MLURI

Land Capability Classification for Agriculture

Macaulay Land Use Research Institute

MLURI

Land Capability Classification for Agriculture

J S Bibby
(Soil Survey of Scotland)

H A Douglas
(Meteorological Office)

A J Thomasson
(Soil Survey of England and Wales)

and

J S Robertson
(Soil Survey of Scotland)

Edited by J S Bibby

Macaulay Land Use Research Institute 1991

First published 1982 by The Macaulay Institute for Soil Research, Aberdeen
Reprinted with minor corrections, 1991
© Macaulay Land Use Research Institute, 1991

ISBN 0 7084 0508 8

MLURI

Printed in Great Britain at BPCC-AUP Aberdeen Ltd.

Contents

LIST OF FIGURES

SEPARATE MAP

1:625 000 coloured map of Scotland showing the climate zones established in Figure 1 and used as capability class guidelines

Editor's preface

The classification of land for agricultural purposes in Scotland is, in the general sense, as old as farming itself but the first national surveys were the Land Utilisation Survey directed by Sir Dudley Stamp during the late thirties and the classification of arable land carried out by the staff of the Department of Agriculture and Fisheries for Scotland in the forties. Both, however, were based largely on observation of the land use then current. In the mid-sixties interpretations of soil survey maps, laying more stress on the properties of land and its potential for agriculture, were developed at the Macaulay Institute for Soil Research, Aberdeen. A standard system of Land Use Capability Classification, applied by the Soil Surveys of Scotland, and of England and Wales was published in 1969 (Bibby and Mackney).

In 1973 following a recommendation in the White Paper 'Land Resource Use in Scotland: The Government's Observations on the Report of the Select Committee on Scottish Affairs', a Standing Committee on Rural Land Use was established. One of the first subjects considered by the Committee was land use capability classification and the decision was reached that a published land classification was desirable and that a review should be carried out to establish the one most suitable to Scottish requirements. The Chief Agricultural Officer of the Department of Agriculture and Fisheries, Mr C. Mackay, was appointed chairman of a working party and in subsequent reports (1975 and 1977) it was concluded that the future direction of land classification and mapping in Scotland should be based on the system developed by the Macaulay Institute with some modifications and additions. The reports, which were accepted by the Standing Committee, encouraged continued co-operation with England and Wales through the Agricultural Development and Advisory Service Closed Conference of Advisory Soil Scientists Land Capability Classification Working Party. This had been established in 1974 and included representatives of the Department and Colleges of Agriculture in Scotland and the Macaulay Institute.

From 1974 to 1981 the discussions of this committee were of the utmost value in developing the rationale and guidelines for land classification now presented. Under the able chairmanship of Mr B. Wilkinson, the following members contributed: J. S. Bibby, J. C. Clark, H. A. Douglas, P. E. Francis, G. Goodlass, D. Hewgill, F. M. B. Houston, A. D. Hughes, D. Mackney, M. J. Silverwood, R. B. Speirs,

R. W. Swain, J. F. B. Tew, A. J. Thomasson and R. J. Unwin. Organisations represented included the Agricultural Science and Land and Water Services of the Ministry of Agriculture, the Department of Agriculture for Scotland, the Scottish Colleges of Agriculture, the Meteorological Office (Agrometeorological Branch) and the Soil Surveys of Scotland, and of England and Wales.

The scientific discussions held within the Working Party plus the field excursions in Scotland, England and Wales in order to study the practical application of the system in various land classification exercises contributed significantly to the system's development and final refined version.

In 1980 with progress on a 1:250 000 scale, soil and land capability programme well forward in Scotland, it became necessary to produce firm proposals to allow the work to proceed. The land classification for agriculture now presented owes much to the original United States Department of Agriculture Land Capability Classification (Klingebiel and Montgomery 1961), to the Land Use Capability Classification (Bibby and Mackney 1969) and to the Survey staff who have helped to improve that classification, to the various working parties and, finally, to individual discussions, contributions from Mr E. L. Birse of the Macaulay Institute being particularly helpful. The assistance of such a wide range of authorities and people is gratefully acknowledged. Nevertheless, the responsibility for errors, omissions and short-comings rest entirely with the authors.

The Land Capability Classification for Agriculture incorporates significant advances in methods of assessment and is the basis of the interpretative maps produced by the Soil Survey Department of the Macaulay Institute for Soil Research, Aberdeen.

J.S.B.

ROBERT GRANT, Head of the Soil Survey of Scotland

1 Land capability classification for agriculture

The Land Capability Classification for Agriculture has as its objective the presentation of detailed information on soil, climate and relief in a form which will be of value to land use planners, agricultural advisers, farmers and others involved in optimising the use of land resources.

Its applications include the following:

1 Contributing to an inventory of the national land resource
2 Providing a means of assessing the value to agriculture of land on a uniform basis as an input to planning decisions
3 Contributing to farm planning and technical advisory work
4 Defining major limitations to land use
5 Defining land quality in connection with land restoration
6 Assisting in environmental and amenity planning
7 Assisting in economic evaluation of land.

The classification ranks land on the basis of its potential productivity and cropping flexibility determined by the extent to which its physical characteristics (soil, climate and relief) impose long term restrictions on its agricultural use. It is derived from a system used by the United States Department of Agriculture (Klingebiel and Montgomery 1961) which was designed to be applicable to any scale of mapping and has been modified extensively to fit British conditions and requirements. As part of these modifications an assessment of vegetation has been introduced, which is more properly described as a biological rather than a physical characteristic.

This Technical Monograph is a natural extension and revision of previous publications and is intended to act as a handbook to explain the classification and guide the classifiers when engaged on specific projects. The remainder of this chapter is devoted to a brief introductory discussion of properties of land as they affect agricultural use. Then follows a chapter giving the description of the various categories of the classification which ends with conventions for the symbolling and colouring of maps. The chapter entitled 'Guidelines' is most important, for it contains discussion and description of the values of the criteria (outlined in chapter 1) chosen as limits for the various classes. In this respect it is important to note that these are guidelines not rules, although it is expected that they will be adhered to by classifiers in most cases. However, where local conditions exist which have resulted in modification of the effects of the limiting factors, the local condition obviously assumes priority over the national guideline. To assist field workers a short summary of the guidelines is presented in chapter 4. Finally chapter 5 comprises a short section of illustrations.

PHYSICAL FACTORS AND THEIR EFFECT UPON AGRICULTURE

Agriculture is conducted within a physical framework, the components of which interact with one another and influence both crop growth and land management. The extent to which the interactions are favourable or unfavourable to the growth of a crop determine the potential area within which that crop can be grown. The range of crops that can be grown at any site, flexibility of cropping, is an important concept in land capability classification since it is a reflection of the extent to which a producer can respond to market forces. Good land management will enhance suitable conditions, ameliorate unsuitable ones and increase crop yields. The identification of factors which limit crop growth and affect the management of crops is therefore critical.

In this section a description of the principal components of the physical framework and their interactions is given. The limits chosen as guidelines for classification will be found in section 3.

Climate

Climate is a vital factor in assessing the capability of any area of land. Its various components influence agricultural activities directly, through the effect of weather on stock or on the above-ground parts of plants, and indirectly through an interaction with soil properties affecting water and nutrient supplies to the plant root and cultivation practices. To aid description the climatic limitation is confined to direct influences. Indirect effects which are interactive and strongly modified by soil factors are treated separately (e.g. wetness and droughtiness p. 6).

Climate is variable over the years but its resultant effect on agriculture is also dependent on recently introduced crop varieties and agricultural practices. It is therefore important to establish the climatic limitations and assessment on a sound scientific basis so that future changes in capability (defined by cropping practice) due to changes in climate or technology can be distinguished.

There are many parameters which can be used to describe the varying conditions and the current approach continues that initiated by Birse (Birse 1970a,b, 1971a,b) for Scotland and later adopted in a modified form for England and Wales (Bendelow and Hartnup 1977, 1980). The approach uses a two-parameter (accumulated temperature and maximum soil moisture deficit) array classification modified, where it affects cropping selection, by the consideration of exposure to high wind speeds. This is given in greater detail on page 21.

Further consideration must be given in the final analysis to local effects such as frost-hollows, additional shelter, south-facing slopes. It is not possible to quantify these factors on a national scale, but an assessment of their likely effects should be made and marginal classifications adjusted accordingly.

Gradient

Conventional agricultural machines are designed for optimum performance on level ground and their ability to cope with sloping surfaces and still produce acceptable quality of work varies. The limits are often set by the geometry of the machine and the ground conditions (Spencer 1978). For instance, gradients that can be worked by a tractor with a

Table 1 Slope classes and tractor-implement combinations

Overall gradient no higher than	Slope class	Implement limitations
3°	Gently sloping	No limitations in the use of current equipment
7°	Moderately sloping	Limit of use of 3-in-line forage harvesting equipment
11°	Strongly sloping	Limit of operation of combines and trailed equipment with 2-wheel drive tractors
15°	Very strongly sloping	Limit of operation of 2-wheel drive tractors with fully mounted equipment
25°	Steeply sloping	Limit of operation of 4-wheel drive tractors with trailed equipment
30°	Very steeply sloping	Slopes up to 30° can be worked using 4-wheel drive tractors with fully mounted equipment. No working is possible over 30°

fertiliser spreader depend on whether the tractor has two or four wheel drive, whether the spreader is mounted or trailed, whether the surface is bare or vegetated and upon the exact configuration of the ground. The ability to cope with slopes may be different when the spreader is full to when it is empty, for example, at the end of its run. Even similar types of machines (e.g. combine harvesters) vary widely in their performance on slopes due to differences in design.

Table 1 lists slope classes together with an approximate guide to the limitations of typical tractor-implement combinations in present-day use. It must be stressed that they are not precise because the limits of operation are determined by many variables.

Soil

Soil limitations relate to shallowness, stoniness, poor soil texture and structure, or inherent low fertility and are expressed in practical farming terms as workability, surface and subsurface structural problems, low available water capacity, and restrictions on cultivation. It is important to attempt an *overall* assessment of the various components rather than dwell on one or two.

Soil texture and structure

Limitations of soil texture and structure are principally due to problems of workability and structural instability.

Workability problems are considered in relation to wetness elsewhere (p. 7). In eastern parts of Britain, dry weather conditions can interact with soil properties to cause difficulties or extra costs in producing a seedbed or harvesting root crops. This limitation is most pronounced in clay soils with low organic matter content in which cohesive forces cause very strong, coarse, clods. It is negligible in sandy or humose soils or well-structured, calcareous loams. The general effect in heavier land is to curtail the period for efficient cultivations. This can be a serious disadvantage if shortly afterwards the land becomes too *wet* for cultivation. The limitation is mainly found in land which also has some degree of wetness problem.

The structural condition of any soil depends on the balance between processes tending to create fissures and pores (freeze-thaw, wetting and drying cycles, root and faunal activity, judicious cultivation) and those tending to close fissures and pores (rain impact at the surface, waterlogging, slaking, swelling in clayey soils, loading by traffic, stock or cultivation when soil strength is weak). A predominance of the structure-forming processes, expressed as well developed subangular or rounded aggregates with many fissures and pores, is commonly associated with good drainage (Wetness Class I or II, Table 2) and good organic matter status (>3%) and/or less intensive cropping or stocking. Predominance of break-down processes, expressed as capping, coarse, dense or massive structure with few fissures and pores, is usually associated with defective drainage (Wetness Classes III or wetter), low organic matter levels, intensive cropping or stocking, either singly or in combination.

Instability can be narrowly defined as the results of the slaking process due to rain impact and/or waterlogging which chiefly affects soils with small clay or large fine sand or silt content. The effects of these processes are very difficult to separate from compaction due to cultivation, traffic or treading by stock which affects all particle size classes to varying degrees. A broader definition of instability including weak soil strength in relation to imposed loadings as well as slaking processes, is more appropriate in the context of Land Classification.

Shallowness

Shallowness is not a characteristic of soils which affects crop growth directly but it can be used with caution as an expression of a number of associated factors such as low available water capacity,. restricted rooting range and inadequate nutrient uptake. The limiting effect of some of these properties also depends on factors such as rainfall or texture, so the relationships are not simple. However, shallow soils do have a direct effect on management and the use of certain farm implements may be impractical where rock, especially hard rock, is near the surface.

Stoniness

The stone content of soils can adversely influence crop growth and land management in the following ways:

1 Reduce the quality of soil tilth and seed beds
2 Reduce the efficiency of working machinery and labour during the range of farm operations, notably in the harvesting of root crops, cutting grass for conservation and sometimes combining of cereals
3 Reduce plant population due to the reduction of efficiency in drilling, poorer seed coverage and mechanical damage to seedlings in subsequent operations—these effects are particularly critical when it is necessary to drill to a stand
4 Reduce soil depth following the formation of cultivation/stone pans
5 Interfere with, or eliminate, essential mechanical subsoil operations
6 Reduce the available water capacity of the soil through dilution of the fine earth

7 Reduce the total nutrient reserves of the soil through dilution of the fine earth
8 Preclude mechanised operations totally when large boulders regularly break the soil surface.

Droughtiness

Soils with inadequate moisture reserves often have a restricted crop range and always carry a yield penalty unless deficiencies can be made good by irrigation. Droughtiness limitations result from interactions between soil water reserves, climatic conditions and crop water requirements. In moist western climates, droughtiness will rarely be a critical limitation. The main impact of this limitation is in the drier eastern lowlands on land where other limitations are absent or slight.

Soil fertility

The provision of adequate nutrient supplies for plant growth is considered to be normal management technique. Occasionally, extreme alkalinity or acidity or other problems difficult to correct by management occur. In Britain these are not usually extensive.

Wetness

The moisture status of a soil is the result of interactions between many soil properties (e.g. porosity, structure and texture), relief and rainfall. When large soil water contents regularly persist into the growing season, the choice, growth and yield of crops is affected. Over large areas of Britain wetness is a major limitation to agriculture. Wetness has many causes; very small amounts of rain on slowly permeable soils of fine texture can cause workability problems which are just as severe as those caused by shallow ground water tables. Impermeable layers of various kinds, flushing by springs, regular flooding by rivers or simply excessively high rainfall all cause wetness and each requires different remedial measures.

Workability, trafficability and poaching risk

The most widespread effects of the wetness limitations involve land management—workability, trafficability and poaching risk—rather than direct effects on the growing plant.

Workability is defined as the ease with which cultivations can be undertaken to produce a satisfactory seed-bed, or the ease with which the harvesting of root crops can be carried out. For land classification the duration of the period when efficient cultivations or harvesting are possible is more important than the precise operation. Under British

Table 2 Soil wetness classes (see also Hodgson 1976; Robson and Thomasson 1977)

Wetness class	General properties of the soil profile and site
I	The profile normally lacks gley features* within 70 cm or an impermeable horizon within 80 cm depth. Many strongly gleyed, permeable soils, with efficient drainage systems also occur in this class.
II	The profile normally lacks gley features within 40 cm or an impermeable horizon within 60 cm depth
III	The profile normally lacks gley features or an impermeable horizon within 40 cm depth
IV	The profile normally has gley features and an impermeable horizon within 40 cm depth, but lacks a humose or peaty topsoil greater than 20 cm thick
V	The profile normally has prominent gley features within 40 cm depth and is usually wet within 70 cm depth. Commonly the topsoil is humose or peaty and the natural vegetation has numerous hydrophilous species
VI	The profile normally has a peaty topsoil, a prominently gleyed mineral subsoil and is usually wet within 40 cm depth. The natural vegetation consists predominantly of hydrophilous species

* Greyish soil colours with associated ochreous mottling resulting from reduction and mobilisation of iron compounds under anaerobic conditions.

conditions, excessive soil wetness is the main restriction for trafficability and poaching risk and a major (but not the only) restriction for workability.

Minor differences in organic matter content, structural condition and the recent cropping system can affect workability. A severely poached or otherwise physically damaged soil has an increased susceptibility to further damage. These features are recognised under good land management and corrected by appropriate measures, or adjustments made concerning husbandry and the cropping or stocking systems.

Recovery of soil structure following damage is improved by the presence of calcium carbonate (>1%), or humose or peaty topsoils, providing drainage is reasonably good (Wetness Class I or II). However, the large amounts of water retained and the lower bearing strength of organic soils increases the initial risks of damage by machinery or stock.

Flooding

Wetness limitations due to flooding affect well defined, readily identifiable areas of land, but the precise risk is often difficult to assess owing to the wide range of possible conditions. Frequent winter flooding can be less damaging to crops than a rare (1 to 10 years) summer flood when soil temperatures are high and root systems active. Permeable soils can dry out quickly but be susceptible to erosion. Impermeable land is less likely to erode but water may remain ponded for longer periods with greater risk of damage to crops. The effect of protective works or channels may require a number of years to assess.

Erosion

Water and wind erosion of land surfaces are fundamental geomorphic processes operative at varying intensity under all soil and climatic conditions. In the agricultural context, however, the principal concern is with accelerated erosion, the increased rate of erosion that often arises when man alters a natural eco-system by various land use and management practices. Erosion becomes a limitation only if it regularly interferes with cropping flexibility, reduces yield, requires extra costs to contain or causes progressive deterioration of the soil. The rate of soil erosion is controlled by variables which relate to climate, topography, soil characteristics, vegetation and land use patterns (Cooke and Doornkamp 1974). Although a serious problem in many parts of the world, in Britain it is only infrequently serious and then only in small localised areas. Nevertheless, evidence of erosion is common in areas under regular arable cultivation (Evans 1980).

