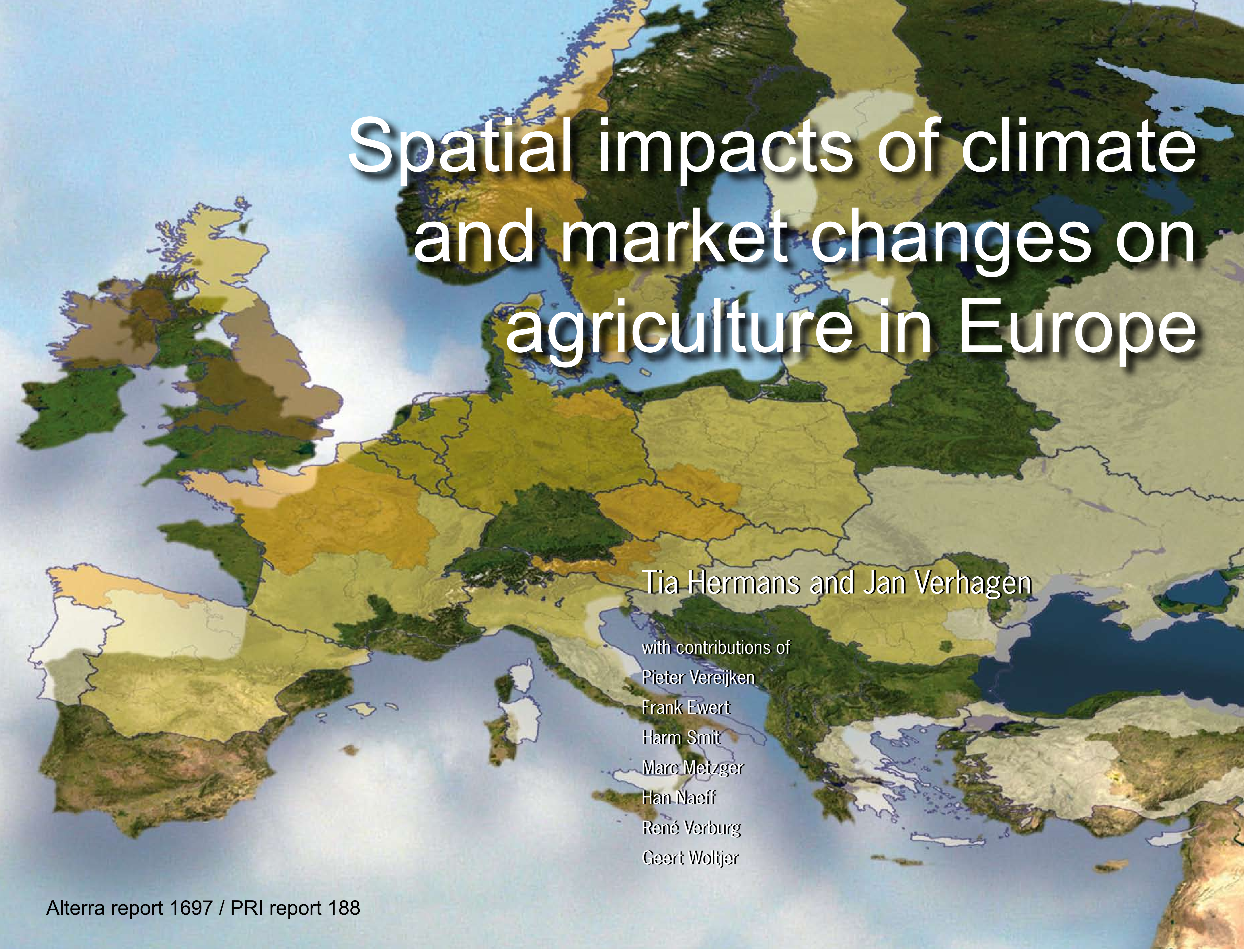

Spatial impacts of climate and market changes on agriculture in Europe

Tia Hermans and Jan Verhagen

with contributions of
Pieter Vereijken
Frank Ewert
Harm Smit
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Alterra report 1697 / PRI report 188

WAGENINGEN UR
For quality of life

Abstract

Tia Hermans and Jan Verhagen, 2008. Spatial impacts of climate and market changes on agriculture in Europe.

Farmers and farming regions in the EU are increasingly concerned about whether they can remain competitive in a liberalising economy. Until now, climate change, which poses an additional stress to agriculture, is not included in recent assessment studies on the future competitiveness of the sector. In this atlas future changes in agricultural production and land use are projected considering combined effects of market and climate change. The study aims to identify regions in Europe that are likely to remain agricultural or that are likely to convert to other land uses. Two IPCC scenarios (global market with extensive fossil fuel use and regional markets) are considered for three time slices: 2005, 2020 and 2050. Two spatial boundaries are considered (Europe restricted to the EU-27 including Norway and Switzerland and Europe enlarged up to the Urals). The atlas focuses on the arable crops wheat and potato and on dairy farming. The assessment methodology includes three steps. 1) Calculation of the achievable food supply for wheat, potato and milk considering effects of climate change and technology development. 2) Calculation of the demand for wheat, potato and milk based on the GTAP (Global Trade Analysis Project) model. 3) Adjustment of achievable supply to demand by adapting the area cultivated. This adjustment is based on the economic size of the farms used as competitiveness indicator. The results presented suggest spatial changes of agricultural production across EU-27 or EU-Ural.

Keywords: EU member states, global market, regional market, climate change sustainable agriculture 2050

Alterra report 1697
PRI report 188

Design: Karel Hulsteijn, Communication Services, Wageningen UR
Printing: van Eck & Oosterink, Dodewaard

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Dedicated to Pieter Vereijken (1948 – 2007)
the founding father of the approach used in this project.

Preface

The idea for the work upon which this atlas is based arose from a consultation exercise in the north of The Netherlands. In the winter of 2005 the *Noordelijke Landbouwraad* held a meeting with members from the private sector, provincial governments and other stakeholders to address the issue of climate change. The main question was whether it had become a factor for consideration in planning and development strategies.

Questions related to the validity of the scientific arguments underlying the debate on climate change were discussed, together with issues regarding positive action to deal with its effects. Since the region is predominantly agricultural the discussions focused primarily on this subject. Planners were already devising and undertaking initiatives on the greenhouse gas agenda, via wind power and biomass. Responses to possible adverse effects or the exploitation of opportunities arising from climate change had yet to be considered. Perhaps the only exception in the region was the Grontmij which contacted Wageningen UR for advice on how to approach adaptation to climate change.

The resulting consortium including the northern provinces, water boards together with the private sector, farmer organisation LTO-noord and research groups from Wageningen UR set out to assess the impacts of market and climate change on agriculture in the Northern provinces of the Netherlands to provide a sound basis for adaptation strategies in the region.

Adaptation is a complex issue and it can be argued that it is an intrinsic feature of agriculture and not a new phenomenon. However, climate change has the potential to alter dramatically the risks and opportunities for agricultural development. Agriculture is also an economic activity which responds to changes in markets. Alterations in production areas, whether driven by climate or by market changes, are important for the planning and the formulation of adaptation strategies in regional agricultural development.

The European context is of crucial importance for agriculture in The Netherlands, therefore assessing the impacts of climate and market changes in Europe is a first step that must be taken before meaningful adaptation strategies can be formulated for the region.

The European analysis is restricted to three relevant crops for the northern Netherlands: wheat, potatoes and grass for dairy farming. The analysis shows the regions of Europe where crop and milk production are likely to persist following market or climate changes, and the combination of both over the next forty years. Anticipating alterations in the composition of the European Union and stronger regional market cooperation in the future, Turkey and Europe up to the Urals were also included.

The aim of this atlas is to present the results of the study on the impacts of climate and market changes, therefore the methods sections is concise. The detailed results are presented as maps for each crop, with explanatory text. The layout is kept consistent to facilitate reading. The atlas finishes with a discussion and conclusions and it is anticipated that it will be useful to a number of stakeholders: farmers, the processing industries and policy makers. Feedback is welcome to improve future versions (tia.hermans@wur.nl).

This atlas is the result of collaboration between researchers of the Plant Sciences Group (Jan Verhagen, Pieter Vereijken, Frank Ewert, Harm Smit), the Environmental Sciences Group (Tia Hermans, Han Naeff, Marc Metzger) and the Social Sciences Group (René Verburg, Geert Woltjer) of Wageningen UR with Jan Verhagen as the project leader. The lay-out is the work of Karel Hulsteijn.

Wageningen June 2008

Jan Verhagen

Content

Introduction

Agriculture is an economic activity providing incomes and jobs. The sector responds strongly to market forces and changes in policy. This is clearly visible in the impact of the Common Agricultural Policy (CAP) on farming in the European Union (EU). Policy reforms leading towards the abolition of subsidies and tariffs - which currently protect farmers against internal and external competition - will change the options and opportunities available.

In future decades a crucial question for farmers and agricultural regions in the EU will be whether they can remain competitive in an increasingly free market. There are three possible answers:

- No, because there are too few options. Depending on the region, a large part, or even most, of the agricultural land may become available for both alternative agrarian and non-agrarian activities. This may help remaining farmers to scale-up and remain competitive, and encourage the expansion of non-agrarian activities.
- Yes, because by modernising and scaling-up production, new products - such as non-food crops - could be grown in a given region; or diversification into non-agrarian activities, e.g. recreation and care, may be an alternative option.
- Yes, though in another region of the country, in the EU, or even outside the EU, where opportunities are better, where good quality land is available and favourable social and economic conditions prevail.

Currently, decisions are based mainly on market pressures and policy outlooks. Climate change, which imposes an additional stress on agriculture, is not usually included in decisions on whether or how to continue. This may lead to inappropriate or belated decisions and investments, which could prove very damaging, or even fatal, for the future of many farmers. This would also affect the industries involved in processing and delivery and also, eventually, regional economies.

Aim of the atlas

In this atlas changes in both market and climate are considered, in order to provide information for predicting which parts of Europe are most likely to remain agrarian, and for which regions non-agrarian land uses are likely to become more important. A selection of contrasting market and climate scenarios were therefore chosen for consideration, involving two time slices. The atlas focuses on wheat and potatoes as arable crops and dairy farming is addressed via grassland.

Selection of scenarios

Market and climate scenarios

The International Panel for Climate Change (IPCC) Special Report on Emission Scenarios has formulated four alternative storylines based on markets and societal developments during the 21st century. Each represents a set of plausible demographic, social, economic, technological and environmental parameters. The future developmental paths described for various industries and human activities result in a wide range of emissions of greenhouse gases and associated climate changes (IPCC, 2000).

In this study, two contrasting storylines were selected: A1 and B2. In general terms A1 describes a future world of very rapid economic growth and the rapid introduction of new and more efficient technology. The global population reaches a peak in 2050 and gradually declines thereafter. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The energy system is based on fossil technology.

In contrast B2 describes a world in which the emphasis is on local solutions for economic, social and environmental sustainability. In this storyline the focus is on sustainable development within European regions. Compared to A1, the B2 world results in less rapid, and more diverse, technological development and lower economic growth. Population growth continues but at lower rates than in the A1 storyline. In this study the A1 and B2 storylines are called scenarios.

For each scenario, changes in climatic conditions were used, projected by the global climate model HadCM3 for 2020 and 2050 (Mitchell et al, 2004). Five monthly climatic variables are included, with a spatial resolution of 10 minutes. The variables are temperature, diurnal temperature range, precipitation, vapour pressure and cloud cover.

Policy scenarios

For agriculture, in particular, the influence of trade policies (such as the Common Agricultural Policy) has proved to be very strong. In the present study two policy directions were selected and combined with the IPCC storyline. The first, which is linked to A1, is a liberalised (i.e., free) market without government intervention. The second, in which the EU operates as an economic block within the global economy, is a continuation of the current policy and is linked to the B2 scenario.

Spatial boundaries

While looking at the two scenarios, changes in the spatial extent of the present European Union (EU) are considered. The basis is provided by the EU, which at the moment consists of 27 countries and Norway (further called EU27). In addition an extended economic region including Turkey, Belarus, Ukraine and part of Russia up to the Urals is considered (EU-Ural). It is expected that in coming decades these areas will either be part of the EU, or will have a large influence on markets and the development of the agrarian sector in the EU. The Urals are seen as a natural boundary between Europe and Asia and include major production areas for the selected commodities.

Time slices

For the two scenarios, A1 and B2, temporal changes are presented for two time slices: 2020 and 2050. The year 2005 is used as the reference year.

Method

In order to determine which regions are likely to remain agrarian in the future and what their associated production levels will be, the following steps were adopted:

1. estimation of the achievable supply (in tons) of wheat, potatoes and milk in 2020 and 2050, based on the estimated productivity (tons/ha) in 2020 and 2050 and the agricultural production areas (ha) in Europe in 2005;
2. estimation of the production demand from Europe (in tons) for wheat, potatoes and milk in 2020 and 2050, based on global trade and production, population dynamics and economic growth;
3. adjustment of the achievable supply for wheat, potatoes and milk to the production demand, in 2020 and 2050, by adjusting the agricultural production areas in Europe; based only on competitiveness of regional agriculture in the global food market (2020, 2050), and on the competitiveness of regional agriculture within global food markets and regional land markets (2050).

