JRC Scientific and Technical Reports

# Common Biophysical Criteria for Defining Areas which are Less Favourable for Agriculture in Europe

Proceedings from the Expert Meeting 19-20th of April, 2007
The Institute for Environment and Sustainability
Joint Research Centre, Ispra (Italy).

***Editors: Å. Eliasson, J.-M. Terres and C. Bamps***

EUR 22735 EN - 2007

JRC
EUROPEAN COMMISSION

ies
Institute for Environment and Sustainability

# Common Biophysical Criteria for Defining Areas which are Less Favourable for Agriculture in Europe

Proceedings from the Expert Meeting 19-20th of April, 2007
The Institute for Environment and Sustainability
Joint Research Centre, Ispra (Italy)

***Editors: Å. Eliasson, J.-M. Terres and C. Bamps***

JRC
EUROPEAN COMMISSION

ies
Institute for Environment and Sustainability

The mission of the Institute for Environment and Sustainability is to provide scientific-technical support to the European Union's Policies for the protection and sustainable development of the European and global environment.

European Commission
Joint Research Centre
Institute for Environment and Sustainability

**Contact information**
Address: Åse Eliasson, Joint Research Centre
Institute for Environment and Sustainability
T.P. 262
E-mail: ase.eliasson@jrc.it
Tel.: +39-0332-785758
Fax: +39-0332-785230

http://ies.jrc.ec.europa.eu
http://www.jrc.ec.europa.eu



PUBSY 7852

EUR 22735 EN
ISSN 1018-5593

Luxembourg: Office for Official Publications of the European Communities



*Printed in Italy*

*Cover photograph: Courtesy of Andreas Brink*

## Foreword

This report presents potential common biophysical, soil and climate criteria that can be used for defining areas which are less favourable for agriculture in Europe. The work is part of the Joint Research Centre technical support to DG Agriculture and Rural Development in their preparatory work to find a new definition for classifying the EU Other/Intermediate Less Favoured Areas (Article 19) to be implemented after 2010.

The report is based on the findings of the expert meeting that was organised by the Joint Research Centre and occurred on the 19th and 20th of April 2007 in Ispra, Italy. The meeting included 33 participants, including 14 experts from various scientific institutes, four participants from DG Agriculture and Rural Development and 15 experts from the DG Joint Research Centre. A wide range of expertise in various fields was covered by the participants, including land quality assessment methods, soil, terrain, climate, water, environment, agriculture, implementation of EC agricultural policy and Less Favoured Areas.

The proceedings of this meeting includes: an introduction to the Less Favoured Areas, the work in which the Joint Research Centre provides technical support to DG Agriculture and Rural Development, abstracts of presentations, reports from working groups, results on potential common criteria and selected maps from presentations. It also summarises discussions on context, common criteria and application of these criteria by the Member States.

The expert meeting builds on the results from an earlier expert meeting (May 2006) on land quality assessment, which was organised to anticipate the technical work from the Joint Research Centre for DG Agriculture and Rural Development in the new definition of the Other Less Favoured Areas. Participants from that expert meeting were asked to make presentations on potential criteria, mainly based from that event, to be challenged at this expert meeting.

The proceedings are aimed to be a base for DG Agriculture and Rural Development in their consultation with Member States and future networks with scientists involved in the progress of classifying the Other Less Favoured Areas from biophysical criteria, seen as natural handicaps to agriculture.

## Acknowledgements

The expert meeting on Common biophysical criteria for defining areas which are less favourable for agriculture in Europe took place at the Joint Research Centre, Ispra on the 19th and 20th of April 2007. The event and this report was co-ordinated and prepared by Åse Eliasson with support from Jean-Michel Terres and Catharina Bamps of the Rural, Water and Ecosystem Resources Unit, Institute for Environment and Sustainability, Joint Research Centre.

Many thanks to Catharina Bamps and Stephanie Foisneau, Rural, Water and Ecosystem Resources Unit, and Jean Dusart, Spatial Data Infrastructures Unit Joint Research Centre, for preparing maps and analyses for this event and to Michaela Rossi, Management Support Unit, Joint Research Centre, for organising the practical aspects. Many thanks to Joanne Gartlon, for proof-reading services.

Special thanks to Christine Le Bas (INRA, France); Freddy Nachtergaele (FAO, Italy); Harrij van Velhuizen (IIASA, Austria); Jos Van Orshoven (Catholic University of Leuven, Belgium); Christiane Canenbley, Jean-Michel Courades and Alexander Page (DG AGRI, Belgium); Bettina Baruth (Agriculture and Fisheries Unit, JRC); Jean Dusart (Spatial Data Infrastructures Unit, JRC) and Florence Carré (Land Management and Natural Hazards Unit, JRC) for contributions to the project, this event and/or report.

The organisers would like to express their sincerest gratitude to all the authors, speakers and participants whose ideas and comments in discussions and working groups contributed to the results of this meeting.

## Contents

*Page*

Foreword ..... iii
Acknowledgements ..... v
Contents ..... vii

**I. Background Document** ..... 1
Context of the Expert Meeting *Å. Eliasson et al.* ..... 1

**II. Abstracts: Context** ..... 11
Aim of the Expert Meeting *J.-M. Terres* ..... 11
What are the Less Favoured Areas? *J.-M. Courades* ..... 13
New definition of the Other Less Favoured Areas *A. Page* ..... 14
Conclusions from the Evaluation of the Less Favoured Areas Measure *C. Canenbley* ..... 15
The new Thematic European Strategy for Soil Protection *F. Carré and L. Montanarella* ..... 17
Soil and Climate Criteria for the Less Favoured Areas *Å. Eliasson* ..... 18
Introduction to Pan-European Datasets: MARS Interpolated Grid Weather *B. Baruth* ..... 21
Introduction to Pan-European Datasets: European Soil Database *B. Houšková* ... 23

**III. Abstracts: Climate and Soil Criteria** ..... 25
Criterion on Temperature *G. Fischer and H. van Velhuizen* ..... 25
Criterion on Soil Water Balance *G. Fischer and H. van Velhuizen* ..... 26
Criterion on Heat Stress *F. Ruget* ..... 28
Criterion on Slope *J. Dusart* ..... 29
Criterion on Drainage *J. Van Orshoven and A. Gobin* ..... 30
Criterion on Texture and Stoniness *C. Le Bas* ..... 31
Criterion on Rooting Depth *C. Le Bas* ..... 32
Criterion on Chemical Soil Constraints *F. Nachtergaele* ..... 33
Climate Variability and Impact on Agriculture *G. Genovese et al.* ..... 33
Use of Remote Sensing for Defining the Length of the Growing season *E. Ivits-Wasser et al.* ..... 34

**IV. Reports from the Workshop** ..... 37
Session 1: Challenge of Presented Criteria ..... 37
Session 2: Working Groups on Criteria. ..... 40
Working group 1: Climate, Soil Water Balance and Terrain Criteria *P. Persson and J. Van Orshoven* ..... 40
Working Group 2: Soil Criteria *C. Le Bass and F. Nachtergaele* ..... 43

**V. Summary of Results and Reflections** ..... 47

**VI. Annexes**
Annex 1: Agenda ..... 55
Annex 2: List of participants ..... 57
Annex 3: Maps of presented criteria ..... 61

# I. Background Document

This document describes the background of the EU Less Favoured Areas (LFA) measure and the context of the work for which the Joint Research Centre provides technical support to DG Agriculture and Rural Development of the European Commission on the re-definition of the LFA and the objectives of the expert meeting.

## Context of the Expert Meeting

**Å. Eliasson*, J.-M. Terres and C. Bamps**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 262, I-21020 Ispra (VA), Italy.
(E-mail: ase.eliasson@jrc.it)
*corresponding author

### A. Background on the Less Favoured Areas

#### Objectives of the scheme

Certain rural areas are classified as LFA because conditions for farming are more difficult due to natural constraints, which increase production costs and reduce agricultural yields. The aid for the LFA in the EU dates back to 1975 and has since then undergone several reforms from being focused on addressing rural depopulation towards increased focus of maintaining certain agricultural land use and environmental protection. In addition, over time Member States have been offered increased flexibility of the implementation of the measure, i.e. Member States are responsible for changing the LFA classified, defining the types of agricultural production that are covered by the scheme and fixing the level of compensatory payments within a set framework. This has also resulted in regional differences on how the measure is applied within the Member States.

The LFA measure is under the legislation of the EU's Rural Development Policy 1257/1999 [1] where the aims of the LFA measure are:

- to ensure continued agricultural land use
- to maintain the countryside
- to maintain and promote sustainable farming
- to ensure environmental requirements and safeguarding farming in areas with environmental restrictions
- to contribute to viable rural communities in the LFA

However, a transition into the Rural Development Policy 1698/2005[2] (2007-2013) is in preparation, where the social objective "to contribute to viable rural communities in the LFA" has disappeared from the objectives.

[1] Council Regulation (EC) No 1257/1999 of 17 May 1999, Article 13 (Official Journal L 160/80, 26.06.1999).
[2] Council Regulation (EC) No 1698/2005 of 20 September 2005 (Official Journal L 277/1, 21.10.2005).

The LFA scheme is part of the Axis 2 measure on Land Management and Environment of the Rural Development Programming, which is part of the second pillar of the Common Agricultural Policy. The Rural Development programmes and the LFA scheme are financially supported by the European Agricultural Guidance and Guarantee Fund.

**Categories**

There are four categories classified as LFA. Each category covers a specific cluster of natural handicaps in Europe in which the continuation of agricultural land use is threatened.

1. **Mountain areas (Article 18) –** are characterised as those areas handicapped by a short growing season because of a high altitude, or by steep slopes at a lower altitude, or by a combination of the two.
2. **Other LFA (Article 19) –** are those areas in danger of abandonment of agricultural land use and where the conservation of the countryside is necessary. They exhibit all of the following handicaps: land of poor productivity, production which results from low productivity of the natural environment, and a low or dwindling population predominantly dependent on agricultural activity.
3. **Areas affected by specific handicaps (Article 20) –** are areas where farming should be continued in order to conserve or improve the environment, maintain the countryside, and preserve the tourist potential of the areas, or in order to protect the coastline.
4. **Areas subjected to environmental restrictions (Article 16) –** are areas with restrictions on agricultural usage resulting from the implementation of limitations on agricultural land use imposed by the EC.

In 2004, the surface area classified as LFA in the EU 25 Member States accounted for 91 million hectares, which represents 54% of the utilised agricultural area of the EU. Of the total LFA classified, the category 2 (Other LFA) represented as much as 66% Figure I.1) [3].

Category 3 (specific handicaps) cannot exceed 10% of the area of the Member State concerned. The spatial distributions of the municipalities/communes classified as LFA in Europe are shown in Figure I.2.

[3] Implementation of Article 18, 19, 20 and 16 of regulation (EC) no 1257/1999 in the 25 Member States of the European Union. Report prepared by the Institute of European Environmental Policy for DG Agriculture. August 2006.

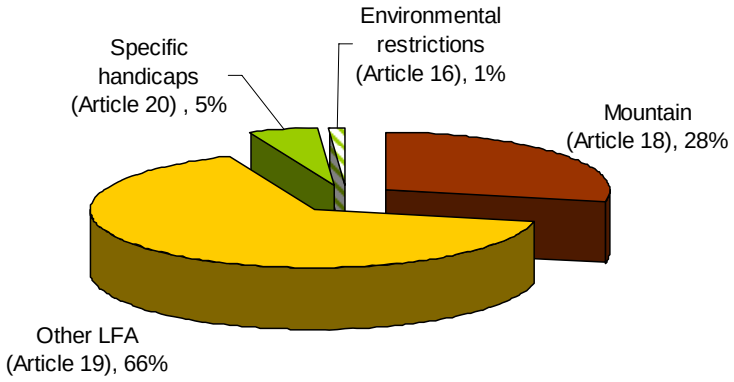



*Figure I.1. Representation of the different categories of the total area classified as LFA.*

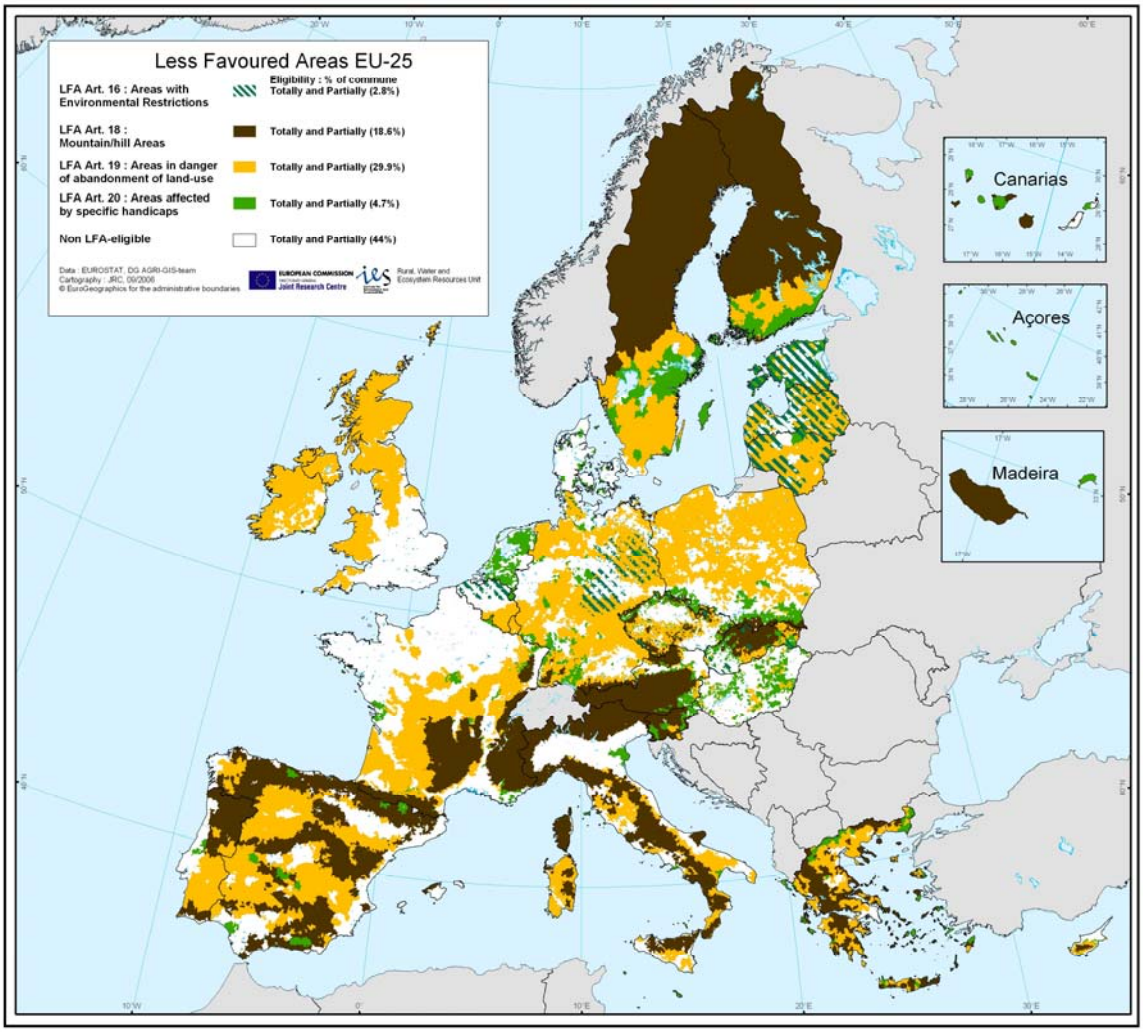



*Figure I.2. The map shows the distribution of communes in Europe, i.e. Local Administrative Unit 2 (Nuts 5) that have been classified under the current legislation as being eligible for LFA support for the 4 categories. Please note that the map shows the information aggregated at communal level: the communes for which the whole (total) or part of the communal territory (partially) is eligible for LFA support. The percentage of the total number of communes eligible by the different articles is shown in brackets in the legend.*

## Classification

For a farmer to be eligible for LFA payments there are two distinct levels of eligibility. Firstly, the farm has to be located in an area classified as an LFA. Eligible LFA are designated at the commune or lower level in the Member States (see Figure I.2). Secondly, it is the conditional criteria which are defined at farm level, for which the farmer has to apply with a number of rules and criteria. The Joint Research Centre LFA project concerns the first level of eligibility, the areas classified as Other LFA (refer to areas shaded in yellow Figure I.2).

The Other LFA is defined by Article 19 as areas which are in danger of abandonment of land use and where conservation of the countryside is necessary. Eligible areas for the Other LFA must be homogenous in natural production conditions and fulfil the characteristics of all the criteria below (current legislation):

- Land productivity: Criteria indicating poor land conditions and low productivity, difficult cultivation and limited potential which cannot be increased except at an expensive cost, and which is mainly suitable for extensive farming. (Example of indicators applied: yields in relation to national average yields; stocking rate; percentage of grazing land; diverse indices of land quality.)
- Economic performance of agriculture: Criteria indicating low level of agricultural production, acknowledged below average output per hectare. (Example of indicators applied: farm/labour income per working unit.)
- Population: Criteria indicating low or declining population predominantly dependent on agricultural activity, the accelerated decline of which would jeopardise the viability of the area concerned and its continued habitation. (Example of indicators applied: population density, agricultural population and depopulation rate.)

Member States use a wide range of different criteria for classifying the Other LFA. Examples of indicators that are applied in the Member States are shown in brackets under the respective characteristic. For the first condition on land productivity a wide range of different criteria and methods are used in the Member States. This is the category of criteria which relates to the JRC LFA project on identifying potential common biophysical criteria.

## Eligibility at farm level

The second level of eligibility for LFA payments concerns the eligibility at farm level. The eligibility criteria are the same for all the four different categories of the LFA and are defined as[4]:

- Farm a minimum land area. The limit applied varies between Member States from 0.1124 ha in Malta to 10 ha in England, with the majority having a limit of 1-3 ha.
- Undertake to farm for at least 5 years.
- Apply Good Farming Practices, standards consistent with the protection of the environment/countryside to promote sustainable agriculture.

[4] Council Regulation (EC) No 1257/1999 of 17 May 1999, Article 14.2 (Official Journal L 160/80, 26.06.1999).

In addition to these mandatory eligibility criteria, most Member States apply a variety of additional criteria to define eligibility for the scheme at farm level. Examples of additional farm eligibility criteria concern the following:

- Type of land use: e.g. grasslands only eligible, grassland and/or crops for fodder only eligible, exclusion of certain crops (corn, flowers, permanent crops and tobacco) and exclusion of irrigated areas.
- Type of livestock: certain type of livestock required and minimum and maximum stocking density is required for the farm to be eligible.
- Criteria on farm properties: age of farmer, farm income, family income, residence of farmer.

**Compensatory payments**

In 2004 compensatory payments were granted to 1.8 million farmers (18% of total), where 40 million hectares[5] were used as a calculation base for the compensatory payments, which amounts to approximate 24% of the utilised agricultural areas of the EU 25[6]. The public expenditure amounted to 3 075 million Euros, including 1 561 million Euros from the European Agricultural Guidance and Guarantee Fund, which equates to an average co-financing rate from Member States of 51%[6].

In 2004, the weighted average payment per hectare for LFA was 75 Euro for the EU 25 Member States, but payments ranged from 15-25 Euro/hectare in Spain and Estonia to 180-250 Euro/hectare in Malta, Finland and Austria. Previously, the LFA payments were based on per head of livestock, but then changed under Agenda 2000 to area payments to break the link with production.

The payments are often differentiated in the Member States depending on various factors such as: type of land use, stocking rate, zones (on land quality, yields), farm size, full time or part time farmers.

**Evaluations of the LFA scheme**

In 2003 a review of the LFA scheme was carried out by the Court of Auditors[7]. The main points of criticisms were that:

- Member States use a wide range of indicators to determine whether areas are less favoured or not, which lead to differences in the eligibility of the beneficiaries.
- The surface areas classified as LFA were highly variable. The rate of surface areas classified as LFA of the utilised agricultural areas varies considerably in the Member States, from 1% in Denmark to 98% in Luxembourg.
- The category of Other LFA (Article 19) is considerably larger than the other categories, and for this category the regulation has not been so clearly defined.

[5] This figure relates only to areas which actually received compensatory allowances, excluding Cyprus, Italy and Lithuania.
[6] Implementation of Articles 18, 19, 20 and 16 of Regulation (EC) no 1257/1999 in the 25 member States of the European Union. Report prepared by the Institute of European Environmental Policy for DG Agriculture, August 2006.
[7] Court of Auditors – special report n°4/2003 (Official Journal C151 of 27.06.2003).

In response to these criticisms, in 2005 the European Commission proposed a new definition of the Other LFA (Article 19) condition in the Council Regulation 1698/2005 article 50, 3. (a) which states that the Other LFA,

"*must be affected by significant natural handicaps, notably a low soil productivity or poor climate conditions and where maintaining extensive farming activity is important for the management of the land".*

The application of this definition was not accepted by the Member States due to the absence of fully examining other options[8]. A non-paper[9] was proposed in the discussions of the Rural Development Council working groups, but rejected. The non-paper suggested the following criteria for classifying the Other LFA:

- Average cereal yield (excluding rice and maize) less than 60% of EU 25 average (2.68 t/ha) and arable land representing at least 60% of total utilised agricultural area.
- Permanent grassland representing at least 60% of total utilised agricultural area.
- Average cereal yield (excluding rice and maize) less than 60% of EU 25 average and arable land and permanent grassland representing at least 60% of total utilised agricultural area.
- Stocking density not exceeding 1 LU/ha of forage area and forage area representing at least 60% of total utilised agricultural area.
- Average planting density of olive orchards not exceeding 100 trees/hectare and olive plantations representing at least 60% of total utilised agricultural area.

For a commune to be classified as LFA it would have to fulfil one of the five criteria. In addition, irrigated areas were excluded from the proposal. Due to the rejection of the earlier proposal (non-paper), a revision of the definition of the Other LFA is therefore foreseen for 2010[10] which will use natural conditions to re-define the Other LFA.

In 2006, a comprehensive evaluation of the LFA measure was carried out by Institute for European Environmental Policy (IEEP)[11] for DG Agriculture and Rural development. The evaluation report concluded that:

- The principal goal of the LFA measure had been attained in the EU 15. The area of total land abandonment is small in comparison to other industrialised countries although it is difficult to determine this on the data available.
- The LFA measure is of importance for the contributions of the objective "maintaining the countryside", through the continued use of agricultural land and also to "maintain and promote sustainable farming systems". Continued agricultural management has made greater contribution to the countryside where it

[8] Council Regulation (EC) No 1698/2005 of 20 September 2005, Article 93 (Repeal) (Official Journal L 277/1, 21.10.2005).
[9] A non-paper is a non official document.
[10] Council Regulation (EC) No 1698/2005 of 20 September 2005, Article 93 (repeal) (Official Journal L 277/1, 21.10.2005).
[11] An evaluation of the LFA measure. A report prepared by the Institute of European Environmental Policy for DG Agriculture, November 2006.

supports the maintenance of valued open landscapes, semi-natural habitats and biodiversity, it assists in the control of forest fires, or contributes to good soil and water management. Furthermore, features such as grazed semi-natural grasslands and hillside terraces stem from farming practices.

- The objective "to contribute to viable rural communities" in order to prevent rural depopulation through continued agricultural activity (which was removed in the Rural Development Plan 1698/2005) has ceased to be relevant for most part of the EU 15 as the share of employment directly dependent on agriculture has declined.
- The measure has been most effective on livestock farms, which have been the focus of payments in most Member States.
- The compensatory payments have been more effective in maintaining land use rather than securing the most appropriate form of management with both intensification and under-grazing in some areas. However, the pressure of over intensive management has been removed with the change to area payments instead of per head of livestock.

**B. New definition of the Other LFA**

The JRC is supporting DG Agriculture and Rural Development in the new definition of the Other LFA (Article 19) by providing technical support and consulting with experts through informal networks in the Member States.

The motive for changing the current definition of the category Other LFA (Article 19) is to allow for objective criteria for a more transparent approach in Europe and to respond better to the Axis 2 objectives on Land Management and Environment of the Rural Development planning. The aim is to make compensatory payments for the additional cost of managing the land due to natural handicaps.

The reason for the future new definition to be based on natural conditions and not to include socio-economic indicators, e.g. on farm/labour income per working unit, is to better achieve the new policy objectives: Axis 2, were LFA is one of the measures. This is inline with the negotiations with the World Trade Organisation to allow support related to environmental constraints (green box).

**C. Recommendations on criteria**

It is envisaged that the criteria should be based on the definition in the Council Regulation 1698/2005 article 50, 3. (a) which states that the Other LFA:

"*must be affected by significant natural handicaps, notably a low soil productivity or poor climate conditions and where maintaining extensive farming activity is important for the management of the land"*

As a first step, the common criteria and application of common criteria at the European level should focus on natural criteria in terms of soil and climate. As a second step, after ex-ante assessment (September 2007), other criteria linking with the countryside and landscape function could possibly be included relating to e.g. High Nature Value farmland, land abandonment and remoteness.

A number of desirables and recommendations for the development of common criteria on natural constraints to agriculture and application at the European level for the re-definition of the Other LFA have been given[12] (Table I.1 and Table I.2). The list is not exhaustive and some questions are left open.