Water erosion

The principal agent of erosion by water in Britain is raindrop impact followed by subsequent transport of dislodged material over short distances. At most risk is bare sloping ground with coarse loamy or sandy soils and weak structure, particularly during heavy rainfall events in winter, early spring or summer. Sheet, rill and small (<1 m cross section) gulley erosion may then occur. Clay topsoils are less easily eroded since structural aggregation is stronger, but where frost has formed a fine tilth on compacted subsoils, or unprotected sloping topsoils are found, rill of varying intensity may arise. Evidence of erosion is most frequently seen on convex crests where shallowing of the soil can lead to patchy crop development (an interactive process with soil depth and droughtiness).

Severe gulleying (Class 3 or 4, Soil Survey Manual 1951) is rare and confined to steep slopes in high rainfall areas (often due to violent storms on a surface weakened by burning or overgrazing or prolonged periods of rain when the solum becomes supersaturated).

Wind erosion

Wind erosion is most serious when wind speeds and evaporation rates are high, precipitation is low, soil surfaces bare and the soil structural binding agents are weakly expressed (Chepil and Woodruff 1963, Wilkinson *et al.* 1969). This combination of factors occurs in spring and early summer under specific arable conditions, particularly in the eastern areas with a high proportion of spring-drilled crops. Susceptible soils are sands and loamy sand (mainly $<8\%$ clay), peats and peaty or humose sands.

Pattern

In all the major limitation types outlined above, there are areas where short range variation in properties occur which seriously affect land use. Obvious examples are in stoniness or soil texture, affecting both crop growth and management, or in slope, particularly in upland regions. Variations over short space scales in the physical state of the atmospheric boundary layer close to the surface of the earth are embodied in the term microclimate. Many of these effects are relevant in a local context and should always be taken into account in assessment of land capability.

BIOLOGICAL FACTORS AND THEIR EFFECT UPON AGRICULTURE

It is usual, in land classification, to give priority to the stable components of the resource, for example climate, relief, geology and soils, at the expense of the relatively unstable components. Unstable components are those subject to rapid and fluctuating change, for example economic or political conditions or many of the agricultural structural features of the landscape. Natural biological communities have considerable internal stability (Vink 1975) but agricultural systems are essentially unnatural and biologically unstable. Much agricultural effort is concerned with preventing reversion to stable conditions and it is no coincidence that expenditure on pesticides and fungicides are a major element in the farm budget. Agriculture, in the widest sense, is concerned with the manipulation of biological response to conditions of change. For the most part, this manipulation, or management, controls unfavourable biological responses and is covered by an assumption of good management in assessing land potential; that is that the farmer has sufficient knowledge and finance to control most weeds, pests and diseases. In Scottish hill lands, however, opportunities to change physical properties are limited and this necessarily restricts the opportunities for biological management. On much of the land surface the natural sward must be accepted and has only slowly been altered by the very coarse management techniques of grazing and burning through time. The term seminatural is often used for such swards and indicates their place as replacement plant communities for often closely related natural communities.

Vegetation

In areas where there is no scope for improvement the value of the natural and seminatural swards for grazing is an important, perhaps the important, attribute of land for agriculture. A system of evaluation based on the dry matter production of each species, but also containing elements for regularity of production, coarseness and palatability, has been introduced. For general use, the plant species have been grouped into communities and a relative grazing value calculated for each. It is important to realise that in some instances the value of land which is unimprovable, but of high relative grazing value, may be greater to a farmer than land which can be improved but will only maintain its fertility and sward for a relatively short time.

2 The classification

The classification comprises three main categories, the class, the division and the unit, each of which can be supplemented by information on the principal type of limitation applying. The three categories provide a flexible array of information suited to national, regional, local or farm planning requirements.

Although arable land is strictly defined as land fit for ploughing or tillage, its meaning is slightly restricted in the current context to indicate land fit for the growth of a range of crops. Land suited to arable uses is included in Classes 1-4, and that not suited to arable use in Classes 5-7.

Land is grouped in any *class* only because it has a similar *overall degree* of limitation; within any class therefore there may be very different management requirements. This is also true of the *division* which is a ranking of land within the class. There are no divisions within Class 1 and 2; Classes 3 and 4 each have two divisions and Classes 5 and 6 three divisions. The *unit* is based both on the *degree* of limitation applying and upon the specific *type* of limitation. The function of the unit is to supply information concerning detailed types of limitations, suitability for cropping and management problems.

ASSUMPTIONS

A number of important assumptions underlie the classification:

1 The classification is designed to assess the value of land for agriculture.

2 Land is classified according to the degree to which its physical characteristics affect the flexibility of cropping and its ability to produce certain crops consistently. Chemical characteristics (which are usually less permanent and easier to remedy than physical limitations) are, however, recognised where they are long term and severely limiting (e.g. certain nutrient deficiencies, metal toxicities and atmospheric pollution).

3 The classification does not group land according to its most profitable use. This requires additional economic evaluations.

4 Land management is linked to the physical properties of the land, to farm size and structure, to the personal and social circumstances of the farmer and to the level of capitalisation considered economically

justified by the farmer. In view of this complexity, it is clearly impossible to define closely a national management standard for land capability assessment. In broad terms, however, the land should be assessed on its capability under a *satisfactory level of management*, including investment of capital and improvements likely to be economically viable in the foreseeable future. The standard to be adopted should be taken as the level of input and intensity of soil, crop and grassland management applied successfully by the reasonable and practical farmers within the relevant sector of the farming industry. Such management skill will *maintain* or *improve* the physical land resource on a *long term* productivity basis. This level of management is likely to be *above the average* level for that sector of the industry. Wide consultation among agricultural advisers, competent farmers and others is required in order to obtain a consensus as to the actual standard to adopt.

5 Land which has limitations which can be removed or reduced at economic cost by a farmer or his contractors, e.g. field drainage, is classified on the severity of the *remaining* limitations.

6 Land with severe limitations is classified accordingly, except where there is clear evidence that a major improvement project (e.g. arterial drainage) will be undertaken and completed within the next 10 years. In such cases the classification should allow for the improvements as if they had occurred.

7 Location, farm structure, standard of fixed equipment and access to markets do not influence the grading of land quality. These factors may, however, affect land use decisions.

8 The interpretations are an expression of current knowledge and revisions may be necessary with new experience or technological innovations.

THE CLASSES

Land suited to arable cropping

Class 1 Land capable of producing a very wide range of crops

Cropping is highly flexible and includes the more exacting crops such as winter harvested vegetables (cauliflowers, brussels sprouts, leeks). The level of yield is consistently high. Soils are usually well-drained deep loams, sandy loams, silty loams, or their related humic variants, with good reserves of moisture. Sites are level or gently sloping and the climate is favourable. There are no or only very minor physical limitations affecting agricultural use.

Class 2 Land capable of producing a wide range of crops

Cropping is very flexible and a wide range of crops can be grown though some root and winter harvested crops may not be ideal choices because of difficulties in harvesting. The level of yield is high but less consistently obtained than on Class 1 land due to the effects of minor limitations affecting cultivation, crop growth or harvesting. The limitations include, either singly or in combination, slight workability or wetness problems, slightly unfavourable soil structure or texture, moderate slopes or slightly unfavourable climate. The limitations are always minor in their effect however and land in the class is highly productive.

Class 3 Land capable of producing a moderate range of crops

Land in this class is capable of producing good yields of a narrow range of crops, principally cereals and grass, and/or moderate yields of a wider range including potatoes, some vegetable crops (e.g. field beans and summer harvested brassicae) and oil-seed rape. The degree of variability between years will be greater than is the case for Classes 1 and 2, mainly due to interactions between climate, soil and management factors affecting the timing and type of cultivations, sowing and harvesting. The moderate limitations require careful management and include wetness, restrictions to rooting depth, unfavourable structure or texture, strongly sloping ground, slight erosion or a variable climate. The range of soil types within the class is greater than for previous classes.

Class 4 Land capable of producing a narrow range of crops

The land is suitable for enterprises based primarily on grassland with short arable breaks (e.g. barley, oats, forage crops). Yields of arable crops are variable due to soil, wetness or climatic factors. Yields of grass are often high but difficulties of production or utilisation may be encountered. The moderately severe levels of limitation restrict the choice of crops and demand careful management. The limitations may include moderately severe wetness, occasional damaging floods, shallow or very stony soils, moderately steep gradients, erosion, moderately severe climate or interactions of these which increase the level of farming risk.

Land suited only to improved grassland and rough grazing

Class 5 Land capable of use as improved grassland

The agricultural use of land in Class 5 is restricted to grass production but such land frequently plays an important role in the economy of

British hill lands. Mechanised surface treatments to improve the grassland, ranging from ploughing through rotavation to surface seeding and improvement by non-disruptive techniques are all possible. Although an occasional pioneer forage crop may be grown, one or more severe limitations render the land unsuited to arable cropping. These include adverse climate, wetness, frequent damaging floods, steep slopes, soil defects or erosion risk. Grass yields within the class can be variable and difficulties in production, and particularly utilisation, are common.

Class 6 Land capable only of use as rough grazing

The land has very severe site, soil or wetness limitations which generally prevent the use of tractor-operated machinery for improvement. Some reclamation of small patches to encourage stock to range is often possible. Climate is often a very significant limiting factor. A range of widely different qualities of grazing is included, from very steep land with significant grazing value in the lowland situation to moorland with a low but sustained production in the uplands. Grazing is usually insignificant in the arctic zones of the mountain lands but below this level grazings which can be utilised for five months or longer in any year are included in the class. Land affected by severe industrial pollution or dereliction may be included if the effects of the pollution are non-toxic.

Class 7 Land of very limited agricultural value

Land with extremely severe limitations that cannot be rectified. The limitations may result from one or more of the following defects: extremely severe wetness, extremely stony, rocky land, bare soils, scree or beach sand and gravels, toxic waste tips and dereliction, very steep gradients, severe erosion including intensively hagged peat lands and extremely severe climates (exposed situations, protracted snow-cover and short growing season). Agricultural use is restricted to very poor rough grazing.

THE DIVISIONS

A division is a ranking within a class; the approach to it however needs to be selective. Because the requirements of the crops suited to Classes 1 and 2 are fairly stringent, land in these classes has inherently low degrees of internal variability. The requirements of crops grown in the remaining classes are less rigorous, consequently land included is more variable in character and covers larger areas. For purposes of strategic and regional planning, it is quite clear that some further guidance is necessary in these areas, although for detailed planning the variability of the class dictates that on-site inspections must always be made.

Classes 3 and 4 each have two divisions based on increasing restrictions to arable cropping. These are principally climate, in particular the reliability of suitable weather conditions and interactions between soil properties and climatic features. Qualities of land such as workability and droughtiness are particularly affected. Relatively small amounts of rain upon clayey topsoils may equal or exceed in their effect upon farming, that of large amounts upon coarser topsoil textures for example. Site criteria and erosion play relatively small parts.

Class 5 land has three divisions based on potential for successful reclamation and Class 6 three based upon the value of the existing vegetation for grazing purposes.

The divisions of Class 3

The definition of Class 3 incorporates land which has a good capability for the production of a moderate range of crops, that part of the British farmscape which is usually regarded as 'average arable land'. For economic reasons it is devoted principally to cereal and grass farming, but the land is often capable of producing in addition, potatoes, oilseed rape, field beans or some vegetables. The picture throughout the class is one of variability so that it is possible that, in any one year, the situation may differ drastically from the mean. It is against this background that the farmer has to plan the long-term investment on his farm and decide the kinds of enterprise he wishes to practise and thus the *actual* farming patterns found reflect social as much as physical conditions.

In dividing any class, the choice of limits is difficult and their significance to agricultural operations more tenuous. This is particularly so in Class 3 and for this reason only two divisions are proposed.

Division 1

Land in this division is capable of producing consistently high yields of a narrow range of crops (principally cereals and grass) and/or moderate yields of a wider range (including potatoes, field beans and other vegetables, and root crops). Short grass leys are common.

Division 2

This land is capable of average production but high yields of grass, barley and oats are often obtained. Other crops are limited to potatoes and forage crops. Grass leys are common and reflect the increasing growth limitations for arable crops and degree of risk involved in their production.

The divisions of Class 4

The class comprises land marginal for the economic production of crops and usually confined to types suitable for winter feeding to livestock. Farming enterprises on this land are based primarily on livestock production. As with Class 3, year to year variability in crop yield is large, but the risks of crop failure or poor weather interfering with harvests are higher.

Class 4 land is principally found where the deleterious effects of many types of limitation combine. Foremost among these are high rainfall causing wetness limitations, particularly in central and western Scotland. In southern and eastern Scotland, however, shallow or sandy soils and low rainfall are responsible for some areas being included in the class because of drought limitations. As with Class 3, the critical parameters are climate, wetness and droughtiness.

Division 1

Land in this division is suited to rotations which, although primarily based on long ley grassland, include forage crops and cereals for stock feed. Yields of grass are high but difficulties of utilisation or conservation may be encountered. Other crop yields are very variable and usually below the national average.

Division 2

The land is primarily grassland with some limited potential for other crops. Grass yields can be high but the difficulties of conservation or utilisation may be severe, especially in areas of poor climate or on very wet soils. Some forage cropping is possible and, when the extra risks involved can be accepted, an occasional cereal crop.

The divisions of Class 5

By definition, land included in Class 5 is suited to use as grassland and to improvement by mechanised means. Improvement may take the form of regeneration (reseeding of previously sown swards which have deteriorated in quality through time) or reclamation (the production of new grasslands from previously uncultivated natural or semi-natural vegetation). By 'mechanised means' is understood all techniques for the production of grassland from full ploughing to surface seeding without the disruption of soil.

Class 5 land is broadly constrained by climate limitations to hill areas where risks are too great for arable cropping. Other limitations are usually subsidiary in determining the overall pattern of class distribution but become important in intra-class ranking and in determining the boundary between Classes 5 and 6. The assumption regarding level of management (p. 11) is significant in determining what land is to be considered improvable, since it involves a favourable balance in input-output relationships. This latter criterion should not be carried too far however, for it is the physical qualities of the land which are diagnostic. Many other characters, such as the pattern of land ownership, farm structure, availability of roads and the farmer's preference may determine the actual areas selected for improvement within the class.

The allocation of land to Class 5 only indicates a potential for some improvement, which is attainable within a very short time scale compared with the slower improvements which result from careful grazing management within Class 6. It is useful, therefore, to know whether the improvement results in valuable grassland with long term potential or grassland with only short term potential and requiring constant maintenance.

Sward quality of improved grasslands and their levels of production are always high compared with the semi-natural grasslands found in hill areas (Table 20). The important factors to be considered in improvement are (a) the ease or otherwise of establishment of the sward, (b) the persistence of the sown species, (c) the costs of maintenance and (d) whether the resultant sward can be used for grass conservation or whether it must be grazed.

Division 1 Land well suited to reclamation and to use as improved grassland

Establishment of a grass sward and its maintenance present few problems and potential yields are high with ample growth throughout the season. Patterns of soil, slope or wetness may be slightly restricting but the land has few poaching problems. High stocking rates are possible.

Division 2 Land moderately suited to reclamation and use as improved grassland

Sward establishment presents no difficulties but moderate or low trafficability, patterned land and/or strong slopes cause maintenance problems. Growth rates are high and despite some problems of poaching, satisfactory stocking rates are achievable.

Division 3 Land marginally suited to reclamation and use as improved grassland

Land in this division has properties which lead to serious trafficability and poaching difficulties and although sward establishment may be easy, deterioration in quality is often rapid. Patterns of soil, slope or wetness may seriously interfere with establishment and maintenance. The land cannot support high stock densities without damage and this may be serious after heavy rain, even in summer.

The divisions of Class 6

Land included in Class 6 is unsuited to improvement by mechanised means but has some sustained grazing value. The grazings must be available for five months or more in any year. Improvements to sward quality and quantity have been practised in these areas for many years and include stock control by fencing, encouragement to the grazing animal to range (mosaic improvements of small areas (<40%) by limited mechanical means) and by burning. In general, such improvement techniques are slow compared with those available on Class 5 land and often achieve their more striking successes only on the best land of the class.

With such a wide range of sward quality included, attention has been given to developing a technique of assessing relative grazing values of different swards. In this, the use of adequately described and defined plant communities (e.g. Birse and Robertson 1976) was invaluable. The number and type of plant communities in any area can be determined and the value of each to the grazing animal assessed. Communities dominated by grasses are usually of high relative value; those by dwarf shrubs and mosses of low value. Management of hill and mountain areas has often resulted in the modification of the original plant communities, sometimes fairly substantially. The resultant replacement communities have a relationship with the original communities and, if the particular form of management ceases, will revert to them within a short period. In the broad sense there is a relationship between the semi-natural and replacement communities and the underlying soil types, and both are related to climatic zones in mountainous areas which allow useful suitability groups to be identified. It must be stressed that rarely does one plant community cover a large enough area to map individually, but mosaics of plant communities are found which are averaged to give values for the area.

Division 1 High grazing value

The dominant plant communities contain high proportions of palatable herbage, principally the better grasses, e.g. bent–fescue or meadow-grass–bent pasture.

Division 2   Moderate grazing value

Moderate quality herbage such as white and flying bent grasslands, rush pastures and herb-rich moorlands, or a mosaic of high and low grazing values characterises land in the division.

Division 3   Low grazing value

The vegetation is dominated by plant communities with low grazing values, particularly heather moor, bog heather moor and blanket bog.

THE UNITS

Capability units comprising groups of appropriate soil mapping units have similar potentials and limitations. The land units are sufficiently uniform physically to require similar management and improvement practices, support the same range of crops and produce comparable yields. The capability unit provides detailed information for application at the farm and field level (Wilkinson 1968).

Although little mapping at this level has so far been carried out in Scotland, capability units will be described in terms of their physical and chemical characteristics, their management problems and requirements and their suitability for cropping. Information for this purpose will be largely available through agricultural advisory research organisations, so it is essential that these bodies as well as farmers and other users of land, participate in the recognition and description of capability units. Establishment of small consultative groups interested in project areas are to be encouraged (Kellogg 1961, Vink 1963, Wilkinson 1974).