These steps are executed for two scenarios (A1 and B2), each for EU27 and EU-Ural. In case of EU27, we calculate and present results at NUTS1[1] level. In case of EU-Ural, we calculate and present results at NUTS0 level. Data on crops and farms at NUTS1 or NUTS0 level are obtained from Eurostat (2007).

Step 1: estimation of the achievable supply

The achievable supply of wheat, potatoes and milk in the subsequent time slices was estimated by:

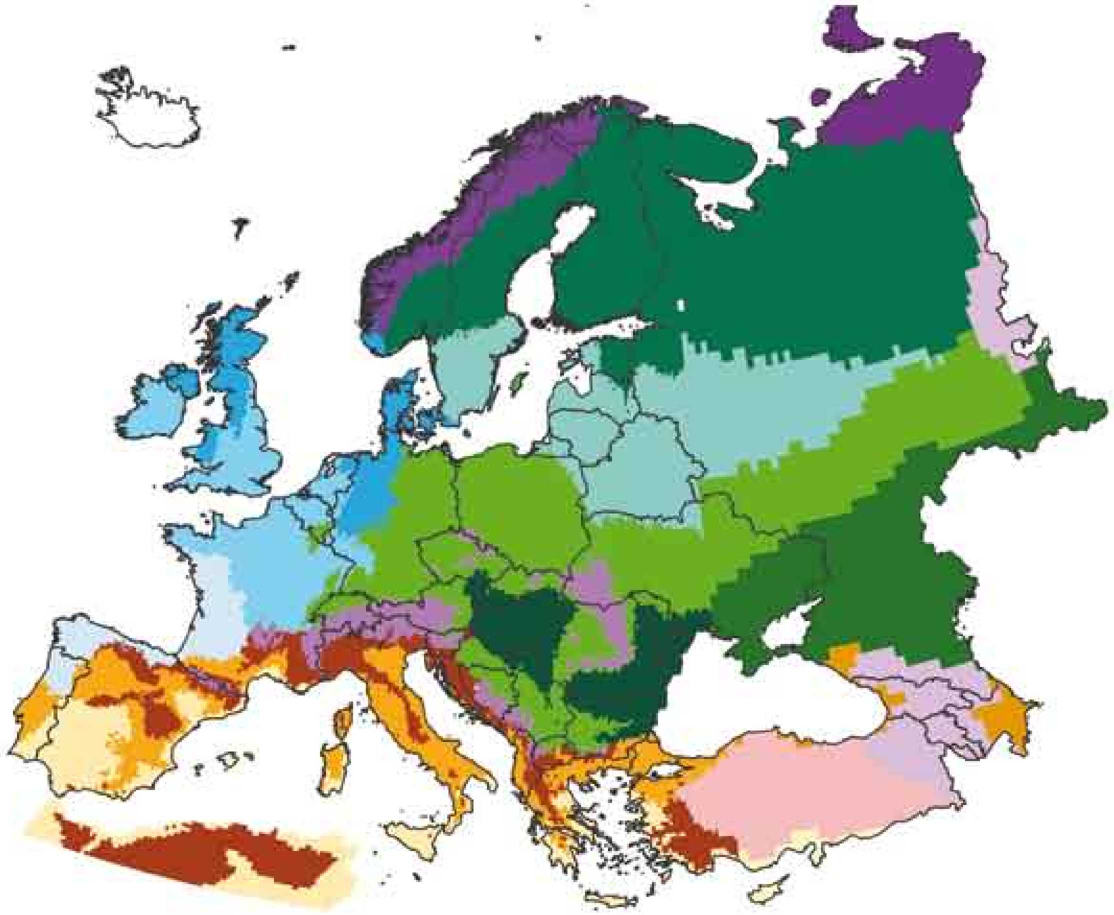
- calculating the productivity (tons/ha) of wheat, potatoes and grass in 2005, 2020 and 2050 per NUTS1 and NUTS0 respectively, depending on changes in climatic conditions, atmospheric CO_2 concentration and technology improvements (see textbox: Calculation of productivity in various time slices based on shifts in environmental stratification);
- calculating the achievable yield (tons) of wheat, potatoes and grass in 2005, 2020 and 2050 per NUTS1 and NUTS0 respectively, by multiplying the productivity (tons/ha) by the hectares per crop in 2005 per NUTS1 and NUTS0 respectively, available from Eurostat;
- converting the achievable yield of grass (tons) into the achievable milk yield[2] (tons) per NUTS1 and NUTS0 respectively;
- calculating the achievable supply (tons) of wheat, potatoes and milk in 2005, 2020 and 2050 by adding up the yields per NUTS1and NUTS0 respectively.

The result is the total achievable yield for wheat, potatoes and milk (tons) for EU27 and EU-Ural in the two scenarios and the various time slices.

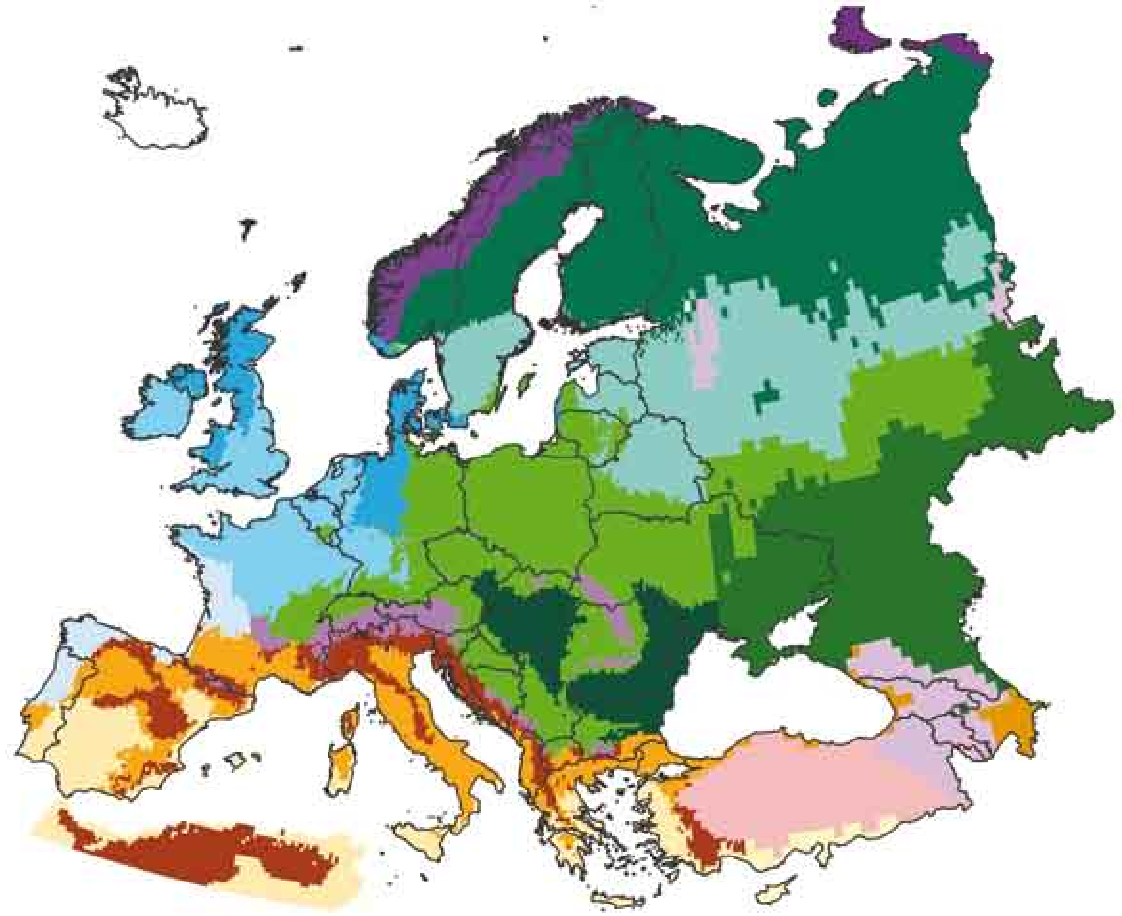
[1]NUTS = Nomenclature of Territorial Units for Statistics with 35 NUTS0 regions and 107 NUTS1 regions in EU27
[2]For grass the achievable yield of grass (tons) in 2020 and 2050 was recalculated into the achievable milk yield (tons) per NUTS1 respectively NUTS0 via the ratio total milk production in 2005/total grass production in 2005.

Map 1. Distribution of environmental strata in Europe in different time slices

2005



2020



Calculation of productivity in various time slices based on shifts in environmental stratification

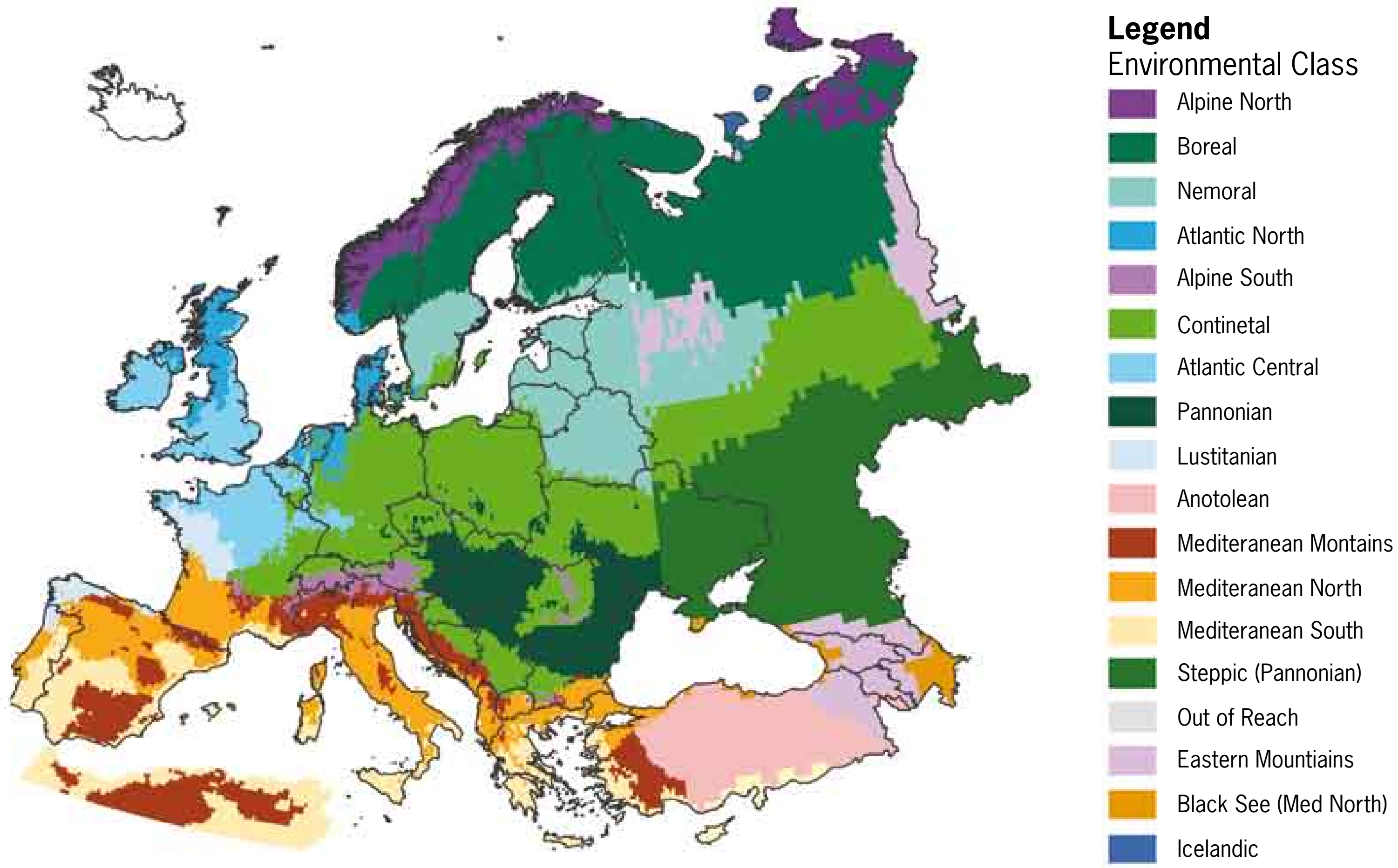
Changes in crop productivity depend on a large number of factors, such as environmental change (climate and atmospheric CO_2 concentration) and technological development. The method developed by Ewert et al (2005) is used to calculate changes in crop productivity.

