Netherlands Scientific Council for Government Policy

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Crop produktion potential of rural areas within the European Communities

V : Qualitative suitability assessment for forestry and fruit crops

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PREFACE

The Netherlands Scientific Council for Government Policy has asked the Winand Staring Centre in Wageningen to investigate the crop production potential of the rural areas within the European Communities. The Council needed this information for a project on the possible future developments in the rural areas of the EC as a result of an ongoing growth in agricultural productivity. To get a clear view the Council explored the possible changes in the rural areas.
When exploring possible developments or options it is crucial to define the objectives at stake. Within agriculture not only production is of importance, but also (regional) employment, emissions of pesticides and nutrients to the environment, impact on the landscape, etc. Land use is taken as the key factor in the explorations by the Council. Trough different types of land use different goals can be attained. The explorations show the differences in possible future land use when a certain priority is given to the various objectives.
Information on the physical possibilities for land use was absolutely necessary to carry out the explorations. A team from the Winand Staring Centre consisting of Ir J.D. Bulens, Ir A.K. Bregt, Ir C.A. van Diepen, Ir C.M.A. Hendriks, Ir G.H. de Koning and Ir G.J. Reinds lead by Dr Ir H.A.J. van Lanen compiled this information. A report of their research is given in a series of five separate documents under the common title "Crop production potential of rural areas within the European Community". The series consists of:
I : GIS and datamodel (W65)
II : A physical land evaluation procedure for annual crops and grass (W66)
III : Soils, climate and administrative regions (W67)
IV : Potential, water-limited and actual crop production (W68)
V : Qualitative suitability assessment for forestry and perennial crops (W69)
The full report shows that a combination of Geographical Information Systems and simulation models can provide useful quantitative information on crop productions potentials for different crops at different locations. With this approach the Winand Staring Centre opened up a new and promising line of research.

Prof.Dr Ir R. Rabbinge

SUMMARY

Intensification of agriculture in the past 25 years has resulted in a surplus of agricultural products in the European Communities (EC). Many of the intensively cultivated areas are suffering from groundwater pollution and soil degradation. In other rural areas, less-endowed for agriculture, abandonment is occurring. These developments are forcing policy-makers to reorient policies on rural land management. In this context, the Dutch Scientific Council for Government Policy (WRR) is developing a model for the general optimal allocation of land use (GOAL) to explore possible regional land use options within the EC. The GOAL model requires data on the regional production potential of various agricultural activities at different levels of input.

In this report, the production potential is given for some perennial crops as far as it is affected by biophysical resources, i.e. soils and climate. A qualitative physical land evaluation method was applied to assess the production potential of these crops. This implies that the potential is expressed in a descriptive way, e.g. suitability classes of well suitable land, moderately suitable land, or unsuitable land. Insufficient crop data prevent further quantification in terms of crop yield and required amounts of nutrients and water as done by quantitative physical land evaluation. The crops considered include forest trees and fruit trees. According to the timber production capacity the forest trees were subdivided into three groups of tree species, i.e. fast growing tree species, normal growing more demanding tree species, and normal growing less demanding tree species. Possibilities for growing fruit trees were evaluated in two different ways. First, a broad analysis was carried out considering only general soil and management requirements which apply to most fruit trees. Next, fruit trees with more specific requirements, i.e. citrus, olives and grapes were analysed. Two different input levels were distinguished for the fruit trees, such as rainfed and irrigated. The production potential of grapes, however, was considered for the rainfed situation only.

Expert knowledge on crop and management requirements, which is characteristic of qualitative physical land evaluation, was captured in a computer system. The Automated Land Evaluation System, ALES, was applied to convert the expert knowledge into decision rules. These rules define how the land characteristics of the mapping units should be evaluated taking into account the requirements of a particular crop. The expert knowledge system was linked to a geographical information system (GIS). Soil and climatic data of the thousands of land evaluation units were retrieved from the GIS and stored in the database of the expert knowledge system. Subsequently, land evaluation was carried out by the expert knowledge system for each of the units. Then, the results were transmitted to the GIS and further processed to allow production of maps and tables showing distribution or areas of suitability classes in the EC. Maps and tables were made for different spatial aggregation levels, such as NUTS-1 regions, EC member states and the whole EC. The complete information system with its modules, partly implemented on a PC and partly on a VAX, is described.

One of the modules allows land units which are suitable for more crops to be estimated, which implies that the crops might have to compete for this land in some land use scenarios. The GOAL model needs data on this so-called competitive land in order to allocate efficiently.

The evaluation shows that about 30% of EC land was evaluated to be suitable for fruit trees considering general applicable requirements only. Individual fruit tree species with additional requirements cover smaller suitable areas, of course. No more than 2% of the EC is suitable for heat-demanding crops, such as citrus. This area applies to rainfed conditions; when irrigation is assumed to be used the suitable area increases to about 6%. Under rainfed conditions commercial grape growing can be done on about 15% of EC area, whereas the suitable area for olives was assessed to be about 25% for a low input system. For a high input system producing olives, slightly less of EC land is suitable, i.e. 22%.

For most forest tree species a similar area as for fruit trees is suitable (30%). The normal growing less demanding species are an exception, the suitable area for this group covers about 50% of the EC.

The results for the individual member states and the NUTS-1 regions show that suitable land for the perennial crops considered is non-uniformly distributed throughout the EC. Heat-demanding crops can only be cultivated in the southern regions, of course. For the non-heat demanding crops suitable areas in the northern member states are usually larger than in the southern member states. Drought susceptibility, slopes and soil physical quality (e.g. soil texture, soil depth, stoniness) strongly affect the distribution of suitable land in the EC.

In lowland regions, usually high percentages of the suitable land are competitive for two or more crops. In regions with land located on slopes, the area only suitable for perennial crops is generally larger than for annual crops because of the higher demands of the annuals. Furthermore, in regions with stony soils, potential is higher for perennial crops than for some annual crops, i.e. root crops.

The results presented in this report give a first impression of the suitability of EC land for some perennial crops. Results can be improved by additional gathering of soil data, such as the areas and land characteristics of the associated soil units. Data from more meteorological stations should also be made accessible. Furthermore, crop and management requirements should be further refined.

1 INTRODUCTION

The Common Agricultural Policy (CAP) of the European Communities (EC) has stimulated agricultural production to such a level that surpluses of some major commodities, such as wheat, sugar, milk, and wine has become structural. In areas favourable for agriculture, farm size has increased, narrow crop rotations have been introduced, and large amounts of relatively inexpensive agro-chemicals and feedstuffs are being used. The intensification of agriculture in these regions has detrimentally affected the environment, nature and landscape (Briggs and Wilson, 1987). In areas less favoured for agriculture, the abandonment of land and associated social hardship occurs.

EC funds are increasingly called upon to mitigate the undesirable socio-economic and environmental effects of the CAP. However, little or nothing is known about the cost-effectiveness of investments for agricultural development in the various EC regions in relation to the long term perspectives.

Therefore, the Netherlands Scientific Council for Government Policy (WRR) has started a project on the possible developments of the rural areas in the EC. Different land use scenarios will be evaluated in terms of their impact on rural development, taking into account agricultural, socio-economic, environmental, and physical planning aspects.

The WRR will develop and apply a model for the General Optimal Allocation of Land use (GOAL). This model uses a method known as Interactive Multiple Goal Linear Programming. For the purpose of this model the WRR requires, among other input data, information about the regional production potentials of major crops at different input levels.

At the request of the WRR, the Winand Staring Centre has investigated the physical crop production potential of rural areas in the EC. The yield potential of some indicator crops, when grown on major land units suitable for agricultural use, was determined by a combined use of physical land evaluation methods and a Geographical Information System (GIS).

Quantitative physical land evaluation methods are based on computer models simulating soil water balance, crop growth, and crop production. The crop production potential for forest trees and fruit trees, such as olives, grapes and citrus, was determined by a *qualitative physical land evaluation* approach. For these perennial crops a quantitative evaluation procedure could not be used because of insufficient crop characteristics. The qualitative physical land evaluation approach produces descriptive expressions for the production potential of EC land (e.g. well suitable, moderately suitable land). The qualitative evaluation method is based on expert knowledge, which is captured in a computer system.

This working document deals with the qualitative land evaluation applied to forest trees and fruit trees. In Chapter 2 the physical qualitative land evaluation procedure is explained. First, the basic principles will be presented. Then, the way the expert knowledge was processed is described. An essential tool in this context is the expert system framework, ALES. The expert knowledge is implemented in a computer system using the Automated Land Evaluation System (ALES). ALES provides an expert system framework within which land evaluators build their own expert systems to evaluate land. The framework was developed at Cornell University (Rossiter, 1989; 1990). The use of ALES allows land evaluators to concentrate on their core responsibility, viz. the collection of expert knowledge for a certain land use type. The time-consuming application of the expert knowledge to the land units is left to the computer. The use of ALES in our study was essential owing to the many land evaluation units occurring within the EC. The conventional application of qualitative evaluation by hand was beyond the scope of our study.

In Chapter 3 the soil and climatic data used are presented. Types of results are presented, and examples of input files are given. Furthermore, the data processing and subsequent data flow between the GIS, implemented onto a VAX 3600, and ALES, implemented onto a PC, are discussed.

In Chapter 4 the procedure is presented which was applied to determine which land units are suitable for more crops ('competitive land'), and which units are only suitable for one particular crop and not for another. Furthermore, the procedure indicates which land units are unsuitable for the crops considered.

Suitability for forestry and fruit trees is extensively discussed in Chapter 5. The results are presented separately for each group of timber species, or fruit crop. First, the soil and climatic requirements are given. Then, the suitability results are presented. Suitability is expressed as a percentage of the area of geographic units covered with well suitable, moderately suitable, and unsuitable land. Few results are presented for land evaluation units, being geographic units on the largest map scale. For presentation reasons, most suitability results in this report are given for geographic units on smaller map scales. These scales comprise the EC administrative EEgions at NUTS-1 level, the EC member states, and the whole EC. Furthermore, attention is mainly restricted to the results on smaller map scales, because the above-mentioned GOAL model has been designed for input at the NUTS-1 level. Chapter 5 starts with the description of the results for forestry. The suitability assessment for forestry is subdivided into separate evaluations for fast growing, and normal growing tree species. The latter group is further subdivided into more demanding and less demanding tree species. After forestry, the suitability evaluation for a broad group of fruit trees is presented. In that section, no results for specific fruit tree species are presented. Land is evaluated for a number of common requirements demanded by many fruit tree species (e.g. demands for available soil water, soil drainage conditions). However, no particular temperature requirements of individual fruits crops are taken into account. We have assumed that in every EC region with land suitable for this broad group of fruit trees, one or more fruit tree species with appropriate production can be grown. The suitability for the broad group of fruit tree species is discussed for both rainfed and irrigated conditions. After the suitability assessment for the broad group of fruit trees, evaluation results for particular fruit tree species with specific requirements are dealt with. Suitability of EC land for citrus fruit is given because it could be a major fruit crop in those regions of the EC expected to have limited possibilities for other agricultural purposes. Potentials and constraints of EC land for citrus growing is given for rainfed and irrigated conditions. After citrus, the suitability of EC land for the cultivation of olives is discussed. A subdivision is made between a low and a high management level. Finally, the suitability of EC land for grape growing for commercial purposes is described. The description of the results for each crop is concluded by providing information on how far the suitable land for that crop is also suitable for other crops ('competitive land').

In Chapter 6 some perspectives of the crops considered, the data used and results obtained are descussed. In this context the reliability of the results is also touched upon.

This working document is one of a series of documents on the SC project "Crop Production Potential of the Rural Areas within the European Communities". The titles of the other working documents are presented in appendix 1. The documents are summarized in a few other publications (Bregt et al., 1989; Bulens et al., 1990; van Diepen et al, 1990; van Lanen et al., in press a; van Lanen et al., in press b).

2 QUALITATIVE PHYSICAL LAND EVALUATION PROCEDURE

First, the basic principles of the qualitative physical land evaluation procedure are explained. In the procedure used in our study, the application of the Automated Land Evaluation System (ALES) is essential. This expert system framework is described in a separate section.

2.1 Basic principles

Land evaluation is the process of suitability assessment of land for a specified kind of land use. Possibilities for land use types such as high input arable farming, or growing of particular tree species can be explored. The principal purpose of land evaluation is to predict the potentials and constraints of land for land use change (Dent & Young, 1981). The principles of land evaluation are comprehensively described by FAO (1976).

Ideally, land evaluation starts with the selection and description of one or more land use types (LUTs). At first, the formulation of the LUTs can be relatively vague (Fig. 1). Based on the LUTs, crop and management specific requirements (LURs) are defined; this implies a characterization of what the land should offer. Furthermore, required inputs (such as labour, fertilizer) and expected outputs (such as crop yield, or timber production) are described in this phase. Then, relevant land qualities (LQs) are selected, which are derived from a combination of land characteristics (LCs). LQs provide information on what the land units offer. In the suitability evaluation according to FAO standards land is not evaluated as a whole, but is split up into LQs and LCs. In a matching procedure, LQs of each land unit are compared with the LURs in order to obtain an overall suitability assessment of the land unit for each of the LUTs considered. Besides an estimate of the production potential, the overall suitability includes an assessment of the environmental impact. This overall suitability has a provisional status, because the LUTs have to be investigated for required modifications. These modifications could include either adapted LURs or land improvements which, of course, increase the costs of the intended land use change, but which improve one or more LQs. After modifying the LURs or the LQs the next iteration step in the evaluation process is conducted. This leads to a further refinement of LUTs, LURs, LQs and overall suitabilities as the number of iterations increases. Finally, acceptable results are obtained, which include the final description of the LUTs and the overall suitability of the land units for each of these LUTs.

The overall suitability, which is derived from the severity levels of the LQs, is usually based on the limitation method, although other methods are available (Dent and Young, 1981). This procedure, which is analogous to Liebig's Law of Minimum, takes the lowest individual severity level of the LQs considered as limiting to the overall suitability. The suitability evaluation is preferably concluded with a field check of the estimated suitability.

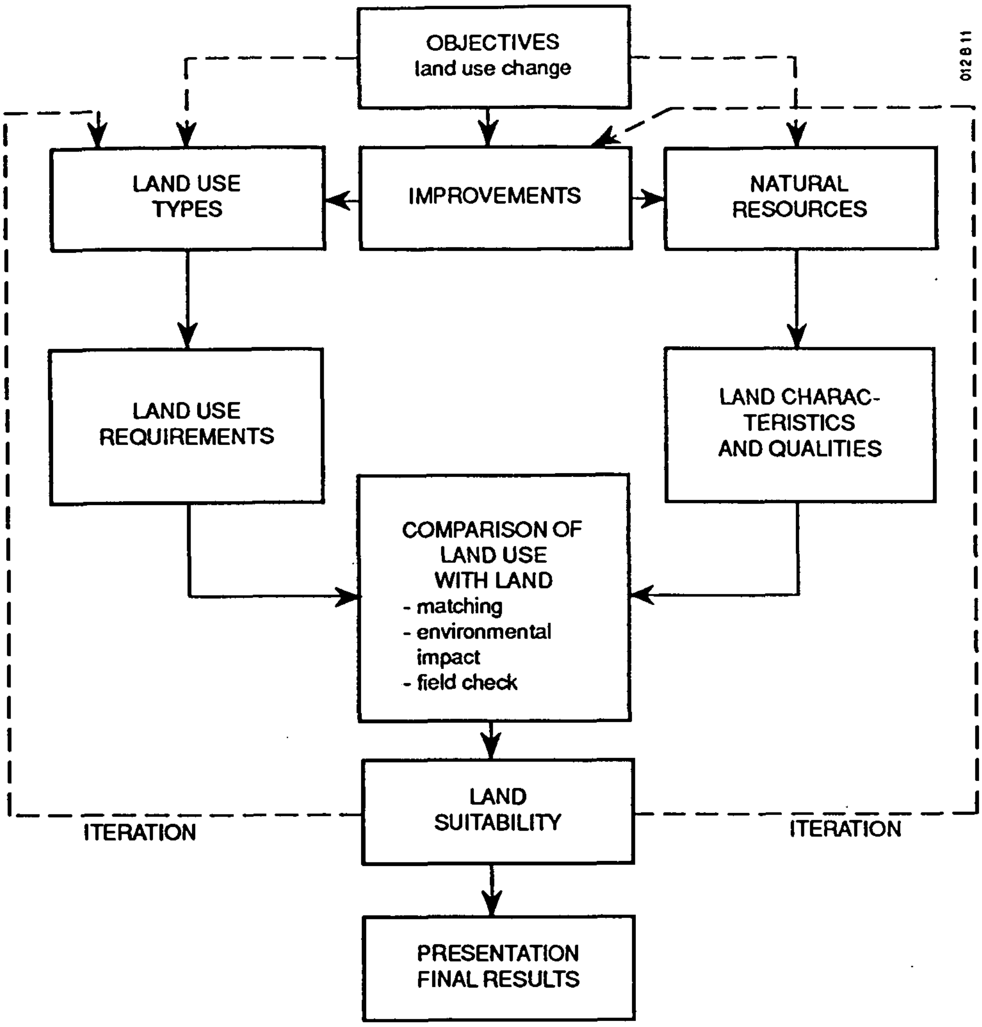


Fig. 1 General outline of the land suitability evaluation process (adapted from Dent and Young, 1981)

One of the prerequisites of FAO standards is that the LUTs selected must be relevant to the physical, economic, and social content of an area. This implies that a proper land evaluation should integrate biophysical and socio-economic resources.

The above-mentioned FAO standards have been indicated as the FAO-framework for land evaluation (FAO, 1976). The FAO-framework itself does not contain an evaluation system, but is a set of principles and concepts through which local, regional or national evaluation systems can be constructed.

Usually in land evaluation projects only parts of the FAO-framework have been used. For instance, even some major FAO projects (FAO, 1978) have concentrated on physical aspects of land only against a simple socio-economic background. Furthermore the proposed iteration procedure (Fig. 1) has often been omitted. This approach was also applied in our study. The LUTs considered, e.g. irrigated citrus growing or olive growing in a low management production system, were usually fully defined at the beginning of the land evaluation. This means that the complete evaluation procedure was carried out only once. A field check was beyond the scope of our study owing to the still strong exploratory nature.

The essence of land suitability evaluation is the comparison of LQs with the LURs of the various kinds of land use for which the land might be suitable. A severity level of a LQ for a land unit indicates the degree of limitation of that particular unit for the defined land use. When no limitations are evaluated, it means that the LURs are fulfilled. Characteristic descriptions of the severity levels are, for instance, no or slight limitations, severe or extreme limitations. Land evaluation according to the FAO-framework uses expert knowledge based on farmers' expertise, supplied with field experience of relationships between LQs and farm outcome or the output of woodlots. The knowledge can be collected in the field, but can also be derived from the literature. The latter approach was followed in our study.

The comparison of LQs with LURs for each land unit can be conducted using relatively simple technical procedures. These procedures, however, yield less specific answers. The results are expressed in a descriptive way, e.g. moderate limitations, or highly suitable land. Results are not further quantified. Because of the type of answers which are associated with the underlying technical procedure, these methods are indicated as 'qualitative' physical land evaluation procedures (van Lanen, 1991).

2.2 Automated Land Evaluation System, ALES

2.2.1 Introduction

The applicability of land evaluation according to FAO standards was substantially increased by the introduction of computer technology in land evaluation during the eighties. Wood and Dent (1983) demonstrated the combined use of computer databases and expert knowledge implemented in a computer system to evaluate land suitability for a number of specific crops and tree species under tropical conditions.

Similar evaluation systems but for other crops and environments have been established by many others, as mentioned by van Lanen (1991). All these evaluation systems contain knowledge on ratings for land qualities and overall suitability for specific crops in agro-climatic zones. Their transferability is limited because the expert knowledge only applies to conditions for which the systems were developed. A more versatile way of evaluating land according to FAO standards is the Automated Land Evaluation System (ALES). The framework was developed at Cornell University (Rossiter, 1989; 1990). This system in itself contains no knowledge, but offers the opportunity to capture it quickly. The expert models for forest trees and fruit trees were built with ALES.

ALES allows the integration of biophysical and socio-economic resources in the land evaluation to be conducted. In our study, ALES was only used to evaluate the physical resources. We did not need to take advantage of the ability of ALES to perform economic evaluation.

ALES recognizes three main components, viz. a database, a knowledge base, and an evaluation domain (Fig. 2). ALES also provides facilities to import data on land characteristics, and to export suitability results to geographical information systems. Furthermore, many other user-friendly options are available; a detailed review is given in the user's manual (Rossiter and Van Wambeke, 1989). Rossiter (1989; 1990) reviews main principles and features of ALES.

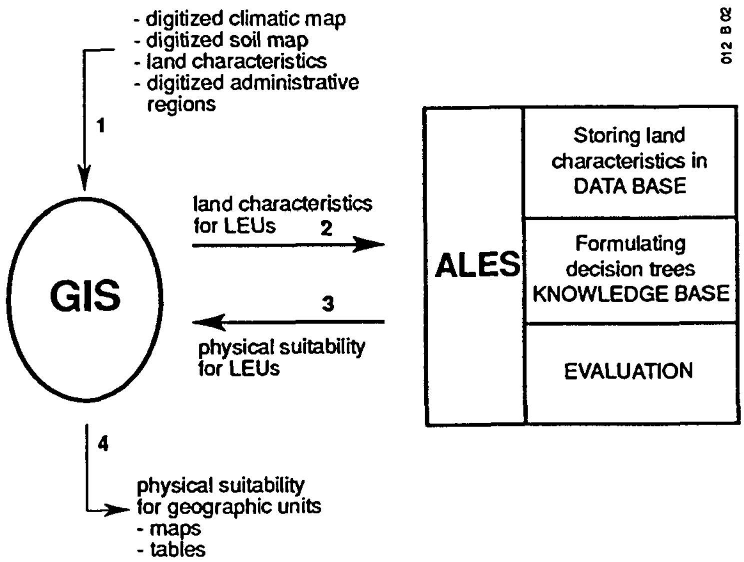


Fig. 2 Main components of ALES linked to a GIS

2.2.2 Database

Land can only be evaluated if the land characteristics are accessible. In the ALES concept the characteristics are stored inside the ALES configuration. Therefore, facilities are available for creating a database. The data on land units can be entered from the keyboard. Another option is to import the data from external databases. This option was relevant for our study, because we were coping with thousands of land units and associated land characteristics. Moreover, the data were already stored in a database (Reinds et al., in prep.). Besides land characteristics for the land units, ALES requires a definition of the units. When a land unit is specified to be compound the homogeneous subunits (constituents) must be provided. Moreover, the percentage of the compound unit made up by the subunits should be given.

The ability of ALES to cope with compound land units was relevant for our study because almost all land units considered are compound. However, we did not use the above-mentioned option of specifying compound units because we only had data on the range of soil textures and slopes within a unit (Reinds et al., in prep.). This type of data can be handled in another way by ALES. ALES offers a second option of considering compound land units, i.e. by specifying multivalued (probabilistic) land characteristics. This means that for a land characteristic multivalues instead of single data values are entered. For example, a land unit can be defined as being 60% coarse-textured and 40% medium textured. In this case ALES distinguishes two subunits, which are separately evaluated and combined at the end.

In the evaluation domain (Fig. 2), ALES can only use land characteristics expressed in classes. These so-called class characteristics (Bouma and Van Lanen, 1987) are either defined by a specified narrow range of values (e.g. a texture class), or by a symbol (e.g. horizon designation). In the database continuous land characteristics can also be stored for a land unit, such as the percentage of slope or temperature. However, for further processing, ALES requires these data to be converted into analogous class characteristics. Therefore, the number of classes and class limits need to be specified for these continuous characteristics. Land characteristics obtained in this way are indicated as 'commensurate land characteristics' (Rossiter and Van Wambeke, 1989).

More details on the data stored in the ALES' database are provided in Chapter 3, where the import and export of data are also explained.

2.2.3 Knowledge base

ALES provides an expert system framework, or 'shell', within which land evaluators build their own expert models to evaluate land. In fact, this framework is the core of ALES (Fig. 2). Model building starts with a definition of the land use types (LUTs) considered (step 1, Fig. 3). When only a physical land evaluation is carried out for one crop, as done in our study, the main information to be provided for each LUT is the land use requirements (LURs) which need to be considered (step 2, Fig. 3). For instance, a LUT might impose certain requirements to average minimum temperature in the period October to April. In this stage of model building, the number of so-called severity levels should be defined. These levels express the degree to which the qualities of the land (LQs) fulfil the LURs. A LQ indicates what the land can offer in a particular sense, e.g. temperature regime. When a LQ completely fulfils the LUR, a situation with no limitation occurs. Conversely, a severe limitation is allocated to land when extreme conditions prevail. Intermediate severity levels are also defined to evaluate intermediate conditions.

After selecting the LURs, and defining the corresponding LQs in terms of number and description of severity levels, a decision tree is formulated for each LQ (steps 3 and 4, Fig. 3). These trees are structured representations of a reasoning process necessary for reaching decisions. Decision rules are the key factors of the knowledge base to be built into ALES by the modeller. For instance, the LQ soil aeration could be deduced from the land characteristics (LCs) soil drainage class, soil texture, and annual precipitation deficit (e.g. Van Lanen and Wopereis, in press). This relatively simple decision tree is presented in Figure 4.

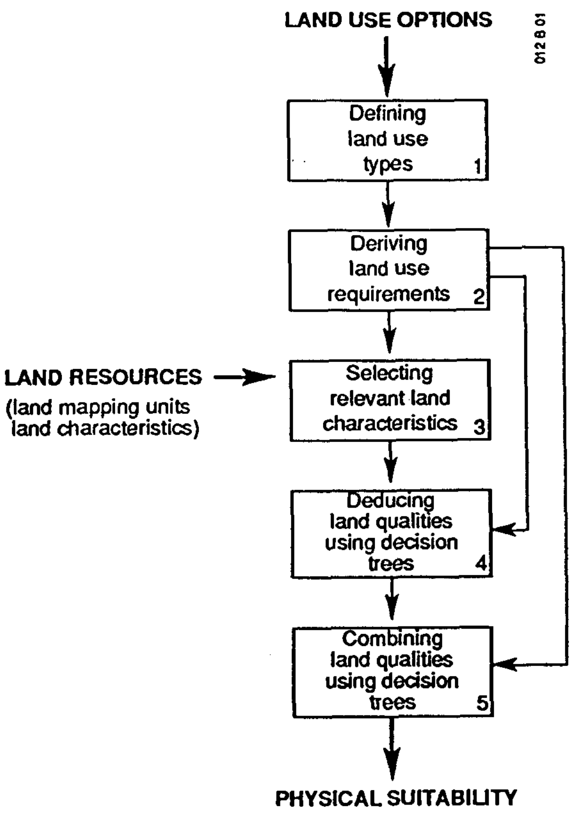


Fig. 3 Relational diagram for assessing the physical suitability using ALES

Finally, the overall physical suitability for a certain LUT is inferred from the severity levels of the LQs (step 5, Fig. 3). Usually, the maximum limitation method was applied in our study, as mentioned in the previous section. The disadvantage of this approach is that the evaluation focuses on one particular LQ, i.e. the LQ imposing the strongest limitation. Other limitations are not taken into account.

For example, land with a number of moderate limitations might be less suitable than land with only one moderate limitation for a LQ. Therefore, ALES allows a more sophisticated physical suitability assessment to be applied. A decision can be made which enables the land evaluator to deduce the physical suitability from the severity levels of all LQs. This approach was applied for forestry in our study.

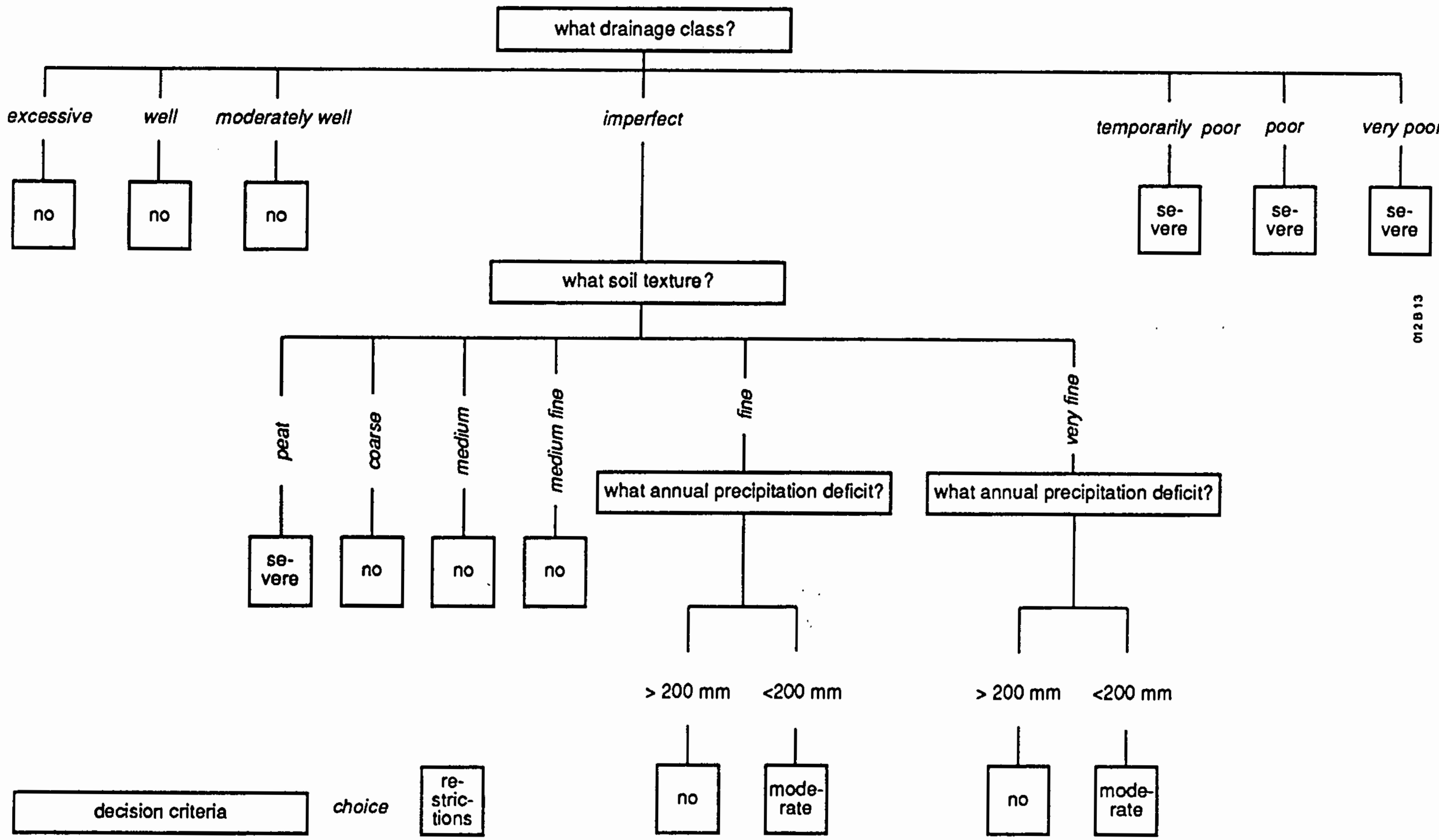


Fig. 4 Decision tree for the qualitative evaluation of land on limitations of the land quality soil aeration

Thus, the decision trees, which are characteristic for capturing expert knowledge, can be used at several places in the process of assessing the physical suitability with ALES (Fig. 5). As mentioned above, a decision tree (DT3 and DT4, Fig. 5) can be applied to derive a severity level for a LQ from LCs. Furthermore, a decision tree can be defined to infer the suitability from the LQs (DT5, Fig. 5). Of course, ALES also allows the LQ from one LC only to be deduced (DT2, Fig. 5). In fact, this implies that when assessing physical suitability, both LQs and LCs can be used. ALES also provides the option of deriving a certain LC from other LCs (DT1, Fig. 5). Van Lanen et al. (in press c) has classified this type of LC as an inferable land characteristic (ILC). So, readily available LCs can be related to an ILC which is more difficult to obtain. For instance, the ILC soil bulk density may derived from LCs soil texture, organic matter content, and horizon designation. Usually, class pedotransfer functions (Van Lanen and Bouma, 1987) are applied to relate LCs and ILCs.

2.2.4 Evaluation domain

Evaluations using ALES can be executed when data are stored in the database, and decision rules captured in the knowledge base. Of course, all land units and LUTs can be evaluated at any one time. But, ALES also allows the specification of particular land units and LUTs to be evaluated. The results of ALES are presented as a table; the columns represent the different LUTs and the rows the land units. The results comprise, for instance, severity levels of LQs and overall suitabilities. The results can be presented on a screen, but can also be directed to a printer or to a file on disk. A valuable option in the evaluation domain is the 'Why interface'. This interface informs the evaluator why a particular result has been obtained for a land unit. The decision trees used and the land characteristics considered are presented. The interface also permits the land evaluator to edit decision trees or land characteristics. During the model building stage, the availability of a 'Why interface' is extremely efficient.

2.2.5 Software and hardware configuration

ALES software was written with the so-called MUMPS language (DataTree, 1986). MUMPS is a procedural language with a built-in database manager. Linguistically, it is a hybrid of LISP and BASIC, with the added feature of sparse, hierarchical, disk-based arrays as the main data structure. According to Rossiter and Van Wambeke (1990), MUMPS will never be a major programming language. The main reasons being the introduction of more sophisticated database languages, and linguistically superior procedural languages.

The type of language used does not permit the entry of formulas into ALES. This implies that no calculations can be performed inside ALES. Computations must be executed outside ALES, and results may subsequently be imported.

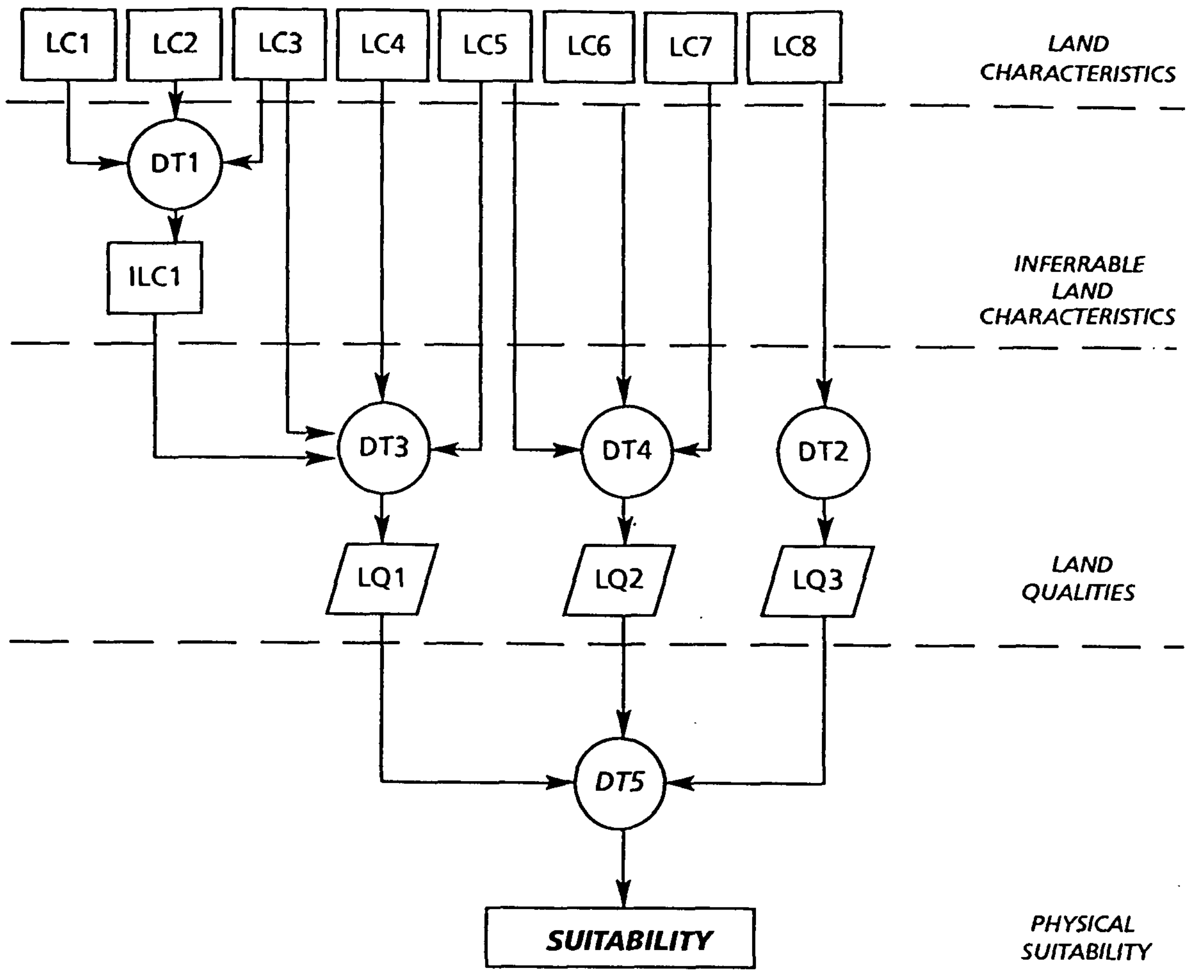


Fig. 5 Schematic outline of the situation of land characteristics (LCs), inferable land characteristics (ILCs), land qualities (LQs), and decision trees (DTs)

ALES was developed for a PC environment. To run ALES, it requires at least 384 kilobytes of primary memory, and preferably 640 kilobytes. The program, its support files and a minimal database need 2.25 megabytes of space on hard disk (Rossiter and Van Wambeke, 1990). In our study with a relatively large database we used slightly less than 10 megabytes on hard disk. Furthermore, another 10 megabytes were necessary for either a system-wide backup or to compress the database. An evaluation for one land use type and all the evaluation units of the EC (about 2760) lasted about 40 minutes on a PC/AT.

3 DATA

The data used for qualitative land evaluation using ALES are discussed in this chapter. The data are only briefly discussed because they are extensively reviewed by Reinds et al (in prep.). In this volume, the emphasis is on adaptions required for ALES. Furthermore, only data on soils and climate are explained. The data concerning administrative regions are only touched upon because they have no biophysical significance. Hence, they do not affect the suitability itself. Administrative regions are, however, used indeed for the presentation of the suitability results. In the last section, the data processing and subsequent data flow processes between the GIS and ALES are discussed.

3.1 Soils

The qualitative land evaluation was based on the EC Soil Map, scale 1 : 1 000 000 (CEC, 1985). The map consists of 312 different soil associations. When soil phases, such as the gravelly phase or lithic phase, are included the number of associations increases to 546. These associations are distributed over about 15 000 map delineations. Each of the soil associations contains a dominant soil unit, one or more associated soils, and one or more inclusions. The associated soils usually cover less than 50% of the area of a soil association, and more than 10%. Inclusions cover less than 10% of the area of a soil association. In addition to the geographical location of the soil associations, soil characteristics were required for the physical land evaluation. Examples of soil characteristics are: soil texture and soil drainage. As already mentioned by Reinds et al. (in prep.), soil characteristics were only available for the dominant soil units of the associations.

A broad analysis of the relative area covered by the dominant soil unit of each soil association demonstrated that about 60 associations (20% of total) have a dominant unit which covers less than half the area of the association (Fig. 6). One third of the soil associations has a dominant soil unit which covers 75% or more of the area of the association. All dominant soil units together cover more than 60% of the EC area. It should be realized that some of the associated soils or inclusions do not functionally differ from the dominant unit. For example, a difference in base saturation (eutric versus dystric soils) between the dominant soil and associated soils may not seriously affect the suitability assessment. This applies to most land use types of our study. Furthermore, the number of dominant soil units, viz. 78, is significantly lower than the number of soil associations. This implies that the dominant soil unit of a certain soil association is an associated unit of another association. When these associations occur in the same agro-climatic region, the suitability result of the former association also applies to part of the area of the latter association. As a first approximation, we assumed that the results for the dominant soil unit also apply to the area of a soil association covered by associated soils and inclusions.

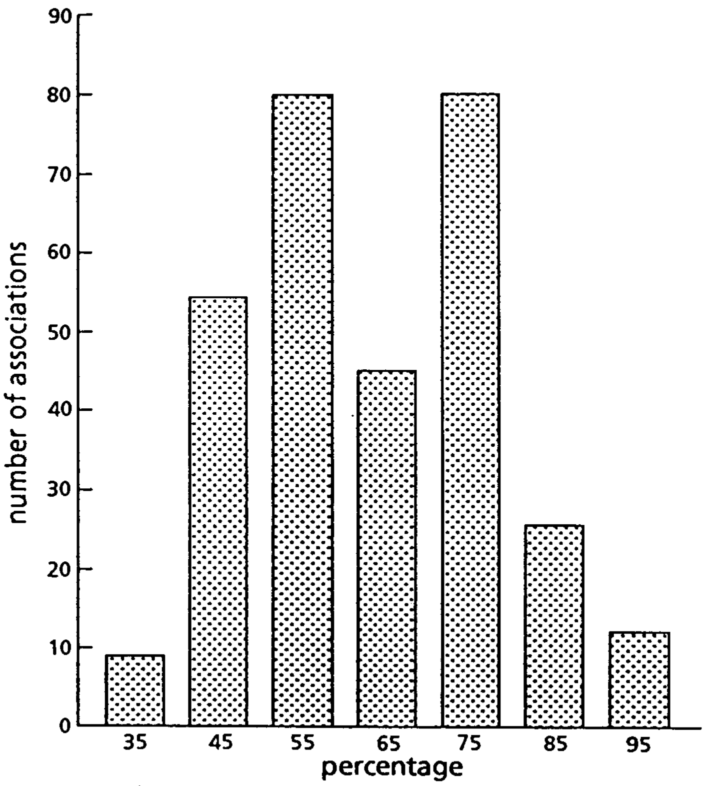


Fig. 6 Distribution of the relative area covered by the dominant soil units within the European Communities

This relatively crude assumption needed to be made because data for associated soils and inclusions for the EC soil associations are still lacking. When soil characteristics become available for the associated soils and inclusions the outcome may be further refined.

The land characteristics available for each dominant soil unit have been extensively discussed by Reinds et al. (in prep.). The following characteristics were processed for storage into ALES' database: alkalinity, base saturation, presence of calcium carbonate, presence of gypsum, cation exchange capacity (CEC), soil drainage, organic matter content, soil phases, maximum rooting depth, salinity, slope, and soil texture of the topsoil. For these characteristics the number of classes, codes, and description of the classes are given in Appendix 2.

For most dominant soil units a range of soil textures or slopes is specified in the legend of the soil map instead of just a single value. So, these units have a compound nature. For example, on the soil map a Rc3/4bc occurs, which involves an area of land covered by a dominant soil unit classified as a Calcaric-Regosol (Rc) with a medium fine (3), and a fine soil texture (4), and which is located on moderately steep (b), and steep slopes (c). In fact, four different subunits may occur (Reinds and van Lanen, in prep.). Because data on the extent of these subunits are not yet available, we assumed that subunits cover equal parts of the area of the soil association. Of course, this assumption must be considered as a first approximation which needs further refinement.

Data processing of the land characteristics to obtain a format accessible for ALES is further discussed in Section 3.3.

3.2 Climate

Besides soil conditions, the physical suitability of land depends on the prevailing agro-climatic conditions. Hence, an agro-climatic map was compiled, comprising 109 agro-climatic regions. A representative meteorological station was allocated to each zone, assuming no climatic variation within the zone. We assumed that most agricultural activities occur under lowland conditions. Therefore, in mountainous regions a station was selected that was representative of valley conditions.This assumption might provide too favourable conditions for higher elevations, which could result in an overestimation for less-demanding land use types (e.g. some tree species).

In the qualitative evaluation, we used long-term mean monthly weather data for each agro-climatic region as land characteristics. These mean data were obtained in two different ways. First, for 80% of the regions the means were computed from 26 years of records of monthly weather data. The historical weather data were required for another study, which included year to year weather variation (De Koning et al., in prep.). Second, for the remaining 20% of the regions the means were taken directly derived from the literature.

Reinds et al. (in prep.) provides an extensive review of the selection of the stations, their characteristics, and replacement of missing values.

The long-term mean monthly weather data, which could be stored in ALES, comprised minimum temperature, maximum temperature, global radiation, wind speed, vapour pressure, rainfall and number of rain days. Mean daily temperature was derived from minimum and maximum temperatures. Moreover, mean annual precipitation deficit was computed, which is defined as the difference between the monthly potential evapotranspiration of a reference crop and rainfall. Only the values of the months with a deficit were used (Reinds et al., in prep.). Not all these mean values were imported into ALES in order to keep the ALES database manageable. Only land characteristics which were relevant in terms of climatic requirement of the tree species and fruit trees were stored.