***Table I.1. Recommended properties of common criteria on natural constraints to agriculture for delimiting areas eligible for LFA support.***

| No. | Recommendation | Description |
|---|---|---|
| 1 | Agricultural areas | The criteria should focus on agricultural areas which include permanent grasslands, permanent crops and arable land. Forest is not included. |
| 2 | Potential production | The criteria should be based on the potential production of land, i.e. not based on actual production. This means that the issues such as level of input (e.g. farming technology, soil nutrition input and management) and socio-economic factors are not considered. |
| 3 | EU 27 | The criteria should be applicable for all EU 27 Member States. However, some of the criteria might not be "mapped" at the European level. |
| 4 | Scientifically clear and internationally accepted criteria | The criteria should be straightforward, scientifically clear and internationally accepted to facilitate negotiations for DG Agriculture and Rural Development with Member States. |
| 5 | Not crop specific | The criteria should not be crop specific. However, it is important to recognise that both climate and soil properties determine crop potential. Under prevailing climate and soil conditions certain crops grow well whereas others cannot grow. |
| 6 | Not annually dependent | The criteria should not change during the period of the programme, seven years. Concerning climate, it should not be based on a particular year, but rather on an average weather situation. However, it is important to recognise that agriculture is largely dependent on the variability of the climate (e.g. occurrence of early rains, rain patterns, frost and dryness). |
| 7 | Soil and climate criteria | The criteria should initially be based on only soil and climatic constraints to agricultural production. |
| 8 | No socio-economic criteria | It is aimed that the common criteria should not be socio-economic (e.g. production indices, population indicators). However, it is important to recognise that criteria others than soil and climate (e.g. access to markets, levels of input and management options) may have a larger influence on the actual agricultural production. |
| 9 | Local Administrative Unit 2 | It is envisaged that the criteria should be defined on the level LAU 2 (communes)[13] by the Member States. |

[12] Based on recommendations from the joint activity, DG Agriculture and Rural Development and Joint Research Centre.

[13] There are 110 266 communes in EU 25, with the area ranging from in size from 0.001 to 20 688 $km^2$ with median value 14 $km^2$ and mean value 38 $km^2$.

***Table I.2. Recommended properties of the application of the common criteria on natural constraints to agriculture on the European level.***

| No. | Recommendation | Description |
|---|---|---|
| 1 | Publicly available existing datasets | The application of the common criteria of the European level should be based on publicly available existing pan-European datasets. |
| 2 | Classes of severity | It is desirable that the application can distinguish between different classes concerning the level of constraint, e.g., land very severely constrained, land severely constrained. |
| 3 | Not dealing with farm level eligibility: | The application should define the overall areas and does not deal with the eligibility for LFA aid at farm level. |
| 4 | Thresholds for EU 27 | For the application at the European level, indicative thresholds should be provided. |

The method does not consider the issue of economic performance: for example, a poor soil can still provide a high income (e.g., vineyards, asparagus). This relates to the question 'land constrained to what type of agriculture practiced?' However, as currently applied in many Member States specific crops are excluded for LFA support. It needs to be recognised that the economic performance of a farmer may not correlate with the soil and climate conditions. Other factors may be more important such as, e.g. access to markets, levels of input and management options.

Recommendations from the evaluation of the LFA measure in 2006 by the IEEP[14] which relate to the classification of the Other LFA areas are:

- *"With a view to the renewed focus of LFA policy on 'maintaining and promoting sustainable farming systems' the criteria for the classification of LFAs as well as the eligibility criteria need to be revised in view of adapting them more precisely to recognised environmental priorities and region-specific land management requirements.*
- *Clarification needs to be sought regarding which classification criteria of LFA areas should be applied at the EU level and what degree of discretion should be left to the Member States. In particular, this clarification is needed for the criteria concerning Articles 19 and 20 where, for the time being, only a few criteria exist which are comparable at a European level.*
- *Given the political concern about land abandonment and the central goal of LFA policy to maintain land under agricultural use, it is recommended that approaches to the collection of land use and management data with greater sensitivity to abandonment are investigated, with data collected on a regular basis".*

[14] An evaluation of the LFA measure. A report prepared by the Institute of European Environmental Policy for DG Agriculture, November 2006.

## D. Aim of the expert meeting and time frame

The aim of the expert meeting is to identify common criteria that can be used for defining agricultural areas that are constrained to agriculture. The criteria should be biophysical, soil and climate related and seen as natural handicaps to agriculture. The output of the workshop will contribute to an inventory of potential common criteria for DG Agriculture and Rural Development to aid their preparatory work on a new definition of the Other EU Less Favoured Areas to be implemented after 2010.

The common criteria deal with the first eligibility defining areas classified as Other LFA (Article 19), i.e. areas that are homogenous in natural production potential.

### *What is the time frame?*

Below is a provisional work and time schedule for the project component at the JRC and important dates for the overall process carried out by DG Agriculture and Rural Development.

| | |
|---|---|
| 2007 | Inventory of methods |
| 2007 | Development of common criteria and application at the European level. Ex-ante assessment. |
| 2007 (Sept.) | Refinement of approach and if necessary broadening to other criteria. |
| 2008 | Synthesis report and proposal. |
| 2008 | European Commission report on the designation of LFA to the European Council (draft legislation). |
| 2009 | Council decision. |
| 2010 | New designation of LFA into force. |

## E. Further information

Evaluation of the Less Favoured Area Measure in the 25 Member States of the European Union
http://ec.europa.eu/agriculture/eval/reports/lfa/index_en.htm

Council Regulation 1698/2005
http://eur-lex.europa.eu/LexUriServ/site/en/oj/2005/l_277/l_27720051021en00010040.pdf

Council Regulation 1257/1999
http://ec.europa.eu/comm/agriculture/rur/leg/1257_en.pdf

DG Agriculture and Rural Development website
http://ec.europa.eu/comm/agriculture/index_en.htm

Basic key agricultural statistics in the EU
http://ec.europa.eu/comm/agriculture/agrista/2005/table_en/2012.pdf

# II. Abstracts: Context

## Aim of the Expert Meeting

**J.-M. Terres**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 262, I-210 20 Ispra (VA), Italy.
(E-mail: jean-michel.terres@jrc.it)

**Background – Rationale**
The Less Favoured Areas (LFA) policy instrument revision was fostered by a report from the Court of Auditor (2003) which asked for a more transparent and homogeneous approach amongst Member States. Indeed the new Rural Development strategy (2007-2013) defined Axis 2 objectives to better manage the land and the environment. Indeed the follow-up in the Council Regulation 1698/2005 (RD 2007-2013) envisaged that "Other LFA" (Article 19) should be based on areas that:

> "*must be affected by significant natural handicaps, notably a low soil productivity or poor climate conditions and where maintaining extensive farming activity is important for the management of the land".*

DG Agriculture and Rural Development and theJoint Research Centre (JRC) have agreed on a joint technical activity to prepare and to assess a proposal definition for the "Other LFA" (Article 19). The way to proceed should be in line with DG Agriculture and Rural Development Evaluation criteria for Rural Development programme, therefore the method should:

- Be based on territorial and bottom-up approaches ⇒ geo-spatial tools + large consultation with Member States (bi-lateral + Joint Research Centre meetings).
- Look for funding provisions and delivery mechanisms ⇒ need for harmonisation, improve consistency of LFA designation in Member States, re-focus on natural conditions.
- Use networks and exchange of good practice to increase programme efficiency ⇒ need to build technical consensus to facilitate political discussions.

**Scope of this expert meeting**

- To identify common biophysical soil and climate criteria to identify natural constraints to agriculture.
- To get recommendations and criteria for quantifying "natural constraints" to agriculture. Which analytical framework? Which criteria shall be used?
- To get a common understanding between scientific experts and to facilitate / prepare discussions with policy makers.

*Boundary conditions:*

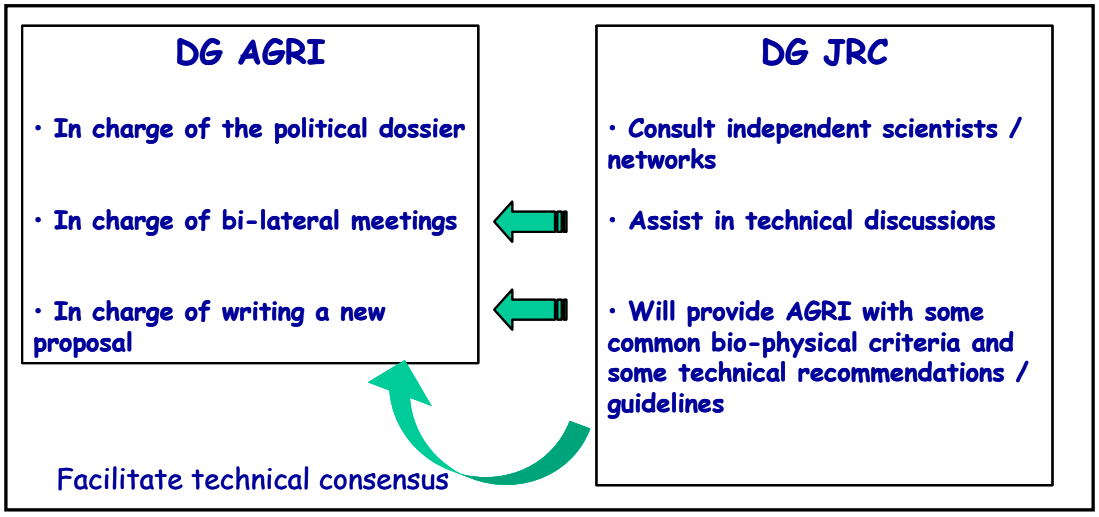
- Transparent, robust method, acceptable by Member States and able to be translated into policy regulation (clear, understandable methodology).
- Coverage: all Member States (EU 27), homogeneous, publicly available datasets

**Agenda of the LFA research at the JRC**

From the policy side: In the new Rural Development Regulation (reg. 1698/2005), the Commission committed to revise the designation of LFA (Article 19 "other intermediate areas"). Plans are to draw a proposal by 2008, to propose it to the Council in 2009 in order to start with a new scheme coming into force in 2010.

From the research side: Inventory of methods will be carried out in 2007, Common criteria – EU Analysis will be developed in mid 2007 in order to provide a joint synthesis report / proposal: early 2008. Interactions and roles between DG Agriculture and Rural Development and the JRC are shown in Figure II.1.

***Figure II.1. Interactions and roles between DG Agriculture and Rural Development and the JRC for the LFA project.***




**Activities of the action Integration of Environmental Concerns in Agriculture**

*Objectives of the Action:*

- Support to RD axis II: LFA, method development for indicators for Land abandonment, High Nature Value Farmland, Landscape state and diversity, share of agriculture in Nitrate pollution
- Support to environmental regulation (Nitrates directive, Water Framework Directive)

*Tools:*

- GIS geo-spatial modeling / development of databases
- Bio-physical process models for assessing the impact of farm practices on the environment (fate of fertilisers, pesticides, erosion, carbon content in soil etc.)

*Research networks – partners:*

CAPRI Dynaspat ⇒ economic and environmental modelling
LUMOCAP ⇒ CAP impact and spatialisation of land-use
CCAT ⇒ cross-compliance and environment
SENSOR ⇒ Multi-sector modeling at Nuts 2 level
Euroharp ⇒ methods for water quality (Nitrate)
HAIR ⇒ Risk of pesticide indicator

*The action Integration of Environmental Concerns in Agriculture is currently working on activities with potential inputs in the LFA re-definition such as:*

- Identification of High Nature Value farmland at EU level.
- Methodological development for an Indicator for risk of land abandonment.
- Methodological development to better classify European administrative units using criteria such as remoteness – peripherality.

## What are the Less Favoured Areas?

**J.-M. Courades**
DG Agriculture and Rural Development, European Commission, Unit F3 - Rural Development, Rue de la Loi 130, B-1049 Brussels, Belgium.
(E-mail: jean-michel.courades@ec.europa.eu)

The Less Favoured Areas (LFA) 2000-2006 measure is split into two measures in the new programming period (2007-2013): natural handicap payments to farmers in mountain areas and the payments to farmers in areas with handicap other than mountain areas. This second measure corresponds to two different types of areas: Other LFA and areas affected by specific handicap.

With the exception of these new titles for the measures and of cross compliance standards eligibility conditions all the provisions from the previous period will still apply in the new programming period: under Articles 18 (Mountain Areas), Article 19 (Other LFA) and Article 20 (Areas Affected by Specific Handicaps of Regulation (EC) no. 1257/99 Member States of the European Union will provide compensatory allowances to farmers. The criteria used under Article 18 refer directly to a measure of slope, altitude or a combination of the two, and are clearly-defined. There is a wide variation in the criteria developed to classify Article 19 areas although they are clearly defined. Under Article 20, the criteria developed are highly variable; they reflect local conditions and so are not comparable at a Community level.

In 2004, 14 Member States designated LFA under Article 18 of which nine were old Member States and five are new Member States. They include, Czech Republic, Germany, Greece, Spain, France, Italy, Cyprus, Austria, Poland, Portugal Slovenia, Slovak Republic, Finland and Sweden. 23 Member States designated LFA under Article 19. Malta and the Netherlands are the only Member States which do not designate LFA under this Article. 24 Member States designate LFA under Article 20. Latvia is the exception.

In 2004, the area of Utilised Agricultural Area falling under the LFA delimitation in the European Union accounted for approximately 91 million hectares, which is equivalent to 54% of the Utilised Agricultural Area:

- Mountain LFA (Article 18) represent 28% of the total surface of the LFA
- Other LFA (Article 19) represent 66% of the total surface of the LFA
- Areas affected by specific handicaps (Article 20) represent 5% of the total surface of the LFA

In 2004, compensatory allowances were granted to 1.78 million holdings in the EU 25. This accounts for approximately 18% of the total number of holdings in the Union.

Since the 2004 enlargement, by far the largest number of recipients is in Poland, (520 000) although other Member States with more than 100 000 recipients include Germany, Ireland, Greece, Spain, France, Lithuania, Austria and Portugal.

In 2004, 40 million hectares were used as a calculation base for the compensatory allowances, which accounts for approximately 24% of the total Utilised Agricultural Areas of the EU 25.

## New Definition of the Less Favoured Areas
### - LFA evaluation 2010 project

**A. Page**
DG Agriculture and Rural Development, European Commission, Unit F3 - Rural Development, Rue de la Loi 130, B-1049 Brussels, Belgium.
(E-mail: alexander.page@ec.europa.eu)

**Introduction**
EC Regulation 1698/2005 is the new Rural Development Regulation which came into force on 1st January 2007, as part of the negotiations when EC Regulation 1698/2005 was being discussed and because of issues raised by the European Court of Auditors on the designation of Less Favoured Areas (LFA) in EC Regulation 1257/1999, a non-paper was originally tabled during the working group discussions. The proposals in the paper met with some resistance amongst Member States and it was therefore proposed that the Commission would undertake an extensive review of the LFA measures.

Therefore the LFA designation in 1257/1999 will stay in place until 2010. Before this time the EC would like to initiate a project to look at and discuss how they currently designate under Article 19 and the other LFA Articles of EC Regulation 1257/1999.

**Scope of project**
- Evaluate Member States implementation of LFA measures both on a historical basis and what they have implemented in their previous programmes.
- To enhance our understanding of ‘Natural Handicaps’ so as to be able to provide a scientific evidence based classification of LFA.
- To produce a Legislative proposal to the Council so as to enable the implementation of the LFA designation in Regulation 1698/2006.
- Only Article 19 or 'Other LFA' are being evaluated and only the physical delimitation is within the scope of this project, this is to say that the objective of LFA payments and ways to pay are not part of the evaluation project.

**Project deliverables**

- A programme of bilateral meetings to be completed by the spring of 2007. This is to gather and evaluate Member States current designation and LFA measure.
- An evaluation report of LFA measures to look at historical LFA implementation and evaluate the effects of the measure over time and provide some recommendations and conclusions of the effectiveness of the policy intervention lever.
- Evidence for natural handicaps, a clear set of defined descriptors of what cause natural handicaps and how this can be defined to include thresholds.
- Analysis of criteria and methods which can be used as a European wide system for designation of LFA. To provide a technical working document which Member States can use to test the method using Member States datasets.
- Synthesis report, of all the evaluation meetings and studies and a suggested best model.
- Draft Legislative proposal to the Council on the possible change to the Rural Development Regulation.
- Council working group, to provide a secretariat for any technical or Council working groups which may need to be held, in order to ratify the proposed amended articles to the regulation.

**Project timeline**

- Evaluation report, Dec 2006
- Bi-laterals, April 2006 – Spring 2007
- Draft Technical paper to Rural development Council Summer 2007
- Further bi-laterals, Autumn 2007 – Spring 2008
- Draft Legislative proposal to Council, Spring 2008
- Council working groups, Autumn 2008 – Spring 2009
- Implementation, Jan 2010

## Conclusions from the Evaluation of the Less Favoured Area Measures

**C. Canenbley**
DG Agriculture and Rural Development, European Commission, Unit G4 - Evaluation of measures applicable to agricultural studies, Rue de la Loi 130, B-1049 Brussels, Belgium.
(E-mail: christiane.canenbley@ec.europa.eu)

The evaluation of the Less Favoured Area (LFA) measures was carried out with regard to requests made by the European Parliament and the Court of Auditors both asking for a report on the LFA measures. The evaluation study was carried out by IEEP (Institute for European Environmental Policy, London, United Kingdom) in 2006 on behalf of DG Agriculture and Rural Development.

The evaluation had to examine the impact of EU support measures specific to LFA since the introduction of these measures in 1975. The evaluation included two parts: a first descriptive part with a full inventory of the implementation of the LFA measure throughout the EU and a second part containing the analysis.

The evaluation questions were framed by the following Evaluation Themes:

- the implementation of the LFA measures
- the effects on farm structures and incomes
- the impact on land use, environment and viability of rural communities

These evaluation themes were investigated in EU 15. As regards the New Member States, the study covered only aspects of implementation.

As highlighted above, the evaluation covered a much broader range of questions related to the LFA measure than just the classification criteria. But also with respect to classification criteria some interesting findings are presented in the report. The following points only present findings and recommendations which are relevant in this context.

All 25 Member States implemented LFA schemes with a steady increase in the area classified as LFA. The increase in area concerned mainly so-called "other LFA" (e.g. areas in danger of abandonment), while "mountain areas" declined. "Areas subject to environmental restrictions" and "areas affected by specific handicaps" remained relatively small.

With the significant increase of "other LFA", the somewhat unclear definition of this type of LFA became a matter of particular concern. Similarly unclear are the criteria for "areas affected by specific handicaps". For both types of LFA, Member States apply a wide range of national criteria which are not comparable at EU level. In addition, problems arise from the fact that some of the classification criteria concerning "Other LFA" (e.g. rural population) probably no longer reflect the core objectives of LFA measures.

Not all farms within LFA receive a compensatory allowance under established eligibility rules. Between 2000 and 2003, the number of beneficiaries was less than half of the total number of farms in the areas classified as LFA (EU 15). Participation is generally higher in North West Europe in comparison to the Mediterranean regions, partly because a significant number of farms in southern Europe fall below the minimum size threshold.

This North/South divide is also noticeable with respect to payment levels. The expenditure for LFA is skewed towards a limited number of Member States (low levels of expenditure in the Mediterranean countries as compared to North Western Europe), leading to a higher contribution to farm incomes in Northern Member States.

On the basis of this evaluation, the following recommendations related to the classification of criteria were put forward:

- The evaluators conclude that LFA payments need to be concentrated on areas where there is a clear need for agricultural management and there are genuine risks of abandonment or inappropriate land use changes.

- The criteria for the classification of LFA as well as the eligibility criteria need to be revised in view of adapting them more precisely to recognised environmental priorities and region-specific land management requirements.

- In particular for the criteria concerning "Other LFA" and "areas affected by specific handicaps", clarification is needed concerning the approach towards establishing classification criteria (EU level or Member States).

- Better guidance is needed on the measurement of handicaps in order to afford a more effective and transparent implementation of LFA policy in the future.

## The new Thematic European Strategy for Soil Protection

**F. Carré* and L. Montanarella**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 280, I-210 20 Ispra (VA), Italy.
(E-mail: florence.carre@jrc.it)
* corresponding author.

*After having recognised soil as an essential resource for life and the environment, and after having issued a communication on soil degradation in Europe and on the urgency to set up corrective actions (April 2002), on the 22nd of September 2006, the European Commission proposed a Thematic Strategy for Soil Protection.*

In the introduction, the strategy recalls the different functions of soil such as (i) food and other biomass production, (ii) storage, filtration and transformation of many substances including water, carbon, nitrogen; (iii) platform for human activities, landscape and heritage, (iv) habitat and gene pool. These functions should be protected because of their socio-economic and environmental importance. This strategy aims to protect soil functions and to guarantee the sustainable use of soil by preventing degradation while preserving functions and restoring degraded soil.

Although soil is generally managed locally and some Member States have already set up specific legislations, a European action is necessary, particularly because:
- soil degradation affects other environmental compartments for which there already exists a legislation (e.g. air and water)
- there is an internal market distortion, due to different national politics for soil protection (e.g. soil remediation obligations are very heterogeneous between countries and this can create unbalanced costs or investments decrease)
- soil management can have transboundary impacts (e.g.: EU obligations for CO2 decrease can be in contradiction with soil organic matter decrease, soil erosion or, flooding in one Member State can have consequences on the neighbouring country)
- soil contaminants can be transferred into the food products and can affect food security of European market, thus creating a health risk for consumers.

This strategy, while respecting subsidiarity and proportionality principles, should protect soil and indirectly other environmental compartments and human health. The

strategy consists of three components: a Communication from the Commission to the other European Institutions, a proposal for a framework Directive (a European law), and an Impact Assessment. The Communication (COM(2006)231) sets the frame by explaining why further action is needed to ensure a high level of soil protection, outlining the overall objective of the Strategy and describes what kind of measures must be taken over a ten-year work program. The proposal for a framework Directive (COM(2006)232) sets out common principles for protecting soil across the EU. Within this common framework, the EU Member States will be in a position to decide how best to protect and manage soil in a sustainable way on their own territory. The Impact Assessment (SEC(2006)1165) and (SEC(2006)620) contains an analysis of the economic, social and environmental impacts of the different options that were considered in the preparatory phase of the strategy and of the measures finally retained by the Commission.

The strategy is based on four pillars:

- the proposal for a framework Directive (COM(2006)232);
- the integration of soil protection in other national and European politics, such as the new Common Agricultural Policy, waste and water management, and national rural development planning;
- the reinforcement of research on soil which has to be implemented at a global level (scale of existing soil research mainly focuses on field). To this aim, the Framework Programme 7 should emphasise soil research.
- Awareness of European citizens on soil functions and soil degradation is insufficient, and should be increased in education and public communications.

## Soil and Climate Criteria for the Less Favoured Areas

**Å. Eliasson**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 262, I-210 20 Ispra (VA), Italy.
(E-mail: ase.eliasson@jrc.it)

The presentation gives an introduction to the soil and climate criteria that have been chosen for presentations at this expert meeting. It, a) presents why these criteria have been chosen, b) illustrates criteria used in other land quality assessment methods, applied on the national, European and international level, c) shows some recommendations given by Member States, d) illustrates issues of scale on maps derived from pan-European datasets in relation to the LFA, and e) it draws out key questions to be addressed in discussions for which guidelines for presentations has been given.

The criteria chosen for presentations at this expert meeting are based on the outcome of an expert meting held in May 2006[15] to anticipate the work with DG Agriculture

[15] Land quality assessments for the definition of the EU Less Favoured Areas focusing on natural constraints, proceedings from expert meeting 16-17 May 2006, Joint Research Centre, Ispra , Italy, 2006 - JRC Technical Note.

and Rural Development. At this meeting the Problem land approach[16, 17], was identified as a suitable base for simple criteria and method that could be applied for the new definition of the Other LFA for an assessment on the European level. The Problem land approach is based on a simple and systematic approach. The approach starts from the top, searching for land with the defined problem land key, i.e. starting from areas defined by the criterion Temperature (Table II1.1), going down the list. If none of the characteristics are found on the surface, the land is identified as suitable for agriculture.

***Table II.1. Criteria chosen for presentations at this expert meeting, based on the outcome from the expert meeting in May 2006 and further developed within the context of the LFA project, recommendations from bilateral meetings and criteria used in other land quality assessment methods.***

| **Criterion** | **Description** |
|---|---|
| Temperature | The number of days with cold temperature - short growing season due to temperature. Defined by the Length of the Growing Period by temperature (LGPt5) above 5 degree Celsius. |
| Heat stress | The number of days with excessive temperature/heat stress for crop growth. |
| Water balance | No of days with limited water moisture availability for crop growth within the temperate growing season – short growing season due to soil moisture availability. Defined by the Length of the Growing Period by temperature and soil moisture availability. |
| Slope | Land areas with dominant slope >15%. |
| Rooting depth | Land areas which have depth limitations within 50 cm of the surface caused by the presence of coherent, hard rock or hard-pans. |
| Soil texture | Land areas which have coarse textures with less than 18% clay and more than 65% sand, or have gravel, stones, boulders or rock outcrops in surface layers or at the surface |
| Drainage | Land areas which are water logged and/or flooded most part of the year. |
| Bad chemical soil properties | Land areas comprised of soils with a high salt content and/or exchangeable sodium saturation and/or toxicity within 100 cm of the surface. This affects the natural availability of plant uptake affecting chemical fertility. Soils with deficiencies in plant nutritions. |

The set of criteria was further developed for the purpose of the LFA project, recommendations from bilateral meetings and criteria used in other land quality assessment methods. Changes made to the criteria and its definitions proposed at the

[16] FAO/RAPA (1990) Problem soils of Asia and the Pacific. RAPA Report 1990/6. FAO/RAPA Bangkok. 283 pp.
[17] Nachtergaele, F. (2006). The FAO Problem Land Approach adapted to EU conditions. Presentation at the expert meeting "Land quality assessment for the definition of the EU Less Favoured Areas focusing on Natural constraints, 16-17 May 2006, JRC, Ispra, Italy.

expert meeting in May 2006 can be summarised as follows, criterion on temperature redefined, criterion on heat stress added, criterion on peat included under drainage, criterion on heavy cracking clay included under texture and chemical criteria grouped together. One of the aims of this expert meeting is to challenge these criteria as shown in the Table II.1.

A review of the criteria covered in European and international assessments show that these criteria are also included in the AEZ (Agro-Ecological Zoning methodology)[18], ESCAPE (Expert System for Constraints to Agricultural Production in Europe)[19, 20], the Problem land approach[15, 16] and CGMS (Crop Growth Monitoring System)[21].

