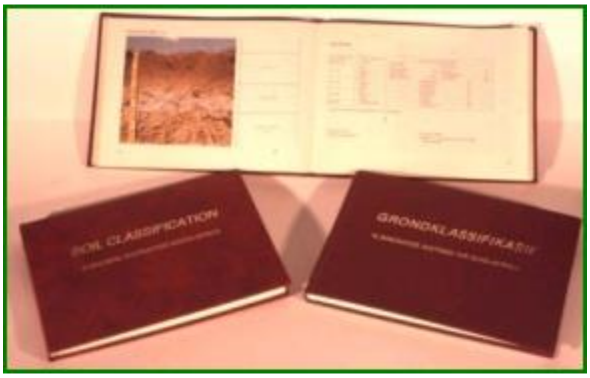
# SOIL CLASSIFICATION - A BINOMINAL SYSTEM FOR SOUTH AFRICA




The object of this book is to present a simple, definitive statement of the first detailed system for classifying the soils of South Africa. The system has evolved over a period of years and is now being formally released for general use after extensive performance-testing by a wide variety of individuals and organizations. Its general acceptability in the agricultural sphere has been established and its implementation as a national system approved by the Department of Agricultural Technical Services. Publication of a definitive edition at this juncture is thus appropriate. This is a first edition; it is certain that the system as presented here is not the final word. It will continue to develop in step with expanding knowledge of the soils of this country; future changes will reflect refinements in the appreciation of the soil both as a natural phenomenon and as an essential life support.

Because there exist many popular misconceptions regarding the nature and purpose of soil classification, it is important that those who would wish to use this system develop an early appreciation both of its possibilities and its limitations. Soil properties – visible as well as non-visible (but measurable) – form the basis of the classification. Since properties, individually and collectively, determine the intrinsic behaviour and capability of soils, a vast amount of information that is potentially relevant to land use and management is contained in and can be conveyed by the language of classification. Those, therefore, who see soil classification as a theoretical or academic exercise – something for the experts only – deprive themselves of sharing in the practical benefits that result from its use. On the other hand, it must not be thought that classification will, in itself, provide answers to all questions. It must be coupled to soil mapping for it to yield any information on the geographical distribution of soils. It must be coupled to information on other resources such as climate, topography and management before it will have any specific meaning in terms of land use and agricultural production. As part of an integrated information system it has immense utility; alone it has limited value.

This soil classification has as its primary aim the identification and naming of soils according to an orderly system of defined classes, whereby the inter-relationships between soil properties are clearly revealed and communication about soils in an accurate and consistent way is made possible. It also has secondary and more practical aims relating to land utilization and management; these it achieves by pointing up similarities and differences between soils that are pertinent to land use, and by giving clarity and meaning to map legends. However, none of these secondary aims is achieved without additional inputs of information and interpretation. A clear distinction must therefore be made between the classification of soils, and interpretations based on the classification. The former is dealt with here, the latter not. And for very good reasons. In the first place, land use interpretations must be preceded by a statement of objective, and so great is the number of potential objectives involving the soil that it is impossible in a work of this nature to anticipate, let alone discuss them.

Secondly, only a part of the information required to make interpretations is contained in the classification; other non-soil information, and not infrequently other soil information, is invariably also required, and about this the soil classification has nothing to say. Local climatic, topographic, engineering, socio-economic and many other factors must normally be considered and integrated with the soil factor when making interpretations for a specified objective. It is thus beyond the scope of this book to venture any statements, however simple or generalized, on the ability of soils to fulfil certain functions or on their behaviour when put to a particular form of use. Such statements are more appropriately made at the level of local land capability studies.

This book is intended then to serve as a vade mecum for soils identification in South Africa. It does not include a discussion of the theory of soil classification, nor does it purport to be a manual for soil survey or a treatise on soil genesis. However, to enable those who might not be well-versed in the technicalities of soil science to use the system independently of other sources of information, to promote insight into the significance for land use of soil classes and to facilitate interpretation of maps and reports relating to the quality of soil, explanatory notes on various terms and concepts are included in the glossary.