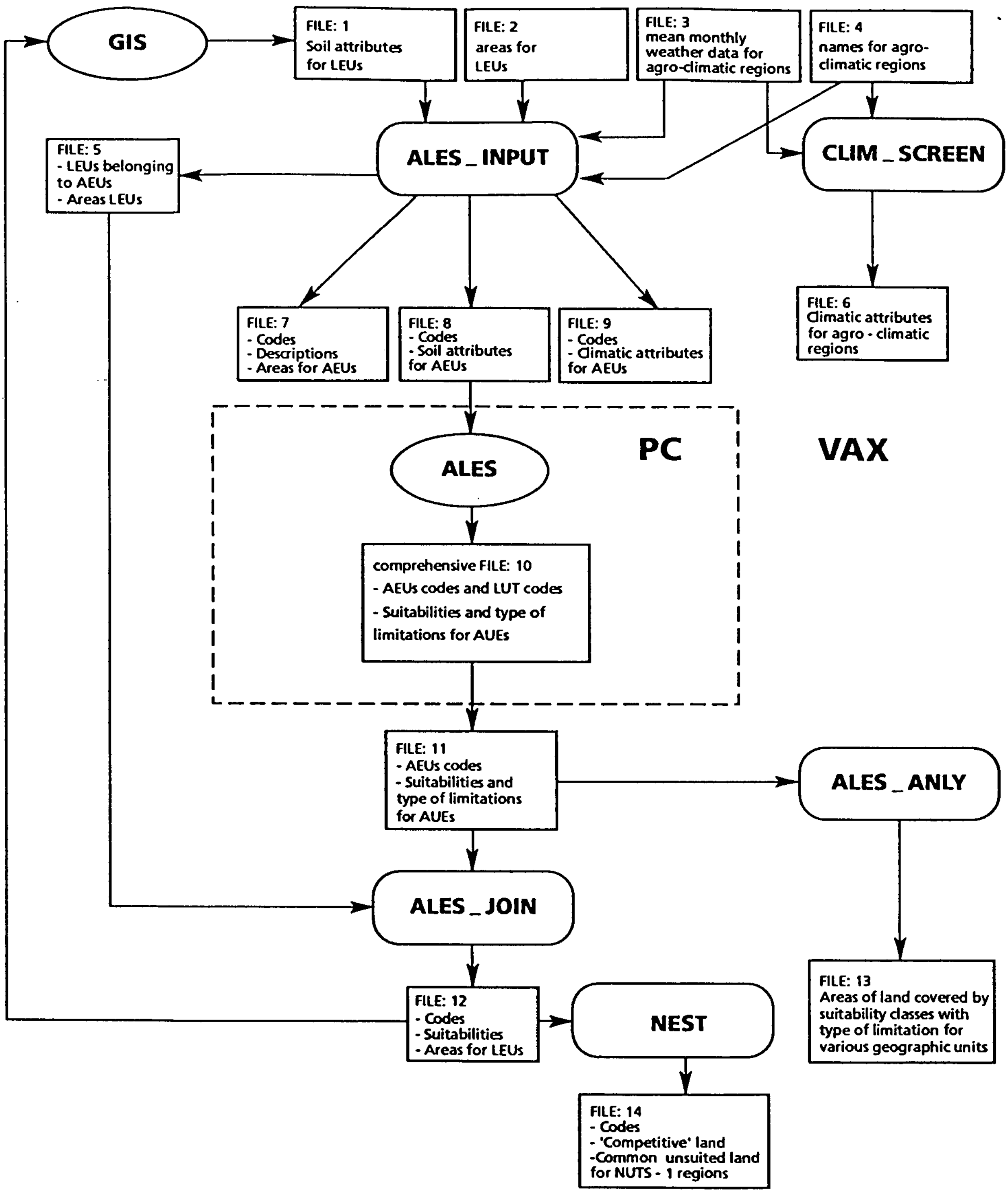


Fig. 7 Overview of data processing for the qualitative evaluation procedure using ALES and a GIS

All the land characteristics associated with climate have a continuous nature (Section 2.2.2). This implies that the number of classes and class limits had to be specified. These items were selected depending on the climatic requirements of the crops to be evaluated. Some major land characteristics associated with climate are given in Appendix 3.

Data processing of the land characteristics in order to obtain a format accessible for ALES is discussed further in the following section.

3.3 Data processing and data flow between the GIS and ALES

Land evaluation models built with ALES do not have a spatial reference (Fig. 2). Each land unit is evaluated independently of the geographical locations of the delineations belonging to the unit. Geographical references of the unit's delineations, however, were needed because the prevailing combinations of soils and climates within the EC needed to be known for a proper suitability assessment. Furthermore, eventual physical suitability for the various crops had to be presented for the 64 EC administrative regions, the so-called NUTS-1 regions (NUTS: Nomenclature des Unites Territoriales). So, it was necessary to know the delineations of combinations of soils and climate occurring in a NUTS-1 region. Hence, the geographical distribution of soils, climatic regions, and NUTS-1 regions were stored in a geographical information system (GIS). A map overlay was carried out using ARC/INFO software. This overlay procedure resulted in a compounded map with land evaluation units (LEUs). About 4200 LEUs were distinguished, distributed over more than 22 000 delineations (Bulens et al., 1990; Bulens and Bregt, in prep.). A LEU is a unique combination of a dominant soil, an agro-climatic region, and a NUTS-1 region. The physical land evaluation methods were applied to these LEUs.

The GIS was implemented onto a VAX 3600 computer, whereas ALES runs on a PC. Several steps were required to convert the outcome of the GIS and other data into a compatible form for ALES, to transport the data from the VAX to the PC, and to import the data into the ALES' database (Fig. 2). After evaluation with ALES, data exchange proceeded in the other direction. The outcome of ALES had to be analysed and converted. It then had to be transported from the PC to the VAX, and, next, imported into the GIS. Finally, the GIS allowed tables and maps to be presented. Usually, the results of the LEUs had to be aggregated to weighted values for administrative regions, such as the NUTS-1 regions, EC member states, and the whole EC. A number of software modules were written in FORTRAN to facilitate the above-mentioned data processing. These modules and the data flow process are explained in the following (Fig. 7).

Processing of input data for ALES
ALES requires at least two different data files. First, a file with the description of the land units. This implies a land unit code, a descriptive name of the land unit, the area of the unit, and a code providing information on whether the land unit is homogeneous or compound. The area is required to eventually allow a computation

of total area within a region occurring in the different suitability classes. Second, one or more files with the code and land characteristics of the units must be provided. The land unit code is used for recognition purposes. But, is also used by ALES as a key item, i.e. it properly links data in the different files with definitions and land characteristics.

A section of the file with land unit descriptions (file 7, Fig. 7) is given in Table 1. The module ALES_INPUT was used to create this file. Files with soil data, names of meteorological stations representative of agro-climatic regions, and areas of the LEUs were needed to assemble the records (files 1, 2 and 4, Fig. 7). These files were mainly obtained by using the GIS. For each land, unit one record needed to be specified. The code of the ALES evaluation unit (AEU) contains a sequence number, the symbol of the dominant soil unit with information on soil texture and the slope, and information on the geographical location. For instance, 'E-n3' means the third agro-climatic region in northern Spain.

Table 1 Descriptions of some selected land units (AUEs) as used by ALES

AEU code	Descriptive name	Code[1]	Area (ha)
0002Je2aE-n3	EutricFluvisols*LESESCALDES	h	34217
0026Jegl/4aD	GleyicEutricFluvisol*SCHLESWIG	h	12714
0246Ge2/4abU	EutricGleysol*TIREE	h	184260
0428Rc3/4bcI	CalcaricRegosol*ROMA/FIUMICINO	h	35316
0466Ie2dGrw2	EutricLithosol*TRICALA	h	136898
0592QclabE-n	CambicArenosol*VALADOLID	h	230115
0638Eo2/3abF	OrthicRendzina*BOURGES	h	272516
0807U2cF-w4	Ranker*NANTES	h	263023
0857To2cdE-e	OchricAndosol*ZARAGOSA	h	4993
2749OdbUKn4	DystricHistosol*TIREE	h	223239
2762pP1BCukW	PlacicPodzol*BELFAST/ALDERGROVE_AP	h	243

[1] homogeneous

Some AEUs do not provide much information on the location, because the maximum code length is eight characters, and priority was given to full presentation of sequence number and the symbol of the soil unit. A sequence number was necessarry because ALES ranks the AEUs alphabetically, whereas we wanted to follow the sequence in the legend of the soil map. A logical AEU code makes the unit recognizable in the database and the evaluation domain. In the descriptive name the full name of the soil unit and the agro-climatic region is specified. The code 'h' for a unit being homogeneous was allocated to each AEU. As mentioned in Section 2.2.2 we used another option of ALES to deal with heterogeneity.

An important task of ALES_INPUT was also to define ALES land units (AEUs) which were only unique in terms of soils and climate. LEUs, which only differ in terms of their location in NUTS-1 regions, were joined in one AEU. So, AEUs are only unique in terms of a combination of a dominant soil unit and an agro-climatic region, whereas LEUs are unique in terms of a combination of a dominant soil unit, an agro-climatic region, and a NUTS-1 region. The distinction of AEUs reduced the number of units to be evaluated from about 4200 to 2760. However, in a later phase of the evaluation process, the results of the AEUs had to be linked to LEUs. The GIS used the codes of the LEUs as a key item to relate all kinds of attribute data to the delineations on the land evaluation map. Hence, a file was created in which the relationship between the AEUs and LEUs was stored (File 5, Fig. 7).

In addition to a file with descriptions of the units, files with land characteristics had to be compiled. ALES allows storage of the land characteristics in more than one file. We stored the soil characteristics and the climatic characteristics in separate files (Files 8 and 9, Fig. 7). In fact, the climatic data were also stored in two different files. For reasons of clarity, this was not presented in Figure 7. A section of the file with soil characteristics is given in Table 2. This file was created with ALES_INPUT. The input was retrieved from the file containing the soil characteristics (File 1, Fig. 7). One record with the land characteristics had to be provided for each AEU.

Table 2 Descriptions of some soil characteristics for selected land units (AUEs) as used by ALES

AEU code	soil texture	CEC	Max. rooting depth	Slope	Soil drainage
0002Je2aE-n3	m	l	mod	le	i[1)]
0025Je2aE-e5	m	l	mo	le	i
0086Jeg4aDKn	f	h	mod	le	i
0108Jeg4aUKs	f	h	mo	le	i
0113Jegl/2al	c=.5,m=.5	vl=.5,l=.5	mod	le	i
0114Jegl/2al	c=.5,m=.5	vl=.5,l=.5	mo	le	i
0177Jcf4aGre	f	h	md	le	i
0182Jcf4aGre	f	h	mo	le	i
0492Ie2cdP-s	m	l	vsh	most=.5,st=.5	w
0493Ie2cdP-s	m	l	vsh	most=.5,st=.5	w
0700Eo2/3bB-	m=.5,mf=.5	l=.5,m=.5	sh	sl	w

1) abbreviations refer to classes provided in Appendix 2.

The codes of the classes of land characteristics (Appendix 2) were used as input for ALES. For instance, 'i' on the first record means that this Eutric Fluvisol is imperfectly drained. Instead of the codes of classes ALES also permits the use of levels indicated by figures. Because these figures are less meaningful during the phase of expert model building, the codes were used. The figures in Table 2 show these of multivalued land characteristics. As mentioned in Section 3.1 the dominant soil units may be characterized by ranges in the soil texture and slope. These ranges were handled by allocating multivalued land characteristics to the AEUs (cf. Section 2.2.2). In the case of Gleyic Eutric Fluvisols (0113Jegl/2al), 50% of the area was assumed to be covered with coarse-textured soils (c=.5), and another 50% with medium-textured soils (m=.5). The Eutric Lithosols (0492Ie2cd) were assumed to have 50% of the land located on moderately steep slopes (most=.5), and 50% on steep slopes (st=.5). When multivalued land characteristics are distinguished, ALES automatically recognizes different subunits. Other land characteristics may also be multivalued, if they have been derived from soil texture or slope (Reinds et al., in prep.). For instance, the cation exchange capacity (CEC) has been deduced from soil texture. Table 2 demonstrates that when a multivalued soil texture occurs, the CEC is also multivalued (e.g. 0113Jegl/2aI).

The input file with climatic characteristics (File 9, Fig. 7) was created with ALES_INPUT based on the input from the files with soil attributes and mean monthly weather data. The file with soil data was required because of the assemblage of the code of AEUs. The climatic characteristics were provided as continuous land characteristics (Table 3). As mentioned above, in ALES the continuous characteristics were automatically converted into class characteristics when class limits are specified. The classes and their limits are given in Appendix 3.

Table 3 Descriptions of some climatic characteristics for selected land units (AUEs) as used by ALES

AEU code	Mean minimum temperature coldest month (°C)	Mean annual temperature (°C)	Mean annual rainfall (mm)	Mean rainfall in August (mm)	Mean rainfall in April-September (mm)	Number of months with mean temperature between 13 °C and 30 °C
0001Je2aD-s2	-5.2	7.9	955.	120.	618.	4
0002Je2aE-n3	-1.3	10.1	808.	98.	481.	4
0003Je2aF-s3	2.1	14.4	554.	28.	209.	6
0005Je2aI-w3	4.3	15.3	1022.	48.	317.	7
0006Je2aUKw3	1.4	9.8	923.	78.	412.	4
0007Je2aE-n4	6.5	13.9	1198.	84.	493.	6
0008Je2aF-s8	4.0	13.8	1475.	125.	655.	6
0011Je2aE-e3	6.7	16.3	603.	54.	286.	8
0026Jegl/4aD	-2.1	7.9	917.	86.	446.	4
0027Jegl/4aD	-2.3	8.5	765.	68.	402.	4

On the basis of geographical locations of the LEUs, which were included in the codes of the LEUs (Reinds and Van Lanen, in prep.), climatic characteristics of the agro-climatic regions were allocated to the AUEs. In the input for ALES hardly any monthly weather data were stored. Instead, preprocessed weather data were stored, such as number of months with a mean temperature in a particular range, or the mean minimum temperature of the coldest month (Table 3). All this preprocessing was executed with ALES_INPUT. Procedures for preprocessing of mean monthly weather data were elaborated with the module CLIM-SCREEN (Fig. 7). Climatic criteria derived from the literature were confronted with the mean monthly weather data (File 3, Fig. 7). In this way, effects of certain criteria on crop growth potential, as affected by agro-climatological conditions, were investigated. Exploring these effects at an initial stage in the evaluation and outside ALES saved considerable time. Use of preprocessed weather data was also attractive in order to keep the ALES' database relatively small. Moreover, some preprocessing was necessary because ALES cannot perform arithmetical operations.

The input files for ALES were transmitted from the VAX to the PC environment. Total size of the input files for the EC was about 0.7 megabytes.

Processing of ALES's output
ALES has various options for presenting the evaluation results. In our study, output to screen or printer was not feasible because of the size of the outcome. Hence, outcome was exported to a comprehensive file on disk (File 10, Fig. 7). One long record was produced for each evaluation unit. This record comprises information on codes of AEU and LUT, suitability, and type of limitation. When suitabilities of the subunits differ, each suitability class was presented. Moreover, the relative area of the class was given as well as the type of limitations. The comprehensive file contains raw outcome, i.e. quotes and question marks could occur. The latter were removed, and the file was then transmitted from the PC to the VAX (File 11, Fig. 7). A section of this file is presented in Table 4.

Table 4 Suitability classes and type of limitations as assessed with ALES for some selected land units (LEUs)

AEU code	Area (km^2)	Suitability classes and type of limitation[1)]
0017Je2aE-w1	10	2ae
0024Je2aP-e2	42	3cl
0405Rc3/4cdI	53	1=.5,2top=.5
0434Rc3/4bcI	8567	1
1783Bk2/4bcP	340	1=.5,2top=.5
1932Bc2acP-w	210	1=.66,2top=.34
2150Lo2/4bE-	558	1
2214Lc2/4dI-	1528	2sp/top=.67,2sf/sp/top=.33
2293Lkc4bdP-	760	1=.33,2top=.33,3top=.34
2320Lv3/4abP	984	1

1) suitability class: 1: well suitable (no limitations), 2: moderately suitable (moderate limitations), and 3: unsuitable (severe limitations); type of limitation: ae: soil aeration, cl: climate, top: slope, sp: soil physical quality, sf: natural soil fertility

When a unit was evaluated as 'class 1 land', little information was provided (e.g. 2150Lo2/4bE-). Besides the AEU code, only the figure '1' was given. However, when an unit was evaluated as having some limitations, substantially more information was presented. Especially when the unit has a compound soil texture and slope which leads to different subunits, the record could become very long (up to 200 bytes). For instance, 33% of the land of the unit of the Chromo Calcic Luvisols located in the agro-climatic region Lisbon (2293Lkc4bdP-), was evaluated to be well suitable. Another 33% was assessed to have moderate limitations owing to the slope, and the remaining 34% has severe limitations, also because of the slope.

The file with the suitability data for each AEU (File 11, Fig. 7), was used as input for the program ALES_JOIN. The main task of this module was to analyse the suitability data in order to produce a short record for each evaluation unit. The record comprises information on the code of the evaluation unit, and the relative areas of the unit occurring in the suitability classes considered (File 12, Fig. 7). A section of the file containing this information is given in Table 5. Some units were evaluated as having all their land in one suitability class (e.g. 100111_C2_08329).

Table 5 Relative areas (%) covered by the suitability classes as assessed with ALES for some selected land units (LEUs)

LEU code	Area (km^2)	Suitability class[1] 1	2	3
100111_C2_08329	10	0	100	0
100111_C1_08575	42	0	0	100
104211_3A_16429	53	50	50	0
104311_3A_16429	8567	100	0	0
209311_C1_08536	340	50	50	0
210511_C1_08536	210	66	34	0
302111_C1_08329	558	100	0	0
303214_3A_16429	1528	0	100	0
304511_C1_08536	760	33	33	34
304711_C2_08536	984	100	0	0

[1] suitability class: 1: well suitable (no limitations), 2: moderately suitable (moderate limitations), and 3: unsuitable (severe limitations);

Other units with compound soil textures or slopes may have land in all the suitability classes considered (e.g 304511_C1_08536). The short records with suitability results were assembled for the LEUs instead of for the AEUs. Therefore, the module ALES_JOIN also used the file with the relationship between AEUs and LEUs as input (File 5, Fig. 7). So, the link of the land units with the administrative regions on a NUTS-1 level was again established. Suitability results had to be allocated to the LEUs because the GIS recognized them as key items. The file with the short records (File 12, Fig. 7) was imported by the GIS for further processing, such as production of maps and tables, and spatial aggregations to obtain mean results for geographic units on small-map scales. These types of results are extensively discussed in Chapter 5 for the various land use types.

The file with the short records, with suitability results for the LEUs, was also used to compute 'competitive' land for some crops by applying the module NEST. The principles and the task of the module NEST are discussed in Chapter 4.

Analysis of ALES results was also carried out with a module called ALES_ANLY (Fig. 7). The module ALES_ANLY used the file with the long records containing data on suitability classes and type of limitations as input (File 11, Fig. 7). The main task is to produce an overview of the type of limitations which occur in a suitability class. Relative areas of land with a particular limitation or combination of limitations are calculated for each suitability class. The overview can be produced for geographic units at different levels, viz. NUTS-1 regions, agro-climatic regions, EC member states, or the whole of the EC. Outcome of ALES_ANLY for a particular region and land use type is given in Table 6.

In the example, 24.8 % of the region was evaluated as well suitable, 1.2% of the region was moderately suitable because of management limitations, and 11.0% of the region was unsuitable owing to severe limitations of both soil aeration and management. The module ALES_ANLY also allows us to specify which dominant soil units occur in class 1.

Overviews of relative areas with different type of limitations are extensively discussed in Chapter 5.

Table 6 Example of the outcome of the module ALES_ANLY

Suitability class	Type of limitation[1]	Area (km^2)	Relative area (%)
1[2]	n.r.	23620	24.8
2	ma	285	1.2
	sw	230	1.0
3	ae/ma	2589	11.0
	fe/ae	1176	5.0
	ae	361	1.5
	sw	4036	17.1
	fe	8914	37.7
	sw/ma	150	0.6

[1]) n.r.: not relevant, ma: management, sw: soil water deficit, ae: soil aeration, and fe: natural soil fertility
[2]) 1: well suitable (no limitations), 2: moderately suitable (moderate limitations), and 3: unsuitable (severe limitations)

4 DETERMINATION OF COMPETITIVE LAND

The Dutch Scientific Council for Government Policy (WRR) required suitability results for various crop types at the level of the NUTS-1 regions. These data are used as input for the GOAL-model (General Optimal allocation of Land Use). When applying the GOAL model, the geographical location of land within the NUTS-1 region is not needed. However, the model requires information as to whether land suitable for a particular activity partly or completely coincides with the suitable area of another activity (Fig. 8). The coinciding area of suitable land for both activities is called 'competitive'. In this chapter the term 'activity' sometimes replaces the expression of 'crop' or 'land use type'.

When the GOAL-model allocates competitive land to one of the activities, it cannot be allocated to the other activity as well. Then, it is obvious that the suitable area for the other activity needs to be reduced.

If we need to determine competitive land for different activities, it is relevant to know whether the land suitable for a particular activity is completely included in the area of suitable land for another activity or not. When suitable land is completely included, we have classified this land as 'nested' suitable land. For instance, in Figure 8A the suitable land of activity 'A' is nested in the suitable area of activity 'B'.

In the quantitative land evaluation procedure, the 'nesting' approach was followed for the selection of suitable land for annual crops and grass (Reinds and van Lanen, in prep.). The module EC MIXED was applied to select unsuitable land. If one of the land characteristics of a certain land evaluation unit does not meet the selection criteria, the unit was called unsuitable irrespective of the other characteristics. The basic set of selection criteria for the above-mentioned type of crops (intensively managed grass, cereals and root crops) was identical. Besides the basic set, some additional criteria were formulated for cereals as compared to grass. For instance, temporarily poorly drained soils were assumed to be unsuitable for mechanized cereal farming, whereas they were still suitable for grass. For grass, no selection criteria were defined which did not apply to cereals. Hence, the suitable area for cereals in a region is usually smaller than the suitable area for grass, and is completely nested (Fig. 8A). The set of selection criteria for cereals was further extended for root crops. For instance, soils with a clay content of between 35% and 60% were assumed to be unsuitable for root crops, whereas they were still suitable for cereals and grass. Again, for grass and cereals no selection criteria were defined which did not apply to root crops. This implies that the suitable land for root crops is less extensive than for cereals and grass, and further it is nested within the suitable land of both crop types. The GOAL model can easily deal with this type of nesting.

For the groups of forest tree species and fruit trees considered in this report, ALES instead of EC MIXED was applied to evaluate land as unsuitable. Similar to EC MIXED, ALES offers the opportunity to screen the suitability of land for single land characteristics as if they act independently.

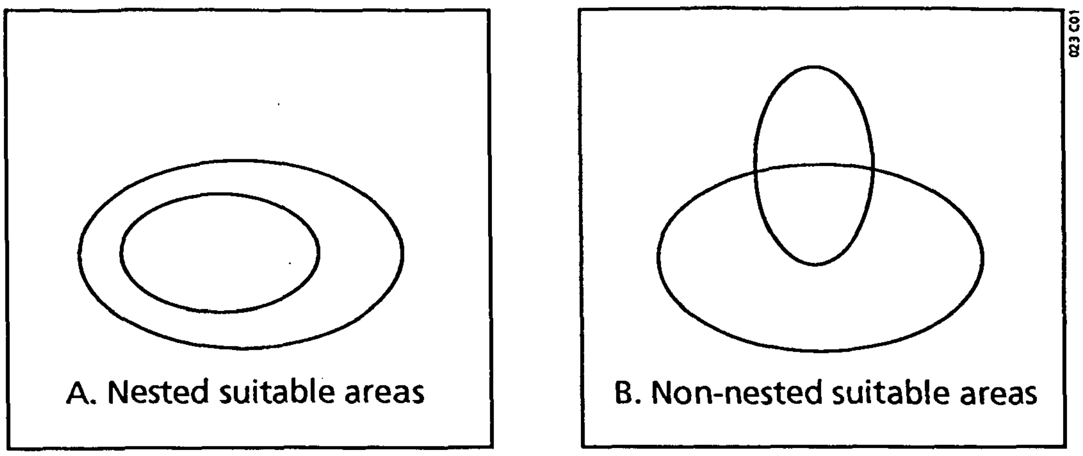


Fig. 8 Possible configurations of suitable land in a NUTS-1 region for two different crops

The basic set of selection criteria could be extended to crops with higher demands. However, for forest tree species and fruit trees no basic set of selection criteria were defined. For particular fruit tree species, different selection criteria were applied to evaluate land as unsuitable than were applied for certain groups of forest tree species. For instance, for certain groups of forest trees a low natural soil fertility resulted in severe limitation, whereas natural fertility was not considered for some fruit trees. Conversely, the presence of some soil phases may impose a severe restriction for some fruit trees, whereas they were not assumed to hamper timber growth. This implies that the crop types considered in this report were not completely nested according to a sequence from low to high demanding crops. Furthermore, if we compare the selection criteria for forest and fruit trees with those of intensively managed grass, cereals, and root crops, then no complete nesting occurs either.

Moreover, ALES allows us to evaluate land as unsuitable based on certain combinations of land characteristics. For example, a land evaluation can be assessed to be unsuitable if the clay content is higher than A%, but only if soil drainage class is 'B' and slope is 'X' or 'Y'. We also used these criteria to evaluate suitability of land for forest trees and fruit trees.

The use of land characteristics as done by ALES may result in incomplete nested areas of suitable land for different activities (Fig. 8B). This indicates that both activities have suitable land which do not coincide. When applying the GOAL model, however, it must be known which part of the suitable areas coincides. At the start of the study this was not foreseen. Selection criteria were independently defined for each crop.

After aggregating the results of the individual land evaluation units to a weighted mean for an administrative region (NUTS-1 level), it is impossible to discover whether the area of land is competitive. For example, when in region A 50% of suitable land occurs for activity 1 and only 25% for activity 2, the relative area of competitive land is usually less than 25%.

Theoretically, determination of coinciding suitable or unsuitable land could have been done at the level of the land evaluation unit. However, this would have had to have been incorporated in the expert models built with ALES. This analysis was beyond the scope of this study. Therfore, a more pragmatic approximation was followed to estimate the percentage of coinciding suitable land for two activities. The percentage of suitable land for an activity was compared with the percentage of another activity at the level of the land evaluation unit, instead of comparison at the NUTS-1 level. The phenomenon of non-nested land occurs less frequently at the level of the evaluation unit.

The percentage of suitable land of a land evaluation unit does not usually equal 0% or 100% because the land evaluation units are usually compound (Table 5). In a separate analysis, each of the groups of forest trees and fruit trees were compared with each of the three types of crops (grass, cereals, root crops) considered by Reinds and Van Lanen (1991). First, the smallest percentage of suitable land of one of the two crops to be compared was calculated for each evaluation unit. This percentage was assumed to be the percentage of coinciding suitable or competitive land for both crops. Second, the percentage of remaining suitable land for one of the two crops was determined. Then, the percentage of coinciding unsuitable land for both crops was determined for each of the units. Finally, the data of the land evaluation units were aggregated to weighted means for the NUTS-1 region. Examples of the temporary file with results for some land evaluation units, and for NUTS-1 regions are given in Tables 7 and 8.

Table 7 Results of the nesting procedure for some selected land evaluation units

LEU code	Area (km^2)	Relative area (%) of unit			
		competitive land	suitable for crop 1 only	suitable for crop 2 only	coinciding unsuitable land
100111_C2_08329	10	50	50	0	0
100111_C1_08575	42	0	0	10	90
104211_3A_16429	53	25	75	0	0
104311_3A_16429	8567	0	100	0	0
209311_C1_08536	340	33	67	0	0
210511_C1_08536	210	25	75	0	0
302111_C1_08329	558	0	100	0	0
303214_3A_16429	1528	50	50	0	0
304511_C1_08536	760	66	0	10	24
304711_C2_08536	984	0	100	0	0

The principal assumption in this approach is that the best soils can be used for each crop. So, the best soils are always included in the percentage of suitable or competitive land for every crop. Moreover, it was assumed that if the area of suitable land for one activity is greater than for another, the crop and management system of the suitable land puts lower demands on it.

Table 8 Results of the nesting procedure for some selected NUTS-1 regions

NUTS-1 region	Relative area (%) of unit			
	competitive land	suitable for crop 1 only	suitable for crop 2 only	coinciding unsuitable
Schleswig-Holstein	38	0	51	11
Ile de France	37	19	19	25
Nord-Ovest	4	4	20	72
Noord-Nederland	14	0	56	30
Vlaams gewest	49	0	50	1
Luxembourg (G.D.)	6	38	25	31
North	8	4	57	31
Ireland	42	1	31	26
Denmark	34	0	64	2
Ellas (North)	7	0	7	86

The procedure for each land evaluation unit can be summarized as followed:

$$s_c(i) = s_1(i) \qquad \text{if } s_1(i) < s_2(i)$$
$$s_r(i) = s_2(i) - s_1(i)$$
$$u_c(i) = 100 - s_2(i)$$

$$s_c(i) = s_2(i) \qquad \text{if } s_2(i) < s_1(i)$$
$$s_r(i) = s_1(i) - s_2(i)$$
$$u_c(i) = 100 - s_1(i)$$

where:

$s_c(i)$: coinciding area of suitable or competitive land (%) of a land evaluation unit i for both crops;

$s_1(i)$, $s_2(i)$: area of suitable land (%) of a land evaluation unit i for crop 1 and 2;

$s_r(i)$: remaining area of suitable land (%) of a land evaluation unit i for one of the crops;

$u_c(i)$: coinciding area of unsuitable land (%) of a land evaluation unit i for both crops.

Procedure proceeds with the aggregation for the NUTS-1 region:

$$S_c = (\Sigma\, s_c(i) * o(i)) / O$$
$$S_{r1} = (\Sigma\, s_{r1}(i) * o(i)) / O$$
$$S_{r2} = (\Sigma\, s_{r2}(i) * o(i)) / O$$
$$U_c = (\Sigma\, u_c(i) * o(i)) / O$$

where:

S_c : coinciding area of suitable or competitive land (%) in an administrative region (NUTS-1 level);

S_{r1} : area of suitable land for crop 1 (%) in an administrative region (NUTS-1 level);

S_{r2} : area of suitable land (%) for crop 2 in an administrative region (NUTS-1 level);

U_c : coinciding area of unsuitable land (%) in an administrative region (NUTS-1 level);

o(i) : acreage of land evaluation unit i (in km^2);

O : acreage of particular administrative region (NUTS-1 level),(in km^2).

So, if a land evaluation unit is not completely suitable or unsuitable, this procedure assumes a nesting of suitable land at the level of a land evaluation unit (Fig. 8A). This assumption does not apply completely to every crop as mentioned above. These cases are indicated in Chapter 5.

The nesting operations were carried out using the module NEST (Fig. 7). A section of the outcome of the module NEST is given in Table 8 (File 13, Fig. 7). The file with the results at the land evaluation unit level (Table 7) is of a temporary nature.

5 SUITABILITY FOR FORESTRY AND VARIOUS FRUIT CROPS

5.1 Forestry

No discussion is required about whether or where a forest can flourish within the European Communities. For the greatest part of the EC this is always possible. Originally, most EC land was coverd by forest. Unfortunately, due to human intervention, vast areas have disappeared. The primeval forests were very different from the forests we know today (Buis, 1985, Hesmer and Schroeder, 1963), especially with regard to species and structure. It is also likely that the production of the ecosystems was substantially different. Therefore, the question of where productive forests could thrive within the EC, is totally different from the question of whether they could thrive. And, with regard to the large amount of imported wood and wood products from other parts of the world to the EC, this question needs special attention. Increasing timber production within the EC is not only a socio-economic matter for the EC itself, but could also contribute to solutions for global problems such as the vanishing tropical rain forests.

Before answering the question of where productive forests could thrive within the EC, much needs to be known about the requirements of tree species to be grown on such sites and about the land qualities. Recent developments in Geographical Information Systems (GIS) and in Automated Land evaluation Systems (ALES), make it possible to give a more detailed analysis than was possible a few years ago.

In this study, the land evaluation for forestry was carried out for the Land Utilization Type (LUT) 'Fully Mechanized Production Forestry'. Within the EC, are great differences in climate and soil types, between the northern and southern regions. This greatly effects the possible dispersion of tree species. Because tree species have different ecological requirements and different yield potentials, the evaluation for forestry is presented for three broad groups of tree species:

- Fast growing tree species
- Normal growing more demanding tree species
- Normal growing less demanding tree species.

For several reasons no detailled production levels are given for the three distinguished groups of tree species. First, there is considerable lack of comparable production data. Second, if information on the production level is available, little is known about the site where producion was established. A third reason is the possible difference in production potential of tree species in one of the three groups. However, the ecological range of species within one group are much the same, their highest yields may differ consirably. Further, the production potential of crops increases in an absolute sense from, roughly, the northern EC regions to the Mediterranean regions (Koning et al., in prep.). Considering this as a whole, we decided to indicate only the gross production level. As mentioned, the ecological requirements and yield potential of tree species within a group may, however, also vary. Therefore, the results must be considered as a first indication. For example, a prediction that there will be no limitations for a particular group may only refer to one or a few species from of that group.

Fast growing tree species
High productive species, such as Poplar (Populus spec.), Willow (Salix spec.) and Eucalypts (Eucalyptus spec.), belong to the group of fast growing tree species. When moisture supply, nutrients supply, temperature and radiation are adequate, the annual increment may reach a yield of 30 m^3 ha^{-1} $year^{-1}$ (Rosa and Moreira, 1987). On many, somewhat favourable sites, however, a yield of 20 m^3 ha^{-1} $year^{-1}$ seems a reasonable value. To reach such a high yield, these species need a permanent soil water supply (Fabiao et al., 1985, Penfold and Willis, 1961, Mayer, 1984). In general, Poplars demand more nutrients than Eucalypts. In the evaluation, the nutrient requirements of Poplar were chosen as reference. Compared with the other groups of tree species, the fast growing species require a much higher soil water and nutrients supply. Furthermore, Poplar can resist a high groundwater level or even inundation for a longer period. The distribution area of Poplar is far more north than that of Eucalypts because of resistance to frost. Therefore, Eucalypts do not grow in the northeastern part of the EC which has cold continental winters.

Normal growing more demanding tree species
The tree species belonging to the group of normal growing more demanding species have a normal yield compared with the fast growing species (viz. less than for fast growing species). The requirements for soil water and nutrients are still relatively high compared with the group of normal growing less demanding tree species. Tree species from this group are, for example, European silver fir (Abies alba), Western and Eastern hemlock (Tsuga hetrophylla, T. canadensis) and Beech (Fagus sylvatica). On the best sites, the yield of the coniferous species may be more than 20 m^3 ha^{-1} $year^{-1}$. For the deciduous species, 10 m^3 ha^{-1} $year^{-1}$ may be considered as a good yield. This yield can be obtained if the soil moisture supply is adequate during the whole growing season. Further, a well-drained and well-aerated soil is needed (Mayer, 1984, Schutt et al., 1984). Compared with the fast growers, these species may need less soil moisture. However, compared with the group of less demanding tree species, they still require a higher nutrient and moisture supply from the soil. As already mentioned, this group consists of deciduous and coniferous trees. They both occur on dry sites. On 'wet' sites, it are mainly deciduous trees that are of any importance to timber production. For reasons of clarity, this group will be indicated as a 'more demanding tree species' in the following.

Normal growing less demanding tree species
Tree species belonging to the group of normal growing less demanding tree species produce a relatively high yield on relatively poor sites. A 'poor' site may refer to nutrients supply or to soil water supply or to both. Tree species from this group are mainly Pine species such as Scots pine (Pinus sylvestris), Maritime pine (P. pinaster) and Black pine (P.nigra). On the very poor sites, timber growth still continues, but is more concerned with survival than to timber production. If conditions are more favourable, however, the yield of some species may reach 10 m^3 ha^{-1} $year^{-1}$. For Scots pine, 7 m^3 ha^{-1} $year^{-1}$ may be considered as being a good growth. Compared

with both other groups, this group has the lowest site requirements but cannot attain an equally high level of production. Tree species from this group may occur on both wet and dry sites. Normal growing less demanding trees can also grow on the better sites. They do not usually occur three, however, because other, more productive species are planted on such sites. For reasons of clarity, this group is indicated as a 'less demanding tree species' in the following.

5.1.1 Evaluation criteria

As a boundary condition in this study, forestry was considered to be using modern exploitation techniques. Sustainability of land use is another objective. No possible improvements of the site (e.g. fertilization, irrigation) were included in the evaluation. Therefore, land evaluation units were evaluated in their natural state. When forestry for timber production is considered, it means that sites may be evaluated as unsuitable for forestry, while they may be suitable for other kinds of forest products or services. These forests may be valuable for purposes other than timber production, for example land conservation (e.g. prevention of erosion), nature conservation or recreation. Moreover, forest products other than timber, such as cork, resin or leaves may be harvested. Sites suitable for these products are not necessarily suitable for timber production.

Land suitability for forestry was derived from the following land use requirements which hold for all three groups of tree species:

- soil water deficit
- soil aeration
- fertility (natural)
- chemical conditions
- temperature regime
- management conditions

If all requirements are optimally met by the land (Land Qualities), the evaluation results in 'no limitation'. If one or more requirements are suboptimally met by the land, the evaluation will result in a 'moderate limitation'. In such cases the production level will usually be less than in those of 'no limitations'. Although the same type of requirements were defined for all three groups of tree species, the level of the requirements necessary for a good, moderate or low yield, varies among the three groups. This means, for instance, that a soil water deficit of x mm for fast growing tree species results in 'severe limitations' while for the group of normal growing tree species the result may be 'no limitations'. In general, forest trees place more and higher demands on the soil when their possible maximum yield is higher. When land meets several requirements only suboptimally, or meets one requirement poorly, it is poorly suitable, and tree growth will usually be seriously reduced compared with optimal conditions. In this study, poorly suitable means that the production is (very) low or harvesting may be (very) difficult because of severe management problems. In many cases, however, sites with severe limitations are currently covered by forest because a low production level is considered to be better than no production at all. Also, arguments other than timber production, for example nature conservation, soil protection etc., may be the reason why land is being covered by forest. Sometimes special harvesting techniques, such as winch-harvesting or winter logging, are used. These special techniques allow harvesting, but also increase the costs. Therefore, they were not considered in our study.

Soil water deficit
To evaluate soil water deficit of land the drainage status, mean annual precipitation deficit, maximum rooting depth, texture of the topsoil and soil phases were taken into account. The large ALES decision tree used to evaluate the soil water deficit cannot be completely presented in this report. Therefore, some general decision rules that were applied are given.

The climatic and soil characteristics are divided into classes (Reinds et al., in prep.). The first entrance of the decision tree is the soil characteristic of the drainage status. If a land evaluation unit is very poorly, poorly or temporarily poorly drained it was assumed to have no soil water deficit. On the other hand, if the unit is excessively drained the soil water deficit depends on other land characteristics. Second, the precipitation deficit was considered. The soil water deficit was assumed to be zero or low if the precipitation deficit is also low. The soil water deficit may be high in areas with a high precipitation deficit and a soil water supply. The third characteristic used is the maximum rooting depth. If roots can grow deeper, the soil water deficit will become less. The fourth characteristic applied is the texture of the topsoil. In certain agro-climatic zones, soils with a medium to fine texture have a smaller soil water deficit than soils with a coarse or very fine texture. Peat soils were usually evaluated as medium-textured soils. The fifth and last characteristic used is the presence of soil phases, such as gravel (>35%), stones (>35%) or petrocalcic, saline, and sodic horizons. The presence of a soil phase usually resulted in a (very) severe soil water deficit.

As mentioned, the three distinguished groups of tree species place different requirements on the site, for instance with regard to the soil water deficit. Therefore, different decision trees were developed to evaluate soil water deficit for the three groups of tree species. The most important assumptions are presented in Tables 9 to 11. In the last column of these tables, the severity level of a possible limitation of the soil water deficit is given. From severity level 1 to 5 the soil water deficit increasingly limits tree growth. In Tables 9 to 11, the severity level is generally given as a range. The lower limit of the range applies to relatively better site conditions than the upper limit. Although these site characteristics were considered in the evaluation, for instance soil texture, they were not included in the tables for reasons of clarity.

Table 9 Decision criteria for evaluating soil water deficit for fast growing tree species

Drainage status	Precipitation deficit (mm)	Rooting depth (cm)	Soil water deficit limitation class 1)
very poor, poor, temporarily poor	n.r.2)	n.r.	1
imperfect	<50	n.r.	1
	>50	<10	4-5
	50-300	40-60	1-2
	>300	40-60	2-3
	>50	>80	1-2
moderately good	<25	n.r.	1
good	>50	<10	5
excessive	25-100	40-60	1-2
	>200	40-60	4-5
	25-200	>80	1-2
	>300	n.r.	4-5

1) 1 = no, 2 = slight, 3 = moderate, 4 = severe, 5 = very severe limitation.
2) n.r.= not relevant.

Table 10 Decision criteria for evaluating soil water deficit for normal growing more demanding tree species

Drainage status	Precipitation deficit (mm)	Rooting depth (cm)	Soil water deficit limitation class 1)
very poor, poor, temporarily poor	n.r.2)	n.r.	1
imperfect	<50	n.r.	1
	>50	<10	4-5
	50-300	40-60	1-2
	>400	40-60	2-3
	>50	>80	1
moderately good, good, excessive	<25	n.r.	1
	>50	<10	4-5
	50-300	40-60	1-2
	>300	40-60	4-5
	50-400	>80	1-2
	>400	n.r.	5

1) 1 = no, 2 = slight, 3 = moderate, 4 = severe, 5 = very severe limitation.
2) n.r.= not relevant.

Table 11 Decision criteria for evaluating soil water deficit for normal growing less demanding tree species

Drainage status	Precipitation deficit (mm)	Rooting depth (cm)	Soil water deficit limitation class 1)
very poor, poor, temporarily poor	n.r.2)	n.r.	1
imperfect	<100	n.r.	1
	>200	<10	4-5
	100-300	40-60	1-2
	>400	40-60	1-3
	>100	>80	1
	>600	n.r.	4-5
moderately good, good, excessive	<50	n.r.	1
	>100	<10	5
	50-200	40-60	1-2
	>400	40-60	4-5
	50-400	>80	1-2
	>400	n.r.	4-5

1) 1 = no, 2 = slight, 3 = moderate, 4 = severe, 5 = very severe limitation.
2) n.r.= not relevant.

Soil aeration

The soil aeration was assumed to be dependent on the drainage status and texture of the topsoil. In Table 12 the ALES decision tree for soil aeration is presented schematically.

Table 12 Decision criteria for evaluating soil aeration for fast growing, normal growing more demanding and, normal growing less demanding tree species

Drainage status	Texture of topsoil	fast growing	more demanding	less demanding1)
very poor	coarse, medium, fine, medium fine, very fine	5	5	5
	peat	3	5	3-5
poor	coarse	3	5	4
	medium, medium fine, fine, very fine	5	5	5
temporarily poor	coarse	2	5	3
	medium, medium fine, fine	3	5	3
	very fine	4	5	5
imperfect	coarse	1	2	1
	medium, medium fine, fine	2	3	3
	very fine	3	4	3
moderately good	coarse	1	1	1
	medium, medium fine, fine	2	2	2
	very fine	2	3	3
good, excessive	n.r.2)	1	1	1

1) 1 = no, 2 = slight, 3 = moderate, 4 = severe, 5 = very severe limitation.
2) n.r.= not relevant.

Fertility

Assessment of the natural fertility of land was based on evaluation of the cation exchange capacity (CEC), and the base saturation (BS). The ALES decision tree developed is schematically shown in Table 13.

***Table 13** Decision criteria for evaluating fertility of land for fast growing, normal growing more demanding and, normal growing less demanding tree species*

CEC[1]	BS[2]	fast growing	more demanding	less demanding
very low,	low	3[3]	3	2
low	medium	2	2	1
	high	2	2	1
medium	low	3	2	2
	medium	2	1	1
	high	2	1	1
high,	low	2	2	1
very high	medium	1	1	1
	high	1	1	1
peat	low	2	2	2
	medium	1	1	1
	high	1	1	1

1) CEC = Cation Exchange Capacity
2) BS = Base saturation
3) 1 = no, 2 = moderate, 3 = severe limitations.

Chemical conditions

In the assessment of fertility, those soil characteristics were included which determine nutrient availability and nutrient retention. There are some other soil characteristics which detrimentally affect tree growing possibilities. These characteristics were evaluated through the chemical conditions. For instance, alkalinity and salinity will negatively affect yield. Therefore, their presence or absence was taken into account. Table 14 shows the ALES decision tree schematically.

***Table 14** Decision criteria for evaluating chemical conditions for fast growing, normal growing more demanding and, normal growing less demanding tree species*

Exchangeable Sodium >15%	Salinity >4 mmho/cm	Limitation[1]
present	n.r.[2]	2
absent	present	2
	absent	1

1) 1 = no, 2 = severe limitations.
2) n.r. = not relevant.

Temperature regime

Low temperatures may cause growth stress or even prohibit the growth of trees. The temperature regime during the growing season, and especially during July is of great importance. If the mean temperature in July is below 9 degrees Celsius, forest growth was considered to be impossible. Forest growth is also impossible if the mean temperature during the growing season does not rise above 10 degrees Celsius (Tranquillini, 1979). Close to these temperature limits, tree growth was assumed to be suboptimal. In Table 15 the developed ALES decision tree is schematically given.

Table 15 Decision criteria for evaluating temperature effect on forest growth

Mean temperature during July (degrees Celsius)	Mean maximum temperature during growing season (degrees Celsius)	Limitation[1)]
<9	n.r.[2)]	3
9-11	<10	3
>10	n.r.	2
>11	<10	3
10-12	n.r.	2
>12	n.r.	1

1) 1 = no, 2 = moderate, 3 = severe limitation.
2) n.r. = not relevant.

Management conditions
Besides qualities of soil and climate, which affect tree growing, other qualities are important which may influence management operations in the forests. Mechanized harvesting and planting techniques were assumed to impose certain upper limits on acceptable slope angle and drainage status. Table 16 shows the implemented ALES decision tree schematically.