Observations of the methodologies applied by the Member States for the classification of the Other LFA show that these criteria are also found in the methods applied by e.g. Austria, Cyprus, Estonia, Finland, Germany, Hungary, Latvia, Poland, Slovenia and the UK.

In the bilateral meetings with Member States various criteria have been suggested for a new definition on e.g. length of growing period, temperature sum, frost killing in spring, frequency of extreme events, rainfall during harvest/spring, proportion of handicapped soils (texture, stoniness, rooting depth and drainage), proportion of clay fields, probability of crop damage, proportion of field area in commune (as a proxy for remoteness), actual yield (as a proxy for impact of natural conditions), High Nature Value farmland, land abandonment, scattered land and small plots.

The issue of scale of maps is also being illustrated by a) the difference in the size of communes (Local Administrative Unit 2) comparing Member States with small communes e.g. France with Member States which have large communes, e.g. Sweden, b) the difference in size of the soil mapping units in the pan-European soil map, and c) the combination of the two.

[18] Fischer, G., van Velthuizen, H., Shah, M., and Nachtergaele, F.O. (2002). Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results. Research Report RR-02-02. International Institute for Applied Systems Analysis, Laxenburg, Austria. pp 119 + CD-ROM.
[19] Le Bas, C., Boulonne, L., King D. (2001). Expert system for Constraints to agricultural production in Europe, Rapport final. INRA and European Soil Bureau. (in French).
[20] Le Bas, C., Boulonne, L., King D. and Montanarella, L. (2002). A Tool for assessing land suitability for Europe. INRA and European Soil Bureau. 17th world congress of Soil Science, 14-21 of August 2002, Bangkok, Thailand, Symp. 48, 256-1-11.11pp.
[21] Baruth, B., Genovese, G., and Montanarella, L. (2006). New soil information for the MARS Crop Yield Forcasting System. EUR report 22499 EN.

# Introduction to Pan-European Datasets MARS Interpolated Grid Weather

**B. Baruth**
Joint Research Centre, European Commission, Institute for the Protection and Security of the Citizen, T.P. 483, I-210 20 Ispra (VA), Italy.
(E-mail: bettina.baruth@jrc.it)

The following abstract is an extract from the METAMP report – "Methodology of the MARS Crop Yield Forecasting System - Eur Rep 21291 EN/1-4"

The Meteorological Infrastructure which is a part of the MARS (Monitoring Agriculture with Remote Sensing) Crop Yield Forecasting System run at the Agrifish-Unit of the IPSC (Institute for the Protection and Security of the Citizen) is briefly described. The database 'Interpolated Grid Weather' which forms a part of the meteorological infrastructure is supposed to be the information source for the climate based criteria for the classification of Less Favoured Areas for the application on the European level.

It is the objective of the Mars Crop Yield Forecasting Systems (MCYFS) to provide precise, accurate, scientific, traceable and independent forecasts for the main crops yields at EU level. The forecasts and analyses are used since 2001 as a benchmark by analysts from DG Agriculture and Rural Development in charge of food balance estimates for Common Agricultural Policy decisions. The system itself consists of three levels: 1. weather monitoring, 2. crop simulation taking into account the actual weather situation and 3. final yield forecasting.

The weather monitoring comprises daily acquisition of raw meteorological data from stations within Europe and the processing and quality checking of this data. The total number of available daily stations is around 6000. The processed daily meteorological data consists of 29 meteorological parameters including various cloud cover indicators, air temperature, vapour pressure, wind speed and rainfall. Each day, the processed daily meteorological data are inserted into the CGMS (Crop Growth Monitoring System) database by the program.

In this way an up-to-date database was established of harmonised, quality checked daily data from a network of stations across western and eastern Europe, western Russia, the Maghreb and Turkey . The longest time series go back to 1933. Over the years the number of stations has increased. Good coverage over Western Europe is obtained since 1975. The extension to the other regions has taken place during the nineties. Evapotranspiration and global radiation are necessary for the agrometeorological model in the MCYFS, but not all the stations provide this data and they are derived from the other available data and added to the database.

The daily meteorological data is interpolated towards the centre of a regular climatic grid that measures 50 by 50 kilometres and amounts to 5625 cells. The data of the climatic grid is stored in the database and includes the parameters in Table II.2:

***Table II.2 Daily parameters in the MARS database***

| Parameter | Unit | Abbreviation |
|---|---|---|
| Minimum Temperature | °C | Tmin |
| Maximum Temperature | °C | Tmax |
| Cumulated Mean Temperature | °C | Tsum |
| Mean Temperature | °C | Tmean |
| Precipitation | mm | Rain |
| Potential Evapotranspiration (3 values) | mm | E0, ES0,ETO |
| Climatic Water Balance | mm | CWB |
| Global Radiation | KJ/m2*day | Rg |
| Snow Depth | cm | SD |

The grid cell size is based on the assumption that within a region of 50 by 50 kilometres the meteorological data are homogeneous. It is expected that temperature, sunshine, humidity, and wind speed gradually change over distances of 50 to 150 kilometres. More complicated is the spatial variation in precipitation, usually in the form of rainfall. Rain may fall from a local cumulonimbus in showers with high density (convective rains), or in a front passage with low density over large areas (depression rains). Geographic patterns of rainfall are influenced by the geometry of land and sea surfaces, and by general circulation patterns. Western facing slopes of hill and mountain ranges receive more than average rainfall, east facing slopes less. Therefore, the spatial distribution patterns of rainfall are thus irregular (Beek, 1991a; van Diepen, 1998).

The methodology for the spatial interpolation of the data of the existing network of meteorological stations towards the climatic grid cells centre is based on the studies of Beek et al. (1991a) and van der Voet et al. (1994). It is described by van der Goot (1998a). This method was chosen because its simple approach made it easy to automate while the accuracy was sufficient to serve as input to the crop growth model. The interpolation is executed in two steps: first the selection of suitable meteorological stations to determine representative meteorological conditions for a specific climatic grid cell. The following parameters are taken into account to define the most similar stations: distance between the weather stations and the grid centre, difference in altitude, to coast, climatic barrier separation. Second, a simple average is calculated for most of the meteorological parameters, with a correction for the altitude difference between the station and grid cell centre in case of temperature and vapour pressure. As an exception rainfall data are taken directly from the most suitable station. The MARS interpolated Grid weather DB is accessible through the MARSOP website upon login request (http://www.marsop.info/)

# Introduction to Pan-European Datasets: European Soil Database

**B. Houšková**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 280, I-210 20 Ispra (VA), Italy.
(E-mail: beata.houskova@jrc.it)

The European Soil Database (ESDB) at scale 1:1,000,000 is part of the European Soil Information System (EUSIS). Till present time two versions have been published: ESDB v1.0 (European Soil Database v1.0) and ESDB v2.0 (European Soil Database v2.0). The first version is using the FAO soil classification and the second one is using both FAO (1985) and World reference base for soil resources (WRB, 1998) classification systems. The database has been created from the first digitised soil map of Europe in 1985. This database has been developed jointly with partners from participating countries, mainly joined in European Soil Bureau Network (ESBN). The result was coverage of digital soil information for Europe as only one existing for these countries in harmonised level. The database consists of four components:

1. The **Soil Geographical Database of Europe at scale 1:1 000 000 (SGDBE)**, which is a digitised European soil map and related attributes;
2. The **PedoTransfer Rules Database (PTRDB)**, version 2.0, which holds a number of pedotransfer rules which can be applied to the SGDBE;
3. The **Soil Profile Analytical Database of Europa (SPADBE)**;
4. The **Database of Hydraulic Properties of European Soils (HYPRES)**.

Both ESDB versions (v1.0 and v2.0) contain the following components: SGDBE, PTRDB, HYPRES and SPADE. The changes have been made in SGDBE component, the others components remain unchanged.

The SGDBE at Scale 1:1 000 000 as part of version1.0 of European Soil Database version was known as version "3.2.8.0" and in version2.0 of European Soil Database has become version "4 beta"; with title Soil Geographical Database of Eurasia. The general changes are reflected in:

- A larger geographical extent which includes the New Independent States
- The names of some attributes have been changed
- The list of possible values for some attributes has changed
- Some new attributes have been defined
- The database structure in version 4 has been changed using the manual "Soil Geographical Database for Eurasia and The Mediterranean: Instructions Guide for Elaboration at scale 1:1 000 000. Version 4.0", but the structure of version 3.2.8.0 is still available.

The structure of the European Soil Database is represented by:

- Coverage: digital form of the soil map in ArcInfo database consisting of geometric and semantic datasets;
- Polygons with areas greater than 25 $km^2$;
- Soil Mapping Units (SMU) represented on the map at least by one polygon according to the rule that one polygon can belong only to one SMU and SMU can consist of several polygons;

- Soil typological units (STU) defining soil type having the set of homogeneous properties for a defined area. Each STU must be part of at least one SMU.

The database is extensively used for many purposes mainly in evaluation of environmental issues like agriculture, water protection, climate change, flood forecasting, desertification assessment, etc.

# III. Abstracts: Climate and Soil Criteria

Experts presenting criteria were asked to address the bellow questions:

1. ***What handicap(s) is/are the criterion an indicator off?*** (description of the constraint to agricultural production that can be shown by using this indicator, examples of current application areas)
2. ***What is the definition of the criterion?*** (How can the constraint be defined?)
3. ***What is an indicative threshold for a severe constraint?*** (Can an indicative threshold be given for a European assessment of what is a very severe constraint and a severe constraint to agricultural production? What are the parameters/local conditions that influence the representations of such a value?)
4. ***How is the criterion related to other criteria?*** (Inter-relationship with other criteria presented or other criteria generally used in land quality assessments)?
5. ***Are there alternative criteria****?* (Are there other criteria that can be used giving an indication of the same constraint)
6. ***What is the usefulness (strengths and weaknesses) of this criterion?*** (is the concept well-defined, applied in other land quality assessment methods, is the definition accepted by the (international) scientific community, is there data available, at what scale and time.)
7. ***Describe coverage in Europe from map*** (what is the coverage in Europe in relation to the proposed thresholds, what is the data resolution, data availability?)
8. ***Conclusions*** (What are your recommendations and personal views on the application of this criterion.)

## Criterion on Temperature

**G. Fischer and H. van Velthuizen***
The International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, A-2361 Laxenburgh, Austria.
(E-mail: velt@iiasa.ac.at).
*corresponding author

Temperature criteria are linked to agricultural crop requirements related to crop photosynthesis and growth, crop phenology and frost damage.

Temperature regimes required for photosynthesis and growth of agricultural crops vary between 5-45 degree Celsius. Most common crop groups grown in Europe are C3 crops (adapted to cool temperatures ranging between 5-30 degree Celsius with optimum temperatures between 15-20 degree Celsius (e.g., wheat, barley, potato, beet, rape, various vegetables), C3 crops adapted to warm temperatures ranging between 15-35 degree Celsius with optimum temperatures between 25-30 degree Celsius (e.g., soybean, rice, cotton), and C4 crops adapted to moderately warm conditions ranging from 10-35 degree Celsius with optimum temperatures between 20-30 degree Celsius (e.g., maize, sorghum, millet).

To quantify year round temperature conditions, the concept of temperature growing periods and accumulated temperatures are used. The period during the year with temperatures above 5 degree Celsius ($LGP_{t5}$) has been chosen, since generally below 5 degree Celsius very little photosynthesis and crop growth occurs. The period during the year with temperatures above 10 degree Celsius ($LGP_{t10}$) has been used, to more or less, define the period during the year when late and early frost risks are limited. Accumulated temperatures (with generic base temperature of 5 degree Celsius ($TS_5$) have been selected for comparison with heat requirements of agricultural crops. As can be seen from the presented maps, there is a close correlation between the three temperature parameters suggested ($LGP_{t5}$, $LGP_{t10}$ and $TS_5$).

The following criteria have been considered for low temperature limitations:

- Below 5 degree Celsius very little photosynthesis and crop growth occurs;
- Minimum period required to produce yield by low temperature tolerant crops (spring wheat, potato) equates to about 120 days with temperatures above 5 degree Celsius ($LGP_{t5}$);
- $LGP_{t5}$ zone of 120-180 days has severe to moderate constraints for photosynthesis and growth and risks of late and early frost occurrence, and
- $LGP_{t5}$ zone with more than 180 days has slight or no constraints to adapted crops.

The following examples of temperature related criteria are shown in the presentation:

  - Number of days of $LGP_{t5}$ exceeded in 80% of the years[22]
  - Coefficient of variation of $LGP_{t5}$
  - Number of days of $LGP_{t10}$ exceeded in 80% of the years
  - Average number of days respectively of $LGP_{t5}$ and $LGP_{t10}$
  - Accumulated temperatures $TS_5$ exceeded in 80% of the years
  - Spatial comparison of $LGP_{t5}$, $LGP_{t10}$ and $TS_5$

## Criterion on Soil Water Balance

**G. Fischer and H. van Velthuizen***
The International Institute for Applied Systems Analysis (IIASA), Schlossplatz 1, A-2361 Laxenburgh, Austria.
(E-mail: velt@iiasa.ac.at)
*corresponding author

Moisture balance criteria are based on crop water requirements of main agricultural crops grown in Europe:

- Crops require varying amounts of water throughout their growth cycle;
- Moisture requirement is varying by growth stage and is relative to Potential Evapotranspiration (40-60% to 90-110%), and
- Crop growth cycles vary between 60 days (very short) to all-year round. Most European annual agricultural crops have growth cycles between 90 days and 210 days.

[22] Median and percentiles are calculated for the period 1971-2000.

A simple robust approach for defining moisture balance criteria is through the FAO/IIASA concept of Length of Growing Period (LGP), which is defined as the period during the year when both temperature and water supply are conducive to crop growth. Short growing periods are either reflecting dry conditions, cold conditions or a combination of both.

Short growing periods either from moisture balance, temperature or both criteria provide unfavourable conditions for agriculture. We tentatively propose the following classification

- Total LGP <90 days: very severe limitations
- Total LGP 90 - 120 days: severe limitations
- Total LGP 120 - 150 days: moderate limitations
- Total LGP 150 - 180 days: slight limitations
- Total LGP >180 days: no constraints

As for the temperature criterion, we have adopted the recommendation of the expert meeting to use median values and probabilities of 80% exceedance.

Apart from the annually available growing period days, the quality of the growing period has to be taken into account. The latter can be expressed in precipitation (P) /potential evapotranspiration (PET) or actual evapotranspiration (ETa)/maximum evapotranspiration (ETm) ratios for the year, individual seasons or for the duration of the growing period.

The following examples of moisture balance related criteria are shown in the presentation:

- Median number of growing period days
- Number of growing period days exceeded in 80% of the years
- Coefficient of variation of number of growing period days (1961-2000)
- Median of annual P/PET ratio
- Median of P/PET ratio for year round conditions, winter months and summer months.
- Share of thermal growing period days for which reference ETa/ETm >0.95
- Share of thermal growing period days for which reference ETa/ETm <0.50

# Criterion on Heat Stress

**F. Ruget**
French National Institute for Agricultural Research (INRA), Site Agroparc, F-84914 AVIGNON Cedex 9, France.
(E-mail: francoise.ruget@avignon.inra.fr)

## The heat stress

"Heat stress is often defined as where temperatures are hot enough for sufficient time that they cause (irreversible) damage to plant function or development. In addition, high temperatures can increase the rate of reproductive development, which shortens the time for photosynthesis to contribute to fruit or seed production" [23].

This means that heat stress is the effect of high temperatures which can decrease yield especially through effects on grain set and grain filling. In temperate conditions, for winter crops (cereals e.g. wheat and barley), grain can be scalded by the heat, that is the growth of grain is stopped for some days or definitively. For summer crops (e.g. corn and sorghum) or tropical crops (rice), heat happens earlier in the plant cycle and the damages affect the number of grains or the number of cells in each grain[24, 25]. The factor giving rise to damages is the higher temperatures, even only after a few hours, because they cause damages to the proteins (membranes and metabolic machinery of the cells).The acting temperature is the organ temperature.

## The studied criterion

The criterion used to estimate the heat stress comes from the ESCAPE (Expert System for Constraints to Agricultural Production in Europe) criterion on heat stress. It is the number of ten-day periods with mean temperature higher than 25 degree Celsius over the period 1975-2005.

One question is the relevance of this temperature: is the mean temperature a good indicator of maximum organ temperature? Organ temperature is only close to air temperature when the organs are well water supplied and ventilated. In stress conditions, when the organ is near the soil, when air is dry (for pollen) or, above all, when the plant is not well water supplied, organ temperature is higher than air temperature. The maximum temperature will probably give better information on the damage risks than the mean temperature. Another information is that the same mean temperature can occur with highly different extreme temperatures. The dryer the air, the greater the probability of a higher daily temperature amplitude and higher maximum temperature. So, it is probably better to build a new indicator based on maximum temperature. The next question regards the value of threshold and the universality of this threshold for most common plants. For most plants, the thresholds are  when maximum temperatures are up to 35 degree Celsius or more. Even if it

[23] Hall, A. E. 2001. Crop Responses to Environment. CRC Press LLC, Boca Raton, Florida.
[24] Prasad PVV, Boote KJ, Allen LH (2006a) Adverse high temperature effects on pollen viability, seed-set, seed yield and harvest index of grain-sorghum [Sorghum bicolor (L.) Moench] are more severe at elevated carbon dioxide due to higher tissue temperatures *:* Agric. and Forest. Meteorol., 139: 237-251.
[25] Prasad PVV, Boote KJ, Allen LH, Sheehy JE, Thomas JMG (2006b) Species, ecotype and cultivar differences in spikelet fertility and harvest index of rice in response to high temperature stress *:* Field Crops Research 95: 398-411.

seems logical that thresholds are different according to plants, between temperate and tropical plants, (and probably also between more or less resistant cultivars), it is reasonable to think that we can choose values for "mean" temperate plants.

**The relation with other criteria**
Heat stress is linked with the water stress because it is higher when the plant is water stressed. In spite of this relation between both stresses, heat stress must be taken into account, because it can be different. It is really a stress for crops, and it is useful to find the adapted variable and threshold.

**The Europe map**
On the Europe map of ten days with mean 25 degree Celsius, only some points suffer from extreme temperatures. Moreover, the 30 years mean leads to high values only if that event occurs at the same period each year. This criterion corresponds to a very high and sure stress, but hot stress can cause big damage even if it is not systematic (each year).

My personal view on the criterion coming from ESCAPE: as defined in the map, the stress seems to be extremely rare in time and space, what is probably not true: some crops are not possible in South of France or Italy because of high temperature, (even if water would be available), like cereals (only cereals with short life cycle are cultivated to avoid the hot summer period). In the MARS (Monitoring Agriculture with Remote Sensing) project, one criterion is the number of periods of two days with maximum temperature higher than 35 degree Celsius: this criterion is probably better than the other one, even if the occurrence of this event is too frequent and don't cause systematic damages. Can we take into account a risk of damages that is 50 or 80 % of chances of one event?

A better criterion could be based on the number of 5 or 10 day periods with maximum temperature higher than 35 degree Celsius each year.

## Criterion on Slope

**J. Dusart**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 262, I-210 20 Ispra (VA), Italy.
(E-mail: jean.dusart@jrc.it)

In large parts of Europe, slope reduces the efficiency of agriculture production. Depending on the crop type and the local conditions (e.g. climate, morphology), slope thresholds for identification of Less Favoured Areas can vary substantially. Two important issues require additional consideration before setting the criteria for identification of the best thresholds. The first one deals with the quality of the data used for deriving slopes. DEMs (Digital Elevation Models) generally available might not allow determination of slope with the accuracy necessary for identification of LFA. The second consideration relates to the choice of slope as the sole geomorphological determinant of land suitability. Aspect and other terrain

characteristics also play an important role in determining the productivity for a given crop. In light of the recent development, such as the FAO SOTER (Soil and Terrain Database) initiative, for description of landforms on the basis of several terrain characteristics, it might be worthwhile to reconsider the choice of geomorphological criteria for identification of Less Favoured Areas.

## Criterion on Drainage

**- Poor soil drainage is a constraint for agricultural production**

**J. Van Orshoven* and A. Gobin**
K.U.Leuven, Spatial Applications Division, Celestijnenlaan 200E, BE-3001 Leuven, Belgium
(E-mail: jos.vanorshoven@sadl.kuleuven.be)
* corresponding author

### Excess water and crop growth

A major factor of sub-optimal crop growth and yield is the presence of excess water in the root zone during the agricultural season. Excess water leads to lack of oxygen in the soil which hampers the normal root metabolism. This effect is amplified by the disturbance of bio-chemical soil processes which are fundamental for soil fertility like mineralisation of organic matter. Moreover, mechanisation of the agricultural practices under too wet soil conditions generates physical degradation of the soil and damage to the equipment.

Two basic conditions must be fulfilled during prolonged periods for water excess to occur: (i) input of water into the soil (rainfall, groundwater, runoff water, flood water) minus output (evapotranspiration) exceeds the soil's storage capacity and (ii) the excess water is poorly evacuated. Valley bottoms, fine textured soils and soils with impermeable layers at shallow depth occurring in humid climates are most prone to water excess.

Various technologies can be used to remedy the drainage problem. However, artificial drainage is not always a solution, e.g. in situations where the evacuation of the excess water is technically too complex or too costly or has undesired environmental effects, e.g., enhanced mineralisation of organic matter leading to emission of extra carbon dioxide or to destruction of high value agricultural habitats, intimately linked to the poor drainage status.

### Assessment of soil water regime

Soil properties, climatic characteristics, types of vegetation and their interactions must all be taken into account to assess soil drainage condition or water regime. However, water regime is often considered a mere soil property since many soils show observable morphological features which provide information about the 'average' hydrodynamic behaviour: iron and manganese will appear in reduced forms and change colour in those soil layers which are saturated by water during a major part of the year. Depth to saturated soil layer or to phreatic water table can of course also be monitored, at the expense however of large efforts. In Belgium a soil suitability for apple orchards was found to correspond to 90% or more of potential productivity in well drained loam soils without oxydo-reduction features in the upper 120 cm while

for similar soils with oxydo-reduction features present between 20 and 50 cm of depth, suitability was 50 to 70% of potential productivity only. Similar soils with reduced layers occurring at a depth less than 40 cm were rated at 30% or less of potential productivity.

**Soil maps for delineation of zones**

Most soil classification systems and soil map legends worldwide include water-regime related criteria like average, maximum or minimum values for (i) depth to saturated layers, (ii) length in time of saturation and/or (iii) depth of occurrence of oxydo–reduction mottles. Similar to its co-variables, topographic position, soil texture and geological exposure, soil drainage is extremely variable in space. It is a typical terrain attribute. As a consequence, depth to saturated soil layer or phreatic water table or depth of presence of oxido-reduction features can be assessed only for individual observation points. In order to obtain a map, interpolation is necessary. In most soil maps, interpolation is done in an expert-based way. Firstly observations at points are classified and then given a spatial extent based on an interpretation of the surrounding landscape features. The result is most often polygons characterised by a soil drainage class as part of a soil class or soil map unit.

Up to scales of 1:25.000 to 1:50.000, polygons delineated in this way can be considered to be functionally homogeneous and useful as agricultural management units. At smaller scales, important generalisation is required to display the drainage information. At such scales various, often distinct, soil typological units are aggregated in soil associations.

**Concluding remarks**

Soil maps with a legend encompassing information on water regime, can be used to delineate areas characterised by water excess. A careful assessment of the purity of the designated areas for the characteristics under study, i.e. soil water regime, is however required. Small scale maps, e.g. the soil geographical database of Eurasia, can be used to provide gross stratification and area statistics. More detailed data must be used to obtain more functional delineations. Such delineations need periodic updates to account for new artificial drainage and also for climate change.

## Criterion on Texture and Stoniness

**C. Le Bas**
French National Institute for Agricultural Research (INRA), Avenue de la Pomme de pin F-45166 Olivet Cedex, Frace.
(E-mail: Christine.Le-Bas@orleans.inra.fr)

The texture and stoniness indicators are two major soil constraints to agricultural production. Texture is an indicator of water availability to plants and rooting conditions and stoniness is an indicator of a) water availability to plants, by reduction of the volume of soil usable by crops ( depending on the nature of the stones, some can contribute to the soil water holding capacity), b) rooting conditions, i.e. obstacle to roots, and c) mechanisation conditions.

Texture is defined as the classification of the particle size distribution of fine earth (<2 mm), for mineral soils only and stoniness is defined as the volume of particles >2 mm, depending on the size of these particles several types of stones can be distinguished: gravels, stones, boulders.

The texture and stoniness criteria are related with the following criteria, a) for water availability: rooting depth, drainage, nature of parent material, rainfall and potential evapotranspiration, and b) for rooting and mechanisation conditions: rooting depth, drainage and nature of clay.

It is concluded and/or recommended that:
1. For water availability: it is preferable to use the soil water holding capacity and a water balance.
2. For rooting and mechanisation conditions: modulation with nature and size of coarse fragments. Inclusion of Vertisols should be discussed.
3. To show the purity as well as the percentage of the selected area for the criteria (relevant for all soil criteria), which is illustrated for the criterion on texture and stoniness applying to the European soil geographical database at scale 1:1 000 000.
4. Indicative threshold of a severe constraint are for texture: too coarse texture (low water retention capacity) and too clayey texture (bad rooting conditions) and for stoniness: volume of stones higher than 30-40%.

## Criterion on Rooting depth

**C. Le Bas**
French National Institute for Agricultural Research (INRA), Avenue de la Pomme de pin
F-45166 Olivet Cedex, Frace.
(E-mail: Christine.Le-Bas@orleans.inra.fr)

The rooting depth can be described as the depth to which plants can develop their roots. It can be limited if there is presence of an obstacle to roots: hard rock or hard pan. It is an indicator of water availability to plants, rooting conditions and mechanisation conditions.