Firstly, Europe is subdivided into 84 Environmental Strata (Metzger et al, 2005, 2008) aggregated into 13 Environmental Zones for presentation. The strata are derived from statistical clustering of minimum/maximum temperature, precipitation, sunshine, altitude and slope, oceanity and latitude. The resulting strata capture the variability in climatic conditions among regions in Europe, and the associated effects on yields. Predicted variations in climatic conditions in 2020 and 2050 are then used to calculate changes in the distribution of these Environmental Strata in those years (Map 1). Regional yield statistics of wheat, potatoes and grass at NUTS2 (Eurostat, 2007) are related to the specific strata and, as a result of this, changes in the distribution of strata result in changes in the distribution of yields. The most striking changes (Figure 1) are associated with the decreasing size of the Environmental Zones of the Alpine North and South Zones, as well as the Mediterranean Mountain and Atlantic North. The Continental Zone decreases in size and shifts to the east, in favour of an increased Atlantic Central Zone.

Subsequently, the effects of increasing atmospheric CO_2 concentration and technology are added. The effect of the former on crop yields is relatively insignificant, therefore a simplified statistical approach is used, resulting in a fixed percentage yield increase per crop, per time slice.

To estimate the effect of technological improvements on yields, historical trends are extrapolated into the future, by using a fixed percentage yield increase per crop and per time slice. Technological improvement in Eastern Europe is less advanced than in the West, therefore a lower percentage is used for these countries with regard to potatoes.

2050



Step 2: estimation of the demand

To estimate the demand for subsequent time slices required for the different scenarios, an extended version of the global trade model, the Global Trade Analysis Project (GTAP) (Hertel, 1997; van Meijl et al, 2006) is used. GTAP makes use of a worldwide database on trade and input-output data. In the construction of GTAP, the world is divided into a restricted number of regions, e.g. individual countries, groups of countries like the EU, or complete continents. The model uses population and economic growth - Gross Domestic Product per capita (GDP) - as driving variables, and estimates the growth of commodities ($) in percentages, starting with 2001 as the reference year in the regions, and takes into account imports and exports of a given agricultural commodity. These growth percentages are multiplied with the yield data of wheat, potatoes and milk in the reference year, obtained from the Food and Agriculture Organisation (FAO, 2006), to calculate the demand (tons) in 2020 and 2050 for EU27 respectively EU-Ural. Wheat and milk are commodities available in GTAP. Potatoes are approximated via the commodity horticulture. Assumed population and economic growth differ in the two scenarios. Due to major uncertainties about the developments in the market, only estimates up to 2050 are made.

The result is the total production demand (tons) for wheat, potatoes and milk, for two scenarios (A1 and B2) and the two regions (EU27 and EU27-Ural) for two time slices, 2020 and 2050.

Production levels and competitiveness of regional agriculture are among the data used to determine which regions or sub-regions will be needed to fulfil this demand.

Step 3: adjusting the achievable supply to the production demand

To adjust the achievable supply to the production demand for wheat, potatoes and milk in 2020 and 2050 the agricultural production areas in Europe are ranked, based on the competitiveness of regional agriculture within global food markets. As a variant, for 2050 the competitiveness on the regional land market is also included. Therefore, it was necessary to:

- calculate the total amount (tons) to be reduced in Europe, as the difference between achievable supply (step 1) and demand (step 2);

- use European Size Units per holding (ESU[3]) as the indicator for the competitiveness of regional agriculture on the global food markets, and inhabitants per agrarian ha as the indicator for competitiveness of regional agriculture on the regional land market (arable farms for wheat and potatoes, dairy farms for milk) (see textbox Competitiveness of Regional Agriculture);
- rank regions from high to low indicator values with regard to ESUs per holding, and from low to high indicator values with regard to inhabitants per agrarian ha,
- calculate the potential reduction percentage of hectares per region by using the indicator value per region according to the formula:

(1 - indicator value of the region/maximum indicator value) x 100.

This means that the region with the highest indicator value will always maintain its total number of hectares. Whether or not other regions are reduced depends on the gapbetween the total supply and total production demand, and the ranking value of the region. In the event of production demand exceeding the supply, there will be a shortage of land and all regions will maintain their agricultural area in production. No attempt has been made to allocate surplus land in this study. In the event of supply exceeding the production demand, then the higher the ranking value of the region, the sooner it will be considered for a reduction of agricultural land. As soon as enough land is taken out of production, it is when the achievable supply and production demand are balanced, the remaining regions can maintain their land in use.

The difference between scenarios A1 and B2 should be noted. The above mentioned formula is used in scenario A1. In scenario B2, it is assumed that European and national governments will support regional agriculture hence - although competitiveness will still play a role - it will be less pronounced. Therefore, the above mentioned formula is multiplied by 0.5, resulting in less land per region being taken out in the event of a production surplus and, eventually, in more regions being required to take land out of production;

- multiply the remaining area (ha) per region by its productivity (tons/ha);
- order regions from high to low production (tons);
- map the regions in three classes, each containing 33.3% of total production (tons). Regions producing less than 0.1% of total production are left grey.

Combining the supply and production demand using competitiveness results in a (re)distribution of production regions. This results in maps showing regions and the importance of their supply role in the near future.

Competitiveness of regional agriculture

To adjust the demand to the supply spatially, the method of Vereijken & Hermans (2008) was used.

The competitiveness of regional agriculture within global food markets is approximated by the mean economic size of its agrarian holdings, measured in ESUs per holding, and by total regional production, measured in ESUs. ESUs take the Gross Margin (excluding fixed costs and labour) as common denominator of plant or animal production. One ESU is equivalent to about € 1,200 (Eurostat, 2007). Most recent data on ESUs are obtained from Eurostat (EU27) or FAO (Belarus, Ukraine, Turkey and Russia-Ural).

The competitiveness indicator covers differences in soil, climate and regional development, including technological, economic and management capacities of farmers. Therefore, it is a robust indicator for long-term (10-20 years) competitiveness of agrarian regions. The indicator shows the potential to remain profitable and continue to contribute to the viability of the region. A low ESU value indicates low competitiveness. The smaller the regional economic size of the holdings (ESU/holding), the more likely it is that agriculture will lose out to other regions, leaving the land available for other use.

To examine the predictive value of competitiveness for future prospects, EU-regions have been ranked, based on their indicator values relating to ESU/holding in 1995, derived from Eurostat (Figure 1). The analysis is restricted to the EU-10, because no data are available on the new EU member states for 1995. The indicator values for 2005 are given for comparison. Although the indicator values of the most favourable regions were much higher in 2005, their ranking hardly changed. The ranking values for the region can thus be used with confidence as predictors for the next 20 years, as well as for comparison among regions.

Competitiveness within global food markets will not be limited to farms or regions. At later stages of the supply chain, e.g. in delivery and processing industries and services, competition will also become more intense, therefore the capacity to supply larger quantities will be an advantage. Regions are classified in order of total production before they are mapped into three classes.

From 2050 onwards, it is assumed that the pressure of increasingly wealthy inhabitants on agrarian land will have increased significantly. Under such conditions, the market would also gradually adjust supply to production demand by competitiveness in the regional land markets. Therefore, the population pressure, expressed as the number of inhabitants per agrarian ha, is included as a second indicator to determine the competitiveness of regional agriculture. It indicates the regional demand for alternative land uses, and is reflected by increasing pressures on agricultural land, e.g., for housing, infrastructure, recreation or the provision of green space. The larger the population pressure, the faster the agriculture in a region will give way to other non-agricultural uses. The region with the lowest mean population pressure gets ranking value 1 (most competitive in the regional land market). As can be seen from Figure 2, the current ranking order of inhabitants per agrarian ha is robust and is therefore indicative of future developments.

The ranking values of both indicators per region are added up. The region with the lowest sum of ranking values of farm size and population pressure gets ranking value 1.

[3] 1 ESU = € 1,200

European Size Units per holding

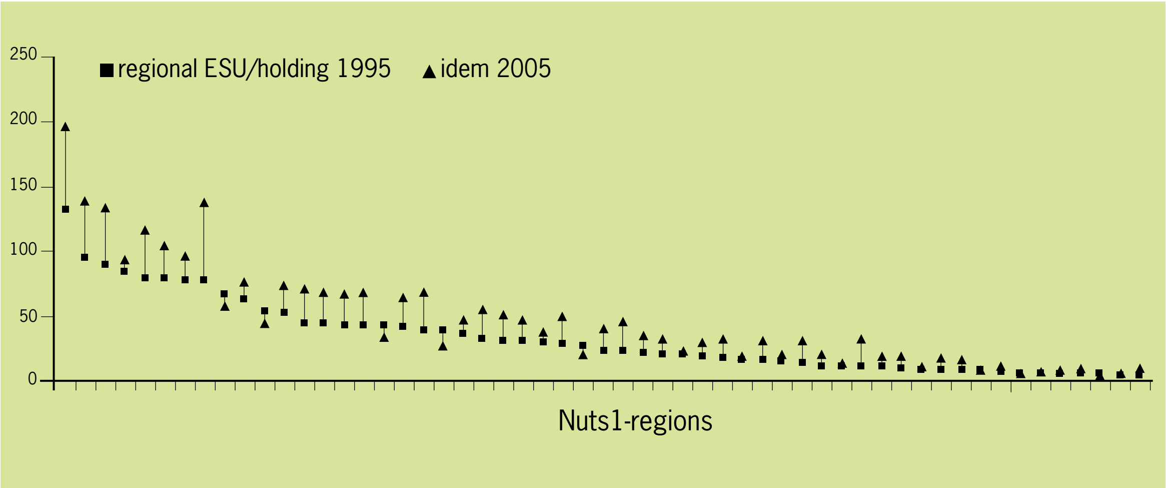


Figure 1. Validation of mean economic size of regional holdings, as a predictive indicator for future competitiveness within the global food market. Regions of 10 initial EU-member states ranked by indicator values in 1995 and compared by indicator values in 2005.

Inhabitants per agrarian ha

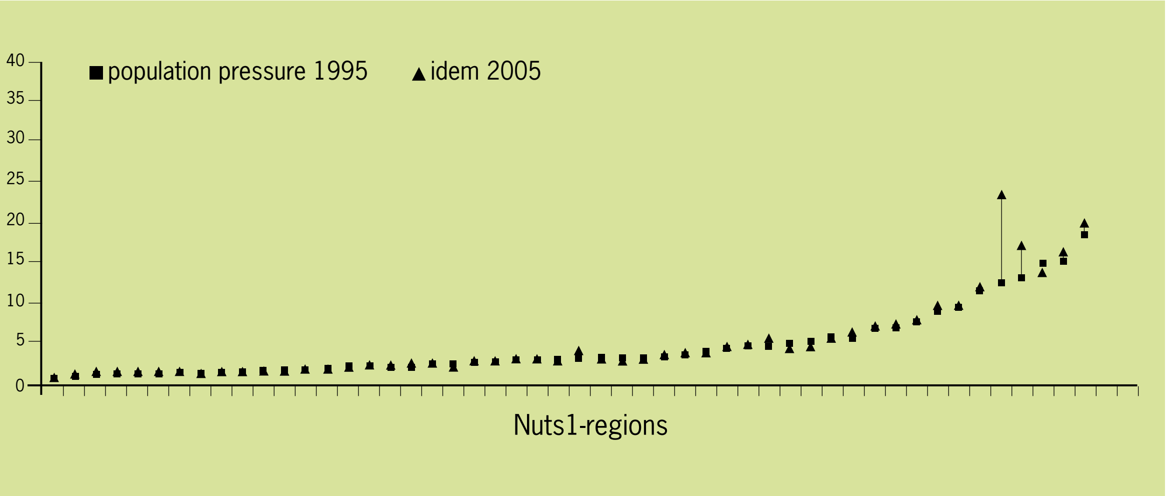


Figure 2. Validation of regional population pressure (Inhabitants/agrarian ha) as a predictive indicator for future competitiveness within the regional land market. Regions of EU25 member states ranked according to indicator values in 1995 and compared to indicator values in 2005.

Results

For 2050, it was predicted that wheat productivity would increase throughout Europe, compared with 2005. However, there are large regional differences, ranging from +40% in south-eastern France to +170% in parts of Sweden.

These increases in productivity are the combined effect of changes in climate (precipitation and temperature), CO_2 and technology. From Figure 3 it is clear that technology is the main determining factor. When looking at changes in temperature and precipitation only, the productivity in 2050 compared to 2005 is likely to be lower in about 50 out of 125 regions. When the effects of CO_2 and technology are added, all regions show an increase in productivity. For example, in south-western France, effects of precipitation and temperature resulted in a productivity change of -25%; if the effect of CO_2 was added the change was only -13%; when technology was included the productivity increased to +48%.

The regions with the highest productivity for 2050 were found in Ireland, the United Kingdom, northern Germany, Denmark, The Netherlands and Belgium, where over 12 tons/ha could be achieved. The regions with the lowest productivity were southern Spain, eastern Turkey and northern Russia. There productivity reached no more than 3 tons/ha (Map 2).