Table 16 Decision criteria for evaluating management conditions of forest land for fast growing, normal growing more demanding and, normal growing less demanding tree species

Drainage status	Texture	Slope (%)	Limitation[1)]
very poor	coarse, medium, medium fine, fine, very fine	n.r.[2)]	3
	peat	<8	2
		>8	3
poor, temporarily poor	n.r.	<15	2
		>15	3
imperfect, moderately good, good, excessive	n.r.	<15	1
		15-25	2
		>25	3

1) 1 = no, 2 = moderate, 3 = sever limitations.
2) n.r.= not relevant.

5.1.2 Suitability for forestry

In this section, the evaluation results for the situation of the EC are explained for each of the three distinguished groups of tree species. The evaluation process is schematically shown in Figure 3. The physical suitability for forestry was determined by evaluating for each land evaluation unit the land qualities as determined by the above-mentioned decision trees (Tables 9 to 16). Therefore, for each group of tree species, a physical suitability decision tree was made. In this decision tree, the combined effect of the current land qualities was translated into four suitability classes. Determining the overall suitability in this way resulted in land being allocated to one of the four suitability classes. Class 1 comprises well suitable land with no limitations, and class 2 contains still suitable land but with moderate limitations. Land in classes 1 and 2 is indicated as suitable land. Unsuitable land was allocated to either class 3 or 4. Class 3 land has (very) severe limitations with respect to tree growing conditions and possibly management, whereas class 4 land has (very) severe limitations associated with management options only.

The results of the evaluation of the physical suitability are given in Tables 17 to 20. The results were aggregated at NUTS-1 level and presented as tables in Appendix 4. On Maps 1, 2 and 3 the percentage of land with no or moderate limitations (suitable land) for each NUTS-1 region is given for the groups of fast growing, normal growing more demanding and, normal growing less demanding tree species, respectively. On maps 4, 5 and 6 the results are presented per land evaluation unit.

The results of the evaluation of the physical suitability for the entire EC are given in Table 17. The suitability is given in acreages (km^2) as well as in percentages of the total EC area. The figures in this table are rounded off. The figures are discussed per group of tree species in following sections. Some attention is also given to soil types with regard to their suitability for one of the three groups of tree species. Although only the names of the soil types are given, the texture is also of great importance. For reasons of clarity, however, this is not given.

***Table 17** Total areas (km^2) and percentages (%) of suitability classes for fast growing, normal growing more demanding and, normal growing less demanding tree species for the European Communities*

Group of tree species		Suitability class 1	2	3	4
fast growing	**(km^2)**	**398 000**	**214 000**	**1 631 000**	**19 000**
	(%)	**18**	**9**	**72**	**1**
normal growing more demanding	**(km^2)**	**435 000**	**204 000**	**1 601 000**	**22 000**
	(%)	**19**	**9**	**71**	**1**
normal growing less demanding	**(km^2)**	**768 000**	**315 000**	**1 042 000**	**136 000**
	(%)	**34**	**14**	**46**	**6**

1) 1 = no, 2 = moderate, 3 = severe limitations,
4 = severe management limitations only.

Fast growing tree species

Suitability at EC level

About 18% of the EC has no limitations for fast growing tree species, whereas 9% has moderate limitations (Table 17). Half the area with moderate limitations (5% of EC) has an insufficient soil moisture supply capacity. Other moderate limitations are caused by management (2%), aeration (3%), or by a combination of these conditions. Severe limitations prevail on 72% of the EC area. The dominant reasons being a severe soil water deficit (38%) and a poor fertility level (30%). No more than 1% of the total area is unsuitable for timber production because of solely severe management restrictions. It is likely that a greater percentage than 1% is unsuitable because of management restrictions. But this could not be derived from the results because severe limitations associated with a soil water deficit or fertility overrules the management limitation. In such cases, the land evaluation unit is allocated to class 3 and not to class 4. Because both classes contain unsuitable land, the predicted production potential is not affected by this. In the following part of this section, the fast growing tree species are referred to as FG species.

Map 4, with the results of the individual land evaluation units, gives a better insight into the distribution of the suitable areas. Similar to the other maps, this map also presents relative areas of land with no or moderate limitations. Relative areas of land, even at the level of a land evaluation unit, had to be given because most of the units are compound (Reinds and Van Lanen, in prep.). The compound nature could imply that part of the unit is unsuitable whereas the other part is suitable. The map clearly shows that the best suitable soils have groundwater influence. In the south of the EC these soils are mainly located in river valleys and deltas, whereas in the north other soils with a groundwater influence or with water stagnation also occur which are well suitable. The largest areas of suitable land are found in the northwest of the EC and in northern Italy.

Suitability at country and NUTS-1 level

The suitability for FG species is presented in Table 18 for each member country of the EC. The suitability per NUTS-1 region is given in Appendix 4.

The most suitable NUTS-1 regions for FG species, i.e. those with the highest percentage of land with no or moderate limitations, was found in the southeastern regions of the UK (Map 1). For example, in the regions South East and East Anglia more than 80% of the area is evaluated as suitable. Other favourable regions (60-80% of the area with no or moderate limitations) are the East and West Midlands, both located in the United Kingdom, West Netherlands and Nord-pas-de-Calais in France. Most other regions, except for the Mediterranean regions, Scotland and Wales, have no or moderate limitations over 40-60% of the region. The southern regions of Spain, Portugal, and Greece, and southern Italy and the Mediterranean regions of France are suitable for no more than 20% of their area. This is mainly because of the high potential transpiration in these regions combined with an insufficient soil water supply capacity. The poorly suitable regions in the UK have severe fertility restrictions and are therefore suitable for no more than 20% of the region.

Table 18 Total areas (km^2) and percentages (%) of suitability classes for <u>fast growing tree species</u> for the member countries of the European Communities

Country		Suitability class[1)] 1	2	3	4
West-Germany	(km^2)	86 000	23 000	130 000	8 000
	(%)	35	9	53	3
France	(km^2)	131 000	77 000	340 000	1 000
	(%)	24	14	62	0
Italy	(km^2)	33 000	30 000	237 000	6 000
	(%)	11	10	78	2
Netherlands	(km^2)	14 000	3 000	18 000	-
	(%)	41	8	52	-
Belgium	(km^2)	8 000	4 000	18 000	0
	(%)	28	12	60	1
Luxembourg	(km^2)	1 000	0	1 000	1 000
	(%)	21	4	50	25
United Kingdom	(km^2)	42 000	13000	143 000	0
	(%)	18	22	61	0
Ireland	(km^2)	20 000	14 000	35 000	-
	(%)	29	21	51	-
Denmark	(km^2)	15 000	7 000	20 000	0
	(%)	36	17	47	0
Greece	(km^2)	11 000	0	13 000	-
	(%)	9	0	92	-
Spain	(km^2)	33 000	5 000	47 000	4 000
	(%)	6	1	92	1
Portugal	(km^2)	4 000	0	89 000	0
	(%)	4	0	96	0

1) 1 = no limitations, 2 = moderate limitations, 3 = severe limitations,
4 = severe management limitations

At country level, France has the largest area of land within the EC with no or moderate limitations for FG species. About 21 million hectares are suitable which is about 38% of the land. Germany has the second largest suitable area, about 11 million hectares or 44% of the country's area. The smallest area of suitable land is found in Luxembourg: 13000 hectares or 25% of the land. This is of course, due to the small size of the country. If we consider the percentage of suitable land, Denmark has the highest percentage of suitable land, i.e. 53%, followed by Ireland and the Netherlands, where about 50% of the land is suitable. The smallest percentages of suitable land are found in Portugal (4%), Spain (7%) and Greece (8%). This is mainly due to the very high precipitation deficits in large parts of these countries (e.g. Reinds et al., in prep.).

In the next part of this section, the most and least suitable soils for FG species are presented for each member country. Furthermore, the main limitations are given as well as the percentages of suitable and unsuitable land.

In West-Germany the most suitable soils for FG species are mainly Eutric Gleyic and Fluvi Calcaric Fluvisols and, Orthic Luvisols. About 44% of Germany has no or moderate limitations for FG species (Table 18). The main limitation is a poor fertility level on about 42% of the land. This mainly occurs on Distric Cambisols and Humic or Orthic Podzols which have a very low CEC and a low base saturation. The most suitable NUTS-1 regions are Schleswig-Holstein (55%), Bremen (70%) and Baden-Wurttemberg (56% of NUTS-1 area). In these regions, large areas with Orthic Luvisols occur. The least suitable region is Rheinland-Pfalz where 31% is suitable. In this region, Dystric Cambisols with a poor fertility state are dominant.

In France the most suitable soils are principally Fluvisols. Cambisols may also be well suitable if the soil water supply capacity and fertility level are sufficient. About 48% of France has no or moderate limitations for FG species (Table 18). The main causes of growth stress are severe soil water deficit and a poor fertility level, which account for 26% and 35% respectively. The soil water deficit varies not only per soil type but also per agro-climatic zone. Because of drier climatic conditions, the soil water deficit becomes greater in the southern regions. The soil water deficit may overshadow other limiting factors, such as management conditions due to slopes. Severe soil water limitations mainly occur on Eutric Cambisols and Orthic Rendzinas. Severe fertility limitations mainly occur on Orthic and Leptic Podzols, Podzoluvisols, Rankers and Dystric Lithosols. The most suitable NUTS-1 regions are found in the north: Bassin Parisien (49%), Est (49%) and Nord-pas-de-Calais (77% of NUTS-1 area) where Fluvisols, Gleyic, Calcaric and Vertic Cambisols and Orthic Luvisols are frequent. The least suitable region is the southern Mediterranean with 14% suitable land. In this region, the potential transpiration is too high compared with the soil water supply capacity of most soils.

Italy is for about 21% suitable for FG species. The most suitable soils are principally Fluvisols. On about 55% of Italian land a severe soil water deficit dominates on mainly Eutric Cambisols, Calcaric Regosols and, Calcaric Luvisols. Severe fertility limitations occur on about 21% of the land on mainly Dystric Cambisols and Dystric Lithosols which both have a very low CEC and a low base saturation. The most suitable regions at NUTS-1 level are the northern regions: Lombardia (48%), Nord-Est (48%) and Emilia-Romagna (54% of the NUTS-1 area), where potential transpiration is relatively low and relatively large areas of Eutric Cambisols and Orthic Rendzinas occur.

In the Netherlands about 48% of the land has no or moderate limitations for FG species. The main well suitable soils are Fluvisols. A poor fertility level is the dominant limitation on about 50% of the land. This mainly occurs on Podzols and

Dystric Histosols. West Netherlands is the most suitable NUTS-1 region. There, 75% of the land has no or moderate limitations. The dominant soil types are Fluvisols and Eutric Histosols. The least suitable region is South Netherlands with 34% suitable land and where Podzols are dominant.

In Belgium 39% of the land is suitable. Also in Belgium, Fluvisols and Orthic Luvisols are the best suitable soil types. The main severe limitation is a poor fertility level which occurs on about 56% of the land, which mainly comprises Podzols, Podzoluvisols and Dystric Cambisols. The most suitable NUTS-1 region is Brussels with 72% of suitable land. The most suitable soils in this region are Fluvisols and Orthic Luvisols. The Flemish region is the least suitable (33% of NUTS-1 area) because of large areas of Podzols and Dystric Podzoluvisols which have a low natural fertility state.

About 25% of Luxembourg has no or moderate limitations for FG species. The most suitable soil types are mainly Vertic Cambisols. The dominant severe limitation is a poor fertility status which principally occurs on Dystric Cambisols, for about 34% of the land. Luxembourg is not further subdivided into NUTS-1 regions.

In the United Kingdom about 39% of the land is suitable for FG species. The most suitable soils are mainly Fluvisols, Eutric and Gleyic Cambisols and Orthic and Gleyic Luvisols. On about 50% of the land a poor fertility level seriously reduces tree growth. Map 1 shows a remarkable decrease in suitability from south to north in the UK which is determined by the prevailing soil types. Hence, the most suitable NUTS-1 regions can be found in East Anglia (80%), the East Midlands (76%) and the South East (83% of NUTS-1 area). Here, large areas occur with well suitable Fluvisols, Cambisols and Gleysols. The least suitable NUTS-1 regions are Scotland (12%) and Wales (14%). The low figure for Scotland is due to large areas of Dystric Histosols, Podzols, and Dystric Cambisols which have a poor fertility status. In Wales, Dystric Cambisols with a poor fertility state also occur frequently.

About 48% of Ireland has no or moderate restrictions for the group of FG species. The most suitable soils are mainly Orthic Luvisols and Stagno Dystric Gleysols. About 46% of the land has severe fertility restrictions which mainly occur on Dystric Cambisols, Dystric Lithosols and on Podzols.

As mentioned above, Denmark, of all the member countries of the EC, has the highest percentage of suitable land for FG species, i.e. 53%. Well suitable soils are principally Eutric Cambisols and Orthic Luvisols. About 47% of the land suffers from severe fertility restrictions, mainly on Humic Gleysols and Podzols.

About 8% of Greece is well suitable for FG species. Nearly all the well suited soils are Fluvi Calcaric Fluvisols in which the FG species are permanently fed by groundwater through capillary rise. Other soils are unsuited because of an insufficient soil water supply capacity and very high potential transpiration. The North is the most suitable NUTS-1 region. About 11% has no or moderate limitations. In this region, the largest area of Fluvisols occur in which permanent groundwater ensures an adequate soil water supply. The least suitable regios, with only 2% suitable land are the East and Southern Islands. Hardly any Fluvisols or other groundwater affected soils are found here. Hence, a severe soil water deficit is the most important limitation.

In Spain about 7% of the land has no or moderate limitations for FG species. Because of the high potential transpiration, only soils with a permanent groundwater influence are well suited. Hence, the best soils are mainly Fluvisols. The most important restriction is a soil water deficit which occurs on a wide range of soil types (68% of the land). On about 22% of Spanish land a poor fertility level reduces tree growth. This land mainly comprises Humic and Dystric Cambisols, Podzols, Dystric Lithosols, and Rankers. The most suitable NUTS-1 regions are Noreste and Madrid with 13% and 16% of land with, respectively, no or moderate limitations. The least suitable regions are Noroeste and Sur with 3% and 5% suitable land respectively. A severe soil water deficit is the dominant restriction.

Portugal has the lowest percentage of suitable land of all the EC member countries: about 4% of Portuguese land. Suitable soils are mainly Fluvisols and Luvisols. A poor fertility level and severe soil water deficit are the main limitations on about 47% of Portuguese land. Growth limitation caused by a soil water deficit prevails on almost all soil types, whereas a limitation caused by poor fertility mainly occurs on Cambisols. In Portugal, the most suitable NUTS-1 region is Sud do Continente where about 7% of the land has no or moderate limitations for FG species. Suitable soils are Eutric Fluvisols and Gleyic Luvisols. In the Norte do Continente region, no more than 2% of the land is suitable. A poor fertility level is the dominant limitation in about 70% of this region.

Normal growing more demanding tree species

Suitability at EC level

In the following part of this section the normal growing more demanding tree species are indicated as NGM species.

About 28% of the EC has no or moderate limitations for normal growing more demanding tree species (Table 17). This percentage is equivalent to about 64 million hectares. The moderate limitations, which occur on 8% of EC land, mainly refer to a poor soil aeration (6% of EC land). On about 72% of the EC area, severe limitations prevail for NGM species. About 36% of the EC has a severe soil water deficit, 25% has a poor fertility status, 9% has inadequate aeration, and about 1% has severe management limitations only.

Suitability at country and NUTS-1 level

The suitability for NGM species is given in Table 19 for each member country of the EC. The suitability per NUTS-1 region is presented in Appendix 5.

Table 19 Total areas (km²) and percentages (%) of suitability classes for <u>normal growing more demanding tree species</u> for the member countries of the European Communities

Country		Suitability class[1)] 1	2	3	4
West-Germany	(km²)	83 000	21 000	135 000	8 000
	(%)	33	9	55	3
France	(km²)	197 000	87 000	264 000	0
	(%)	36	16	48	0
Italy	(km²)	55 000	16 000	228 000	4 000
	(%)	18	5	75	2
Netherlands	(km²)	4 000	10 000	20 000	-
	(%)	12	29	59	-
Belgium	(km²)	8 000	3 000	19 000	-
	(%)	28	10	62	-
Luxembourg	(km²)	0	0	2 000	-
	(%)	21	5	74	-
United Kingdom	(km²)	41 000	9 000	186 000	0
	(%)	18	4	79	0
Ireland	(km²)	19 000	3 000	47 000	-
	(%)	28	4	68	-
Denmark	(km²)	22 000	0	20 000	0
	(%)	51	1	47	0
Greece	(km²)	0	11 000	126 000	-
	(%)	0	8	92	-
Spain	(km²)	5 000	40 000	463 000	6 000
	(%)	1	8	90	1
Portugal	(km²)	300	3 000	89 000	0
	(%)	0	4	96	0

1) 1 = no limitations, 2 = moderate limitations, 3 = severe limitations,
4 = severe management limitations only.

The evaluation results per NUTS-1 region for NGM species are presented on Map 2. This map shows that the most suitable regions can be found in northwest France. More than 60% of this land is suitable. All regions close to the Alps in northern Italy, eastern France and the southern part of West Germany, southwest France, southeast Britain and Denmark have no or moderate limitations on 40-60% of the area. In the more southerly regions than these, the area of suitable land decreases, mainly because of high soil water deficits. No more than 20% of the land in these regions is suitable. The northern part of the United Kingdom is also suitable for no more than 20%. This is mainly due to inadequate soil aeration and poor fertility of the soils.

In an absolute sense, France has the largest area with no or moderate limitations for NGM species, i.e. about 28 million hectares, which is about 52% of the area of the country. The smallest area of well suitable land is found in Luxembourg: 69 000 hectares or 26%. If we only consider the percentages, both France and Denmark have the highest percentages of suitable land, i.e. both about 52%. The lowest percentage of suitable land is in Portugal, and amounts to 4% of the land.

In West-Germany the most suitable soils are mainly Orthic Luvisols which have many favourable characteristics. About 42% has no or moderate limitations for NGM species. The main restriction is a poor fertility level which occurs on about 50% of the land. The dominant soil types with fertility problems are Podzols and Dystric Cambisols. At NUTS-1 level, the regions with the highest percentage of no or moderate limitations are Bremen (61%), Nordrhein-Westfalen (49%) and Baden-Wurttemberg (55% of NUTS-1 area). The least suitable regions are Niedersachsen and Rheinland-Pfalz, where 30% is suitable.

France: about 52% of French land has no or moderate limitations for NGM species. The most suitable soils are Orthic Luvisols, Eutric Cambisols, and some of the Fluvisols. A severe soil water deficit (26%) and a poor fertility level (21% of the land) are the main causes of growth reduction. In the regions with a high potential transpiration, soil water deficits occur on almost every soil type without groundwater influence. A poor fertility level mainly occurs on Podzols and Dystric Cambisols. Most of the French NUTS-1 regions have vast areas of suitable land for NGM species. In Nord-pas-de-Calais 83% of the area is suitable. Conversely, the Mediterranean is unsuitable for about 85%; 60% because of a soil water deficit and 24% because of a poor fertility level. Hence, it was found to be the least suitable NUTS-1 region of France.

In Italy 23% of the land has no or moderate limitations for NGM species. The most suitable soils mainly comprise Eutric and Vertic Calcaric Cambisols and Orthic Luvisols. Calcaric Regosols are also suitable. The main growth limiting factor (48% of Italian land) is a severe soil water deficit which occurs on many soil types. The second important limiting factor is a poor fertility level on 21% of the land which occurs on mainly Dystric Cambisols and Podzols. The most suitable NUTS-1 regions are found in the north of Italy. In Nord-Est and Lombardia, about 55% of the region has no or moderate limitations. The southern regions are the least suitable. Sicilia is evaluated as completely unsuitable for NGM species, whereas in the regions Sardegna and Sud suitable land covers no more than 1% and 4% respectively.

In the Netherlands 40% of the land has no or moderate limitations. For the most part, Calcaric Fluvi Cambisols and Orthic Luvisols contribute to the area of suitable land. The predominant restriction is a poor fertility level (41% of Dutch land) occurring mainly on Podzols. The highest percentage of suitable land is found in the NUTS-1 region West-Netherlands (59%), where large areas of Fluvisols occur. Although the Fluvisols are evaluated as suitable, half of them have moderate limitations with regard to soil aeration. Better suitable soils, such as Fluvi Calcic Cambisols, cover only small areas in this region. The least suitable NUTS-1 regions are North and South Netherlands where about 33% of the land is suitable.

In Belgium about 37% is suitable for NGM species. The most suitable soils are Orthic Luvisols. The main growth limitation (56% of Belgian land) is caused by poor fertility which predominantly occurs on Podzols and Dystric Podzoluvisols. The NUTS-1 region Brussel is the most suitable region of Belgium. In this small region, 83% of the land is suitable. The dominant soil type is an Orthic Luvisol which has no limitations. In the least suitable region, viz. the Flemish region, 33% of the land is suitable. There, large areas of Podzols occur, the fertility status of which is too low for NGM species.

In Luxembourg 26% of the land is suitable, the soils of which are mainly Vertic Cambisols. Because of a vast area of Dystric Cambisols, about 34% of the land has severe fertility limitations. Severe aeration limitations occur on about 25% of the land.This area mainly consists of Stagno Gleyic Luvisols. Luxembourg is not further subdivided into NUTS-1 regions.

About 22% of the United Kingdom has no or moderate limitations for NGM species. This is the lowest percentage of suitable land of the northern member countries and equals about the percentage for Italy. The most suitable soils are some Fluvisols, Eutric, Gleyic or Calcaric Cambisols (or combination of these), and Orthic or Calcaric Luvisols. The predominant limiting factor is a poor fertility status. Severe aeration restrictions mainly occur on soil types with water stagnation and with a fine texture, such as (Stagno) Gleysols, (Stagno) Luvisols and on Histosols. On the latter soils, the drainage is very poor. Fertility problems mainly occur on Dystric Cambisols. Regosols and Podzols also often have fertility limitations. Great differences in the area of suitable land occur among the UK NUTS-1 regions. In East Anglia 45% of the land has no limitations for NGM species, whereas in Northern Ireland and in the North no more than 3% of the land has no limitations. Conversely, in the southeastern regions relatively high percentages of suitable land occur. In the poorly suitable regions, large areas of Histosols, Stagno Gleysols and Placic Podzols occur, which are unsuitable because of inadequate aeration.

In Ireland about 32% of the land is suitable for NGM species. The most suitable soils are principally Orthic Luvisols. About 43% of the land is unsuitable because of inadequate aeration. This severe restriction mainly occurs on Gleysols, Placic Podzols and Histosols. Another 24% of the land is unsuitable because of fertility limitations. Most Dystric Lithosols, Dystric Cambisols and Orthic Podzols have this adverse quality. Ireland is not further subdivided into NUTS-1 regions.

In Denmark 52% of the land is suitable for NGM species. This percentage is the highest of all the EC member countries. The most suitable soils are Eutric Cambisols and Orthic Luvisols. The dominant limitation is the poor fertility status of the Dystric Regosols and Podzols. Denmark is not further subdivided into NUTS-1 regions.

In Greece no land without limitations for NGM species occurs, and no more than 8% of the land has moderate limitations. On the other 92% of Greek land, severe limitations for NGM species were assessed to occur. The moderate limitations occur on Fluvisols. In Greece, the main limiting factor is a high soil water deficit which occurs on about 78% of the land and includes almost every soil type. This indicates the importance of an adequate soil water supply capacity. The NUTS-1 region North has the highest percentage of suitable land, i.e. 11%. The regions East and South have the lowest percentage, i.e. 2%. This difference between the north and south is because of the Fluvisols which are mainly situated in the north of Greece.

Spain has about 9% of land with no or moderate limitations for NGM species. No limitations occur on no more than 1% of Spanish land, which is chiefly covered by Calcaric Cambisols. Moderate limitations can mainly be found on Fluvisols. The most suitable regions are Noreste and Madrid where about 15% of the land has no or moderate limitations. In these regions, relatively large areas of Fluvisols occur. The least suitable NUTS-1 region is Sur with no more than 5% of suitable land. 84% of this region is unsuitable because of a severe soil water deficit. On Map 2, these differences are not visible because all Spanish NUTS-1 regions are classified under the devision of 0-20% suitable land. Map 5 offers a better insight into the dispersal.

In Portugal only 4% of the land is suitable for NGM species. Hence, Portugal has the smallest area of suitable land for NGM species of all the EC member countries. The suitable soils comprise Eutric Fluvisols, Calcaric or Chromic Cambisols, and Orthic, Calcic or Calcaric Luvisols. About 43% of Portuguese land is unsuitable because of a severe soil water deficit and 47% is unsuitable because of a poor fertility status. The latter restriction mainly occurs in NUTS-1 region Norte do Continente on Cambisols. A severe soil water deficit mainly occurs in Sud do Continente where potential transpiration is very high.

Normal growing less demanding tree species

Suitability at EC level

Of the total area of the EC, about 34% (Table 17) has no limitations for normal growing less demanding tree species (NGL species), and 14% has moderate limitations. The total area of suitable land, viz. 48% of EC land, is the highest percentage for the three groups of tree species considered in this study. This is not surprising as NGL species demand the lowest requirements of the land. A severe soil water deficit is by far the most important limitation within the EC for NGL species. About 40% of the EC has such a severe soil water deficit, and on another 6% of the EC severe management limitations occur. Northwest Europe has large areas of suitable land for NGL species (Map 3). Similar to the other groups of tree species, it is mainly a severe soil water deficit that prevents land being evaluated as suitable for NGL species. Most of the regions in Spain, Portugal and Greece are suitable for no more than 20%. In Ireland and the south of the United Kingdom 60-80% of the area has no limitations.

The suitability of NGL species is given for each member country of the EC in Table 20. The suitability per NUTS-1 region is given in Appendix 6.

Table 20 Total areas (km²) and percentages (%) of suitability classes for normal growing less demanding tree species for the member countries of the European Communities

Country		Suitability class[1)] 1	2	3	4
West-Germany	(km²)	180 000	28 000	26 000	14 000
	(%)	73	11	10	6
France	(km²)	279 000	112 000	120 000	37 000
	(%)	51	20	22	7
Italy	(km²)	81 000	30 000	167 000	28 000
	(%)	27	10	55	9
Netherlands	(km²)	18 000	12 000	4 000	0
	(%)	54	34	11	1
Belgium	(km²)	23 000	5 000	2 000	0
	(%)	76	18	7	0
Luxembourg	(km²)	2 000	0	1 000	0
	(%)	59	11	30	0
United Kingdom	(km²)	101 000	34 000	74 000	28 000
	(%)	73	14	31	12
Ireland	(km²)	38 000	7 000	17 000	6 000
	(%)	55	10	26	9
Denmark	(km²)	23 000	17 000	3 000	0
	(%)	53	40	8	0
Greece	(km²)	0	13 000	124 000	0
	(%)	0	9	91	0
Spain	(km²)	24 000	49 000	422 000	21 000
	(%)	5	10	82	4
Portugal	(km²)	0	8 000	82 000	3 000
	(%)	0	9	88	3

1) 1 = no limitations, 2 = moderate limitations, 3 = severe limitations, 4 = severe management limitations only.

The largest area in a member state of the EC with no or moderate limitations for NGL species was found in France, i.e. about 39 million hectares, which is about 71% of the land (Table 20). The second largest area was in Germany where 21 million hectares or 84% of the land has no or moderate limitations. The smallest area of suitable land was found in Luxembourg where no more than 0.2 million hectares or 70% has no or moderate limitations. The highest percentage of suitable land was found in Belgium and Denmark, viz. 93%. Belgium has the highest percentage of land with no limitation, namely 76%. The lowest percentages of suitable land were found in Greece and Portugal, where no more than about 9% of the land was suitable. In these countries, the soil water deficit is so high that tree growth is seriously reduced on most soils.

Suitability at country and NUTS-1 level

About 84% of Germany has no or moderate limitations for NGL species. The major well suitable soils are Eutric and Dystric Cambisols, Orthic Luvisols, Dystric Podzoluvisols and Podzols. The main restriction is poor soil aeration on about 9% of German land which is covered with Gleysols, Gleyic Cambisols and Eutric Histosols. On about 5% of German land, severe management limitations prevail. The most suitable NUTS-1 regions are Hessen, Schleswig-Holstein, Bremen, Nordrhein-Westfalen, Rheinland-Pfalz and Saarland where about 90% of the land is suitable. In these regions, large areas of Dystric Cambisols and Orthic Luvisols occur. The least suitable region is Bayern where 77% of the land is suitable. About 10% of the land in Bayern has severe aeration problems for NGL species. This land mainly consists of Cambisols and Eutric Histosols. Furthermore, about 10% has severe management limitations only.

In France 71% of the land has no or moderate limitations for NGL species. The most suitable soils are mainly all kinds of Cambisols and Luvisols. A severe soil water deficit is the main limitation on 21% of the French land. This may occur on various soil types. On about 7% of French land, which is often covered with Cambisols severe management limitations prevail. The most suitable NUTS-1 regions are Nord-pas-de-Calais (92%), Ile de France (83%), Bassin Parisien (83%), Sud-Ouest (81%) and Ouest (85% of NUTS-1 area). The least suitable NUTS-1 region in France is the Mediterranean where 27% has no or moderate limitations. A severe soil water deficit is the most important limiting factor on about 61% of the land in this region and occurs on nearly all soil types.

About 36% of Italy has no or moderate limitations for NGL species. The most suitable soils are mainly Eutric, Calcaric and Dystric Cambisols, Orthic Luvisols and Dystric Lithosols. The main restriction is a severe soil water deficit which prevails on about 53% of Italian land. About 9% is unsuitable because of severe management limitations. The most suitable NUTS-1 regions are found in the northern part of the country: both Nord-Est and Lombardia are suitable for about 71% of the NUTS-1 area. In these regions, relatively large areas of favourable Cambisols and Luvisols are found. Compared with many other regions, the potential transpiration in these regions is relatively low, which means that the soil water supply capacity of these soils is sufficient to fulfil demand. The least suitable NUTS-1 region is Sardegna where 15% of the land is classified as suitable. There, potential transpiration and the precipitation deficit are very high. The latter can reach 500 mm.

In the Netherlands 88% is suitable for NGL species. The most suitable soils are chiefly Calcic, Dystric and Gleyic Cambisols, Orthic, Humic and Gleyic Podzols and Orthic Luvisols. The main limitation is poor soil aeration which occurs on 11% of Dutch land. Poor aeration is principally found on Eutric Histosols and Gleysols. The most suitable NUTS-1 regions are East and South Netherlands with 96% and 99%

of suitable land respectively. In these regions, large areas of Podzols and Cambisols occur. The least suitable NUTS-1 region, West Netherlands, has 77% suitable land. In this region, large areas of Eutric Histosols occur which have severe aeration or management limitations.

In Belgium 93% of the land is suitable for NGL species. Of the EC member countries, both Belgium and Denmark have the highest percentage of suitable land for NGL species. The most suitable soils are mainly Orthic Luvisols, Podzoluvisols and Podzols. Most Regosols and Cambisols are also suitable. The main limitation is a soil water deficit combined with management limitations on about 4% of Belgian land. These combined limitations mainly occur on Dystric Cambisols and Orthic Luvisols.

In Luxembourg 70% of the territory is suitable. The most suitable soils are mainly Eutric, Dystric and Vertic Cambisols. About 25% of the land has severe aeration limitations, which chiefly occur on Stagno Gleyic Luvisols. Luxembourg is not further subdivided into NUTS-1 regions.

The United Kingdom has about 57% land with no or moderate limitations for NGL species. The most suitable soils are mainly Calcic Gleyic Fluvisols, Dystric, Eutric and Gleyic Calcic Cambisols, Gleyic Podzols, and Stagno Gleyic Luvisols. The most suitable NUTS-1 region is the South West where 82% of the land has no or moderate limitations. In this region, Orthic and Chromic Luvisols as well as Eutric, Dystric and Gleyic Cambisols frequently occur. The least suitable NUTS-1 regions are the North and North West where 20% of the region is suitable. In these regions, vast areas occur with perched watertables.

About 73% of Ireland has no or moderate limitations for NGL species. The major part of the most suitable soils are Eutric and Dystric Cambisols, Orthic Luvisols, and Orthic Podzols. The dominant limitation is caused by poor soil aeration which occurs on 25% of Irish land. The land with poor soil aeration is mainly covered with Gleysols. Ireland is not further subdivided into NUTS-1 regions.

In Denmark about 93% of the land has no or moderate limitations for NGL species. This is the highest percentage found within the EC and equals the percentage of suitable land in Belgium. The most suitable soils are principally Eutric Cambisols and Orthic Luvisols. Poor soil aeration is by far the main limitation. Poor aeration occurs on 8% of the land, which is mainly covered with Humic Gleysols. Denmark is not further subdivided into NUTS-1 regions.

In Greece about 9% of the land is suitable for NGL species. This percentage, together with that of Portugal is, the lowest within the EC. The most suitable soils, which mainly comprise Fluvi Calcaric Fluvisols, still have moderate limitations. On all other soils, a severe soil water deficit is the predominant restriction. The most suitable NUTS-1 region is the North where 12% of the land has moderate limitations. This land is covered with Fluvisols. For the East and Southern Islands region no more then 3% of the land is suitable. There, large areas of Lithosols occur in which the rooting depth is shallow (10-40 cm) whereas the precipitation deficit is high.

In Spain 14% of the land has no or moderate limitations for NGL species. The most suitable soils are Calcic Cambisols. Some Humic Podzols, Gleyic Cambisols, Rhodo Chromic Luvisols, Vertic Andosols and Rankers are also suitable. The main limitation is a severe soil water deficit on about 82% of Spanish land. The most suitable NUTS-1 region is Noroeste where 30% of the land is suitable. The least suitable region is Sur where no more than 5% is suitable.

In Portugal 9% of the land is suitable for NGL species. Together with Greece this is the lowest percentage within the EC. The most suitable soils are Chromic Cambisols. The main limiting factor is a severe soil water deficit on 87% of the land. A severe deficit occurs on many soil types because of the high potential transpiration. The most suitable NUTS-1 region is Norte do Continente where 11% of the land is suitable. Because Portugal is subdivided into two NUTS-1 regions, the other NUTS-1 region, Sud do Continente, becomes the least suitable with 7% of suitable land. In this region, potential transpiration is higher than in the northern region, whereby the soil water deficit also becomes higher.

Competitive land for forest trees and other crop types

Areas of land of a NUTS-1 region, suitable for both forest trees and other crop types (e.g. intensively managed grass, cereals and root crops) were estimated. This land was indicated as competitive land. Because of the different requirements, and hence, different suitable areas, the procedure was repeated three times, viz. for fast growing, normal growing more demanding and normal growing less demanding tree species. Furthermore, the area that was only suitable for one of the three groups of tree species or only for the other type of crop was assessed. Moreover, the common area of unsuitable land was estimated. The estimation procedure is explained in Chapter 4. Further explanation can also be found in this section where competitive suitable land for fruit trees and other crops is discussed. In the following section competitive land for each of the three groups of tree species is dealt with separately.

Competitive land for fast growing tree species and other crop types.

Appendix 7 (first column) illustrates that high percentages of competitive land (> 50% of the NUTS-1 region) occur in Bremen (Germany), Nord-Pas-de-Calais (France), West Netherlands, Denmark, East Anglia, East and West Midlands, and the South East (United Kingdom). These high percentages principally refer to grass. In Bremen, Nord-Pas-de-Calais, West Netherlands, and Denmark, suitable land for fast growing trees also competes with cereals. The percentage of land on which fast growing trees compete with root crops is usually lower than the percentage for cereals. If we consider Appendix 7 it is striking that in nearly all cases the percentage of competitive land (first column) is higher than the percentage of land only suitable for FG species (second column). There are exceptions in most of the UK and half of the German NUTS-1 regions where the percentage of competitive land with root crops is lower than the percentage only suitable for FG species. In these regions, large areas of Orthic Luvisols and Gleysols occur on which fast growing trees grow very well but root crops have aeration or workability limitations. Another striking point is the percentage of land only suitable for grass, cereals or root crops (third column) which, in many cases, is higher than the percentage of land only suitable for FG species. There are two reasons for this. First, a soil water deficit is more limiting for fast growing trees than for the agricultural crops considered. FG species can archieve a good yield if there is a large and permanent supply of soil water. It is likely that agricultural crops can adapt to less. Second, is the difference in importance of the natural fertility status between fast growing trees and agricultural crops. A starting point for evaluating the land evaluation units for fast growing trees was their natural status without any improvement to the soil, such as fertilization. Hence, the natural fertility status may be a limiting factor for forest trees. The potential of agricultural crops was assessed without taking natural fertility into account because of the regular nutrient inputs. For such crops, natural fertility is never a limitation. The fourth and last column of Appendix 7 specifies the percentage of land of each NUTS-1 region which is unsuitable for FG species, grass, cereals and root crops. The percentages for some regions, especially the Mediterranean ones, may be very high (more than 80%). The reasons for this, such as a severe soil water deficit, are stated earlier in 5.1.2 of this Section .

Competitive land for normal growing more demanding tree species

High percentages with competitive land (> 50% of the NUTS-1 region) between normal growing more demanding tree species (NGM-species) occur in Bremen (Germany), Bassin Parisien, Nord-Pas-de-Calais, Est, Ouest (France), West Netherlands and Denmark (Appendix 8). Very low percentages of competitive land (< 5% of the NUTS-1 region) occur in Lazio, Sud, Sicilia, Sardegna (Italy), the North, Northern Ireland (United Kingdom), East and Southern Islands (Greece), Noroeste, Sur (Spain) and Norte do Continente (Portugal). In these regions, the percentage of competitive land is low because the total percentage of suitable land is very low. Hence, there is no land to compete for. The second column of Appendix 8 gives the percentage of land which is only suitable for NGM species. It is striking that in nearly all regions, the percentage of land only suitable for NGM species and not for root crops is (much) higher than the percentage not suitable for grass and cereals. Root crops, however, demand additional requirements of the land compared with cereals and grass (e.g. workability, stoniness, aeration). In several German, British, Belgian, Dutch and Spanish regions the percentage of land only suitable for agricultural crops (Appendix 8 third column) is relatively high. The fertility status of the soil, which places no restrictions on the agricultural crops because of artificial nutrient inputs causes the different suitability assessment compared with NGM species. The last column of Appendix 8 specifies the percentage of land of each NUTS-1 region unsuitable for all crop types. Similar to the fast growing trees, in most Mediterranean regions, the percentage of unsuitable land for NGM species and agricultural crops is high.

Competitive land for normal growing less demanding tree species

Appendix 9 gives the estimated competitive percentages of land, and the percentages of common unsuitable land for normal growing less demanding tree species (NGL species) and three groups of agricultural crops (e.g. grass, cereals, root crops). Furthermore, the percentage of land only suitable for NGL species or one of the three other crop types is presented. The high percentages of competitive land in many of the NUTS-1 regions are striking. Therefore, the percentages that are only suitable for other crop types are low. Exceptions are the percentages of land only suitable for grass in the NUTS-1 regions of the United Kingdom, Spain and Portugal as well as for cereals in Spain and Portugal, which are relatively high. Of the three groups of tree species, the group of NGL species, has the highest percentage of land which is only suitable for these types of trees. Thus, as expected, NGL species have different and lower demands than the agricultural crops. However, there are regions with a very high percentage of land which is unsuitable for NGL species and all the agricultural crop types considered: examples are Lazio, Campania and Sardegna (Italy), North, Central and East and Southern Islands (Greece) which have 80% or more of unsuitable land. The reasons for this, such as severe soil water deficit, have already been given in 5.1.2 of this Section.

5.2 Rainfed and irrigated fruit trees

The principal EC areas for fruit trees (excluding olives and citrus) are located in Spain, Italy, France, Portugal and Greece (Eurostat, 1988). They cover about 95% of the EC area, and produce about 75% of all the fruit harvested in the European Communities. However, fruit trees can grow in all the member states of the European Communities. In Scotland and Ireland, it is likely that fruit trees can only develop on sheltered and relatively dry and sunny locations. For instance, slightly less than 2000 hectares of apple orchards occur in Northern Ireland, and in Ireland there are only 1300 hectares, mainly localized in the south and east (Hough, 1990). According to Thran and Broekhuizen (1965) only in the very northern part of the UK does the climate not allow fruit growing. In Scotland therefore, the orchard area is small (Hough, 1990).

In this section, the suitability of EC land for the cultivation of trees producing fruit will be presented. This suitability assessment will be of a general nature. So, land will only be evaluated for general climatic and soil requirements which are relevant for a broad group of fruit trees. The trees of this broad group have one particular property in common, viz. the trees considered have a low drought susceptibility. Fruit trees with more specific requirements, for example citrus, olives and grapes are widely discussed in other sections of this report. First, the generally applicable climatic and soil requirements are explained. Next, the percentages of well suitable, moderately suitable and unsuitable land for each NUTS-1 region are given. Finally, some results are presented on how far suitable land for the broad group of fruit trees coincides with suitable land for grass, cereals and root crops.

5.2.1 Evaluation criteria

Generally applicable soil and climatic requirements are dealt with to evaluate EC land for its potential to grow trees which produce fresh fruit. We have assumed that trees producing fruit can be grown in each country within the European Communities. In this section, no particular fruit tree species is defined, such as apple, peach, cherry etc. EC land will only be evaluated for general requirements. When the suitability for a particular fruit tree needs to be known for detailed investigations, more specific climatic requirements should be included. In particular, it is the temperature regime that governs the regional cultivation possibilities of certain fruit tree species. For instance, the main woody fruit crops, e.g. apple, pear, peach, apricot and cherry, have distinctly different heat requirements (e.g. Papadakis, 1970). Pear is less winter resistant than apple, and its heat requirements are a little higher. Cherry also is less winter resistant than apple, but its chilling requirements are perhaps as high of those of apple. The heat demands of cherry are comparable with those of apple. Apricot and peach have approximately the same climatic requirements. The chilling demands of both crops are lower than those of apple. However, apricot is more susceptible to early night frosts than peach. Kronenberg (1989) pointed out that even among the cultivars of a certain fruit tree crop, differences occur in the required temperature regime. He showed that the northern limit of the apple cultivar 'Cox's Orange Pippin' follows a line from central England through the south of Norway, whereas the cultivar 'Granny Smith' has its northern boundary approximately through the middle of France.

The number of fruit tree species and cultivars which can grow in the different EC regions will vary depending on the prevailing temperature regime. However, we assumed that the temperature regime of each administrative region (NUTS-1 level) allows at least one fruit tree crop to be cultivated. Apples can usually be grown in the northern member states, whereas peaches can be cultivated in the southern member states.

The evaluation criteria for the cultivation of fruit trees were subdivided into general soil and climatic requirements. Two different management situations were defined, namely a rainfed situation and a situation with irrigation. In both situations proper management was assumed to prevail (e.g. selection of appropriate rootstocks, pruning, application of nutrients and pesticides, establishment of windbreaks, late night frost protection by sprinkling etc.).

Climatic criteria

Generally, trees producing fruit are susceptible to drought. Hence, under rainfed conditions, it was assumed that drought susceptibility of EC land should be evaluated. First, it is relevant to consider the mean annual precipitation deficit. The mean precipitation deficit has been defined as the sum of the difference between the monthly potential evapotranspiration and rainfall in months having a deficit (Chapter 3). The mean annual precipitation deficit varies from less than 100 mm in the northern member states to more than 400 mm in the southern member states. In some parts of Southern Portugal and Spain, the deficit amounts to more than 800 mm. In areas with a mean annual precipitation deficit of less than 50 mm, no limitations were assumed to occur. This amount of water can easily be supplied by available soil water. In areas with higher mean annual precipitation deficits, soil characteristics were considered to appraise the drought susceptibility of the land.

As mentioned above, when assessing the potential for the broad group of fruit trees, no temperature requirements were taken into account.

Soil criteria

Drought susceptibility

The drought susceptibility of land evaluation units located in areas with a mean annual precipitation deficit higher than 50 mm, was determined by analysing soil drainage, soil texture, soil depth and soil phase (Appendix 2). The tree with decision rules is too detailed for a full presentation. Hence, only the principal criteria captured in the decision tree are outlined.

Non-mineral soils (Histosols) were assumed to have a low drought susceptibility, irrespective of the mean annual precipitation deficit (Table 21). In areas with a precipitation deficit of between 50 mm and 100 mm only the excessively drained mineral soils were assumed to have moderate restrictions for producing fruit. All other soils in these areas are wetter, and were therefore considered to have no drought limitations. The moderately well and well drained, coarse textured soils are an exception. These soils have moderate constraints. In agro-climatic regions where the deficit varies between 100 mm and 300 mm, all moderately well, well, and excessively drained soils were expected to have moderate or severe limitations. In areas with a deficit higher than 300 mm, the temporarily poorly and imperfectly drained soils were also assumed to have limitations. If these soils have other drawbacks (e.g. a shallow soil depth or a coarse texture) severe limitations were assumed to prevail. The very poorly and poorly drained soils were usually expected to have no drought problems.

Very shallow and shallow soils (soil depth <40 cm) do not supply sufficient soil water to the fruit trees to cover long rainless periods. So, in areas with a mean annual precipitation deficit of higher than 50 mm these soils were assumed to be unsuitable because of a high drought susceptibility. In areas with a precipitation deficit of more than 300 mm even the moderately shallow soils (depth <60 cm) were appraised to be unsuitable for producing fruit. The drought susceptibility of soils with a soil depth of more than 60 cm, was assumed to depend on the soil texture, and the presence of soil phases. Generally, the coarse textured or heavy textured soils were assumed to have more restrictions than medium, medium fine or fine textured soils. The occurrence of soil phases (e.g. gravelly, stony, lithic phases) was estimated to adversely affect the suitability for fruit producing compared with similar soils without phases. When the mean annual precipitation deficit is relatively low (50-100 mm) the presence of a soil phase was assumed to be a moderate restriction. However, in areas with a higher precipitation deficit, soils with a soil phase were assumed to be unsuitable. An exception was made for soils located in agro-climatic regions with a deficit of between 100 mm and 200 mm, with soil depths of more than 60 cm, and with a medium, medium fine or fine soil texture. This group of soils was appraised to have moderate limitations.