The criterion on rooting depth is related with the following criteria, a) for water availability: texture, stoniness, drainage, rainfall and potential evapotranspitration and b) for rooting and mechanisation conditions: stoniness, drainage, and nature of clay.

Information on rooting depth is available from several attributes in the European soil geographical database at scale 1:1 000 000: ROO (Depth of an obstacle to roots), AGLIM1 and AGLIM2: (Code of the most important and secondary limitation to agricultural use of the Soil Typological Unit: especially lithic, petrocalcic phases), soil name (especially lithosol) and derived from pedotransfer rules that combine these attributes.

An indicative threshold of a severe constraint for rooting depth is 30 -50 cm. It could be higher depending on the water availability to crops during the growing period.

## Criterion on Chemical Soil Constraints

**F. Nachtergaele**
Food and Agriculture Organization (FAO) of the UN, Viale delle Terme di Caracalla
I-001 00 Roma, Italy.
(E-mail: freddy.nachtergaele@fao.org)

The presentation focuses on two major indicators of chemical soil constraints (1) a soil fertility indicator and (2) a soil salinity and soil sodicity indicator (including other toxic soils)

For each of these, the definition of the indicator, its effects on agricultural production, the threshold values and pedo-transfer functions used to estimate its extent, the relationship with other constraint criteria, the occurrence of the constraint in Europe and the pros and cons of using the indicator in the problem land methodology are discussed.

It is concluded that:

1. Chemical soil criteria affecting agricultural productivity can be inventoried using the Soil Database for Europe at a regional scale. National larger scale soil maps may be required to investigate these factors more accurately.
2. The soil fertility indicator has little independent value given its close correlation with other criteria already used and therefore can be eliminated from the problem land approach.
3. The soil salinity and sodicity criteria should be retained whatever approach is adopted (including the gypsic soils and possibly alkaline and acid sulfate soils).

It is recommended to:

1. Investigate extents of problem land in each country versus the actual crop lands in use in the countries affected
2. Apply the problem land approach rather than considering each factor independently as was done in this analysis.

## Climate Variability and Impact on Agriculture

**G. Genovese*, F. Micale, C. Lazar, and J. Gallego**
Joint Research Centre, European Commission, Institute for the Protection and Security of the Citizen, TP 483, I-21027 Ispra (VA), Italy.
(E-mail: giampiero.genovese@jrc.it)
*corresponding author

Among others, agriculture is one of the most weather sensitive productive sectors. Both the average and, much more, the extreme conditions deeply influence the plants growth and finally the crops productive performances. Therefore, in order to identify the impacts of climate variability on the final crop yield, a precise and detailed analysis (on space and time) of the climatic conditions occurred in the European continent since 1975 was performed.

The spatial-temporal analysis was performed on the mainly agro-meteorological parameters influencing the crops growth and performance: average air temperatures, cumulative active temperatures (GDD), thermal continentality, maximum daily temperatures, minimum temperatures, number of frost events, annual thermal amplitude, cumulative rain, number of rainy days, potential evapotranspiration, global solar radiation, etc. All those were also put in relation (concomitance) to the most sensitive stages of development (heading, flowering, grain filling, and maturity at harvest) of some crops, largely spread in Europe: winter wheat and grain maize. Afterwards, specific indexes of risk were calculated (drought risk index, risk of excessive rain at maturity, frost risk, etc.) and was analysed the inter-annual variability and the long-term variability of some agrometeorological indicators (e.g.: Standardised Precipitation Index, length of Growing Season, standardised index of air daily maximum temperatures, etc.).

The impact of the past climate variability on the two crops was evaluated on the base of a crop numerical simulation model showing the effects on the crop cycles, the dry matter biomass, the grains production, etc.

## Use of Remote Sensing for Defining the Length of the Growing Season

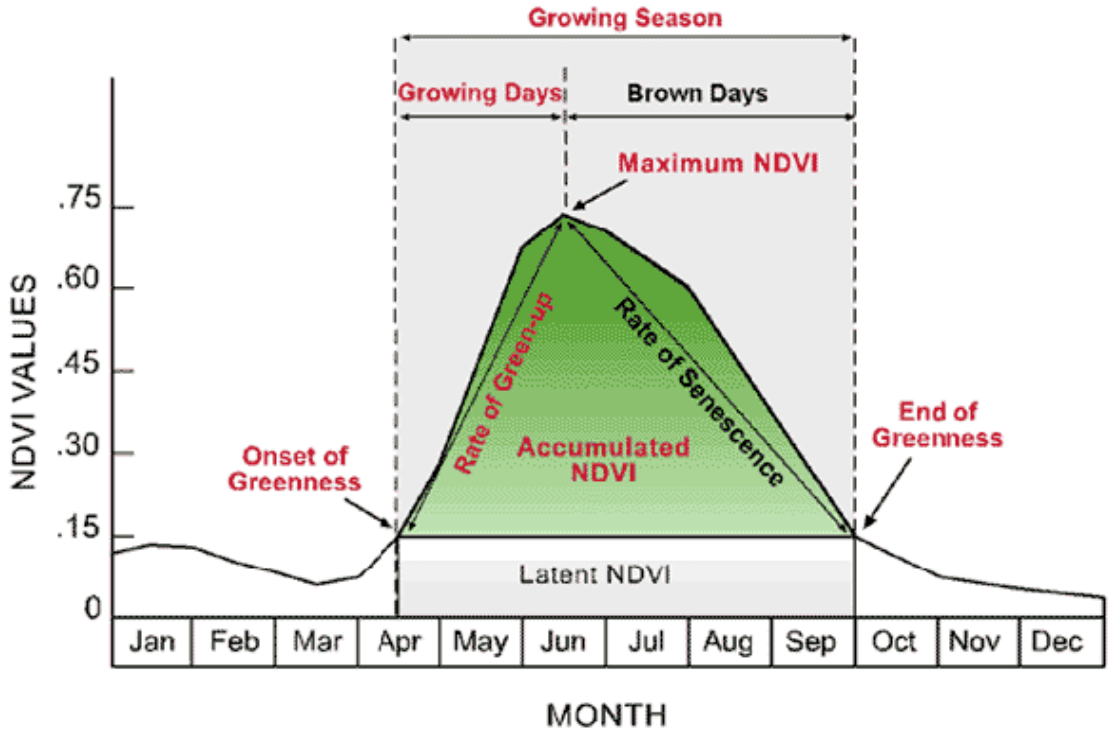
**E. Ivits-Wasser *, M. Cherlet, W. Mehl and S. Sommer,**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 460, I-210 20 Ispra (VA), Italy.
(E-mail: eva.ivits-wasser@jrc.it)
*corresponding author

The Length of Growing Period (LGP) is considered an important criterion for determining areas that suffer bio-physical constraints for sustainable agriculture and thus may be accounted for in the delimitation of Less Favoured Areas in the sense of the EU's new Rural Development Policy.

LGP has been typically defined as a bio-climatical indicator primarily based on the definition of temperature and moisture criteria conditioning the potential of vegetation to growth and biomass production. While these criteria have been well acknowledged as valid approach to define the principal potential of vegetation/crop productivity under given bio-climatical conditions it does not allow to directly infer how efficiently the actual vegetation is able to optimize productivity under the given natural conditions. Moreover vegetation growth also depends on more complex interactions e.g. between climate and soil properties. All these factors are very site specific and interpolation is not straightforward.

Therefore spatial information about actually observed vegetation growth over large areas could be an important complement to the classical LGP indicators. Such information further allows in depth analysis of the actual interrelationship, and related actual impact on vegetation growth, between LGP and other proposed criteria to be combined for the delimitation of LFA, in particular the soil criteria.

There is a growing body of research indicating that the phenological behaviour of different broad vegetation types can be observed, analysed, and mapped using multi-year temporal profiles of vegetation indices derived from satellite observations. Different key phenological events can be derived from these Vegetation Indices (VI) time series. A number of parameters can be directly calculated from the annual VI profiles which in principal determine the actual length of growing period, such as the onset, the end and the peak (maximum) of greenness as shown in Figure III.2.




***FigureIII.2: Principal parameterisation of LGP from remotely sensed time series of vegetation indices.***

Both long term vegetation monitoring archives of older generation satellites (NOAA-AVHRR, 1989 to recent) and second/third generation systems (SeaWifs, VEGETATION, MERIS, since 1998) are available and maintained thus assuring long term monitoring capabilities of derived information layers.

Archives are calibrated and geo-referenced, thus they are in principal compatible over time with improving geometric and radiometric accuracy of the more recent systems, important for improvements of assessments and monitoring. This continuous observation capacity and time series approach is important for characterising vegetation dynamics, hence Length of Growing Period, due to its high natural inter-annual variability.

Consequently remote sensing can provide the necessary continuous observation of vegetation development to allow the parameterisation of annual phenological behaviour over a period of many years. This makes it possible to determine the actual annual length of growing season, its inter-annual variability and multi-annual trends.

Starting from the approach described by Reed et al. (1994)[26], a software package has been developed by IES, which enables computation of a series of remote sense indices of vegetation phenology based on the approach outlined above. The approach has been applied to the region of Andalusia using a 15 years time series (1989 to 2004) of NOAA-AVHRR providing observation every ten days.

The preliminary results of this on-going research can be summarised as follows:

- The tested approach of deriving LGP from time series of observed vegetation growth works independently from external ancillary data on local bio-climatic conditions.

- The results appear to reflect the spatial and temporal variability of vegetation functioning in a comprehensible way. Further evaluation against detailed land cover/land use data is underway in order to conclude the best way to optimise the use this information in the LFA context.

- Discussion is needed on definitions e.g. of start/end points of LGP for the LFA purpose, in order to decide the most adapted way of analysis and integration with the other criteria.

- Derived parameters on the multi-year variability and standard deviation of remote sense derived LGP and associated variables may be the most meaningful and important criterion to be used in the context of LFA delimitation. Such information can reflect the uncertainty for repeated occurrence of favourable LGP conditions, hence indicate a probable risk for farming.

- Pan-European application would probably imply a stratified approach in evaluating LGP variables in terms of natural handicap relevant for LFA, e.g. on the basis of bio-climatical regions.

[26] Reed, B.C., Brown, J.F., VanderZee, D., Loveland, T.R., Merchant, J.W., Ohlen, D.O., 1994. Measuring phenological variability from satellite imagery. Journal of Vegetation Science, 5, 703-714.

# IV. Reports from the Workshop

Friday 20th April 2007, 11.30-16.00
J.-M. Terres (chairman)
Å. Eliasson (facilitator and reporter)
C. Bamps (reporter)

**Participants**: I. Condliff, J.–M. Courades, G. Fischer, C. Giupponi, B. Houskova, A. Kendra, A. Laggner, C. Le Bas, P. Persson, L. Montanarella, F. Nachtergaele, J. Van Orshoven, A. Page, A. Lopatka, L. Podmaniczky, F. Ruget, G. Toth, I. Walter, M. Yli-Halla, and A. Zona,

## Session 1: Challenge of Presented Criteria

**Purpose:**
The purposes of this workshop were, a) to summarise the recommendations from presenters and issues raised in the discussions from the previous two sessions on soil and climate criteria, b) to challenge the presented criteria, and c) to provide a key set on common biophysical soil and climate criteria that can be used for identifying areas that are constrained to agriculture. The exercise was also carried out as an initial step for the continuation of working groups to ensure that we as a group were considering the same boundaries and recommendations given for proposing criteria in a new definition of the Other Less Favoured Areas (Article 19).

**Workshop focus question:**
Which are the most important biophysical, soil and climate criteria to consider for classifying areas presenting constraints to agriculture that could be used for a future classification of the Other Less Favoured Areas (European assessment)?

**Process and results:**
Recommendations and points addressed after presentations on criteria and followed discussions were organised displaying cards on boards. The information on the boards was addressed by analysing the criteria on an objective, reflective, interpretive and decisional level using the top focused conversation method.

The information organised on the boards concerned, a) criteria, b) definitions of criteria, c) thresholds of criteria for a European assessment, d) comments on criteria, and e) challenging/alternative criteria. Please note that presenters had been asked to address a set of questions (see section on Abstracts: Climate and Soil criteria, p. 25) covering this information. The presented criteria were challenged with alternative criteria, recommended before and during this workshop, with origin from bilateral meetings, soil thematic strategy and discussions during presentations.

The discussion focused on the type of criteria and which criteria that were considered as most important. The group identified the presented criteria as the core set of criteria for classification of areas less favourable to agriculture, apart from the fertility criteria

which was said to be taken out as it has little independent value. The information presented on the boards are summarised in Table IV.1.

***Table IV.1. Recommendations and ideas from presentations on criteria and issues raised in the discussions following each presentation. Each criterion holds information on its definition, thresholds and comments or questions raised. Alternative criteria proposed at workshop session are given in the final column.***

| ***Presented criteria*** | ***Definition*** | ***Threshold*** | ***Comments*** | ***Alternative criteria*** |
|---|---|---|---|---|
| **Temperature** | LGPt5 (no. of days T >5˚C)<br>- Daily climatic data<br>- growing period | <120 days severe<br><150 days moderate<br><180 days slight | - Robust: low variability<br>-Defining the length of the growing period | - TSUM<br>- AET/PET<br>- P/PET<br>- Tmin<0˚C |
| **Soil water balance** | LGP based on:<br>a) LGPt5<br>b) soil water balance (reference crop) | <60 days very severe<br>60-74 days severe<br>75-90 days moderate<br>90-120 days slight<br>>120 days no constraint | - Higher variability<br>- Look into complexity: how big is the difference<br>- Continuous days | - |
| **Heat stress (extreme event)** | Tmax >35˚C | > 5 to 10 consecutive days<br>- No. of occurrences per year and between years | - | - Longest heat wave period<br>- 10 day T > 25˚C |
| **Slope (terrain)** | Average max technique (3X3 pixel) | >8% severe<br>>15% very severe | - Landform<br>- Resolution DEM | - |
| **Drainage** | -Water regime<br>- PTR drainage | -WR class 3 (wet within 80cm for 11months)<br>-WR class 4 (wet within 40cm for 11 month)<br>-PTR drainage | <u>Scale-two tier approach:</u><br>- EU: water regime, PTR drainage<br>- National: difficult and limiting, look on similar properties | |
| **Texture** | -texture attribute | - Coarse texture<br>- Clayey texture (rooting depth) | -Include vertic properties?<br>-texture constraint in most climate regimes: simple method<br>-soil water balance: more scientific, more complex | |
| **Stoniness** | -PTR stoniness | >30-40% volume of stones | | |
| **Rooting depth** | -PTR rooting depth | 30-50 cm severe | | |

***Continuation Table IV.1***

| ***Presented criteria*** | ***Definition*** | ***Threshold*** | ***Comments*** | ***Alternative criteria*** |
|---|---|---|---|---|
| **Fertility** | -PTR fertility | Very severe (severe)<br>CEC <4 (4-10) cmol/kg<br>org carbon <0.4 (0.4-0.6)%<br>base sat <20 (20-35)%<br>soil depth <10 (10-50)cm | -shallow soils more constrained than fertility<br>(-): no absolute constraints<br>(+): easily understood | |
| **Saline soils** | PTR salinity | saline ECdS/m:<br>>16 very severe<br>4-16 severe | (+):saline and sodic soils independent criteria<br>(+): robust<br>(-): limited coverage<br>(-): toxic soils rare, no data | |
| **Gypsic soils** | PTR gypsum | Gypsum (%)<br>> 15% very severe<br>5-15% severe | | |
| **Sodic soils** | PTR sodicity | Sodic (ESP):<br>>15% very severe<br>5-15% severe | | |
| **Acid/Alkaline soils (natural toxic)** | PTR Acidity/Alkalinity | pH:<br>>8.5 and<4.5 very severe<br>7.8-8.5 and 4.5 to 5.5 severe | | |
| | | | | Soil name/soil type |
| | | | | Soil water holding capacity |
| | | | | Net primary production |
| *Transboundary issues*<br>Climate variability - reference time period? – coefficient of variation<br>Soil criteria not independent<br>Relationship criteria-method-datasets | | | | |

*Notes:*
*AET: Actual evapotranspiration*
*LGPt5: Length of growing period defined by temperature above 5 degrees Celsius*
*LGP: Length of growing period*
*PTR: Pedotransfer rule*
*PET: Potential evapotranspiration*
*T: Temperature*
*P: Precipitation*
*WR: Water regime*

## Session 2: Working Groups on Criteria

**Purpose:**
The purpose of the working groups was to determine the recommendations on the soil and climate criteria by discussing on how the selected criteria from the previous workshop session can be defined, if indicative thresholds can be given, what is the usefulness of the criterion, strengths and weaknesses and recommendations for implementation of this or these criteria in the Member States.

**Workshop focus questions:**
For the selected criteria in the workshop session 1:

1. What is the definition of the criterion?
2. What is an indicative threshold of a very severe and severe constraint to agriculture?
3. What are the usefulness, strengths, and weaknesses of this criterion?
4. What are your recommendations on the implementation of this or other criteria in Member States?

**Process and results:**
The group divided into two groups, the first group covered, climate, soil water balance and terrain criteria and the second group covered soil criteria. The groups were asked to cover the questions above and present their findings and provide a report.

## Working group 1: Climate, Soil Water Balance and Terrain Criteria

**P. Persson and J. Van Orshoven (reporters)**

**Participants:** G. Fischer, F. Ruget, C. Giupponni, L. Podmaniczky and A. Lopatka.

**Recommendations for dealing with time series**

- In order to assess climatic constraints for annual agricultural production, it is recommended to do the analysis for a series of years so that between-years variability can be assessed. The result of computing an indicator for e.g. 30 years is a set of 30 annual indicator values. After ranking from low to high or vice versa, a probability of (non-)exceedance for each indicator value can be determined. We propose to use probabilities of (non-)exceedance of 80%.
- If 30 years of daily data are not available, a shorter time series may be used on the condition that it begins before 1990, the assumed break point for agrometeorology.

**Question 1, 2 and 3: Definitions, Severity Thresholds and Usefulness of the criteria**

**Heat stress**

- Definition: Occurrence of 1 or more periods of at least 10 consecutive days for which maximum temperature exceeds 35 degrees Celsius, within the period from the last day of frost (measured by Tmin, 80% probability of non-exceedance) in spring to the first day of frost (Tmin, 80 % probability of exceedance) in autumn.
- (Very) severe constraints: The threshold of 10 consecutive days and its differentiation for indicating (very) severe constraints needs further confirmation.
- Usefulness: prolonged excessive heat induces crop sterility and is hence especially applicable to the flowering stage of the crop
- Strength: simple and robust
- Weakness: too little knowledge/information available about the appropriate thresholds: number of days, consecutive or not consecutive

**Temperature availability**

- Definition: Sum of average daily temperature above the base temperature of 5 degrees Celsius within the period from the last day of frost (measured by Tmin, 80% probability of non-exceedance) in spring to the first day of frost (Tmin, 80 % probability of exceedance) in autumn.
- Constraints: A suitable threshold for severe constraints could be 1800 degree (Celsius) days. During the available time the working group did not come to a conclusion concerning a threshold corresponding to very severe constraints.
- Usefulness: The working group concluded that a temperature criterion defined in the way described above is relevant for defining LFA. In combination with the Heat-criterion this criterion focuses upon climate conditions when crops have their highest growing potential. Below 5 degree Celsius the growing activity in plants is low and above a high limit (>35 degree Celsius) the temperature has a negative impact on the crop. The Heat criterion mentioned above is valid when the temperature is over 35 degrees.
- Strength: Clear, simple and robust
- Weakness: Does not cover the combined effect between temperature and supply of water (number of mm rain etc). It is therefore necessary to combine with other criteria.
- Recommendations: It is important to base the criteria on the best possible statistical source. For each Member State national sources should be compared with EU produced statistics and assessment has to be done concerning most relevant data.

**Slope**

- Definition: a) Geographical areas characterised by sloping shape of individual fields used for agriculture production. During the discussion the working group was not able to formulate a clear proposal for an operational definition of the criterion. This item must therefore be subject to further discussions.
- b) Closely linked to Sloping shape of individual fields is Landform. This sub-criterion should be used when there are physical constraints for agriculture production because of bad landform. Such a constraint could be used when the

degree of small fields with irregular forms widely spread in the geography is the dominant characteristic of a geographic area.

- Constraints, criterion a): A suitable threshold for severe constraints could be a slope of 8 percent. A threshold for very severe constraints could be a slope of 15 percent. Practical ways for classifying an area to the criteria is discussed under "Recommendations".
- Criterion b): Measurement concerning degree of small and split fields with irregular form was not discussed during the seminar. Neither was a suitable threshold for how to distinguish such areas.
- Usefulness: The measure is useful for taking into account disadvantages for cultivating areas with sloping fields and also areas with small and split fields with irregular form. Substantial associated problems for the farmers are the difficulties in using effective machines and also disadvantages concerning accession to the land.
- Strength: There is a clear link between natural handicaps for an area and these criteria.
- Weakness: Does not cover all types of bad landforms. Could also be difficult to implement in practice because of lack of appropriate data.
- Recommendations: In practice the slope criteria could be based on so called Landpixels which correspond to land areas with a size of, e.g. 90 times 90 m. The middle point of each pixel gives the coordinate for the pixel. The differences in height between the coordinates form the practical criterion for classifying an area. Lack of appropriate data does not permit all Member State to use this model. It is therefore necessary to allow other types of practical measurements for classifying "sloping areas". As concerns the criterion for small and split fields with irregular shapes no practical measurement was discussed. A good source for information could be the field information systems used for different area payments within pillar 1.

**Soil water availability**

- Definition: Number of days which are not water limited within the period from the last day of frost (measured by Tmin, 80% probability of non-exceedance) in spring to the first day of frost (Tmin, 80 % probability of exceedance) in autumn. A day is not water limited if the ratio of daily actual and potential evapotranspiration exceeds 0.5. Water storage capacity of the soil and preferably also capillary rise and losses by deep drainage have to be taken into account.
- Very severe constraints: number of days $\leq 60$; Severe constraint: number of days $\leq 75$. So, if in 80% of the years, the number of days matching the criterion is between 60 and 75, than the constraint is severe.
- Usefulness: integrated soil-climate indicator
- Weakness: requires soil data to parameterise the soil compartment for available water capacity: water content at field capacity and at wilting point,
- Recommendations:
    - 'Soil texture' and 'stoniness' are included in the assessment of available water capacity. We think that both soil texture and stoniness should also be used as stand-alone criteria to express conditions for mechanisation.
    - Rooting depth is also included in assessment of available water capacity. It can be argued that rooting depth as such is not required to be taken into account as a separate soil constraint. If a soil is capable of supplying

sufficient water and nutrients to the crop, the actual rooting depth can be considered to be irrelevant.

- Drainage conditions can be derived from the time series of daily soil water balance as the number of days within the period defined as suitable from the base-temperature point of view, during which the soil is saturated upto a given soil depth. This requires the characterisation of the 'bottom boundary condition' (depth of phreatic water table must be known at each day) and the inclusion of capillary rise.

**Question 4: Recommendations on the implementation by the Member States.**

**Overall point of concern**

- The use of a reference crop for the soil water balance criterion rather than a list of possible crops is causing some discomfort with the group members as it may mask situations which are important at a local level.

**Climatic variability**

By deriving constraints from an evolving time series of observed climatic data or computed terms of the soil water balance, i.e. each year, data about the most recent 30 years are used, the indicator values for 80% probability of (non-)exceedance will (slightly) change every year. This will allow climate change to be taken into account when periodically updating the classification of LFA.

## Working Group 2: Soil Criteria

**C. Le Bas and F. Nachtergaele (reporters)**

**Participants:** I. Condliff, B. Houskova, A. Kendra, A. Laggner, G. Toth, I. Walter and M. Yli-Halla.

**Question 1 and 2: Definitions and Severity thresholds of the criteria**

**Drainage:**

- Definition: Land areas which are water logged and/or flooded for significant duration of the year.
- Very severe: Water Regime class 4 (Wet within 40 cm for over 11 months) or very poorly drained or if classes not available derived from soil types: Gleysol, Histosols and Planosols
- Severe: Water regime class 3 (Wet within 80 cm for over 6 months but not wet within 40 cm for over 11 months) or poorly drained or if classes not available derived from Soil type: Gleyic soils.
- Comment: Is it needed if soil water balance is calculated? Excess water may be simulated?

**Texture** (proxy for Chemical soil fertility, Soil Moisture holding capacity, workability)
Definitions (severe):

- Sandy texture (coarse textures with less than 18% clay and more than 65% sand)
- Heavy clay soils (>45% clay in the topsoil)
- Vertic Features (Vertisol and Vertic-soils)
- Comment: No absolute severity class depends on climate (to be modelled). If used separately do not use very severe class. To avoid double counting do not use sandy textural rating if the water balance is calculated. Vertic properties and high clay content are to be considered as a severe constraint with or without water balance. If no water balance is calculated then consider all of these as a severe constraint.

**Stoniness**

- Definition: Volume of particles >2mm fraction
- Very Severe: >50% volume of stones in the topsoil
- Severe: >40% volume of stones in the topsoil
- Comment: Can be included in soil moisture balance calculation. In which case it is still to be used as obstacle to mechanisation.

**Rooting Depth**

- Definition: Land areas which have depth limitations of the surface caused by the presence of coherent, hard rock or hard-pans.
- Very severe: <10cm rooting depth
- Severe: < 30cm rooting depth
- Comment: To be included as a factor in soil moisture balance calculation. Still an absolute constraint for root development and nutrient supply.