› Historical Background
› Structure of the Classification System

## HISTORICAL BACKGROUND

The first edition of a new soil classification system for South Africa is presented in response to a widely-felt need for some means of identifying and naming soils in a consistent way and for distinguishing between those whose properties and behaviour demand that they be set apart. This need has arisen notwithstanding the meritorious contributions of earlier South African soil scientists. For a time the broad groupings of Van der Merwe (1941), together with those made in terms of the CCTA/SPI legend for the soil map of Africa (D'Hoore, 1964) and its early drafts, provided an adequate perspective of the general nature of the soil mantle and permitted orientation at an atlas scale. But as objectives became more practical in terms of agricultural and other kinds of land utilization and attention consequently became focused on individual landscapes, individual farms, and individual fields, these groupings proved to be inadequate. They were not sufficiently rigorous in definition, nor were they sufficiently specific in differentiation, for the purpose of detailed soil identification and mapping.

The past fifteen years have seen a dramatic increase in the tempo of soil mapping in South Africa and inevitably the problem of selecting or developing a classification had to be faced. Without a generally accepted classification system soil mapping programmes lack continuity in time and space and the resulting maps lose much of their interpretability. There was no intention, initially, of developing a new system. On the contrary, considerable effort was devoted to examining the applicability of available systems, notably that of the USDA Soil Survey Staff (1960). However, as information accumulated it became evident that there was no factual, logical and, above all, simple system which would satisfactorily accommodate the soils of South Africa.

It is of interest to reflect on the stimuli which gave rise to the period of heightened enquiry into the nature and distribution of the soils of this country. Foremost was probably a growing realization that existing information on soil and other land resources was grossly inadequate to serve a variety of needs. Impending intensification in land use, coupled with increasing world-wide concern over population trends and dwindling natural resources, undoubtedly did much to precipitate this realization. It was predictable that planning, in all its aspects, would be needed in order to optimize land utilization and fully develop the natural resources potential of the country. But such planning demands a complex information infrastructure which is not developed overnight. Soils information was in a parlous state and there seemed thus to be compelling reasons why a systematic study of the soil resources of the nation should be initiated.

The inadequacies were highlighted by agricultural research in various spheres. For example, the question arose as to whether the problems that were being addressed by agronomic research and field experimentation were sufficiently widespread to justify the effort and, once results were obtained, where were they applicable? The much discussed gap between research and the extension of its results could be traced largely to the absence of a secure basis for extrapolation.

Little was known about unique yield ceilings and response patterns of individual soils and soil-climate interactions. Consequently, fertilizer advisory work developed upon fairly standard recommendations which, even though they were guided by soil analysis, inescapably under-exploited the inherent production potential in some situations and probably overestimated it in others.

Most disturbing of all, perhaps, was the fact that scant attention was being given to the nature of the soil during farm planning. Ideally, farm planning involves the integration of all available agricultural information and the application of that which is relevant to a particular site or situation. Increasing demands upon the agricultural industry cause farming to become more intensive and specialized. This in turn brings about an increase in the proportion of technology that must be applied vertically, that is, selectively to the sites and situations to which it is appropriate. Consequently, site and situation, of which soil is a vital component, need to be more and more closely circumscribed.

Various surveys were carried out in response, we believe, to these stimuli. Among the early field studies to be undertaken was that in the Tugela Basin of Natal. As part of its efforts to establish an adequate planning base, the Natal Town and Regional Planning Commission initiated, in 1956, a soil survey of the Basin in conjunction with the University of Natal and the Department of Agricultural Technical Services. In many respects this major undertaking laid the foundations of the new classification. The survey report (Van der Eyk et al., 1969) contained a prototype of the system, and a summary of the underlying rationale which had been presented elsewhere (MacVicar, 1969).

Numerous other surveys provided a growing base of experience which made possible the evolution of the system to the stage where it now approaches comprehensive, country-wide applicability. The Experiment Station of the South African Sugar Association at Mount Edgecombe had accumulated much information on the soils of the Natal Coast Lowlands. This was incorporated into a first list of soil series definitions (MacVicar et al., 1965). The Soil and Irrigation Research Institute launched a programme of key-area surveys which yielded much valuable information in previously unexplored regions. Considerable momentum was added to the data gathering when the fertilizer industry and the Government of the Republic commissioned extensive soil surveys in various parts of the country. Several university departments also ran field survey programmes in conjunction with post-graduate training and, more significantly, the teaching of soil science in this country underwent something of a renaissance.

This was an exciting time pervaded by an atmosphere of experimentation and improvisation. In the United States, the USDA Soil Survey Staff (1960) was developing an imaginative new system through a concerted application of talent and experience that is unique in contemporary soil science. This was happening in full view of world attention. The logic of the new approach was refreshing and, although it may not have presented everyone with a classification to suit his needs, it loosened the shackles 'of traditionalism and stimulated re-thinking on soil classification. The appearance in recent years of several new classification schemes bears testimony to this.