Drought susceptibility was evaluated for rainfed conditions only. Irrigated fruit trees were not expected to have drought stress.

Salinity and alkalinity

Generally, soils which have an electrical conductivity of more than 4 mmho/cm (saline soils or soils with a saline phase) or an exchangeable sodium percentage of more than 15% (alkaline soils or soils with a sodic phase) were considered unsuitable for fruit production. Although irrigation water can be applied to leach soluble salts no difference was made between rainfed and irrigated conditions.

Soil-physical quality

Land with very shallow or shallow soils (soil depth <40 cm)) was expected to be unsuitable to cultivate fruit trees. In these conditions the soil depth is inadequate to provide sufficient foothold for the tree roots. Moderately shallow and moderately deep soils (soil depth: 40-60 cm and 60-80 cm, respectively) were assumed to have restrictions, depending on the presence of a soil phase (e.g. stony, lithic phase). Moderately shallow soils with a soil phase were assumed to be unsuitable, and moderately deep soils with a soil phase were assumed to have moderate restrictions for fruit production.

Peat soils, and fine textured and very fine textured soils (clay content >35%) were considered to be unsuitable for producing fruit. The high clay content of the mineral soils usually results in a low vertical permeability, especially in the subsoil, which severely hampers fruit production. No difference in the evaluation of the soil-physical quality of a land evaluation unit was made between rainfed and irrigated conditions.

Natural soil fertility

A low cation exchange capacity (CEC <5 meq/100 gram soil) was expected to represent conditions with moderate restrictions for fruit growing, both under rainfed and irrigated conditions. In this case, the nutrient retention capacity is low, which could easily lead to leaching beyond the root zone. To minimize this, small quantities of fertilizer should be applied frequently. The presence of gypsum was also expected to cause moderate limitations.

Soil drainage

Very poorly drained and poorly drained soils were considered to be unsuitable for the cultivation of fruit trees. Lack of oxygen will frequently prevail. However, moderately well drained, well drained and excessively drained soils will seldom have aeration problems. So, these soils were evaluated as being suitable with no restrictions.

Soils with a temporarily poor drainage or imperfect drainage belong to an intermediate group. In such cases the suitability was assumed to depend on the soil texture and wetness of the climate. The wetness of the climate is characterized by the mean annual precipitation deficit. Coarse textured, medium textured, and medium fine textured soils, which are temporarily poorly drained, were considered to have severe restrictions in relatively wet regions (precipitation deficit <200 mm). In the drier regions (precipitation deficit >200 mm) moderate restrictions occur in these soils. Fine textured and very fine textured soils with a temporarily poorly drainage were assumed to have severe restrictions irrespective of the wetness of the climate.

An imperfectly drained soil with a coarse texture, a medium texture, or a medium fine texture was assumed to have no restrictions. Soil with a similar drainage but a higher clay content (fine texture and very fine texture) were considered to have no restrictions in the relatively drier regions (precipitation deficit >200 mm). In regions with a smaller mean annual precipitation deficit, fine textured and very fine textured soils were expected to have moderate or severe restrictions. Moderate restrictions occur as long as the precipitation deficit is higher than 50 mm, and severe restrictions prevail under wetter conditions. No difference in the evaluation of the drainage of a land evaluation unit was made between rainfed and irrigated conditions.

Slope

Mechanized operations on a fruit producing enterprise are hampered or even impossible on land located on slopes. Moreover, possible water erosion on sloping land must be controlled by soil conservation measures. As light equipment is generally used, fruit tree cultivation can cope more easily with slopes than, for instance, arable farming. Furthermore, orchards are usually partly covered with grass which reduces erosion. So, land on slopes no steeper than 15% was expected to have no or only slight restrictions for fruit tree cultivation. On land with moderately steep slopes (15-25%) moderate restrictions were considered to occur. Steep slopes (>25%) are assumed to be unsuitable.

The above-mentioned evaluation of the slope refers to fruit cultivation under rainfed conditions. If irrigation is applied, the requirements are higher. More operations need to be carried out, so slopes are more of a hindrance. On sloping land, irregular wetting of the soil may arise depending on the irrigation system used. Furthermore, more energy is usually required to supply water to fruit crops on slopes. Hence, sloping land (8-15%) was evaluated to impose moderate restrictions, whereas moderately steep slopes (15-25%) were assumed to be unsuitable for the cultivation of fruit trees. No differences were made in the evaluation of level land (<8%) or land located on steep slopes (>25%) under rainfed or irrigated conditions. The former was expected to have no problems, and the latter was assumed to impose severe limitations for the cultivation of fruit trees. The above-mentioned general climatic and soil requirements are summarized in Table 21.

***Table 21** Summary of general climatic and soil criteria to evaluate EC land for the cultivation of fruit trees*

Requirement		Limitation		
		no	moderate	severe
Soil-physical quality	*	-soils with depth between 60-80 cm and without a soil phase -soils with depth >80 cm, irrespective of soil phases	-soils with depth between 40-60 cm and without a a soil phase -soils with depth between 60-80 cm with a soil phase	-soils with depth <40 cm, irrespective of soil phases -soils with depth between 40-60 cm with a soil phase
	*	-coarse, medium, or medium fine textured soils	n.r.[1]	-peat soils -fine or fine-textured soils

Requirement		Limitation		
		no	moderate	severe
Soil drainage	*	-moderately good, good, or excessively drained soils -imperfectly drained soils with a coarse, medium, or medium fine soil texture in all agro-climatic regions -imperfectly drained soils with a fine or very fine soil texture and an ET_p-P >200 mm	-temporarily poorly drained soils with a coarse, medium or medium fine textured soils and an ET_p-P >200 mm[2)] -imperfectly drained soils with a fine, or a very fine soil texture and an ET_p-P between 50-200 mm	-very poorly or poorly drained soils -temporarily poorly drained soils with a fine, or a very fine soil texture in all agro-climatic regions -temporarily poorly drained soils with a coarse, medium, medium, or a medium fine soil texture and an ET_p-P <200 mm
Slope	*	rainfed <15%	rainfed 15-25%	rainfed >25%
	*	irrigated <8%	irrigated 8-15%	irrigated >15%
Natural soil fertility	*	CEC[3)] >5	CEC <5	n.r.
	*	absence of gypsum	presence of gypsum	n.r.
Salinity and alkalinity	*		EC[4)] <4	n.r. EC >4
	*	ESP[5)] <15%	n.r.	ESP >15%
Drought susceptibility	*	peat soils in all agro-climatic regions		soils with a depth <40 cm in all agro-climatic regions
	*	regions with an ET_p-P <50mm -all mineral soils with a soil depth >40cm	n.r.	n.r.
	*	ET_p-P =50-100 mm -very fine or coarse textured soils with a soil depth between 40-60 cm, without a soil phase, and a very poorly, a poorly, a tempora-	ET_p-P =50-100 mm -very fine or coarse textured soils with a soil depth between 40-60 cm, without a soil phase, and a moderately well, well,	ET_p-P =50-100 mm n.r.

Requirement	Limitation		
	no	moderate	severe
	rily poorly, or an imperfectly drained soil -medium, medium, fine, or fine textured soils, with a depth >40 cm, without a soil phase, and not excessively drained	or excessive soil drainage -medium, medium, fine, or fine textured soils, with a depth >40 cm, without a soil phase, and a excessively soil drainage -all mineral soils with a soil depth >40 cm, and with a soil phase	
*	ET_p-P =100-200 mm -very fine or coarse textured soils with a soil depth between 40-80 cm, without a soil phase, and a very poorly, a poorly, a temporarily poorly, or an imperfectly drained soil -medium, medium fine, or fine textured soils with a soil depth between 40-60 cm, without a soil phase, and a very poorly, a poorly, a temporarily poorly, or an imperfectly drained soil -medium, medium fine, or fine textured soils with a soil depth >60 cm without a soil phase, irrespective of soil drainage	ET_p-P =100-200 mm -very fine or coarse textured soils with a soil depth between 60-80 cm, without a soil phase, and a moderately well drained soil -medium, medium fine, or fine textured soils with a soil depth between 40-60 cm, without a soil phase, and a moderately well soil drainage -medium, medium fine, or fine textured soils with a soil depth >60 cm, with a soil phase, and irrespective of soil drainage	ET_p-P =100-200 mm -very fine or coarse textured soils with a soil depth between 40-80 cm, and with a soil phase -very fine or coarse textured soils with a soil depth between 40-80 cm, and with a moderately well, a well, or an excessive soil drainage -medium, medium fine, or fine textured soils with a soil depth between 40-60 cm, and a soil phase -medium, medium fine, or fine textured soils with a soil depth between 40-60 cm, and a good, or an excessive soil drainage
*	ET_p-P =200-300 mm -very fine or coarse textured soils with a soil depth > 60cm, without a soil phase, and a very poor,	ET_p-P =200-300 mm -very fine or coarse textured soils with a soil depth between 40-60 cm, without a soil phase and a	ET_p-P =200-300 mm -very fine or coarse textured soils with a soil depth > 40cm, with have a soil phase -very fine or

Requirement	Limitation		
	no	moderate	severe
	poor, temporarily poor or imperfect soil drainage -medium, medium fine, or fine textured soils with a soil depth > 40cm and a very poor, poor, temporarily poor or imperfect soil drainage a soil depth >60 cm and with a moderately good or good soil drainage	very poor, poor, temporarily poor, or imperfect soil drainage -medium, medium fine, or fine textured soils with a soil depth >60 cm with a soil phase -medium, medium fine, or fine textured soils with -medium, medium fine or fine textured soils with a soil depth between 40-60 cm, and with a moderately good, good, or excessively good drainage -medium, medium fine, or fine textured soils with a soil depth >60 cm, and excessive soil drainage	coarse textured soils with a soil depth > 40cm, and a moderately good, good, or excessively good soil drainage -medium, medium fine or fine textured soils with a soil depth between 40-60 cm, and with a soil phase
*	ET_p-P >300 mm -very fine or coarse textured soils with a soil depth >60 cm, without a soil phase, and with a very poor, or poor soil drainage -medium, medium fine, or fine textured soils with a soil depth >60 cm and with a very poor, a poor, temporarily poor, or imperfect soil drainage	ET_p-P >300 mm -very fine or coarse textured soils with a soil depth >60 cm, without a soil phase, and with a temporarily poor, or imperfect soil drainage	ET_p-P >300 mm -soils with a soil depth between 40-60 cm -soils with a soil phase -soils with a moderately good, good, or excessively good soil drainage

1) n.r.: limitations does not prevail;
2) annual precipitation deficit;
3) CEC: cation exchange capacity (in meq/100 gr. soil);
4) EC: electric conductivity (in mmho/cm);
5) ESP: exchangeable sodium percentage;

5.2.2 Suitability for fruit

In this section the suitability for the cultivation of fruit trees in the European Communities is explained. The suitability is presented for both rainfed and irrigated conditions. Land with no or moderate limitations is referred to as suitable land. Some yield data are also provided. Finally, some information is given on how far suitable land for fruit tree cultivation is competitive with other types of land use, such as wheat-growing or the cultivation of root crops.

Suitability for fruit tree cultivation

The suitability of EC land for the cultivation of fruit trees was qualitatively analysed using ALES. For each of the approximately 2800 land evaluation units (unique combinations of soil and climate) the percentage of the area having no, moderate or severe limitations was determined. As the land use requirements differ between rainfed and irrigated conditions, the evaluation was carried out separately. Suitability was determined by using the so-called maximum limitation method (e.g. Sys, 1985; Rossiter, 1990). So, the maximum limitation of one particular climatic or soil property of a land evaluation unit determines the suitability, irrespective of all the other climatic and soil properties. The results for each evaluation unit were too detailed for further processing by the Dutch Scientific Council for Government Policy in the subsequent project phase. Hence the results were aggregated to obtain weighted average figures for the EC administrative regions at NUTS-1 level. In Appendices 10 and 12 the suitability for the NUTS-1 regions is presented for rainfed and irrigated conditions, respectively. Maps 7 and 8 give the percentage of land for each NUTS-1 region, which has no limitations for fruit tree cultivation.

Suitability for rainfed fruit tree cultivation

About 14% of EC land has no restrictions for growing fruit under rainfed conditions. On the other hand about 73% of EC land has severe drawbacks. A severe soil water deficit is the most prominent reason for evaluating EC land as unsuitable (about 53% of the area). A poor soil-physical quality is another important characteristic which inhibits fruit growing (about 50% of EC land). Of course land occurs which has both a poor soil-physical quality and a high soil water deficit. Unsuitable land for rainfed fruit growing is not equally distributed throughout the EC (Table 22). High percentages of land (>20% of the country) without limitations can be found in the Federal Republic of Germany, France, Belgium, Ireland and Denmark. Low percentages of land with no limitations (<10% of the country) occur in the Mediterranean countries and Luxembourg. Luxembourg has a relatively high percentage of land with moderate restrictions for the cultivation of fruit trees. The Mediterranean countries are mainly unsuitable (90% of the land or more has severe restrictions). A severe soil water deficit is the main reason. The Netherlands and the United Kingdom also have a relatively high percentage of unsuitable land. A poor soil-physical quality is the main reason for land to be evaluated as unsuitable in these countries (75% and 50% of the country, respectively).

Table 22 Area of land (% of area of the country) with well suitable (no limitations), moderately suitable (moderate limitations), and unsuitable land (severe limitations) for rainfed fruit tree growing

Country	limitations		
	no	moderate	severe
Fed. Rep. of Germany	28	30	42
France	20	23	57
Italy	3	7	90
Netherlands	16	7	77
Belgium	30	42	28
Luxembourg	5	40	55
United Kingdom	15	10	75
Ireland	31	12	57
Denmark	34	0	66
Greece	5	0	95
Spain	6	4	90
Portugal	3	1	96

Relatively high percentages of land (>20% of NUTS1 area) with no restrictions for rainfed fruit tree cultivation occur in a zone from southwest France along the West European coast to Denmark (Map 7 and appendix 10). Furthermore, central and southern Germany, Ireland and southern England belong to the zone with a high percentage of suitable land for fruit growing. The western and northern part of the Netherlands, and South Germany are excluded from this zone. Relatively low percentages of land (<10% of NUTS-1 area) with no restrictions can be found in NUTS-1 regions in Portugal, Italy, Greece and in the eastern and southerns part of France. Also, in the western part of the Federal Republic of Germany (Saarbrücken) and in eastern France (Est) less land without drawbacks occurs. In the NUTS-1 regions of the Mediterranean zone a severe soil water deficit is the main reason. The NUTS-1 regions in Germany and France just mentioned have vast areas with a poor soil-physical quality (about 60% of the NUTS-1 region). In Centre-Est (F) only a low percentage of land with no restrictions occurs because of both a poor soil physical quality and a severe soil water deficit (50% of the NUTS-1 region). The situation in the Mediterranean area (Fr) is comparable to that in extensive areas in Portugal, Spain, Italy and Greece. The land is predominantly unsuitable because of severe soil water deficit problems (85% of more of the area). The NUTS-1 region in Madrid (Sp) has a relatively high percentage of land without fruit growing problems (16%). However, the percentage of land with severe problems (84%) is similar to that in adjacent NUTS-1 regions.

Suitability for irrigated fruit tree cultivation

When irrigation is assumed to be applied the area of unsuitable land in the EC slightly decreases from 73% to 69%. Although soil water deficit is no longer a limiting factor, the area of land with no limitations still decreases from 14% to 11% of EC land. The reason for this is the higher demands of irrigated fruit tree cultivation on the slopes. The slope of well suitable land for irrigated fruit growing was not expected to exceed 8%. For rainfed conditions the demands are lower. Thus, slopes between 8% and 15% are still assumed to represent conditions with no limitations.

About 32% of EC land has slopes of between 8% and 15%. If no other limitations occur this land is evaluated as well suitable under rainfed conditions and as moderately suitable under irrigated conditions. In fact, other limitations also often occur; so only 9% of EC land was evaluated as moderately suitable instead of well suitable for irrigated fruit production because of the higher slope requirements.

A poor soil-physical quality (50% of EC land) is the principal reason for land to be evaluated as unsuitable for irrigated fruit growing in the EC. The second important reason is the steepness of the slopes (about 38% of EC land).

Similar to rainfed conditions, the area of suitable land for irrigated fruit tree cultivation is not equally distributed throughout the EC (Table 23). In the southern member states the percentage of unsuitable land is usually higher than in the northern member states.

Table 23 Area of land (% of area of the country) with well suitable (no limitations), moderately suitable (moderate limitations), and unsuitable land (severe limitations) for irrigated fruit tree growing

Country	limitations		
	no	moderate	severe
Fed. Rep. of Germany	20	27	53
France	18	25	57
Italy	6	11	83
Netherlands	16	7	77
Belgium	13	44	43
Luxembourg	3	20	77
United Kingdom	6	17	77
Ireland	12	32	56
Denmark	7	44	49
Greece	5	6	89
Spain	7	18	75
Portugal	2	22	77

In the northern member states, the area with no limitations usually decreases when irrigation is applied (cf. Tables 22 and 23). A distinct drop occurs in Belgium, Ireland and Denmark, i.e. 17%, 27% and 19% of the country area respectively. The area of sloping land (slopes between 8-15%) with no other limitations is the main reason for this drop. In the above-mentioned countries 25%, 20% and 28% of the area is covered with sloping land. This area is only partly counterbalanced by land from which the soil water deficit under rainfed conditions is compensated by irrigation. Although supplementary irrigation is sometimes needed in the northern member states, the land suitability for fruit production under rainfed conditions is of more relevance for these countries. In contrast to this, in the southern member states information on the possible effect of irrigation on land suitability is a essential. The net area of land with no limitations for fruit growing in these countries was assessed not to increase substantially by applying irrigation water (Table 23). In some countries (e.g. Greece and Portugal) the net area does not change. In fact it sometimes even decreases. This means that the increase in the area with no soil water deficit, due to irrigation, is not counterbalanced by the area with slopes between 8% and 15, which was assumed to be a moderate limitation under irrigated conditions. The total area of land with no or moderate restrictions for irrigated fruit tree cultivation, however, increases in all southern member states by 6% up to 19%. Hence, the area of unsuitable land decreases by the same amount. In Portugal, the area with unsuitable land decreases by 19%, but still amounts to 77%. Land located on slopes that are too steep (61% of the country area) and land with a poor soil-physical quality (about 48%) are the main reasons. In Spain, unsuitable land for irrigated fruit growing decreases by 15% compared with rainfed conditions. So, about 75% of Spain is still unsuitable. Again, the moderately steep and steep slopes and the soil-physical quality are the principal reasons (about 50% and 45% of the Spanish area, respectively). In Greece and Italy, the decrease in unsuitable land by applying irrigation water is less (6% and 7%) than at the Iberian Peninsula. The still high percentages of unsuitable land in Greece and Italy (89% and 83%) even under irrigated conditions are caused by the slopes and the soil-physical quality.

In the Mediterranean countries, the NUTS-1 regions Sud-Ouest and Mediterranee (F), Nord-Est and Emilia-Romagna (It) and Madrid (Sp) have a well suitable area for irrigated fruit tree cultivation of more than 10% (Appendix 12 and Map 8). In the regions Madrid and Emilia-Romagna, the area with no limitations is even higher than 15%. High percentages of unsuitable land for irrigated fruit growing (more than 90% of NUTS-1 area) occur in Nord-Ovest, Lazio and Sardegna (It) and in Central Ellas and East and South Ellas (Gr) (Appendix 12). In Italy, the main reasons for these high percentages are a poor soil-physical quality (80% up to 91% of NUTS-1 area) and moderately steep and steep slopes (56% up to 71% of NUTS-1 area). In Greece, both the poor soil-physical quality and the steep slopes are equally important (76% up to 85%).
When irrigation is applied a relatively high decrease in the area of unsuitable land for fruit growing (more than 15% of NUTS-1 region) occurs in Mediterranee (F), Sud and Sicilia (I), Madrid, Centro and Sur (Sp), Norte do Continente and Sud do Continente (P) (cf. Appendices 10 and 12). An increase of 5% or more of the NUTS-1 region with no limitations can be found in Mediterranee (F), Centro and Campania (It) because of applying irrigation .

It should be noted that the percentage of suitable land for fruit tree cultivation could be higher as mentioned above if irrigated and rainfed production were mutually considered in a region. Then, land with a soil water deficit under rainfed conditions could be irrigated and shift from land with severe or moderate limitations to land with no limitations, whereas land located on slopes of between 8% and 15% with no limitations under rainfed conditions remains well suitable as long as the higher requirements for irrigation are not considered. Only a mutual evaluation of land for both rainfed and irrigated conditions could answer the question of how much land is actually suitable when irrigation is optional. Such an evaluation was beyond the scope of our study.

Fruit yield
A detailed characterization of the suitability classes within the different NUTS-1 regions in terms of inputs and outputs was beyond the scope of this study. Some

easily available information on outputs, i.e. yield data, are provided. Fruit production data are only relevant if a particular fruit species is considered because the production substantially differs among the species of the broad group of fruit trees considered.

Apple production in the northern member states depends, of course, on soil and weather. However, cultivar, planting density and pruning also have a profound effect on the fruit yield. Wagenmakers (1985; 1988) reports highest yields for the apple cultivar 'Rode Boskoop' of about 82 tonnes/ha on a well suitable soil in the Netherlands. In an eight-year experiment the worst treatment (e.g. a low planting density) produced about 20% less than the best treatment (e.g. a high planting density). In the context of an international experiment on high planting densities, apple fruit yields of 118 tonnes/ha (cv. 'Golden Delicious') and 88 tonnes/ha (cv. 'Gloster') were attained on well suitable soils in the Netherlands (Wagenmakers, 1988). These figures should be reduced by about 10%, because no field traffic lanes were present in the experiment. The yield differences between the worst and best treatment during a four-year period were about 30% and 20% for the cultivars 'Golden Delicious' and 'Gloster'. Investigations with the apple cultivar 'Elstar' revealed highest fruit yields of 55 tonnes/ha in the Netherlands and 61 tonnes/ha in Denmark (Wagenmakers, 1985). Again planting systems, especially the density, appeared to have a pronounced effect. Apple yield differences of about 30% may occur.

Wagenmakers (1986; 1988) also provides data on the yield of pears on well suitable soils in the Netherlands. The highest yields were obtained during a long-term experiment and amounted to about 56 tonnes/ha (cv. 'Conference') and 53 tonnes/ha (cv. 'Doyenne'). Yield differences between the worst and best treatments on the same location were comparable to those of apples.

Standard figures for apple and pear production on suitable Dutch soils are provided by Joosse (1990). These figures are used for economic analysis. Production depends on the age of the fruit trees, planting density and cultivar. Standard production figures for a full-grown fruit crop are given in Table 24. The fruit yields on the experimental fields, as reported by Wagenmakers, are twice as high as the standard figures. When the highest planting density is considered, the best yielding apple cultivar ('Gloster') produces about 30% more than the worst (cv. 'Cox's Orange Pippin'). Variation in planting density of apple cause yield differences of 10% to 25%. The standard production figures for pears are also significantly lower than the yields attained from the experimental fields, i.e. 30% to 50%. The highest yielding cultivar ('Conference') produces about 40% more than the lowest yielding (cv. 'Doyenne de Comice'), when a planting density of 2500 tree per hectare is considered. Planting density usually causes yield differences of 10% to 20%. However, the cultivar 'Gieser Wildeman' shows a more substantial variation, i.e. about 40%.

Table 24 Standard figures for apple and pear production on suitable Dutch soils (derived from Joosse, 1990)

	cultivar	age years	planting density number of trees/ha	yield tonnes/ha/year
apple	Golden Delicious	>8	1125	40.6
			4500	47.9
	Cox's Orange Pippin	>8	1125	27.1
			4500	35.9
	Schone van Boskoop	>8	1125	33.8
			4500	39.4
	James Grieve	>8	1125	34.4
			500	42.7
	Winston	>8	1125	31.3
			4500	34.5
	Benoni	>8	1125	28.9
			2450	33.4
	Jonagold	>8	1125	41.6
			4500	49.4
	Karmijn de Sonnaville	>8	1500	34.1
			3750	37.3
	Elstar	>8	1125	37.1
			4500	45.4
	Gloster	>8	1950	45.8
			4500	50.1
pear	Conference	>11	870	32.0
			3000	40.5
	Doyenne du Comice	>11	870	21.8
			3000	25.2
	Beurre Hardy	>11	870	24.1
			1425	29.2
	Legipont	>11	870	30.0
			1125	31.0
	Bonne Louise d'Avranches	>11	870	23.4
			1125	26.6
	Tromphe de Vienne	>11	870	15.5
			1125	17.5
	Saint Remy	>11	870	32.5
			2500	37.0
	Giesser Wildeman	>11	870	16.0
			2500	26.0
	Precose de Trevoux	>11	870	24.0

The yield of plum also depends on cultivar, planting system and pruning. For instance, in a Dutch experiment, the highest yield of the cultivar 'Victoria' amounted to about 10 tonnes/ha, whereas the cultivars 'Opal' and 'Reine Claude d'Oullins' did not exceed approximately 8 and 7 tonnes/ha, respectively (Wagenmakers, 1987; 1988).

In the Mediterranean countries, fruit crops with higher heat requirements can be cultivated. De la Rosa and Moreira (1987) analysed the yield of peaches in Andalucia

(Sp). The yield of peaches in this region varied from 6 to 12 tonnes/ha. An average yield of about 10 tonnes/ha was attained.

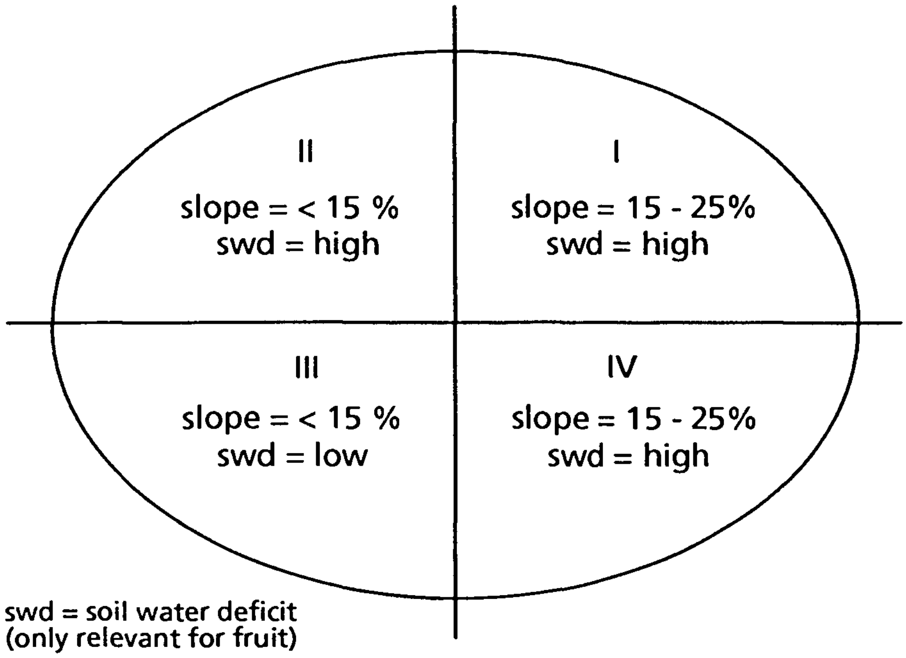
Competitive suitable land for fruit trees and other crop types
An estimate was made of the area of land of a NUTS-1 regions which is suitable for both fruit trees and other types of crops (e.g. intensively managed grass, cereals and root crops). Furthermore, the area was assessed which is only suitable for fruit trees and not for the other type of crops. The common area of unsuitable land was also estimated, i.e. the area which is expected to be of no use for either fruit trees or other type of crops. The estimation procedure used is explained in Chapter 4. The basic assumption is that suitable land is nested at least at the level of a land evaluation unit, as illustrated in Figure 8A. The results for a land evaluation unit, such as the area only suitable for fruit trees or the area suitable for both fruit trees and root crops, are aggregated at the NUTS-1 level (determination of weighted averages of land with a particular suitability using the area of each of the land evaluation units and their suitabilities). In Appendix 11 estimated competitive land, common unsuitable land for fruit trees and some other crop types are presented for rainfed conditions for the NUTS-1 regions. These results are expressed as a percentage of the area of a NUTS-1 region. In Appendix 11 the percentage of land only suitable for rainfed fruit tree cultivation is also given for those cases when the fruit trees have to compete with grass, cereals or root crops. Finally, the percentage of land of a NUTS-1 region is presented which is unsuitable for producing fruit under rainfed conditions, but which is suitable for growing grass, cereals or root crops. In Appendix 13 the same results are given for irrigated fruit tree cultivation.

Under rainfed conditions high percentages of the NUTS-1 region with competitive land (>50% of NUTS-1 region) occur in Nord-Pas-de-Calais and Ouest in France (Appendix 11). So, this means that many land units are suitable for both fruit tree growing and other crop types, such as intensively used grassland, cereals and root crops. Relatively high percentages of land only suitable for rainfed fruit production can be found in Saarland (34%) and Region Wallone (57%). These regions have vast areas with slopes of between 15% and 25%, which are assumed to be suitable for rainfed fruit growing but not for arable farming or intensively used grasslands. Regions with hardly any competitive land or land suitable for fruit tree cultivation, but with significant percentages of land suitable for arable farming occur in the Mediterranean countries (e.g. 17% to 30% in Sicilia in Italy dependent on the crop type). Suitable for arable crops actually means potentially suitable. The arable crop grown on this land may suffer water stress, which is finally evaluated by model simulation (Reinds and Van Lanen, in prep.; De Koning et al., in prep.). In the Mediterranean countries also high percentages of land occur which is unsuitable for both rainfed fruits tree and other crop types.

In the Mediterranean countries, the percentage of competitive land increases when irrigation is applied (e.g. in Sicilia by 17% from 1% to 18% of the NUTS-1 region; cf. Appendices 11 and 13). In these countries, the area of suitable land for irrigated fruit production is only relatively small. This means that irrigated fruit tree cultivation and arable farming must compete on the same good soils. In some regions, an exception needs to be made for competition between irrigated fruit and root crops (e.g. in Spain and Nord-Est in Italy). In these regions, significant percentages of land (11% up to 19% of the NUTS-1 region) still occur which are suitable for irrigated fruit production and which are unsuitable for root crops. The high stone content of the soils in these regions is the reason for this.

The assessment of competitive and unsuitable land was based on the assumption that suitable land is nested (Fig. 8A) as mentioned above. Usually this assumption is correct. However, in the case of fruit tree cultivation occasionally non-nested suitable land may occur (Fig. 8B). Non-nested suitable land results in an overestimation of the percentage of competitive land and an underestimation of land which is expected to be only suitable for one of the crops considered. Non-nested suitable land exists if part of a compound land evaluation unit is suitable for a particular crop and unsuitable for another crop, whereas on another part of the land evaluation unit the opposite prevails. For instance, the percentage of suitable land of a land evaluation unit for rainfed fruit tree cultivation may be higher because moderately steep slopes (15%-25%) are still assumed to be suitable for fruit production whereas they are unsuitable for intensively managed grass, cereals or root crops. On the other hand, the percentage may be smaller because land with severe drought restrictions was evaluated as unsuitable for rainfed fruit production, although it is still assessed as potentially suitable for grass, cereals and root crops. So, non-nested suitable land under rainfed conditions may occur when a compound land evaluation unit (LEU) has subunits with slopes less than 15% and subunits with slopes between 15% and 25%. The land evaluation unit must be comprised of subunits with severe drought restrictions and subunits with no or moderate restrictions (Fig. 9). In the hypothetical situation given in Figure 9, 50% of the LEU is suitable for both rainfed fruit cultivation and for grass, cereals and root crops. 25% of the LEU consists of competitive land (subunit 2), 25% is only suitable for rainfed fruit growing, 25% is only potentially suitable for grass, cereals and root crops and another 25% is unsuitable for all considered crops. The analysis applied, however, only considers nested suitable land. This means that the analysis in this case incorrectly predicts 50% of competitive land and another 50% as unsuitable. Fortunately, the combinations of characteristics, as presented in Figure 9, are not likely to occur frequently. An estimate of the possible error caused by non-nested land cannot readily be provided, because soil water stress problems can be caused by a combination of several characteristics (see Table 21).

The higher soil texture requirements for root crops than for cereals and intensively managed grass (Reinds and Van Lanen, in prep.) might be another source for different percentages of non-nested land. Land with a fine soil texture (clay content between 35% and 60%) was assumed to be unsuitable for both fruit production and for the cultivation of root crops, whereas it was evaluated as potentially suitable for cereal and grass growing. So, when rainfed fruit production is compared with cereal or grass growing, non-nested suitable land occurs if a compound land evaluation unit contains subunits with a fine soil texture and subunits with coarser textures. The land evaluation unit must also be comprised of subunits with severe drought restrictions and subunits with no or moderate drought restrictions for rainfed fruit production. Again this combination of characteristics is not likely to occur regularly.



I: unsuitable land for rainfed fruit, grass, cereals and root crops

II: unsuitable land for rainfed fruit and suitable for grass, cereals and root crops

III: suitable land for rainfed fruit grass, cereals and root crops

IV: suitable land for rainfed fruit and unsuitable for grass, cereals and root crops

Fig. 9 Example of a compound land evaluation unit with non-nested suitable land

As each crop type has its own requirements (Reinds and Van Lanen, in prep.), the percentage of non-nested land depends on the crop types and management systems compared. For instance, for irrigated fruit production the percentage of non-nested land will be smaller than for rainfed fruit cultivation. Irrigated fruit production imposes the same slope requirements as intensively managed grassland, cereals and root crops. Moreover, drought problems are assumed not to occur (irrigated fruit) or are analysed during a subsequent stage of the investigations (grass, cereals and root crops).

5.3 Rainfed and irrigated citrus

Citrus fruits include among others, oranges, lemons, clementines, mandarins and grapefruit. In the EC oranges cover more than half of the citrus area. Lemons are the second crop among the citrus fruits in the EC. Lemons are cultivated on about 20% of the citrus area. Citrus mainly occurs in Spain, Italy, Greece and Portugal. A small area also occurs in southern France (Eurostat, 1988). The relatively high heat requirements restrict the cultivation of citrus to these regions.

In this section the suitability of EC land for the cultivation of citrus fruits is presented. We assume that the general soil and climatic requirements, as already discussed for rainfed or irrigated fruit trees, also apply to citrus. So, moderate or severe limitations for the cultivation of the broad group of fruit trees (Section 5.2) also hold for the more specific group of citrus fruits. In addition to these general requirements, the higher heat requirements of the citrus crop were taken into account. After explaining of the additional, specific climatic and soil requirements for citrus fruits, the percentages of well suitable, moderately suitable and unsuitable land for each NUTS-1 region is given. Finally, some results are presented on how far suitable land for citrus coincides with suitable land for intensively managed grass, cereals and root crops.

5.3.1 Evaluation criteria

For citrus fruits, essentially the same climatic and soil requirements are used as for the broad group of fruit trees. These requirements are summarized in Table 21. Additionally, a few other requirements are introduced which are more specific for citrus fruits, for example the temperature regime. When evaluating EC land for the potential of citrus growing, the requirements of oranges were mainly considered, if the various citrus fruits have different demands.

The evaluation criteria for the cultivation of citrus fruits were subdivided into climatic and soil requirements. Two different management situations were defined, i.e. a rainfed situation and a situation with irrigation. In both situations a proper management was assumed (e.g. pruning, application of nutrients and pesticides etc.).

Climatic requirements

Citrus fruits have high water demands, hence they are less drought tolerant (e.g. Hackett and Carolane, 1982). De la Rosa and Moreira (1987) reported a water demand of about 800 mm. Hackett and Carolane (1982) mentioned an annual rainfall of between 800-1200 mm needed to grow Mediterranean mandarin (Citrus deliciosa Ten.). The drought susceptibility of EC land to grow citrus fruits was evaluated as for the broad group of fruit trees. The mean annual potential precipitation deficit (potential evapotranspiration minus precipitation) was used as an important climatic characteristic (see Section 5.2.1). In areas with a high potential precipitation deficit, land is only suitable for citrus growing when the available amount of soil moisture is high. So, assessment of the drought susceptibility was done by simultaneously evaluating climatic and soil characteristics.

Citrus fruits belong to the group of subtropical fruit. The heat requirements are relatively high and no particular chilling demands are needed. The demands are substantially higher than for apples and pears, and somewhat higher than for olives. Among the citrus fruits small differences occur. For instance, lemon and mandarin are a little more sensitive to frost than orange. However, along the coasts, lemons advance more in northerly directions than oranges. The relatively high heat requirements are the dominant reason for the absence of the citrus in the northern member states.

The citrus crop needs sufficiently mild winters. However, the winter does not need to be entirely frost free (Papadakis, 1970). The average minimum temperature of the coldest month should be above -2.5°C (Papadakis, 1975). Late frosts in spring or early frosts in autumn are extremely harmful to the trees.

Hackett and Carolane (1982) indicated a base temperature of 13°C for sweet oranges (Citrus sinensis L. Osb.). Below this temperature there is hardly any growth. De la Rosa and Moreira (1987) specified a minimum temperature of between 10°C and 12°C for citrus (Citrus sp.). Hackett and Carolane (1982) also mentioned the most favourable temperature during the growing season, which should be between 20°C and 30°C for sweet orange and between 22°C and 30°C for Mediterranean mandarin. Citrus fruits are able to resist high maximum temperatures. Maximum temperatures of between 38°C and 45°C are permissible (De la Rosa and Moreira, 1987). Only incidently might this type of damage occur in the EC. Because we are working with broad climatic data in our study no land was evaluated as unsuitable for this reason.

Areas with climatic conditions appropriate for citrus fruits must have at least a mean annual temperature as high as the lower limit of olives, i.e. 13°C (Sys, 1985). Moreover, there must be at least two months with a mean temperature in the favourable range between 22°C and 30°C. Furthermore, the climatically suitable land was subdivided into land with no restrictions, and land with moderate restrictions caused by low minimum temperatures in the winter period. Moderate restrictions were assumed to occur when the mean minimum temperature in the period October to March is below 6°C. This limit is derived from an analysis of the monthly minimum temperatures and the current geographic distribution of citrus as presented by Papadakis (1975).

Soil requirements
Citrus fruits impose the same requirements on the soil as fruit trees in general (Table 21). As for fruit trees the drought susceptibility for citrus was derived from the potential precipitation deficit and soil characteristics, such as soil drainage, soil texture, soil depth and the presence of a soil phase (e.g. stony, gravelly phase). Furthermore, soil salinity, alkalinity, soil-physical quality, CEC, soil drainage, slope and the presence of gypsum were evaluated as for the broad group of fruit trees. A distinct difference between the citrus and other fruit trees is their reaction to high amounts of $CaCO_3$ in the soil (Hackett and Carolane, 1982; De la Rosa and Moreira, 1987). Land with high contents of $CaCO_3$ in the soil was assumed to have moderate restrictions for citrus growing, instead of no restrictions as assumed for the other fruit trees.

The additional requirements for citrus fruits are summarized in Table 25. All the requirements mentioned for fruit trees in general (Table 21) also apply to citrus fruits. As for fruit trees in general, the distinction between rainfed and irrigated citrus is the different evaluation of the slope and the drought susceptibility. Under irrigated conditions no water stress was assumed to occur and land located on slopes above 8% was assumed to represent conditions with restrictions.

Table 25 Summary of additional climatic and soil requirements to evaluate EC land for citrus fruits

requirement	**limitations**		
	no	**moderate**	**severe**
mean annual temperature	>13°C		<13°C
number of months mean temperature between 22°C and 30°C	>2		<2
mean minimum temperature in Oct-March	>6°C	<6°C	
$CaCO_3$	**absent**	**present**	

5.3.2 Suitability for rainfed and irrigated citrus

In this section, the suitability for cultivating citrus fruits in the European Communities is explained. The suitability is presented for rainfed and irrigated conditions. Some yield data are also provided. Finally, some information is given on how far suitable land for the cultivation of citrus fruits is competitive with other types of land use.

Suitability for citrus cultivation
The suitability of EC land for the cultivation of citrus fruits was quantitatively analysed using ALES. For each of the approximately 2800 land evaluation units (unique combination of soil and climate) the percentage of the area having no, moderate or severe limitations was determined. As the land use requirements differ from rainfed and irrigated conditions, the evaluation was carried out separately. Suitability was determined by using the so-called maximum limitation method (e.g. Sys, 1985; Rossiter, 1990). So, the maximum limitation of a single climatic or soil property of a land evaluation unit determines the suitability, irrespective of all the other climatic and soil properties. The results obtained by applying ALES to the land evaluation units are too detailed for further processing by the Dutch Scientific Council for Government Policy in the subsequent project phase. Hence, the results were aggregated to obtain weighted average figures for the EC administrative regions at NUTS-1 level. In Appendices 14 and 16 the suitability is presented for rainfed and

irrigated conditions, respectively. Maps 9 and 10 give the percentage of land for each NUTS-1 region, which has no or moderate limitations for citrus fruits. Land with no or moderate limitations is further indicated as suitable.

Suitability for rainfed citrus

Less than 2% of EC land was evaluated to be suitable for growing citrus fruits under rainfed conditions. The specific heat requirements combined with the low drought tolerance are the main reasons for this low percentage. Only about 1% of EC land is unsuitable because of other reasons (e.g. wetness, topography only).

Suitable land for rainfed citrus fruits only occurs in the Mediterranean countries (incl. southern France). The percentage of unsuitable land, however, is still extremely high in these countries (Table 26). This percentage of unsuitable land varies from 95% to 98%. In Italy 46% of the land was assessed to be unsuitable because of an inadequate temperature regime, and on 90% of the remaining potentially favourable land a severe soil water stress would occur if rainfed citrus were to be cultivated. Moderate limitations occur on 1.9% of Italian land, and are caused by a moderate water stress and/or low minimum temperatures during the winter. In Greece, hardly any land was evaluated with no restrictions for rainfed citrus. The moderately suitable land (5.3% of the Greek area) has some problems with a high $CaCO_3$ content in the soils and/or low minimum temperatures during the period October to March. The principal reason for Greek land to be evaluated as unsuitable is the occurrence of severe water stress when citrus is grown (about 95% of the unsuitable area). In Spain, 2% of the land has no restrictions under rainfed conditions. On 1.8% of the land moderate constraints occur, which are caused by low winter minimum temperatures. About 38% of Spanish land has severe climatological limitations for growing citrus fruits and on 94% of the remaining land severe drought problems would be encountered under rainfed conditions. In Portugal 2.6% of the land has no restrictions for growing rainfed citrus fruits. On about 97% of the Portuguese land severe restrictions occur. Climatic limitations occur in 40% of Portugal and on the remaining land (about 94%) a high drought susceptibility would occur.

***Table 26** Area of land (% of area of the country) with well suitable (no or slight limitations), moderately suitable (moderate limitations), and unsuitable land (severe limitations) for rainfed citrus fruits; (100% unsuitable land occurs in the non-mentioned countries)*

Country	limitations		
	no or slight	moderate	severe
France	0.1	0.2	99.7
Italy	0.2	1.9	98.0
Greece	0	5.3	94.7
Spain	2.0	1.8	96.2
Portugal	2.6	0.2	97.2

The dominant soils in southern France and the Mediterranean countries, which have no restrictions, are medium textured, groundwater affected soils which are still adequately drained and located in a level landscape. The soils are classified as Gleyo-Eutric and Dystric Fluvisols. In Portugal Albo-Gleyic Luvisols were also included.

Map 9 shows the percentage of the NUTS-1 regions with no or moderate limitations for growing citrus under rainfed conditions. The percentage of land of the NUTS-1 regions having no, moderate and severe limitations are presented in Appendix 14. The northern limit for citrus cultivation follows a line from northern Portugal, through northern Spain, southern France and northern Italy. The limit is located north of Greece, although in some northern Greek locations damage is reported because of low temperatures (Lionakis, 1989). Moreover, the north-south located mountain chain in Italy, the Apennines, was assumed to be unsuitable because of climatic restrictions. Most NUTS-1 regions have a small percentage of land (0-5%) which was assessed to be suitable (no or moderate limitations). Exceptions are the Sud do Continente (P), Madrid and Este (Sp), Centro (It) and North-Ellas (Gr.). In these regions relatively more of the above-mentioned soils occur.

In the southern EC regions with an adequate temperature regime for citrus cropping, the area of suitable land (no and moderate limitations) for rainfed citrus is similar to that of fruit tree cultivations (cf. Appendices 14 and 10). For instance, the Greek NUTS-1 regions, Sur in Spain, Sud do Continente in Portugal and Centro in Italy have the same suitable area for both land uses. In these NUTS-1 regions differences only occur between the area with no or moderate restrictions for rainfed citrus and rainfed fruit tree cultivation. The presence of $CaCO_3$ was assumed to be a moderate limitation for citrus crops and not for the broad group of fruit trees (cf. Tables 25 and 21). So, for rainfed citrus growing the area with moderate limitations was evaluated to be larger than for fruit tree cultivation, which is clearly indicated by the figures for Greece and for Sur in Spain.

Suitability for irrigated citrus

Irrigation of citrus fruits is a well-known practice in the climatologically relevant regions of the EC. The land suitability to grow citrus may change when irrigation is applied. We assumed that drought susceptibility was no longer relevant. So, potentially more land might be suitable. However, applying irrigation imposes more severe requirements on the steepness of the slope. The same requirements were used as for fruit trees in general (Table 21). Slopes between 8-15% were assumed to represent moderate limitations instead of no limitations under rainfed conditions and land with slopes of between 15-25% was evaluated as unsuitable under irrigated conditions, whereas it was still moderately suited under rainfed conditions. All EC land was evaluated again using these new criteria.