Capability units are intended for use on maps published at scales of 1:25 000 and larger.

THE LIMITATION TYPES

Soil, site and climate are involved in complex interactions which affect land use and it is often helpful to indicate the type of limitation applying in an area. Five principal kinds of limitation are recognised; these are:

Climatic limitations — symbol *c*
Gradient limitations — symbol *g*
Soil limitations — symbol *s*
Wetness limitations — symbol *w*
Erosion limitations — symbol *e*

Limitations due to pattern (p. 9) are incorporated under the main type of limitation (e.g. soil pattern limitations in soil limitations). The symbols may be represented on maps by their mnemonic symbol, singly or in pairs. The limitation type is equivalent to the subclass as defined in previous work (Bibby and Mackney 1969).

Map Symbols

The following conventions are employed for indicating class, division and unit symbols on maps:

Class:	1	Classes are indicated by colour. In some instances it may be necessary to use an arabic numeral
	2	Only one class symbol is allocated to any map unit.
Divisions:	1	Divisions are symbolled in arabic script or indicated by a shade of the appropriate class colour.
Units:	1	Units are symbolled in arabic script.

Limitation type:

1 A limitation-type symbol is shown only where it has been a factor in determining class.
2 No more than two symbols are used in a map to indicate different types of limitations affecting one class. Accompanying texts will contain fuller descriptions.
3 Where two symbols are used, the symbol for the dominant limitation takes priority.
4 The use of the limitation symbol *c* is confined to two cases:
(a) land in which other limitations *at that class level* are negligible and only climate prevents the land being placed in a higher class
(b) where local conditions (e.g. microclimatic factors) result in a significant departure from the 'mean' climate.
In all other cases limitations imposed by the 'mean' climate of the region are taken as read.

3 The guidelines

As the classification is interpretative, guidelines for the recognition of the classes are offered to maintain uniformity. In the first part of this section the guidelines are presented in detail by limitation type. Section 4 provides a class by class summary.

CLIMATE

The data used to verify the classification, and presented in this monograph, is based, for technical reasons, on the 20 year period 1958–78 (except wind which is for 1965–73). However, data from other stations, provided it is derived from a sufficiently lengthy record, and in a similar manner, can be used. Climate is highly dependent on local topographic variations and care must be exercised when interpreting data from stations other than at the site in question. The most appropriate station is not necessarily the nearest. So that data from one or two exceptional years does not bias the results, the practice of using median and quartile values has been introduced.

Maximum potential soil moisture deficit (max PSMD)

This is the theoretical deficit achievable under short grass which completely covers the ground in which the soil is assumed to have a large store of water, and hence crop transpiration is unrestricted (MAFF 1971).* The deficit represents an accumulation of the balance between rainfall and evaporation, calculated on a daily basis. It is the *maximum value* of the deficit rather than the date of occurrence which is considered important for general climate classification, although the period of deficit will be important for detailed studies of other limitations (e.g. trafficability). The median value of the maximum deficit is used in this classification scheme (see below).

Values of PSMD can vary over short distances and care must be exercised in selecting the appropriate value. Generally, it is more important to consider likely similarities in rainfall characteristics

* The Meteorological Office has recently announced changes in the method of calculating maximum potential soil moisture deficit. The new data-set, backdated to 1961, will not be available before 1984. Although values of this parameter at particular stations will change, it is anticipated that the position of a station relative to others will not alter substantially and hence classification will be only marginally affected. —*Editor*

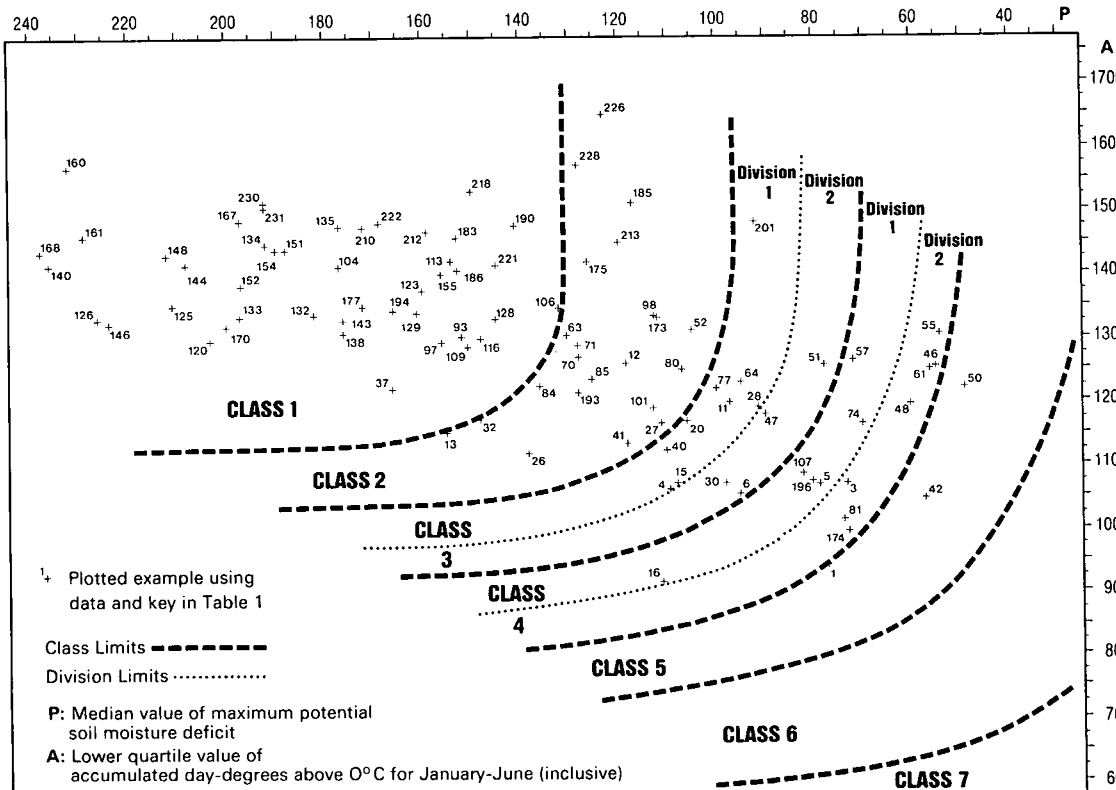


Figure 1 Climate classification and land capability classes. Stations in England and Wales are included for purposes of comparison.

Names of stations shown in Figure 1

1. Lerwick
3. Kirkwall
4. Wick
5. Strathy
6. Lairg
11. Fort Augustus
12. Inverness
13. Nairn
15. Craibstone
16. Braemar
20. Banchory
26. Montrose
27. Faskally
28. Ardtalnaig
30. Glamis Castle
32. Leuchars
37. Haddington
40. Glentress
41. Bowhill
42. Eskdalemuir
46. Inverpolly
47. Stornoway
48. Prabost
50. Kinlochewe
51. Benbecula
52. Tiree
55. Fort William
57. Mull
61. Benmore (YBG)
63. Abbotsinch
64. Glasgow (Sp Park)
70. Prestwick
71. Auchincruive
74. Bargrennan
77. Threave
80. Dumfries
81. Keilder Castle
84. Tynemouth
85. Durham
93. Pickering
97. Cawood
98. Bradford
101. Huddersfield Oakes
104. Hull
106. Sheffield
107. Buxton
109. Warsop
113. Nottingham
116. Newton Linford
120. Cranwell
123. Marham
125. Cromer
126. Gorleston
128. Edgbaston
129. Rugby
132. Wellesbourne
133. Woburn
134. Aylesbury
135. Oxford
138. Santon Downham
140. Cambridge (NIAB)
143. Rothamsted
144. Writtle
146. Wattisham
148. Hurley
151. South Farnborough
152. Boscombe Down
154. Martyr Worthy
155. Fernhurst
160. Ryde
161. St Catherine's Point
167. Hastings
168. Manston
170. Dover
173. Sellafield
174. Malham Tarn
175. Morecambe
177. Squires Gate
183. Colwyn Bay
185. Botwnnog
186. Bidston
190. Hawarden Bridge
193. Keele
194. Shawbury
196. Lake Vyrnwy
201. Gogerddan
210. Malvern
212. Cheltenham
213. Penmaen
218. Bude
221. Cardiff (Rhoose)
222. Long Ashton
226. Penzance
228. St Austell
230. Exeter
231. Sidmouth

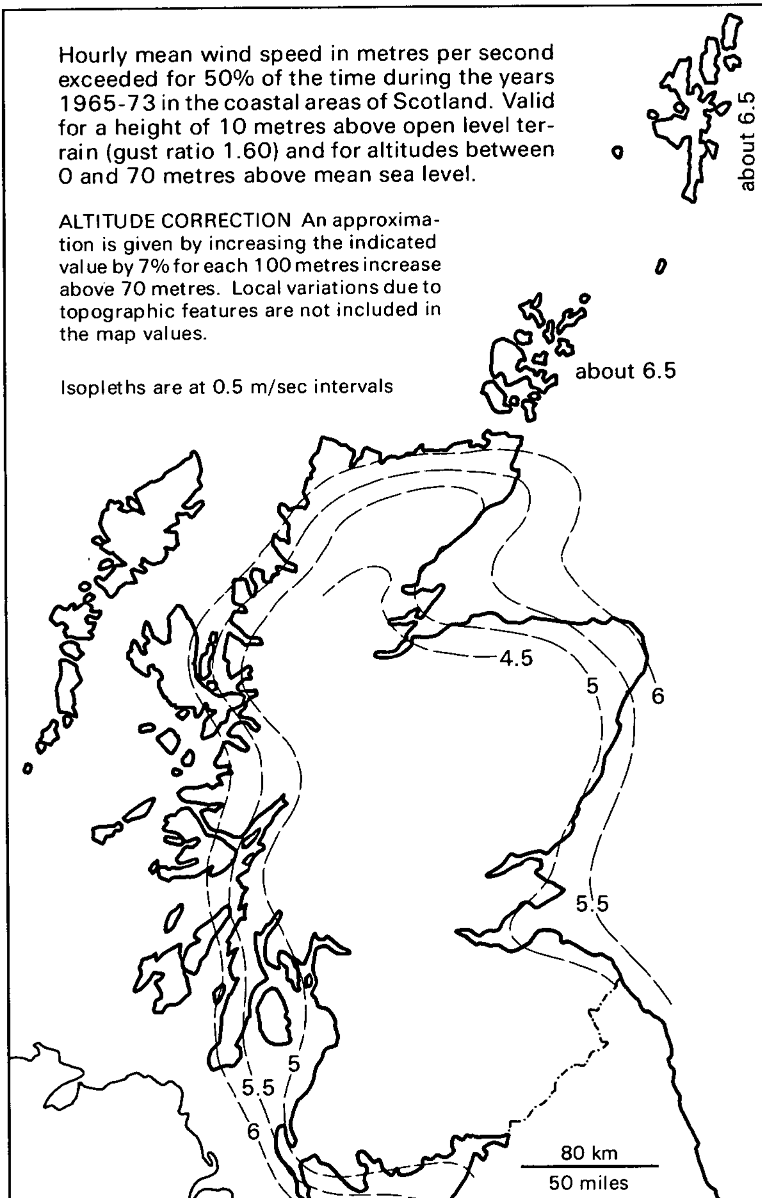


Figure 2 Wind speed.

Table 3 Accumulated temperature, potential soil moisture deficit and site information for selected climate stations

Station	Grid reference	Altitude (m)	Lower quartile value of acc temp	Median value* of max PSMD	Stations* plotted on figure 1	Key for Figure 3
Lerwick	HU 453397	82	954	77	1	1
Baltasound	HP 607089	24	1001	—	—	2
Kirkwall	HY 483076	26	1073	73	3	3
Wick	ND 364522	36	1066	109	4	4
Strathy	NC 830609	38	1067	79	5	5
Lairg	NC 576071	94	1051	95	6	6
Fortrose	NH 749557	5	1207	—	—	7
Geanies House	NH 895793	61	—	120	—	8
Fasnakyle	NH 314288	80	—	97	—	9
Bhlaraidh	NH 382165	70	—	97	—	10
Fort Augustus	NH 381091	21	1199	(97)	(11)	11
Inverness	NH 668462	4	1246	118	12	12
Nairn	NH 869568	6	1153	155	13	13
Banff	NJ 689647	24	1217	—	—	14
Craibstone	NJ 871107	102	1071	108	15	15
Braemar	NO 152914	339	914	111	16	16
Balmoral	NO 260946	283	917	—	—	17
Glenmore Lodge	NH 986095	341	939	—	—	18
Glenlivet	NJ 188303	215	1027	—	—	19
Banchory	NO 692959	94	1165	(106)	(20)	20
Dunnet	NJ 446025	177	1084	—	—	21
Fyvie Castle	NJ 766392	55	1098	—	—	22
Invery House	NO 698940	69	—	106	—	23
Whitehillocks	NO 448800	258	991	—	—	24
Fettercairn	NO 669782	171	1032	—	—	25
Montrose	NO 707617	57	1126	138	26	26
Faskally	NN 918599	94	1163	111	27	27
Ardtalnaig	NN 702394	130	1189	91	28	28
Strathearn	NN 867223	122	—	100	—	29
Glamis Castle	NO 388486	61	1098	98	30	30
Mylnefield	NO 339301	30	1201	—	—	31
Leuchars	NO 468209	10	1175	148	32	32
Loch Leven	NT 171994	110	—	112	—	33
Bridge of Allan	NS 792974	12	—	98	—	34
Turnhouse	NT 159739	35	1237	—	—	35
Bush House	NT 244636	184	1089	—	—	36
Haddington	NT 513736	49	1219	166	37	37
Dunbar	NT 672791	23	1235	—	—	38
Gladhouse Reservoir	NT 299544	279	—	107	—	39
Glentress	NT 283397	165	1132	110	40	40
Bowhill	NT 428278	168	1137	118	41	41
Eskdalemuir	NT 235026	242	1045	57	42	42
Whitchester	NT 721589	255	1022	—	—	43
Marchmont	NT 743484	152	1125	—	—	44
Lochmore Lodge	NC 300386	46	—	36	—	45

Table 3—*continued*

Inverpolly	NC 074134	14	1252	55	46	46
Stornoway	NB 464332	15	1179	90	47	47
Prabost	NG 418501	67	1193	(60)	(48)	48
Duntulm	NG 399718	90	—	60	—	49
Kinlochewe	NH 024630	23	1232	49	50	50
Benbecula	NF 782556	6	1265	78	51	51
Tiree	NL 999446	9	1311	105	52	52
Rhubana	NM 688922	16	—	54	—	53
Achnashellach	NH 038492	67	1189	—	—	54
Fort William	NN 123759	8	1303	54	55	55
Onich	NN 028630	15	1275	—	—	56
Mull	NM 564455	3	1262	72	57	57
Crarae Lodge	NR 986973	6	—	51	—	58
Eallabus	NR 335634	21	—	79	—	59
Ormsary Lodge	NR 739718	15	—	80	—	60
Benmore (YBG)	NS 141856	12	1250	56	61	61
Greenock	NS 274757	61	—	82	—	62
Abbotsinch	NS 480667	5	1301	131	63	63
Glasgow (Sp Park)	NS 608686	107	1223	95	64	64
Coatbridge	NS 714643	66	1236	—	—	65
Townhill Reservoir	NS 694546	131	—	104	—	66
Rothesay	NS 083649	43	1323	—	—	67
Munnoch Reservoir	NS 254481	99	—	92	—	68
Kype Reservoir	NS 735387	287	—	72	—	69
Prestwick	NS 369261	16	1279	128	70	70
Auchincruive	NS 389236	45	1284	(128)	(71)	71
Girvan	NX 184979	8	1407	—	—	72
Euchan Filters	NS 729070	280	—	61	—	73
Bargrennan	NX 361789	110	1163	70	74	74
Penwhirn	NX 127693	166	1078	—	—	75
Stranraer	NX 037619	64	—	100	—	76
Threave	NX 751607	73	1219	100	77	77
Palnure	NX 452646	18	1246	—	—	78
Dundeugh	NX 598879	119	1125	—	—	79
Dumfries	NX 982747	49	1249	107	80	80
Keilder Castle	NY 632935	201	1024	74	81	81
Lilburn	NU 026243	70	—	103	—	82
Cockle Park	NZ 200912	99	1135	—	—	83
Tynemouth	NZ 374695	30	1244	136	84	84
Durham	NZ 267415	102	1232	125	85	85
Tunstall	NZ 063407	221	—	107	—	86
Hartlepool	NZ 510327	9	1324	—	—	87
Haydon Bridge	NY 838645	79	1231	—	—	88
Moor House	NY 758328	556	677	—	—	89
Appleby	NY 684198	146	—	117	—	90
Silpho Moor	SE 957946	203	1099	—	—	91
Thirsk	SE 438818	35	—	154	—	92
Pickering	SE 795842	44	1239	152	93	93
Birdsall House	SE 819650	94	—	142	—	94
High Mowthorpe	SE 888685	175	1106	—	—	95
York	SE 581527	9	—	156	—	96
Cawood	SE 561372	6	1291	(156)	(97)	97
Bradford	SE 149352	134	1253	113	98	98