Being man-made contrivances, classification systems take on different forms depending on circumstances and the background, philosophy, and terms of reference of the persons responsible for developing them. Two.requirements in particular have guided the development of this system. The first was that the classification had to be easy to understand and to use. It was clear at an early stage that the manpower situation was inadequate for the soil survey task that confronted us even if we thought only in terms of the more intensively utilized, higher rainfall areas of the country. Detailed mapping by soil scientists as a means of extending information about soil behaviour to individual users of land was not feasible in the short and medium term as a general procedure (except in the case of highly capitalized forms of land use) and an alternative approach had to be found. Experience that was accumulating at the time suggested that the most likely solution to the impasse lay in reconnaissance mapping backed up by a classification system that would be acceptable to, and could be used by, non-soil scientists for accurate soil identification in the field. Class definitions had to be factual statements of soil properties, preferably those that can be seen and easily measured. To be avoided were criteria which are not always measurable and involve speculation (such as genetic history). This imposed distinct and obvious restraints on the subsequent development of the system and has been the main influence in its evolution up to the present.

The second requirement which applied was that the classification should be comprehensive and should be capable of accommodating all of the soils to be found in the Republic. Parochial classifications of a farm, a district, or a region can serve a useful purpose for a time, but because of their restricted vision they do not serve the needs of soil users on a country-wide basis. A national perspective is required directly by many agriculturists, ecologists and resource scientists and, indirectly, by all. The real objectives of soil classification are largely defeated by a proliferation of ad hoc classification schemes.

There is reason to believe that events have justified the particular course of action taken and the precepts upon which that action was based. In providing a generally acceptable means for the identification of soils in terms of the classes which it sets up, and the consequent rationalization of map legends, the classification has accomplished its minimum objectives. But it has accomplished far more than this. By drawing attention to the similarities and differences between soils and by permitting accurate communication about them, the classification has promoted a better understanding of the relationships that exist among soils, and between them and the environment. It has given to non-specialist users in many spheres the confidence and perspective to exploit soils information more fully, and there is increasing evidence that it is permitting the development of a sound basis for predicting soil behaviour and management responses under defined conditions.

## STRUCTURE OF THE CLASSIFICATION SYSTEM

Master horizons | Diagnostic horizons | Soil forms | Soil series

In essence the system is a very simple one which employs only two categories or levels of classes – an upper or general level containing SOIL FORMS, and a lower, more specific one containing SOIL SERIES. Each of the soil forms in the classification is a class at the upper level, defined by a unique vertical sequence of diagnostic horizons. Each form, except Dundee, is subdivided into a number of series (varying from two to thirty or more) which have in common the properties of the form (that is, the prescribed horizon sequence) but are differentiated within the form on the basis of other defined properties. The range of variation permitted within a class at the series level is thus narrower than that at the form level and the series is a far more specific concept than the form.

Soils (in practice, soil profiles) are classified with reference to this system, being allocated first to a soil form and then to a series on the basis of the relevant soil properties which define the classes. Identification (and communication) is accomplished by means of names, and all classes at both levels are given place names in accordance with convention. The system is thus a two-name one. In this respect it parallels the binomial Linnaean system of classifying plants and animals, form being analogous to the genus of that system and series corresponding to species. No two series in the classification system have the same name. Consequently reference can be made to a series without using its form name. However, as the number of series is fairly large, communication may be made easier by using the form name or its abbreviation: for example, Valsrivier arniston or Va arniston.

The procedure to be followed in the identification of a soil by means of this system involves:

(i) demarcating the master horizons present in the profile (O, A, E, B, C, G and R),

(ii) identifying diagnostic horizons,

(iii) establishing the soil form,

(iv) identifying series differentiae, and

(v) establishing the soil series.

The definitions and criteria needed to apply this procedure of identification are discussed in the pages which follow and lead up to a presentation of the classification itself.

## Master Horizons

Development of genetic horizons, as distinct from depositional or inherited stratifications, has been traditionally accepted as the quintessence of soil formation. Processes which form soil have a net tendency to differentiate the materials on which they act (rocks and loose sediments of various kinds) into horizons. The importance of these horizons to the classifier is that they are reproduced over and over under the same genetic conditions. Soils, therefore, are unique in that they consist of horizons. This is the starting point.

If one regards this attribute of soils as the norm, then the absence or minimal development of genetic horizons in materials which, for practical purposes, are regarded as soil becomes significant and is usually traceable to youthfulness or processes which work against horizonation. Although, they represent the exception rather than the rule, provision is nevertheless made for the inclusion of certain undifferentiated materials in the system (young alluvia, deposits of raw sand).