**Salinity**

- Definition: Land areas comprised of soils with a high salt content (Soil Type: Solonchaks, saline phase)
- Very severe: >16dS/m
- Severe: 4-16dS/m

**Sodicity**

- Definition: Land areas comprised of soils with a high sodium content (Soil type: Solonetz, sodic phase)
- Very Severe: >15 ESP
- Severe: 6-15 ESP

**Gypsum** Definition: Land areas comprised of soils with a high gypsum content (toxic) (Soil type: Gypsisols and gypsic subunits)

- Very severe: >15 %
- Severe: 5-15%

**pH**: Definition -log (H+).

- Concerns soil types: Histosols and Thionic Fluvisols and other soils with extreme acidity or alkalinity indicating possible toxicities (Al, nutrient availability).
- Very severe: pH >8.5 or pH < 4.5
- Severe: pH 8.0–8.5 pH 4.5–5.5

**Question 3. Usefulness of the criteria**

These criteria are all useful in themselves but the weaknesses are that:

1. They are not weighted which is a problem (Member States may decide to weight them). Some are more absolute than others or cost significantly more to correct.
2. They are not integrated and combined which may affect the limits of the severeness and their weighting given above.
3. The thresholds given are by necessity open to criticism, but are considered balanced compromises. Most thresholds are in reality crop-specific. It is particularly difficult not to be able to distinguish between agriculture (including pastures) and arable land.
4. Analytical methods would need to be harmonised to a certain extent.
5. Timing, methodology and if soil is to be considered in its natural state or in its improved state (e.g. when artificially drained or limed) are factors which need further consideration.

**Question 4. Comments on the implementation by the Member States.**

Soil type is not considered under the criteria identified, but it is recognised that soil types give indications for criteria which are known to reach threshold values. For the implementation of the criteria many Member States may/will want to use the soil types. They would also need to document in that case the link between the soil type and the indicator and its threshold value. (Examples are given under the section Question 1 and 2). Countries should look if an additional criterion of flood risk including the seasonality, frequency and duration is needed.

# V. Summary of Results and Reflections

**Å. Eliasson (reporter)**
Joint Research Centre, European Commission, Institute for Environment and Sustainability, T.P. 262, I-210 20 Ispra (VA), Italy.
(E-mail: ase.eliasson@jrc.it)

The aim of the expert meeting was to identify common criteria that can be used for defining agricultural areas presenting constraints to agriculture in Europe. The output of the expert meeting will be a base for DG Agriculture and Rural Development in their consultation with Member States and future networks with scientists involved in the preparatory work on a new definition of the Other Less Favoured Areas (LFA) to be implemented after 2010.

The meeting included 33 participants, including 14 experts from diverse scientific institutes, four participants from DG Agriculture and Rural Development and 15 experts from the Joint Research Centre. A wide range of expertise in various fields was covered by the participants, including land quality assessment, soil, terrain, climate, water, environment, agriculture, implementation of EC agricultural policy and LFA.

Below are some of the main issues summarised from presentations, discussions and working groups.

## Context of the work - classification of the Other LFA

A number of questions and issues brought up during the expert meeting concerned the LFA measure in a wider perspective. Below some key points and answers from DG Agriculture and Rural Development have been summarised to illustrate the framework in which the aim of the expert meeting was carried out. More information on the context of the work is found in the section Background document (p. 1) and Abstracts: Context (p. 11).

The aim of the expert meeting was to propose a set of common soil and climate criteria that can be used for classifying areas presenting constraints to agriculture in Europe. The criteria concern the Other LFA (Article 19), and only the physical classification of the utilised agricultural areas, and not the measure itself (farm eligibility, compensatory allowances). The classification relates to areas that have natural handicaps to agriculture and not to how the land is used, i.e. it does not concern how to produce on these areas or how to manage the land. Moreover, it should be noted that there is a difference between classification of land areas and farmers that receive payments, i.e. between 2000 and 2003 (EU 15) the number of beneficiaries were less than half of the total number of farmers in the area classified as the LFA.

The reason for changing the current definition of the category Other LFA is to, a) better respond to the Axis 2 objective on Land management and Environment of the Rural Development Policy 2007-2013, where the social objectives have disappeared

i.e. rural depopulation is no longer a core objective, and b) for defining objective criteria for a more transparent approach in Europe.

The classification should be based on the principle of subsidiary, i.e. it would be up to the Member States to implement the criteria. A framework for a common approach is searched for, leaving some flexibility of implementation to the Member States and to build on existing capacities and knowledge. It is recognised that the definition of biophysical criteria is more difficult to harmonise in comparison to e.g. criteria on population and economic performance of agriculture. Different climate, terrain and especially soil classification systems are used in the member States and the scale, level of accuracy and availability of these data sources vary between countries. The classification scale aimed for is the commune (Local Administrative Unit 2 or lower) that should correspond to areas that are homogenous in natural production potential.

A bottom – up approach is taken from DG Agriculture and Rural Development in the implementation of a new definition, where a strong evidence base is searched for to facilitate the political acceptance. DG Agriculture and Rural Development are organising bilateral meetings with Member States and as of the 20th April meetings with 19 Member States have been carried out. Moreover, an extensive evaluation of the LFA measure[27] has been carried out by the IEEP (Institute for European Environmental Policy, London, UK) in 2006 on the behalf of DG Agriculture and Rural Development. In the future, a European network of scientists for the Rural development pillar two, will be created where one of the thematic network is planned to cover the LFA.

The role of the Joint Research Centre is to facilitate the technical work by developing a proposal on common criteria to DG Agriculture and Rural Development on technical grounds in collaboration with independent experts in the field of primarily land quality assessment methods. The work includes an inventory of existing methods and collaboration with independent scientists and networks of scientists, expert meetings and participation in bilateral meetings with Member States.

## Proposed Common Soil and Climate Criteria

The proposed common soil and climate criteria developed by the participants at workshop session 1 are provided in Table 5.1. There are eight criteria which are defined by one or more sub-criteria. For example, the criterion on chemical constraints consists of four different chemical properties of the soil. Comments and recommendations on criteria are summarised from discussions and working groups. A further description of the characteristics of criteria, definitions and thresholds are found in the sections Abstracts: Climate and Soil Criteria (p. 25) and Reports from the Workshop (p. 37).

[27] An evaluation of the LFA measure. A report prepared by the Institute of European Environmental Policy for DG Agriculture, November 2006.

***Table V.1. Proposed common soil and climate criteria that can be used for classifying areas less favourable for agriculture on a European scale. An indicative very severe and severe threshold is given in brackets only when defined at the workshop.***

| **CRITERIA** | **DEFINITION** (v) |
|---|---|
| **Climate criteria** | |
| 1. Temperature | Sum of average daily temperature (TSUM) above the base temperature of 5 degree Celsius within the period from the last day of frost in spring to the first day of frost in autumn. (Severe threshold TSUM 1800 degree days.) |
| 2. Heat stress | One or more periods of at least 10 continuous days for which maximum temperature (T max) exceeds 35 degrees Celsius, within the period defined as growing period by temperature. (Very severe threshold: one or more periods of at least 10 consecutive days with Tmax >35 degree Celsius.) |
| **Terrain criteria** | |
| 4. Slope (i) | Land areas with steep slopes not practical for mechanised cultivation. (Very severe threshold: slope >15%; Severe threshold: slope >8%.) |
| **Soil criteria** | |
| 5. Drainage | Land areas which are water logged and/or flooded for significant duration of the year. (Very severe threshold: wet within 40 cm for over 11 months or very poorly drained; Severe threshold: Wet within 80 cm for over 6 months but not wet within 40 cm for over 11 months or poorly drained). |
| 6. Texture and stoniness (ii) | Land areas which have coarse textures, heavy clayey soils and vertic features. Land areas which have gravel, stones, boulders or rock outcrops in surface layers or at the surface. (Very severe threshold: >50% volume of stones (volume of particles >2mm fraction) in the topsoil; Severe threshold: >40% volume of stones in the topsoil; sandy texture (with less than 18% clay and more than 65% sand); heavy clayey soils (>45% clay in topsoil); and vertic features.) |
| 7. Rooting depth | Land areas which have depth limitations of the surface caused by the presence of coherent, hard rock or hard-pans. (Very severe threshold: <10 cm; Severe threshold: <30cm.) |
| 8. Chemical constraints (Salinity, sodicity, toxicity) (iii) | Land areas comprised of soils with a high salt content and/or exchangeable sodium saturation and/or toxicity within the surface. (Very severe thresholds: Salinity: >16dS/m: Gypsum: >15%; Sodicity: >15ESP; pH >8.5 or <4.5; Severe threshold: Salininty: 4-16dS/m: Gypsum: 5-15%; Sodicity: 6-15ESP; pH 8.0-8.5 or 4.5-5.5.) |
| **Integrated soil and climate criterion** | |
| 3. Soil water balance (iv) | No. of days which are not water limited within the period defined as the growing period by temperature. A day is not water limited if the ratio of daily actual and potential evapotranspiration exceeds 0.5. (Very severe threshold: LGP< 60 days: Severe threshold <75) |

*Notes on proposed criteria:*

i. Slope could be linked to other terrain attributes.
ii. Coarse texture, heavy clayey soils and vertic features are recognised as a severe constraint, but not as a very severe constraint.
iii. Fertility criterion removed as it has little independent value. Some soil toxicity conditions (including pollution) can not be evaluated at the EU level.
iv. Soil water balance is a combined soil and climate criteria to assure that the plant has enough water at the right time. A proxy giving an indication of conditions for soil water holding capacity can be derived from the criteria on texture, stoniness and rooting depth. If excess water is simulated, it can also substitute the criterion on drainage.
v. Thresholds are considered a balanced compromise, but some could be regionalised. The criteria are not weighted or given a relative importance.

*Units:*

dS/m (electrical conductivity in deciSiemens/meter);

ESP (Exchangeable Sodium Percentage) = Na/Cation Exchange Capacity or as SAR (Sodium Adsorption Ratio) = Na/{square root of (Mg + Ca)/2}).

The criteria selected for presentations, which were challenged at the workshop by alternative criteria proved to be very valid as the same set was identified as core criteria for classifying areas presenting constraints to agriculture on a European level. The criteria selected for presentations were mainly based on the outcome of an expert meeting held in May 2006[28] to anticipate the work with DG Agriculture and Rural Development. At this meeting the Problem land approach[29 , 30], was identified as a suitable base for simple criteria and method that could be applied for the new definition of the LFA. The Problem land approach is based on a simple and systematic approach, were the most limiting criteria is eliminated first. The set of criteria was further developed within the context of the work, recommendations from bilateral meetings and criteria used in the Agro-Ecological Zoning methodology[31], Expert System for Constraints to Agricultural Production in Europe[32 33], Agricultural Problem Land Approach[21 22], and the MARS Crop Growth Monitoring System methodology[34].

The criteria proposed are the most important soil and climate criteria defined for a European assessment. Some criteria might not be relevant in some countries and

[28] Land quality assessments for the definition of the EU Less Favoured Areas focusing on natural constraints, proceedings from expert meeting 16-17 May 2006, Joint Research Centre, Ispra , Italy, JRC technical note.

[29] FAO/RAPA (1990) Problem soils of Asia and the Pacific. RAPA Report 1990/6. FAO/RAPA Bangkok. 283 pp.

[30] Nachtergaele, F. (2006). The FAO Problem Land Approach adapted to EU conditions. Presentation at the expert meeting "Land quality assessment for the definition of the EU Less Favoured Areas focusing on Natural constraints", 16-17 May 2006, JRC, Ispra, Italy.

[31] Fischer, G., van Velthuizen, H., Shah, M., and Nachtergaele, F.O. (2002). Global Agro-ecological Assessment for Agriculture in the 21st Century: Methodology and Results. Research Report RR-02-02. International Institute for Applied Systems Analysis, Laxenburg, Austria. pp 119 + CD-ROM.

[32] Le Bas, C., Boulonne, L., King D. (2001). Expert system for Constraints to agricultural production in Europe, Rapport final. INRA and European Soil Bureau. (in French).

[33] Le Bas, C., Boulonne, L., King D. and Montanarella, L. (2002). A Tool for assessing land suitability for Europe. INRA and European Soil Bureau. 17th world congress of Soil Science, 14-21 of August 2002, Bangkok, Thailand, Symp. 48, 256-1-11.11pp.

[34] Baruth, B., Genovese, G., and Montanarella, L. (2006). New soil information for the MARS Crop Yield Forcasting System. EUR report 22499 EN.

regions. In addition, there could be other criteria which are more important for individual countries and regions for classifying areas with significant natural handicaps to agriculture.

The criteria are not weighted or given a relative importance which might affect the level of severeness. The inter-relation between criteria and methodology was recognised and the difficulties in keeping the criteria separated from the method was pointed out i.e. some criteria are more absolute than others and others are easier to overcome.

The criterion on texture (sandy soils, heavy clayey soils and vertic features) was not considered as a very severe constraint and even if the soil water balance would not be calculated it was recommended not to include this criterion. If the severe threshold is applied as a classification instead of a very severe threshold it was recommended to include the criterion on texture. Stoniness is considered as a very severe constraint and it was recommended to include this criterion even if the soil water balance is calculated to include handicaps to mechanisation.

The criterion on fertility (included in the presentation on chemical soil constraints, p 31) was removed as it was recognised as having little independent value due to its close relation with other criteria on: coarse texture, poorly drained soils and limited soil depth. However, the strength of the criterion, that it is an informative value easily understood by laymen and farmers, was recognised.

To account for the interaction between the climate and soil it was recommended to carry out a soil water balance calculation, which would be the most scientifically sound solution, but not the most practical due to data needs and computation. As a proxy for the soil water balance, the criteria on: texture, stoniness and rooting depth were recognised. The soil water balance could also substitute the criterion on drainage if excess water is simulated, which would require additional data needs.

Most thresholds are in reality crop-specific and it is particularly difficult to distinguish between different types of agriculture, pasture and arable land. The participants recognised that the thresholds identified are open for criticisms, but are considered a balanced compromise.

Some criteria were identified as having the same indicative threshold across Europe, whereas others were identified as more regional, country specific. Criteria and thresholds identified on the European level, also identified as being representative on a national lever, i.e. indicating the same level of stress were the criterion on temperature (length of the growing period defined by temperature), chemical constraints and slope. Identified criteria and thresholds being more variable were the criterion on heat stress, texture and rooting depth. For example, the criterion on rooting depth, the level of constraint, i.e. limited depth to rooting differs between the north and the south in Europe. In a wet climate, one can grow plants in a more shallow soil in comparison to a dry climate.

Another issue that influences the threshold of constraint is the scale of the data used. This is especially relevant for the determination of slopes from the Digital Elevation Model where the resolution of the Digital Elevation Model and the aggregation of the

pixel to the communes level (up-scaling) influence the result. The importance of also including other terrain attributes (such as slope position, slope aspect, slope gradient, slope shape and shape of fields) with the slope to better define the landform, was recognised. However, in the working groups no clear approach on how to manage this information could be formalised.

Differences in the application of the criteria on the European and national/regional level concern: the level of detailed classification, accuracy and the use of harmonised or heterogeneous datasets. Using pan-European data gives a gross classification of zones using coarse resolution data (small scale maps), but it provides harmonised information, i.e. the agricultural attributes (soil, climate and terrain) are built on the same classification system. National and regional data provides a more detailed classification using finer scale resolution data (large scale maps) and classification systems that are more specific for the national and local agricultural systems. These issues of resolution and scale and accuracy of areas classified as presenting constrains to agriculture was well illustrated for the criterion on drainage (p. 30) for the area of Flanders, Belgium, comparing analyses at the pan–European scale (1:1 000 000) with local scale (1:25 000).

The use of additional information on criteria describing the coefficient of variance in time for climate and extent of soil characteristics was recognised as important information for the evaluation of the occurrence and extent of a specific constraint. It was shown that the criterion on temperature (LGPt5) and similar criteria such as LGPt10 and temperature sum are stable over time (1971-2005), see map No. 2 in Annex 3 as example). In addition, the concept of how the European soil database is built up by the use of the additional information showing the extent of a specific constraint was illustrated for stoniness by, a) purity: indicating the percentage of the soil mapping unit (polygon) that the attribute (in this case information on stoniness) is represented for, and b) percentage of area per soil mapping unit with high stoniness: showing how much of the area (polygon) is represented by the specific constraint, high stoniness (see maps No. 9-11 in Annex 3).

For the calculation of climatic criteria it was recommended to carry out the analysis for a time-series of years and to do a probability analysis. Subsequently, the variability between-years can be assessed in comparison to if average annual climatic data is used. The result of computing an indicator for e.g. 30 years is a set of 30 annual indicator values. After ranking from low to high or vice versa, a probability of (non-) exceedance for each indicator value can be determined. It is advised to use probabilities of (non-) exceedance of 80%, e.g. if in 80% of the years, the number of days matching the criteria on temperature is less than for example 180 days, then the constraint is considered very severe. If the constraint is not present in 80% of the years it is not considered as very severe. In addition, it was recommended that the start and end of the growing season should be defined in a similar way, i.e. from the last day of frost (measured by Tmin, 80% probability of non-exceedance) in spring to the first day of frost (Tmin, 80 % probability of exceedance) in autumn. If no 30 years time-series of daily meteorological data are available, a shorter time-series may be used at the condition that it begins before 1990, the assumed change in trend in time-series.

National soil data are less harmonised in comparison to national climatic data and the approach on how to implement the soil criteria by the Member States was discussed. National soil and land classification systems are represented in various ways according to national and regional characteristics, needs and purposes in the respective countries. Therefore, it is not possible to provide one single answer on how to derive the soil criteria that fits all Member States concerned. Three different approaches were identified, a) to translate the national classification into the classification used at the European level, which needs a substantial work and which might be difficult in many cases due to the different classification schemes used, b) to translate the properties of the definition identifying the most suitable representation of the described characteristics in the national classification systems, which use existing systems and has a higher detail, but is less harmonised between countries, and c) to use pedotransfer rules/functions (deriving properties from soil name and associated characteristics), but restrictions for the translations of the soil name into the soil world reference base code is difficult. The lack of detailed soil data was also recognised for some countries were the best national coverage available is the pan-European datasets (i.e. European soil database).

## Annex 1: Agenda

## Common biophysical criteria for defining areas which are less favourable for agriculture in Europe

**Chair: Jean-Michel Terres**
**Facilitator: Åse Eliasson**
**Reporter: Catharina Bamps**

**Thursday 19th April 2007**

**Session: Context**

9:15 Welcome – Giovanni Bidoglio (JRC)

9:20 Aim of the expert meeting – Jean-Michel Terres (JRC)

9:40 What are the Less Favoured Areas? – Jean-Michel Courades (DG AGRI)

10:10 New definition of the Other Less Favoured Areas – Alexander Page (DG AGRI)

10:40 Coffee

11:00 Experiences from the Soil Thematic Strategy – Luca Montanarella (JRC)

11:30 Conclusions from the evaluation of the Less Favoured Areas measure – Christiane Canenbley (DG AGRI)

12:00 Soil and climate criteria for the Less Favoured Areas – Åse Eliasson (JRC)

12:15 Description of Pan-European datasets – MARS and ESDB - Bettina Baruth and Beata Houskova (JRC)

12:45 Lunch

**Session: Climate, water balance and terrain criteria (15 min presentation)**

**Chair: Bettina Baruth (JRC)**

14:00 Criteria on Temperature – Guenther Fischer (IIASA)

14:30 Criteria on Water balance – Guenther Fischer (IIASA)

15:00 Criteria on Heat stress – Françoise Ruget (INRA)

15:30 Coffee and posters

16:00 Criteria on Slope – Jean Dusart (JRC)

16:30 Climate Variability and Impact on Agriculture – Giampiero Genovese (JRC)

17:00 Use of remote sensing for defining the length of the growing season – Eva Ivits-Wasser (JRC)

17:30 Summary discussion and consolidation

18:00 End of day one

## Friday 20th April 2007

9:00 Summary from yesterday

**Session: Soil criteria (15 min presentation)**

**Chair: Jean-Michel Terres (JRC)**

9:15 Criteria on Drainage – Jos Van Orshoven (SADL)

9:45 Criteria on Texture and Stoniness – Christine Le Bas (INRA)

10:15 Criteria on Rooting depth – Christine Le Bas (INRA)

10:45 Coffee

11:00 Criteria on Fertility, Alkalinity and Sodicity - Freddy Nachtergaele (FAO)

11:30 Summary discussion and consolidation

**Session: Workshop on potential common criteria for LFA**

11:45 Introduction and start of working groups

12:45 Lunch

14:00 Working groups

15:30 Coffee

16:00 Reporting from working groups and discussions

16:50 Summary discussion and consolidation

17:00 End of expert meeting

## Annex 2: List of participants


Catharina Bamps
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: catharina.bamps@jrc.it

Bettina Baruth
Agriculture and Fisheries Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: bettina.baruth@jrc.it

Katarzyna Biala
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: katarzyna.biala@jrc.it

Giovanni Bidoglio
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: giovanni.bidoglio@jrc.it

Silvia Calvo
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: silvia.calvo@jrc.it

Ian Condliffe
35 Clifton Rd,
UK-lS29 8 TU Ilkley
E-mail: ian@iancondliffe.co.uk

Christiane Canenbley
European Commission
DG AGRI - Unit G4
B-1049 Brussels
E-mail: Christiane.Canenbley@ec.europa.eu

Jean-Michael Courades
European Commission
DG AGRI - Unit F3
B-1049 Brussels
E-mail: Jean-Michel.Courades@cec.eu.int

Alessandro Dosio
Climate Change Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: alessandro.dosio@jrc.it

Jean Dusart
Spatial Data Infrastructures Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: jean.dusart@jrc.it

Åse Eliasson
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: ase.eliasson@jrc.it

Guenther Fischer
The International Institute for Applied Systems Analysis (IIASA)
Schlossplatz 1
A- 2361, Laxenburg
E-mail: fisher@iiasa.ac.at

Giampiero Genovese
Agriculture and Fisheries Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: giampiero.genovese@jrc.it

Carlo Giupponi
Universita' degli Studi di Milano -
Via Celoria 2
I-20133 Milano
E-mail: carlo.giupponi@unimi.it

Beata Houšková
Land Management and Natural Hazards Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: beata.houskova@jrc.it

Eva Ivits-Wasser
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: eva.ivits-wasser@jrc.it

Ain Kendra
Rural Economy Research Centre Economic Analysis of Department of Veerenni 58a
EST-11314 Tallin
E-mail: ain.kendra@ramboll.ee

Andreas Laggner
Federal Agricultural Research Center (FAL), Institute of Rural Studies
Bundesallee 50
D-38116 Braunschweig
E-mail: andreas.laggner@fal.de

Christine Le Bas
French National Institute for Agricultural Research (INRA)
Avenue de la Pomme de pin
F-45166 Olivet Cedex
E-mail: Christine.Le-Bas@orleans.inra.fr

Artur Lopatka
Institute of Soil Science and Plant Cultivation - State Research Institute
Czartoryskich 8
PL-24-100 Pulawy
E-mail: artur@iung.pulawy.pl

Luca Montanarella
Land Management and Natural Hazards Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: luca.montanarella@jrc.it

Freddy Nachtergaele
Food and Agriculture Organization (FAO) of the UN
Viale delle Terme di Caracalla
I-001 00 Roma
E-mail: freddy.nachtergaele@fao.org

Alexander Page
European Commission
DG AGRI - Unit F3
B-1049 Brussels
E-mail: Alexander.PAGE@ec.europa.eu

Per Persson
Jordbruksverket
SE-551 82 Jönköping
E-mail: per.persson@sjv.se

Laszlo Podmaniczky
Institute of Environmental Management,
Pater k.u.1.
H-2103 Gödöllö,
E-mail:
Podmaniczky.Laszlo@kti.szie.hu

Françoise Ruget
French National Institute for Agricultural Research (INRA)
Site Agroparc
F-84914 Avignon Cedex 9
E-mail: francoise.ruget@avignon.inra.fr

Stefan Sommer
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: stefan.sommer@jrc.it

Jean-Michel Terres
Rural, Water and Ecosystem Resources Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: jean-michel.terres@jrc.it

Gergely Toth
Land Management and Natural Hazards Unit
Joint Research Centre of the European Commission
I-210 20 Ispra (VA)
E-mail: gergely.toth@jrc.it

Jos Van Orshoven
Catholic University of Leuven, Department of Land Management and Economics & R&D Division Spatial Applications Division Leuven (SADL)
Celestijnenlaan 200E,
B-3001 Leuven-Heverlee
E-mail: jos.vanorshoven@sadl.kuleuven.ac.be

Ingrid Walter
Laboratory for conservation and management of soils
Department of Environment
National Research and Technologies Institute of Agriculture and Food (INIA)
Ctrra. of Coruña km 7,2.
E-28040 Madrid
E-mail: walter@inia.es

Markku Yli-Halla
University of Helsinki
P.O. Box 27
FIN-00014 University of Helsinki
E-mail: markku.yli-halla@helsinki.fi

Antonella Zona
European Commission
DG AGRI - Unit F3
B-1049 Brussels
E-mail: antonella.zona@ec.europa.eu

## Annex 3: Maps of Presented Criteria

A number of maps were prepared for the expert meeting to show the coverage in Europe and to discuss possible thresholds for defining areas that presents constraints to agriculture.

Selected maps from the presentations on criteria are included below to a) give an overview of the coverage in Europe, b) illustrate the criteria presented in the abstracts c) show how the variability of climate criteria can be represented and d) illustrate the representation of the European soil map, i.e. purity and percentage of content of a criteria in a soil mapping unit. The aim of the maps was not to focus on the analyses and the results of the maps, as Member States will be responsible for defining their own LFA. An overview of the selected maps and the providing institute is shown in Table 3.1.

Please note that these maps are not necessarily corresponding to the results of the expert meeting and that some have been slightly revised from the original presentation.