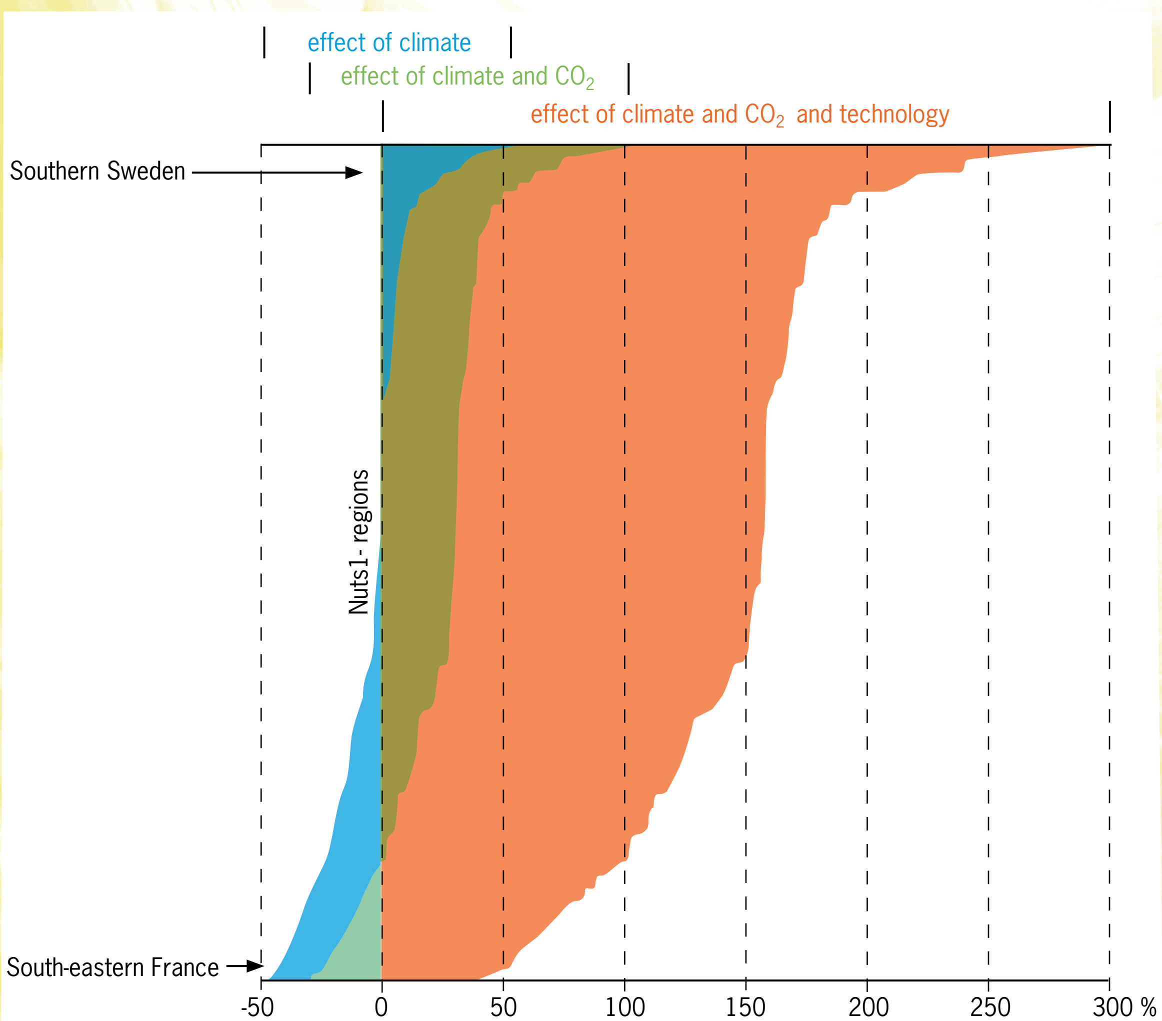
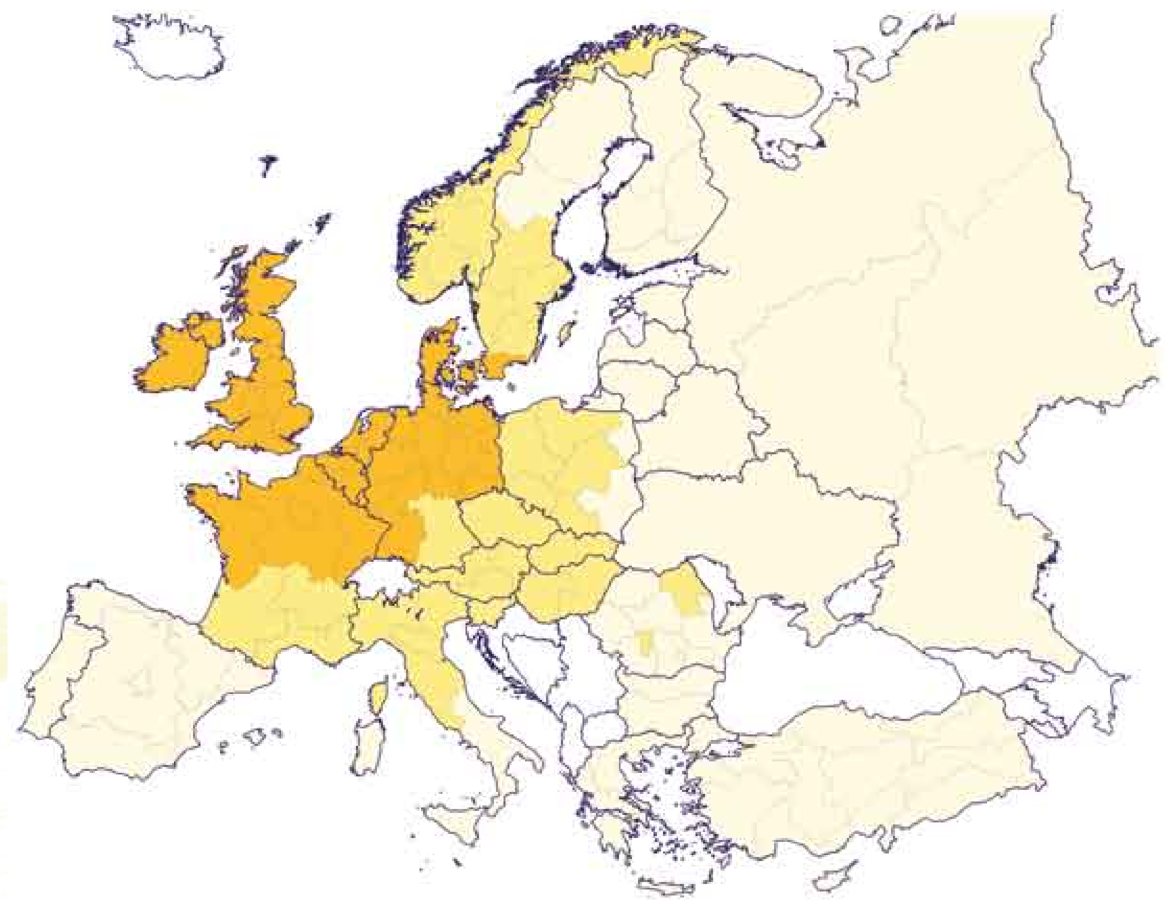


Figure 3: Changes (%) of productivity of wheat in European regions in 2050 compared to 2005 in scenario A1 as a result of climate (precipitation and temperature), CO_2 and technology.

Map 2. Wheat productivity (tons/ha)

2005



By multiplying the area under wheat cultivation in 2005 by the productivity for each region, the total achievable wheat production in the EU27 was calculated, leading to a predicted 160 million tons in 2020 and 220 million tons in 2050. The production demand for wheat, determined by population size and economic growth, was estimated to be 125 million tons in 2020 and 150 million tons in 2050. For wheat in scenario A1 in the EU27, the achievable supply far outweighed the production demand in both time slices, as can be seen in Figure 4.

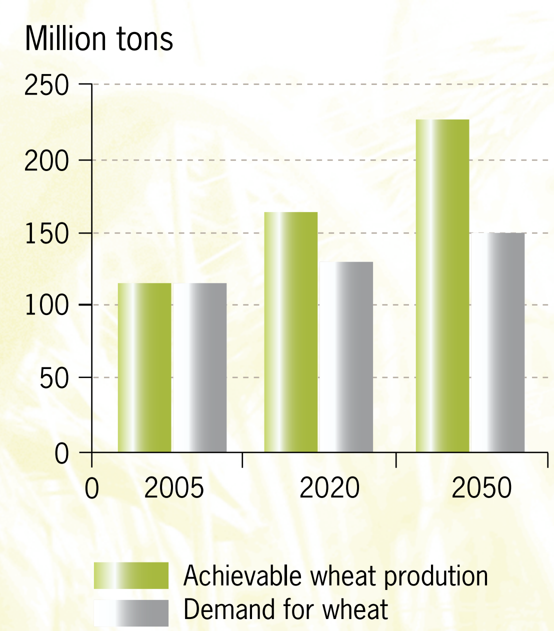
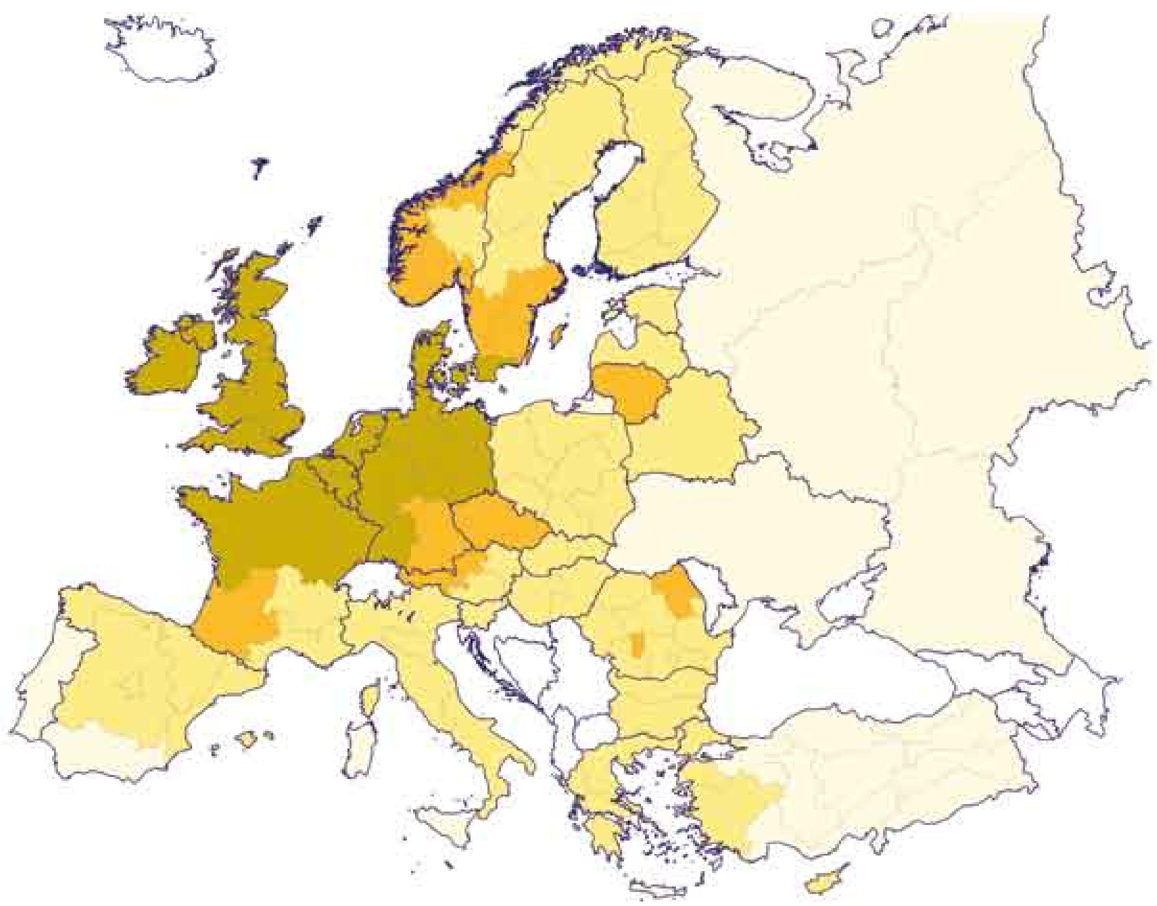