The organization and re-organization of material as R a result of soil formation follows a pattern which can be generalized by recognizing a small number of master horizons as shown in Fig 1. Standard letter symbols are used to denote the master horizons as follows:

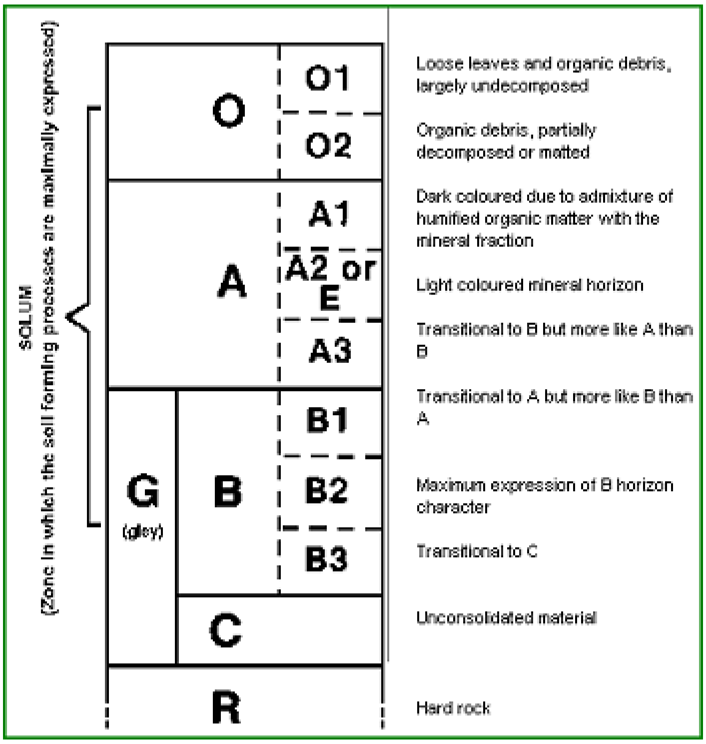
O – An horizon forming the upper part of the soil and consisting of fresh and/or partly decomposed organic matter accumulated under marshy conditions.

A – An horizon at or adjacent to the surface and consisting predominantly of mineral particles intimately mixed with a greater or lesser amount of humified organic matter.

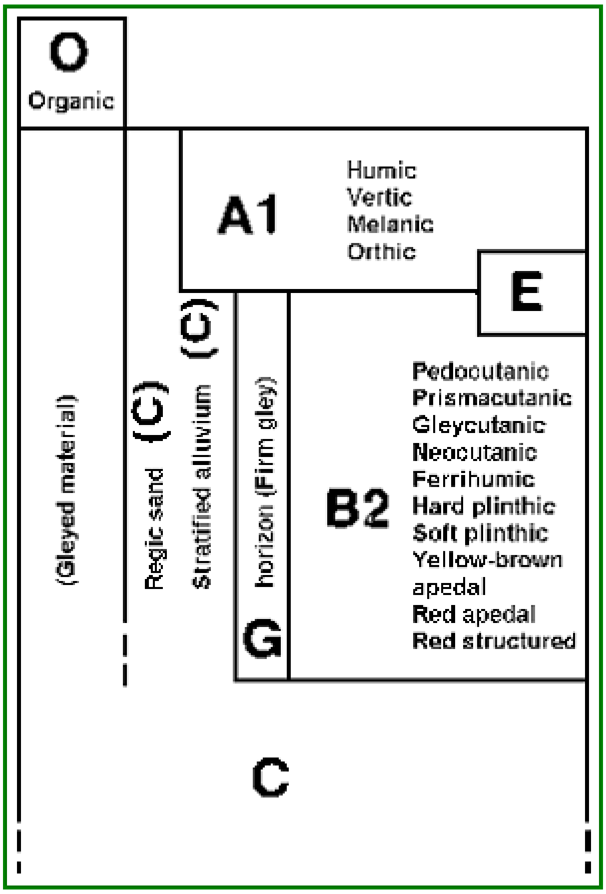
B – An horizon lying between the A and the C or R horizons which is characterized by a concentration of silicate clay (by illuviation or alteration), sesquioxides (by illuviation or residual accumulation) or organic matter (by illuviation), alone or in combination.

C – An horizon consisting of unconsolidated material (including weathered rock) which does not show properties of the other master horizons.