***Table 3.1: Selected maps from the presentations at the expert meeting.***

| **Map Nr** | **Title** | **Provided by** |
|---|---|---|
| 1 | Criterion on Temperature (LGPt5) | IIASA |
| 2 | Coefficient of Variation for LGPt5 | IIASA |
| 3 | Criterion on Temperature sum | IIASA |
| 4 | Criterion on Heat Stress | JRC |
| 5 | Criterion on Slope | JRC |
| 6 | Criterion on Drainage: Water Regime | JRC |
| 7 | Criterion on Drainage | JRC |
| 8 | Criterion on Soil Texture | INRA |
| 9 | Criterion on Soil Stoniness | INRA |
| 10 | Criterion on Soil Stoniness – Purity (i) | INRA |
| 11 | Criterion on Soil Stoniness – Percentage of high stoniness | INRA |
| 12 | Criterion on Soil Rooting Depth | JRC |
| 13 | Criterion on Soil Fertility | JRC |
| 14 | Criterion on Soil Salinity | JRC |
| 15 | Criterion on Soil Sodicity | JRC |
| 16 | Criterion on Soil water balance | IIASA |
| 17 | Climate Variability: Analysis of changes in frequency of draughts | JRC |
| 18 | Climate Variability: Occurrence of the beginning of flowering of winter wheat, between 1975-2006 | JRC |

(i) Purity: percentage of soil mapping unit (polygon) that the soil typological unit, soil stoniness in this case represent.

The pan-European datasets below have been used for the derived maps summarised in Table 3.1.

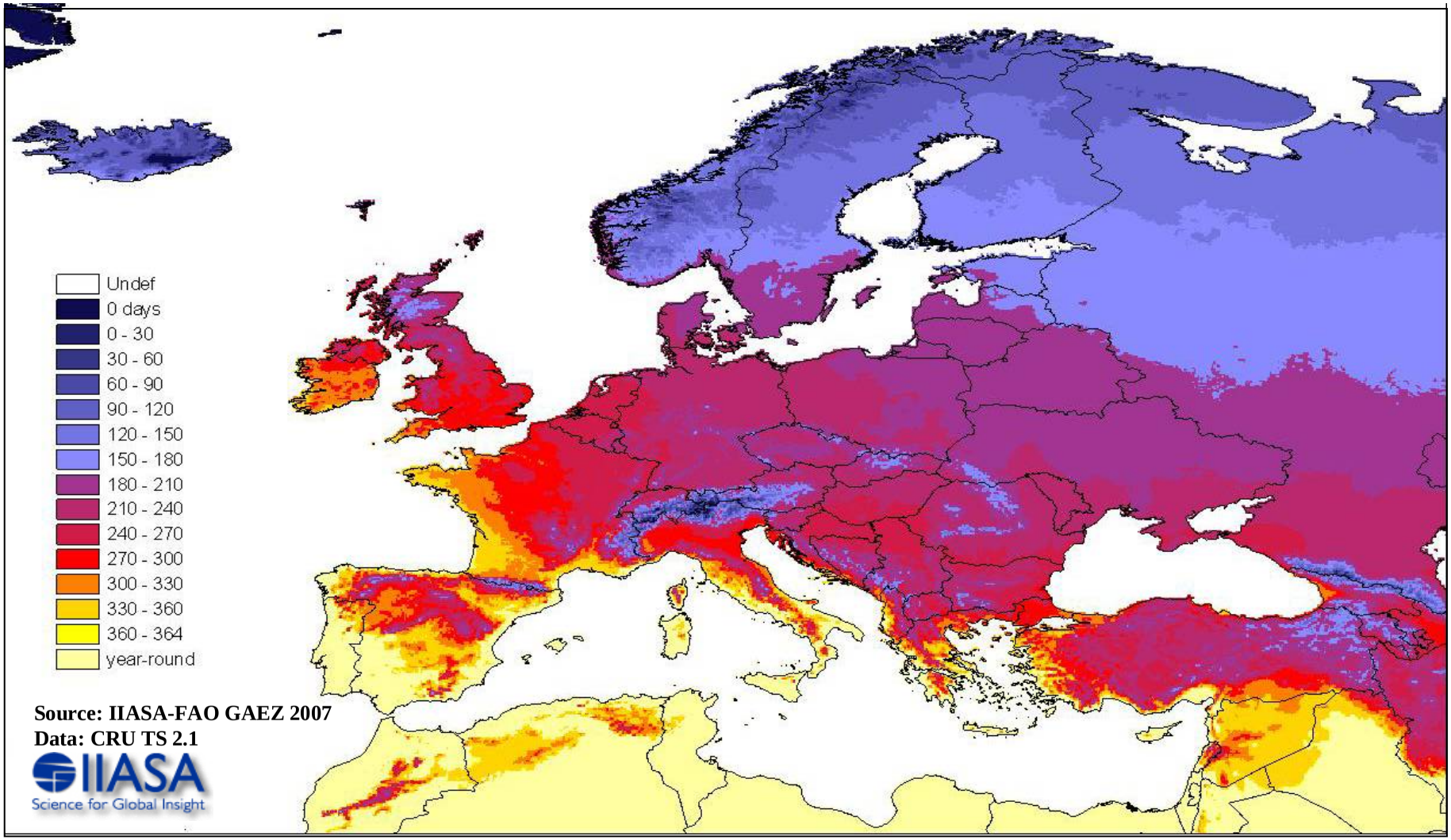
- Soil: The European Soil Database (ESDB)[35], (Scale 1: 1 000 000, available as grid data 1 x1 km).
- Climate: Both MARS[36] (Monitoring Agriculture with Remote Sensing) and the CRU (Climate Research Unit and the Tyndall Centre, University of East Anglia) datasets have been applied. CRU TS 2.1[37] [38] (0.5 degree latitude/longitude grid, equivalent to around 60 x 60 km at the equator). MARS (50 km x 50 km grid). Mars meteorological dataset available as daily data, whereas CRU available as monthly climatic data.
- Land use: CORINE 2000 Land Cover[39] for the identification of agricultural areas (Resolution 100m).
- Topography: SRTM 90 DEM[40] (Shuttle Radar Topography Mission, Digital Elevation Model). Available at Joint Research Centre re-sampled at 100m and aligned with Inspire recommended grid specifications.

[35] ESDB (2004). The European soil database, v2. Joint research Centre. http://eusoils.jrc.it/ESDB_Archive/ESDBv2/index.htm
[36] MARS (2007). JRC/MARS STAT data base, European Commission, interpolated data from national meteorological services. http://www.marsop.info/
[37] Mitchell, T.D., Carter, T.R., Jones, P.D., Hulme, M., New, M., (2003). A comprehensive set of high-resolution grids of monthly climate for Europe and the globe: the observed record (1901-2000) and 16 scenarios (2001-2100). Journal of Climate: submitted.
[38] Mitchell, T.D., 2004: An improved method of constructing a database of monthly climate observations and associated high resolution grids. About to be submitted.
[39] European Environment Agency, data service http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=950
[40] CGIAR-CSI (2006). Consortium for Spatial Information http://srtm.csi.cgiar.org/SRTMdataProcessingMethodology.asp

## Annex 3: Map No. 1. Criterion on Temperature (LGPt5)

# Length of Thermal Growing Period

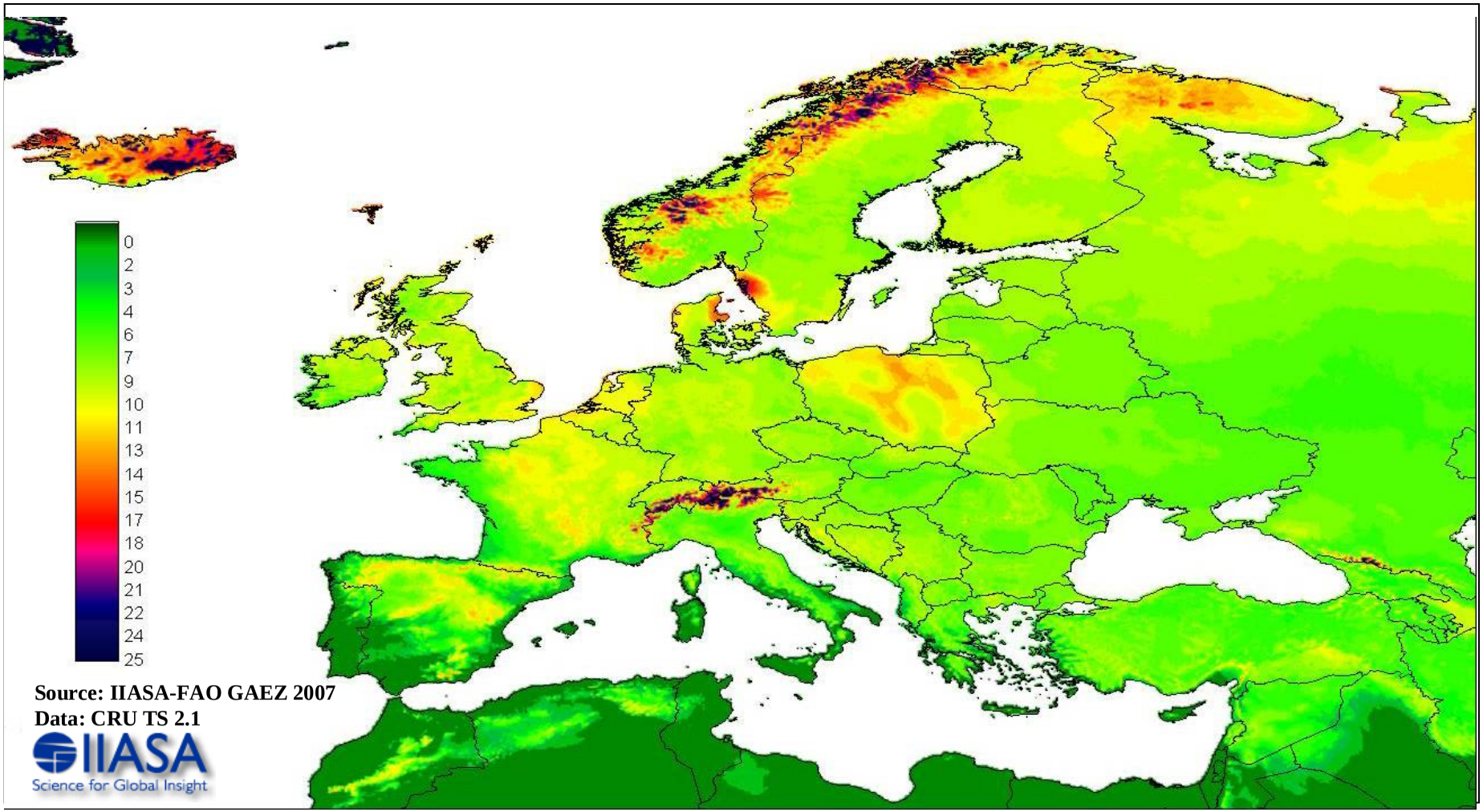
***Note: Number of days with Ta >5 degree Celsius ($LGP_{t5}$) exceeded in 80% of the years during 1971 – 2000***



# Annex 3: Map No. 2. Coefficient of Variation for LGPt5

## Coefficient of Variation of Length of Thermal Growing Period

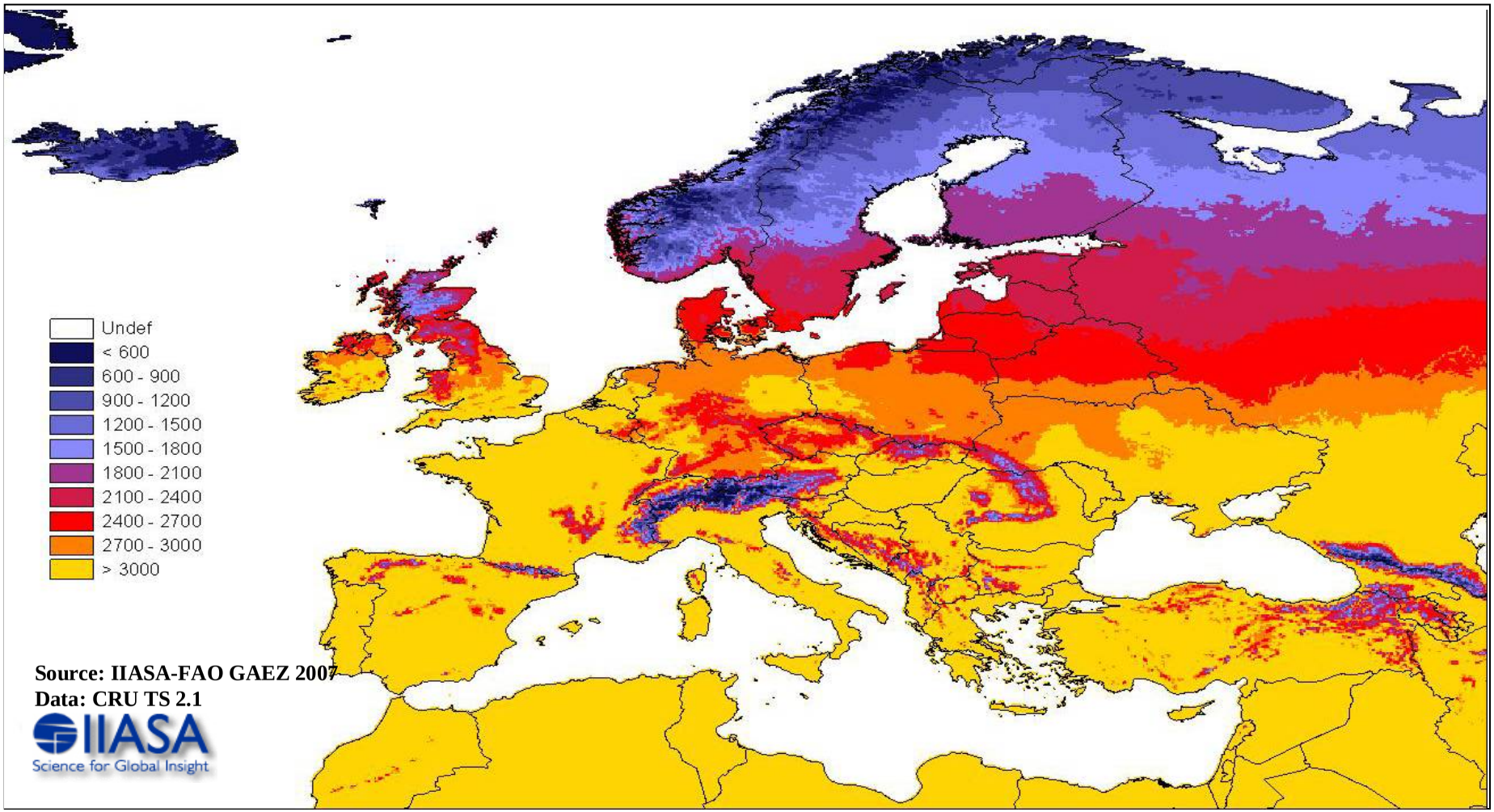
***Note: Calculated for period 1971 - 2000. CV calculated as CV = 100 * standard deviation / mean***



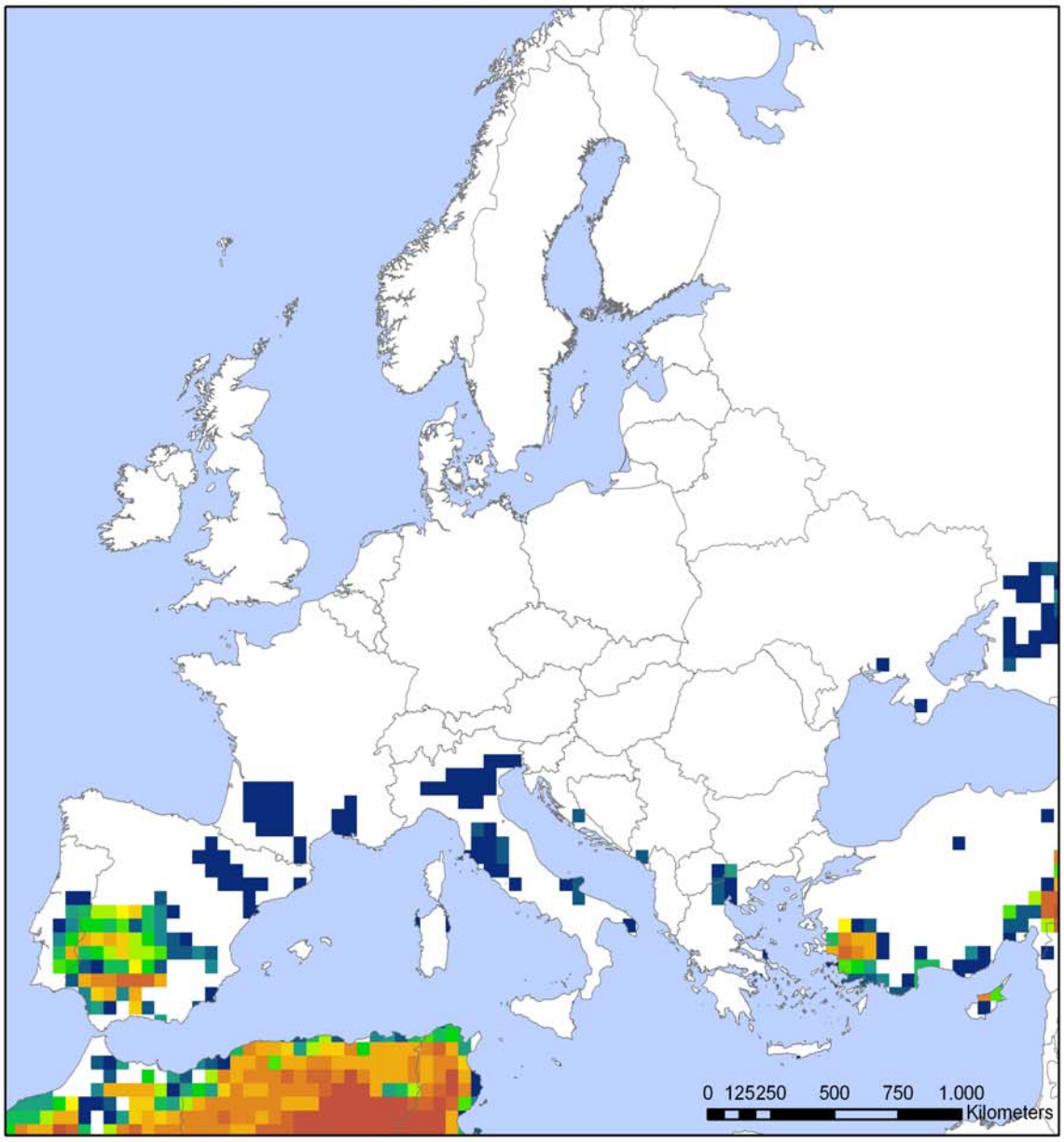
## Annex 3: Map No. 3. Criterion on Temperature sum

# Accumulated Temperature for days with Ta >5 degree Celsius

***Note: The temperature sum was accumulated each year for days with average temperature exceeding 5 degree Celsius. The map shows in classes the temperature sums exceeded in 80% of years during 1971 - 2000***



# Annex 3: Map No. 4. Criterion on Heat Stress




**Number of heatwaves between 1975 and 2006**

Heatwave: Tmax > 35 ° and ≥ 10 consecutive days

Heatwave occurrence

| | |
|---|---|
| 1 | 9 |
| 3 | 10 |
| 3 | 11-20 |
| 4 | 21-30 |
| 5 | 31-40 |
| 6 | >40 |
| 7 | |
| 8 | |

Source: JRC/MARS STAT data base
European Commission,
interpolated data from
national meteorological services

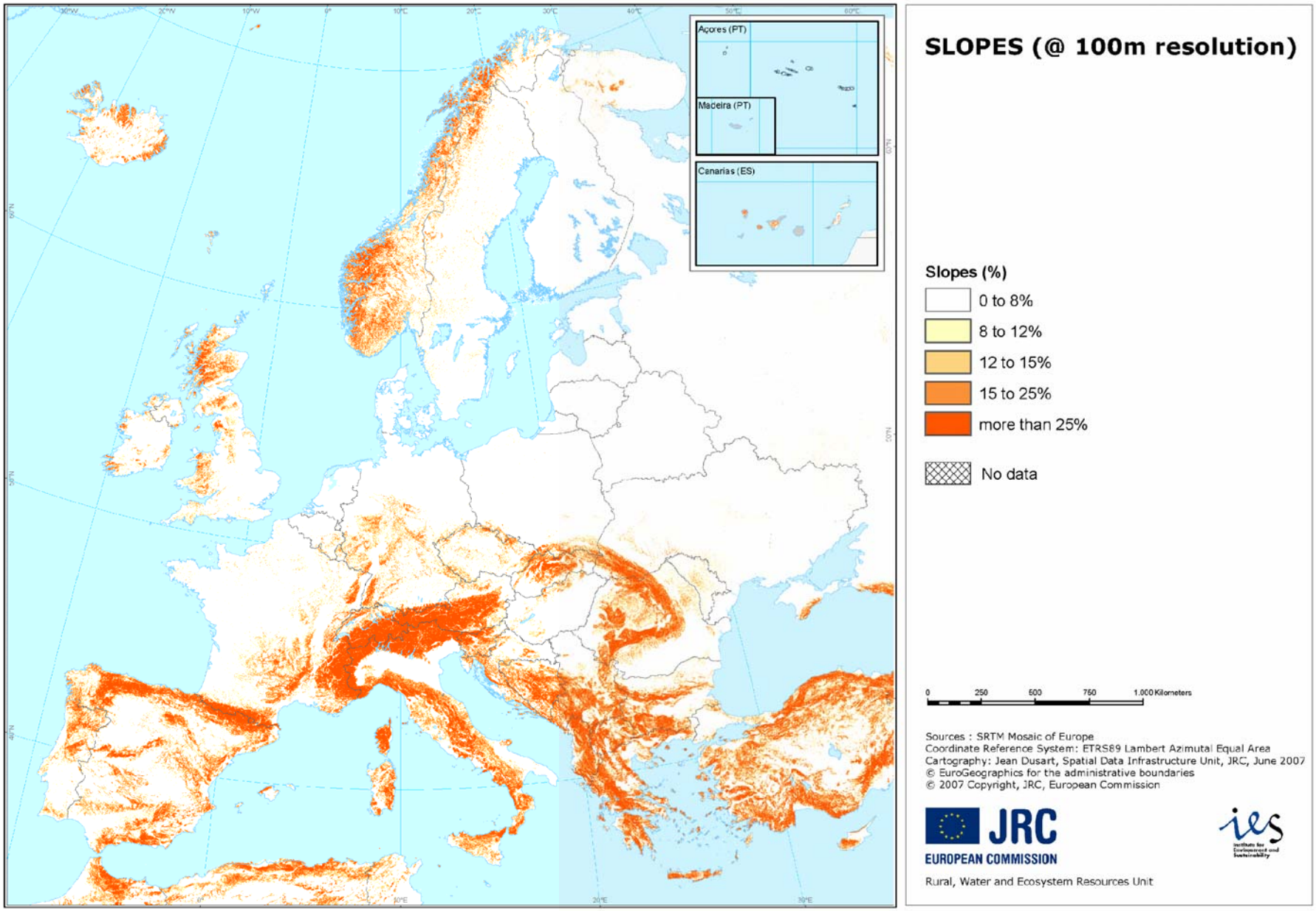
Coordinate Reference System:
Lambert Azimuthal Equal Area


JRC
EUROPEAN COMMISSION

ipsc
Institute for the Protection and Security of the Citizen

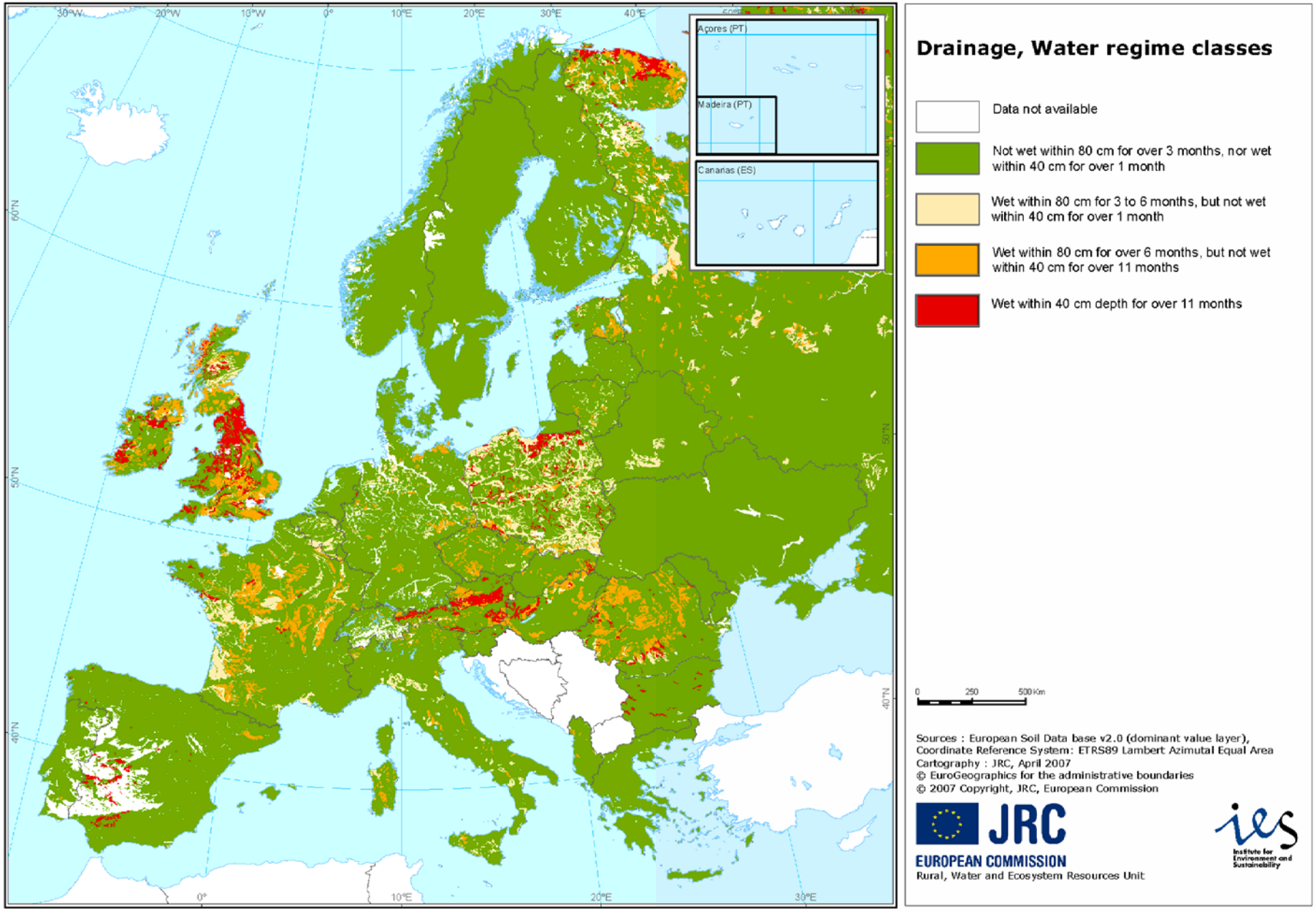
# Annex 3: Map No. 5. Criterion on Slope



