area.
(b) Under the general heading of agriculture and with particular regard to the sections dealing with utilization.
(c) The productivity rating of soil types.

The members of your subcommittee are of the unanimous opinion that we will continue to improve the quality of soil survey reports providing Canadian Soil Scientists are agreed on the purpose of soil survey work and are also agreed that soil survey projects must be classified under the heading of Research.

The purpose of soil survey work is to classify the soils and to prepare an inventory of the quality and quantity of the soil resources of the surveyed area. Insofar as the presentation and discussion of these data is concerned, it is evident that all the information in the report will not be fully understood by all readers.

Quality of Paper

High quality paper has been used during the past few years in the majority of reports and, in general, reproduction of photographs and diagrams has been good. There have been exceptions to this rule and this has resulted in criticism in some quarters.

Too great emphasis cannot be given to the fact that the paper costs of a soil survey report represents a relatively small percentage of the total cost of doing the soil survey work and every soil surveyor should insist that only high quality paper be used in preparing the reports.

Time Lag Before Some Reports Published

Criticism has been directed our way because of the relatively long time which sometimes elapses between the time the field work is completed and the reports appear for distribution. The members of the Publication

Committee are of the opinion that the maps in practically all cases are prepared as rapidly as possible but they also feel that the writing of the report in some cases could be carried out in a much shorter period of time.

There does not seem to be too much difference of opinion among Canadian Soil Scientists concerning the type of information which should be included in a soil survey report, but as the 1948 committee pointed out there does seem to be some differences of opinion as to how this information should be arranged and presented. A number of our workers would like to present the information in a more popular fashion whereas others believe that only the "bare facts should be presented".

Keeping in mind the fact that these differences in opinion exist, and keeping in mind the fact that change is often a sign of progress, your committee now recommends the following for your consideration:

(a) Summary statements first page or pages of report.
(b) Use high quality paper in all Soil Survey Reports.
(c) Use of only best photographs, and use of two or three coloured photographs in each soil survey report.
(d) Place the detailed soil descriptions in a separate section, together with photographs of the profile or schematic drawings of the profile if desired.
(e) In some cases expand the written material under headings of utilization and description. (Tell all you know about the soil).
(f) Make no specific recommendations regarding treatments. Soil management is not the responsibility of the soil surveyor.

The following information was submitted to the Subcommittee by Dr. Newton and it presents the views of a number of the soils men in Alberta

This group recommends that coloured soil maps of counties, or survey sheets or similar unit areas be prepared on a scale, or scales, suitable for reconnaissance or detailed reconnaissance surveys, with brief practical descriptions of the mapped soils and soil profiles on the front of each map. These maps should be prepared and printed as soon as practicable after the field survey work has been completed, and could thus be ready for use before a report has been written. The maps would be made available to farmers in the area and to others interested in the more practical phases of the soil survey.

The group also recommends that scientific monographs or reports of major sections of each province be prepared after the reconnaissance surveys of the area have been completed. These would contain the scientific descriptions of soils and soil profiles, including chemical and physical analyses, and other pertinent and scientific information. Such publications would tend

to eliminate repetition of information in successive soil survey reports of smaller areas. It would be necessary to revise the monograph when more information has been obtained but it would not be necessary to prepare a separate report whenever a new reconnaissance map is issued. It would probably be desirable to prepare a family scale soil map to accompany the monograph.

The desirability of preparing a handbook on soils and crop production to be placed in the hands of professional agriculturists, is recognized. Such a handbook might be prepared on a provincial basis or on a regional basis, and should be revised at frequent intervals. It might be desirable to include information on other phases of agriculture as is done in the Saskatchewan "guide". The handbook should contain general descriptions of soils and up-to-date recommendations regarding the use of fertilizers, cultivation, crop rotations, etc.