Table 3—*continued*

Goole	SE 745235	5	—	169	—	99
Pontefract	SE 453211	78	1307	*187*	*100*	*100*
Huddersfield Oakes	SE 113177	232	1229	113	101	101
Brigg	SE 987062	5	—	175	—	102
Bridlington	TA 172687	48	1183	—	—	103
Hull	TA 083301	2	1409	177	104	104
Finningley	SK 659989	10	—	208	—	105
Sheffield	SK 339873	131	1343	132	106	106
Buxton	SK 058734	307	1083	82	107	107
Waddington	SK 988653	68	1314	—	—	108
Warsop	SK 591699	46	1295	(151)	(109)	109
Mansfield	SK 543618	110	—	141	—	110
Whatstandwell	SK 326554	75	—	118	—	111
Basford	SK 565429	51	—	151	—	112
Nottingham	SK 569395	59	1431	154	113	113
Waltham	SK 804251	174	—	162	—	114
Shobnall	SK 234231	48	—	168	—	115
Newton Linford	SK 530095	119	1297	(147)	(116)	116
Thornton Reservoir	SK 473072	112	—	147	—	117
Hagworthingham	TF 354691	62	—	174	—	118
Skegness	TF 569631	5	1341	—	—	119
Cranwell	TF 004393	62	1290	203	120	120
Boston	TF 323450	3	—	196	—	121
Sandringham	TF 697287	37	—	160	—	122
Marham	TF 726094	23	1395	(160)	(123)	123
Wittering	TF 043026	73	—	212	—	124
Cromer	TG 208422	54	1348	211	125	125
Gorleston	TG 529037	4	1337	(226)	(126)	126
Caldecott	SP 865932	53	1307	—	—	127
Edgbaston	SP 046864	163	1325	145	128	128
Rugby	SP 507749	117	1349	(161)	(129)	129
Ravensthorpe	SP 682704	98	—	161	—	130
Ashdale	SP 306577	46	—	182	—	131
Wellesbourne	SP 271565	47	1341	(182)	(132)	132
Woburn	SP 964360	89	1336	197	133	133
Aylesbury	SP 841115	96	1403	192	134	134
Oxford	SP 509072	63	1477	177	135	135
Brize Norton	SP 289060	84	—	183	—	136
March	TL 421967	2	—	212	—	137
Santon Downham	TL 813901	24	1307	176	138	138
Wyton	TL 284745	40	1394	—	—	139
Cambridge (NIAB)	TL 434604	24	1413	(237)	(140)	140
Cambridge (Bot Gar)	TL 456572	12	—	237	—	141
Felsted	TL 676205	73	—	*208*	—	*142*
Rothamsted	TL 132134	128	1324	176	143	143
Writtle	TL 677066	35	1411	(208)	(144)	144
Lowestoft	TM 543946	25	—	226	—	145
Wattisham	TM 026514	89	1321	(224)	(146)	146
Belstead Hall	TM 127411	38	—	224	—	147
Hurley	SU 823829	43	1429	(212)	(148)	148
Taplow	SU 907821	65	—	212	—	149
Shinfield	SU 729684	62	—	185	—	150

Table 3—*continued*

South Farnborough	SU 867548	69	1445	188	151	151
Boscombe Down	SU 172403	126	1377	197	152	152
Leckford	SU 393362	117	1369	—	—	153
Martyr Worthy	SU 517338	84	1383	190	154	154
Fernhurst	SU 908267	57	1405	(156)	(155)	155
West Dean Park	SU 864127	58	—	156	—	156
Brockenhurst	SU 311028	12	—	183	—	157
Everton	SZ 302937	16	1503	—	—	158
Southsea	SZ 637991	2	—	210	—	159
Ryde	SZ 597928	4	1569	232	160	160
St Catherine's Point	SZ 498753	16	1462	229	161	161
Mickleham	TQ 173527	55	1378	—	—	162
Maidstone	TQ 759561	15	—	235	—	163
Falconhurst	TQ 470426	110	—	189	—	164
Goudhurst	TQ 722333	85	1382	—	—	165
Worthing	TQ 160035	2	—	198	—	166
Hastings	TQ 809094	45	1481	197	167	167
Manston	TR 335666	44	1429	238	168	168
Faversham	TR 007593	48	1404	—	—	169
Dover	TR 320410	6	1316	200	170	170
Brookfield	NY 242478	34	—	118	—	171
Newton Rigg	NY 493310	171	1203	—	—	172
Sellafield	NY 027032	13	1329	112	173	173
Malham Tarn	SD 894672	403	917	73	174	174
Morecambe	SD 431645	7	1417	126	175	175
Kirkham	SD 414346	24	1329	—	—	176
Squire's Gate	SD 316316	10	1363	172	177	177
Bolton	SD 724116	107	1295	—	—	178
Heaton	SD 687096	152	—	91	—	179
Knot Hill	SD 958014	184	—	104	—	180
Llwydiarth	SH 436843	61	—	126	—	181
Valley	SH 309757	10	1483	—	—	182
Colwyn Bay	SH 860787	24	1459	153	183	183
Alwen	SH 957529	335	999	—	—	184
Botwnnog	SH 263313	34	1429	117	185	185
Bidston	SJ 287899	60	1409	153	186	186
Prestatyn	SJ 061836	4	1473	—	—	187
West Kirkby Park	SJ 216865	7	1491	—	—	188
Lostock Gralam	SJ 682743	23	—	115	—	189
Hawarden Bridge	SJ 314694	5	1474	141	190	190
Bwlchgwyn	SJ 236520	386	1009	—	—	191
Wrexham	SJ 305479	113	—	147	—	192
Keele	SJ 820446	179	1211	128	193	193
Shawbury	SJ 553220	72	1339	166	194	194
Milford	SJ 975212	75	—	152	—	195
Lake Vyrnwy	SJ 017188	303	1071	80	196	196
Shrewsbury	SJ 517136	55	1378	—	—	197
Penkridge	SJ 920116	101	1241	—	—	198
Lelterston	SM 975325	119	—	101	—	199
Aberdovey	SN 621963	52	—	95	—	200
Gogerddan	SN 627835	31	1413	92	201	201
Aberystwyth	SN 584814	4	1418	—	—	202
Bwlch-y-Graig	SN 579595	241	—	79	—	203

Table 3—*continued*

Aberporth	SN 242521	133	1363	–	–	204
Abergorlech	SN 585336	76	–	78	–	205
Church Stretton	SO 438911	187	–	131	–	206
Oakley Park	SO 491762	91	–	162	–	207
Bluith Wells	SO 061605	235	–	104	–	208
Lyonshall	SO 339576	155	1347	–	–	209
Malvern	SO 790461	62	1471	173	210	210
Llangrosser	SO 287380	343	–	131	–	211
Cheltenham	SO 946218	65	1463	159	212	212
Penmaen	SS 531889	87	1449	120	213	213
Mumble's Head	SS 627870	35	1441	–	–	214
Hawkridge	SS 877327	314	1166	–	–	215
Hartland Point	SS 231276	95	1447	–	–	216
South Molton	SS 716256	131	–	108	–	217
Bude	SS 208063	15	1533	150	218	218
Filton	ST 600805	59	–	169	–	219
Wroughton	SU 151802	137	–	161	–	220
Cardiff (Rhoose)	ST 064679	67	1415	145	221	221
Long Ashton	ST 535699	51	1477	(169)	(222)	222
Millfield	ST 492362	30	–	169	–	223
Taunton	ST 229238	22	–	216	–	224
Rosewarne	SW 643412	76	1544	–	–	225
Penzance	SW 469302	19	1658	123	226	226
Swincombe	SX 633719	317	–	83	–	227
St Austell	SX 018525	94	1571	128	228	228
Plymouth	SX 492529	27	1575	–	–	229
Exeter	SY 001933	32	1515	192	230	230
Sidmouth	SY 124873	10	1511	(192)	(231)	231
Wareham	SY 911823	69	–	189	–	232
Scilly Isles	SV 913121	51	1707	177	–	233

Note: Care must be taken when applying the above data to areas other than where the measurements were made, to make sure that the data is representative (e.g. not using an urban site for a non-urban area without modification). In cases of doubt you should contact the Meteorological Office (Met. O.8a, Agricultural Section).

* The use of brackets indicates that a nearby value for max PSMD has been used.
Stations in England and Wales are included for comparative purposes.

(altitude and position relative to hill ranges) when selecting a comparison station than choosing the closest geographically. The median values for 175 sites have been calculated and are given in Table 3 and their locations shown in Figure 3.

Accumulated temperature

In any climatic assessment for land classification, there must be a factor to represent the availability of energy (from direct radiation). Since detailed radiation information is only available for a very limited number of sites, all classifications are based on some derivative of

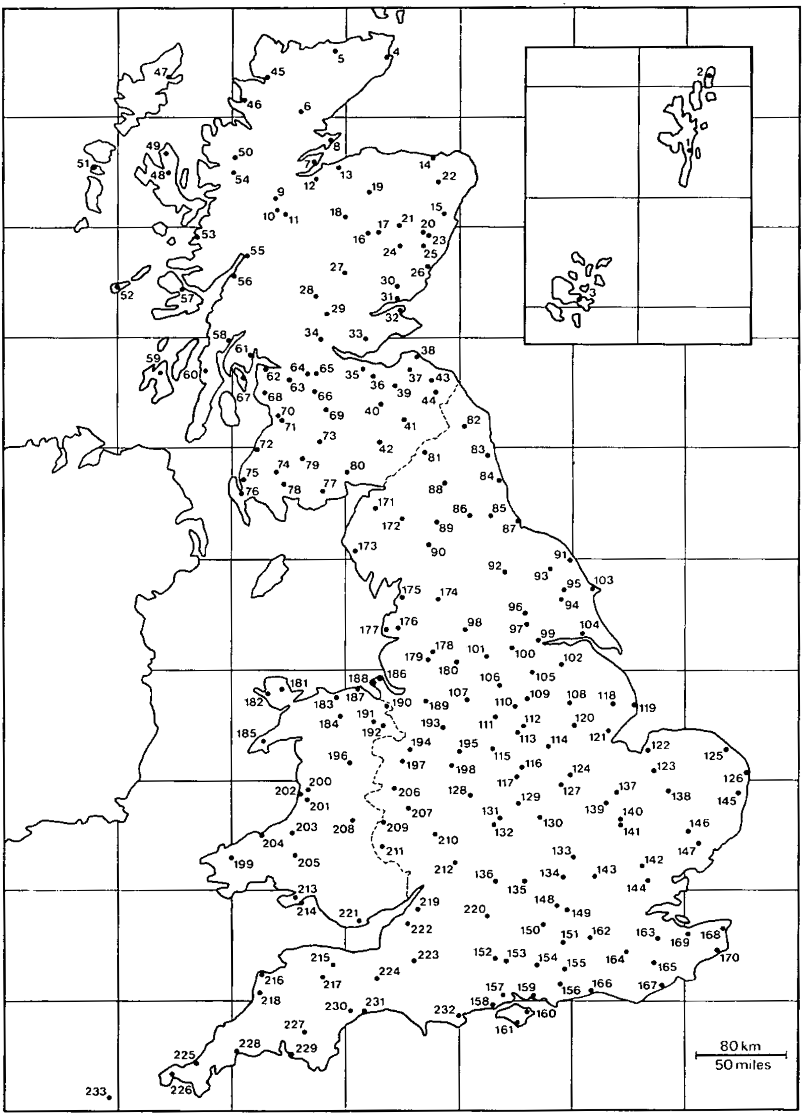


Figure 3 Location of stations listed in Table 3. Stations in England and Wales are included for comparative purposes.

temperature. It has previously been assumed that growth starts at a temperature around 5.6°C or 6°C and these values have been used as thresholds for several classification schemes. Recent work (Peacock 1975, 1976; Biscoe and Gallagher 1978) has shown, however, that grass and cereals maintain leaf growth, albeit slowly, down to 0°C and this has been taken as the base value for this classification. Previous temperature classifications have used sums over the entire year, or through a notional growing season. Recent work (Waring and Cooper 1971) indicates that, over a wide range of crops, temperature is most important during leaf growth and that high temperatures in late summer can adversely affect yields. As leaf growth occurs at slightly differing times of the year in different parts of the country, the final parameter selected for this classification was the lower quartile value of accumulated temperature above 0°C over the first six months of the year (e.g. January-June inclusive).

Application of maximum potential soil moisture deficit and accumulated temperature

The appropriate maximum PSMD and accumulated temperature values are combined in Figure 1 to provide a single classification. The capability classification indicated by this method is the highest possible, based on macroclimatic factors only. In general, the temperature (energy supply) dominates for low values of accumulated temperature (higher altitude or more northerly latitudes), whereas soil moisture dominates elsewhere. It should be noted that the position within a classification band is as important as the band itself when comparisons between sites are being made. Thus Glasgow (code 64) and Threave (77) can expect to have more similarities with each other than either have with Wick (4) or Craibstone (15).

Modification due to exposure (wind speed)

Detailed measurements of wind are known for a limited number of sites, although indications which serve to establish the pattern may be derived from the Forestry Commission tatter flag experiments and from estimations derived from tree crown shape and heather-cut (Birse and Robertson 1970). Figure 2 illustrates the distribution of the isopleths of median wind speed over open country and for low altitudes (below 70 metres). An accurate adjustment for higher altitude is not possible, but approximate guidance can be obtained by increasing the indicated speed by 7% for each 100 metre increase in altitude *above* 70 metres. Local topographic features may further increase or decrease this value. If, after any necessary adjustment, the site lies in an area where the median wind speed exceeds 5 metres per second ($m\ s^{-1}$), serious consideration should be given to the possibility of downgrading. Before downgrading, evidence would be required that the range of possible successful crops is limited compared with a site with a similar climatic classification but experiencing less wind. It is expected that downgrading will be probable for median wind speeds above 6.0 $m\ s^{-1}$; but because exposure is a limitation on crop selection, downgrading will only take place where the original classification is 3 or higher. As with all factors, the divisions across the thresholds are not sharp, and downgrading due to exposure should only take place where there is supporting evidence.

The map of climate zones included with this booklet has been compiled to provide a general guide to the severity of limitations imposed by climate throughout Scotland. It should be checked wherever possible using local data. The Meteorological Office (Met. O. 8a, Agricultural Section) may be able to provide further guidance on local factors or availability of data.

GRADIENT

The great variation in the ability of machinery to cope with sloping ground has been described earlier. In addition to slope angle the influence of length, pattern and shape should not be overlooked. The use of sloping land is often controlled by whether turning space is available at head or foot; short steep slopes may well be worked while long slopes at similar angles are not. Rough microrelief is equally serious, for implements may be tipped beyond their limit of stability. In view of this wide variation only very general guidelines for slope are proposed.

Table 4 Capability class slope limits

Class	Slope limit
1	3
2	7
3.1	7
3.2	11
4.1	11
4.2	15
5.1	11
5.2	15
5.3	25
6	not applicable
7	not applicable

SOIL

Under this heading is grouped a complex set of qualities and their interactions. It is important to attempt an overall assessment of the various components rather than dwell on one or two.

Soil structure

Structural instability can usually be reduced to acceptable levels by appropriate management techniques. It will therefore rarely alter the land class or division, but can be important at unit level to distinguish land with a greater or lesser susceptibility to slaking and/or compaction and hence differing management requirements. There are a few areas of land, mainly well drained, coarse loamy or silty soils, under intensive cropping and with low organic matter contents, where no other limitation (workability, droughtiness or erosion) than instability can be recognised. It is necessary to confirm that the problem cannot be controlled by good management and that cropping flexibility and/or yields are affected in most years before downgrading such land.

Shallowness

Shallowness does not affect crop growth directly but it sometimes reflects the effects of combinations of several factors. The guidelines should be used with care and understanding and, where possible, individual effects should be checked.

Table 5 Capability class depth limits

Class	Depth limits
1	more than 60 cm
2	more than 45 cm
3.1	more than 45 cm
3.2	more than 20 cm
4.1	more than 20 cm
4.2	more than 20 cm
5-7	not applicable

Stoniness

A method of classifying stones in soil is described in the *Soil Survey Field Handbook* (Hodgson 1976) in terms of size, abundance, shape and lithology. This classification was based on properties identifiable in the field. Stoniness limitations for land classification, based upon the size and abundance scales, modified by shape and lithology are given in Table 6.

Table 6 Capability class stone size and abundance limits

	Volume %	Stone size: Very small and small 2 mm-2 cm	Medium and large 2-20 cm	Very large >20 cm
Stoneless	<1	1	1	1
Very slightly stony	1-5	1	2-3	2-3
Slightly stony	6-15	1-2	3-4	4
Moderately stony	15-35	3	4-5	4-5
Very stony	36-70	4	5	5
Extremely stony	>70	5	5	5

1 When either size or abundance approach class limits, classification may be modified by shape or lithology:
a. downgrade if a significant proportion of the stones are of hard lithology.
b. upgrade if stones are particularly porous or of soft lithology.

2 Stone removal: a few large boulders or stones than can easily be removed or avoided may be disregarded. When repeated stone crushing or windrowing or removal is necessary for cropping, the suggested criteria should be applied.

Droughtiness

Thomasson (1979) has given a comprehensive description of the problems associated with soil droughtiness and has suggested a method for its evaluation. Few parts of Scotland are seriously affected by drought but as they are in areas with otherwise good agricultural potential, the assessments are significant.

Soil droughtiness is assessed for any crop by calculating the available soil water reserves (AP) within the depth likely to be exploited by the crop and subtracting from this the excess of potential transpiration over rainfall during its growing season (PSMD). The calculations are modified for the period before the crop achieves full ground cover, since the maximum rate of transpiration is only achieved under full crop cover. The resulting *droughtiness class* is then interpreted in terms of *capability class* (Figure 4).