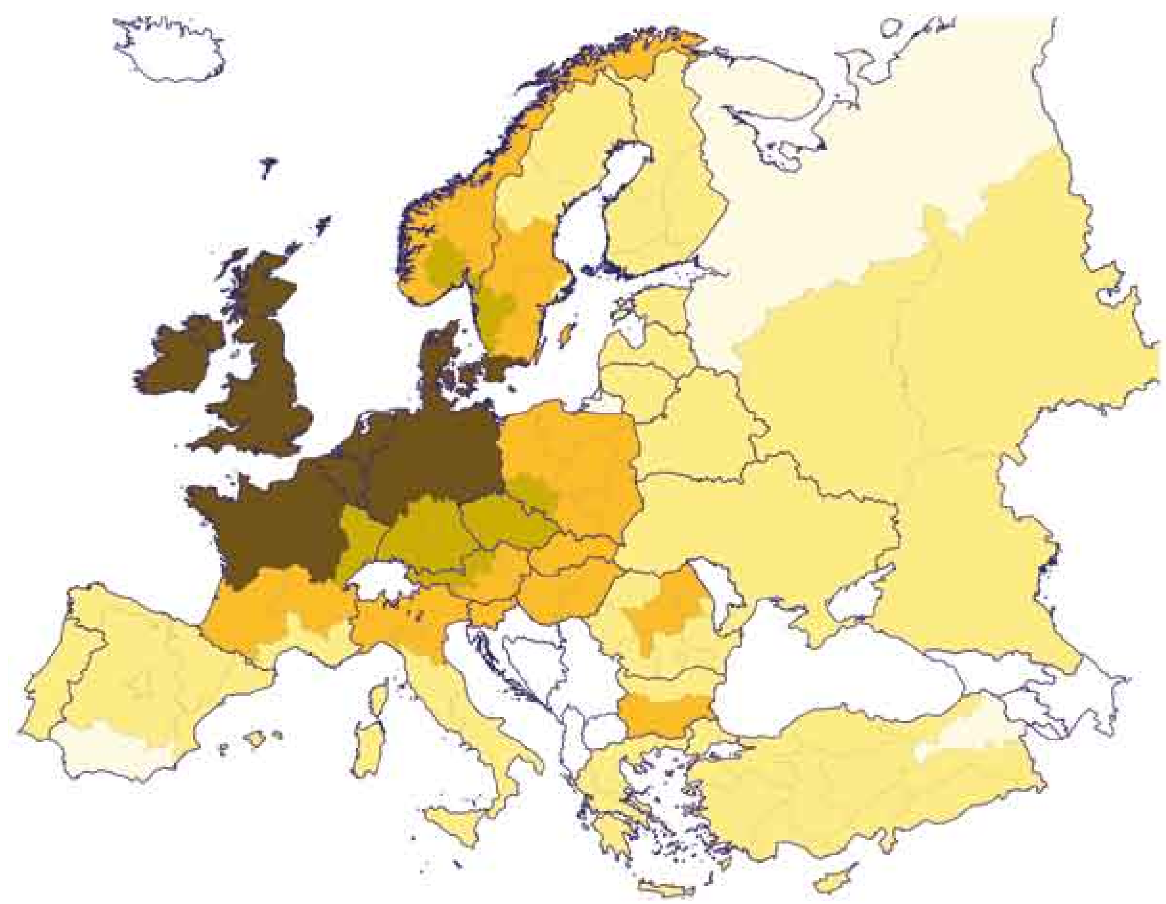
Figure 4: Achievable production of and demand for wheat in EU27 in scenario A1 at three time slices.

in Europe in **scenario A1** at three time slices

2020



2050



National instead of regional data were used to calculate the achievable production of wheat in the EU-Ural. The total was calculated by multiplying the productivity per country by the national wheat production area in 2005. The achievable production predicted was 235 million tons in 2020, and 345 million tons in 2050. The demand for wheat, which is related to population size and economic growth, was estimated at 195 million tons in 2020 and 260 million tons in 2050. Therefore, in scenario A1 in the EU-Ural, the achievable supply far outweighed the future demand for wheat, as can be seen in Figure 5.

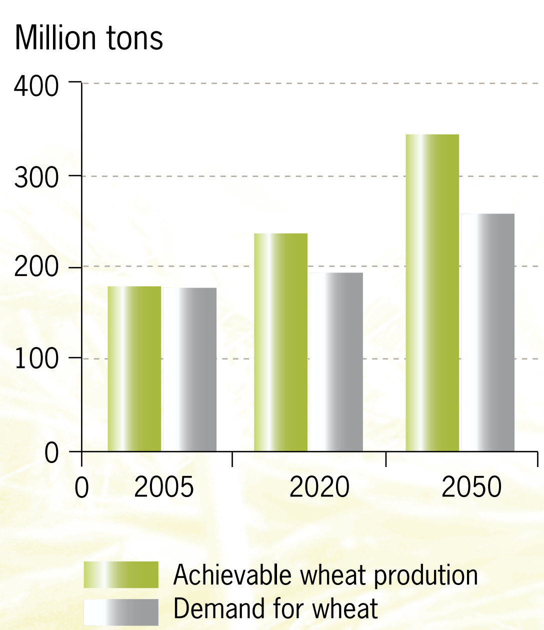


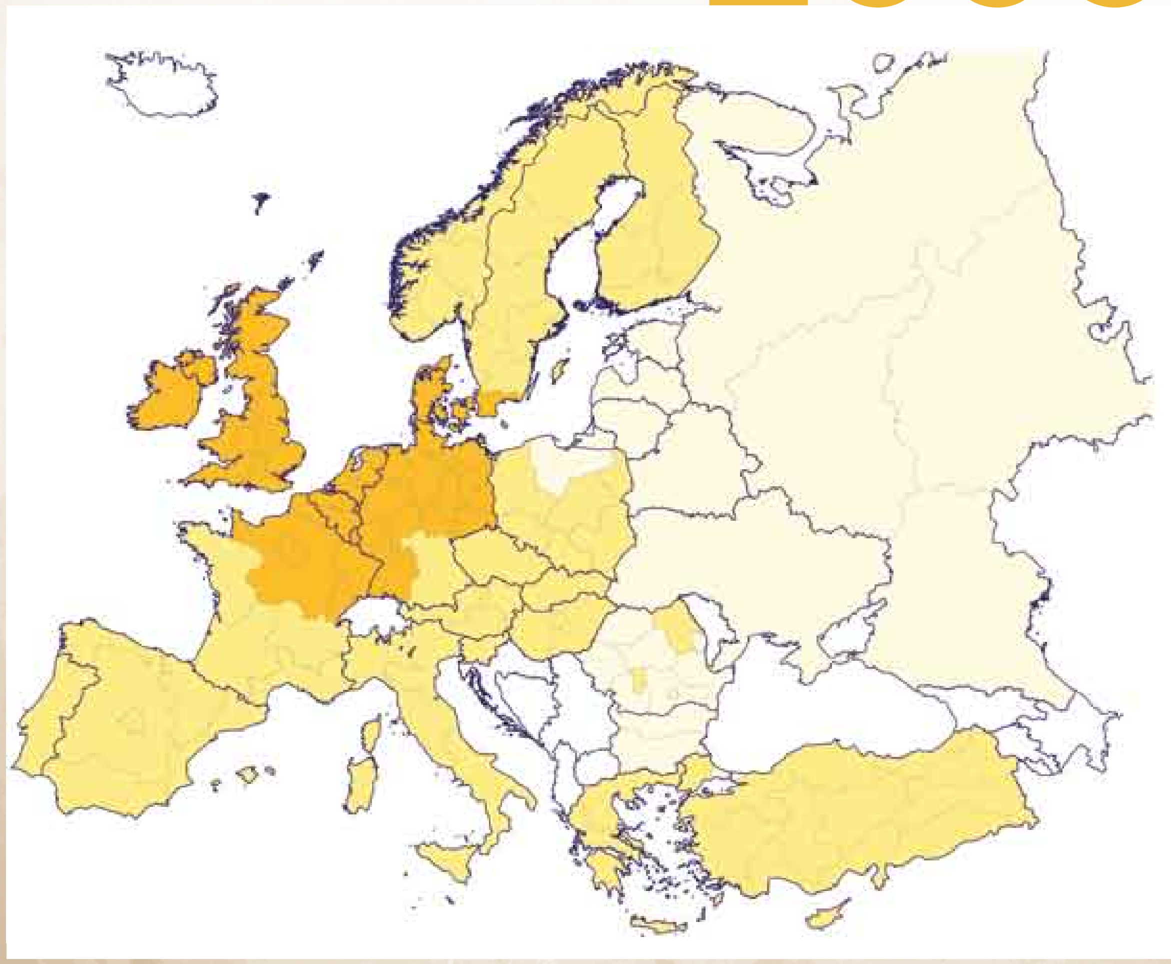
Figure 5: Achievable production of and demand for wheat in EU-Ural in scenario A1 at three time slices.

Legend

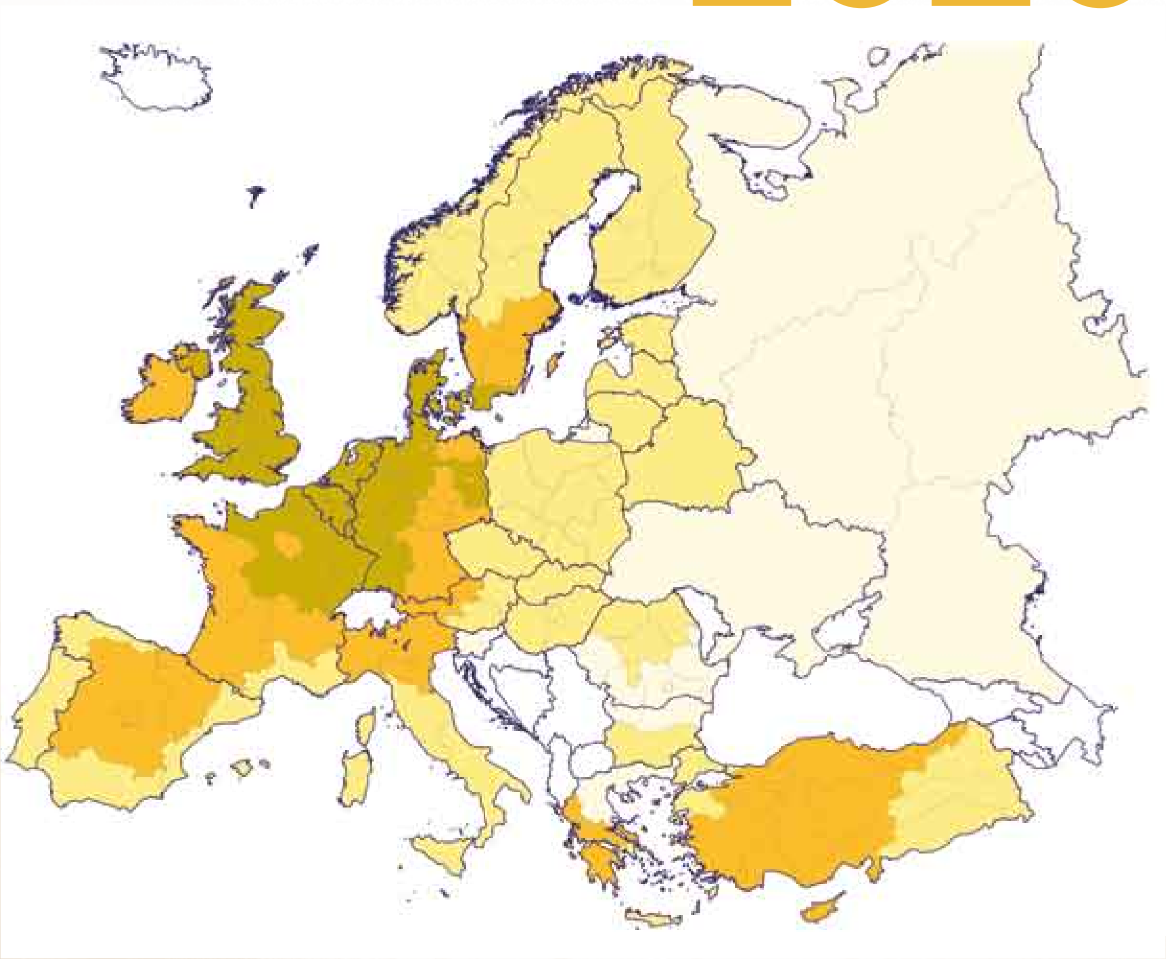
< 3	tons / ha
3 - 6	tons / ha
6 - 9	tons / ha
9 - 12	tons / ha
> 12	tons / ha