The area with an inadequate temperature regime (70% of EC) does not change, of course. So, about 30% of the EC remains potentially favourable for irrigated citrus fruits. If drought susceptibility were the only limiting land quality, all this land would be suitable if irrigation is applied. Other limiting factors, however, occur. The suitable land for growing citrus in the EC was assessed to increase from less than 2% to slightly more than 6% when irrigation is applied. This means that only about 20% of the potentially suitable land is actually suitable. The dominant reasons for this land to be evaluated as unsuitable, although there are no temperature and drought constraints, are the soil-physical quality (shallow and/or fine textured soils) and the slope. On 63% of the climatologically potentially favourable land for irrigated citrus severe soil-physical limitations occur, and on 57% of the land severe slope problems. Some land has both restrictions, for example shallow soils on a steep slope.

***Table 27** Area of land (% of area of the country) with well suitable (no or slight limitations), moderately suitable (moderate limitations), and unsuitable land (severe limitations) for irrigated citrus fruits; (100% unsuitable land occurs in the non-mentioned countries)*

Country	limitations		
	no or slight	moderate	severe
France	0.6	1.5	97.9
Italy	1.4	7.2	91.4
Greece	0	11.0	89.0
Spain	2.0	13.6	84.4
Portugal	1.6	11.0	87.4

In the Mediterranean countries, the percentage of suitable land (no or moderate limitations) varies from 9% to 15% when irrigation is applied (Table 27). The area of suitable land increases by a factor of 2 to 5 as a result of irrigation. In Italy, 1.4% of the land was evaluated to have no restrictions, and 7.2% has moderate restrictions. A number of land characteristics cause these moderate limitations, such as a low winter minimum temperature, presence of $CaCO_3$, slopes of between 8% and 15%. In areas with an appropriate temperature regime (54% of Italian land), a poor soil-physical quality and steep slopes are the dominant reasons for land to be evaluated as unsuitable. About 70% of the climatologically potentially favourable Italian land has a poor soil-physical quality, and 48% of the land has slopes that are too steep. In Greece there would be no suitable land for citrus even if irrigation is applied. This is unlikely; the small-scale soil map used in this study, could be a reason for this questionable result. About 11% of Greece is covered by land with moderate restrictions. Just as in Italy, several of land characteristics cause these moderate restrictions. On 71% of Greek land, the poor soil-physical quality prevents the cultivation of citrus and on 73% of the land slopes prohibit citrus cultivation. About 16% of Spanish land was assessed to be suitable for irrigated citrus fruits (no or moderate limitations). As in the other Mediterranean countries, the shallowness or fine texture of the soils preclude the cultivation of citrus. In Portugal, about 13% of the land is suitable for irrigated citrus cultivation. In those Portuguese regions with an adequate temperature regime, about 62% of the area is unsuitable because of severe soil-physical problems and 56% of the land has severe slope drawbacks.

The dominant soils with no restrictions for irrigated citrus cropping are medium textured (medium and medium fine) and have slopes of less than 8%. In France, the Gleyo-Eutric Fluvisols and Chromic Luvisols predominantly belong to this group. In Italy, some of the Eutric Cambisols and Gleyo-Eutric Fluvisols have no restrictions. In Spain, more than 95% of the area with no limitations is covered by Gleyo-Eutric Fluvisols. The dominant Portuguese soils are Gleyo-Eutric Fluvisols and Chromic Cambisols which cover more than 80% of the land with no drawbacks.

Map 10 shows the percentage of the NUTS-1 regions with no or moderate limitations for growing citrus under irrigated conditions. The percentage of land of the NUTS-1 regions with no, moderate and severe limitations are presented in Appendix 16. The northern climatic limit, previously explained for rainfed conditions, does not, of course, shift by applying irrigation. In many NUTS-1 regions with an adequate temperature regime, the area with no or moderate drawbacks substantially increases when irrigation is assumed to be applied. An increase of more than 10% occurs in the NUTS-1 regions Mediterranee in France, Sud and Sicilia in Italy, Noreste, Madrid, Centro, Este and Sur in Spain, and Sud do Continente in Portugal. Especially the area with moderate restriction increases. The area with no limitations increases by no more than 5% in all NUTS-1 regions. In Sud do Continente (P) the area with no limitations is, under rainfall conditions (5%), even higher than under irrigated conditions (3%).

As previously explained for the rainfed conditions, the suitable area (no or moderate limitations) for irrigated citrus growing is similar to that of irrigated fruit tree cultivation (cf. Appendices 16 and 12). Because of the presence of $CaCO_3$ the area with moderate restrictions for irrigated citrus growing was evaluated to be, however, larger than for irrigated fruit tree cultivation. For instance, in the Greek NUTS-1 regions the area with moderate restrictions for irrigated citrus cultivation was assessed to be 1% to 7% larger than for irrigated fruit trees.

Citrus yield

A detailed characterization of the suitability classes within the different NUTS-1 regions in terms of inputs and outputs was beyond the scope of this study. Some easily available data on the outputs expressed as yield, are provided. Citrus production should be expressed for each particular citrus species, because pronounced differences prevail in the fruit production capacity.

The citrus production in Andalucia ranges from 7.5 to 25.2 tons/ha for oranges and 9.7 to 13.0 tons/ha for lemons (De la Rosa and Moreira, 1987). Substantially higher yields are attained on Cyprus. There, the yield of Valencia oranges can reach 60 tons/ha on well suitable soils under irrigated conditions (Orphanos et al, 1986). Grapefruit trees can produce even more, for exemple 70 tons/ha, under well watered conditions (Van der Weert et al., 1973). Hackett and Carolane (1982) reported a typical sweet orange yield of 30 tons/ha, and a yield range for Mediterranean mandarin and satsuma mandarin of 4-10 tons/ha and 24-48 tons/ha, respectively.

Competitive suitable land for citrus fruit and other crop types

An estimate was made for the areas of land of NUTS-1 regions which are suitable for both citrus fruit and for other types of crops (e.g. intensively managed grass, cereals and root crops). Furthermore, the area was assessed which is only suitable for citrus or one of the other type of crops considered. The common area of unsuitable land was estimated. The estimation procedure used is explained in Chapter 4. The basic assumption is that suitable land is nested, at least at the level of a land evaluation unit, as illustrated in Figure 8A. The results for a land evaluation unit were aggregated (determination of weighted averages of the suitability classes using the area of each of the land evaluation units and their suitabilities) and presented for the NUTS-1 regions. In Appendix 15 estimated competitive land, common unsuitable land for citrus fruit and some other crop types are presented for rainfed conditions. These results are expressed as a percentage of the area of a NUTS-1 region. In Appendix 15 also the percentage of remaining suitable land for rainfed citrus cultivation is also given if the citrus fruits have to compete with grass, cereals or root crops. Finally, the percentage of land of a NUTS-1 region is presented which is unsuitable for producing citrus under rainfed conditions, but which is suitable for grass, cereals or root crops. In Appendix 17 the same results are given for irrigated citrus cultivation.

Under rainfed conditions no high percentages of the NUTS-1 region with competitive land (>25% of NUTS-1 region) occur (Appendix 15). The NUTS-1 region Madrid has the highest percentage with 16% land which is suitable for rainfed citrus growing as well as for crop types such as intensively grown grass, cereals and root crops. Land suitable only for rainfed citrus cultivation and not for the other crop types considered can hardly be found in the EC. The NUTS-1 region Centro (It) has the highest percentage of land only suitable for rainfed citrus, i.e. 3% of the area. Most NUTS-1 regions have substantial areas which are unsuitable for rainfed citrus (Appendix 14); these regions are either only suitable for the other crop types considered or are even unsuitable for these activities.

Under irrigated conditions the percentages of competitive land increase (Appendix 17). A percentage of more than 10% competitive land can be found in ten out of nineteen NUTS-1 regions which are climatologically suitable. The NUTS-1 region Madrid has again the highest percentage, i.e. 43%, 43%, and 32% when irrigated citrus has to compete with intensively grown grass, cereals, and root crops, respectively. Percentages of 5% or more of the NUTS-1 regions which are only suitable for irrigated citrus and not for all the other crop types regarded were assessed to occur in Sud (It) and Ellas North (Gr). A remarkable percentage of land (>10% of the NUTS-1 region) only suitable for irrigated citrus and not for root crops can be found in the Spanish regions Madrid, Este and Sur. The presence of stony soils which were assumed to be unsuitable for root crops cause this relatively higher percentage. Similar to the rainfed situation most NUTS-1 regions have substantial areas which are unsuitable for irrigated citrus (Appendix 16); these regions are either only suitable for the other crop types considered or are even unsuitable for these activities.

The estimation of the figures in Appendices 15 and 17 was based on the assumption that suitable land is nested, at least at the level of the land evaluation unit, as explained in Chapter 4. This assumption does not apply to a minor number of units. Examples, which also hold for citrus, are given in Section 5.3.2.

5.4 Olives

The main olive producing countries in the world are Algeria, Greece, Italy, Morocco, Spain, Syria, Tunisia, Argentina and Brazil. In this section the suitability of EC land for the cultivation of olives is presented. The requirements and evaluation criteria are discussed first. Then, the percentages of well suitable, moderately suitable and unsuitable land for each NUTS-1 region are given. Finally, some results are presented on how far suitable land for olive growing coincides with suitable land for grass, cereals and root crops.

5.4.1 Evaluation criteria

Olive cultivation is generally not considered as an economically attractive activity in the Mediterranean countries. Olive trees are often planted in marginal areas, where no other agricultural alternatives prevail. Sometimes they are used as ornamental trees. The olive tree easily recovers from drought stress. The olive tree does not need much care, but biennial bearing is a common feature then. However, by carefully selecting plant material and site, and by applying proper management techniques, olive trees can produce enough to compete with other fruit trees.

The evaluation criteria for the cultivation of olives were subdivided into climatic requirements and soil requirements. The soil requirements are further subdivided into criteria for low and high management conditions. In both management situations no irrigation water was assumed to be applied. So, EC land was evaluated for a rainfed olive crop. Furthermore, some minimum inputs were assumed to be applied (e.g. some pruning, application of some animal manure).

Climatic requirements
The olive is a subtropical fruit tree or shrub. The northern member states of the European Communities are too cold to grow olives (e.g. Papadakis, 1960; 1970; Hackett and Carolane, 1982). The favourable temperature range for olive growing is between 15°C and 34°C (Hackett and Carolane, 1982). Sys (1985) reported that suitable land for olives requires a mean annual temperature of above 13°C. This criteria was used in our evaluation.

Fruit productivity of the olive may be adversely affected by extremely high temperatures in the period before and during bloom. Temperatures above approximately 38°C in April or May are critical (Denney and McEachern, 1982). Only incidentally does this type of damage occur in the EC. Because we worked with broad climatic data in our study no land was evaluated as unsuitable for this reason.

The olive crop requires a cool season. Olives flower earlier and better when they are exposed to low temperatures each winter. Hence, the crop cannot be grown in continuously warm climates. The southern boundary of wheat in the northern hemisphere generally coincides with the southern boundary of olives (Papadakis, 1970). This boundary, however, is located south of the European Communities. The chilling requirements of olives are comparable to those of grapes. But olives are less resistant to winter coldness than grapes. For the vernalization process, the minimum temperature may not exceed 8°C over a specific periode of time (Papadakis, 1975). Denney and McEachern (1985) defined days of vernalization for the olive crop as days on which the minimum temperature is between 0°C and 12.5°C. De la Rosa and Moreira (1987) mentioned minimum temperatures required of 8°C to 10°C, and Sys (1985) indicated a minimum temperature of 6°C. In our evaluation, we assumed that suitable land for olive cultivation has an average minimum temperature of the coldest month below 10°C.

The olive may be damaged by extremely low temperatures. There are several factors which may determine whether or not a particular tree will sustain damage at a specific minimum temperature. Nevertheless, experiments and observations from a variety of olive producing sites show that the olive will not survive temperatures below -12°C (Denney and McEachern, 1985). Abdullaev (1985; cited by Denney and McEachern, 1985) provided a critical temperature range from -8°C to -10°C, which leads to slight damage. Imenson et al. (1987) reported that the olive will be harmed by a temperature below -12°C. In his analysis of agricultural potential of world climates, Papadakis (1970) stated that the average minimum temperature of the coldest month must be higher than -7°C. Sys (1985) and Abdel-Razik et al. (1987) indicated that olives can be exposed to an average minimum temperature in the colder months of higher than -8°C, without showing frost damage. In our evaluation we assumed that unsuitable land for olive cultivation has an average minimum temperature of below -8°C.

The olive crop is very resistant to drought (e.g. Papadakis, 1975; Hackett and Carolane, 1982; Abdel-Razik et al., 1987). In dryland conditions, however, the crops survives but the yields are very low. De la Rosa and Moreira (1987) reported that a good olive crop needs 500 mm to 550 mm water per year. Sys (1985) proposed to evaluate land for olive growing on, among others, the basis of the annual rainfall. His data were further elaborated for our analysis. Land with an annual rainfall of less than 150 mm was assumed to be unsuitable for the cultivation of olives. In areas with more than 150 mm rain per year, the soil characteristics also determine the suitability for olive growing. These are explained in the following section which deals with soil characteristics.

The olive tree requires a long rainless period, otherwise phytosanitary problems will arise (Papadakis, 1975). Areas with a rainfall of more than 1000 mm per year, or more than 335 mm in the period from April to September were evaluated as unsuitable. This limit was derived from a broad analysis of the prevailing climatic data in the EC and should be considered as a first approximation. In other climatic regions in the world, the limit must be further elaborated. In areas with an annual rainfall of more than 1400 mm, olives cannot be grown irrespective of the summer rainfall (Sys, 1985).

Sys (1985) reported that in the northern hemisphere the rainfall in August and September must exceed 20 mm and 15 mm, respectively. The olive needs this rain for a good sclerification of the stone. In our evaluation we also linked this criteria to available soil moisture. Therefore, we evaluated land with coarse or a very fine textured soil as unsuitable if the rainfall is lower than the above-mentioned amounts. Land with medium textured soils was assumed to have no problems with a low rainfall in August or September.

Soil requirements
When the annual rainfall is more than 150 mm, **drought susceptibility** was further analysed by evaluating the annual rainfall in combination with soil texture. In dryland conditions, land with a coarse texture or a very fine soil texture, was considered to have a lower ability to store rain. Coarse textured soils have a relatively low moisture retention capacity and very fine textured soils lose considerable amounts of water because of bypass flow (e.g. Bouma, 1989). Land with an annual rainfall of between 150 mm and 300 mm has moderate limitations for olive-cultivation, unless the soil texture is coarse or very fine. Coarse and very fine textured soils still have severe limitations in such dryland conditions. In areas with an annual rainfall of between

300 mm and 400 mm, coarse and very fine textured soils were evaluated as moderately suitable, whereas all other land was characterized as suitable if there are no other restrictions. Susceptibility to drought is further evaluated by analysing the soil-physical environment. Peat soils were assumed to have a soil-physical environment which is unsuitable for the cultivation of olives. For the other mineral soils, soil depth or maximum rooting depth was used in combination with the presence of a soil phase (e.g. stony, gravelly) as measures of evaluating the soil-physical environment. Very shallow soils (maximum rooting depth <10 cm) were assumed to be unsuitable, and shallow soils (maximum rooting depth between 10 cm and 40 cm) were expected to impose moderate limitations for the cultivation of olives. The moderately deep soils (maximum rooting depth between 40 cm and 60 cm) also have moderate limitations, irrespective of the presence of a soil phase. Moderately deep, deep and very deep soils (maximum rooting depth between 60 cm and 80 cm, 80 cm and 120 cm and >120 cm, respectively) were assumed to have no restrictions, unless a soil phase occurs. Land with moderately deep to very deep soils and a soil phase (e.g. gravelly, concretionary) was assumed to have moderate limitations.

Soil drainage; a productive olive tree requires a well drained soil. Hence, all land with very poor, poor or temporarily poor drainage was considered to be unsuitable. An imperfectly drained soil was expected to have moderate limitations, and moderately well, well or excessively well drained soils have no limitations for olive growing.

Salinity and alkalinity; the olive crop is moderately tolerant to soluble salts in the soil. However, with a sodium saturation of the absorbtion complex of more than 15%, land was believed to have moderate limitations. If the electrical conductivity of a soil exceeds 4 mmho/cm, the land was assumed to have severe restrictions for olive cultivation. Furthermore, land with a sodic phase or a saline phase has moderate or severe restrictions, respectively.

Slope; the previously mentioned evaluation criteria were assumed to be independent of the management level. The following criteria depend on the management level. For instance, steep slopes are less restrictive in a farming system with animal traction or handwork than in a system with full mechanization. In contrast to this, natural fertility is mainly relevant in systems with a low management level.

In olive producing systems with full mechanization, slopes steeper than 15% were assumed to be moderately suitable and slopes steeper than 25% cannot be utilized. When animal traction or handwork dominates (low input system), slope steepness was no longer expected to be a severe problem. In such management conditions slopes steeper than 25% were assumed to give moderate problems. No restrictions occur on land with slopes of less than 25%.

Nutrient retention capacity; in production systems with a high nutrient input, the cation exchange capacity (CEC) is no longer a severe problem. Only in soils with a very low CEC (<5 meq/100 gram soil) were moderate limitations were assumed to prevail. The presence of gypsum was expected to cause moderate restrictions even in a high input system.

When hardly any fertilizers are applied, which is characteristic of a low input system, the CEC was assumed to be more relevant. Land with a very low CEC (<5 meq/100 gram soil) was considered to be unsuitable. When the CEC is low (5-15 meq) moderate restrictions were expected to occur. Land with a CEC above 15 meq/100 gram soil was assumed to be well suitable. In a low input system, the presence of gypsum cannot easily be corrected, this land was therefore evaluated as unsuitable for olive growing.

The above-mentioned soil evaluation criteria were derived from Hackett and Carolane (1982), Sys (1985) and De la Rosa and Moreira (1987). The soil and climatic requirements are summarized in Table 28.

Table 28 Summary of climatic and soil requirements used to evaluate EC land for olive growing

	limitations		
requirement	**no**	**moderate**	**severe**
mean annual temperature	**>13°C**	**>13°C**	**<13°C**
minimum temperature coldest month	**>-8°C <10°C**	**>-8°C <10°C**	**<-8°C >10°C**
August rainfall	**>20 mm if texture is coarse or very fine No restrictions for other soil texture classes**	**<20 mm if texture is coarse or very**	**not-relevant**
September rainfall	**>15 mm if texture is coarse or very fine No restrictions for other soil texture classes**	**<15 mm if texture is coarse or very fine**	**not-relevant**
mean annual rainfall	**>400 mm or >300 mm if texture is medium, medium fine of fine.**	**300-400 mm if texture is coarse or very fine or 150-300 mm if texture is medium, medium fine or fine**	**<150 mm or <300 mm if soil texture is coarse or very fine or >1000 mm if summer rainfall > 335mm or >1400 mm**
soil depth	**>80 cm**	**40-80 cm**	**<40 cm**
soil drainage	**moderately good, good and excessive**	**imperfect**	**temporarily poor, poor and very poor**
parent material	**mineral soils**	**not-relevant**	**peat soils**

	limitations		
requirement	no	moderate	severe
soil phases:			
-gravelly	absent	present	not-relevant
-stony	absent	present	not-relevant
-lithic	absent	present	not-relevant
-concretionary	absent	present	not-relevant
-petrocalcic	absent	present	not-relevant
-saline	absent	not-relevant	present
-sodic	absent	present	not-relevant
-combinations of soil phases	absent	present	not-relevant
salinity	<4 mmho/cm	not-relevant	>4 mmho/cm
alkalinity	ESP< 15%	ESP> 15%	not-relevant
slope			
-high input level	<15%	15-25%	>25%
-low input level	<25%	>25%	not-relevant
gypsum			
-high input level	absent	present	not-relevant
-low input level	absent	not-relevant	present
CEC			
-high input level	>5 meq per 100 gram soil	<5 meq per 100 gram soil	not-relevant
-low input level	>15 meq per 100 gram soil	5-15 meq per 100 gram soil	<5 meq per 100 gram soil

5.4.2 Suitability for olives

In this section, suitability for the cultivation of olives in the European Communities is explained. Some yield data are also provided. Finally, some information is given on how far suitable land for olive cultivation is competitive with other types of land use.

Suitability for olive cultivation in a low and a high input system
The suitability of EC land for the cultivation of olives was quantitatively analysed using ALES. For each of the approximately 2800 land evaluation units (unique combination of soil and climate) the percentage of the area with no, moderate or severe limitations was determined. Suitability was assessed by using the so-called maximum limitation method (e.g. Sys, 1985; Rossiter, 1990). This implies that the maximum limitation of a single climatic or soil property of a land evaluation unit

determines the suitability, irrespective of all the other climatic and soil properties. This information was too detailed for further processing by the Dutch Scientific Council for Government Policy in the subsequent project phase. Hence, the results were aggregated to obtain weighted average figures for the EC administrative regions at NUTS-1 level. In Appendices 18 and 20 the suitability is presented for a low and high management level, respectively. Maps 11 and 12 give the percentage of land of each NUTS-1 region, which has no limitations for olive cultivation.

When a low input system was assumed to be applied about 25% of EC land was evaluated to be suitable, i.e. land with no or moderate restrictions. About 6% of EC land has no limitations. When a high input system was assumed to be used the suitable area slightly decreases by 3% to 22% of EC land. The area with no limitations decreases from 6% to 5%.

Climatic conditions in the EC determine that suitable land for olive cultivation can only be found in southern France, Portugal, Spain, Italy and Greece (Tables 29 and 30). More than 90% of the French area was evaluated to be unsuitable for olive cultivation because of climatic reasons. In Italy, Spain and Portugal severe climatic restrictions prevail on 46%, 38% and 29% of the area, respectively. In this broad analysis, no land with severe climatic limitations was assessed to occur in Greece. Greek land with moderate climatic restrictions does, however, prevails.

Table 29 Area of land (% of area of the country) with well suitable (no limitations), moderately suitable (moderate limitations), and unsuitable land (severe limitations) for olive cultivation; low input system

Country	limitations		
	no	moderate	severe
France	2	4	94
Italy	12	36	52
Greece	5	59	36
Spain	15	36	49
Portugal	10	24	66

Table 30 Area of land (% of area of the country) with well suitable (no limitations), moderately suitable (moderate limitations), and unsuitable land (severe limitations) for olive cultivation; high input system

Country	limitations		
	no	moderate	severe
France	2	3	95
Italy	10	28	62
Greece	4	28	68
Spain	12	40	48
Portugal	10	38	52

The type of input system does not affect areas of land with severe climatic restrictions. When a low input system is assumed, vast areas of suitable land (no and moderate limitations) were evaluated to occur in the Mediterranean countries except for France. The percentages of suitable land vary from 34% (Portugal) to 64% (Greece). On most of the suitable land, moderate restrictions prevail. Land with no limitations covers 15% or less of the area of a country. In Greece, 5% of the area was evaluated to have no limitations (Table 29). If a high input system instead of a low input system was assumed to be applied, the area of suitable land decreases in Greece and Italy by 32% and 10% respectively. In Portugal, however, the area was assessed to increase by 14% (cf. Tables 29 and 30). The relative change in suitable land, being positive or negative, depends on the area of land with steep slopes (slope angle >25%), the CEC and the gypsum content (Table 28). In a high input system, the CEC and gypsum were assumed not to result in severe restrictions, whereas in a low input system it was assessed to be a severe limitation. A steep slope was assumed to impose severe restrictions in a high input system, whereas it was expected to be a moderate restriction in a low input system. Even in a high input system the suitable area in the Mediterranean countries is substantial, i.e. from 32% (Italy) to 52% (Spain). Similar to the low input system most land of the suitable area was evaluated to be covered with land with moderate restrictions. When a high input is assumed to be applied, land with no limitations covers 12% or less.

Maps 11 and 12 show that NUTS-1 regions with 10% or more land with no limitations, were evaluated to be mainly located along the coast in Portugal and Spain. In Italy, these NUTS-1 regions are found south of the Po basin, and they hardly occur in Greece. In northwest Spain (NUTS-1: Noroeste; Appendices 18 and 20) the climatic conditions impose severe restrictions on olive cultivation (too wet and too cold). The NUTS-1 region Madrid has a relatively high percentage of land with no limitations (32% and 25% for low and high management conditions, respectively). This land is covered by well drained, deep rootable Calcic Cambisols and Vertic Luvisols. These soils have a medium fine or fine texture and are predominantly situated in a level or sloping landscape. In Portugal, a clear distinction was assessed to occur between the northern and the southern part of the country. In parts of northern Portugal (NUTS-1: Norte do Continento) agro-climatic conditions prevail which were expected to be unsuitable for olive growing. Moreover, in northern Portugal well suitable soils only occur as part of a compound land evaluation unit (Cambisols and Luvisols having a medium to fine texture and slopes steeper than 8%). In southern Portugal (NUTS-1: Sud do Continento), the soils contain less coarse fragments than in the northern part, and about 32% of the soils have a medium fine or fine texture, whereas in northern Portugal these soils cover only 6%. In southern Portugal the slopes are also less steep. Moderately steep (15%-25%) and steep slopes (>25%) comprise 53% of the area of southern Portugal, whereas this figure amounts to 69% in northern Portugal. In Greece, a shallow rooting depth and a stony soil phase are the dominant limiting factors for the cultivation of olives. About 18%, 42% and 62% of the area has a very shallow rooting depth in northern, central and eastern Greece (NUTS-1 regions: Ellas), respectively. A stony soil phase occurs in 54%, 40% and 20% of these regions. Topography, especially in the high input situation, is another limiting factor in Greece. In the Greek NUTS-1 regions, between 65% and 85% of the area is covered with moderately steep and steep slopes (slope angles >15%).

In the climatically suitable areas for olives within the EC, notable areas of unsuitable land (>60% of the NUTS-1 region) were evaluated to occur in the NUTS-1 regions Norte do Continento (P) and Ellas (East and S. Isl; GR). These results can be derived for the low input system from Appendex 18. In high input conditions, this number of NUTS-1 regions increases (Appendix 20). Mediterranee (F), Abruzzi-Molise (I), Ellas (North; GR) and Ellas (Central; GR) also have more than 60% land with severe limitations.

When the olive producing system is changed from a low to a high input system, the impact of topography and natural fertility was evaluated differently. In most regions, the area of land with severe restrictions increases (cf. last column of Appenidices 18 and 20). Exceptions are some NUTS-1 regions in Spain (Madrid, Centro and Sur) and Portugal. In Greece, the unsuitable area was assessed to increase by 19% to 39%, and in Italy the unsuitable area increases by 8% to 19%. In southern Portugal the unsuitable area, however, decreases by about 20%.

Generally, the area of land with no limitations decreases when the inputs increase from low to high (cf. first columns Appendices 18 and 20). The NUTS-1 region Campania (I) was evaluated to be an exception. A substantial decrease occurs in the NUTS-1 region Sicilia (I). There the area of land with no limitations decreases by 17% (Maps 11 and 12; Appendices 18 and 20). The excessive area of land with moderately steep slopes (40% of Sicilia has a slope of between 15%-25%) is the main reason for the decrease. In Italy and Greece the area of land with moderate restrictions also decreases when the inputs increase (cf. second column Appendices 18 and 20). In Greece in particular, the decrease is substantial, and amounts to about 18% to 38%. In Spain and Portugal, however, the area of land with moderate limitations increases when higher inputs are applied.

Olive yield

A detailed characterization of the suitability classes within the different NUTS-1 regions in terms of inputs and outputs was beyond the scope of this study. Some easily available data on the outputs expressed as yield, are provided. De la Rosa and Moreira (1987) analysed the yield of olives for table consumption and for oil producing in Andalucia (S). The average yield was 1.8 tonnes/ha/yr for both purposes. They also provided data on the yield range in the various regions within Andalucia. For table consumption, the range was 0.8 to 2.4 tonnes/ha/yr and for oil producing 0.5 to 2.7 tonnes/ha/yr. Abdel-Razik et al. (1987) presented yield data for fresh olives from various sources. In Tunisia, the average yield of fresh olives was about 1.3 tonnes/ha/yr, taking into account the phenomenum of alternate bearing. The average yield per hectare in Egypt was estimated to be 1.6 to 1.9 tonnes/ha. When the production was increased by applying improved management techniques (e.g. precise pruning, proper pest and disease control) the average production in the northwestern coastal zone in Egypt increased by about 50%, to a production of about 2.5 tonnes/ha/yr. Under full irrigation, annual yields of about 5 to 6 tonnes of fresh olives could be attained per hectare. Hackett and Carolane (1982) reported typical annual olive yields of 5 to 8 tonnes/ha for the main olive producing regions.

Competitive suitable land for olives and other crop types
An estimate was made for the areas of land of the NUTS-1 regions which are suitable for both olives and other types of crops (e.g. grass, cereals and root crops). The area was assessed which is only suitable for olives and not for the other crop types. Similarly, the area suitable for the other types of crops and not for olives was assessed. The common area of unsuitable land was also estimated. The estimation procedure used is explained in Chapter 4. The basic assumption is that suitable land is nested, at least at the level of a land evaluation unit, as illustrated in Figure 8A. The results for a land evaluation unit were aggregated (determination of weighted averages of the suitability classes using the area of each of the land evaluation units and the suitabilities) and presented for the NUTS-1 regions. In Appendix 19 estimated competitive land, common unsuitable land for olives and some other crop types are presented for the low management input level. These results are expressed as a percentage of the area of a NUTS-1 region. In Appendix 19 the percentage of remaining suitable land for olives is also given if the crop has to compete with grass, cereals or root crops. Finally, the percentage of land of a NUTS-1 region is presented which is unsuitable for the production of olives, but which is still suitable for growing grass, cereals or root crops. In Appendix 21 the same results are given for high management conditions.

Because of climatic conditions, north of southern France, no competitive land for olives and other types of crops was recognized. In the Mediterranean area of France, olives have to compete with grass or cereals for low input conditions on 20% of the land (Appendix 19). Because of higher demands of root crops, the area of competitive land for olives with the root crops is smaller, i.e. 16%. In the Mediterannean area, common unsuitable land for olives and the crop types grass, cereals and root crops is 49%, 49% and 52%, respectively.

Land only suitable for olive growing and not for the other crop types covers substantial areas in Greece and Italy (Appendix 19), and a relatively smaller area in Spain and Portugal.

Compared with the low input situation, the area of competitive land in the climatologically suitable areas in a high input system generally increases slightly (cf. Appendices 19 and 21). In Italy and Greece, the unsuitable area also increases as mentioned above (cf. also Tables 29 and 30). In Spain the opposite occurs.

The assessment of competitive and unsuitable land was based on the assumption that suitable land is nested (Fig. 8A) as mentioned previously. Usually this assumption is correct. However, in the case of olives, occasionally non-nested suitable land may occur (Fig. 8B). For instance, some compound land evaluation units have some moderately steep slopes which are suitable for olives but unsuitable for cereals and root crops, whereas other parts (subunits) are assumed to be too dry to grow olives but were not excluded for cereals and root crops. This phenomenum of being non-nested, however, may only occur in the very dry regions within the European Communities. The agro-climatic zone of Murcia in southeastern Spain is an example of such an area.

5.5 Grapes

In the northern member states of the European Communities grape growing (*Vitus, Vinifera L.*) is almost impossible because of the governing temperature regime. The northern limit broadly coincides with a line from mid-France to mid-Germany. North of this line some grape growing prevails on sheltered locations, as reported, for instance, for the United Kingdom by Skelton (1988). But, in the context of the evaluation of potentials within the EC, these areas are of little relevance. Nowadays, according to Eurostat (1988) the principal areas of grape growing are located in Spain (15740 km^2), Italy (10968 km^2), and France (10492 km^2). Smaller, but commercially important areas, also occur in Portugal (2704 km^2), Greece (1700 km^2), and Germany (1007 km^2). From the total EC production of grapes in 1986, about 4% was produced in West Germany. A similar amount was produced in Portugal, and slightly more was harvested in Greece, viz. 5%. The most significant grape producing countries are Italy, France and Spain, which accounted for 38%, 30%, and 19% of EC production, respectively (Eurostat, 1988). The grapes are used for wine and for consumption as fresh grapes.

In this section, the suitability of EC land for the cultivation of vines producing grapes is presented. This suitability assessment has a general character. So, land is only evaluated for climatic and soil requirements which apply to a broad group of grape varieties. The general data of the small-scaled maps do not allow a very specific outcome. In other words, small areas with favourable conditions among areas of land with inadequate characteristics (e.g. slopes directed towards the south at relatively high latitudes) could not be assessed in our study.

After explaining of the generally applicable climatic and soil requirements, the percentages of well suitable, moderately suitable and unsuitable land for each NUTS-1 region is given. Finally, some results are presented on how far suitable land for grape growing coincides with suitable land for grass, cereals and root crops.

5.5.1 Evaluation criteria

Generally applicable soil and climatic requirements are dealt with for the growing of vines which produce grapes. South of the climatic limit for grape growing, most land is capable of producing grapes. The vine places relatively low demands on the land in order to survive, and to occasionally produce grapes. The land, however, is usually low-yielding. For commercial purposes a high production is required. High production, however, can only be attained on appropriate land which also applies special cultivation measures. In our study, the suitability assessment was directed at grape growing for commercial purposes. This implies that high quality rootstocks are assumed to be used, and that regionally adapted varieties are planted. It was also assumed that moderate amounts of nitrogen, phosphorus and potassium were applied, and that the input of biocides to control pests and diseases was at the required level. It was also assumed that the vine was adequately pruned. Although yield response of grapes to irrigation is high in some regions (e.g. Papadakis, 1975; Hackett and

Carolane, 1982), it was assumed that no irrigation water was applied. Thus, a rainfed grape growing enterprise using a relatively high input was considered in our study.

To evaluate EC land for grape growing, four severity levels were distinguished, i.e. no, slight, moderate and severe limitations. The severity levels specify the degree to which a particular requirement is fulfilled by the land. Land with no or slight limitations was classified as well suitable or suitable land, whereas land with moderate limitations can only be used for grape growing when either special measures are conducted, usually requiring higher inputs, or when a substantially lower yield than under optimal conditions is accepted. Land with severe limitations is unsuitable for commercial grape production. South of the climatic limit this unsuitable land, can, however, have some low potentials for producing grapes for domestic purposes.

The evaluation criteria applied in our study are summarized in Table 31.

Climatic requirements
Grapes belong to the group of crops requiring a cool season, they cannot be grown in a continuously warm climate. Their chilling requirements are analogous to those of wheat, and their heat requirements are approximately those of maize (e.g. Papadakis, 1970). In fact the vine demands long, warm to hot, dry summers and cool winters (Dent and Young, 1981). This implies that the vine in its dormant period can resist temperatures down to -10°C and -29°C in the coldest month. The maximum temperature of coldest months should be above 5°C. If we consider the temperature regime of the coldest month only, grapes could be grown almost anywhere within the EC. Frost resistance, however, during the growing period is low. During the growing period, an appropriate base temperature is 10°C (Hackett and Carolane, 1982), whereas De la Rosa and Morena (1987) mention a minimum temperature of between 5°C and 10°C. According to the former authors, acceptable average temperatures during the growing period are between 13°C and 30°C. The temperature should preferably be in the range of 20°C - 25°C (Dent and Young, 1981). Acceptable upper temperature limits of 35°C (Hackett and Carolane, 1982) and between 40°C and 45°C have been reported (De la Rosa and Morena, 1987).

In our study, two temperature criteria were applied (Table 31). First, the mean of the maximum temperatures during the six warmest months must be 21°C or more (Papadakis, 1975), and, second, the number of months with an average temperature in the favourable range, i.e. between 13°C and 30°C (Hackett and Carolane, 1982), must be five or more.

In addition to certain temperature requirements, the vine has certain humidity requirements. Although a high yield vine needs at least 450-500 mm water for optimal growth, the crop demands a rainless summer (e.g. Papadakis, 1970). Hence, grapes should preferably be grown on soils with a high soil water supply capacity. The crop benefits from a low humidity, primarily to prevent all kinds of diseases. The fruit is not well protected and can be spoiled before ripening (Papadakis, 1975; Hackett and Carolane, 1982). Therefore, in our study we introduced the criterion that the rainfall in the period May-October should be less than 700 mm. This figure was established by analysing rainfall data of regions with an adequate temperature regime, but which were known for their severe restriction for growing grapes owing to humidity reasons as reported by Papadakis (1970). The criterion of 700 mm should be used with reserve in regions outside the EC, because a limited number of regions were analysed.

Soil requirements
The following soil requirements were distinguished: soil-physical quality, soil wetness, drought susceptibility, slope, salinity, alkalinity, and soil-chemical aspects, such as base saturation, cation exchange capacity, and calcium carbonate content.

Soil-physical quality
The vine prefers a deep rootable soil. Hence, soils with a depth of less than 40 cm impose moderate restrictions for grape growing, and soils with a depth of less than 10 cm were assumed to be unsuitable (Hackett and Carolane, 1983; De la Rosa and Morena, 1987). Grapes can be grown well on light textured soils (e.g. Dent and Young, 1981; De la Rosa and Morena, 1987). Hence, soil textures that were coarser rather than fine were assumed to have no limitations. Fine textured, and very fine textured soils were assumed to impose moderate and severe limitations, respectively.

Soil wetness
High grape yields can be attained on well drained soils, whereas the yield decreases on land with wetter conditions (Dent and Young, 1981; Hackett and Carolane, 1982; De la Rosa and Morena, 1987). Therefore, very poorly and poorly drained soils were assumed to have severe limitations, and temporarily poorly drained soils moderate limitations. Other land was assumed to have no limitations. These criteria refer to conditions needed in order to reach high yields. To survive, the vine can resist much wetter conditions. According to Hackett and Carolane (1982), vines can even withstand waterlogged soils for about one or two weeks.

Drought susceptibility
As mentioned above, the vine requires at least 450-500 mm water during the growing season (De la Rosa and Morena, 1987). According to Dent and Young (1981) the required amount of water varies between 500-1200 mm. These requirements apply to high yield conditions. In fact, the vine is drought resistant, and can withstand very severe periods of drought. Under these conditions, however, grape production is very low. There is a large difference between the requirements for survival and for commercial production (Hackett and Carolane, 1982).

A large decision tree was developed to derive the severity level for drought susceptibility for a high yield to be attained. It is beyond the scope of this report to present the full decision tree. The decision tree is schematically presented in Table 31. Soil and land characteristics, such as summer rainfall (April-September), soil drainage, soil texture, and soil depth, play a vital role in assessing the severity level. If the summer rainfall is above 500 mm no drought susceptibility was assumed to prevail, whereas a rainfall of less than 200 mm was assumed to impose severe limitations. All land with a very poor, a poor, temporarily poor, and an imperfect soil drainage was assumed to have no drought stress because of root zone supply by capillary rise. The severity level of well drained, very well drained, and excessively drained land with a summer rainfall of between 200-500 mm was assumed to be dependent on land characteristics, such as soil texture and soil depth.

Table 31 Summary of climatic and soil requirements used to evaluate EC land for grape growing

Requirement	Limitation: no	slight	moderate	severe
Temperature regime	* $Tmax_g$[1] >= 21°C	n.r.[2]	n.r.	$Tmax_g$[1] <21°C
	* Period length Topt[3] >= 150 days	n.r.	n.r.	Period length Topt < 150 days
Humidity	Rainfall May-October < 700 mm	n.r.	n.r.	Rainfall May-October >= 700 mm
Soil-physical quality	* soil depth > 60 cm	soil depth between 40-60 cm	soil depth between 10-40 cm	soil depth <= 10 cm
	* coarse, medium, medium fine textured soils	n.r.	fine textured soils	very fine textured soils
Soil wetness	imperfectly, moderately good, good, and excessive soil drainage	n.r.	temporarily poor soil drainage	very poor, poor soil drainage
Slope	0-8%	8-15%	15-25%	> 25%
Soil-chemical conditions	* BS[4] >= 50%	n.r.	BS < 50%	n.r.
	* CEC[5] > 15	CEC between 5-15	CEC <= 5	n.r.
	* presence of $CaCO_3$	absence of $CaCO_3$	n.r.	n.r.
Salinity and alkalinity	* EC[6] < 4	n.r.	n.r.	EC >= 4
	* ESP[7] < 15%	n.r.	n.r.	ESP >= 15%
Drought susceptibility	• soils with very poor, poor, temporarily poor, and imperfect soil drainage, and peat soils irrespective of other land characteristics	n.r.	n.r.	n.r.
	* regions with a Psum[8] >= 500 mm	n.r.	n.r.	regions with a Psum <=200 mm

Requirement	Limitation			
	no	slight	moderate	severe
	* Psum = 400-500 mm; -soils with soil depth > 60 cm, and -soils with soil depth 40-60 cm without soil phases	Psum = 400-500 mm; -soils with soil depth 10-40 cm with a medium, a medium fine, or a fine soil texture and without soil phases	Psum = 400-500 mm; -soils with soil depth 40-60 cm with soil phases -soils with soil depth 10-40 cm with a coarse or very fine soil texture and without soil phases	Psum = 400-500 mm; -soils with soil depth 10-40 cm with soil phases
	* n.r.	Psum = 300-400 mm; -soils with soil depth > 60 cm without soil phases -soils with soil depth 40-60 cm with a medium, a medium, or a fine soil texture without soil phases	Psum = 300-400 mm; -soils with soil depth 40-60 cm with a coarse, or very fine soil texture without soil phases -soils with soil depth > 80 cm with soil phases	Psum = 300-400 mm; -soils with soil depth < 40 cm -soils with soil depth 40-80 cm with soil phases
	* n.r.	n.r.	Psum = 200-300 mm; -soils with soil depth > 80 cm irrespective of soil texture or soil phases -soils with soil depth 60-80 cm with a medium, a medium fine, or a fine soil texture without soil phases -soils with a soil depth < 60 cm irrespective of soil texture or soil phases	Psum = 200-300 mm; -soils with soil depth 60-80 cm with a coarse or a very fine soil texture irrespective of soil phases -soils with a soil depth 60-80 cm with a medium, a medium fine, or a fine soil texture and with soil phases

1) $Tmax_g$: mean maximum temperature in the six warmest months;
2) n.r.: limitations do not prevail;
3) Topt: average temperature in acceptable range, i.e. 13°C and 30°C;
4) BS: base saturation;
5) CEC: cation exchange capacity (in meq/100 gr. soil);
6) EC: electrical conductivity (in mmho/cm);
7) ESP: exchangeable sodium percentage;
8) Psum: summer rainfall (April-September).

Slope
Land located on a slope may, depending on the slope orientation, benefit from a higher exposure to sunlight. In the northern regions, such as West Germany and Alsace (F), this is a very dominant aspect. Conversely, slopes hamper various management operations. Although adapted equipment has been developed, slopes above 15% were assumed to impose some limitations. At least higher inputs are required to grow and harvest grapes on this land (e.g. expensive equipment and grafting). Hence, land on slopes of between 15% and 25% was assumed to have moderate limitations, and land with slope angles above 25% has severe limitations.

Salinity and alkalinity
The vine has some tolerance to salts in the root zone (e.g. Dent and Young, 1981; Hackett and Carolane, 1982; De la Rosa and Morena, 1987). Hence, if electrical conductivity (EC) is below 4 mmho/cm, and if the exchangeable sodium percentage (ESP) is below 15% no limitations were assumed to occur. Otherwise, severe limitations were expected to occur.

Soil chemical conditions
The vine prefers soils with a pH greater than 5.5; the favourable range is 6.5-8.5 (Hackett and Carolane, 1982; De la Rosa and Morena, 1987). Hence, acid soils with an estimated base-saturation (BS) below 50%, were assumed to have moderate limitations. Land with a BS greater than 50% has no limitations. Furthermore, the presence of $CaCO_3$ was assumed to have a positive effect on yield. Therefore, land without $CaCO_3$ in the soil was found to have slight limitations, and land with $CaCO_3$ no limitations. The cation exchange capacity (CEC) affects the availability of nutrients. Furthermore, the application of nutrients to soils with a low CEC can more easily result in losses to the environment. Soils with a very low CEC (< 5 meq/100 gr. soil) were assumed to have moderate limitations, and soils with a low CEC (5-15 meq/100 gr. soil) slight limitations. Soils with higher CECs were assumed to have no limitations.

5.5.2 Suitability for grapes

In this section the suitability for grape growing in the European Communities is explained. The suitability is presented for rainfed conditions. Some yield data are also provided. Finally, some information is given on how far suitable land for grape growing is competitive with other types of land use.

Suitable and unsuitable areas
The suitability of EC land for grape growing is quantitatively analysed using ALES. Each of the approximately 2800 land evaluation units (unique combination of soil and climate) was allocated to a suitability class having no, slight, moderate, or severe limitations. If land evaluation units are compound, the suitability class of the subunits was determined separately. Then, for each of the land evaluation units the subunits with identical suitability classes were combined, and percentages covered by the suitability classes computed. Suitability was determined by using the so-called

maximum limitation method (e.g. Sys, 1985; Rossiter, 1990). So, the maximum limitation of a single land quality or land characteristic of a land evaluation unit determines the suitability, irrespective of all the other qualities or characteristics. All these operations were carried out using ALES (Section 3.3).

The suitability assessment per land evaluation unit is too detailed for further processing by the Dutch Scientific Council for Government Policy. Hence, the results were aggregated to obtain weighted average figures for the EC administrative regions at NUTS-1 level. For each NUTS-1 region the relative area covered by the suitability classes is presented (Appendix 22). On Map 13 the percentage of land of each NUTS-1 region, which has no or slight limitations for grape growing is given. Despite some dispersion due to the size of the NUTS-1 regions, for example Bassin Parisien, the northern limit for grape growing can be clearly recognized on this map.