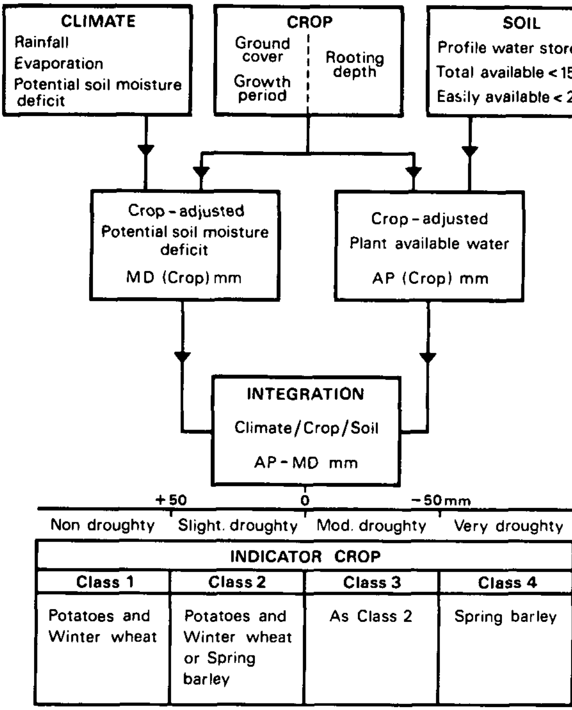


Figure 4 Flow chart to show assessment of droughtiness limitation.

Assessment of droughtiness class

(i) Calculation of available soil water reserves adjusted for crop, AP (crop) mm.

Given particle size class, packing density class and horizon depths, the volume of water available for a particular crop can be calculated from Tables 7, 8 and 9.

For annual crops the amount of available water which is generally accessible varies with crop and soil. The depth of rooting under favourable conditions is near 120 cm for cereals, whereas potato roots do not appear to search so deeply and 70–80 cm may be an average limit (Durrant *et al.* 1973). Sugar beet can root below 120 cm and extract appreciable water from that depth in sand land. Generally, however, with increasing depth, crop rooting systems are less well developed and their ability to abstract water is diminished. Only easily available water (0.05–2 bar) is then significant in productive growth. The crop rooting depths of common agricultural crops are summarised in Table 7 and an indication of the suctions applied at these depths given.

Table 7 Crop rooting depths and suction limits of common agricultural crops

	Depth (cm)	Suction (bar)
Wheat, Barley, Temporary grass	0–50	0·05–15
	50–120	0·05–2
Potatoes	0–70	0·05–15
Sugar beet	0–80	0·05–15
	80–130	0·05–2
Permanent grass	0–70	0·05–15
	70–100	0·05–2

A value for profile available water (AP crop mm) for any specified crop growing over any given profile can be arrived at as follows:

1 Assess horizon thickness and the particle-size and packing density classes of the fine earth in each horizon of the profile
2 From Table 7 read the appropriate rooting depths and water suctions for the crop
3 Interpret the profile data in terms of rooting depths and suctions. Where a horizon is divided by the rooting depth figure, treat as two separate layers
4 From the appropriate table (total available water, Table 8, for suctions 0·05–15 bar or easily available water, Table 9, for suctions 0·05–2 bar) read the value under particle-size class and packing density class for each horizon and repeat for each horizon
5 Multiply this value by the thickness of the horizon (cm), sum and divide by 10 to obtain profile available water AP (crop) mm.
6 Repeat for each crop as necessary.

The AP values obtained by this method represent 'potential' values under British conditions. Temporarily impenetrable horizons, or rock, will restrict rooting and field evidence may require the summation to be curtailed at shallower depth. However, in soils over well-shattered rocks (e.g. chalk, some sandstones and oolitic limestones), crops do appear to abstract water from depths of 80 to 100 cm.

Table 8 Available water (0.05—15 bar) per cent for mineral soils in relation to horizon, particle-size class and packing density class

		Av (%) for different packing density classes		
Particle-size class	Horizon	Low (<1.40 g cm^{-3})	Medium (1.40–1.75 g cm^{-3})	High (>1.75 g cm^{-3})
Clay	A	22	18	(15)
Clay	E,B,C	14	16	13
Silty clay	A	23	18	—
Silty clay	E,B,C	23	15	12
Silty clay loam	A	23	19	(17)
Silty clay loam	E,B,C	20	15	12
Clay loam	A	21	17	(14)
Clay loam	E,B,C	20	15	12
Sandy clay	A	(21)	—	—
Sandy clay	E,B,C	—	(13)	(13)
Sandy clay loam	A	(20)	17	15
Sandy clay loam	E,B,C	(21)	15	13
Loam	A	25	19	(15)
Loam	E,B,C	22	16	13
Silty loam	A	24	20	—
Silty loam	E,B,C	24	19	13
Silt	A	—	(31)	—
Silt	E,B,C	(24)	(24)	—
Sandy loam	A	20	17	(17)
Sandy loam	E,B,C	19	16	12
Loamy sand	A	17	16	—
Loamy sand	E,B,C	15	14	(10)
Sand	A	(13)	(18)	—
Sand	E,B,C	13	12	(5)

A dash, —, indicates no information. Brackets, ( ), indicate limited data (n<10)
Packing density classes after Hodgson (1976)
High density topsoils and low density subsoils are rare.
Packing density classes after Hodgson (1976).

Table 9 Easily available water (0.05—2 bar) per cent volume, for mineral subsoils in relation to particle-size class and packing density class

Particle-size class	Dominant sand grade (medium = 200 – 600 μm; fine = 60 – 200 μm)	Av (%) for different packing density classes		
		Low (<1.40 g cm^{-3})	Medium (1.40 – 1.75 g cm^{-3})	High (>1.75 g cm^{-3})
Clay		14	9	7
Silty clay		14	9	6
Silty clay loam		14	9	7
Clay loam		13	9	6
Sandy clay		—	(8)	(7)
Sandy clay loam		(15)	10	8
Loam		15	10	7
Silty loam		15	12	7
Silt		—	(18)	—
Sandy loam	medium	15	10	7
Sandy loam	fine	17	12	10
Loamy sand	medium	13	9	(8)
Loamy sand	fine	13	15	—
Sand	medium	(10)	7	(3)
Sand	fine	(13)	15	—

A dash, —, indicates no information. Brackets, ( ), indicate limited data (n< 10)
Packing density classes after Hodgson (1976).

Where horizons are stony, a correction may be made to the available water percentage as follows:

$$A_v\,(\text{horizon}) = A_v\,\text{fine earth} \times \frac{100 - \%\ \text{stones}}{100}\ .$$

For porous stones (oolitic limestone or ironstone) deduct half the volume of stones before calculating A_v (horizon). Very porous stones (e.g. chalk) can be treated as fine earth.

(ii) Calculation of potential soil moisture deficit (April–August).

The basic climatic parameter is the median end of month accumulated potential soil moisture deficit (under grass), for the months of April to August. The calculation of these values is based on the same process as that

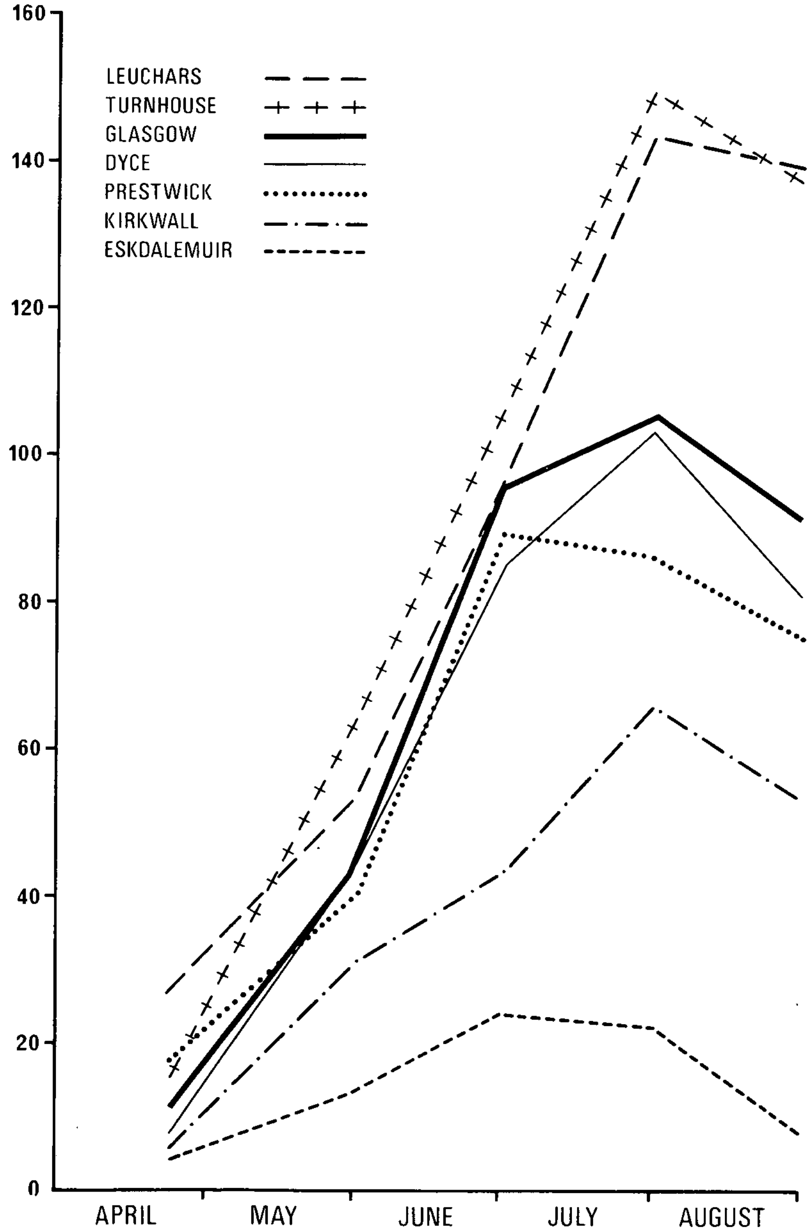


Figure 5 Cumulative potential soil moisture deficit (April–August) for seven stations in Scotland.

for the median maximum PSMD, as defined in the climate section (p. 21) but the end of month values are used so that they can be related to the cropping pattern as described below. Median end of month potential soil moisture deficits for a range of Scottish stations are shown in Figure 5.

Since moisture losses from ground with a full crop-cover are greater than from bare or only partially covered ground by virtue of increased transpiration, adjustments of values for individual crops are necessary. Procedures to adjust PSMD values for three common arable crops are summarised below. The adjusted value is referred to as MD (crop). The deductions used are large but similar to those used in irrigation experiments to estimate soil moisture deficit. For grass, the median maximum PSMD from the climate section is the appropriate parameter. Other crops can be fitted into one or other of the patterns with suitable adjustments for ground cover and/or the onset of senescence. Some slight adjustments may also be necessary in different areas of Scotland.

MD (Winter wheat)

Winter wheat does not usually achieve full ground cover until the end of April. The outcome of this may be summarised as:

$$\text{PSMD (mid-July)} - \frac{\text{PSMD April}}{3} \quad \text{mm}$$

Example: MD (Winter wheat) Turnhouse, Midlothian

Partial crop cover to end of April; full crop cover to mid-July

Mid-July PSMD =	128
Deduct $\frac{1}{3}$ end of April PSMD (24 mm) for partial crop cover =	8
MD Winter wheat =	120 mm

MD (Spring barley)

Spring barley achieves full ground cover about mid-May but the growth pattern is otherwise similar. Hence MD (barley) is:

$$\text{PSMD (mid-July)} - \frac{\text{PSMD Mid-May}}{3} \quad \text{mm}$$

Example: MD (Spring barley), Dyce, Aberdeen

Partial crop cover to mid-May; full crop cover to mid-July

Mid-July PSMD =	94
Deduct $\frac{1}{3}$ mid-May PSMD (29 mm) for partial crop cover =	10
MD (Spring barley) =	84 mm

MD (main crop potatoes)

Most root crops can be considered to be in bare ground conditions until mid-May. Full crop cover is generally achieved by the end of June.

Growth then continues through the period of maximum deficit (usually the end of July or very early in August). The general formula to derive MD for potatoes is:

$$\text{PSMD (July)} - \frac{2\ \text{PSMD (mid-May)}}{3} - \frac{\text{PSMD (June)} - \text{PSMD (mid-May)}}{3}\ \text{mm}$$

Example: MD (potatoes) Leuchars, Fife

Bare ground until mid-May; partial crop cover to end June, full cover to August

End of July* PSMD =		143
Deduct $\frac{2}{3}$ mid-May PSMD (43 mm) for bare ground	=	28
Deduct $\frac{1}{3}$ increase (52 mm) from mid-May (43 mm) to end June (95 mm) for partial crop cover	=	17
MD (potatoes)	=	98 mm

(iii) Calculation of droughtiness class.

The droughtiness class is calculated by AP−MD (crop) mm. A value above +50 mm, Table 10, indicates that the soil has appreciable surplus reserves of water in the average season and some additional resistance to drought stress in dry years. Any value below −50 implies severe shortage of water in all but the wettest summers.

Table 10 Droughtiness classes

AP MD (crop) (mm)	Descriptive term
	Non-droughty
+50	
	Slightly droughty
0	
	Moderately droughty
−50	
	Very droughty

Application of droughtiness class to capability classification

For land capability purposes droughtiness limitations chiefly affect arable crops on the better class land (Classes 1 to 3). The general sequence of crop sensitivity to water stress is:

BARLEY < WHEAT < POTATOES

* At this station PSMD at the end of July is higher than at the end of August. In these cases it is preferable to use the larger value.

Thus if a soil, in its climatic setting, is non-droughty for potatoes it will also be non-droughty for wheat, barley etc. The system adopted uses the above crops as broad indicators, thus:

Class 1. Non-droughty for potatoes and winter wheat

Class 2. Not worse than slightly droughty for potatoes and winter wheat or spring barley

Class 3. Not worse than moderately droughty for potatoes and winter wheat or spring barley

Class 4. Any soil which is very droughty for winter wheat or spring barley.

Where irrigation is a feasible management tool the land is classed as if irrigation had been applied.

WETNESS

Like droughtiness, wetness is a complex soil property. Its principal effect is through workability and trafficability in the arable categories and trafficability and poaching in grassland, although physiological effects on the plant from waterlogging and the susceptibility of some sites to flooding are also important.

Workability, trafficability and poaching risk

Susceptibility of soils to structure damage by cultivations, traffic or stock, with consequent penalties for sustained crop production, is governed by three main factors (Thomasson 1982):

1 Soil wetness class (Table 2) and the depth to effectively impermeable horizons (defined below)

2 Water retention, plasticity and strength properties of the topsoil; mainly related to particle size class and organic matter content

3 The climatic environment, mainly the length of the field capacity period.

For land classification purposes, the aim is to assess the surviving limitations *after* appropriate drainage measures to alleviate wetness and workability problems. This is particularly important for land with adequate arterial drainage/outfalls in climatic zones/classes 1 and 2 (Figure 1). Care should be taken to ensure that gleying features of the profile are not relict.

Impermeable horizons are defined as subsurface horizons at least 15 cm thick and with an upper boundary within 80 cm depth. As with many other soil characteristics, varying levels of precision in the identification of impermeable horizons are required, depending on the resources available and the purpose of the study.

Within the above descriptive and boundary contexts, the most *precise*

physical definition of an impermeable horizon is that it has a horizontal saturated hydraulic conductivity (K_s) of less than 10 cm/day.
Morphological criteria for impermeable horizons are:

(a) particle size classes finer than sandy loam
and (b) massive, platy or prismatic structure; weak, moderate or strongly developed *coarse* angular blocky structures; weakly developed fine or medium angular blocky structures
and (c) moderately firm, or firmer ped strength when moist
and (d) few, or widely spaced (<0·5%) visible pores (Hodgson 1976, p. 45)
(e) impermeable horizons will usually meet the gleying criteria for Bg or BCg horizons or be overlain by an EG (ibid. p. 75). In soils developed from red materials (5YR or redder), evidence of gleying may be weak but criteria (a) to (d) above are usually conclusive.

Supplementary criteria to identify impermeable horizons may be needed where criteria (b), (c) or (d) are indefinite and a measurement of K_s is not practicable. Normally a horizon having an air capacity value of less than 5 per cent can be considered impermeable. This will usually be associated with high packing density, but some fine silty and fine loamy materials which are near permanently wet have medium packing density and air capacities of less than 5 per cent.

The method to assess soil profile components of this limitation is shown in Tables 11 to 13. Topsoil retained water capacity is defined as the volume of water held by an undisturbed core sample equilibrated at 0·05 bar suction (Hall *et al.* 1977). The class limits for this property are:

Low	<35 per cent
Medium	35–45 per cent
High	>45 per cent

Humose and peaty topsoils, although mainly retaining more than 45 per cent water, are treated separately. The pattern of retained water capacity in relation to broad texture classes and organic matter content is given in Table 11.

Table 12 integrates topsoil retained water capacity with wetness class and depth to impermeable horizon to form a soil assessment. The table is designed primarily to express workability and trafficability for arable cropping.