R – Consolidated bedrock and strictly, therefore, not an horizon.




Arrangement of master horizons




Diagnostic horizons

These conventions are observed more or less universally. G In recent years there have been proposals to add two further master horizons, namely:

E – An horizon showing features of strong reduction under anaerobic conditions, usually with bluish, greenish or greyish colours or combinations of these, and having subordinate expression of properties diagnostic of A, E or B horizons.

G – An horizon underlying the O or A horizon (if present), having a lower content of organic matter and/or sesquioxides and/or clay than the immediately underlying horizon, usually reflected by a pale colour and a relative accumulation of quartz and/or other resistant minerals of sand or silt sizes.

## Diagnostic Horizons

Few soils contain all of these horizons, but all soils contain some of them, and in a majority of cases they are quite easily identifiable in vertical exposure such as is provided by the face of a soil pit.

Recognition of master horizons is the first step in examining, describing and identifying soils in the field. However, it will be appreciated that the master horizons only really contain or convey information relating to position in the profile (a B horizon, for example, occurs below an A and above a C or R material) and the general nature of the processes which have taken place (for example, accumulation of organic matter, development of soil structure, weathering). B horizons, for example, are found which have such widely contrasting properties as to be entirely different from one another in all respects except those which determine that they are B horizons. These more specific properties of the master horizons are as, or more important than the master horizons themselves when it comes to identifying (and utilizing) soils. Subscripts have been used as a device for specifying some of the more outstanding properties of master horizons: Bca, for example, signifies a B horizon having an accumulation of calcium carbonate. However, this device has limitations. Recently there has been a trend towards defining, more completely, specific kinds of master horizons. Unfortunately there is as yet no general agreement on a standard set of such diagnostic horizons nor on the criteria that should be used for their definition. This classification system defines in fairly rigorous terms a number of diagnostic horizons (Fig 2) that are tailored to fit the soils of South Africa. These definitions are presented in Chapter 3. For two reasons a short discussion of the underlying concept of the horizon follows its definition. Firstly, definitions of horizons have been worked out with the object of includingcertain things and excluding others. They are phrased in terms of soil properties and areas concise as possible. Each gives expression to a concept but, because the definitions eventually can become complicated (they describe a complex system), the underlying concepts tend to become obscured and the meaning behind the definition somewhat unintelligible. It is not very satisfying to apply a definition more or less slavishly without some appreciation of what is intended by it. Secondly, although correct identification will be achieved by literal application of the definitions in the vast majority of soils, there will always be anomalous cases which are not accommodated altogether comfortably in all respects. It is probably impossible to formulate definitions that will take care of all eventualities. In such instances the user is at a disadvantage if he cannot fall back on personal judgement and common sense, backed by an understanding of the concepts and intentions behind the definitions of diagnostic horizons.

In addition to meeting specified requirements in terms of properties, soil horizons should also occur wholly or in part within 1 200 mm of the surface in order to be diagnostic for the purposes of classification. A depth limit is necessary and that chosen, although arbitrary, is convenient in that it coincides with the depth to which soils are normally investigated during systematic surveys (using a hand auger), and acceptable insofar as the importance of soil for a majority of agricultural purposes diminishes rapidly beyond this depth. This limit is a guideline in that an element of common sense is needed in its application. Clearly material at a depth of 20 m is of little importance to most land users and is excluded by this guideline. However, a soil form comprizing say three horizons may occur in a landscape in such a way that in some places the third horizon occurs partly or wholly within 1 200 mm depth, and in other places it is below, often not by far, the 1 200 mm mark. In these instances, and even when the third horizon just misses the 1 200 mm mark throughout the landscape, it would be wrong to ignore it on such an arbitrary basis. Excluding it in these cases would frequently mean ignoring properties and processes, such as hydromorphy, important to land use as well as to an appreciation of genesis.

Top

## Soil forms

Recognition of horizons as definable entities amounts to dissection of the soil profile into a number of discrete, component parts. This analytical step is essential in the classification procedure but it should not be misinterpreted. Soils are not random combinations of horizons – they are unique integrated wholes. The horizons of a soil do not form independently of one another but are produced by the operation of a set of processes which affect the entire soil, albeit to different degrees in different parts of the depth profile. Diagnostic horizons have been abstracted and defined by studying whole soils as they occur in the field.

Because one is classifying whole soils and not horizons, it is necessary to reconstitute the soil after identifying master and diagnostic horizons. This is accomplished by means of the SOIL FORM which is a specification of the kind and sequence of diagnostic horizons present and, in some cases, also of the general nature of ,the underlying material.