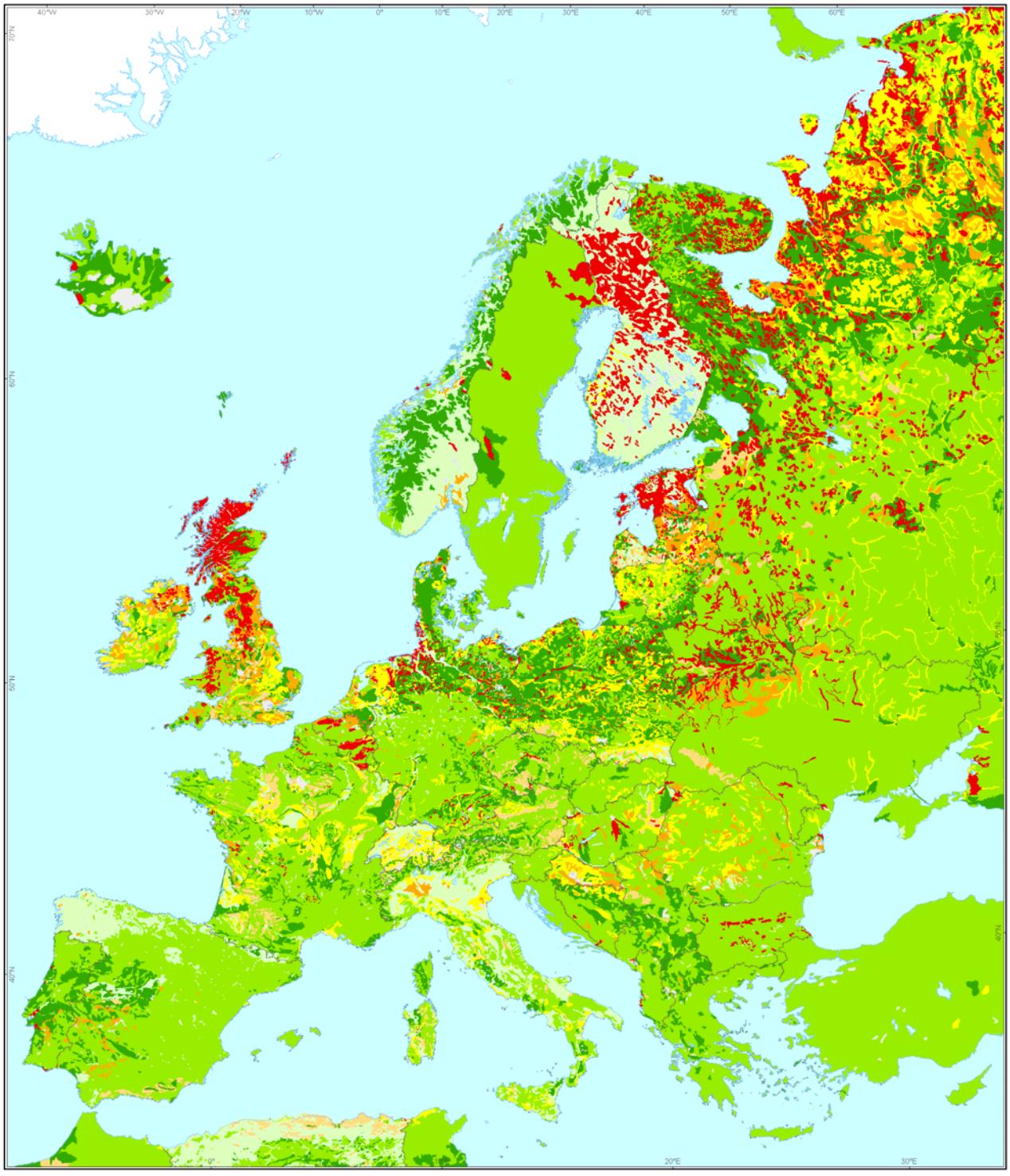


# Annex 3: Map No. 6. Criterion on Drainage: Water Regime





# Annex 3: Map No. 7. Criterion on Drainage



**Drainage**

**Drainage classes**

- Excessively drained
- Well drained
- Moderately drained
- Imperfectly drained
- Temporarily poorly drained
- Poorly drained
- Very poorly drained
- Not evaluated

0 500 1.000 Km

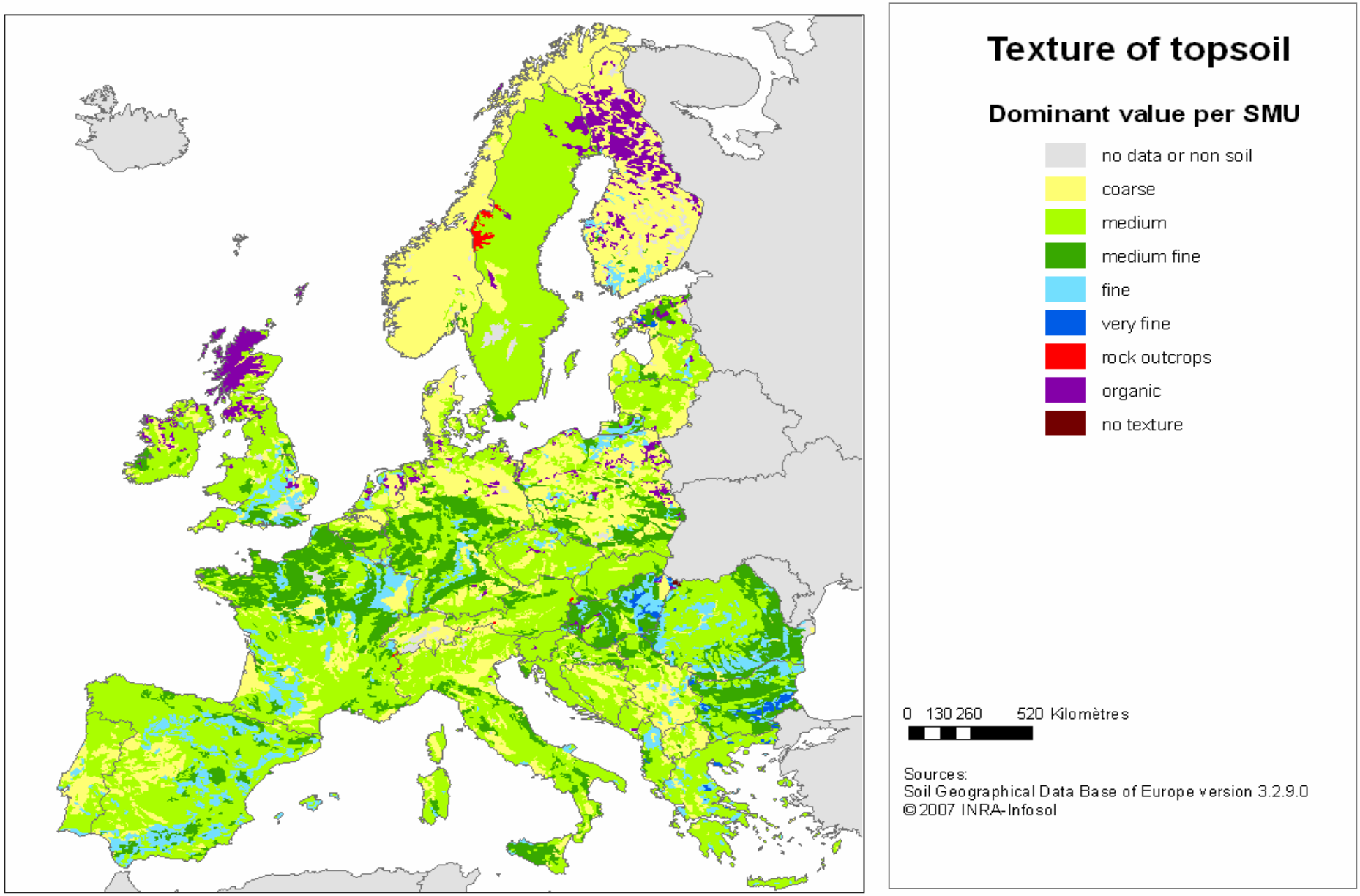
Sources : European Soil Data base v4.0
Pedo transfer rules developed in the frame of the MARS Crop Yield Forecasting System, AgriFish Unit, IPSC
Coordinate Reference System: ETRS89
Lambert Azimuthal Equal Area


JRC EUROPEAN COMMISSION

ipsc Institute for the Protection and Security of the Citizen

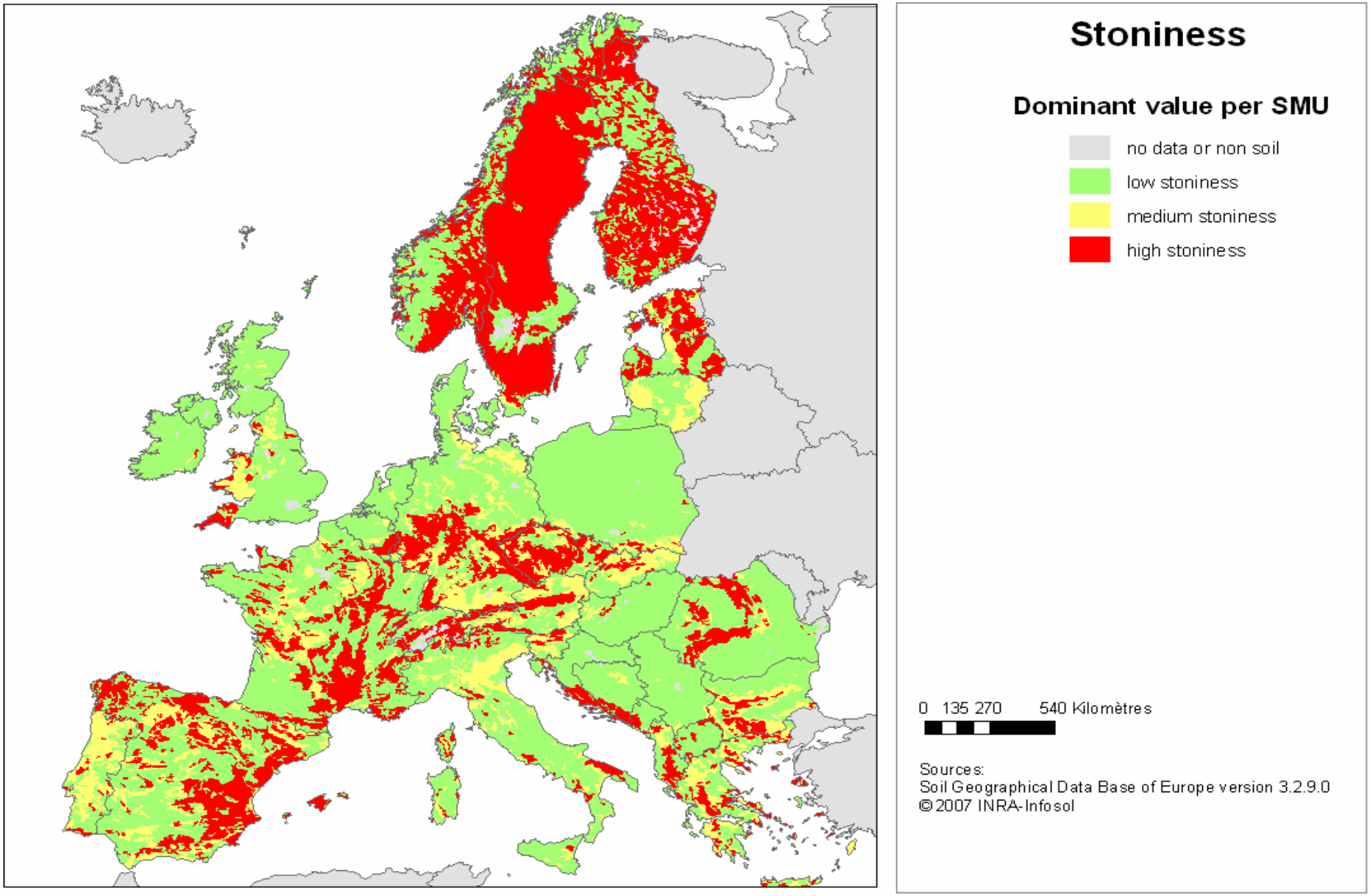
# Annex 3: Map No. 8. Criterion on Soil Texture





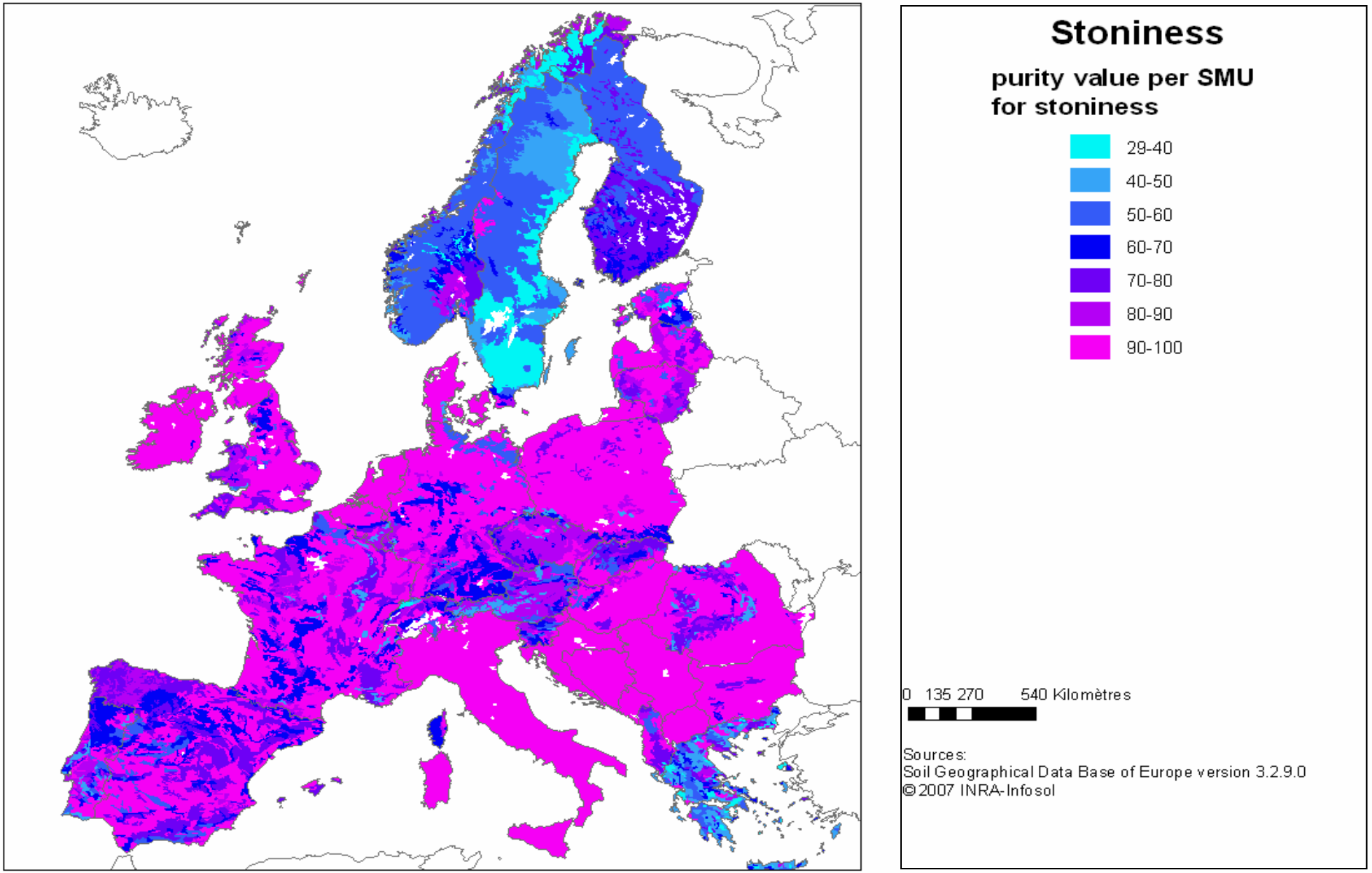
# Annex 3: Map No. 9. Criterion on Soil Stoniness





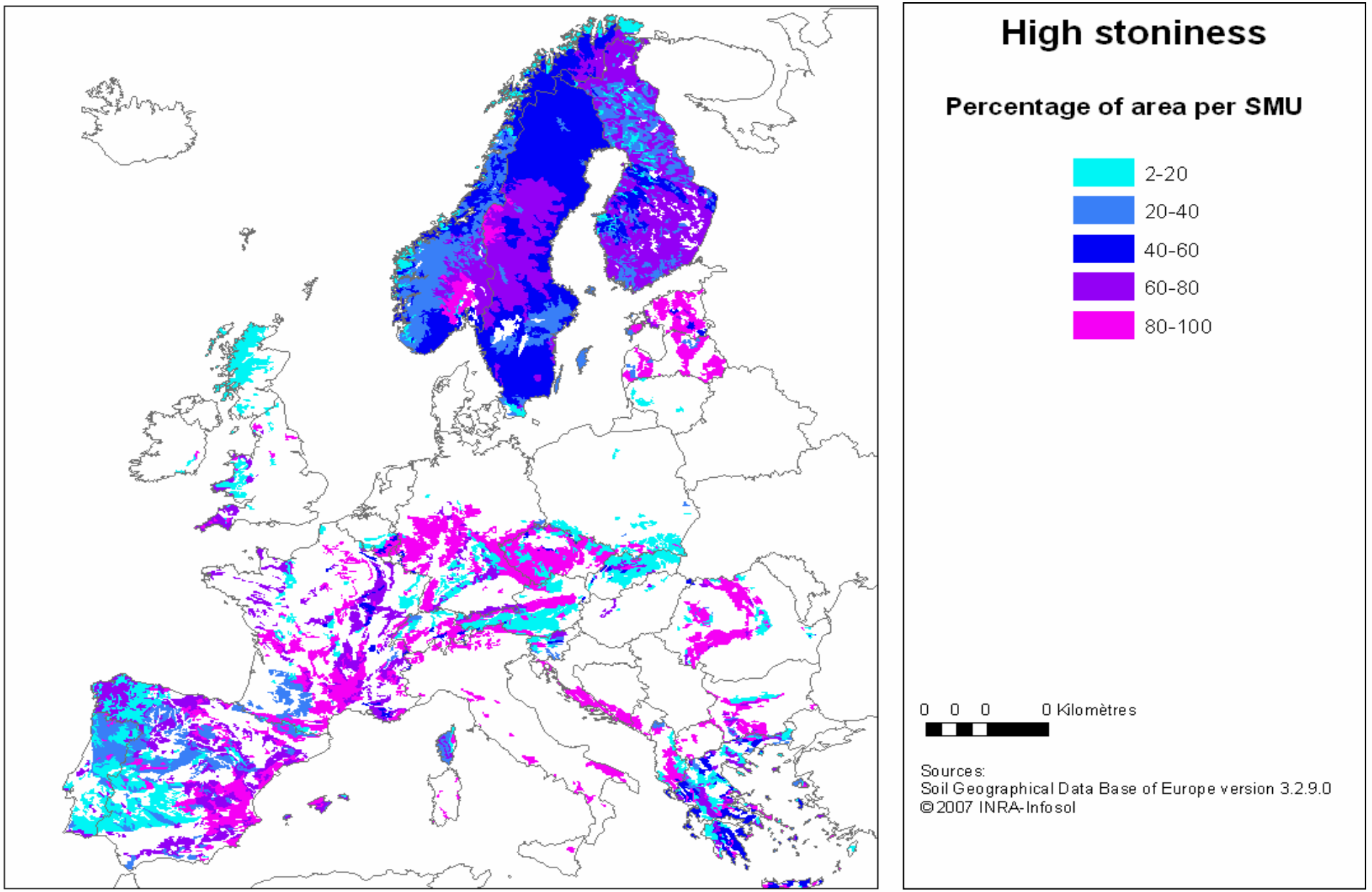
# Annex 3: Map No. 10. Criterion on Soil Stoniness – Purity



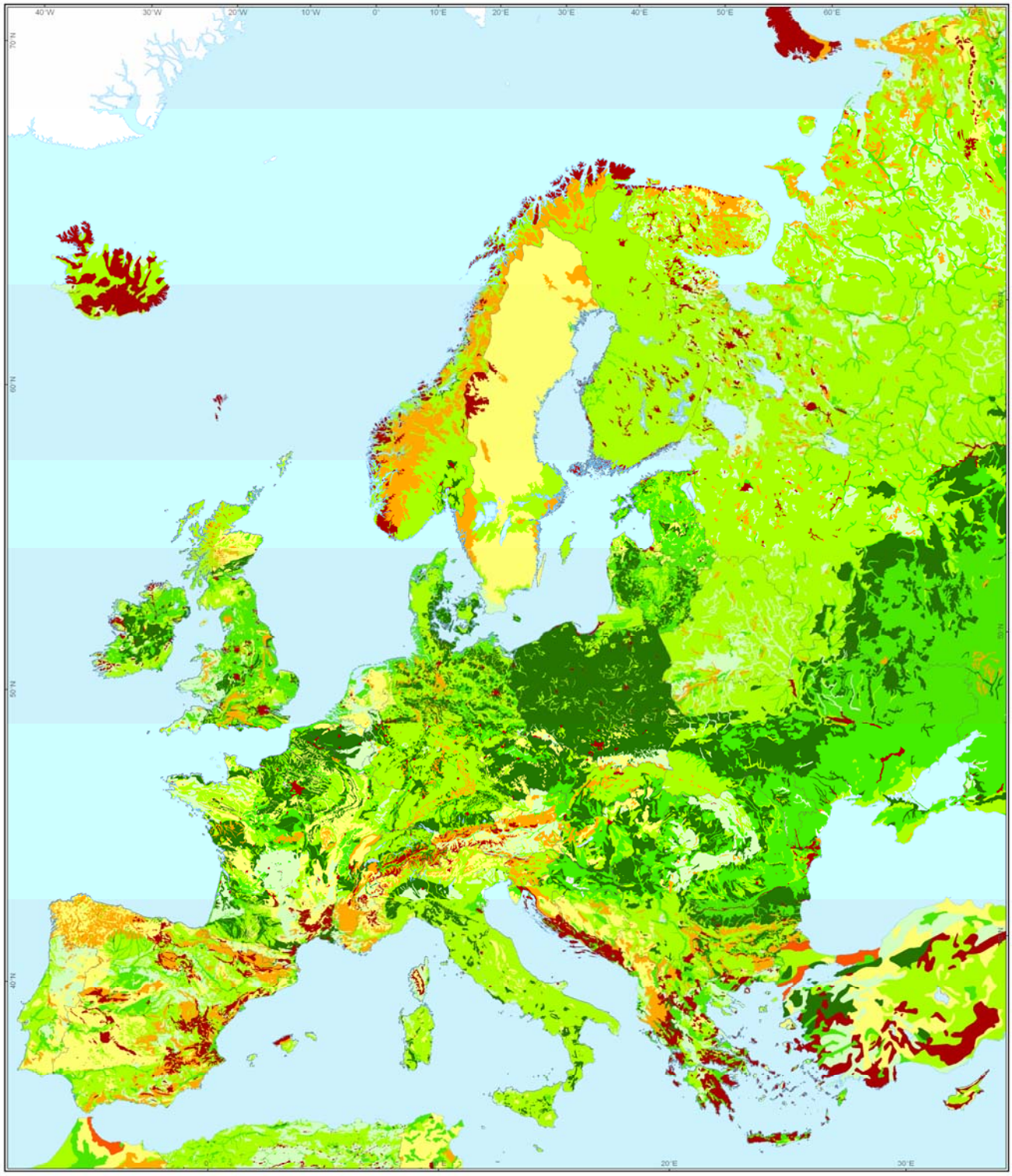


# Annex 3: Map No. 11. Criterion on Soil Stoniness – Percentage of high stoniness





# Annex 3: Map No. 12. Criterion on Soil Rooting Depth



**Root depth**

**Root depth classes**

- < 10 cm
- 10 - 20 cm
- 20 - 40 cm
- 40 - 60 cm
- 60 - 80 cm
- 80 - 100 cm
- 100 - 120 cm
- 120 - 150 cm
- Not evaluated