Climatic parameters are introduced in Table 13 and integrated with the soil assessments to allocate land class and division. Median annual values of field capacity days (Smith and Trafford 1976) are the most easily available measure of general climatic restrictions to farm operations in England and Wales. Figure 6 shows the general pattern of

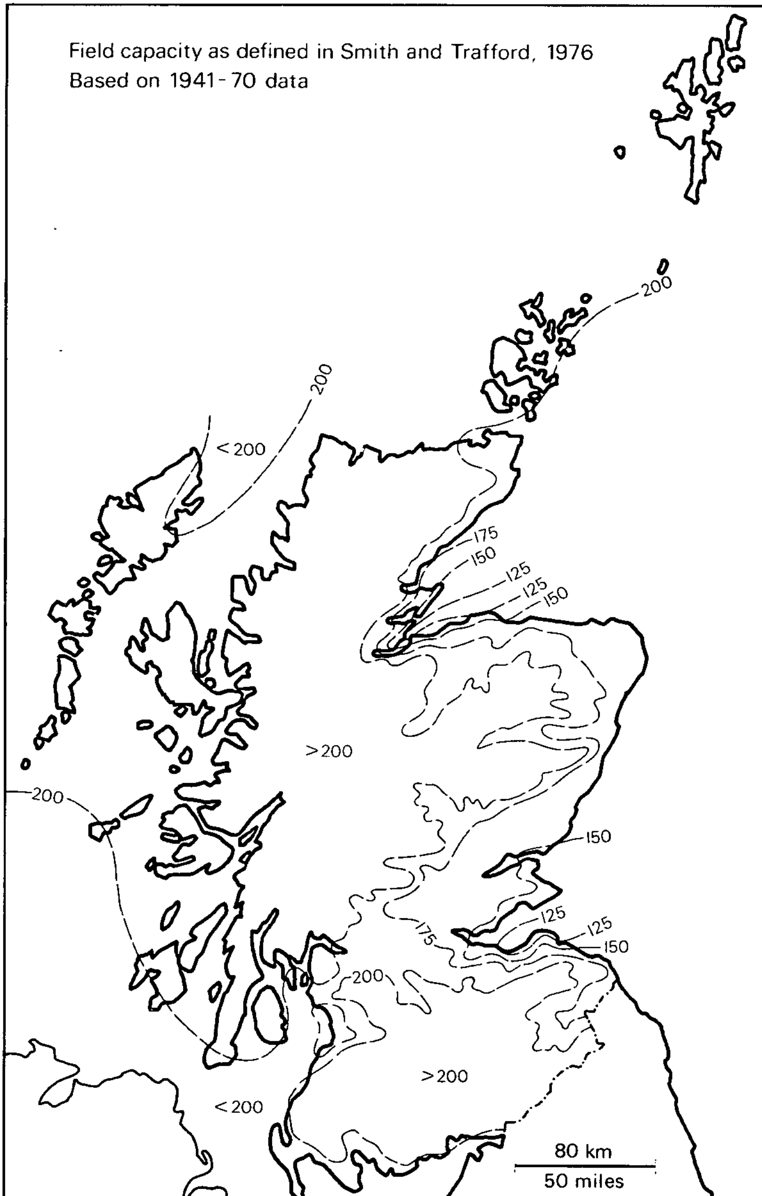


Figure 6 Number of days of field capacity (median value).

mean field capacity days on the same basis for Scotland. In wetter soils or those retaining large amounts of water (c, d, e, f) appreciable drying, involving development of a soil moisture deficit, is needed before good working conditions are achieved in spring. In clayey soils the onset of waterlogging and poor working conditions in autumn is often brought forward due to shrinkage of the soil mass during summer and slow re-swelling in response to excess autumn rain. Conversely, on much well drained, loamy and sandy land, acceptable working conditions can occur *within* the field capacity period after one or two rain-free days, although no appreciable moisture deficit has developed. This aspect is expressed in Table 13 by not allocating a workability limitation to type 'a' soils, under climates with less than 175 FC days, implying that in most years there is an opportunity to carry out necessary field work under passable conditions at or about the appropriate time.

Table 11 Relation of retained water capacity to particle size classes, (texture)

Retained water capacity % volume	Texture classes (USDA 1951)
High >45	Peaty and humose soils Clay, silty clay, sandy clay Part: clay loam, silty clay loam
Medium 35–45	Loam, silt loam, silt, sandy clay loam Part: clay loam, silty clay loam
Low <35	Sandy loam, loamy sand, sand

Workability and trafficability are important in Classes 1–3, where arable-based enterprises are extensive. In Classes 4–5 grassland is the predominant use and trafficability and poaching risk are critical.

A good description of the problems associated with the intensive use of land for grass is given by Harrod (1979). Guidelines for trafficability and poachability, including assessment of wetness class, depth to

Table 12 Soil assessments for workability and trafficability

Wetness class	Depth to impermeable horizon (cm)	Retained water capacity of topsoil mineral soils: Low	Medium	High	Humose or peaty soils
I	>80	a	a	a	a
II	>80	a	a	b	a
	40-80	b	b	c	b
III	>80	b	c	c	b
	40-80	c	c	d	c
	<40	c	d	d	d
IV	>80	c	d	d	d
	40-80	c	d	d	e
	<40	d	e	e	f
V	>80	d	e	e	f
	40-80	e	f	f	f
	<40	e	f	f	f
VI	All depths	f	f	f	f

Table 13 Climate and soil assessments giving capability class

Climatic assessment: Median field capacity days	Soil assessment: a	b	c	d	e	f
	Class limits					
<125	1	1	2	3	3	3
125-150	1	2	3	3	3	4
150-175	1	2	3	3	4	4
175-200	2	3	3	4	4	5
>200	2	3	3	4	5	6

impermeable layers, the retained water capacity of the surface soil and climatic regime are given in his paper on grassland suitability. They are relevant to Class 5 land and have been adopted as the basis for divisions within it, with additions for peaty soils (Tables 14 and 15).

Table 14 Estimation of grassland trafficability and poaching risk[1] (after Harrod 1979)

Wetness class	Depth to impermeable layer (cm)	Climate: Max. PSMD > 100 mm[2], Retained water capacity[3]				Max. PSMD < 100 mm[2], Retained water capacity[3]			
		Low	Medium	High	Peat[4]	Low	Medium	High	Peat[4]
I	>80	a	a	a	a	a	b	b	c
and	80-40	a	a	b	b	b	b	c	d
II	<40	a	a	b	—	b	b	c	—
III	>80	a	b	b	c	c	c	c	f
and	80-40	b	b	c	d	c	c	d	f
IV	<40	c	c	d	—	d	d	e	—
V	>80	d	d	e	e	e	e	e	f
and	80-40	e	e	e	e	e	e	e	f
VI	<40	e	e	e	—	e	e	e	—

1 When trafficability is high, poaching risk is low and vice versa
2 See climate section
3 Class of retained water capacity in mineral A horizons and O horizons <50 cm deep
Low <35 per cent
Medium 35-45 per cent
High >45 per cent
4 Peat soils have O horizons >50 cm thick and have very high retained water capacities.

Table 15 Division limits for class 5 according to trafficability and poaching risk

Division	Trafficability and poaching risk category
1 Very suitable for use as grassland	a and b
2 Suitable for use as grassland	c and d
3 Marginally suitable for use as grassland	e
Not suited to use as grassland	f

In describing capability units within any division, those units suited to grass conservation will be given priority over those suited only to grazing.

Flooding
Information on flooding in agricultural land is often fragmentary and only held locally. The following table provides a general guideline:

Table 16 Flood risk and capability class

Flood risk	Capability class
Negligible	1 and 2
Non-damaging winter floods of short duration; very rare summer floods	3
Damaging floods 1 year in 5 and risk of summer flooding	4
Damaging floods 1 year in 3 or more frequent flooding provided that soil scouring is negligible	5
Damaging floods in most years	6

EROSION

The processes and control of wind erosion in Britain have been studied (Davies and Harrod 1970). For the purpose of land classification, information over a period of years on crop damage necessitating redrilling, crop yield penalties or restrictions in the range of cropping, together with site evidence of loss or accumulation of soil material must be used in order to assess the degree of risk. As with water erosion, wind erosion risk occurs usually as a subsidiary descriptive limitation and can be contained by good management practices. It may affect grading at class level in very exposed areas.

Table 17 Erosion risk and capability class

Erosion risk	Capability class
Very slight	1
Slight	2–3
Moderate	4–5
Severe	6–7

PATTERN

Accurate information on the effect of the pattern of good and bad physical conditions within a unit is difficult to obtain. Levels of variation which would be critical in Class 1 due to their effect on management or yield could easily be acceptable in Class 5. If an impurity of 15% occurs as one patch, it affects management less than if it is distributed as small areas throughout the unit. The guideline to be adopted is that variation within the class should not substantially interfere with the levels of either crop growth or management normally expected in that unit. Table 18 provides a general guide to acceptable levels of impurity.

Where mnemonics for limitation type are used and pattern is a significant factor in determining class, the mnemonic to be applied is that of the general group to which the pattern applies, e.g. patterns of stoniness or shallowness shown as s, patterns of slope as g.

Table 18 Pattern and capability class

per cent of area with land of lower quality than the class	Class
<2	1
<5	2
<10	3
<25	4
<50	5
<60	6

VEGETATION

In any assessment of hill areas, the composition of the existing vegetation is among the properties that should be considered in determining the quality of the land. On Class 5 land or better, the present vegetation cover is in itself not of any great importance since it may be replaced with relative ease by a cultivated or improved pasture, although it may be used indirectly as a measure of the drainage or fertility of the soil. The vegetation of hill land that is not improvable by normal mechanical means (Class 6) is significant, however, as it represents a resource which may only be altered by management of burning and grazing. It is therefore useful to consider the plant communities of such areas in terms of their value as hill grazings and to group such values into 'high', 'moderate' and 'low' grazing divisions.

Rating of plant species

A number of workers in the field of grassland husbandry have sought to establish a simple method for assessing the grazing quality of pasture swards, in particular de Vries (1949) and Klapp (1953). The system described by Klapp has been adapted for use in assessing the relative grazing values of Scottish plant communities, principally because he considered by far the greatest number of species in his assessment.

Plant species are given a rating on a scale of − 1 to 8 (10 point) which is basically an expression of their dry matter productivity but which also includes an element relating to their sward-forming ability, regularity of production, coarseness, hairiness and palatability. Values for species commonly occurring in Scottish plant communities are given in Table 19, these being modified slightly from those of Klapp's original list. The amendments are based on the grazing habits of the black-face sheep, the principal grazing animal of the Scottish Uplands. Species with a value of − 1 are poisonous to some degree, especially in the form of hay or silage (e.g. marsh marigold, ragwort, iris). Those with a value of 0 or 1, although possibly forming an important fraction of the animal's intake, do not contribute significantly towards a positive energy balance. The plant species which are most efficiently utilised and which have the highest dry matter production rates are allotted values of 7 or 8. These species are usually grasses (e.g. cock's-foot, meadow-grass, rye-grass) and so assessment of grazing value is fundamentally an assessment of the abundance of productive grasses present in the sward.

Calculating relative grazing value (RGV)

To calculate the RGV of a given plot of vegetation, a list of the more abundant species is made (e.g. all species with a cover abundance of more than 5 per cent) and the percentage areal cover of each is noted. A total figure of more than 100 per cent is possible as there are usually several different overlapping layers of vegetation present. The grazing value for each species is then multiplied by its percentage cover value and the products are totalled to give the RGV of the sample. If cover abundance ratings have been used instead of numerical values, an approximate average cover value may be used instead, viz:

dominant — 75 per cent
abundant — 35 per cent
frequent — 20 per cent
occasional — 10 per cent
(rare — 5 per cent)

An alternative to calculating the RGV of each vegetation sample at every site is to identify the plant community in which it occurs and refer to the RGV already calculated for it as in Table 20. This will give a much better impression of the grazing quality of the vegetation as a whole, although there may be considerable variation from point to point within the unit. The first two examples in the table refer to improved pastures and are not normally encountered on Class 6 land, but they have been quoted as a contrast to the 'natural' communities that follow. The communities so listed have been based on the classification of Scottish plant associations (Birse and Robertson 1976; Birse 1980; Robertson 1982), but this system has been derived from the Continental European classification and can therefore be extended to incorporate areas elsewhere in Britain.

The RGV of the vegetation at any given site may vary considerably due to regional variation in climate, soil type or management, but in practice a grouping of values into a three-point scale of 'high', 'moderate' and 'low' is wide enough to accommodate this variation. The divisions are as follows:

RGV:	>500	Grazing division:	high
	200–500		moderate
	<200		low

This grouping is such that the richer grassland communities nearly all fall within the 'high' category, whereas all but the herb-rich moorland communities and flushed bogs are 'low'. Intermediate communities such as rough grasslands and sedge mires are classed as being of 'moderate' grazing value. A rating of 'low' does not necessarily mean that a particular vegetation type is of little use for grazing, but that, whilst healthy productive animals can be raised on it, the stocking rates it can carry are much lower than those of the better categories.

Examples

A Rich bent–fescue grassland

plant species	percentage cover	grazing value	total
Agrostis tenuis	30	5	150
Festuca rubra	30	5	150
Lotus corniculatus	30	6	180
Festuca ovina	20	3	60
Thymus drucei	10	1	10
Anthoxanthum odoratum	10	3	30
Carex caryophyllea	10	2	20
Luzula campestris	10	2	20
Achillea millefolium	10	5	50
Galium verum	10	3	30
Hieraceum pilosella	10	2	20
Potentilla erecta	10	2	20
Trifolium repens	10	8	80
			820

RGV = 820 Grazing division — high

B Moist Atlantic heather moor

plant species	percentage cover	grazing value	total
Calluna vulgaris	75	1	75
Empetrum nigrum	20	0	—
Molinia caerulea	20	2	40
Erica cinerea	10	1	10
Juncus squarrosus	10	1	10
Erica tetralix	10	0	—
Nardus stricta	10	2	20
			155

RGV = 155 Grazing division — low

Mapping units and complexes

Many mapping units in the upland areas will inevitably be complexes of various soil types, especially at small map scales, and it is therefore necessary to make a further calculation to arrive at the overall RGV of those units. Some indication of the percentage occurrence of the soil types making up the complex is required, together with a note on the dominant vegetation type associated with each soil. The percentage occurrence of each soil type is then multiplied by the RGV of the associated plant community, the products are totalled and the result is divided by 100 to give the RGV of the complex. An overall assessment of moderate grazing quality is much more commonly encountered when dealing with complex soil/vegetation units.

Examples

A. Funtack Complex (Countesswells Association). Soils formed on drifts derived from granites and granitic rocks. Hills and undulating lowlands with gentle and strong slopes; moderately rocky.

soil type	*associated vegetation*	*% age of unit*	*RGV*	*total*
Peaty podzol	moist Atlantic heather moor	10	145	1,450
Peaty gley	northern bog heather moor	40	105	4,200
Peat	lowland blanket bog	10	95	950
	flying bent bog	30	223	6,690
				13,290

RGV = 133 Grazing division — low (L.C.A. Class 6.3)

B. Tearnait Complex (Countesswells Association). Hill and valley sides with strong to very steep slopes; moderately rocky and bouldery.

soil type	*associated vegetation*	*% age of unit*	*RGV*	*total*
Humus-iron podzol	dry Atlantic heather moor	20	145	2,900
Brown forest soil	meadow-grass–bent pasture with bracken	25	444	11,100
	acid bent–fescue grassland	10	570	5,700
Peaty gley	species-rich sharp-flowered rush pasture	10	639	6,390
	moist Atlantic heather moor	10	145	1,450
Peaty podzol	flying bent grassland	10	390	3,900
Peat	species-poor sharp-flowered rush pasture	10	549	5,490
				36,930

RGV = 369 Grazing division—moderate (L.C.A. Class 6.2)

C. Grigadale Complex (Insch Association). Soils formed on drifts derived from gabbros and allied igneous rocks. Hills and valley sides with strong to very steep slopes; moderately rocky.

soil type	*associated vegetation*	*% age of unit*	*RGV*	*total*
Brown forest soil and	rye-grass–crested dog's tail pasture	10	1175	11,750
brown ranker	acid bent–fescue grassland	45	570	25,650
	meadow-grass–bent pasture with bracken	20	444	8,880
	herb-rich Atlantic heather moor	5	250	1,250
Humus-iron podzol	dry Atlantic heather moor	5	145	725
Peaty gley	moist Atlantic heather moor	8	145	1,160
	soft rush pasture	2	480	960
				50,375

RGV = 504 Grazing division—high (L.C.A. Class 6.1)

Table 19 Grazing values of some common plant species (after Klapp 1953)