Discussion of Report on Publications

Leahey	What does the committee mean by specific recommendations?
Smith	Specific fertilizer recommendations etc., which may change. Recommendations made in some reports are no longer valid now.
Stobbe	Should specific recommendations be made for other conditions, e.g. drainage, land use, etc.?
Ripley	The committee did not have in mind such things as drainage and land use when it made this statement.
Newton	Want to be sure of ground, must have recommendations based on sound evidence.
Matthew	Should point out problems not methods in the report.
Ellis	Report is read by individuals who are not soil scientists. Soil reports should not be too technical. More technical data should go into scientific publications.
Whiteside	Description of soils creates considerable interest on the part of the reader.
Newton	Some workers do not like descriptions in the main body of the report.
Ripley	Table of analysis should be placed in the appendix - put problems in the front.

Stobbe — If too much material is placed in the back of the report, it will be ignored.

Bentley — For particular soil, popular and technical descriptions should be placed side by side.

Leahey — Report is for reference - chemical and physical data should be placed with profile descriptions.

Bowser — Won't accomplish anything by putting soils data in the back of reports - want descriptions together.

Ripley — Scientific journals - put figures, photos, etc., at the back.

Newton — Chemical analysis easier to compare if not separated from the profile descriptions.

Smith — How many in favour of transferring descriptions to another part of the report? Want one part in descriptive form and one in detail in the book. (For - 12; Against - 11)

Richards — Offered to publish a trial copy and Wicklund agreed to assist in the preparation of the report.

Ripley — Reports written more for appraisers, soil conservationists and extension men - should write at this level.

Simonson — Don't underestimate your audience - they like it more scientific. Pressure of county agent is to tone down reports - this is not accepted by the public. Reports should not be popularized - but give more information. Make them more technical.

Richards — The idea is not to simplify the reports but rather to have them better organized and make them more readable. We do not wish to talk down to the reader.

Smith — Keep report at high level.

Smith — Recommend:
- (a) summary on first page of report (Agreed)
- (b) High quality paper to be used (Agreed)
- (c) Photographs - use only the best photographs in report (Agreed)
  - try some coloured photographs in one or two reports (Agreed).

Simonson — We do not use coloured photographs in U.S. reports - poor quality photos forwarded by the field man seems to be the big factor.

Chancey — Need to take time to get good picture. Should have considerable experience and good equipment before undertaking job of taking photographs for soil survey reports.

Odynsky — Can't reproduce colour.

Bentley — Good negatives will sometimes give poor reproductions.

Ripley — Use black and white.

Lajoie — Some soils, such as brown podzolic can not be shown in black and white.

About time lag of maps and reports

Newton — Map without report should be published soon after field work completed. He showed Alberta map as example.

Richards — Southern part of Ontario covers 22 million acres and the soils have been classified in low families by Matthews - a report describing the families will accompany the generalized map for this area. Later it will be possible to publish county maps with an expanded key and without report.

Simonson — Generally a county used at universe level. A farm in a more detailed survey could be a universe. Province, county, and farm all need different scales. Reports must be governed by the type of work done.

Stobbe — (1) Where impossible to get the regular report out with a map, I would suggest a simple report on soils 6 to 8 pages-10 pages at the most.
(2) Legend alone on map is not sufficient. Have to read report.
(3) Would prefer ordinary report and maps, otherwise simplified report, giving known facts.
(4) Later, more scientific data can be collected and published separately.

Bowser — Is it only emergency measure?

Smith — Yes - to get information out sooner - ahead of report which might be 3 - 4 years. Must be careful not to retard report by such procedure.

Newton	Figures are educational, not necessary to write report for every map.

Handbook Discussion

Newton	Bowser suggested loose leaf handbook describing the soils.
Simonson	In U.S., 15 were published to get reaction.
Smith	Committee recommends bound books not loose leaf.
Newton	Handbook could be revised
Ripley	What is in here that isn't in the reports?
Bowser	Nothing - but saves repetition of descriptions. It is meant for a limited group of people - not for use by the farmer.