Map 3. Potato productivity (tons/ha) in Europe in **scenario A1** at three

2005



2020



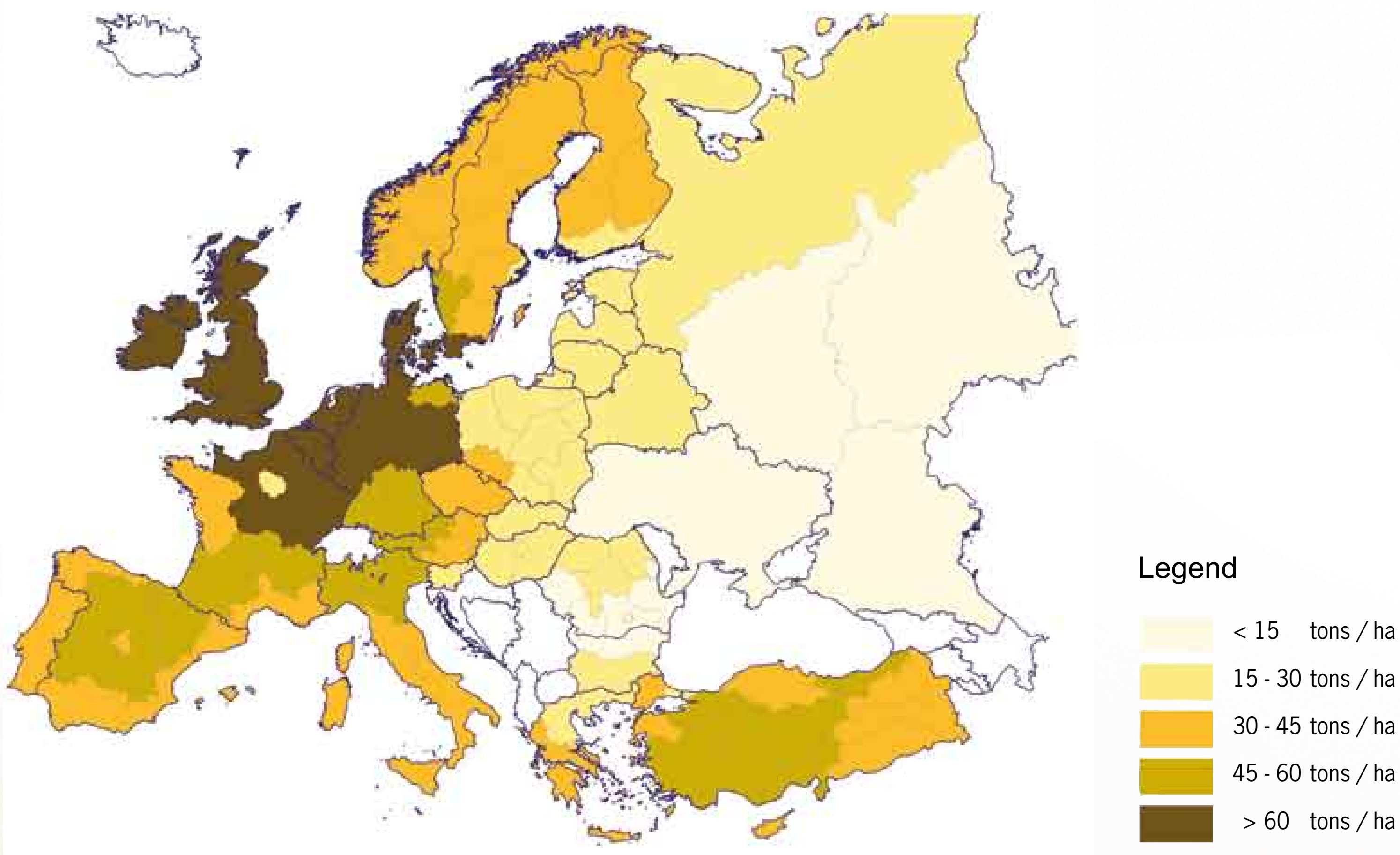
For 2050, it was predicted that potato productivity would increase throughout Europe but thirty regions, compared to 2005. However, there are large regional differences, ranging from -40% in the north of Greece to + 130% in Brandenburg in Germany.

These increases in productivity are the combined effect of changes in climate (precipitation and temperature), CO_2 and technology. Also for potato, technology is the main determining factor. When looking at changes in precipitation and temperature only, the productivity in 2050 is likely to be lower in about 80 out of 125 regions. When the effects of CO_2 and technology are added, all regions but 30 show an increase in productivity. Technological improvement in Eastern Europe is less advanced than in the West, therefore a lower percentage is used for these countries with regard to potatoes. This technology gap remains for all time slices and as a result, in regions with a low technology development stage, effects of CO_2 and technology are not always able to compensate a decrease in productivity for potatoes due to precipitation and temperature effects. In the Czech Republic, Slovenia, Slovakia, and in some regions in Poland, Romania and the north of Greece, productivity in 2050 will be lower than in 2005.

The regions with the highest productivity for 2050 were found in the United Kingdom, Denmark, the Netherlands and Belgium, Nordrhein-Westfalen and Rheinland-Pfalz in Germany and northern France, where over 60 tons/ha could be achieved. The regions with the lowest productivity were Russia, Ukraine, southern Romania and northern Bulgaria. There productivity reached no more than 15 tons/ha (Map 3).

time slices

2050



By multiplying the area under potato cultivation in 2005 by the productivity for each region, the total achievable potato production in the EU27 was calculated, leading to a predicted 68 million tons in 2020 and 89 million tons in 2050. The demand for potatoes, determined by population size and economic growth, was estimated to be 56 million tons in 2020 and 67 million tons in 2050. For potatoes in scenario A1 in the EU27, the achievable supply outweighed the production demand in both time slices, as can be seen in Figure 6.

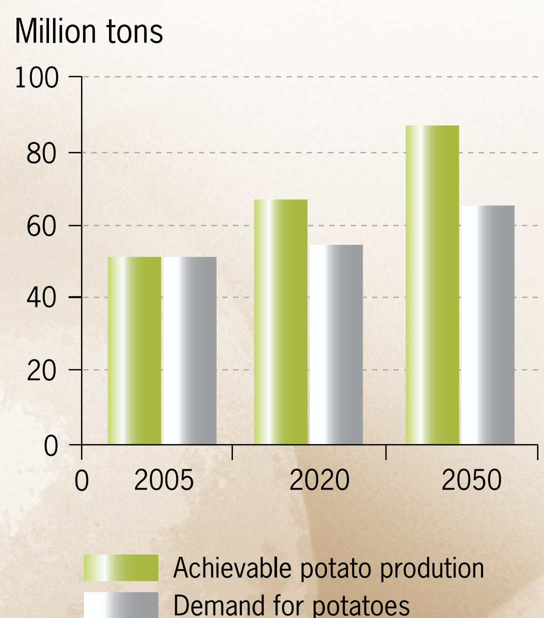


Figure 6: Achievable production of and demand for potatoes in EU27 in scenario A1 at three time slices.

National instead of regional data were used to calculate the achievable production of potatoes in the EU-Ural. The total was calculated by multiplying the productivity per country by the national potato production area in 2005. The achievable production predicted was 118 million tons in 2020, and 150 million tons in 2050. The demand for potatoes, which is related to population size and economic growth, was estimated at 98 million tons in 2020 and 126 million tons in 2050. Therefore, in the A1 scenario in the EU-Ural, the achievable supply outweighed the future demand for potatoes, as can be seen in Figure 7.

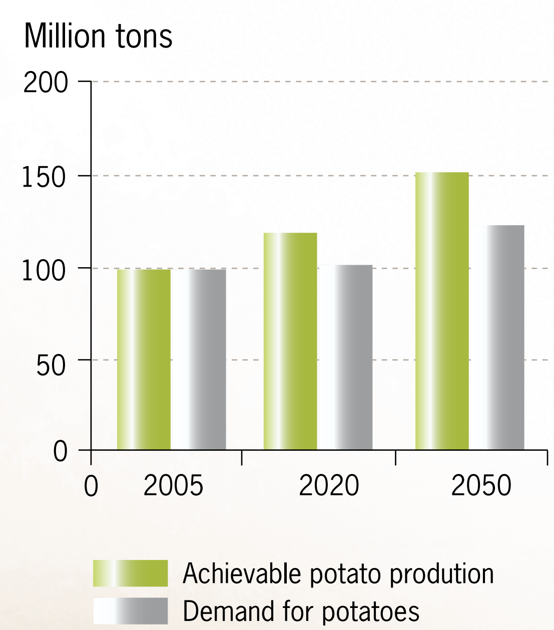
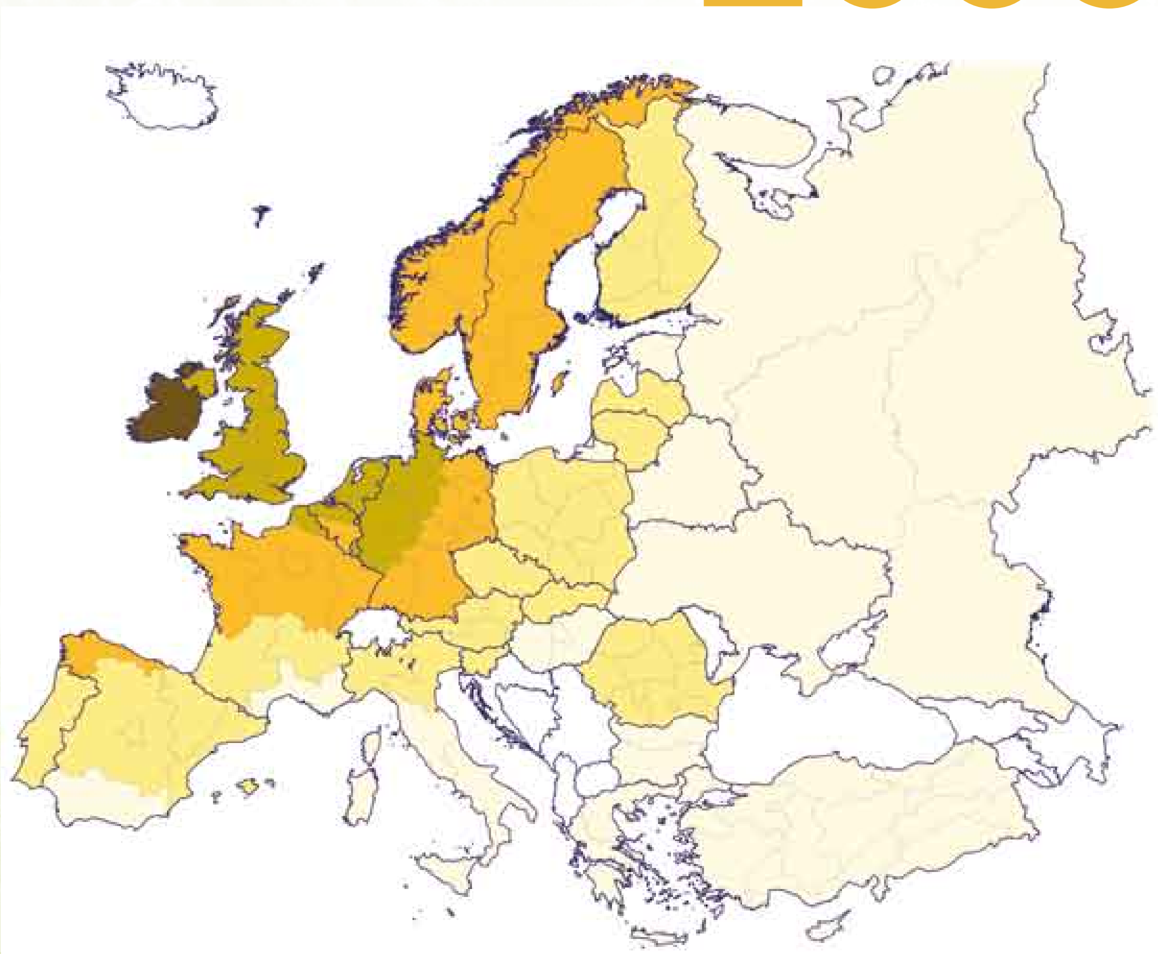


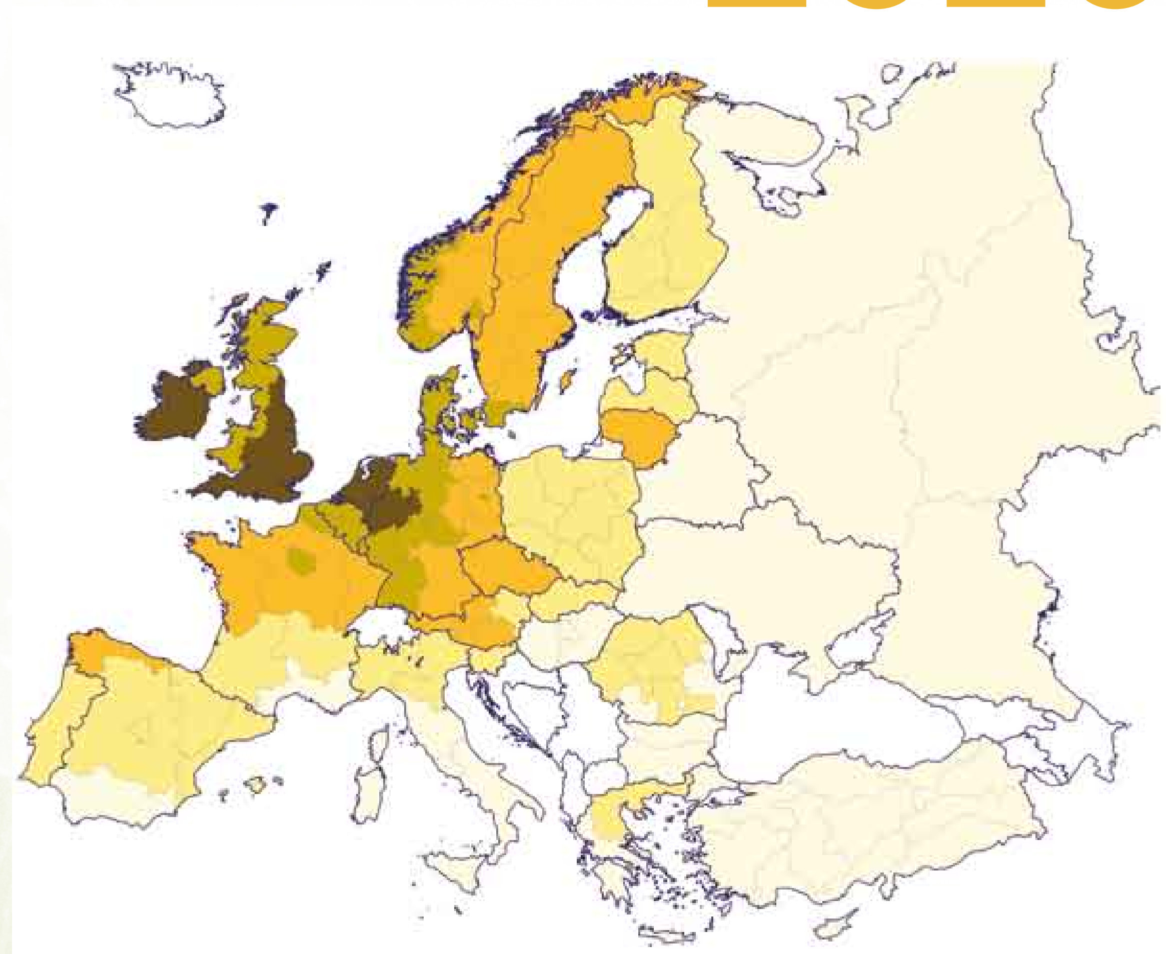
Figure 7: Achievable production of and demand for potatoes in EU-Ural in scenario A1 at three time slices.