Besides aggregation to NUTS-1 levels, aggregations were also carried out to obtain results for the EC member states and the whole EC.

Slightly less than 1% of EC land was assessed to have no limitations at all for growing grapes for commercial purposes. About 8% of EC land has slight limitations, and 5% has moderate limitations. This means that about 15% of EC land was evaluated to be suitable, and about 85% unsuitable for grape growing. About 45% of EC land is either too cold or too wet to grow grapes. It is likely that this percentage is somewhat higher. In agro-climatic regions with substantial elevation differences the selected meteorological stations are representative of the low elevation locations (Section 3.2). This implies that potentials of land with high elevations are overestimated in a climatic sense. Land with climatic restrictions is primarily located north of the climatic limit (Map 13). Large areas of land with severe climatic limitations also occur in northwest Spain, central Spain, Massif Central (F), southwest France, and northern Italy. Most of these areas cannot be recognized on Map 13, due to the aggregation process and the size of the NUTS-1 regions. In areas with no severe temperature or humidity limitations, the dominant reason for land found to be unsuitable is a a severe drought susceptibility. Severe drought stress was assessed to prevail on slightly more than 35% of EC land.

Table 32 Area of land (% of the country) with no, slight, moderate, and severe limitations for grape growing for commercial purposes

Country[1)]	Limitations			
	no	slight	moderate	severe
West Germany	1	4	3	92
France	1	18	13	68
Italy	0	14	11	75
Luxembourg	0	7	2	93
Greece	6	3	1	90
Spain	0	5	1	94
Portugal	0	4	1	95

1) only countries with some suitable land are given

Suitable land for commercial grape growing occurs in eight of the twelve EC member states (Table 32). In Ireland, the United Kingdom, Denmark, the Netherlands, and Belgium no suitable land was found to occur because of severe climatic limitations. In most countries with suitable land the area with severe limitations was assessed to be more than 90%, viz. in West Germany, Luxembourg, Greece, Spain, and Portugal. In France and Italy, however, a vast percentage of area with suitable land prevails, viz. 32% and 25%.

In West Germany, more than 80% of the area was evaluated to have severe climatic restriction for grape growing. As mentioned above it is likely that the German area with severe climatic restrictions is somewhat larger. The main reason for the overestimation is because the meteorological stations selected (Reinds et al., 1991) were not representative of the higher elevations. Another important severe limitation in Germany was found to be drought susceptibility, which occurs on about 9% of German land. The small area with no limitations is covered with medium textured Fluvi-Calcaric Fluvisols.

In France more than 40% of the area was evaluated to have severe climatic restrictions for grape growing. Slightly less than 20% of the area without severe temperature and humidity restrictions, was still assessed to be unsuitable owing to a high drought susceptibility. About 30% of French land has slight or moderate limitations. Various types of limitations cause these severity levels. From these types, the soil-chemical conditions, were evaluated to be the most important. Slight or moderate limitations with respect to the soil-chemical conditions occur on about 11% of French land. These are caused by a low base saturation, a low CEC, or absence of $CaCO_3$. The small area with no limitations is covered with medium textured Fluvi-Calcaric Fluvisols and medium textured Calcic Cambisols.

About 12% of Italian land has severe limitations because of the temperature regime and humidity. As mentioned above it is likely that the area with severe climatic restrictions is somewhat larger. A severe drought susceptibility was evaluated to be the dominant reason for unsuitable land in Italy. These severe restrictions occur on slightly less than 60% of Italian land. On the suitable land, which covers 25% of Italian land, the dominant limitations are the soil-chemical conditions. About 10% of Italy has a low CEC, a low base saturation, or absence of $CaCO_3$. On 8% slight or moderate limitations due to drought susceptibility occur. In this broad evaluation analysis no Italian land was found to occur with no limitations at all. The small-scaled maps used are the main reason for this underestimation.

More than 90% of Luxembourg was evaluated to be unsuitable for grape growing. Severe climatic restrictions are the principal reason. On the area with slight and moderate limitations, drought susceptibility, soil-chemical conditions, and topography are the limiting aspects. Land with no limitations was assessed not to occur.

In Greece, unsuitable land usually has a high drought susceptibility combined with severe slope and soil-physical quality limitations. Land with these severe limitations cover slightly less than 70% of Greek territory. Another 20% of Greek land has a high drought susceptibility only. Land with slight limitations mainly have less optimal soil-chemical conditions. Greek land was evaluated to have moderate limitations predominantly because of the susceptibility to drought. In Greece, the highest percentage of land with no limitations at all prevails. This land is usually covered with medium textured Fluvi-Calcaric Fluvisols.

About 30% of Spain has severe limitations because of the temperature regime and humidity. On another 55% of the Spanish area a high drought susceptibility prevails. In Spain, land was assessed to have slight and moderate limitations owing to similar restrictions as in Greece, viz. soil-chemical conditions and drought susceptibility, respectively. According to the broad analysis used in our study, no Spanish land without limitations was assessed to occur.

In Portugal slightly less than 60% of its territory has a high drought susceptibility only and no other severe limitations. On another 30% this type of restriction is combined with severe limitations of slope, or soil-physical conditions. On the suitable land slight or moderate limitations mainly prevail because of limitations of the slope, and the soil-chemical conditions. According to the broad analysis used in our study, no Spanish land without limitations was assessed to occur.

The distribution of suitable land over the NUTS-1 regions is shown in Appendix 22. Between 10% and 20% suitable land was evaluated to occur in the following NUTS-1 regions: Campania, Abruzzi-Molise, Sud, and Sardegna in Italy, North Ellas in Greece, and Madrid and Est in Spain. More than 20% suitable land prevails in: Hessen, Rheinland-Pfalz, and Saarland in West Germany, Bassin Parisien, Est, Ouest, Sud-Ouest, Centre-Est, and Mediterranee in France, and Nord-Ovest, Lombardia, Nord-Est, Emilia-Romagne, Centro, and Lazio in Italy. In the other NUTS-1 regions less than 10% suitable land was evaluated to occur. In the Mediterranean countries the high drought susceptibility was evaluated as imposing severe restrictions for most land being used for commercial grape growing. The high drought susceptibility is usually combined with severe limitations of slope and soil-physical conditions.

Grape yield

A detailed characterization of the suitability classes within the different NUTS-1 regions in terms of inputs and outputs was beyond the scope of this study. Some easily available data on the outputs expressed as yield, are provided.

Yield of grapes depends on variety, age, and many other cultivation practices. Yield figures are often not presented in weight per unit area; especially in experimental trials, weights are indicated per vine. According to Höfäcker (1974) the yield of the Riesling grape varied between 2.9 kg and 4.1 kg per vine among three mid-German locations. In his trials the vines were spaced 1.7 m apart in the row, and the rows were 1.5 m apart. Under these conditions yields of between 11.6 and 16.4 t ha^{-1} yr^{-1} can be reached. Klenert (1972) reported yields of a Riesling-Traminer variety of between 17.3 and 21.3 t ha^{-1} yr^{-1} under mid-German conditions. He also demonstrated that a reduction in radiation on sunny days by 60% resulted in a yield decrease from 30% to 65% compared with normal conditions. This result illustrates the importance of exposure to sun in the northern regions of the EC. In Andalusia the average grape yield amounted to 13.6 t ha^{-1} yr^{-1}. In this region, the yields vary between about 2 t ha^{-1} yr^{-1} and 15 t ha^{-1} yr^{-1} (De la Rosa and Morena, 1987). Similar yields of the muscadine grape have been reported in the southeast area of the United States (Goldy, 1988), viz. 15 to 20 t ha^{-1} yr^{-1}. Hackett and Carolane (1982) mentioned grape yields for the major global production locations of up to 30 t ha^{-1} yr^{-1}. However, they do not specify the characteristics of the locations where these high yields have been obtained. If we consider the statistical data on yields and acreages within the EC (Eurostat, 1988), the above-mentioned yields have not been reached on average. In 1986, the overall average yield of grapes amounted to about 7.2 t ha^{-1} yr^{-1} within the EC. The highest average yields were attained in West Germany, Italy, France, and Greece, i.e. 13.1, 10.6, 8.9 and 8.8 t ha^{-1} yr^{-1}, respectively. Relatively low average yields were reported in Portugal and Spain, i.e. 4.1 and 3.7 t ha^{-1} yr^{-1}.

Competitive suitable land for grapes and other crop types
An estimate was made for the areas of land of a NUTS-1 region which is suitable for both grapes and other types of crops, i.e. intensively managed grassland, cereals and root crops. The area which is only suitable for either grapes or for one of the other types of crops was also assessed. The common area of unsuitable land was also estimated. Suitable land was defined as land with no, slight, or moderate limitations. The estimation procedure used was explained in Chapter 4. The basic assumption is that suitable land is nested at least at the level of a land evaluation unit, as illustrated in Figure 8A. The results for a land evaluation unit were aggregated (determination of weighted averages of the suitability classes using the area of each of the land evaluation units and its suitabilities) and presented for the NUTS-1 regions. In Appendix 23 estimated competitive land, and common unsuitable land for grapes and some other crop types are presented for rainfed conditions. These results are expressed as percentages of the area of a NUTS-1 region. In Appendix 23 the percentage of suitable land for grape growing only is also given if grapes have to compete with grass, cereals or root crops. Finally, the percentage of land of a NUTS-1 region which is unsuitable for grape production, but which is suitable for grass, cereals or root crops is presented.

Relatively high percentages with competitive land (>20% of NUTS-1 region) occur in some regions in West Germany, France and Italy. Examples are: Hessen in West Germany, Est, Ouest, and Mediterranee in France, and Emilia-Romagne in Italy. Areas in NUTS-1 regions only suitable for grape growing are small. When grape growing has to compete with grass or cereal growing, this area is less than 14% maximum, and is usually even less than 10%. When grape growing has to compete with root crops, in some German, French and Italian regions, the area suitable for grape growing is only substantially higher than when the grapes have to compete with grass or cereals. For instance, in the NUTS-1 regions Saarland and Lombardia areas suitable for grapes and unsuitable for root crops are 44% and 32% respectively. The main reason for this relatively high percentage of suitable land for grapes only is the percentage of soils with a fine soil texture in these regions, which was assumed to be unsuitable for root crops (Reinds and Van Lanen, in prep.). The high percentages of unsuitable land for grapes and the other crop types (>75% of NUTS-1 region) were evaluated to prevail in Mediterranean regions such as Campania, Abruzzi-Molise, and Sardegna in Italy, North and Central Ellas in Greece, and Norte do Continente in Portugal.

The assessment of competitive and unsuitable land was based on the assumption that suitable land is nested (Fig. 8A). Usually this assumption was correct. However, in the case of grapes, non-nested suitable land may occasionally occur (Fig. 8B). For instance, some compound land evaluation units have subunits with moderately steep slopes (15-25%) which were evaluated as suitable for grape growing but unsuitable for cereals and root crops. Conversely, other subunits of these units were assessed to be too dry to grow grapes but were not excluded for cereals and root crops. This phenomenum of being non-nested, however, only occurs in the dry regions within the European Communities.

6 DISCUSSION AND CONCLUSIONS

The procedure developed in our study, which links a system to capture expert knowledge to a geographical information system (Chapter 2), has proved to be very efficient in evaluating natural resources of land for various perennial crops in a qualitative way. After the time-consuming storage of the huge amounts of soil and climate data and establishing a procedure to process the data and results (Chapter 3), evaluations could be rapidly carried out. Expert knowledge characteristics for qualitative land evaluation could readily be captured in a computer system.

Evaluation of a number of perennial crops shows that about 30% or less of the total EC area was assessed to be suitable for production (no, slight or moderate limitations). Normal growing less demanding tree species are an exception; the suitable area for this group amounts to slightly more than 50% of the EC area. Small suitable areas were evaluated to occur for citrus crops, i.e. 2% under rainfed conditions and 6% under irrigated conditions. For other heat-requiring crops, such as olives and grapes, larger suitable areas were evaluated to prevail. About 15% of EC land was assessed to be suitable for rainfed grape growing, and about 25% is suitable for olives. Suitable land for fruit trees species (rainfed or irrigated) was evaluated to cover about 30% of EC land. A similar figure was obtained for fast growing tree species, and normal growing more demanding trees species.

The suitability of the individual member states of the EC varies significantly among the countries and for the perennial crops considered (Tables 18, 19, 20, 22, 23, 26, 27, 29, 30, and 31). The northern member states, i.e. Denmark, the United Kingdom, Ireland, the Netherlands, and Belgium, were assessed to be unsuitable for heat-demanding crops, such as citrus, olives and grapes. West Germany and Luxembourg were evaluated to be unsuitable for the cultivation of the first two crops, but some land was evaluated to be suitable for grapes, i.e. 8% and 7% of the country, respectively. In the above-mentioned member states the suitable area for fruit trees and forest trees amounts to 42% to 58% in West Germany, 23% to 48% in the Netherlands, 38% to 72% in Belgium, 23% to 45% in the United Kingdom, 32% to 59% in Ireland, and 34% to 53% in Denmark. Larger suitable areas, however, occur for normal growing less demanding tree species, i.e. from 57% in the United Kingdom to 93% in Belgium.

All considered crops can grow in France. The heat-demanding crops such as citrus and olives, however, can only be cultivated in southern France. Therefore, less than 10% of France was evaluated to be suitable for these crops. The suitable French area for fruit trees, forest trees, and grapes varies from 32% to 52%. Similar to the other countries, the land potential in France for growing normal growing less demanding tree species is higher, i.e. 71%.

In the Mediterranean member states Italy, Greece, Spain and Portugal, all crops considered can be cultivated. Relatively large areas of land were assessed to be suitable for growing olives in all these countries; the percentage of suitable land varies from 32% to 64%. In Italy considerable areas were evaluated to be suitable for forest trees, i.e. between 20% and 36%, and for rainfed grape growing, i.e. 25%. The potential for cultivating fruit trees, and especially citrus, is lower in Italy. Under rainfed conditions, 10% of Italian land is suitable for fruit trees, and no more than 2% for citrus cultivation. When irrigation was assumed to be applied, suitable land increases. Then, 17% and 9% of Italian land was evaluated to be suitable for both groups of crops. Under rainfed conditions, suitable land in Greece, Spain and Portugal was assessed to be less than 10% for most crops other than olives. Only the normal growing less demanding tree species in Portugal and Spain exceed the figure of 10%, they cover 12% and 18% of suitable land. When irrigation was assumed to be applied, suitable areas in these countries increase. For instance, in Greece suitable land for fruit trees increases from 5% to 11% because of irrigation. In Portugal and Spain the increase is even more pronounced. In these two countries, the suitable area under rainfed conditions was evaluated to be 4% and 10%, whereas under irrigated conditions suitable land amounts to 23% and 24%, respectively.

Generally, in the Mediterranean countries, suitable areas for crops which can be grown all over the EC, are smaller than in the northern member states. This implies that suitable land is not uniformly distributed over the EC. A non-uniform distribution of suitable land for these crops also applies to some, individual countries (Appendices 4, 5, 6, 10, 12, 14, 16, 18, 20 and 22, and Maps 1, 2 and 3, and from 7 to 13 inclusive). For instance, the NUTS-1 regions in the northern part of the United Kingdom (e.g. Scotland, North) have significantly lower percentages of suitable land than those in the east and south (e.g. East Anglia, South East, Midlands). In France, distinct differences in percentages of suitable land can be recognized between the south (Mediterranee) and the north (e.g. Bassin Parisien, Nord-Pas-de-Calais). Examples of NUTS-1 regions with very low percentages of suitable land for most crops considered are: Norte do continente (P), Centro (Sp), Ellas (East and South islands; Gr), Sicilia (It), and North (UK). Examples with high percentages are: Schlewig-Holstein and Bayern (D), Nord-Pas-de-Calais (F), Nord-Est (It), Region Wallone (B), Denmark, and South East (UK).

Although the percentage of suitable land for a certain crop in most regions is (far) below 100%, the total EC area of suitable land for the crop is usually sufficient to significantly increase production if only the crop in question were to be cultivated on all this land. Hendriks et al. (1991) analysed the regional potential for three different groups of tree species, and estimated that if all the suitable land were to be afforested, timber production would twice exceed consumption. Another example is the suitable area for fruit trees in the Mediterranean countries, which is two to fifteen times greater than the area currently used. Our study, however, shows that suitable land for a certain crop is also usually suitable for another crop, and unsuitable land is usally unsuitable for most crops. This means that the crops generally have to compete for the same tracts of suitable land. Areas of competitive land were assessed for combinations of most crops considered (Appendices 7, 8, 9, 11, 13, 15, 17, 19, 21 and 23). Only when crops or management systems have different requirements, may percentages of competitive land be relatively low (e.g. low input olive producing versus root-crop growing on intensively managed farms). The question of which crop can grow where best, is not answered in our study because it depends on EC policies formulated for rural land. The Dutch Scientific Council for Government Policy will address these questions in a subsequent study using our results as input data.

Usually, the crop yield which can be obtained on land with a particular suitability differs considerably between the regions, because of agro-climatological conditions. In terms of production potential, one unit of suitable land in the Mediterranean countries cannot simply be replaced by the same unit in the northern member states (Van Lanen, in press). In the Mediterranean countries, the yield of land with a particular suitability class is often higher than in the nothern countries. Thus, the process of allocating crop yield data to a particular suitability class must consider the agro-climatological region.

The results presented in our study give an indication of the suitability of EC land for some perennial crops. They do not represent the absolute truth. Insufficient data on natural resources and insufficient knowledge on crop and management requirements may result in a deviation between the results and reality. In fact, we are in an exploration phase of assessing the regional production potential. The results of our study can be improved if:

- a representative soil profile for the dominant soil is determined. The description should preferably include the range and probability distribution of the land characteristics;
- the associated soil units of the mapping units are determined. Their area and characteristics must be included. These data also need to be gathered for inclusions on the mapping units;
- more meteorological stations were available, especially those located on higher elevations.

In addition to the lack of soil and climatic data, restricted knowledge on crop and management requirements adversely affects the reliability of the results. For instance, no precise definitions prevail for the upper limit of the slope which still permits land to be used for a particular activity. Only broad descriptions are available. Sensitivity analyses, for instance, show that if the same slope requirements were applied for irrigated fruit as for rainfed fruit (Table 21), the suitable area for irrigated fruit cultivation would be substantially larger. Then, in about 20% of the NUTS-1 regions between 5% and 10% more suitable land would occur, and in about 30% of the NUTS-1 regions the increase in suitable land would be between 10% and 20% (cf. Table 23). In 10% of the NUTS-1 regions the increase in suitable land would be as large as 20% to 30%. Decision criteria on permissible slope angles are especially relevant in the Mediterranean regions where less suitable land occurs when high demands are defined. Usually, a lower sensitivity of the decision criteria was determined as found for the slope. For example, if the suitability of EC land for citrus cultivation was carried out without considering a moderate limitation if $CaCO_3$ is present (Table 25), the area with no limitations hardly increases. In less than 15% of the NUTS-1 regions the area with no limitations would increase by more than 5%. The maximum increase in land with no limitations in a certain NUTS-1 region amounts to 9% (cf. Table 26).

Our evaluation results could also be improved if knowledge on the effects of land (e.g. temperature regime, humidity) on the quality of the harvested products (e.g. size, colour, taste) were to increase. Probably, suitable land for fruit trees in Ireland and in the NUTS-1 regions of the western United Kingdom is overestimated because of insufficient knowledge about the quality of the products.

In our study, land suitability was explored for each perennial crop separately and, subsequently, competitive land was determined for the crops considered. In this way, competitive land can only be approximated as explained in Chapter 4. In following studies, an alternative option could be a mutual evaluation of the land for all crops. This evaluation would yield more reliable results about which land units are suitable for many crops, and which are only suitable for one crop or a limited number of crops. This comprehensive analysis, however, would not answer the question of which crop grows where best. These types of questions can only be properly addressed when land use policies are considered.

REFERENCES

ABDEL-RAZIK, M.S., S.M.O. EL-DARIER, H.S. HUSSEIN and G.W.J. VAN DE VEN, 1987. Fruit tree cultivation in the northwestern coastal zone of Egypt. In: M.A. Ayyad and H. van Keulen (Eds.). The 'Mariut' project, Final Report, part 2. CABO, Wageningen. Appendix 10, CABO Verslag nr. 68, 56 pp.

BOUMA, J., 1989. Using soil survey data for quantitative land evaluation. Advances in Soil Science. Vol. 9. pp. 177-213.

BOUMA, J. and H.A.J. VAN LANEN, 1987. Transfer functions and threshold values: from soil characteristics to land qualities. In: K.J. Beek, P.A. Burrough and D.E. McCormack (Eds.), Quantified Land Evaluation Procedures, Proc. of Int. Workshop, ITC Publication Number 6, pp. 106-110.

BREGT, A.K., J.D. BULENS, G.H.J. DE KONING, & G.J. REINDS, (1989). Geographical Information System and crop production potential within the European Community. Proc. 4th Annual ESRI European User Conference. Rome. 10 pp.

BRIGGS, D.J. and D. WILSON, 1987. The state of the environment in the European Community in 1986. Commission of the European Communities, EUR 10633, Luxembourg, 370 pp.

BUIS, J., 1985. Historia Forestis. HES uitgevers, Utrecht, 1058 pp.

BULENS, J.D., A.K. BREGT, G.H.J. DE KONING, G.J. REINDS, C.A. VAN DIEPEN, & H.A.J. VAN LANEN, (in prep.). GIS supporting crop production potential research for the European Communities. In: EGIS'90 Proc. of First European Conference on Geographical Information Systems, eds. J. Harts, H.F.L. Ottens, H.J. Scholten & D.A. Ondaatje. EGIS Foundation, Utrecht, Vol.1, pp 117-125.

BULENS, J.D., and A.K. BREGT, (in press). Crop production potential of rural areas within the European Communities. I: GIS and data model. WRR Technical Working Document, The Hague.

CEC, 1985. Soil map of the European Communities, 1 : 1 000 000. Commission of the European Communities, Directorate-General for Agriculture, Luxembourg, 124 pp., 7 sheets and legend.

DATATREE, 1986. DTM-PC reference manual and operation guide. DataTree Inc., Waltman, MA.

DENNEY, J.O., and MCEACHERN, 1985. Modeling the thermal adaptability of the olive (Olea europaea L.) in Texas. Agricultural and Forest Meteorology, 35: 309-327.

DENT, D., and A. YOUNG, 1981. Soil survey and land evaluation. George Allen & Unwin, London, 278 pp.

DIEPEN, C.A. VAN, G.H.J. KONING, G.J. REINDS, J.D. BULENS and H.A.J. VAN LANEN, 1990. Regional analysis of physical crop production potential in the European Communities. In: The greenhouse effect and primary productivity in European agro-ecosystems (eds. J. Goudriaan, H. van Keulen & H.H. van Laar), Pudoc, Wageningen, pp. 74-79.

EUROSTAT, 1988. Statistical yearbook. Theme 5 Agricultural, Forestry and Fisheries. Luxembourg. 262 pp.

EVANS, J. 1983. A key to Eucalypts in Britain and Ireland. Forestry commission. Booklet 50. Her Majesty's stationery office, London, 23 pp.

FABIAO, A., H.A. PERSSON and E. STEEN, 1985. Growth dynamics of superficial roots in Portuguese plantations of Eucalyptus globulus Labill. studied with a mesh bag technique. Plant and Soil 83 (2): 233-243.

FAO, 1976. A framework for land evaluation. FAO Soils Bulletin 32, Rome, 72 pp.

FAO, 1978. Report on the agro-ecological zones project. Vol. 1 Methodology and results for Africa. World Resources Report 48, FAO, Rome, 158 pp.

GOLDY, R.G., 1988. Variation in some yield determining components in muscadine grapes and their correlation to yield. Euphyrica 39: 39-42.

HAAREN, H.A.J. VAN, G.J. JANSEN, J. VAN DEN BURG en M. DE KAM, 1987. Populieren in Nederland. Pudoc, Wageningen, 175 pp.

HACKETT, C., and J. CAROLANE, 1982. Edible horticultural crops. A compendium of information on fruit, vegetable, spice and nut species. Academic press. Sydney, New York and London.

HENDRIKS, C.M.A., H.A.J. VAN LANEN and J.D. BULENS, 1991. Regional analysis of physical potential of timber production in the European Community. X^{e} Congress Forestier Mondial, 'La foret, Patrimoine de l'avenir, Paris, 17-26 Sept. 1991, voulme 6, pp 54-59.

HESMER, H. and F.G. SCHROEDER, 1963. Waldzusammensetzung und Waldbehandlung in Niedersächsischen Tiefland westlich der Weser und in der Münsterchen Bucht bis zum Ende des 18. Jahrhunderts. Decheniana-Beihefte nr. 11, Bonn, 304 pp.

HÖFÄCKER, W., 1974. Einfluss von Umweltfaktoren auf Ertrag und Mostqualität der Rebe. Ein Beitrag zur methodischen Ermittlung der optimalen Standortbedingungen im Weinbau. Dissertation, Universität Hohemheim, 126 pp.

HOUGH, M.N. 1990. Agrometeorological aspects of crops in the United Kingdom and Ireland. A review for sugar beet, oilseed rape, peas, wheat, barley, oats, potatoes, apples and pears. Joint Research Centre, Commission of the European Communities, EUR 13039 EN, Brussels-Luxembourg, 303 pp.

IMENSON, A.C., H. DUMONT, A. EKONOMOU-AMILLI, S. STAMATIS and L. SEKLIZIOTIS, 1987. Impact analysis of climatic change in the Mediterranean region. European workshop on interrelated bioclimatic and land use changes. Noordwijkerhout, Netherlands. Vol. F.

JOOSSE, M.R., 1990. Personal communication based on: Kwantitatieve opbrengsten van appel en peer by J. Goedegebure. Wilhelminadorp, the Netherlands.

KLENERT, M., 1972. Künstliche Veränderung der meteorologischen Verhältnisse im Rebestand und ihre Auswirkung auf den Ertrag und die Fruchtbarkeit der Rebe sowie das Wachstum der Traubenbeeren. Dissertation, Justus Liebig-Unversität, Giessen, 132 pp.

KONING, G.H.J. DE, C.A. VAN DIEPEN, C.A., G.J. REINDS, J.D. BULENS and H.A.J. VAN LANEN, van (in prep). Crop production potential of rural areas within the European Communities. IV. Potential, water-limited and actual crop production. WRR Technical Working Document, The Hague.

KRONENBERG, H.G., 1989. Apple growing potentials in Europe. 3. Northern limits. Neth. J. of Agric. Sci. 37:35-45.

LANEN, H.A.J., VAN (1991). Qualitative and quantitative physical land evaluation: An operational approach. PhD Thesis, Agricultural University, Wageningen.

LANEN, H.A.J., VAN, and F.A. WOPEREIS, (in prep.). Computer-captured expert knowledge to evaluate possibilities for injection of slurry from animal manure in the Netherlands. Geoderma.

LANEN, H.A.J. VAN, J. BOUMA and Y. VAN RANDEN, 1989. Mixed qualitative/quantitative land evaluation methodology applied to the EC Soil Map. Step I: selection of potentially favourable areas. In: H.A.J. van Lanen and A.K. Bregt (Eds.). Proc. of CEC-workshop on 'Application of computerized EC soil map and climate data'. EUR Report 12039, Luxembourg. pp. 11-20.

LANEN, H.A.J. VAN, C.A. VAN DIEPEN, G.J. REINDS, G.H.J. DE KONING, J.D. BULENS and A.K. VAN BREGT, (in prep. a). Physical land evaluation methods and GIS to explore crop growth potential and its effects within the European Communities. Agricultural Systems.

LANEN, H.A.J. VAN, C.A. VAN DIEPEN, G.J. REINDS and G.H.J. DE KONING, (in prep. b). Comparison of Qualitative and Quantitative Physical Land Evaluation using the Assessment of the Sugar Beet Growing Potential of the European Communities. Soil Use and Management.

LANEN, H.A.J. VAN, M.J.D. HACK-TEN BROEKE, J. BOUMA, and W.J.M. DE GROOT, (in prep. c). A mixed qualitative/quantitative physical methodology. Geoderma.

LINDER, S., R.E. MCMURTRIE and J.J. LANDSBERG, 1985. Growth of Eucalypts: a mathematical model applied to Eucalyptus globulus. In: P.M.A. Tigerstedt, P. Puttonen and V. Kosk (eds.) 1985. Crop physiology of forest trees. University of Helsinki, Finland, 336 pp.

LIONAKIS, S.M., 1989. Tropical and subtropical fruit trees in Greece. In: Farre, J.M. and Monastra, F. (Eds.). Proc. of Workshop on 'Cultures tropicales et subtropicales pour les regions mediterranees'. EUR Report 11922, Luxembourg. pg. 71-75.

MAYER, H., 1984. Waldbau auf soziologisch-okologischer Grundlage. Gustav Fischer Verlag, Stuttgart-New York, 514 pp.

MOHRMANN, J.C.J., and J. KESSLER, 1959. Water deficiences in European agriculture. A climatological survey. ILRI publication no. 5, Wageningen. 60 pp.

ORPHANOS, P.I., V.D. KRENTOS and P.A. LOIZIDES, 1986. Effects of N, P and K fertilizing and sheep manure on yield and quality of Valencia oranges. Min. of Agric. and Nat, Res., Nicosia, Cyprus. Miscellaneous reports 28. 11 pp.

PAPADAKIS, J., 1960. Geografia Agricola Mundial. Salvat Editoros s.a. Barcelona.

PAPADAKIS, J., 1970. Agricultural potentialities of world climates. Buenos Aires, Argentina.

PAPADAKIS, J., 1975. Climates of the world and their potentialities. Buenos Aires, Argentina.

PENFOLD, A.R. and J.L. WILLIS, 1961. The Eucalypts. Leonard Hill Books Limited, London, Interscience publishers inc. New York, 550 pp.

REINDS, G.J. and H.A.J. VAN LANEN, (in prep.). Crop production potential of rural areas within the European Communities. II: A physical land evaluation procedure. WRR Technical Working Document, The Hague, 28 pp.

REINDS G.J., G.H.J. DE KONING and J.D. BULENS, (in prep.). Crop production potential of rural areas within the European Communities. III. Soils, climate and administrative regions. WRR Technical Working Document, The Hague, 39 pp.

ROSA, D. DE LA, and J.M. MOREIRA, 1987. Evaluacion Ecologica de Recursos Naturales de Andalucia. Serv. de Eval. Rec. Nat., AMA, Junta de Andalucia. Sevilla, 192 pp.

ROSSITER, D.G., 1989. ALES: a microcomputer program to assist in land evaluation. In: J. Bouma and A.K. Bregt (Eds.). Proc. of symposium on 'Land qualities in space and time'. Pudoc, Wageningen. pp. 113-116.

ROSSITER, D.G., 1990. ALES: a framework for land evaluation using a microcomputer. Soil Use and Management 6: 7-20.

ROSSITER, D.G. and A.R. VAN WAMBEKE, 1989. ALES, Automated Land Evaluation System. Ales Version 2.2 User's Manual, September 1989. Department of Agronomy, Cornell University, Ithaca, New York, USA.

SCHUTT, P., K.J. LANG and H.J. SCHUCK, 1984. Nadelholzer in Mitteleuropa. Gustav Fischer Verlag Stuttgart-New York, 274 pp.

SKELTON, S., 1988. Grapes. Weathering a poor season. The Grower, 109 (11): 33.

SYS, C., 1985. Land evaluation. Report of the State University of Ghent, Belgium. 352 pp.

THRAN, P. and S. BROEKHUIZEN, 1965. Agro-climatic atlas of Europe. Pudoc. Wageningen.

TRANQUILLINI, W., (ed.) 1979. Physiological Ecology of the Alpine Timberline. Ecological studies Vol. 31. Springer-Verlag, Berlin-Heidelberg-New York, 137 pp.

WAGENMAKERS, P.S., 1985. Plantdichtheid en rangschikking grootfruit (PFW 73), lichthuishouding in intensieve beplantingen (PFW 74) en snoei en boomvorm (PFW 83). In: Jaarverslag 1985. Proefstation voor de Fruitteelt. Wilhelminadorp. (in Dutch).

WAGENMAKERS, P.S., 1986. Plantdichtheid en rangschikking grootfruit (PFW 73), lichthuishouding in intensieve beplantingen (PFW 74) en snoei en boomvorm (PFW 83). In: Jaarverslag 1986. Proefstation voor de Fruitteelt. Wilhelminadorp. (in Dutch).

WAGENMAKERS, P.S., 1987. Plantdichtheid en rangschikking grootfruit (PFW 73), lichthuishouding in intensieve beplantingen (PFW 74) en snoei en boomvorm (PFW 83). In: Jaarverslag 1987. Proefstation voor de Fruitteelt. Wilhelminadorp. (in Dutch).

WAGENMAKERS, P.S., 1988. Plantdichtheid en rangschikking grootfruit (PFW 73), lichthuishouding in intensieve beplantingen (PFW 74) en snoei en boomvorm (PFW 83). In: Jaarverslag 1988. Proefstation voor de Fruitteelt. Wilhelminadorp. (in Dutch).

WEERT, R. VAN, K.J. LENSELINK and D.H. VAN SLOTEN, 1973. Opbrengst van citrus in relatie tot bodemvocht. Landbouwproefstation Suriname. Bulletin no. 90. (in Dutch).

WOOD, S.R. and F.J. DENT, 1983. LECS: A land evaluation computer system. Manual 5: Methodology. Ministry of Agriculture, Bogor, Indonesia.

APPENDIX 1 LIST OF WORKING DOCUMENTS OF PROJECT ON 'PRODUCTION POTENTIAL OF RURAL AREAS WITHIN THE EUROPEAN COMMUNITIES'

1 Crop production potential of rural areas within the European Communities. I: GIS and data model.
J.D. Bulens and A.K. Bregt

2 Crop production potential of rural areas within the European Communities. II: A physical land evaluation procedure.
G.J. Reinds and H.A.J. van Lanen

3 Crop production potential of rural areas within the European Communities. III: Soils, climate and administrative regions.
G.J. Reinds, G.H.J. de Koning and J.D. Bulens

4 Crop production potential of rural areas within the European Communities. IV: Potential, water-limited and actual crop production.
G.H.J. de Koning, C.A. van Diepen, G.J. Reinds, J.D. Bulens and H.A.J. van Lanen.

5 Crop production potential of rural areas within the European Communities. V: Qualitative suitability assessment for forestry and fruit crops.
H.A.J. van Lanen, C.M.A. Hendriks and J.D. Bulens.

APPENDIX 2 LAND CHARACTERISTICS DERIVED FROM THE EC SOIL MAP

Land characteristic: **alkalinity**

level	code	description
1	a	absent
2	p	present (Sodium Saturation rate >15%)

Land characteristic: **base saturation**

level	code	description
1	l	low (<50%)
2	m	medium (50-99%)
3	h	high (100%)

Land characteristic: **calcium carbonate**

level	code	description
1	a	absent
2	p	present

Land characteristic: **gypsum**

level	code	description
1	a	absent
2	p	present

Land characteristic: **cation exchange capacity**

level	code	description
1	vl	very low (<5 meq)
2	l	low (5-15 meq)
3	m	medium (15-30 meq)
4	h	high (30-40 meq)
5	vh	very high (>40 meq)
6	p	peat

Land characteristic: soil drainage

level	code	description
1	vp	very poor
2	p	poor
3	tp	temporarily poor
4	i	imperfect
5	mg	moderately good
6	g	good
7	ex	excessive

Land characteristic: organic matter content (%)

level	code	description
1	l	humous (0.6-2.0%)
2	h	rich (>2.0%)
3	p	peat (>50%)

Land characteristic: phases; subdivisions of units

level	code	description
1	no	none
2	gr	gravelly; >35% gravels < 7.5 cm
3	st	stony; >35% stones >7.5 cm
4	li	lithic; hard rock within 50 cm
5	co	concretionary; >35% con.
6	pe	petrocalcic horizon within 100 cm
7	sa	saline horizon within 100 cm
8	so	sodic horizon within 100 cm

Land characteristic: maximum rooting depth

level	code	description
1	vsh	very shallow (<=10 cm)
2	sh	shallow (10-40 cm)
3	mo	moderate (40-60 cm)
4	mod	moderately deep (60-80 cm)
5	d	deep (80-120 cm)
6	vd	very deep (>120 cm)

Land characteristic:		salinity
level	code	description
1	a	absent
2	p	present (EC > 4.0 mmhos/cm)

Land characteristic:		slope
level	code	description
1	le	level (<8%)
2	sl	sloping (8-15%)
3	most	moderately steep (15-25%)
4	st	steep (>25%)

Land characteristic:		texture of topsoil (0-30 cm)
level	code	description
1	c	coarse
2	m	medium
3	m	medium fine
4	f	fine
5	vf	very fine
6	p	peat

APPENDIX 3 LAND CHARACTERISTICS ASSOCIATED WITH CLIMATE

Land characteristic: mean annual precipitation deficit

level	code	description
1	<25	<25 mm
2	25-50	25- 50 mm
3	50-100	50-100 mm
4	100-200	100-200 mm
5	200-300	200-300 mm
6	300-400	300-400 mm
7	400-600	400-600 mm
8	600-800	600-800 mm
9	>800	>800 mm

Land characteristic: mean temperature July (°C)

level	code	description
1	<9	forest-growth impossible
2	9-11	moderate forest-growth
3	>11	forest-growth possible

Land characteristic: mean maximum temperature of six warmest months

level	code	description
1	<21	<21 °C
2	>21	>=21 °C

Land characteristic: average minimum temperature of coldest month

level	code	description
1	-8	<-8 °C
2	-6	-8 to -6 °C
3	-4	-6 to -4 °C
4	-2	-4 to -2 °C
5	0	-2 to 0 °C
6	2	0 to 2 °C
7	4	2 to 4 °C
8	10	4 to 10 °C
9	>10	>10 °C

Land characteristic:		number of months with optimum mean temperature between 13°C and 30°C
level	**code**	**description**
1	<5	<5 months
2	>5	>= 5 months

Land characteristic:		mean annual temperature
level	**code**	**description**
1	13	<13 °C
2	13.99	13 -13.99 °C
3	15	13.99-15 °C
4	16	15 -16 °C
5	20	16 -20 °C
6	22	20 -22 °C
7	24	22 -24 °C
8	26	24 -26 °C
9	>26	>26 °C

Land characteristic:		Summer rainfall (April-September)
level	**code**	**description**
1	<100	<100 mm
2	100-200	100-200 mm
3	200-300	200-300 mm
4	300-400	300-400 mm
5	400-500	400-500 mm
6	>500	>500 mm

Land characteristic:		August rainfall
level	**code**	**description**
1	<20	<20 mm
2	20-45	20-45 mm
3	>45	>45 mm

Land characteristic:		number of rain days per month
level	**code**	**description**
1	<5	<5 days
2	5-10	5-10 days
3	>10	>=10 days

APPENDIX 4 SUITABILITY OF NUTS-1 REGIONS FOR FAST GROWING TREE SPECIES

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe bio-physical limitations	Severe management limitations
11	Schleswig-Holstein	46	9	44	0
12	Hamburg	43	8	49	0
13	Niedersachsen	26	10	63	1
14	Bremen	60	10	30	0
15	Nordrhein-Westfalen	42	6	47	5
16	Hessen	28	15	57	1
17	Rheinland-Pfalz	26	5	67	2
18	Baden-Wurttemberg	37	19	41	3
19	Bayern	39	5	51	6
1A	Saarland	41	7	51	1
21	Ile de France	22	25	54	0
22	Bassin Parisien	30	19	52	0
23	Nord-Pas-de-Calais	50	27	23	0
24	Est	43	6	51	0
25	Ouest	20	13	66	0
26	Sud-Ouest	21	22	57	0
27	Centre-Est	18	6	76	0
28	Mediterranee	9	5	86	0
31	Nord-Ovest	15	2	81	1
32	Lombardia	41	7	48	4
33	Nord-Est	24	16	48	11
34	Emilia-Romagna	32	14	54	0
35	Centro	2	22	75	0
36	Lazio	0	6	94	0
37	Campania	0	11	88	0
38	Abruzzi-Molise	0	15	85	0
39	Sud	0	3	97	0
3A	Sicilia	0	0	99	0
3B	Sardegna	1	9	90	0
41	Noord-Nederland	33	12	55	0
42	Oost-Nederland	36	2	62	0
45	Zuid-Nederland	33	1	66	0
47	West-Nederland	59	16	25	0
51	Vlaams gewest	33	0	67	0
52	Region Wallonne	22	21	55	2
53	Brussel	72	0	28	0
60	Luxembourg (G.D.)	21	4	50	25

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe bio-physical limitations	Severe management limitations
71	North	4	30	66	0
72	Yorkshire & Humberside	12	41	47	0
73	East Midlands	41	35	24	0
74	East Anglia	45	35	20	0
75	South East	42	41	17	0
76	South West	25	14	61	0
77	West Midlands	41	35	25	0
78	North West	7	53	40	0
79	Wales	6	8	86	0
7A	Scotland	6	6	88	0
7B	Northern Ireland	2	23	75	0
80	Ireland	29	21	51	0
90	Danmark	36	17	47	0
A1	Ellas (North)	11	0	89	0
A2	Ellas (Central)	8	0	92	0
A3	Ellas (EastandS.isl)	2	0	98	0
B1	Noroeste	1	2	95	2
B2	Noreste	8	5	83	4
B3	Madrid	16	0	84	0
B4	Centro	7	0	93	0
B5	Este	8	0	91	0
B6	Sur	5	0	95	0
C1	Norte do continente	1	1	98	0
C2	Sud do Continente	7	0	93	0

APPENDIX 5 SUITABILITY OF NUTS-1 REGIONS FOR NORMAL GROWING MORE DEMANDING TREE SPECIES

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe bio-physical limitations	Severe management limitations
11	Schleswig-Holstein	30	17	54	0
12	Hamburg	5	38	57	0
13	Niedersachsen	19	11	69	1
14	Bremen	2	59	40	0
15	Nordrhein-Westfalen	39	7	49	5
16	Hessen	24	18	57	1
17	Rheinland-Pfalz	24	6	68	2
18	Baden-Wurttemberg	54	1	43	3
19	Bayern	37	7	50	6
1A	Saarland	41	4	54	1
21	Ile de France	37	17	45	0
22	Bassin Parisien	39	25	36	0
23	Nord-Pas-de-Calais	62	21	17	0
24	Est	39	19	42	0
25	Ouest	50	18	31	0
26	Sud-Ouest	46	11	43	0
27	Centre-Est	19	7	74	0
28	Mediterranee	7	6	86	0
31	Nord-Ovest	17	5	76	2
32	Lombardia	46	9	39	6
33	Nord-Est	38	16	34	12
34	Emilia-Romagna	42	6	50	2
35	Centro	20	7	72	0
36	Lazio	1	1	98	0
37	Campania	11	2	86	0
38	Abruzzi-Molise	14	2	83	0
39	Sud	3	1	96	0
3A	Sicilia	0	0	100	0
3B	Sardegna	0	1	99	0
41	Noord-Nederland	2	31	67	0
42	Oost-Nederland	15	21	64	0
45	Zuid-Nederland	21	12	67	0
47	West-Nederland	10	49	41	0
51	Vlaams gewest	16	17	67	0
52	Region Wallonne	37	4	59	0
53	Brussel	77	6	16	0
60	Luxembourg(G.D.)	21	5	74	0

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe bio-physical limitations	Severe management limitations
71	North	3	2	95	0
72	Yorkshire & Humberside	12	3	85	0
73	East Midlands	34	10	56	0
74	East Anglia	45	5	50	0
75	South East	43	6	51	0
76	South West	24	4	71	0
77	West Midlands	43	2	55	0
78	North West	8	1	90	0
79	Wales	5	2	92	0
7A	Scotland	6	4	90	0
7B	Northern Ireland	2	0	98	0
80	Ireland	28	4	68	0
90	Danmark	51	1	47	0
A1	Ellas (North)	0	11	89	0
A2	Ellas (Central)	0	8	92	0
A3	Ellas (EastandS.isl)	0	2	98	0
B1	Noroeste	2	5	89	5
B2	Noreste	4	11	80	5
B3	Madrid	0	16	84	0
B4	Centro	0	8	92	0
B5	Este	0	9	90	0
B6	Sur	0	5	95	0
C1	Norte do continente	1	1	98	0
C2	Suddo Continente	0	7	93	0

APPENDIX 6 SUITABILITY OF NUTS-1 REGIONS FOR NORMAL GROWING LESS DEMANDING TREE SPECIES

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe bio-physical limitations	Severe management limitations
11	Schleswig-Holstein	54	34	11	1
12	Hamburg	27	55	16	1
13	Niedersachsen	69	18	8	5
14	Bremen	19	71	10	1
15	Nordrhein-Westfalen	83	5	7	6
16	Hessen	86	6	7	1
17	Rheinland-Pfalz	83	6	6	5
18	Baden-Wurttemberg	78	2	16	3
19	Bayern	66	11	13	10
1A	Saarland	77	13	5	5
21	Ile de France	44	39	17	0
22	Bassin Parisien	55	28	16	1
23	Nord-Pas-de-Calais	74	18	8	0
24	Est	59	14	20	7
25	Ouest	62	23	13	2
26	Sud-Ouest	63	18	10	9
27	Centre-Est	41	14	27	18
28	Mediterranee	12	15	62	11
31	Nord-Ovest	30	9	36	24
32	Lombardia	66	5	12	17
33	Nord-Est	68	3	1	27
34	Emilia-Romagna	51	9	36	4
35	Centro	25	9	62	4
36	Lazio	2	16	81	1
37	Campania	13	3	77	6
38	Abruzzi-Molise	17	2	80	1
39	Sud	4	12	81	3
3A	Sicilia	0	21	78	0
3B	Sardegna	1	14	85	0
41	Noord-Nederland	39	48	12	1
42	Oost-Nederland	72	24	3	1
45	Zuid-Nederland	86	13	1	0
47	West-Nederland	22	50	27	1
51	Vlaams gewest	85	15	0	0
52	Region Wallonne	68	19	12	0
53	Brussel	95	5	0	0
60	Luxembourg(G.D.)	59	11	30	0

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe bio-physical limitations	Severe management limitations
71	North	16	5	71	9
72	Yorkshire & Humberside	26	7	65	2
73	East Midlands	41	17	41	1
74	East Anglia	45	19	36	0
75	South East	56	9	35	0
76	South West	69	13	17	1
77	West Midlands	57	6	37	1
78	North West	16	7	75	2
79	Wales	57	2	29	12
7A	Scotland	35	25	11	29
7B	Northern Ireland	44	6	44	6
80	Ireland	55	10	25	9
90	Danmark	53	40	7	0
A1	Ellas (North)	0	12	88	0
A2	Ellas (Central)	0	8	92	0
A3	Ellas (EastandS.isl)	0	3	97	0
B1	Noroeste	17	13	48	22
B2	Noreste	13	9	70	9
B3	Madrid	0	16	84	0
B4	Centro	2	9	89	1
B5	Este	4	16	76	4
B6	Sur	0	5	95	0
C1	Norte do continente	1	10	83	6
C2	Sud do Continente	0	7	93	0

APPENDIX 7 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR FAST GROWING TREE SPECIES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR FAST GROWING TREE SPECIES OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for fast growing tree species			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	46.	46.	33.	9.	9.	22.	43.	41.	41.	2.	4.	4.
12 Hamburg	37.	37.	4.	7.	7.	40.	40.	33.	33.	16.	23.	23.
13 Niedersachsen	26.	26.	19.	10.	10.	17.	49.	48.	47.	15.	16.	17.
14 Bremen	55.	55.	4.	9.	9.	60.	26.	26.	26.	10.	10.	10.
15 Nordrhein-Westfalen	41.	41.	39.	6.	6.	8.	24.	19.	17.	29.	34.	36.
16 Hessen	28.	28.	26.	15.	15.	17.	9.	6.	1.	48.	51.	56.
17 Rheinland-Pfalz	26.	26.	15.	5.	5.	16.	5.	2.	1.	64.	67.	68.
18 Baden-Wurttemberg	29.	29.	19.	26.	26.	36.	10.	9.	7.	35.	36.	38.
19 Bayern	33.	33.	29.	11.	11.	14.	10.	10.	8.	46.	46.	49.
1A Saarland	41.	41.	1.	7.	7.	47.	0.	0.	0.	52.	52.	52.
21 Ile de France	39.	39.	34.	0.	0.	6.	17.	17.	10.	44.	44.	50.
22 Bassin Parisien	48.	48.	32.	0.	0.	16.	24.	24.	11.	28.	28.	41.
23 Nord-Pas-de-Calais	73.	73.	66.	1.	1.	8.	10.	10.	4.	16.	16.	22.
24 Est	48.	48.	12.	0.	0.	36.	14.	14.	1.	38.	38.	51.
25 Ouest	31.	31.	25.	2.	2.	8.	31.	31.	30.	36.	36.	37.
26 Sud-Ouest	36.	36.	26.	6.	6.	17.	25.	24.	23.	33.	34.	34.
27 Centre-Est	22.	22.	16.	1.	1.	7.	9.	9.	8.	68.	68.	69.
28 Mediterranee	13.	13.	10.	0.	0.	3.	16.	16.	14.	71.	71.	73.
31 Nord-Ovest	16.	16.	2.	1.	1.	15.	9.	4.	0.	74.	79.	83.
32 Lombardia	41.	41.	9.	5.	5.	37.	17.	6.	0.	37.	48.	54.
33 Nord-Est	27.	27.	16.	12.	12.	24.	13.	13.	0.	48.	48.	60.
34 Emilia-Romagna	39.	39.	25.	6.	6.	20.	4.	4.	1.	51.	51.	54.
35 Centro	17.	17.	12.	8.	8.	12.	7.	7.	3.	68.	68.	73.
36 Lazio	1.	1.	1.	4.	4.	4.	12.	12.	5.	83.	83.	90.
37 Campania	9.	9.	8.	2.	2.	3.	2.	2.	0.	87.	87.	89.
38 Abruzzi-Molise	10.	10.	7.	5.	5.	8.	5.	5.	2.	80.	80.	83.
39 Sud	2.	2.	1.	1.	1.	3.	22.	22.	7.	75.	75.	89.
3A Sicilia	1.	1.	1.	0.	0.	0.	30.	30.	17.	69.	69.	82.
3B Sardegna	2.	2.	2.	8.	8.	8.	9.	9.	5.	81.	81.	85.