Shrubs	
Arctostaphylos uva-ursi	0
Calluna vulgaris	1
Empetrum nigrum	0
Erica cinerea	1
Erica tetralix	0
Genista anglica	0
Salix repens	1
Thymus drucei	1
Vaccinium myrtillus	1
Vaccinium vitis-idaea	0
Vaccinium uliginosum	1
Grasses	
Agropyron repens	6
Agrostis canina	3
Agrostis stolonifera	3
Agrostis tenuis	5
Alopecurus geniculatus	4
Anthoxanthum odoratum	3
Arrhenatherum elatius	7
Brachypodium sylvaticum	2
Briza media	5
Bromus mollis	3
Cynosurus cristatus	6
Dactylis glomerata	7
Deschampsia cespitosa	3
Deschampsia flexuosa	3
Festuca ovina	3
Festuca rubra	5
Festuca vivipara	3
Glyceria fluitans	4
Helictotrichon pratense	2
Helictotrichon pubescens	4
Holcus lanatus	4
Holcus mollis	3
Hordeum secalinum	2
Koeleria cristata	2
Lolium multiflorum	7
Lolium perenne	8
Molinia caerulea	2
Nardus stricta	2
Phalaris arundinacea	5
Phleum bertolonii	3
Phleum phleoides	3
Phleum pratense	8
Phragmites communis	2
Poa annua	5
Poa nemoralis	5
Poa palustris	7
Poa pratensis	8
Poa trivialis	7
Puccinellia maritima	7
Sesleria albicans	2
Sieglingia decumbens	2
Trisetum flavescens	7
Sedges and Rushes	
Carex arenaria	1
Carex bigelowii	1
Carex binervis	1
Carex caryophylea	2
Carex demissa	1
Carex dioica	1
Carex disticha	2
Carex echinata	1
Carex flacca	2
Carex hostiana	1
Carex maritima	1
Carex nigra	1
Carex ovalis	1
Carex pallescens	2
Carex panicea	2
Carex pilulifera	1
Carex pulicaris	1
Carex rostrata	1
Eleocharis palustris	2
Eleocharis quinqueflora	1
Eleocharis uniglumis	1
Eriophorum angustifolium	1
Eriophorum latifolium	1
Eriophorum vaginatum	1
Juncus acutiflorus	2
Juncus articulatus	2
Juncus conglomeratus	1
Juncus effusus	1
Juncus gerardii	2
Juncus kochii	2
Juncus squarrosus	1
Luzula spp.	2
Rhynchospora alba	1
Schoenus nigricans	0
Trichophorum cespitosum	1
Triglochin spp.	0
Typha spp.	1
Forbs	
Achillea millefolium	5
Achillea ptarmica	3
Aegopodium podograria	3
Agrimonia eupatoria	2
Ajuga reptans	2
Alchemilla alpina	2
Alchemilla vulgaris	5
Allium ursinum	−1
Anemone nemorosa	−1
Angelica sylvestris	2
Antennaria dioica	1
Anthriscus sylvestris	4
Armeria maritima	1
Aster tripolium	4
Anthyllis vulneraria	5
Astragalus danicus	5
Bellis perennis	2
Caltha palustris	−1
Campanula rotundifolia	3
Capsella bursa-pastoris	1
Cardamine spp.	−1
Carlina vulgaris	0
Carum verticillatum	5
Centaurea nigra	3
Cerastium arvense	3
Cerastium holosteoides	3
Chrysanthemum leucanthemum	2
Cirsium spp.	0
Conopodium majus	1
Convolvulus arvensis	3
Crepis paludosa	4
Dactylorchis maculata ericetorum	1
Drosera spp.	−1
Eleocharis palustris	2
Epilobium spp.	2
Euphorbia spp.	−1
Euphrasia spp.	−1
Filipendula ulmaria	3
Fragaria vesca	2
Galium spp.	3
Gentianella spp.	2
Geranium pratense	2
Geranium robertianum	2
Geranium sylvaticum	2
Geum rivale	2
Geum urbanum	1
Glaux maritima	3
Glechoma hederacea	1
Gymnadenia conopsea	1
Heracleum sphondylium	5
Hieraceum pilosella	2
Hydrocotyle vulgaris	−1
Hypericum pulchrum	1
Hypochoeris radicata	1
Iris pseudacorus	−1
Lathyrus pratensis	7
Lathyrus montanus	5
Leontodon autumnalis	5
Linum catharticum	0
Listera cordata	1
Listera ovata	1
Lotus corniculatus	7
Lotus uliginosus	7

Table 19—*continued*

Lychnis flos-cuculi	1	Primula spp.	2	Trifolium arvense	4
Lysimachia nemorum	1	Prunella vulgaris	2	Trifolium campestre	6
Lythrum salicaria	2	Ranunculus acris	1	Trifolium dubium	6
Medicago lupulina	7	Ranunculus bulbosus	1	Trifolium medium	4
Melampyrum pratense	0	Ranunculus ficaria	1	Trifolium pratense	7
Mentha spp.	0	Ranunculus flammula	0	Trifolium repens	8
Menyanthes trifoliata	−1	Ranunculus repens	4	Trollius europaeus	0
Meum athamanticum	3	Rhinanthus spp.	0	Tussilago farfara	1
Moehringia trinervia	2	Rumex acetosa	4	Urtica dioica	1
Myosotis spp.	2	Rumex acetosella	1	Valeriana dioica	1
Ononis repens	0	Rumex crispus	1	Valeriana officinalis	1
Orchis spp.	1	Sagina procumbens	1	Veronica arvensis	1
Parnassia palustris	1	Scrophularia spp.	0	Veronica chamaedrys	2
Pedicularis spp.	−1	Sedum spp.	0	Veronica officinalis	1
Pimpinella saxifraga	5	Senecio aquaticus	−1	Veronica serpyllifolia	1
Pinguicula vulgaris	0	Senecio jacobaea	−1	Vicia angustifolia	5
Plantago coronopus	3	Silene dioica	2	Vicia cracca	6
Plantago lanceolata	6	Solidago virgaurea	2	Vicia hirsuta	5
Plantago major	2	Spergularia media	2	Vicia sepium	6
Plantago maritima	3	Spergularia marina	2	Viola spp.	1
Polygala spp.	1	Stellaria spp.	2		
Polygonum amphibium	1	Succisa pratensis	2	*Ferns etc.*	
Polygonum persicaria	1	Taraxacum officinale	5	Equisetum arvense	0
Polygonum viviparum	1	Teucrium scorodonia	1	Equisetum fluviatile	−1
Potentilla anserina	1	Thalictrum alpinum	−1	Equisetum palustre	−1
Potentilla erecta	2	Tragopogon pratensis	4	Pteridium aquilinum	−1
Potentilla sterilis	2				

Table 20 Ordering of plant communities in terms of their relative grazing value for sheep

	Plant community	Grazing division	RGV
1	Permanent and long ley pastures (rye grass–crested dog's tail pasture)	high	1175
2	Ley pastures (rye grass–crested dog's tail pasture)	high	1080
	MARITIME—dunes, saltings and salt spray communities		
3	Milk-vetch—red fescue dune pasture	high	590
4	Vernal squill maritime pasture	high	578
5	Sea poa salt-marsh	high	534
6	Mud rush salt-marsh	high	515
7	Eye-bright—red fescue dune pasture	high	500
	SWAMP		
8	Marsh marigold meadow	moderate	360
9	Meadow-sweet meadow	moderate	330
10	Yellow flag swamp	low	149

Table 20—*continued*

	PASTURE—sedge, rush and grassland communities		
11	Crested hair-grass grassland	high	740
12	Sweet vernal—Yorkshire fog pasture	high	739
13	Meadow-grass—bent pasture	high	710
14	Herb-rich bent–fescue grassland	high	660
15	Upland bent–fescue grassland	high	650
16	Species-rich sharp-flowered rush pasture	high	639
17	Acid bent–fescue grassland	high	570
18	Species-poor sharp-flowered rush pasture	high	549
19	Bent–fescue grassland with bracken	high	545
20	Heath grass—white bent grassland	high	540
21	Soft rush pasture	moderate	480
22	Rockrose—fescue grassland	moderate	480
23	White bent grassland	moderate	460
24	Meadow-grass—bent pasture with bracken	moderate	444
25	Tussock-grass—white bent grassland	moderate	414
26	Flying bent grassland	moderate	390
27	Tussock-grass pasture	moderate	370
28	Star sedge mire with sharp-flowered rush	moderate	353
29	Carnation-grass pasture	moderate	343
30	Silverweed pasture	moderate	336
31	Flying bent—bracken grassland	moderate	290
32	Flea sedge mire	moderate	261
33	Star sedge mire	moderate	212
34	Star sedge mire with bog myrtle	low	184
35	Bog moss water track	low	165
36	Few-flowered spike-rush mire	low	81
37	Bog-rush mire	low	80
	MOORLAND		
38	Sea plantain—crowberry heath	moderate	317
39	Sea plantain—bell heather moor	moderate	287
40	Herb-rich Atlantic heather moor	moderate	250
41	Common cotton-grass bog	moderate	236
42	Flying bent bog	moderate	223
43	Herb-rich boreal heather moor	moderate	215
44	Blaeberry heath	low	175
45	Flying bent—bog myrtle bog	low	172
46	Maritime Atlantic heather moor	low	157
47	Dry Atlantic heather moor	low	145
48	Moist Atlantic heather moor	low	145
49	Northern Atlantic heather moor	low	140
50	Deer grass and northern deer grass moor	low	108

Table 20—*continued*

51	Upland blanket bog	low	108
52	Northern bog heather moor	low	105
53	Northern blanket bog	low	105
54	Lowland blanket bog	low	95
55	Dry boreal heather moor	low	90
56	Bog heather moor	low	90
57	Mountain blanket bog	low	90
58	Cotton-grass bog	low	87
59	Moist boreal heather moor	low	85
60	Lichen-rich boreal heather moor	low	85
61	Blanket bog terminal phase	low	50
	MOUNTAIN		
62	Viviparous fescue grassland	moderate	370
63	Mountain white bent grassland	moderate	359
64	Stiff sedge grassland	moderate	315
65	Mountain heath rush grassland	moderate	260
66	Alpine clubmoss snow-bed	low	195
67	Bog whortleberry heath	low	163
68	Fescue—woolly fringe-moss heath	low	113
69	Alpine azalea–lichen heath	low	90
	SCRUB AND WOODLAND		
70	Alderwood	moderate	365
71	Bracken scrub	moderate	355
72	Grassy gorse scrub	moderate	316
73	Dry grassy birchwood	moderate	267
74	Hazelwood	moderate	266
75	Grassy oakwood	moderate	239
76	Ashwood	moderate	239
77	Dry heathy birchwood	moderate	228
78	Juniper scrub	moderate	200
79	Bog myrtle scrub	low	172
80	Wet birchwood	low	172
81	Heathy oakwood	low	163
82	Native pinewood and old plantations	low	122
83	Heathy gorse scrub	low	116
84	Elmwood	low	53

4 Summary of guidelines

LAND SUITED TO ARABLE CROPPING

Class 1 Land capable of producing a very wide range of crops

Cropping is highly flexible and includes the more exacting crops such as winter harvested vegetables (e.g. cauliflowers, brussels sprouts, leeks). The level of yield is consistently high. Soils are usually well-drained deep loams, sandy loams, silty loams or their related humic variants with good reserves of moisture. Sites are level or gently sloping and the climate is favourable. There are no or only very minor physical limitations affecting agricultural use.

Climate:	Zone 1 (Figure 1 and map) Not less than 130 mm PSMD or 1150 day °C Hourly median wind speed usually less than 5 m per second No microclimatic limitations
Gradient:	Not greater than 3°
Soil:	Should be no more than very slightly stony (up to 5%) Should be non-droughty for two indicator arable crops Should have no more than minor structural problems Should be at least 60 cm deep
Wetness:	Should be well drained, either naturally or with the assistance of a drainage scheme (soil wetness classes I and II) Should have negligible flood risk or workability limitations
Erosion:	Very slight risk

Class 2 Land capable of producing a wide range of crops

Cropping is very flexible and a wide range of crops can be grown, though some root and winter harvested crops may not be ideal choices because of difficulties in harvesting. The level of yield is high but less consistently obtained than on Class 1 land due to the effects of minor limitations affecting cultivation crop growth or harvesting. The limitations include, either singly or in combination, slight workability or wetness problems, slightly unfavourable soil structure or texture, moderate slopes and slightly unfavourable climate. The limitations are always minor in their effect however and land in the class is highly productive.

Climate:	Zone 1 and 2 (Figure 1 and map) Not less than 95 mm PSMD or 1050 day °C Hourly median wind speed usually less than 5 m per second No microclimatic limitations
Gradient:	Not greater than 7°
Soil:	Should be no more than slightly stony (up to 15% small stones but lower if stones are larger) Should be non- to slightly droughty for two indicator arable crops Should not have more than minor structural problems Should be at least 45 cm deep
Wetness:	Should be moderately well-drained, either naturally or with the assistance of a drainage scheme (soil wetness classes I, II or III Should have negligible flood risk Should not have more than slight workability limitations
Erosion:	Slight risk.

Class 3 Land capable of producing a moderate range of crops

Land in this class is capable of producing good yields of a narrow range of crops, principally cereals and grass, and/or moderate yields of a wider range including potatoes, some vegetable crops (e.g. field beans and summer harvested brassicae) and oil-seed rape. The degree of variability between years will be greater than is the case for Classes 1 and 2, mainly due to interactions between climate, soil and management factors affecting the timing and type of cultivations, sowing and harvesting. The moderate limitations require careful management and include wetness, restrictions to rooting depth, unfavourable structure or texture, strongly sloping ground, slight erosion or a variable climate. The range of soil types within the class is greater than for previous classes.

Division 1

Land in this division is capable of producing consistently high yields of a narrow range of crops (principally cereals and grass) and/or moderate yields of a wider range (including potatoes, field beans and other vegetables and root crops). Short grass leys are common.

Climate:	Zone 1-3.1 (Figure 1 and map) Not less than 80 PSMD or 975 day °C Hourly median wind speed usually less than 5 m per second

Gradient: Not greater than 7°

Soil: Should be no more than moderately stony (up to 35% if stones are small but less if stones are larger)
Should not be more than slightly droughty
Should not have more than moderate structural problems
Should be at least 45 cm deep

Wetness: Can be well to imperfectly drained, either naturally or with the assistance of a drainage scheme (soil wetness classes I, II, III)
Should have negligible flood risk apart from non-damaging winter flooding
Should not have more than slight to moderate workability limitations

Erosion: Slight risk.

Division 2

This land is capable of average production but high yields of grass, barley and oats are often obtained. Other crops are limited to potato and forage crops. Grass leys are common and reflect the increasing growth limitations for arable crops and degree of risk involved in their production.

Climate: Zone 1 3.2 (Figure 1 and map)
Not less than 70 PSMD or 925 day °C
Hourly median wind speed usually less than 5.5 m per second

Gradient: Not greater than 11°

Soil: Should be no more than moderately stony (up to 35% if stones are small but less if stones are larger)
Should be non- to moderately droughty
Should not have more than moderate structural problems
Should be at least 20 cm deep

Wetness: Can be well to poorly drained, either naturally or with the assistance of a drainage scheme (soil wetness classes I, II, III or IV (part))*
Should have negligible flood risk apart from non-damaging winter flooding
Should not have more than moderate workability limitations

Erosion: Slight risk.

* Provided that waterlogging within 40 cm depth does not exceed 140 days.

Class 4 Land capable of producing a narrow range of crops

The land is suitable for enterprises based primarily on grassland with short arable breaks (e.g. barley, oats, forage crops). Yields of arable crops are variable due to soil, wetness or climatic factors. Yields of grass are often high but difficulties of production or utilisation may be encountered. The moderately severe levels of limitation restrict the choice of crops and demand careful management. The limitations may include moderately severe wetness, occasional damaging floods, shallow or very stony soils, moderately steep gradients, moderate erosion, moderately severe climate or interactions of these which increase the level of farming risk.

Division 1

Land in this division is suited to rotations which, although primarily based on long ley grassland, include forage crops and cereals for stock feed. Yields of grass are high but difficulties of utilisation or conservation may be encountered. Other crop yields are very variable and usually below the national average.

Climate:	Zone 1–4.1 (Figure 1 and map) Not less than 60 PSMD or 875 day °C
Gradient:	Not more than 11°
Soil:	Can be very stony (up to 70%) if the stones are small, but is usually not more than moderately stony (up to 35%) Should be non- to moderately droughty Should be at least 20 cm deep; poorly drained soils (soil wetness class IV) where rainfall is near or below 900 mm per annum
Wetness:	Should be freely, moderately well- or imperfectly drained (soil wetness classes I–III) Should not be subject to damaging summer flooding Should not have more than moderate workability limitations
Erosion:	Moderate risk.

Division 2

The land is primarily grassland with some limited potential for other crops. Grass yields can be high but the difficulties of conservation or utilisation may be severe, especially in areas of poor climate or on very wet soils. Some forage cropping is possible and, when the extra risks involved can be accepted, an occasional cereal crop.

Climate: Zone 1 4.2 (Figure 1 and map)
Not less than 50 PSMD or 850 day °C

Gradient: Not more than 15°

Soil: Can be very stony (up to 70%) if the stones are small, but is usually not more than moderately stony (35%)
Soil should be sufficiently deep to permit ploughing

Wetness: Includes soil wetness classes I IV
May have moderately severe workability problems

Erosion: Moderate risk.

LAND SUITED ONLY TO IMPROVED GRASSLAND AND ROUGH GRAZING

Class 5 Land capable of use as improved grassland

The agricultural use of land in Class 5 is restricted to grass production but such land frequently plays an important role in the economy of British hill lands. Mechanised surface treatments to improve the grassland, ranging from ploughing through rotation to surface seeding and improvement by non-disruptive techniques are all possible. Although an occasional pioneer forage crop may be grown, one or more severe limitations render the land unsuitable to arable cropping. These include adverse climate, wetness, frequent damaging floods, steep slopes, soil defects or erosion risks. Grass yields within the class can be variable and difficulties in production, and particularly utilisation, are common.

Division 1 Land well suited to reclamation and to use as improved grassland

Establishment of a grass sward and its maintenance present few problems and potential yields are high with ample growth throughout the season. Patterns of soil, slope or wetness may be slightly restricting but the land has few poaching problems. High stocking rates are possible.

Climate: Zone 1 5 (Figure 1 and map)
Not less than 30 PSMD or 750 day °C

Gradient: Not greater than 11°

Soil: Can be extremely stony (>70%) but sward improvements must not be prevented by surface stoniness or boulders
Should not be droughty

Wetness: Includes soil wetness classes I to III in areas with more than 80 mm PSMD, but only I and II where PSMD is less than this, except for deep peat where the appropriate figure is 100 mm PSMD
Poaching risk usually low
Occasionally subject to summer flooding

Erosion: Moderate risk

Pattern: More than 80% of the area must be usable.

Division 2 Land moderately suited to reclamation and use as improved grassland

Sward establishment presents no difficulties but moderate or low trafficability, patterned land and/or strong slopes may cause maintenance problems. Growth rates are high and despite some problems of poaching satisfactory stocking rates are achievable.

Climate: Zone 1–5 (Figure 1 and map)
Not less than 30 PSMD or 750 day °C

Gradient: Not greater than 15°

Soil: Can be extremely stony but sward improvements must not be prevented by surface stoniness or boulders
Droughty soils are included

Wetness: Includes soil wetness classes III, IV and V in areas with more than 100 mm PSMD, but only III and IV where PSMD is less than this amount
Poaching risk may be moderate to high
Occasionally subject to summer flooding

Erosion: Moderate risk

Pattern: Between 60–80% of the area must be usable.