Map 4. Grass productivity (tons/ha) in Europe in **scenario A1** at three

2005



2020



For 2050, it was predicted that grass productivity would increase throughout Europe but fourteen regions, compared to 2005. However, there are large regional differences, ranging from -35% in eastern France to + 120% in Estonia.

The increases in productivity are the combined effect of changes in climate (precipitation and temperature), CO_2 and technology. Contrary to wheat and potatoes, not technology but climate and CO_2 are the determining factors. The fourteen regions with decreasing grass productivity are eastern Austria, the Czech Republic, Sachsen in Germany, Portugal, northern and eastern Spain, southern France, central Italy, southern Poland, Romania, Slovenia and Slovakia.

The regions with the highest productivity for 2050 were Ireland, the United Kingdom, the Netherlands and northwestern Germany, where over 10 tons/ha could be achieved. The regions with the lowest productivity were the east European countries Russia, Belarus, Ukraine, Bulgaria, Turkey and southern Italy and southern France. There productivity reached no more than 2 tons/ha (Map 4).

By multiplying the area under grass production in 2005 by the productivity for each region, the total achievable grass production per EU27 region is calculated. The achievable grass production is translated into achievable milk production. By adding up the regional milk productions, total achievable milk production in the EU27 was calculated, leading to a predicted 160 million tons in 2020 and 170 million tons in 2050. The demand for milk, determined by population size and economic growth, was estimated to be 155 million tons in 2020 and 160 million tons in 2050. For milk in scenario A1 in the EU27, the achievable supply and the demand were more or less in balance in both time slices, as can be seen in Figure 8.

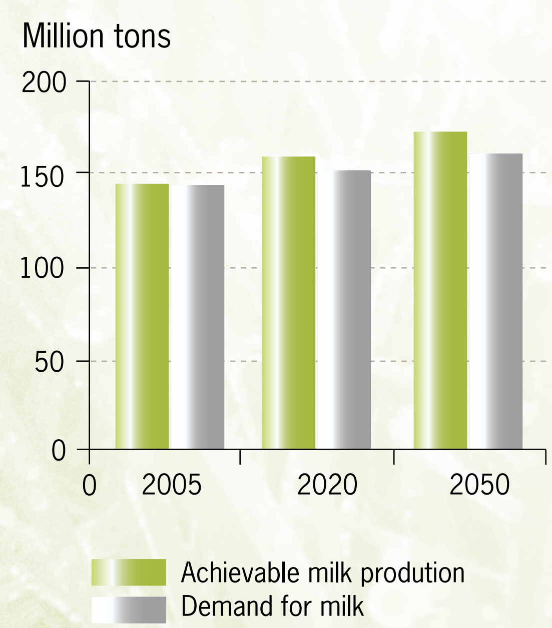
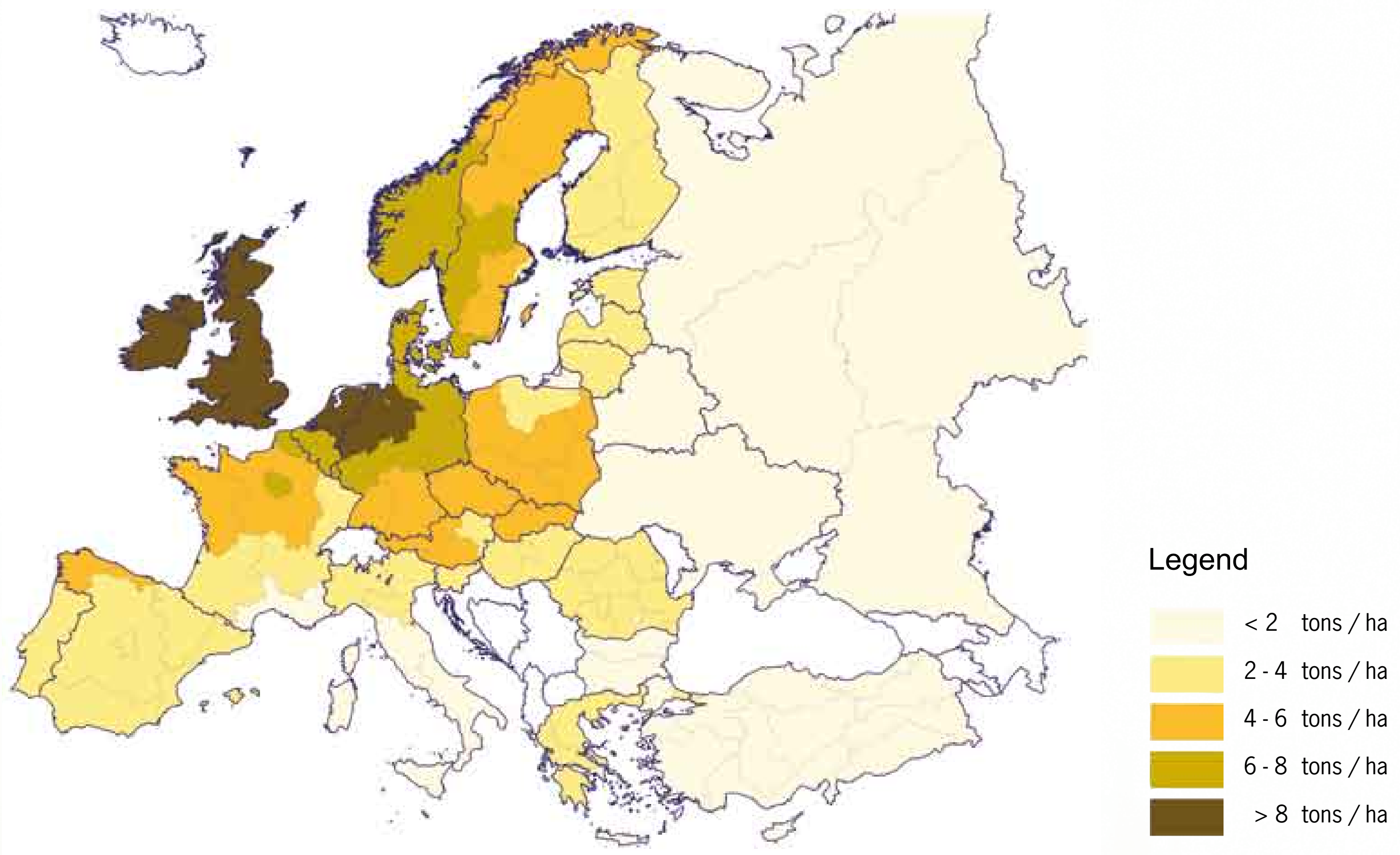


Figure 8: Achievable production of and demand for milk in EU27 in scenario A1 at three time slices.

2050



National instead of regional data were used to calculate the achievable production of grass in the EU-Ural. The national total was calculated by multiplying the productivity per country by its grass production area in 2005. The achievable national production was translated into the national milk production. The achievable production predicted was 200 million tons in 2020 and 225 million tons in 2050. The demand for milk, which is related to population size and economic growth, was estimated at 190 million tons in 2020 and 235 million tons in 2050. For milk in scenario A1 in the EU-Ural, the achievable supply and the demand were more or less balanced, although the demand slightly outruns the supply in 2050, as can be seen in Figure 9.

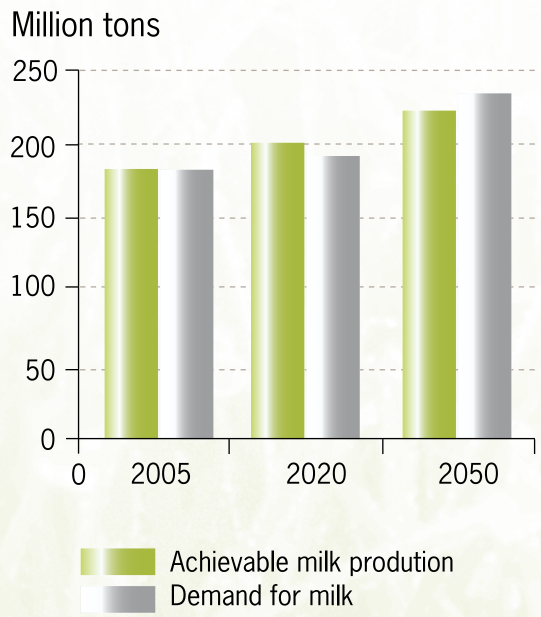
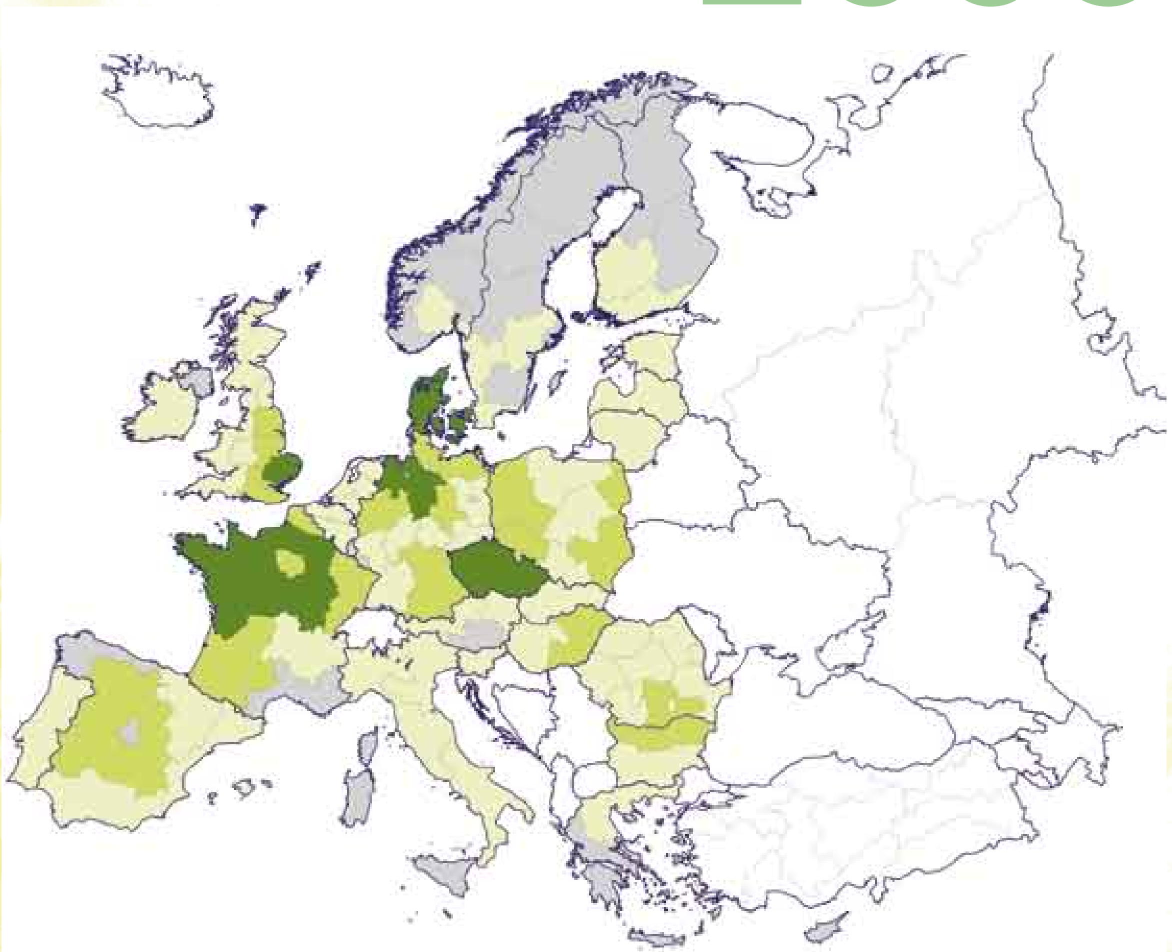