0 500 1.000 Km

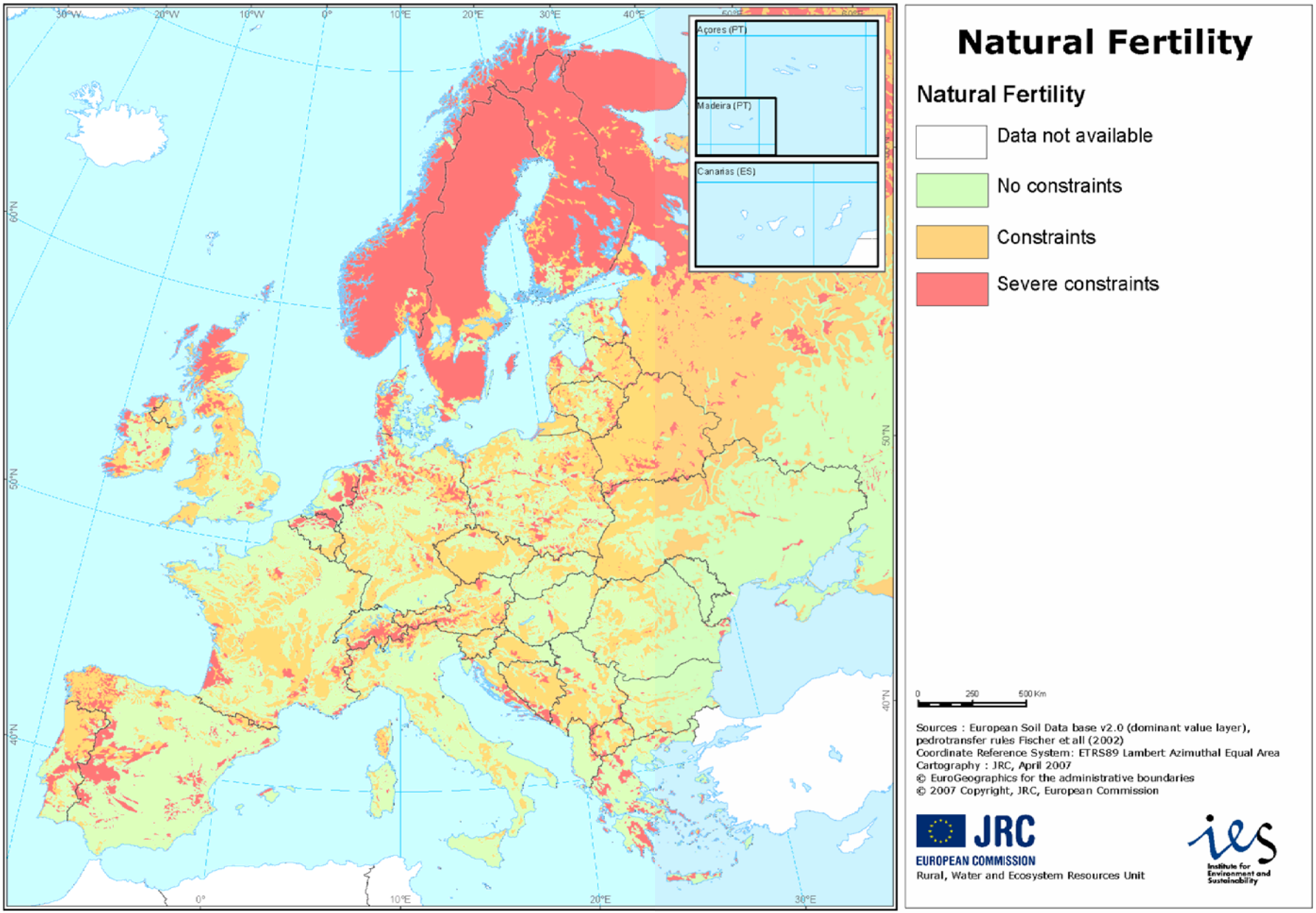
Sources : European Soil Data base v4.0
Pedo transfer rules developed in the frame of the MARS Crop Yield Forecasting System, AgriFish Unit, IPSC
Coordinate Reference System: ETRS89
Lambert Azimuthal Equal Area


JRC EUROPEAN COMMISSION

ipsc Institute for the Protection and Security of the Citizen

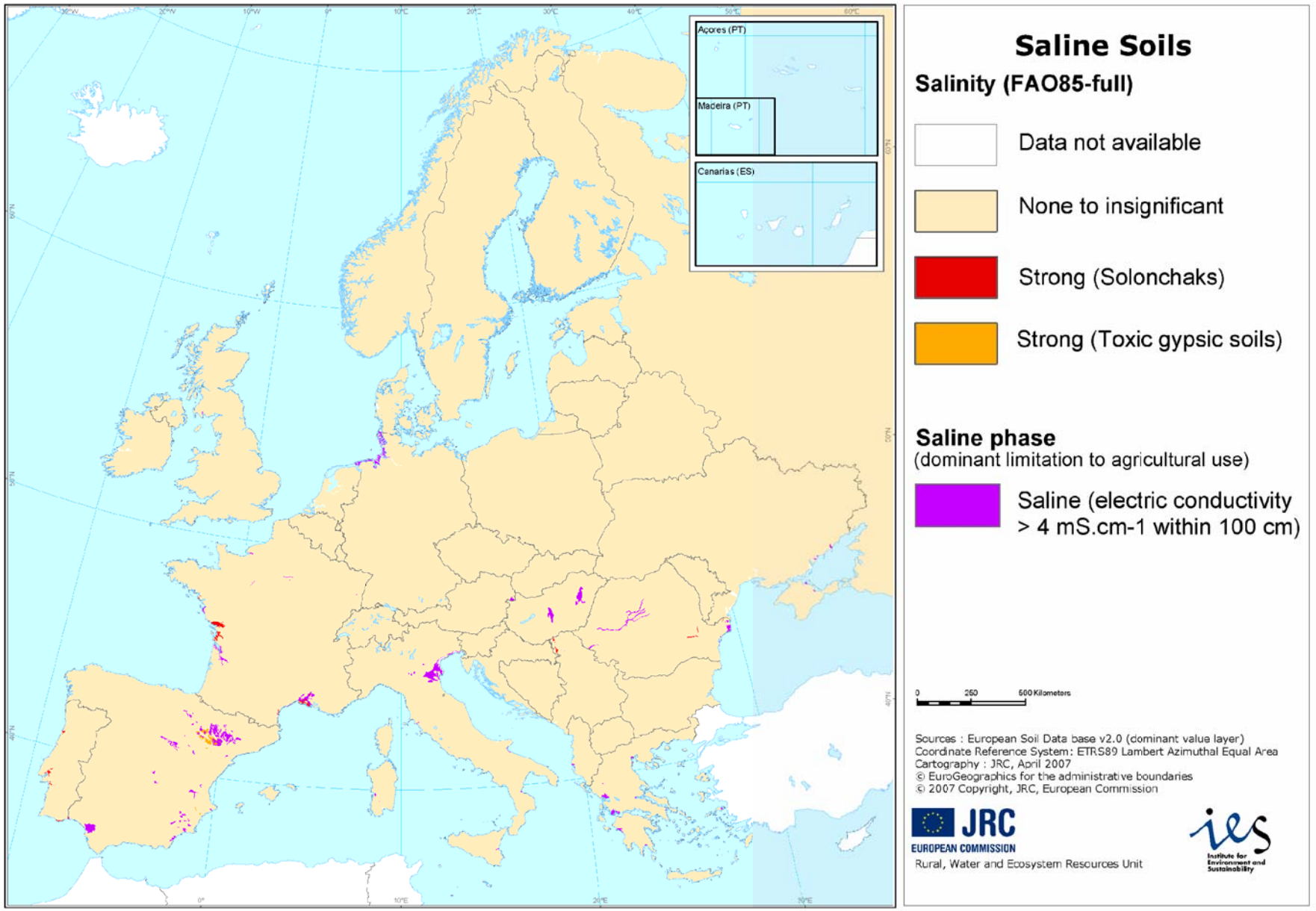
# Annex 3: Map No. 13. Criterion on Soil Fertility





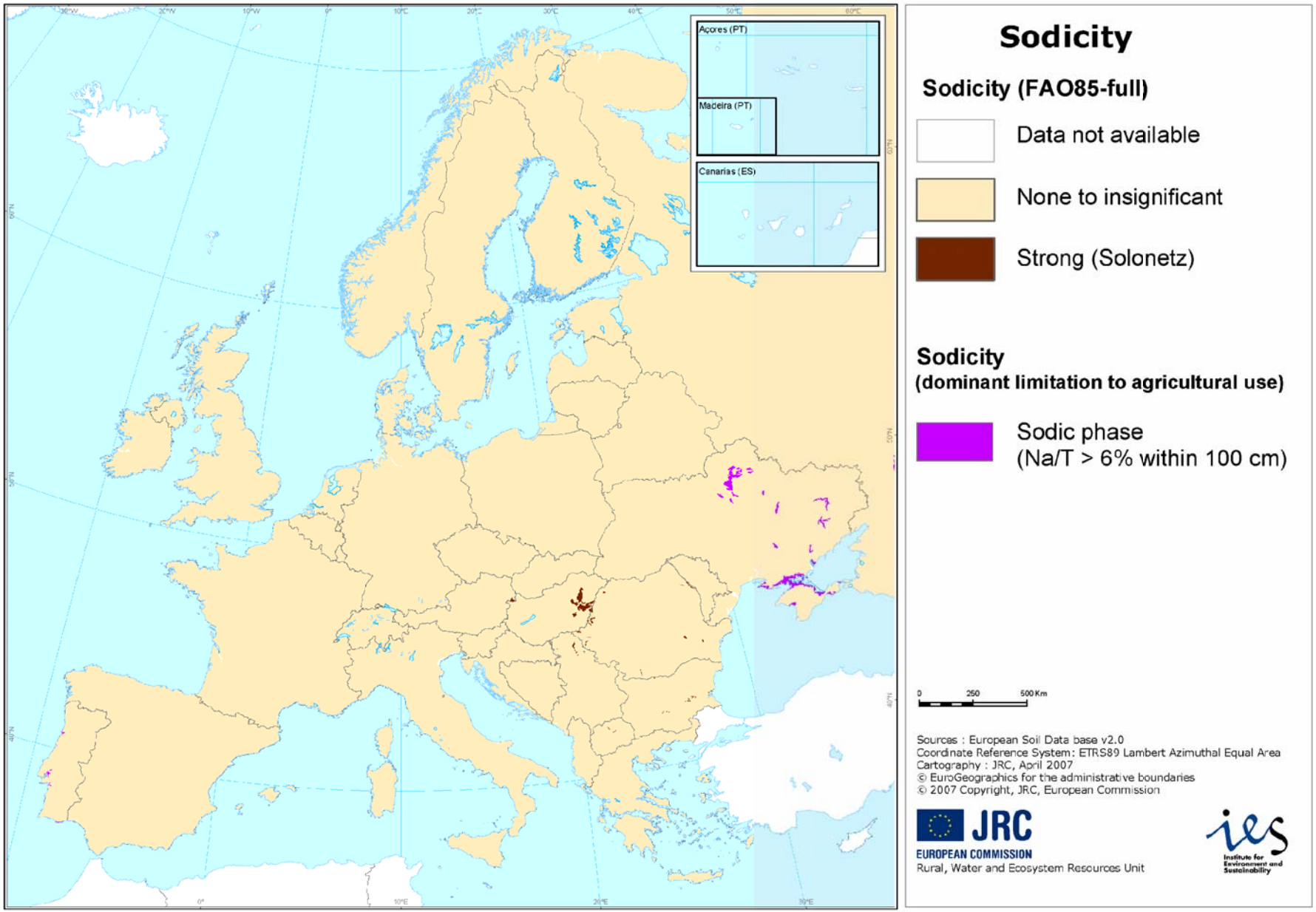
# Annex 3: Map No. 14. Criterion on Soil Salinity





# Annex 3: Map No. 15. Criterion on Soil Sodicity

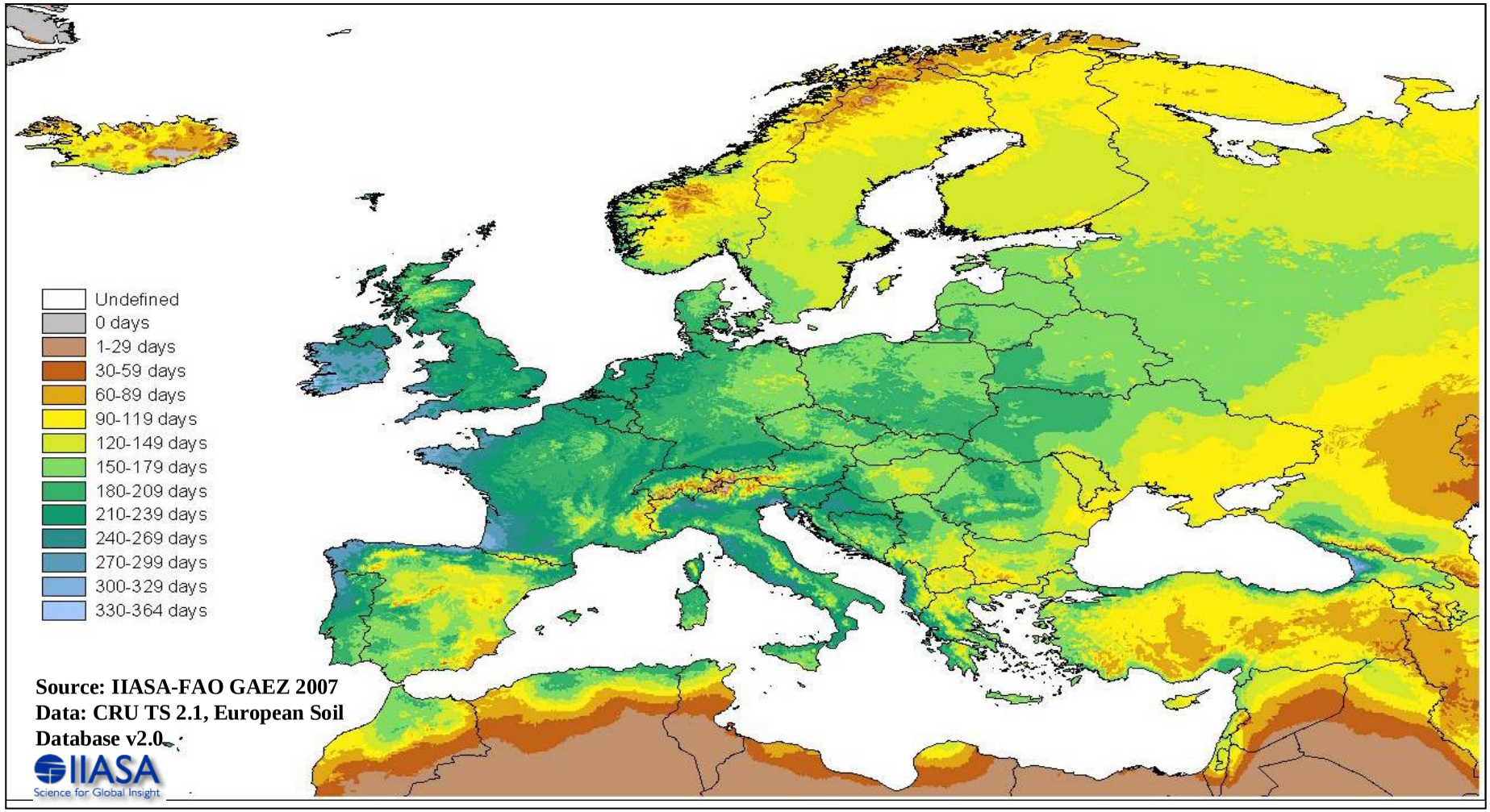




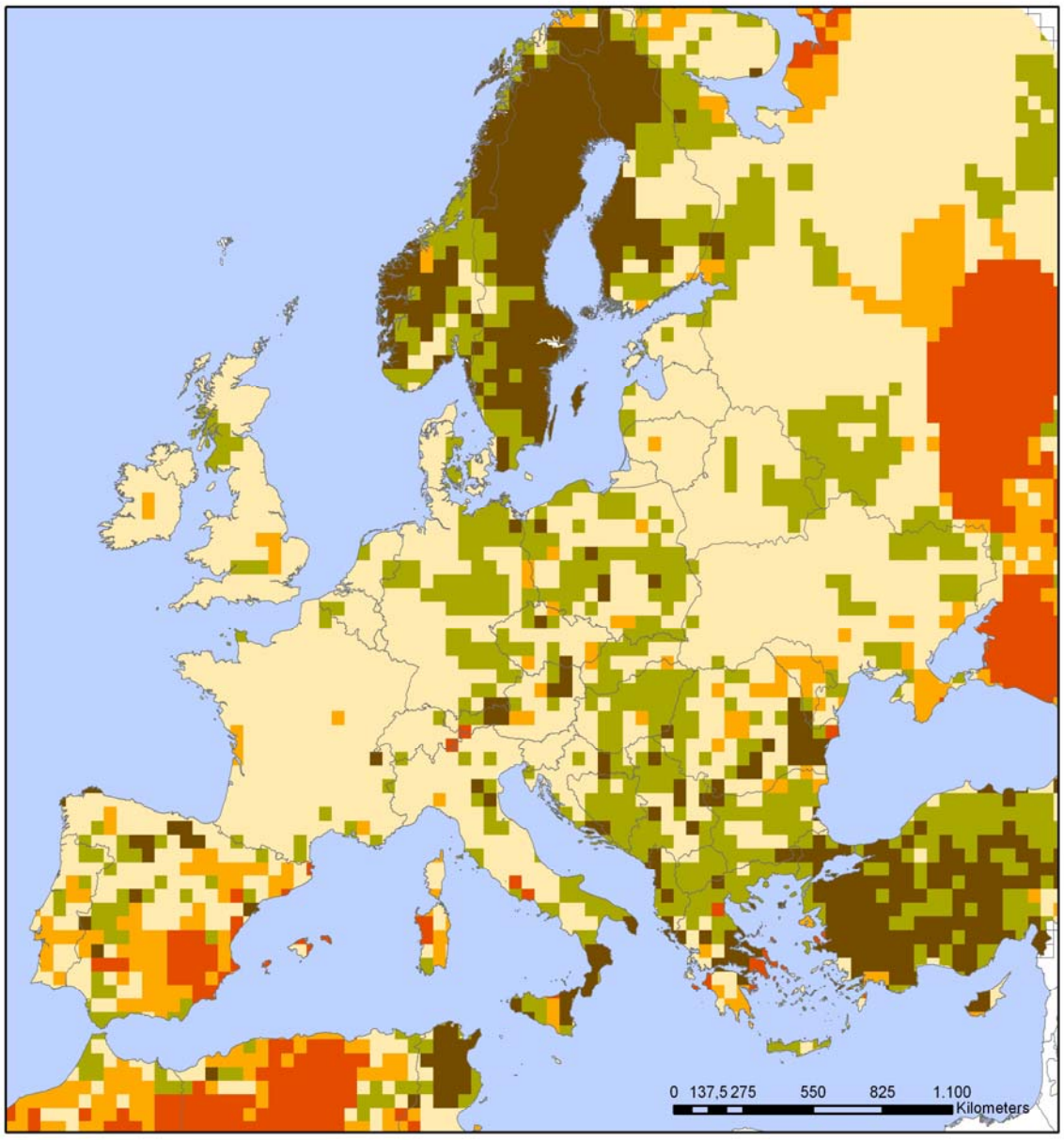
# Annex 3: Map No. 16. Criterion on Soil water balance

## Number of Growing Period Days

***Note: LGP days are defined as having Ta >5 degree Celsius and available soil moisture exceeding half the potential evapotranspiration of FAO reference crop. The map shows results for Soil Mapping Units-specific average soil water holding capacity levels. Soils of the European soil database were grouped into six classes according to water holding capacity and presence of soil depth limitations and Soil Mapping Units were assessed according to their respective Soil terrain composition.***



# Annex 3: Map No. 17. Climate Variability: Analysis of changes in frequency of draughts




## Changes in the frequency of drought events

1992 - 2006 versus the previous 15-year period (1st of April until 25 th of June)

**Frequency of drought events**

- 30 %

decrease of frequency

increase of frequency

+ 30 %

Drought events are defined via the SPI frequency
with a SPI value < -1.5.
(corresponds to the USDA classification for severe drought events)

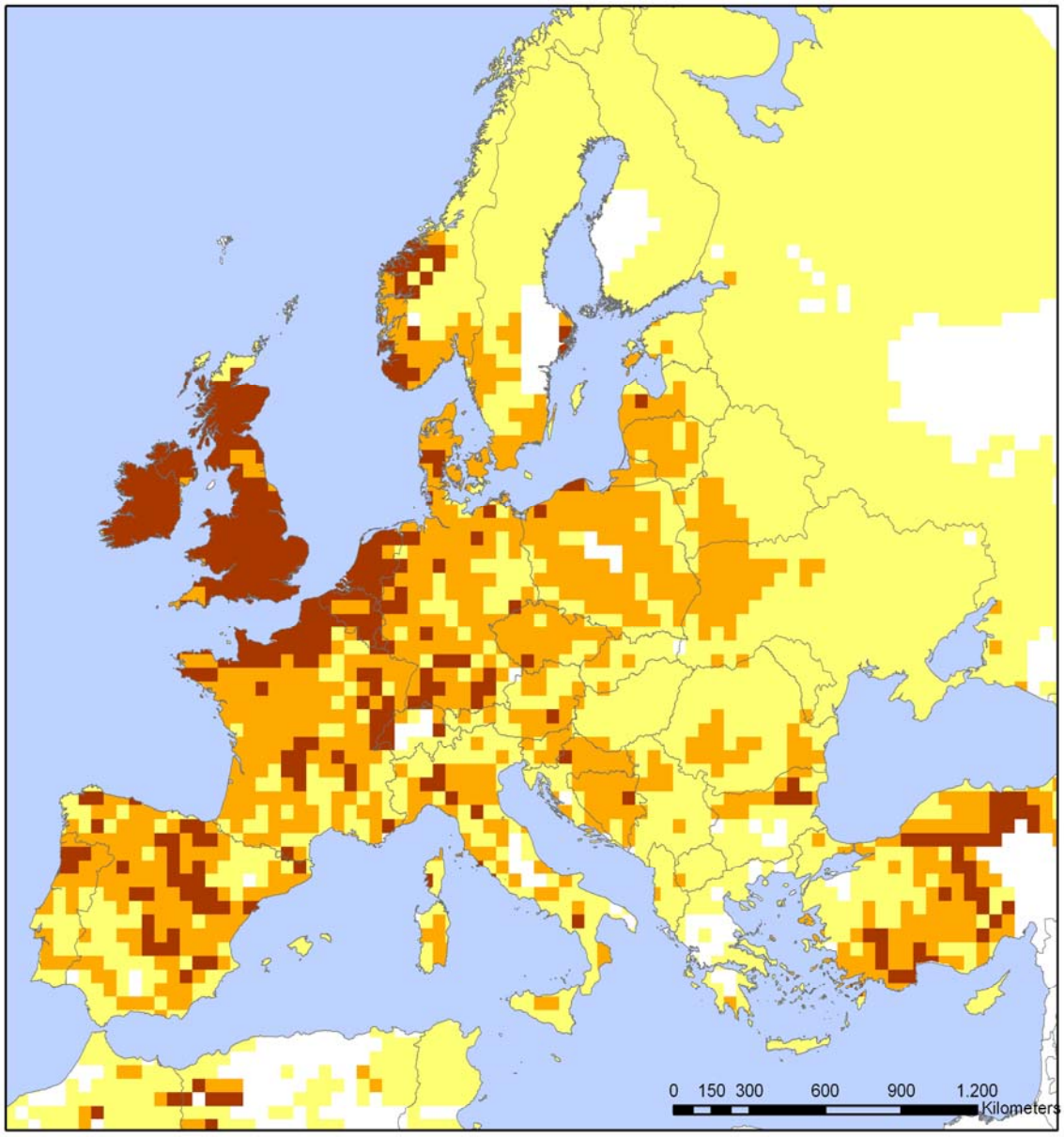
Source: JRC/MARS STAT data base
European Commission,
interpolated data from
national meteorological services

Coordinate Reference System:
Lambert Azimuthal Equal Area


JRC
EUROPEAN COMMISSION

ipsc
Institute for the Protection and Security of the Citizen

# Annex 3: Map No. 18. Climate Variability: Occurrence of the beginning of flowering of winter wheat, between 1975-2006




**Simulated changes in the beginning of winter wheat flowering**

Winter wheat flowering (Development stage 100) between 1975 - 2006

Anticipated winter wheat flowering per year:

- 1 to 0.5 days
- 0.5 to 0.3 day
- no significant anticipation

Source: JRC
MARS CROP YIELD
FORECASTING SYSTEM
European Commission

Coordinate Reference System:
Lambert Azimuthal Equal Area


JRC EUROPEAN COMMISSION

ipsc Institute for the Protection and Security of the Citizen

European Commission

**EUR 22735 EN – Joint Research Centre – Institute for Environment and Sustainability**
Title: Common Biophysical Criteria for Defining Areas which are Less Favourable for Agriculture in Europe. Proceedings from the expert meeting 19-20th of April, 2007, The Institute for Environment and Sustainability, Joint Research Centre, Ispra (Italy).
Editors: Å. Eliasson, J.-M. Terres and C. Bamps
Luxembourg: Office for Official Publications of the European Communities
2007 – 80 pp. – 21 x 29.5 cm
EUR – Scientific and Technical Research series – ISSN 1018-5593

Abstract
This report presents common biophysical, soil and climate criteria that can be used for defining areas which are less favourable for agriculture in Europe. The work is part of the Joint Research Centre technical support to DG Agriculture and Rural Development in their preparatory work to find a new definition for classifying the EU Other/Intermediate Less Favoured Areas (Article 19) to be implemented after 2010. The report is based on the findings of the expert meeting that was organised by the Joint Research Centre and occurred on the 19$^{th}$ and 20$^{th}$ of April 2007 in Ispra, Italy. The meeting included 33 participants, including 14 experts from various scientific institutes, four participants from DG Agriculture and Rural Development and 15 experts from the Joint Research Centre. A wide range of expertise in various fields was covered by the participants, including land quality assessment methods, soil, terrain, climate, water, environment, agriculture, implementation of EC agricultural policy and Less Favoured Areas. The proceedings of this meeting presents: an introduction to the Less Favoured Areas, the work in which the Joint Research Centre provides technical support to DG Agriculture and Rural Development, abstracts of presentations, selected maps from presentations, reports from working groups, and potential common criteria. It also summarises discussions on context, common criteria and application of these criteria by the Member States.

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

JRC
EUROPEAN COMMISSION