Forty-one different horizon sequences, and thus soil forms, have been encountered in South Africa to date. These are arranged systematically for easy reference and as an aid to profile identification in the KEY TO THE SOIL FORMS. Each form is referred to by means of a geographic name (for example Swartland, Estcourt) which serves as a tag or label and has no further intrinsic significance.

The soil forms are illustrated by means of colour plates of selected profiles that have been included with the FORM-SERIES SCHEDULES in a later section. These profiles are representative examples of soils which belong in each particular form, chosen to show as clearly as possible the horizon sequence that defines the form. They do not illustrate the range of variation that occurs or that is possible within the form. This must be deduced from the horizon definitions and from the series specifications.

The soil form with its range of variation has provided the basis upon which correlations have been made between the classes of this system and those of the USDA Comprehensive System1 and the FAO World Soil Map Legend2 at an approximately equivalent level of abstraction. The correlations, which appear with the profile photographs, are of somewhat academic interest and should not concern the majority of local users. They should, however, provide foreign readers with a means of access to the system and will, it is hoped, facilitate orientation. It should be pointed out that the correlations are not exhaustive but relate to more or less modal concepts of the taxa of this system. The impression might be gained from the correlations that the forms have a very broad spectrum of properties since they are seen to span across suborders and even orders of the USDA system, for example. This impression would be mistaken; the forms are, in a majority of cases, rather specific morphological concepts in terms of the criteria used at this level of abstraction and in most cases represent a narrow slice out of the taxa with which they have been correlated. In other words, had the correlation been performed in the reverse direction, the result would have been very similar: taxa of the international systems also cut widely across the forms. The breadth of correlation arises from the use of different class limits for differentiating criteria as well as different criteria at the several levels in the respective systems. For example, base status and other criteria which permit the recognition of climatic zonality are given prominence at a high level in the USDA system, whereas this operates in general only at the series level in the South African system.

## Soil series

Soil forms are conceptual generalizations based on selected soil properties (those used to define diagnostic horizons) with fairly wide permissible variations. To make the classification useful for a variety of objectives, it is necessary to classify further in order to narrow down such wide variations as still exist. For narrower definition, use is made of two kinds of properties: firstly, narrower ranges of properties used to define the diagnostic horizons of the form, and secondly, properties that are not used to define diagnostic horizons. Subdivision of forms into series is the means whereby this further refinement is achieved and expressed. Each series is referred to by a geographic name (for example, Estcourt and Uitvlugt). The form takes its name from one of its constituent series (for example, Estcourt form contains an Estcourt series).

In many respects, this situation has a parallel in the classification of plants. Genera (cf forms) are recognized and defined in terms of a few prescribed attributes, namely the morphology of flowers and fruits (cf diagnostic horizon sequences). Individuals belonging to a genus can vary widely as regards other properties. For example, the genus Acacia includes plants as different as the gomdoring (A. borleae), a thorn tree with mature height of two to three metres, the apiesdoring (A. galpinii) which also has thorns but attains a normal height of some 20-25 m, and the black wattle (A. mearnsii) which is devoid of thorns. Cenchrus is a genus of grass plants, C. ciliaris (bloubuffelsgras) being a valuable pasture grass in the northern parts of the country, whereas C. brownii (fine bristle burgrass) is a proclaimed weed. These and other variations are accounted for by subdivision of the genus into a number of species (cf series).

Criteria used for series differentiation within forms include, most importantly: soil texture in terms of clay content and size grading of the sand fraction (coarse, medium, fine); base status in terms of dystrophic (highly leached), mesotrophic (intermediate), eutrophic (minimally leached or unleached); calcareousness; soil colour where this is not a criterion for the diagnostic horizon; soil reaction; the nature of the C or underlying material. The application of the series criteria is set out in the FORM-SERIES SCHEDULES. Details of standard class limits of certain criteria (base status and sand grades, for example) are provided in the glossary.

It should be noted that certain soil properties, notably soil depth and salinity, are not used in the classification. This does not mean that they are unimportant. On the contrary, a property such as soil depth is often critically important in practice. However, it is difficult to set limits that will be consistently relevant for all soils and all purposes. Practical distinctions which have a variable significance but which are needed to interpret the classification in terms of soil behaviour are introduced (for example during mapping) as phases of soil series. Analogous is the position regarding plant species. Knowledge of the species may sometimes suffice; on the other hand differentiation within the species is frequently necessary.