NUTS-1 region	competitive land			only suitable for fast growing tree species			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
41 Noord-Nederland	33.	33.	14.	11.	11.	31.	37.	37.	37.	19.	19.	18.
42 Oost-Nederland	36.	36.	24.	2.	2.	14.	57.	57.	52.	5.	5.	10.
45 Zuid-Nederland	33.	33.	22.	1.	1.	11.	65.	65.	64.	2.	2.	3.
47 West-Nederland	57.	57.	29.	15.	15.	43.	23.	11.	10.	5.	17.	18.
51 Vlaams gewest	32.	32.	27.	0.	0.	6.	66.	66.	61.	2.	2.	6.
52 Region Wallonne	31.	31.	30.	12.	12.	13.	5.	5.	5.	52.	52.	52.
53 Brussel	34.	34.	33.	0.	0.	1.	13.	13.	13.	53.	53.	53.
60 Luxembourg (G.D.)	21.	21.	6.	4.	4.	19.	10.	10.	9.	65.	65.	66.
71 North	33.	4.	3.	1.	30.	30.	33.	6.	6.	33.	60.	61.
72 Yorkshire & Humberside	50.	13.	12.	1.	38.	39.	28.	9.	9.	21.	40.	40.
73 East Midlands	73.	42.	21.	1.	33.	54.	14.	7.	7.	12.	18.	18.
74 East Anglia	75.	50.	28.	4.	30.	51.	19.	13.	13.	2.	7.	8.
75 South East	74.	44.	31.	1.	31.	44.	13.	11.	11.	12.	14.	14.
76 South West	36.	25.	17.	2.	13.	21.	34.	29.	29.	28.	33.	33.
77 West Midlands	70.	42.	37.	0.	28.	34.	14.	10.	10.	16.	20.	19.
78 North West	50.	8.	7.	1.	43.	44.	23.	7.	7.	26.	42.	42.
79 Wales	13.	6.	5.	1.	8.	9.	37.	26.	26.	49.	60.	60.
7A Scotland	8.	6.	6.	4.	6.	6.	23.	13.	13.	65.	75.	75.
7B Northern Ireland	22.	2.	2.	2.	22.	22.	44.	26.	26.	32.	50.	50.
80 Ireland	44.	30.	30.	4.	19.	19.	28.	17.	17.	24.	34.	34.
90 Danmark	52.	52.	51.	0.	0.	1.	46.	38.	38.	2.	10.	10.
A1 Ellas (North)	11.	11.	7.	0.	0.	4.	4.	4.	2.	85.	85.	87.
A2 Ellas (Central)	8.	8.	5.	0.	0.	3.	4.	4.	2.	88.	88.	90.
A3 Ellas (East and S. isl)	2.	2.	2.	0.	0.	1.	7.	7.	5.	91.	91.	93.
B1 Noroeste	1.	1.	1.	2.	2.	2.	17.	17.	1.	80.	80.	96.
B2 Noreste	8.	8.	7.	5.	5.	6.	34.	34.	5.	53.	53.	82.
B3 Madrid	16.	16.	16.	0.	0.	0.	43.	43.	16.	41.	41.	68.
B4 Centro	7.	7.	7.	0.	0.	0.	37.	37.	5.	56.	56.	88.
B5 Este	8.	8.	8.	0.	0.	0.	32.	32.	4.	60.	60.	88.
B6 Sur	5.	5.	5.	0.	0.	0.	44.	44.	8.	51.	51.	87.
C1 Norte do continente	1.	1.	1.	0.	0.	0.	23.	23.	5.	76.	76.	94.
C2 Sud do Continente	7.	7.	5.	0.	0.	2.	35.	35.	20.	58.	58.	73.

APPENDIX 8 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR NORMAL GROWING MORE DEMANDING TREE SPECIES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR NORMAL GROWING MORE DEMANDING TREE SPECIES OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for normal growing more demanding tree species			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	46.	46.	33.	0.	0.	13.	43.	41.	41.	11.	13.	13.
12 Hamburg	37.	37.	4.	0.	0.	33.	40.	33.	33.	23.	30.	30.
13 Niedersachsen	26.	26.	19.	4.	4.	11.	49.	48.	47.	21.	22.	23.
14 Bremen	55.	55.	4.	0.	0.	51.	26.	26.	26.	19.	19.	19.
15 Nordrhein-Westfalen	41.	41.	39.	5.	5.	7.	24.	19.	17.	30.	35.	37.
16 Hessen	28.	28.	26.	15.	15.	17.	9.	6.	1.	48.	51.	56.
17 Rheinland-Pfalz	26.	26.	15.	5.	5.	16.	5.	2.	1.	64.	67.	68.
18 Baden-Wurttemberg	29.	29.	19.	25.	25.	35.	10.	9.	7.	36.	37.	39.
19 Bayern	34.	34.	29.	10.	10.	15.	9.	9.	8.	47.	47.	48.
1A Saarland	41.	41.	1.	4.	4.	44.	0.	0.	0.	55.	55.	55.
21 Ile de France	43.	43.	37.	4.	4.	9.	14.	14.	6.	39.	39.	48.
22 Bassin Parisien	55.	55.	37.	9.	9.	27.	17.	17.	6.	19.	19.	30.
23 Nord-Pas-de-Calais	75.	75.	66.	5.	5.	14.	8.	8.	4.	12.	12.	16.
24 Est	55.	55.	13.	3.	3.	45.	7.	7.	0.	35.	35.	42.
25 Ouest	60.	60.	53.	9.	9.	15.	3.	3.	1.	28.	28.	31.
26 Sud-Ouest	48.	48.	37.	9.	9.	19.	14.	12.	11.	30.	31.	33.
27 Centre-Est	24.	24.	17.	1.	1.	8.	7.	7.	7.	68.	68.	68.
28 Mediterranee	13.	13.	10.	1.	1.	3.	17.	17.	14.	69.	69.	73.
31 Nord-Ovest	19.	19.	2.	2.	2.	19.	5.	0.	0.	74.	79.	79.
32 Lombardia	47.	47.	9.	6.	6.	44.	10.	0.	0.	37.	47.	47.
33 Nord-Est	40.	40.	16.	13.	13.	37.	0.	0.	0.	47.	47.	47.
34 Emilia-Romagna	40.	40.	25.	7.	7.	22.	3.	3.	1.	50.	50.	52.
35 Centro	19.	19.	12.	8.	8.	15.	5.	4.	3.	68.	69.	70.

NUTS-1 region	competitive land			only suitable for normal growing more demanding tree species			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
36 Lazio	2.	2.	1.	0.	0.	1.	11.	11.	5.	87.	87.	93.
37 Campania	11.	11.	8.	2.	2.	6.	0.	0.	0.	87.	87.	86.
38 Abruzzi-Molise	10.	10.	7.	6.	6.	10.	4.	4.	2.	80.	80.	81.
39 Sud	2.	2.	1.	2.	2.	3.	22.	22.	7.	74.	74.	89.
3A Sicilia	0.	0.	0.	0.	0.	0.	30.	30.	18.	70.	70.	82.
3B Sardegna	1.	1.	1.	0.	0.	0.	9.	9.	5.	90.	90.	94.
41 Noord-Nederland	33.	33.	14.	0.	0.	19.	37.	37.	37.	30.	30.	30.
42 Oost-Nederland	36.	36.	24.	0.	0.	12.	57.	57.	52.	7.	7.	12.
45 Zuid-Nederland	33.	33.	22.	0.	0.	11.	65.	65.	64.	3.	3.	3.
47 West-Nederland	57.	57.	29.	0.	0.	28.	23.	11.	10.	20.	32.	33.
51 Vlaams gewest	33.	33.	27.	0.	0.	6.	66.	66.	61.	1.	1.	6.
52 Region Wallonne	31.	31.	30.	9.	9.	11.	5.	5.	5.	55.	55.	54.
53 Brussel	40.	40.	39.	0.	0.	1.	8.	8.	8.	52.	52.	52.
60 Luxembourg (G.D.)	22.	22.	6.	4.	4.	20.	9.	9.	9.	65.	65.	65.
71 North	4.	4.	3.	1.	1.	2.	62.	6.	6.	33.	89.	89.
72 Yorkshire & Humberside	13.	13.	12.	1.	1.	2.	65.	9.	9.	21.	77.	77.
73 East Midlands	42.	42.	21.	1.	1.	22.	45.	7.	7.	12.	50.	50.
74 East Anglia	50.	50.	28.	0.	0.	22.	44.	13.	13.	6.	37.	37.
75 South East	44.	44.	31.	1.	1.	14.	44.	11.	11.	11.	44.	44.
76 South West	26.	26.	18.	2.	2.	10.	44.	28.	28.	28.	44.	44.
77 West Midlands	42.	42.	37.	0.	0.	6.	41.	10.	10.	17.	48.	47.
78 North West	8.	8.	7.	0.	0.	1.	66.	7.	7.	26.	85.	85.
79 Wales	6.	6.	5.	1.	1.	2.	43.	26.	26.	50.	67.	67.
7A Scotland	6.	6.	6.	4.	4.	4.	25.	13.	13.	65.	77.	77.
7B Northern Ireland	2.	2.	2.	0.	0.	0.	64.	26.	26.	34.	72.	72.
80 Ireland	31.	31.	31.	1.	1.	1.	42.	16.	16.	26.	52.	52.
90 Danmark	52.	52.	51.	0.	0.	1.	46.	38.	38.	2.	10.	10.
A1 Ellas (North)	11.	11.	7.	0.	0.	3.	4.	4.	2.	85.	85.	88.
A2 Ellas (Central)	8.	8.	5.	0.	0.	3.	4.	4.	2.	88.	88.	90.
A3 Ellas (East and S. isl)	2.	2.	2.	0.	0.	1.	7.	7.	5.	91.	91.	93.

NUTS-1 region	competitive land			only suitable for normal growing more demanding tree species			only suitable for crops			unsuitable otherland		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
B1 Noroeste	1.	1.	1.	6.	6.	6.	17.	17.	1.	76.	76.	92.
B2 Noreste	9.	9.	7.	6.	6.	8.	33.	33.	5.	52.	52.	80.
B3 Madrid	16.	16.	16.	0.	0.	0.	43.	43.	16.	41.	41.	68.
B4 Centro	7.	7.	7.	1.	1.	1.	37.	37.	5.	55.	55.	87.
B5 Este	9.	9.	8.	1.	1.	1.	31.	31.	4.	59.	59.	87.
B6 Sur	5.	5.	5.	0.	0.	0.	44.	44.	8.	51.	51.	87.
C1 Norte do continente	1.	1.	1.	0.	0.	0.	23.	23.	5.	76.	76.	94.
C2 Sud do Continente	7.	7.	5.	0.	0.	2.	35.	35.	20.	58.	58.	73.

APPENDIX 9 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR NORMAL GROWING LESS DEMANDING TREE SPECIES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR NORMAL GROWING LESS DEMANDING TREE SPECIES OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for normal growing less demanding tree species			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	86.	86.	73.	1.	1.	13.	2.	0.	0.	11.	13.	14.
12 Hamburg	70.	70.	37.	1.	1.	34.	8.	0.	0.	21.	29.	29.
13 Niedersachsen	74.	74.	66.	13.	13.	21.	2.	0.	0.	11.	13.	13.
14 Bremen	81.	81.	30.	1.	1.	52.	0.	0.	0.	18.	18.	18.
15 Nordrhein-Westfalen	60.	60.	56.	26.	26.	31.	5.	0.	0.	9.	14.	13.
16 Hessen	34.	34.	27.	58.	58.	65.	3.	0.	0.	5.	8.	8.
17 Rheinland-Pfalz	28.	28.	16.	61.	61.	73.	3.	0.	0.	8.	11.	11.
18 Baden-Wurttemberg	38.	38.	26.	42.	42.	54.	1.	0.	0.	19.	20.	20.
19 Bayern	43.	43.	37.	34.	34.	39.	0.	0.	0.	23.	23.	24.
1A Saarland	42.	42.	1.	48.	48.	89.	0.	0.	0.	10.	10.	10.
21 Ile de France	45.	45.	39.	25.	25.	31.	11.	11.	4.	19.	19.	26.
22 Bassin Parisien	63.	63.	40.	19.	19.	43.	9.	9.	3.	9.	9.	14.
23 Nord-Pas-de-Calais	78.	78.	69.	11.	11.	20.	6.	6.	1.	5.	5.	10.
24 Est	62.	62.	13.	11.	11.	60.	0.	0.	0.	27.	27.	27.
25 Ouest	62.	62.	54.	23.	23.	30.	0.	0.	0.	15.	15.	16.
26 Sud-Ouest	60.	60.	49.	21.	21.	32.	1.	0.	0.	18.	19.	19.
27 Centre-Est	31.	31.	24.	22.	22.	29.	0.	0.	0.	47.	47.	47.
28 Mediterranee	23.	23.	20.	3.	3.	7.	6.	6.	4.	68.	68.	69.
31 Nord-Ovest	20.	20.	2.	20.	20.	37.	5.	0.	0.	55.	60.	61.
32 Lombardia	47.	47.	9.	20.	20.	58.	10.	0.	0.	23.	33.	33.
33 Nord-Est	40.	40.	16.	30.	30.	54.	0.	0.	0.	30.	30.	30.
34 Emilia-Romagna	41.	41.	26.	18.	18.	33.	3.	3.	0.	38.	38.	41.
35 Centro	22.	22.	15.	12.	12.	19.	2.	1.	0.	64.	65.	66.

NUTS-1 region	competitive land			only suitable for normal growing less demanding tree species			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
36 Lazio	11.	11.	6.	6.	6.	12.	2.	2.	0.	81.	81.	82.
37 Campania	11.	11.	8.	5.	5.	9.	0.	0.	0.	84.	84.	83.
38 Abruzzi-Molise	12.	12.	8.	7.	7.	11.	3.	3.	1.	78.	78.	80.
39 Sud	12.	12.	5.	4.	4.	11.	12.	12.	3.	72.	72.	81.
3A Sicilia	22.	22.	12.	0.	0.	10.	9.	9.	6.	69.	69.	72.
3B Sardegna	7.	7.	4.	8.	8.	11.	3.	3.	2.	82.	82.	83.
41 Noord-Nederland	70.	70.	51.	16.	16.	36.	0.	0.	0.	14.	14.	13.
42 Oost-Nederland	93.	93.	76.	3.	3.	20.	0.	0.	0.	4.	4.	4.
45 Zuid-Nederland	97.	97.	86.	1.	1.	13.	0.	0.	0.	2.	2.	1.
47 West-Nederland	68.	68.	39.	1.	1.	30.	11.	0.	0.	20.	31.	31.
51 Vlaams gewest	99.	99.	88.	0.	0.	11.	0.	0.	0.	1.	1.	1.
52 Region Wallonne	35.	35.	34.	51.	51.	52.	1.	1.	1.	13.	13.	13.
53 Brussel	48.	48.	47.	0.	0.	1.	0.	0.	0.	52.	52.	52.
60 Luxembourg (G.D.)	31.	31.	15.	39.	39.	55.	0.	0.	0.	30.	30.	30.
71 North	10.	9.	9.	10.	11.	11.	56.	0.	0.	24.	80.	80.
72 Yorkshire & Humberside	23.	23.	22.	9.	9.	10.	55.	0.	0.	13.	68.	68.
73 East Midlands	49.	48.	28.	8.	9.	30.	38.	0.	0.	5.	43.	42.
74 East Anglia	63.	63.	41.	1.	1.	22.	31.	0.	0.	5.	36.	37.
75 South East	56.	55.	42.	3.	4.	17.	31.	0.	0.	10.	41.	41.
76 South West	54.	54.	46.	26.	27.	35.	15.	0.	0.	5.	19.	19.
77 West Midlands	52.	52.	47.	7.	7.	12.	31.	0.	0.	10.	41.	41.
78 North West	15.	15.	14.	5.	5.	5.	58.	0.	0.	22.	80.	81.
79 Wales	32.	32.	31.	27.	27.	28.	17.	0.	0.	24.	41.	41.
7A Scotland	22.	19.	19.	36.	39.	39.	9.	0.	0.	33.	42.	42.
7B Northern Ireland	30.	29.	29.	19.	20.	20.	37.	0.	0.	14.	51.	51.
80 Ireland	52.	47.	46.	12.	18.	18.	20.	0.	0.	16.	35.	36.
90 Danmark	90.	90.	89.	1.	1.	2.	7.	0.	0.	2.	9.	9.
A1 Ellas (North)	12.	12.	8.	0.	0.	4.	2.	2.	1.	86.	86.	87.
A2 Ellas (Central)	8.	8.	5.	0.	0.	3.	3.	3.	2.	89.	89.	90.
A3 Ellas (East and S. isl)	3.	3.	2.	0.	0.	1.	6.	6.	4.	91.	91.	93.

NUTS-1 region	competitive land			only suitable for normal growing less demanding tree species			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
B1 Noroeste	16.	16.	1.	14.	14.	28.	2.	2.	1.	68.	68.	70.
B2 Noreste	13.	13.	7.	8.	8.	14.	29.	29.	5.	50.	50.	74.
B3 Madrid	16.	16.	16.	0.	0.	0.	43.	43.	16.	41.	41.	68.
B4 Centro	9.	9.	7.	1.	1.	3.	35.	35.	5.	55.	55.	85.
B5 Este	18.	18.	10.	3.	3.	11.	22.	22.	2.	57.	57.	77.
B6 Sur	5.	5.	5.	0.	0.	0.	44.	44.	8.	51.	51.	87.
C1 Norte do continente	8.	8.	1.	3.	3.	10.	16.	16.	5.	73.	73.	84.
C2 Sud do Continente	7.	7.	5.	0.	0.	2.	35.	35.	20.	58.	58.	73.

APPENDIX 10 SUITABILITY OF NUTS-1 REGIONS FOR RAINFED FRUIT TREES

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
11	Schleswig-Holstein	34	4	62
12	Hamburg	9	5	86
13	Niedersachsen	23	16	61
14	Bremen	6	5	89
15	Nordrhein-Westfalen	36	27	36
16	Hessen	24	61	15
17	Rheinland-Pfalz	14	59	27
18	Baden-Wurttemberg	24	28	48
19	Bayern	33	30	38
1A	Saarland	1	35	64
1B	Berlin (West)	0	0	100
21	Ile de France	17	39	44
22	Bassin Parisien	25	30	45
23	Nord-Pas-de-Calais	38	33	30
24	Est	9	28	63
25	Ouest	28	32	40
26	Sud-Ouest	21	12	67
27	Centre-Est	14	26	60
28	Mediterranee	6	4	90
31	Nord-Ovest	1	8	91
32	Lombardia	5	16	79
33	Nord-Est	9	24	67
34	Emilia-Romagna	14	8	78
35	Centro	0	10	90
36	Lazio	0	1	100
37	Campania	0	0	100
38	Abruzzi-Molise	0	0	100
39	Sud	0	0	100
3A	Sicilia	0	0	99
3B	Sardegna	0	1	98
41	Noord-Nederland	8	6	86
42	Oost-Nederland	20	4	76
45	Zuid-Nederland	21	1	78
47	West-Nederland	16	13	71
51	Vlaams gewest	44	5	51
52	Region Wallonne	18	72	10
53	Brussel	45	1	53
60	Luxembourg (G.D.)	5	40	55

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
71	North	4	9	88
72	Yorkshire & Humberside	9	5	86
73	East Midlands	12	9	78
74	East Anglia	19	4	77
75	South East	22	3	75
76	South West	20	16	65
77	West Midlands	31	8	61
78	North West	2	4	93
79	Wales	18	24	58
7A	Scotland	9	10	81
7B	Northern Ireland	20	17	63
80	Ireland	31	12	57
90	Danmark	34	0	66
A1	Ellas (North)	7	0	93
A2	Ellas (Central)	5	0	95
A3	Ellas (East and S. isl)	2	0	98
B1	Noroeste	1	18	80
B2	Noreste	7	9	85
B3	Madrid	16	0	84
B4	Centro	7	1	93
B5	Este	8	3	89
B6	Sur	5	0	95
C1	Norte do continente	1	3	97
C2	Sud do Continente	5	0	95

APPENDIX 11 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR RAINFED FRUIT TREES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR RAINFED FRUIT TREES OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for rainfed fruit			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	38.	38.	38.	0.	0.	0.	51.	49.	36.	11.	13.	26.
12 Hamburg	14.	14.	14.	0.	0.	0.	64.	56.	23.	22.	30.	63.
13 Niedersachsen	35.	35.	35.	4.	4.	5.	40.	38.	31.	21.	23.	29.
14 Bremen	11.	11.	11.	0.	0.	0.	70.	70.	19.	19.	19.	70.
15 Nordrhein-Westfalen	41.	41.	39.	22.	22.	24.	24.	19.	17.	13.	18.	20.
16 Hessen	32.	32.	27.	54.	54.	59.	5.	2.	0.	9.	12.	14.
17 Rheinland-Pfalz	16.	16.	15.	57.	57.	58.	14.	11.	1.	13.	16.	26.
18 Baden-Wurttemberg	29.	29.	26.	23.	23.	26.	10.	9.	0.	38.	39.	48.
19 Bayern	40.	40.	35.	22.	22.	27.	3.	3.	2.	35.	35.	36.
1A Saarland	1.	1.	1.	34.	34.	34.	40.	40.	0.	25.	25.	65.
21 Ile de France	37.	37.	37.	19.	19.	19.	19.	19.	6.	25.	25.	38.
22 Bassin Parisien	42.	42.	37.	13.	13.	18.	31.	31.	6.	14.	14.	39.
23 Nord-Pas-de-Calais	67.	67.	67.	3.	3.	3.	16.	16.	3.	14.	14.	27.
24 Est	25.	25.	13.	13.	13.	25.	37.	37.	0.	25.	25.	62.
25 Ouest	55.	55.	53.	4.	4.	7.	7.	7.	1.	34.	34.	39.
26 Sud-Ouest	27.	27.	26.	7.	7.	7.	34.	33.	22.	32.	33.	45.
27 Centre-Est	25.	25.	24.	15.	15.	16.	6.	6.	0.	54.	54.	60.
28 Mediterranee	10.	10.	9.	1.	1.	1.	20.	20.	15.	69.	69.	75.
31 Nord-Ovest	4.	4.	2.	4.	4.	7.	20.	15.	1.	72.	77.	90.
32 Lombardia	15.	15.	7.	6.	6.	14.	42.	32.	2.	37.	47.	77.
33 Nord-Est	26.	26.	12.	8.	8.	21.	14.	14.	4.	52.	52.	63.
34 Emilia-Romagna	19.	19.	18.	2.	2.	3.	24.	24.	8.	55.	55.	71.
35 Centro	8.	8.	7.	3.	3.	3.	16.	15.	8.	73.	74.	82.
36 Lazio	0.	0.	0.	0.	0.	0.	13.	13.	6.	87.	87.	94.
37 Campania	0.	0.	0.	0.	0.	0.	11.	11.	8.	89.	89.	92.
38 Abruzzi-Molise	0.	0.	0.	0.	0.	0.	15.	15.	9.	85.	85.	91.
39 Sud	0.	0.	0.	0.	0.	0.	24.	24.	8.	76.	76.	92.
3A Sicilia	1.	1.	1.	0.	0.	0.	30.	30.	17.	69.	69.	82.
3B Sardegna	2.	2.	2.	0.	0.	0.	9.	9.	5.	89.	89.	93.

NUTS-1 region	competitive land			only suitable for rainfed fruit			only suitable for other crops			unsuitable land		
	crass	rereals	goot crops	crass	rereals	goot crops	crass	rereals	goot crops	crass	rereals	oot crops
41 Noord-Nederland	14.	14.	14.	0.	0.	0.	56.	56.	37.	30.	30.	49.
42 Oost-Nederland	24.	24.	24.	0.	0.	0.	69.	69.	52.	7.	7.	24.
45 Zuid-Nederland	22.	22.	22.	0.	0.	0.	75.	75.	64.	3.	3.	14.
47 West-Nederland	29.	29.	29.	0.	0.	0.	51.	39.	10.	20.	32.	61.
51 Vlaams gewest	49.	49.	49.	0.	0.	0.	50.	50.	39.	1.	1.	12.
52 Region Wallonne	33.	33.	33.	57.	57.	57.	3.	3.	2.	7.	7.	8.
53 Brussel	47.	47.	47.	0.	0.	0.	1.	1.	0.	52.	52.	53.
60 Luxembourg (G.D.)	6.	6.	6.	38.	38.	39.	25.	25.	9.	31.	31.	46.
71 North	8.	8.	8.	4.	4.	4.	57.	1.	0.	31.	87.	88.
72 Yorkshire & Humberside	13.	13.	13.	1.	1.	1.	64.	9.	8.	22.	77.	78.
73 East Midlands	21.	21.	21.	1.	1.	1.	66.	28.	7.	12.	50.	71.
74 East Anglia	23.	23.	23.	0.	0.	0.	71.	40.	18.	6.	37.	59.
75 South East	25.	25.	25.	0.	0.	0.	62.	30.	17.	13.	45.	58.
76 South West	34.	34.	34.	2.	2.	2.	35.	20.	11.	29.	44.	53.
77 West Midlands	38.	38.	38.	1.	1.	1.	46.	14.	8.	15.	47.	53.
78 North West	7.	7.	7.	0.	0.	0.	67.	8.	8.	26.	85.	85.
79 Wales	29.	29.	29.	13.	13.	13.	20.	2.	1.	38.	56.	57.
7A Scotland	12.	12.	12.	7.	7.	7.	19.	7.	7.	62.	74.	74.
7B Northern Ireland	27.	27.	27.	10.	10.	10.	39.	1.	1.	24.	62.	62.
80 Ireland	42.	42.	42.	1.	1.	1.	31.	4.	4.	26.	53.	53.
90 Danmark	34.	34.	34.	0.	0.	0.	64.	56.	55.	2.	10.	11.
A1 Ellas (North)	7.	7.	7.	0.	0.	0.	7.	7.	3.	86.	86.	90.
A2 Ellas (Central)	5.	5.	5.	0.	0.	0.	7.	7.	3.	88.	88.	92.
A3 Ellas (East and S. isl)	2.	2.	2.	0.	0.	0.	8.	8.	5.	90.	90.	94.
B1 Noroeste	15.	15.	1.	4.	4.	18.	3.	3.	1.	78.	78.	80.
B2 Noreste	9.	9.	7.	6.	6.	9.	33.	33.	5.	52.	52.	79.
B3 Madrid	16.	16.	16.	0.	0.	0.	43.	43.	16.	41.	41.	68.
B4 Centro	7.	7.	7.	0.	0.	1.	37.	37.	5.	56.	56.	87.
B5 Este	10.	10.	8.	1.	1.	3.	30.	30.	4.	59.	59.	85.
B6 Sur	5.	5.	5.	0.	0.	0.	44.	44.	8.	51.	51.	87.
C1 Norte do continente	3.	3.	1.	1.	1.	3.	22.	22.	5.	75.	75.	91.
C2 Sud do Continente	5.	5.	5.	0.	0.	0.	37.	37.	20.	58.	58.	75.

APPENDIX 12 SUITABILITY OF NUTS-1 REGIONS FOR IRRIGATED FRUIT TREES

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
11	Schleswig-Holstein	19	22	59
12	Hamburg	8	15	77
13	Niedersachsen	17	24	59
14	Bremen	6	12	82
15	Nordrhein-Westfalen	27	24	48
16	Hessen	19	45	36
17	Rheinland-Pfalz	10	35	55
18	Baden-Wurttemberg	17	20	62
19	Bayern	24	27	49
1A	Saarland	1	27	72
1B	Berlin (West)	0	0	100
21	Ile de France	22	34	44
22	Bassin Parisien	21	29	50
23	Nord-Pas-de-Calais	36	35	30
24	Est	8	17	75
25	Ouest	28	29	43
26	Sud-Ouest	14	32	54
27	Centre-Est	9	22	69
28	Mediterranee	14	12	74
31	Nord-Ovest	2	4	94
32	Lombardia	7	13	80
33	Nord-Est	11	23	65
34	Emilia-Romagna	18	12	71
35	Centro	7	10	83
36	Lazio	3	7	91
37	Campania	5	5	90
38	Abruzzi-Molise	3	7	90
39	Sud	3	14	82
3A	Sicilia	4	15	82
3B	Sardegna	3	3	94
41	Noord-Nederland	8	6	86
42	Oost-Nederland	20	4	76
45	Zuid-Nederland	18	4	78
47	West-Nederland	16	13	71
51	Vlaams gewest	15	35	51
52	Region Wallonne	11	50	38
53	Brussel	15	32	53
60	Luxembourg (G.D.)	3	20	77

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
71	North	1	8	91
72	Yorkshire & Humberside	7	8	85
73	East Midlands	8	14	78
74	East Anglia	15	13	72
75	South East	16	15	69
76	South West	9	26	65
77	West Midlands	12	31	57
78	North West	3	6	91
79	Wales	2	28	70
7A	Scotland	0	12	88
7B	Northern Ireland	1	26	73
80	Ireland	12	32	56
90	Danmark	7	44	49
A1	Ellas (North)	7	8	85
A2	Ellas (Central)	5	3	92
A3	Ellas (Eastand S. isl)	2	5	94
B1	Noroeste	1	16	84
B2	Noreste	6	20	75
B3	Madrid	20	29	51
B4	Centro	7	20	73
B5	Este	8	16	76
B6	Sur	5	18	77
C1	Norte do continente	1	25	75
C2	Sud do Continente	4	18	78

APPENDIX 13 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR IRRIGATED FRUIT TREES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR IRRIGATED FRUIT TREES OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for irrigated fruit			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	41.	41.	41.	0.	0.	0.	47.	45.	32.	12.	14.	27.
12 Hamburg	23.	23.	23.	0.	0.	0.	54.	47.	14.	23.	30.	63.
13 Niedersachsen	37.	37.	37.	3.	3.	4.	38.	36.	29.	22.	24.	30.
14 Bremen	18.	18.	18.	0.	0.	0.	63.	63.	12.	19.	19.	70.
15 Nordrhein-Westfalen	41.	41.	39.	11.	11.	13.	24.	19.	17.	24.	29.	31.
16 Hessen	32.	32.	27.	32.	32.	37.	5.	2.	0.	31.	34.	36.
17 Rheinland-Pfalz	16.	16.	15.	29.	29.	30.	14.	11.	1.	41.	44.	54.
18 Baden-Wurttemberg	29.	29.	26.	9.	9.	12.	10.	9.	0.	52.	53.	62.
19 Bayern	40.	40.	36.	11.	11.	15.	3.	3.	2.	46.	46.	47.
1A Saarland	1.	1.	1.	26.	26.	26.	40.	40.	0.	33.	33.	73.
21 Ile de France	37.	37.	37.	19.	19.	19.	19.	19.	6.	25.	25.	38.
22 Bassin Parisien	42.	42.	37.	8.	8.	13.	30.	30.	6.	20.	20.	44.
23 Nord-Pas-de-Calais	67.	67.	67.	3.	3.	3.	16.	16.	3.	14.	14.	27.
24 Est	25.	25.	13.	0.	0.	12.	38.	38.	0.	37.	37.	75.
25 Ouest	55.	55.	54.	2.	2.	4.	7.	7.	1.	36.	36.	42.
26 Sud-Ouest	39.	39.	38.	7.	7.	8.	22.	21.	10.	32.	33.	44.
27 Centre-Est	25.	25.	24.	6.	6.	7.	6.	6.	0.	63.	63.	69.
28 Mediterranee	26.	26.	24.	0.	0.	2.	4.	4.	0.	70.	70.	74.
31 Nord-Ovest	5.	5.	2.	0.	0.	3.	19.	14.	0.	76.	81.	95.
32 Lombardia	20.	20.	9.	0.	0.	10.	38.	28.	0.	42.	52.	81.
33 Nord-Est	34.	34.	16.	0.	0.	19.	5.	5.	0.	61.	61.	65.
34 Emilia-Romagna	29.	29.	26.	0.	0.	3.	14.	14.	0.	57.	57.	71.
35 Centro	16.	16.	16.	1.	1.	1.	8.	8.	0.	75.	75.	83.
36 Lazio	7.	7.	6.	3.	3.	3.	6.	6.	0.	84.	84.	91.
37 Campania	8.	8.	8.	2.	2.	2.	4.	4.	0.	86.	86.	90.
38 Abruzzi-Molise	10.	10.	9.	0.	0.	1.	5.	5.	0.	85.	85.	90.
39 Sud	12.	12.	8.	6.	6.	10.	12.	12.	0.	70.	70.	82.
3A Sicilia	18.	18.	18.	0.	0.	0.	12.	12.	0.	70.	70.	82.
3B Sardegna	6.	6.	6.	0.	0.	0.	4.	4.	0.	90.	90.	94.

NUTS-1 region	competitive land			only suitable for irrigated fruit			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
41 Noord-Nederland	14.	14.	14.	0.	0.	0.	56.	56.	37.	30.	30.	49.
42 Oost-Nederland	24.	24.	24.	0.	0.	0.	69.	69.	52.	7.	7.	24.
45 Zuid-Nederland	22.	22.	22.	0.	0.	0.	75.	75.	64.	3.	3.	14.
47 West-Nederland	29.	29.	29.	0.	0.	0.	51.	39.	10.	20.	32.	61.
51 Vlaams gewest	49.	49.	49.	0.	0.	0.	50.	50.	39.	1.	1.	12.
52 Region Wallonne	33.	33.	33.	29.	29.	29.	3.	3.	2.	35.	35.	36.
53 Brussel	47.	47.	47.	0.	0.	0.	1.	1.	0.	52.	52.	53.
60 Luxembourg (G.D.)	6.	6.	6.	17.	17.	18.	25.	25.	10.	52.	52.	67.
71 North	8.	8.	8.	1.	1.	1.	57.	1.	0.	34.	90.	91.
72 Yorkshire & Humberside	15.	15.	15.	1.	1.	1.	63.	8.	7.	21.	76.	77.
73 East Midlands	22.	22.	22.	0.	0.	0.	65.	26.	5.	13.	52.	73.
74 East Anglia	28.	28.	28.	0.	0.	0.	66.	35.	13.	6.	37.	59.
75 South East	31.	31.	31.	0.	0.	0.	57.	24.	11.	12.	45.	58.
76 South West	35.	35.	35.	0.	0.	0.	35.	19.	11.	30.	46.	54.
77 West Midlands	43.	43.	43.	0.	0.	0.	41.	10.	4.	16.	47.	53.
78 North West	9.	9.	9.	0.	0.	0.	65.	6.	6.	26.	85.	85.
79 Wales	30.	30.	30.	0.	0.	0.	19.	2.	1.	51.	68.	69.
7A Scotland	12.	12.	12.	0.	0.	0.	19.	7.	7.	69.	81.	81.
7B Northern Ireland	27.	27.	27.	0.	0.	0.	39.	1.	1.	34.	72.	72.
80 Ireland	44.	44.	44.	0.	0.	0.	29.	2.	2.	27.	54.	54.
90 Danmark	51.	51.	51.	0.	0.	0.	47.	40.	38.	2.	9.	11.
A1 Ellas (North)	9.	9.	9.	6.	6.	6.	5.	5.	0.	80.	80.	85.
A2 Ellas (Central)	7.	7.	7.	1.	1.	1.	4.	4.	0.	88.	88.	92.
A3 Ellas (East and S. isl)	6.	6.	6.	0.	0.	0.	3.	3.	0.	91.	91.	94.
B1 Noroeste	16.	16.	1.	0.	0.	16.	1.	1.	1.	83.	83.	82.
B2 Noreste	25.	25.	12.	0.	0.	13.	17.	17.	0.	58.	58.	75.
B3 Madrid	49.	49.	32.	0.	0.	18.	9.	9.	0.	42.	42.	50.
B4 Centro	27.	27.	11.	0.	0.	17.	17.	17.	1.	56.	56.	71.
B5 Este	24.	24.	12.	0.	0.	12.	16.	16.	0.	60.	60.	76.
B6 Sur	23.	23.	11.	0.	0.	11.	26.	26.	2.	51.	51.	76.
C1 Norte do continente	20.	20.	3.	6.	6.	23.	5.	5.	4.	69.	69.	71.
C2 Sud do Continente	19.	19.	13.	3.	3.	8.	23.	23.	12.	55.	55.	67

APPENDIX 14 SUITABILITY OF NUTS-1 REGIONS FOR RAINFED CITRUS

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
11	Schleswig-Holstein	0	0	100
12	Hamburg	0	0	100
13	Niedersachsen	0	0	100
14	Bremen	0	0	100
15	Nordrhein-Westfalen	0	0	100
16	Hessen	0	0	100
17	Rheinland-Pfalz	0	0	100
18	Baden-Wurttemberg	0	0	100
19	Bayern	0	0	100
1A	Saarland	0	0	100
1B	Berlin (West)	0	0	100
21	Ile de France	0	0	100
22	Bassin Parisien	0	0	100
23	Nord-Pas-de-Calais	0	0	100
24	Est	0	0	100
25	Ouest	0	0	100
26	Sud-Ouest	0	0	100
27	Centre-Est	0	0	100
28	Mediterranee	1	3	97
31	Nord-Ovest	0	1	99
32	Lombardia	0	0	100
33	Nord-Est	0	0	100
34	Emilia-Romagna	0	0	100
35	Centro	0	10	90
36	Lazio	0	1	100
37	Campania	0	0	100
38	Abruzzi-Molise	0	0	100
39	Sud	0	0	100
3A	Sicilia	0	0	99
3B	Sardegna	0	1	99
41	Noord-Nederland	0	0	100
42	Oost-Nederland	0	0	100
45	Zuid-Nederland	0	0	100
47	West-Nederland	0	0	100
51	Vlaams gewest	0	0	100
52	Region Wallonne	0	0	100
53	Brussel	0	0	100
60	Luxembourg (G.D.)	0	0	100

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
71	North	0	0	100
72	Yorkshire & Humberside	0	0	100
73	East Midlands	0	0	100
74	East Anglia	0	0	100
75	South East	0	0	100
76	South West	0	0	100
77	West Midlands	0	0	100
78	North West	0	0	100
79	Wales	0	0	100
7A	Scotland	0	0	100
7B	Northern Ireland	0	0	100
80	Ireland	0	0	100
90	Danmark	0	0	100
A1	Ellas (North)	0	7	93
A2	Ellas (Central)	0	5	95
A3	Ellas (East and S. isl)	0	2	98
B1	Noroeste	0	0	100
B2	Noreste	0	4	96
B3	Madrid	0	16	84
B4	Centro	1	1	98
B5	Este	7	1	92
B6	Sur	4	1	95
C1	Norte do continente	0	0	100
C2	Sud do Continente	5	0	95

APPENDIX 15 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR RAINFED CITRUS AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR RAINFED CITRUS OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for rainfed citrus			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	0.	0.	0.	0.	0.	0.	89.	86.	73.	11.	14.	27.
12 Hamburg	0.	0.	0.	0.	0.	0.	78.	70.	37.	22.	30.	63.
13 Niedersachsen	0.	0.	0.	0.	0.	0.	75.	74.	66.	25.	26.	34.
14 Bremen	0.	0.	0.	0.	0.	0.	81.	81.	30.	19.	19.	70.
15 Nordrhein-Westfalen	0.	0.	0.	0.	0.	0.	65.	60.	56.	35.	40.	44.
16 Hessen	0.	0.	0.	0.	0.	0.	37.	34.	27.	63.	66.	73.
17 Rheinland-Pfalz	0.	0.	0.	0.	0.	0.	31.	28.	16.	69.	72.	84.
18 Baden-Wurttemberg	0.	0.	0.	0.	0.	0.	39.	38.	26.	61.	62.	74.
19 Bayern	0.	0.	0.	0.	0.	0.	43.	43.	37.	57.	57.	63.
1A Saarland	0.	0.	0.	0.	0.	0.	42.	42.	1.	58.	58.	99.
21 Ile de France	0.	0.	0.	0.	0.	0.	56.	56.	43.	44.	44.	57.
22 Bassin Parisien	0.	0.	0.	0.	0.	0.	72.	72.	43.	28.	28.	57.
23 Nord-Pas-de-Calais	0.	0.	0.	0.	0.	0.	83.	83.	70.	17.	17.	30.
24 Est	0.	0.	0.	0.	0.	0.	62.	62.	13.	38.	38.	87.
25 Ouest	0.	0.	0.	0.	0.	0.	62.	62.	54.	38.	38.	46.
26 Sud-Ouest	0.	0.	0.	0.	0.	0.	61.	60.	49.	39.	40.	51.
27 Centre-Est	0.	0.	0.	0.	0.	0.	31.	31.	24.	69.	69.	76.
28 Mediterranee	3.	3.	3.	0.	0.	0.	26.	26.	21.	71.	71.	76.
31 Nord-Ovest	0.	0.	0.	1.	1.	1.	24.	19.	2.	75.	80.	97.
32 Lombardia	0.	0.	0.	0.	0.	0.	58.	47.	9.	42.	53.	91.
33 Nord-Est	0.	0.	0.	0.	0.	0.	40.	40.	16.	60.	60.	84.
34 Emilia-Romagna	0.	0.	0.	0.	0.	0.	43.	43.	26.	57.	57.	74.
35 Centro	8.	8.	7.	3.	3.	3.	16.	15.	8.	73.	74.	82.
36 Lazio	0.	0.	0.	0.	0.	0.	13.	13.	6.	87.	87.	94.
37 Campania	0.	0.	0.	0.	0.	0.	11.	11.	8.	89.	89.	92.
38 Abruzzi-Molise	0.	0.	0.	0.	0.	0.	15.	15.	9.	85.	85.	91.
39 Sud	0.	0.	0.	0.	0.	0.	24.	24.	8.	76.	76.	92.
3A Sicilia	1.	1.	1.	0.	0.	0.	30.	30.	17.	69.	69.	82.
3B Sardegna	2.	2.	2.	0.	0.	0.	9.	9.	5.	89.	89.	93.