Division 3 Land marginally suited to reclamation and use as improved grassland

Land in this division has properties which lead to serious trafficability and poaching difficulties and although establishment may be easy, deterioration in quality is often rapid. Patterns of soil, slope or wetness may seriously interfere with establishment and maintenance. The land cannot support high stock densities without damage and this may be serious after heavy rain even in summer.

Climate: Zone 1–5 (Figure 1 and map)
Not less than 30 PSMD or 750 day °C

Gradient:	Not greater than 25°
Soil:	Can be extremely stony (>70%) but sward improvements must not be prevented by surface stoniness or boulders May be very droughty
Wetness:	Includes all soil wetness classes, but peat in areas with <100 mm PSMD is placed in Class 6
Erosion:	Moderate risk
Pattern:	More than 40% of the area must be usable.

Class 6 Land capable of use only as rough grazing

The land has very severe site, soil or wetness limitations which generally prevent the use of tractor-operated machinery for improvement. Some reclamation of small patches to encourage stock to range is often possible. Climate is often a very significant limiting factor. A range of widely different qualities of grazing is included, from very steep land with significant grazing value in the lowland situation to moorland with a low but sustained production in the uplands. Grazing is usually insignificant in the full arctic zones of the mountain lands, but below this level grazings which can be utilised for five months or longer in any year are included in the class. Land affected by severe industrial pollution or dereliction may be included if the effects of the pollution are non-toxic.

Division 1 High grazing value

The dominant plant communities contain high proportions of palatable herbage, principally the better grasses e.g. bent–fescue grassland or meadow grass–bent pasture.

Climate:	Zones 1–6 (Figure 1 and map) PSMD not limiting; greater than 625 day °C
Gradient:	Not limiting
Soil:	Principally mineral soils
Wetness:	Includes soil wetness classes I to IV, but in areas with PSMD <50 mm the soils are usually well and moderately well drained (I and II)
Erosion:	Risk may be severe.

Division 2 Moderate grazing value

Moderate quality herbage such as white and flying bent grasslands, rush pastures and herb-rich moorlands or a mosaic of high and low grazing values characterises land in this division.

Climate: Zones 1–6 (Figure 1 and map)
PSMD not limiting; greater than 625 day °C

Gradient: Not limiting

Soil: Flushed organo-mineral soils and flushed peat dominant

Wetness: Soil wetness classes I to V

Erosion: Risk may be severe.

Division 3 Low grazing value

The vegetation is dominated by plant communities with low grazing values, particularly heather moor, bog heather moor and blanket bog communities.

Climate: Zones 1–6 (Figure 1 and map)
PSMD not limiting; greater than 625 day °C

Gradient: Not limiting

Soil: Principally the unflushed organo-mineral soils and unflushed peat

Wetness: Soil wetness classes IV, V and VI

Erosion: Risk may be severe.

Class 7 Land of very limited agricultural value

Land with extremely severe limitations that cannot be rectified. The limitations may result from one or more of the following defects: extremely severe wetness, extremely stony, rocky land, bare soils, scree or beach sand and gravels, toxic waste tips and dereliction, very steep gradients, severe erosion including intensively hagged peat lands and extremely severe climates (exposed situations, protracted snow-cover and short growing season). Agricultural use is restricted to very poor rough grazing.

Unclassified land. Built up areas, motorways, airports etc.

5 The land capability system illustrated in different landscapes

Plates 1–6 illustrate examples of the principal limitation types found in Scotland. Plates 7–13 show the type of land assigned to various classes. The reader is encouraged to look at the plates as general types rather than specific examples. For this reason locations have been omitted.

Plate 1 CLIMATE. The effects of exposure may sometimes be judged by the appearance of trees, although its real significance to agriculture is in loss of yield from shake of near-ripe grain crops or physiological effects on livestock.

Plate 2 GRADIENT. A tractor, suitably modified for experimental work on stability, overturning on a slope when the angle of stability is suddenly exceeded due to a local slope irregularity. The difficulties of producing firm figures for slope limits is graphically illustrated. Photo: Scottish Institute of Agricultural Engineering

---

Plate 3 SOIL. Stoniness, besides substantially increasing wear on farm implements, may result in patchy crop emergence.

Plate 4 WETNESS. Poaching of topsoil by cattle is one of the common results of soil wetness.

Plate 5 EROSION. Erosion of hill peat is one of Britain's more obvious hill-land phenomena. Accelerated erosion due to burning, over-grazing or other imperfect management practices are of concern.

Plate 6 PATTERN. Patterns of rock or of slope are commonly serious limitations. Aerofilms

Plate 7 CLASSES 1 and 2. The distinction between these classes commonly depends on subtle differences in climate or climate–soil interactions. This and the succeeding plate are examples of intensively used agricultural landscapes. Scotsman Publications

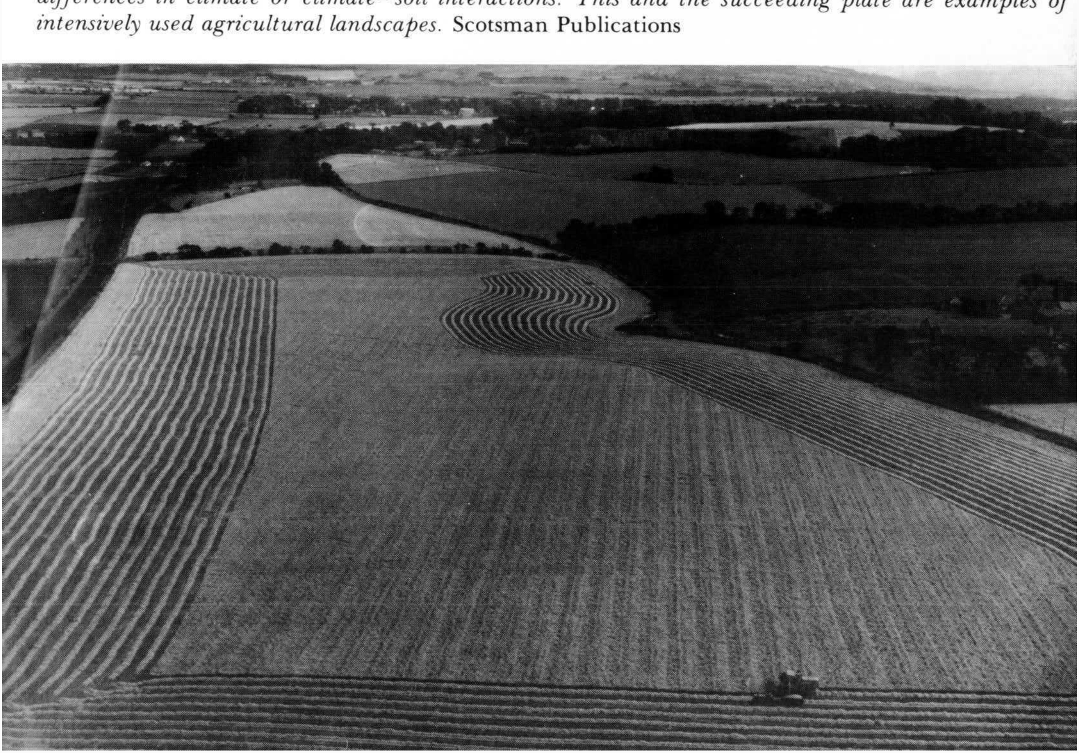


Plate 8 Example of good class agricultural land with a wide range of cropping. Aerofilms

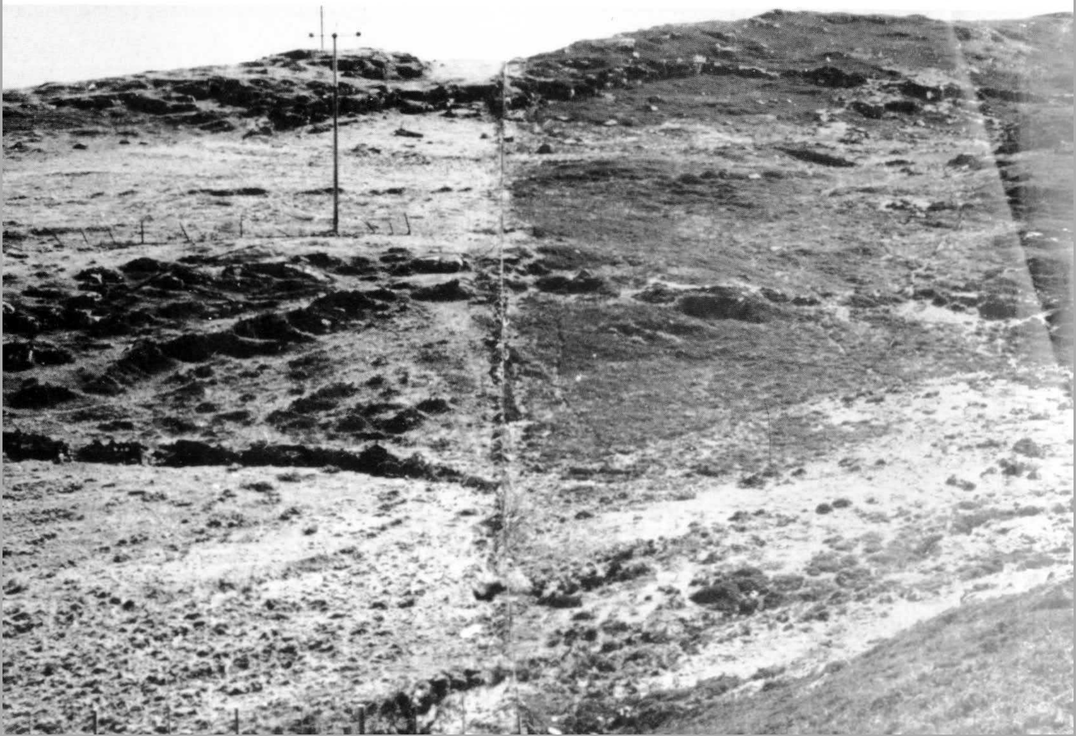
Plate 9 CLASS 3. The land is devoted largely to cereal and grass production. Variable patterns of soil and areas of steeper slopes are examples of increasing limitations. Aerofilms

Plate 10 CLASS 4. The land is predominantly grassland with some cereal crops. It is often marginal to large areas of hill land and suffers adverse climates. The topography is often irregular and patterns of shallow soils are found. Aerofilms

Plate 11 CLASS 5. The land is used largely for grass production. Very variable soil patterns, particularly of wetness, often combined with peatiness, exemplify the limitations on arable cropping. Spoil heaps and industrial tips are often Class 7. Aerofilms

Plate 12 CLASSES 5 and 6. In areas of hill land it is sometimes difficult to assess the extent of improvable land. In the higher hills the different vegetation patterns are utilised at different intensities and at different times of the year by the grazing animals.

Plate 13 Variable management, such as control of grazing by fencing often results in marked differences in the appearances of the sward and the introduction of replacement communities. Only general guidance on grazing value is currently available.



6 References

Agricultural Land Classification (1966). *Tech. Rept.*, No. 11, Agricultural Land Service, MAFF.

Bendelow, V. C. and Hartnup, R. (1977). The assessment of climatic limitations in land use capability classification. *North of England Soils Discussion Group Proceedings*, No. 13, pp. 19 28

Bendelow, V. C. and Hartnup, R. (1980). Climatic Classification of England and Wales. *Tech. Mono.*, No. 15. Harpenden: Soil Survey of England and Wales.

Bibby J. S. and Mackney D. (1969). Land Use Capability Classification. *Tech. Mono.*, No. 1. Soil Surveys of England and Wales and Scotland. Harpenden: Rothamsted Experimental Station, and Aberdeen: Macaulay Institute for Soil Research

Bibby, J. S. (1977). Land Use Capability Map, Isle of Mull. Southampton: Ordnance Survey

Birse, E. L. (1971). (a) Assessment of Climatic Conditions in Scotland 3. The Bioclimatic Sub-Regions. Aberdeen: Macaulay Institute for Soil Research

Birse, E. L. (1971). (b) Climatic Assessment and Land Use Capability. Practical Applications of Soil Survey. *Proceedings of the Stirling Field Meeting*. Aberdeen: Macaulay Institute for Soil Research

Birse, E. L. (1980). Scottish Plant Communities—revised and additional tables. *Bull. Soil Surv. Scot.*, No. 4. Aberdeen: Macaulay Institute for Soil Research

Birse, E. L. and Dry, F. T. (1970). (a) Assessment of Climatic Conditions in Scotland 1. Based on Accumulated Temperature and Potential Water Deficit. Aberdeen: Macaulay Institute for Soil Research

Birse, E. L. and Robertson, L. (1970). (b) Assessment of Climatic Conditions in Scotland 2. Based on Exposure and Accumulated Frost. Aberdeen: Macaulay Institute for Soil Research

Birse, E. L. and Robertson, J. S. (1976). Plant Communities and Soils of the Lowland and Southern Upland Regions of Scotland. Aberdeen: Macaulay Institute for Soil Research

Biscoe, P. V. and Gallagher, J. N. (1978). A Physiological Analysis of Cereal Yield 1. Production of Dry Matter. *Agric. Prog.*, **53**, 34 50

Chepil, W. S. and Woodruff, N. P. (1963). The Physics of Wind Erosion and its Control in *Advances in Agronomy*, No. 16 (ed. A. G. Norman). New York: Academic Press

Cooke, R. U. and Doornkamp, J. C. (1974). *Geomorphology in Environmental Management*. Oxford: Clarendon Press

Davies, D. B. and Harrod, M. F. (1970). The processes and control of wind erosion. *NAAS Quarterly Review*, No. 88, pp. 139 150

Durrant, M. J., Love, B. J. G., Messem, A. B. and Draycott, A. P. (1973). Growth of crops in relation to soil moisture extraction. *Ann. app. Biol.*, **74**, 387–94

Gilfillan, G. (1979). Polar Diagram Representation of Tractor Stability and Control on Slope. Scottish Institute of Agricultural Engineering. *Tech. Rept.*, No. 1. Penicuik

Hall, D. G. M., Reeve, M. J., Thomasson, A. J., and Wright, V. F. (1977). Water retention, porosity and density of field soils. *Tech. Mono.*, No. 9. Harpenden: Soil Survey of England and Wales

Harrod, T. R. (1979). Soil Suitability for Grassland in Soil Survey Applications. *Tech. Mono.*, No. 13. Harpenden: Soil Survey of England and Wales

Hodgson, J. M. (1976). Soil Survey Field Handbook. *Tech. Mono.*, No. 5. Harpenden: Soil Survey of England and Wales

Kellogg, C. E. (1961). Soil Interpretation in the Soil Survey. U.S. Dept. Agric., Soil Conservation Service

Klapp, E., Bocker, P., König F. and Stählin, A. (1953). Wertzalen der Grünlandpflanzen. Dans Grünland 5. Hanover: Schaper

Klingebiel, A. A. and Montgomery, P. H. (1961). Land Capability Classification. US Dept. Agric., Soil Conservation Service. *Agric. Handbk.*, No. 210

MAFF (1971). The Significance of Winter Rainfall over farmland in England and Wales. *Tech. Bull.*, No. 24. London: MAFF

Ott, A. (1978). Methods of mechanisation of forage harvesting on sloping land. Tanikon, Switzerland: Swiss Federal Research Station for Farm Management and Agricultural Engineering (In French)

Peacock, J. M. (1975). Temperature and leaf growth in Lolium Perenne II. The site of temperature perception. *J. Appl. Ecol.*, **12**, 115–123

Peacock, J. M. (1976). Temperature and leaf growth in Lolium Perenne III. Factors affecting seasonal differences. *J. Appl. Ecol.*, **12**, 685–697

Robertson, J. S. (1982). A key to the Common Plant Communities of Scotland. Aberdeen: Macaulay Institute for Soil Research

Robson, J. D. and Thomasson A. J. (1977). Soil Water Regimes. *Tech. Mono.*, No. 11. Harpenden: Soil Survey of England and Wales

Smith, L. P. and Trafford, B. D. (1976). Climate and Drainage. *Tech. Bull. MAFF* No. 34

Soil Survey Manual (1951). *USDA Handbook,* No. 18. Washington: United States Dept. of Agriculture

Spencer, H. B. (1978). Stability and Control of Two-wheel Drive Tractors and Machinery on Sloping Ground. *J. Agric Engng. Res.* **23**, 169–188

Stamp, L. D. (1944). Land Utilisation Survey of Britain (maps). Southampton: Ordnance Survey

Thomasson, A. J. (1979). Soil droughtiness in Soil Survey Applications. *Tech. Mono.*, No. 13. Harpenden: Soil Survey of England and Wales

Thomasson, A. J. (1982). Soil and climatic aspects of workability and trafficability. *Proc. Int. Soil Tillage Res. Org. Osijek, Yugoslavia,* 551–557

Vink, A. P. A. (1963). Planning of Soil Surveys in Land Development. *Publ. Int. Inst. Ld. Reclam. Improv.*, No. 10. Wageningen

Vink, A. P. A. (1975). *Land Use in Advancing Agriculture,* Berlin: Springer-Verlag

Vries, D. M. de, Boer, Th. A. de and Dirvan, J. G. P. (1949). Evaluation of Grassland by Botanical Research in the Netherlands. UN Sc. Conf: Conservation and Utilisation of Resources

Waring, P. F. and Cooper, P. J. (1971) (eds). *Potential Crop Production.* London: Heinemann

Wilkinson B. (1968). Land Capability—has it a place in Agriculture? *Agriculture (Lond.),* **75,** 343–347

Wilkinson, B. (1974). Quantitative Basis for Land Capability Interpretation. *Tech. Bull.,* No. 30. London: MAFF and HMSO