NUTS-1 region	competitive land			only suitable for rainfed citrus			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
41 Noord-Nederland	0.	0.	0.	0.	0.	0.	70.	70.	51.	30.	30.	49.
42 Oost-Nederland	0.	0.	0.	0.	0.	0.	93.	93.	76.	7.	7.	24.
45 Zuid-Nederland	0.	0.	0.	0.	0.	0.	97.	97.	86.	3.	3.	14.
47 West-Nederland	0.	0.	0.	0.	0.	0.	80.	68.	39.	20.	32.	61.
51 Vlaams gewest	0.	0.	0.	0.	0.	0.	99.	99.	88.	1.	1.	12.
52 Region Wallonne	0.	0.	0.	0.	0.	0.	36.	36.	35.	64.	64.	65.
53 Brussel	0.	0.	0.	0.	0.	0.	48.	48.	47.	52.	52.	53.
60 Luxembourg (G.D.)	0.	0.	0.	0.	0.	0.	31.	31.	15.	69.	69.	85.
71 North	0.	0.	0.	0.	0.	0.	66.	9.	9.	34.	91.	91.
72 Yorkshire & Humberside	0.	0.	0.	0.	0.	0.	78.	23.	22.	22.	77.	78.
73 East Midlands	0.	0.	0.	0.	0.	0.	87.	48.	28.	13.	52.	72.
74 East Anglia	0.	0.	0.	0.	0.	0.	94.	63.	41.	6.	37.	59.
75 South East	0.	0.	0.	0.	0.	0.	87.	55.	42.	13.	45.	58.
76 South West	0.	0.	0.	0.	0.	0.	70.	54.	46.	30.	46.	54.
77 West Midlands	0.	0.	0.	0.	0.	0.	84.	52.	47.	16.	48.	53.
78 North West	0.	0.	0.	0.	0.	0.	73.	15.	14.	27.	85.	86.
79 Wales	0.	0.	0.	0.	0.	0.	49.	32.	31.	51.	68.	69.
7A Scotland	0.	0.	0.	0.	0.	0.	31.	19.	19.	69.	81.	81.
7B Northern Ireland	0.	0.	0.	0.	0.	0.	66.	29.	29.	34.	71.	71.
80 Ireland	0.	0.	0.	0.	0.	0.	73.	47.	46.	27.	53.	54.
90 Danmark	0.	0.	0.	0.	0.	0.	98.	90.	89.	2.	10.	11.
A1 Ellas (North)	7.	7.	7.	0.	0.	0.	7.	7.	3.	86.	86.	90.
A2 Ellas (Central)	5.	5.	5.	0.	0.	0.	7.	7.	3.	88.	88.	92.
A3 Ellas (East and S. isl)	2.	2.	2.	0.	0.	0.	8.	8.	5.	90.	90.	94.
B1 Noroeste	0.	0.	0.	0.	0.	0.	17.	17.	2.	83.	83.	98.
B2 Noreste	4.	4.	4.	0.	0.	0.	38.	38.	8.	58.	58.	88.
B3 Madrid	16.	16.	16.	0.	0.	0.	43.	43.	16.	41.	41.	68.
B4 Centro	2.	2.	2.	0.	0.	0.	42.	42.	10.	56.	56.	88.
B5 Este	8.	8.	8.	0.	0.	0.	32.	32.	4.	60.	60.	88.
B6 Sur	5.	5.	5.	0.	0.	0.	44.	44.	8.	51.	51.	87.
C1 Norte do continente	0.	0.	0.	0.	0.	0.	24.	24.	6.	76.	76.	94.
C2 Sud do Continente	5.	5.	5.	0.	0.	0.	37.	37.	20.	58.	58.	75.

APPENDIX 16 SUITABILITY OF NUTS-1 REGIONS FOR IRRIGATED CITRUS

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
11	Schleswig-Holstein	0	0	100
12	Hamburg	0	0	100
13	Niedersachsen	0	0	100
14	Bremen	0	0	100
15	Nordrhein-Westfalen	0	0	100
16	Hessen	0	0	100
17	Rheinland-Pfalz	0	0	100
18	Baden-Wurttemberg	0	0	100
19	Bayern	0	0	100
1A	Saarland	0	0	100
1B	Berlin (West)	0	0	100
21	Ile de France	0	0	100
22	Bassin Parisien	0	0	100
23	Nord-Pas-de-Calais	0	0	100
24	Est	0	0	100
25	Ouest	0	0	100
26	Sud-Ouest	0	0	100
27	Centre-Est	0	0	100
28	Mediterranee	4	12	84
31	Nord-Ovest	0	0	100
32	Lombardia	0	0	100
33	Nord-Est	0	0	100
34	Emilia-Romagna	0	2	98
35	Centro	1	15	84
36	Lazio	3	7	91
37	Campania	5	4	92
38	Abruzzi-Molise	0	8	92
39	Sud	2	15	84
3A	Sicilia	4	15	82
3B	Sardegna	3	3	94
41	Noord-Nederland	0	0	100
42	Oost-Nederland	0	0	100
45	Zuid-Nederland	0	0	100
47	West-Nederland	0	0	100
51	Vlaams gewest	0	0	100
52	Region Wallonne	0	0	100
53	Brussel	0	0	100
60	Luxembourg (G.D.)	0	0	100

NUTS-1 Code	NUTS-1 Description tions	No limita- tions	Moderate limita- tions	Severe limita-
71	North	0	0	100
72	Yorkshire & Humberside	0	0	100
73	East Midlands	0	0	100
74	East Anglia	0	0	100
75	South East	0	0	100
76	South West	0	0	100
77	West Midlands	0	0	100
78	North West	0	0	100
79	Wales	0	0	100
7A	Scotland	0	0	100
7B	Northern Ireland	0	0	100
80	Ireland	0	0	100
90	Danmark	0	0	100
A1	Ellas (North)	0	15	85
A2	Ellas (Central)	0	8	92
A3	Ellas (East and S. isl)	0	6	94
B1	Noroeste	0	0	100
B2	Noreste	0	18	82
B3	Madrid	0	43	57
B4	Centro	1	11	88
B5	Este	7	15	79
B6	Sur	4	19	77
C1	Norte do continente	0	4	96
C2	Sud do Continente	3	19	78

APPENDIX 17 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR IRRIGATED CITRUS AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR IRRIGATED CITRUS OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for irrigated citrus			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	0.	0.	0.	0.	0.	0.	89.	86.	73.	11.	14.	27.
12 Hamburg	0.	0.	0.	0.	0.	0.	78.	70.	37.	22.	30.	63.
13 Niedersachsen	0.	0.	0.	0.	0.	0.	75.	74.	66.	25.	26.	34.
14 Bremen	0.	0.	0.	0.	0.	0.	81.	81.	30.	19.	19.	70.
15 Nordrhein-Westfalen	0.	0.	0.	0.	0.	0.	65.	60.	56.	35.	40.	44.
16 Hessen	0.	0.	0.	0.	0.	0.	37.	34.	27.	63.	66.	73.
17 Rheinland-Pfalz	0.	0.	0.	0.	0.	0.	31.	28.	16.	69.	72.	84.
18 Baden-Wurttemberg	0.	0.	0.	0.	0.	0.	39.	38.	26.	61.	62.	74.
19 Bayern	0.	0.	0.	0.	0.	0.	43.	43.	37.	57.	57.	63.
1A Saarland	0.	0.	0.	0.	0.	0.	42.	42.	1.	58.	58.	99.
21 Ile de France	0.	0.	0.	0.	0.	0.	56.	56.	43.	44.	44.	57.
22 Bassin Parisien	0.	0.	0.	0.	0.	0.	72.	72.	43.	28.	28.	57.
23 Nord-Pas-de-Calais	0.	0.	0.	0.	0.	0.	83.	83.	70.	17.	17.	30.
24 Est	0.	0.	0.	0.	0.	0.	62.	62.	13.	38.	38.	87.
25 Ouest	0.	0.	0.	0.	0.	0.	62.	62.	54.	38.	38.	46.
26 Sud-Ouest	0.	0.	0.	0.	0.	0.	61.	60.	49.	39.	40.	51.
27 Centre-Est	0.	0.	0.	0.	0.	0.	31.	31.	24.	69.	69.	76.
28 Mediterranee	16.	16.	15.	0.	0.	1.	13.	13.	9.	71.	71.	75.
31 Nord-Ovest	0.	0.	0.	0.	0.	0.	24.	19.	2.	76.	81.	98.
32 Lombardia	0.	0.	0.	0.	0.	0.	58.	47.	9.	42.	53.	91.
33 Nord-Est	0.	0.	0.	0.	0.	0.	40.	40.	16.	60.	60.	84.
34 Emilia-Romagna	2.	2.	2.	0.	0.	0.	41.	41.	24.	57.	57.	74.
35 Centro	15.	15.	15.	1.	1.	1.	9.	8.	1.	75.	76.	83.
36 Lazio	7.	7.	6.	3.	3.	3.	6.	6.	0.	84.	84.	91.
37 Campania	6.	6.	6.	2.	2.	2.	5.	5.	1.	87.	87.	91.
38 Abruzzi-Molise	8.	8.	8.	0.	0.	0.	7.	7.	1.	85.	85.	91.
39 Sud	11.	11.	8.	5.	5.	9.	13.	13.	1.	71.	71.	82.
3A Sicilia	18.	18.	18.	0.	0.	0.	12.	12.	0.	70.	70.	82.
3B Sardegna	5.	5.	5.	0.	0.	0.	5.	5.	1.	90.	90.	94.

NUTS-1 region	competitive land			only suitable for irrigated citrus			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
41 Noord-Nederland	0.	0.	0.	0.	0.	0.	70.	70.	51.	30.	30.	49.
42 Oost-Nederland	0.	0.	0.	0.	0.	0.	93.	93.	76.	7.	7.	24.
45 Zuid-Nederland	0.	0.	0.	0.	0.	0.	97.	97.	86.	3.	3.	14.
47 West-Nederland	0.	0.	0.	0.	0.	0.	80.	68.	39.	20.	32.	61.
51 Vlaams gewest	0.	0.	0.	0.	0.	0.	99.	99.	88.	1.	1.	12.
52 Region Wallonne	0.	0.	0.	0.	0.	0.	36.	36.	35.	64.	64.	65.
53 Brussel	0.	0.	0.	0.	0.	0.	48.	48.	47.	52.	52.	53.
60 Luxembourg (G.D.)	0.	0.	0.	0.	0.	0.	31.	31.	15.	69.	69.	85.
71 North	0.	0.	0.	0.	0.	0.	66.	9.	9.	34.	91.	91.
72 Yorkshire & Humberside	0.	0.	0.	0.	0.	0.	78.	23.	22.	22.	77.	78.
73 East Midlands	0.	0.	0.	0.	0.	0.	87.	48.	28.	13.	52.	72.
74 East Anglia	0.	0.	0.	0.	0.	0.	94.	63.	41.	6.	37.	59.
75 South East	0.	0.	0.	0.	0.	0.	87.	55.	42.	13.	45.	58.
76 South West	0.	0.	0.	0.	0.	0.	70.	54.	46.	30.	46.	54.
77 West Midlands	0.	0.	0.	0.	0.	0.	84.	52.	47.	16.	48.	53.
78 North West	0.	0.	0.	0.	0.	0.	73.	15.	14.	27.	85.	86.
79 Wales	0.	0.	0.	0.	0.	0.	49.	32.	31.	51.	68.	69.
7A Scotland	0.	0.	0.	0.	0.	0.	31.	19.	19.	69.	81.	81.
7B Northern Ireland	0.	0.	0.	0.	0.	0.	66.	29.	29.	34.	71.	71.
80 Ireland	0.	0.	0.	0.	0.	0.	73.	47.	46.	27.	53.	54.
90 Danmark	0.	0.	0.	0.	0.	0.	98.	90.	89.	2.	10.	11.
A1 Ellas (North)	9.	9.	9.	6.	6.	6.	5.	5.	0.	80.	80.	85.
A2 Ellas (Central)	7.	7.	7.	1.	1.	1.	4.	4.	0.	88.	88.	92.
A3 Ellas (East and S. isl)	6.	6.	6.	0.	0.	0.	3.	3.	0.	91.	91.	94.
B1 Noroeste	0.	0.	0.	0.	0.	0.	17.	17.	2.	83.	83.	98.
B2 Noreste	18.	18.	9.	0.	0.	9.	25.	25.	3.	57.	57.	79.
B3 Madrid	43.	43.	32.	0.	0.	11.	15.	15.	0.	42.	42.	57.
B4 Centro	12.	12.	4.	0.	0.	8.	32.	32.	8.	56.	56.	80.
B5 Este	21.	21.	11.	0.	0.	10.	19.	19.	1.	60.	60.	78.
B6 Sur	23.	23.	11.	0.	0.	11.	26.	26.	2.	51.	51.	76.
C1 Norte do continente	3.	3.	2.	1.	1.	2.	21.	21.	4.	75.	75.	92.
C2 Sud do Continente	19.	19.	13.	3.	3.	8.	23.	23.	12.	55.	55.	67.

APPENDIX 18 SUITABILITY OF NUTS-1 REGIONS FOR THE CULTIVATION OF OLIVES IN A LOW INPUT PRODUCTION SYSTEM

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
11	Schleswig-Holstein	0	0	100
12	Hamburg	0	0	100
13	Niedersachsen	0	0	100
14	Bremen	0	0	100
15	Nordrhein-Westfalen	0	0	100
16	Hessen	0	0	100
17	Rheinland-Pfalz	0	0	100
18	Baden-Wurttemberg	0	0	100
19	Bayern	0	0	100
1A	Saarland	0	0	100
1B	Berlin (West)	0	0	100
21	Ile de France	0	0	100
22	Bassin Parisien	0	0	100
23	Nord-Pas-de-Calais	0	0	100
24	Est	0	0	100
25	Ouest	0	0	100
26	Sud-Ouest	0	0	100
27	Centre-Est	0	0	100
28	Mediterranee	13	27	60
31	Nord-Ovest	0	18	82
32	Lombardia	0	0	100
33	Nord-Est	0	0	100
34	Emilia-Romagna	3	9	87
35	Centro	19	54	28
36	Lazio	13	65	22
37	Campania	5	60	35
38	Abruzzi-Molise	16	29	56
39	Sud	23	52	25
3A	Sicilia	42	49	10
3B	Sardegna	6	69	25
41	Noord-Nederland	0	0	100
42	Oost-Nederland	0	0	100
45	Zuid-Nederland	0	0	100
47	West-Nederland	0	0	100
51	Vlaams gewest	0	0	100
52	Region Wallonne	0	0	100
53	Brussel	0	0	100
60	Luxembourg (G.D.)	0	0	100

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
71	North	0	0	100
72	Yorkshire & Humberside	0	0	100
73	East Midlands	0	0	100
74	East Anglia	0	0	100
75	South East	0	0	100
76	South West	0	0	100
77	West Midlands	0	0	100
78	North West	0	0	100
79	Wales	0	0	100
7A	Scotland	0	0	100
7B	Northern Ireland	0	0	100
80	Ireland	0	0	100
90	Danmark	0	0	100
A1	Ellas (North)	5	73	22
A2	Ellas (Central)	5	51	44
A3	Ellas (East and S. isl)	10	29	62
B1	Noroeste	0	0	100
B2	Noreste	13	33	54
B3	Madrid	32	37	31
B4	Centro	9	32	59
B5	Este	20	61	19
B6	Sur	32	49	19
C1	Norte do continente	3	17	80
C2	Sud do Continente	17	31	53

APPENDIX 19 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR OLIVES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR OLIVES OR ONE OF THE OTHER CROP TYPES; CULTIVATION OF OLIVES IN A LOW INPUT PRODUCTION SYSTEM

NUTS-1 region	competitive land			only suitable for olives; low input			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	0.	0.	0.	0.	0.	0.	89.	86.	73.	11.	14.	27.
12 Hamburg	0.	0.	0.	0.	0.	0.	78.	70.	37.	22.	30.	63.
13 Niedersachsen	0.	0.	0.	0.	0.	0.	75.	74.	66.	25.	26.	34.
14 Bremen	0.	0.	0.	0.	0.	0.	81.	81.	30.	19.	19.	70.
15 Nordrhein-Westfalen	0.	0.	0.	0.	0.	0.	65.	60.	56.	35.	40.	44.
16 Hessen	0.	0.	0.	0.	0.	0.	37.	34.	27.	63.	66.	73.
17 Rheinland-Pfalz	0.	0.	0.	0.	0.	0.	31.	28.	16.	69.	72.	84.
18 Baden-Wurttemberg	0.	0.	0.	0.	0.	0.	39.	38.	26.	61.	62.	74.
19 Bayern	0.	0.	0.	0.	0.	0.	43.	43.	37.	57.	57.	63.
1A Saarland	0.	0.	0.	0.	0.	0.	42.	42.	1.	58.	58.	99.
21 Ile de France	0.	0.	0.	0.	0.	0.	56.	56.	43.	44.	44.	57.
22 Bassin Parisien	0.	0.	0.	0.	0.	0.	72.	72.	43.	28.	28.	57.
23 Nord-Pas-de-Calais	0.	0.	0.	0.	0.	0.	83.	83.	70.	17.	17.	30.
24 Est	0.	0.	0.	0.	0.	0.	62.	62.	13.	38.	38.	87.
25 Ouest	0.	0.	0.	0.	0.	0.	62.	62.	54.	38.	38.	46.
26 Sud-Ouest	0.	0.	0.	0.	0.	0.	61.	60.	49.	39.	40.	51.
27 Centre-Est	0.	0.	0.	0.	0.	0.	31.	31.	24.	69.	69.	76.
28 Mediterranee	20.	20.	16.	21.	21.	24.	10.	10.	8.	49.	49.	52.
31 Nord-Ovest	0.	0.	0.	18.	18.	18.	24.	19.	2.	58.	63.	80.
32 Lombardia	0.	0.	0.	0.	0.	0.	58.	47.	9.	42.	53.	91.
33 Nord-Est	0.	0.	0.	0.	0.	0.	40.	40.	16.	60.	60.	84.
34 Emilia-Romagna	3.	3.	2.	10.	10.	10.	40.	40.	24.	47.	47.	64.
35 Centro	19.	19.	15.	53.	53.	58.	4.	4.	1.	24.	24.	26.
36 Lazio	11.	11.	6.	67.	67.	72.	2.	2.	0.	20.	20.	22.
37 Campania	7.	7.	6.	58.	58.	58.	4.	4.	1.	31.	31.	35.
38 Abruzzi-Molise	12.	12.	8.	33.	33.	37.	3.	3.	1.	52.	52.	54.
39 Sud	20.	20.	7.	54.	54.	67.	4.	4.	1.	22.	22.	25.
3A Sicilia	29.	29.	18.	62.	62.	73.	2.	2.	0.	7.	7.	9.
3B Sardegna	7.	7.	5.	68.	68.	71.	3.	3.	2.	22.	22.	23.

NUTS-1 region	competitive land			only suitable for olives; low input			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
41 Noord-Nederland	0.	0.	0.	0.	0.	0.	70.	70.	51.	30.	30.	49.
42 Oost-Nederland	0.	0.	0.	0.	0.	0.	93.	93.	76.	7.	7.	24.
45 Zuid-Nederland	0.	0.	0.	0.	0.	0.	97.	97.	86.	3.	3.	14.
47 West-Nederland	0.	0.	0.	0.	0.	0.	80.	68.	39.	20.	32.	61.
51 Vlaams gewest	0.	0.	0.	0.	0.	0.	99.	99.	88.	1.	1.	12.
52 Region Wallonne	0.	0.	0.	0.	0.	0.	36.	36.	35.	64.	64.	65.
53 Brussel	0.	0.	0.	0.	0.	0.	48.	48.	47.	52.	52.	53.
60 Luxembourg (G.D.)	0.	0.	0.	0.	0.	0.	31.	31.	15.	69.	69.	85.
71 North	0.	0.	0.	0.	0.	0.	66.	9.	9.	34.	91.	91.
72 Yorkshire & Humberside	0.	0.	0.	0.	0.	0.	78.	23.	22.	22.	77.	78.
73 East Midlands	0.	0.	0.	0.	0.	0.	87.	48.	28.	13.	52.	72.
74 East Anglia	0.	0.	0.	0.	0.	0.	94.	63.	41.	6.	37.	59.
75 South East	0.	0.	0.	0.	0.	0.	87.	55.	42.	13.	45.	58.
76 South West	0.	0.	0.	0.	0.	0.	70.	54.	46.	30.	46.	54.
77 West Midlands	0.	0.	0.	0.	0.	0.	84.	52.	47.	16.	48.	53.
78 North West	0.	0.	0.	0.	0.	0.	73.	15.	14.	27.	85.	86.
79 Wales	0.	0.	0.	0.	0.	0.	49.	32.	31.	51.	68.	69.
7A Scotland	0.	0.	0.	0.	0.	0.	31.	19.	19.	69.	81.	81.
7B Northern Ireland	0.	0.	0.	0.	0.	0.	66.	29.	29.	34.	71.	71.
80 Ireland	0.	0.	0.	0.	0.	0.	73.	47.	46.	27.	53.	54.
90 Danmark	0.	0.	0.	0.	0.	0.	98.	90.	89.	2.	10.	11.
A1 Ellas (North)	14.	14.	10.	63.	63.	68.	0.	0.	0.	23.	23.	22.
A2 Ellas (Central)	11.	11.	7.	44.	44.	48.	0.	0.	0.	45.	45.	45.
A3 Ellas (East and S. isl)	10.	10.	6.	29.	29.	32.	0.	0.	0.	62.	62.	62.
B1 Noroeste	0.	0.	0.	0.	0.	0.	17.	17.	2.	83.	83.	98.
B2 Noreste	30.	30.	9.	16.	16.	37.	12.	12.	3.	42.	42.	51.
B3 Madrid	52.	52.	32.	17.	17.	37.	6.	6.	0.	25.	25.	31.
B4 Centro	20.	20.	4.	21.	21.	37.	24.	24.	8.	35.	35.	51.
B5 Este	37.	37.	12.	43.	43.	69.	3.	3.	0.	17.	17.	19.
B6 Sur	46.	46.	12.	35.	35.	69.	3.	3.	1.	16.	16.	18.
C1 Norte do continente	9.	9.	2.	11.	11.	18.	16.	16.	4.	64.	64.	76.
C2 Sud do Continente	27.	27.	13.	21.	21.	34.	15.	15.	12.	37.	37.	41.

APPENDIX 20 SUITABILITY OF NUTS-1 REGIONS FOR THE CULTIVATION OF OLIVES IN A HIGH INPUT PRODUCTION SYSTEM

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
11	Schleswig-Holstein	0	0	100
12	Hamburg	0	0	100
13	Niedersachsen	0	0	100
14	Bremen	0	0	100
15	Nordrhein-Westfalen	0	0	100
16	Hessen	0	0	100
17	Rheinland-Pfalz	0	0	100
18	Baden-Wurttemberg	0	0	100
19	Bayern	0	0	100
1A	Saarland	0	0	100
1B	Berlin (West)	0	0	100
21	Ile de France	0	0	100
22	Bassin Parisien	0	0	100
23	Nord-Pas-de-Calais	0	0	100
24	Est	0	0	100
25	Ouest	0	0	100
26	Sud-Ouest	0	0	100
27	Centre-Est	0	0	100
28	Mediterranee	13	26	61
31	Nord-Ovest	0	10	90
32	Lombardia	0	0	100
33	Nord-Est	0	0	100
34	Emilia-Romagna	3	8	89
35	Centro	17	43	40
36	Lazio	12	55	33
37	Campania	7	39	54
38	Abruzzi-Molise	11	25	64
39	Sud	19	39	42
3A	Sicilia	25	53	23
3B	Sardegna	5	50	45
41	Noord-Nederland	0	0	100
42	Oost-Nederland	0	0	100
45	Zuid-Nederland	0	0	100
47	West-Nederland	0	0	100
51	Vlaams gewest	0	0	100
52	Region Wallonne	0	0	100
53	Brussel	0	0	100
60	Luxembourg (G.D.)	0	0	100

NUTS-1 Code	NUTS-1 Description	No limitations	Moderate limitations	Severe limitations
71	North	0	0	100
72	Yorkshire & Humberside	0	0	100
73	East Midlands	0	0	100
74	East Anglia	0	0	100
75	South East	0	0	100
76	South West	0	0	100
77	West Midlands	0	0	100
78	North West	0	0	100
79	Wales	0	0	100
7A	Scotland	0	0	100
7B	Northern Ireland	0	0	100
80	Ireland	0	0	100
90	Danmark	0	0	100
A1	Ellas (North)	4	35	61
A2	Ellas (Central)	3	26	71
A3	Ellas (East and S. isl)	7	11	81
B1	Noroeste	0	0	100
B2	Noreste	9	36	55
B3	Madrid	25	46	28
B4	Centro	8	34	58
B5	Este	17	61	23
B6	Sur	26	57	17
C1	Norte do continente	3	26	71
C2	Sud do Continente	16	51	33

APPENDIX 21 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR OLIVES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR OLIVES OR ONE OF THE OTHER CROP TYPES; CULTIVATION OF OLIVES IN A HIGH INPUT PRODUCTION SYSTEM

NUTS-1 region	competitive land			only suitable for olives; high input			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	0.	0.	0.	0.	0.	0.	89.	86.	73.	11.	14.	27.
12 Hamburg	0.	0.	0.	0.	0.	0.	78.	70.	37.	22.	30.	63.
13 Niedersachsen	0.	0.	0.	0.	0.	0.	75.	74.	66.	25.	26.	34.
14 Bremen	0.	0.	0.	0.	0.	0.	81.	81.	30.	19.	19.	70.
15 Nordrhein-Westfalen	0.	0.	0.	0.	0.	0.	65.	60.	56.	35.	40.	44.
16 Hessen	0.	0.	0.	0.	0.	0.	37.	34.	27.	63.	66.	73.
17 Rheinland-Pfalz	0.	0.	0.	0.	0.	0.	31.	28.	16.	69.	72.	84.
18 Baden-Wurttemberg	0.	0.	0.	0.	0.	0.	39.	38.	26.	61.	62.	74.
19 Bayern	0.	0.	0.	0.	0.	0.	43.	43.	37.	57.	57.	63.
1A Saarland	0.	0.	0.	0.	0.	0.	42.	42.	1.	58.	58.	99.
21 Ile de France	0.	0.	0.	0.	0.	0.	56.	56.	43.	44.	44.	57.
22 Bassin Parisien	0.	0.	0.	0.	0.	0.	72.	72.	43.	28.	28.	57.
23 Nord-Pas-de-Calais	0.	0.	0.	0.	0.	0.	83.	83.	70.	17.	17.	30.
24 Est	0.	0.	0.	0.	0.	0.	62.	62.	13.	38.	38.	87.
25 Ouest	0.	0.	0.	0.	0.	0.	62.	62.	54.	38.	38.	46.
26 Sud-Ouest	0.	0.	0.	0.	0.	0.	61.	60.	49.	39.	40.	51.
27 Centre-Est	0.	0.	0.	0.	0.	0.	31.	31.	24.	69.	69.	76.
28 Mediterranee	21.	21.	17.	18.	18.	22.	9.	9.	8.	52.	52.	53.
31 Nord-Ovest	0.	0.	0.	10.	10.	10.	24.	19.	2.	66.	71.	88.
32 Lombardia	0.	0.	0.	0.	0.	0.	58.	47.	9.	42.	53.	91.
33 Nord-Est	0.	0.	0.	0.	0.	0.	40.	40.	16.	60.	60.	84.
34 Emilia-Romagna	3.	3.	2.	7.	7.	8.	40.	40.	24.	50.	50.	66.
35 Centro	22.	22.	15.	38.	38.	45.	2.	1.	1.	38.	39.	39.
36 Lazio	13.	13.	6.	54.	54.	61.	0.	0.	0.	33.	33.	33.
37 Campania	9.	9.	6.	37.	37.	40.	2.	2.	1.	52.	52.	53.
38 Abruzzi-Molise	13.	13.	8.	23.	23.	29.	2.	2.	1.	62.	62.	62.
39 Sud	22.	22.	8.	36.	36.	50.	2.	2.	1.	40.	40.	41.
3A Sicilia	30.	30.	18.	47.	47.	59.	0.	0.	0.	23.	23.	23.
3B Sardegna	9.	9.	5.	47.	47.	50.	2.	2.	1.	42.	42.	44.

NUTS-1 region	competitive land			only suitable for olives; high input			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
41 Noord-Nederland	0.	0.	0.	0.	0.	0.	70.	70.	51.	30.	30.	49.
42 Oost-Nederland	0.	0.	0.	0.	0.	0.	93.	93.	76.	7.	7.	24.
45 Zuid-Nederland	0.	0.	0.	0.	0.	0.	97.	97.	86.	3.	3.	14.
47 West-Nederland	0.	0.	0.	0.	0.	0.	80.	68.	39.	20.	32.	61.
51 Vlaams gewest	0.	0.	0.	0.	0.	0.	99.	99.	88.	1.	1.	12.
52 Region Wallonne	0.	0.	0.	0.	0.	0.	36.	36.	35.	64.	64.	65.
53 Brussel	0.	0.	0.	0.	0.	0.	48.	48.	47.	52.	52.	53.
60 Luxembourg (G.D.)	0.	0.	0.	0.	0.	0.	31.	31.	15.	69.	69.	85.
71 North	0.	0.	0.	0.	0.	0.	66.	9.	9.	34.	91.	91.
72 Yorkshire & Humberside	0.	0.	0.	0.	0.	0.	78.	23.	22.	22.	77.	78.
73 East Midlands	0.	0.	0.	0.	0.	0.	87.	48.	28.	13.	52.	72.
74 East Anglia	0.	0.	0.	0.	0.	0.	94.	63.	41.	6.	37.	59.
75 South East	0.	0.	0.	0.	0.	0.	87.	55.	42.	13.	45.	58.
76 South West	0.	0.	0.	0.	0.	0.	70.	54.	46.	30.	46.	54.
77 West Midlands	0.	0.	0.	0.	0.	0.	84.	52.	47.	16.	48.	53.
78 North West	0.	0.	0.	0.	0.	0.	73.	15.	14.	27.	85.	86.
79 Wales	0.	0.	0.	0.	0.	0.	49.	32.	31.	51.	68.	69.
7A Scotland	0.	0.	0.	0.	0.	0.	31.	19.	19.	69.	81.	81.
7B Northern Ireland	0.	0.	0.	0.	0.	0.	66.	29.	29.	34.	71.	71.
80 Ireland	0.	0.	0.	0.	0.	0.	73.	47.	46.	27.	53.	54.
90 Danmark	0.	0.	0.	0.	0.	0.	98.	90.	89.	2.	10.	11.
A1 Ellas (North)	14.	14.	10.	24.	24.	29.	0.	0.	0.	62.	62.	61.
A2 Ellas (Central)	11.	11.	7.	18.	18.	22.	0.	0.	0.	71.	71.	71.
A3 Ellas (East and S. isl)	10.	10.	6.	9.	9.	12.	0.	0.	0.	81.	81.	82.
B1 Noroeste	0.	0.	0.	0.	0.	0.	17.	17.	2.	83.	83.	98.
B2 Noreste	30.	30.	9.	14.	14.	35.	12.	12.	3.	44.	44.	53.
B3 Madrid	52.	52.	32.	19.	19.	40.	6.	6.	0.	23.	23.	28.
B4 Centro	21.	21.	4.	21.	21.	37.	23.	23.	8.	35.	35.	51.
B5 Este	37.	37.	12.	40.	40.	66.	3.	3.	0.	20.	20.	22.
B6 Sur	49.	49.	13.	34.	34.	70.	0.	0.	0.	17.	17.	17.
C1 Norte do continente	13.	13.	6.	15.	15.	23.	11.	11.	0.	61.	61.	71.
C2 Sud do Continente	42.	42.	25.	25.	25.	42.	0.	0.	0.	33.	33.	33.

APPENDIX 22 SUITABILITY OF NUTS-1 REGIONS FOR RAINFED CULTIVATION OF GRAPES

NUTS-1 Code	NUTS-1 Description	No limitations	Slight limitations	Moderate limitations	Severe limitations
11	Schleswig-Holstein	0	0	0	100
12	Hamburg	0	0	0	100
13	Niedersachsen	0	0	0	100
14	Bremen	0	0	0	100
15	Nordrhein-Westfalen	0	1	0	98
16	Hessen	3	18	16	63
17	Rheinland-Pfalz	1	17	12	70
18	Baden-Wurttemberg	0	3	1	96
19	Bayern	0	0	0	100
1A	Saarland	0	5	40	55
1B	Berlin (West)	0	0	0	100
21	Ile de France	1	5	1	93
22	Bassin Parisien	1	18	5	75
23	Nord-Pas-de-Calais	0	0	0	100
24	Est	0	22	2	75
25	Ouest	1	22	24	54
26	Sud-Ouest	1	20	9	70
27	Centre-Est	2	17	18	62
28	Mediterranee	4	7	28	61
31	Nord-Ovest	0	18	8	74
32	Lombardia	0	35	6	59
33	Nord-Est	0	22	12	66
34	Emilia-Romagna	0	29	17	53
35	Centro	0	13	23	64
36	Lazio	0	5	16	78
37	Campania	0	9	4	87
38	Abruzzi-Molise	0	2	18	81
39	Sud	0	3	11	86
3A	Sicilia	0	0	0	99
3B	Sardegna	0	11	2	87
41	Noord-Nederland	0	0	0	100
42	Oost-Nederland	0	0	0	100
45	Zuid-Nederland	0	0	0	100
47	West-Nederland	0	0	0	100
51	Vlaams gewest	0	0	0	100
52	Region Wallonne	0	0	0	100
53	Brussel	0	0	0	100
60	Luxembourg (G.D.)	0	6	2	92

NUTS-1 Code	NUTS-1 Description	No limitations	Slight limitations	Moderate limitations	Severe limitations
71	North	0	0	0	100
72	Yorkshire & Humberside	0	0	0	100
73	East Midlands	0	0	0	100
74	East Anglia	0	0	0	100
75	South East	0	0	0	100
76	South West	0	0	0	100
77	West Midlands	0	0	0	100
78	North West	0	0	0	100
79	Wales	0	0	0	100
7A	Scotland	0	0	0	100
7B	Northern Ireland	0	0	0	100
80	Ireland	0	0	0	100
90	Danmark	0	0	0	100
A1	Ellas (North)	7	3	0	89
A2	Ellas (Central)	5	2	1	91
A3	Ellas (East and S. isl)	2	1	0	98
B1	Noroeste	0	0	0	100
B2	Noreste	0	4	0	95
B3	Madrid	0	16	0	84
B4	Centro	0	5	0	95
B5	Este	0	8	9	83
B6	Sur	0	5	0	95
C1	Norte do continente	0	1	0	99
C2	Sud do Continente	0	7	0	93

APPENDIX 23 COMPETITIVE LAND, COMMON UNSUITABLE LAND FOR RAINFED GROWING OF GRAPES AND SOME OTHER CROP TYPES IN THE NUTS-1 REGIONS (% OF AREA OF NUTS-1 REGION) AS WELL AS LAND ONLY SUITABLE FOR GRAPES OR ONE OF THE OTHER CROP TYPES

NUTS-1 region	competitive land			only suitable for grapes			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
11 Schleswig-Holstein	0.	0.	0.	0.	0.	0.	89.	86.	73.	11.	14.	27.
12 Hamburg	0.	0.	0.	0.	0.	0.	78.	70.	37.	22.	30.	63.
13 Niedersachsen	0.	0.	0.	0.	0.	0.	75.	74.	66.	25.	26.	34.
14 Bremen	0.	0.	0.	0.	0.	0.	81.	81.	30.	19.	19.	70.
15 Nordrhein-Westfalen	1.	1.	1.	0.	0.	0.	64.	59.	55.	35.	40.	44.
16 Hessen	23.	23.	22.	14.	14.	15.	14.	10.	5.	49.	53.	58.
17 Rheinland-Pfalz	26.	26.	15.	4.	4.	15.	5.	2.	1.	65.	68.	69.
18 Baden-Wurttemberg	4.	4.	4.	1.	1.	1.	35.	34.	23.	60.	61.	72.
19 Bayern	0.	0.	0.	0.	0.	0.	43.	43.	37.	57.	57.	63.
1A Saarland	42.	42.	1.	4.	4.	44.	0.	0.	0.	54.	54.	55.
21 Ile de France	7.	7.	4.	0.	0.	3.	49.	49.	39.	44.	44.	54.
22 Bassin Parisien	22.	22.	13.	3.	3.	12.	50.	50.	30.	25.	25.	45.
23 Nord-Pas-de-Calais	0.	0.	0.	0.	0.	0.	83.	83.	70.	17.	17.	30.
24 Est	24.	24.	9.	1.	1.	16.	38.	38.	4.	37.	37.	71.
25 Ouest	44.	44.	39.	2.	2.	7.	18.	18.	15.	36.	36.	39.
26 Sud-Ouest	27.	27.	20.	3.	3.	10.	34.	33.	29.	36.	37.	41.
27 Centre-Est	24.	24.	19.	13.	13.	19.	7.	7.	5.	56.	56.	57.
28 Mediterranee	25.	25.	21.	14.	14.	18.	5.	5.	3.	56.	56.	58.
31 Nord-Ovest	19.	19.	2.	7.	7.	24.	5.	0.	0.	69.	74.	74.
32 Lombardia	40.	40.	9.	1.	1.	32.	18.	7.	1.	41.	52.	58.
33 Nord-Est	33.	33.	15.	1.	1.	19.	7.	7.	1.	59.	59.	65.
34 Emilia-Romagna	41.	41.	26.	6.	6.	21.	3.	3.	0.	50.	50.	53.
35 Centro	23.	23.	16.	13.	13.	20.	1.	0.	0.	63.	64.	64.
36 Lazio	12.	12.	6.	9.	9.	15.	1.	1.	0.	78.	78.	79.
37 Campania	11.	11.	8.	2.	2.	6.	0.	0.	0.	87.	87.	86.
38 Abruzzi-Molise	12.	12.	8.	8.	8.	12.	3.	3.	1.	77.	77.	79.
39 Sud	8.	8.	3.	6.	6.	11.	16.	16.	5.	70.	70.	81.
3A Sicilia	1.	1.	1.	0.	0.	0.	30.	30.	17.	69.	69.	82.
3B Sardegna	3.	3.	2.	10.	10.	11.	7.	7.	4.	80.	80.	83.

NUTS-1 region	competitive land			only suitable for grapes			only suitable for other crops			unsuitable land		
	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops	grass	cereals	root crops
41 Noord-Nederland	0.	0.	0.	0.	0.	0.	70.	70.	51.	30.	30.	49.
42 Oost-Nederland	0.	0.	0.	0.	0.	0.	93.	93.	76.	7.	7.	24.
45 Zuid-Nederland	0.	0.	0.	0.	0.	0.	97.	97.	86.	3.	3.	14.
47 West-Nederland	0.	0.	0.	0.	0.	0.	80.	68.	39.	20.	32.	61.
51 Vlaams gewest	0.	0.	0.	0.	0.	0.	99.	99.	88.	1.	1.	12.
52 Region Wallonne	0.	0.	0.	0.	0.	0.	36.	36.	35.	64.	64.	65.
53 Brussel	0.	0.	0.	0.	0.	0.	48.	48.	47.	52.	52.	53.
60 Luxembourg (G.D.)	7.	7.	3.	1.	1.	5.	24.	24.	12.	68.	68.	80.
71 North	0.	0.	0.	0.	0.	0.	66.	9.	9.	34.	91.	91.
72 Yorkshire & Humberside	0.	0.	0.	0.	0.	0.	78.	23.	22.	22.	77.	78.
73 East Midlands	0.	0.	0.	0.	0.	0.	87.	48.	28.	13.	52.	72.
74 East Anglia	0.	0.	0.	0.	0.	0.	94.	63.	41.	6.	37.	59.
75 South East	0.	0.	0.	0.	0.	0.	87.	55.	42.	13.	45.	58.
76 South West	0.	0.	0.	0.	0.	0.	70.	54.	46.	30.	46.	54.
77 West Midlands	0.	0.	0.	0.	0.	0.	84.	52.	47.	16.	48.	53.
78 North West	0.	0.	0.	0.	0.	0.	73.	15.	14.	27.	85.	86.
79 Wales	0.	0.	0.	0.	0.	0.	49.	32.	31.	51.	68.	69.
7A Scotland	0.	0.	0.	0.	0.	0.	31.	19.	19.	69.	81.	81.
7B Northern Ireland	0.	0.	0.	0.	0.	0.	66.	29.	29.	34.	71.	71.
80 Ireland	0.	0.	0.	0.	0.	0.	73.	47.	46.	27.	53.	54.
90 Danmark	0.	0.	0.	0.	0.	0.	98.	90.	89.	2.	10.	11.
A1 Ellas (North)	11.	11.	7.	0.	0.	3.	4.	4.	2.	85.	85.	88.
A2 Ellas (Central)	8.	8.	5.	1.	1.	4.	3.	3.	2.	88.	88.	89.
A3 Ellas (East and S. isl)	2.	2.	2.	0.	0.	1.	7.	7.	5.	91.	91.	93.
B1 Noroeste	0.	0.	0.	0.	0.	0.	17.	17.	2.	83.	83.	98.
B2 Noreste	5.	5.	4.	0.	0.	0.	37.	37.	8.	58.	58.	88.
B3 Madrid	16.	16.	16.	0.	0.	0.	43.	43.	16.	41.	41.	68.
B4 Centro	5.	5.	5.	0.	0.	0.	39.	39.	7.	56.	56.	88.
B5 Este	14.	14.	10.	2.	2.	7.	26.	26.	2.	58.	58.	81.
B6 Sur	5.	5.	5.	0.	0.	0.	44.	44.	8.	51.	51.	87.
C1 Norte do continente	1.	1.	1.	0.	0.	0.	23.	23.	5.	76.	76.	94.
C2 Sud do Continente	7.	7.	5.	0.	0.	2.	35.	35.	20.	58.	58.	73.


MAP 1
SUITABILITY FOR FAST GROWING TREE SPECIES
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-20%
20-40%
40-60%
60-80%
80-100%
no or moderate limitations
area of total nuts-1 region
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CROP PRODUCTION POTENTIAL OF RURAL AREAS WITHIN THE EUROPEAN COMMUNITY
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map composition : J.D.Bulens
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MAP 2
SUITABILITY FOR NORMAL GROWING MORE DEMANDING TREE SPECIES
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-20%
20-40%
40-60%
60-80%
80-100%
no or moderate limitations
area of total nuts-1 region
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MAP 3
SUITABILITY FOR NORMAL GROWING LESS DEMANDING TREE SPECIES
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-20%
20-40%
40-60%
60-80%
80-100%
no or moderate limitations
area of total nuts-1 region
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MAP 4
SUITABILITY FOR FAST GROWING TREE SPECIES
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-20%
20-40%
40-60%
60-80%
80-100%
no or moderate limitations
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MAP 5
SUITABILITY FOR NORMAL GROWING
MORE DEMANDING TREE SPECIES
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-20%
20-40%
40-60%
60-80%
80-100%
no or moderate limitations
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MAP 6
SUITABLILITY FOR NORMAL GROWING
LESS DEMANDING TREE SPECIES
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-20%
20-40%
40-60%
60-80%
80-100%
no or moderate limitations
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MAP 7
SUITABILITY FOR FRUIT
RAINFED
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
45-50%
no limitations
area of total nuts-1 region
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MAP 8
SUITABILITY FOR FRUIT
IRRIGATED
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
45-50%
no limitations
area of total nuts-1 region
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MAP 9
SUITABILITY FOR CITRUS
RAINFED
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
no or moderate limitations
area of total nuts-1 region
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MAP 10
SUITABILITY FOR CITRUS
IRRIGATED
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
no or moderate limitations
area of total nuts-1 region
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MAP 11
SUITABILITY FOR OLIVES
LOW MANAGEMENT LEVEL
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
no limitations
area of total nuts-1 region
STARING CENTRUM
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WAGENINGEN THE NETHERLANDS
CROP PRODUCTION POTENTIAL OF RURAL AREAS WITHIN THE EUROPEAN COMMUNITY
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MAP 12
SUITABILITY FOR OLIVES
HIGH MANAGEMENT LEVEL
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-5%
5-10%
10-15%
15-20%
20-25%
25-30%
30-35%
35-40%
40-45%
no limitations
area of total nuts-1 region
STARING CENTRUM
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MAP 13
SUITABILITY FOR GRAPES
RAINFED
SCALE 1 : 10000000
kilometers
0
600
LEGEND
unsuitable
0-5%
5-10%
10-15%
15-20%
20-25%
20-25%
30-35%
35-40%
40-45%
no or slight limitations
area of total nuts-1 region
STARING CENTRUM
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