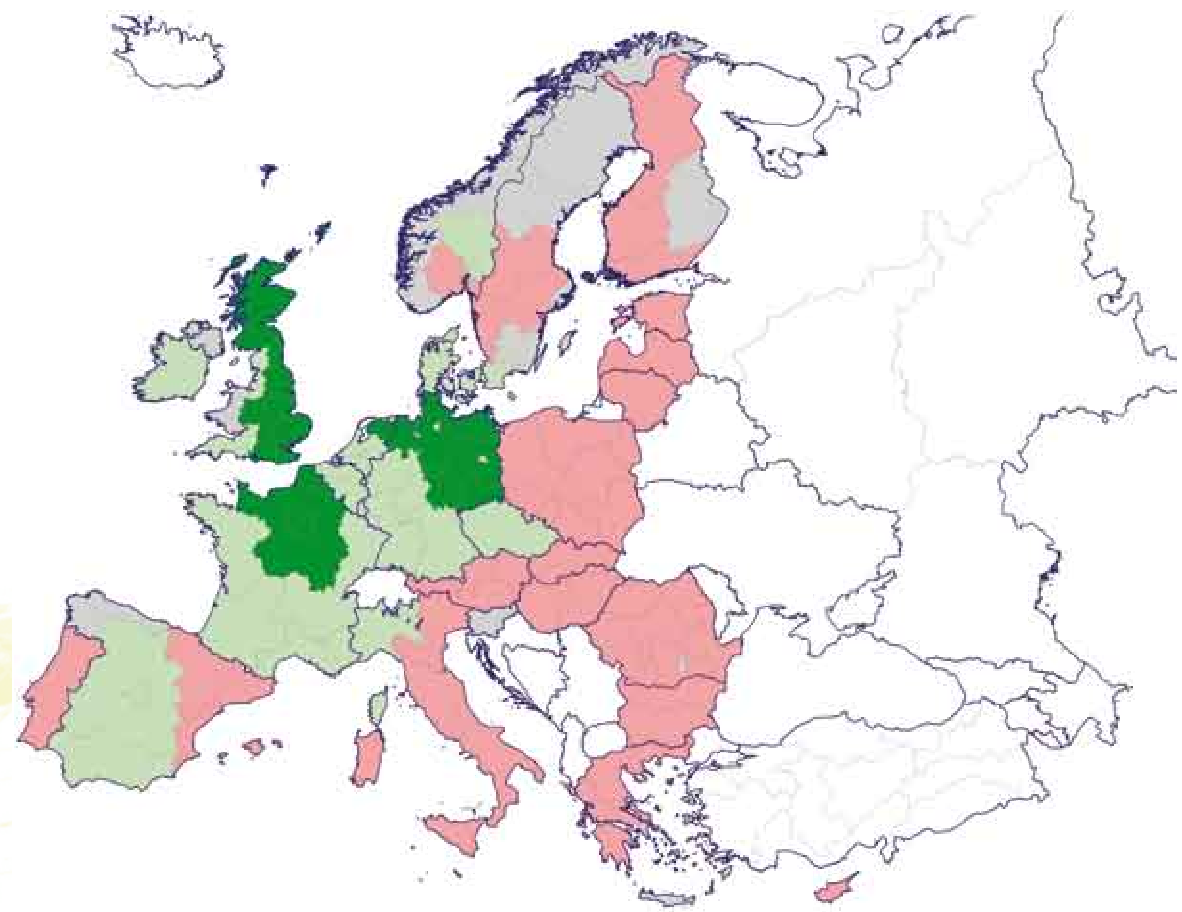
Figure 9. Achievable production of and demand for milk in EU-Ural in scenario A1 at three time slices.

Map 5. Wheat production regions in EU27 based on competitiveness

2005



competitiveness



In 2005, one third of the total wheat production was from Denmark, the Czech Republic, north-western France, eastern England and Niedersachsen in Germany together (Map 5, 2005). The scenario predicts that there will be a surplus of wheat land in 2020, and even more so in 2050 (Figure 4), because the productivity increase will exceed the increase in demand.

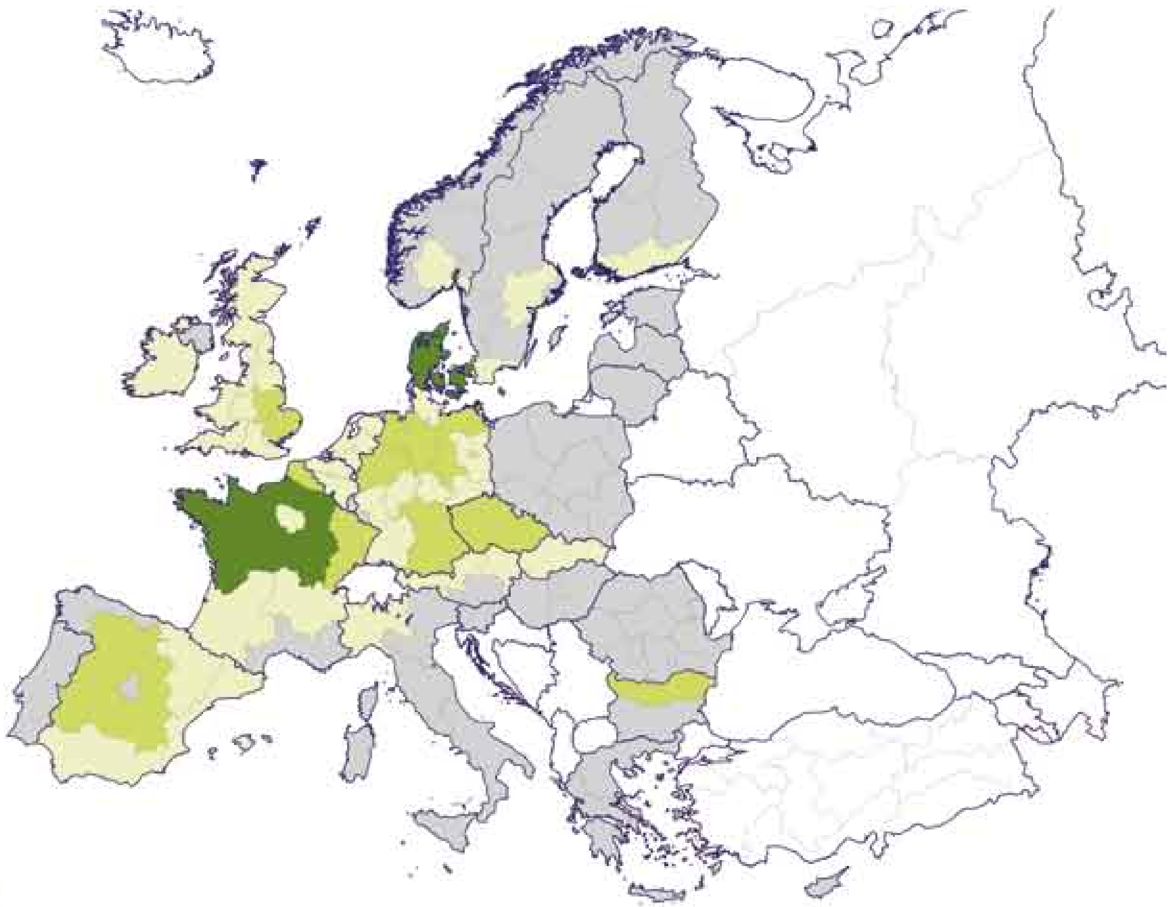
When supply outweighs demand, estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of wheat in 2020 and 2050, it is necessary to consider how competitive regions are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

Firstly, competitiveness on the global food market was considered in isolation (Map 5, competitiveness). The regions with the most favourable prospects are north-western France, north-eastern Germany, northern Netherlands and eastern UK. In these regions, average size is 110 ESU/holding. Regions with the least favourable prospects are (with the exception of the Czech Republic) the new member states, Greece, Italy (except in the northwest), Portugal, eastern Spain, and in the north Norway, Sweden and Finland. In these regions, the average size is only 8 ESU/holding. Hence, competitiveness within the EU27 regions varies widely.

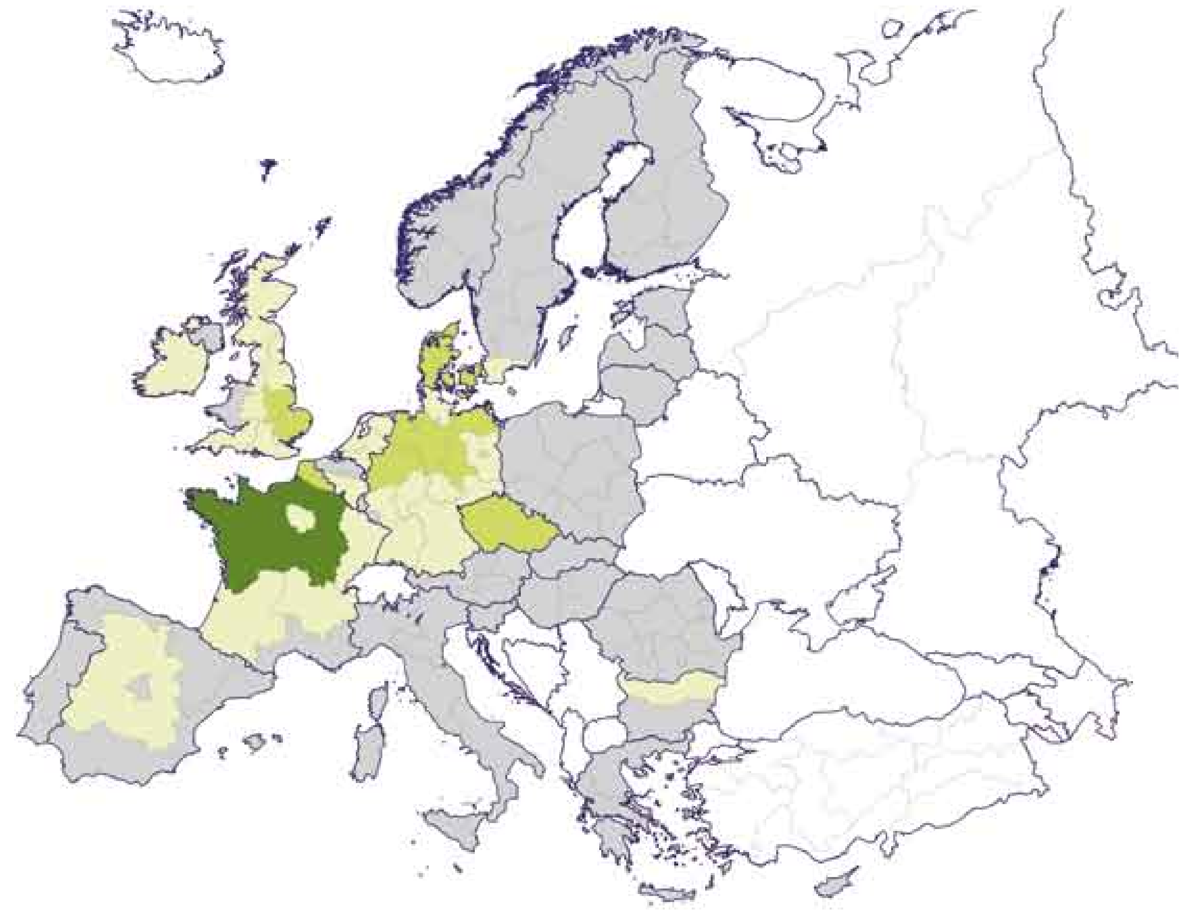
The regions with the least favourable prospects in 2020, which will most likely lose their wheat farms, are the eastern European countries (except the Czech Republic, Slovakia and northern Bulgaria), northern Greece, Italy (except for the northwest), and Portugal (Map 5, 2020). The total demand of 125 million tons will be produced on 15.2 million ha (Figure 10). By 2050 large parts of Spain, north-western Italy, Austria, Slovakia, Wales and Flanders will also go out of wheat production (Map 5, 2050). These areas will become available for alternative agrarian or non-agrarian activities. In 2050, France will be capable of supplying more than one third of the total EU27 wheat demand. The total demand of 150 million tons will be produced on 11.5 million ha (Figure 10).

within the global food market in **scenario A1** at three time slices

2020



2050



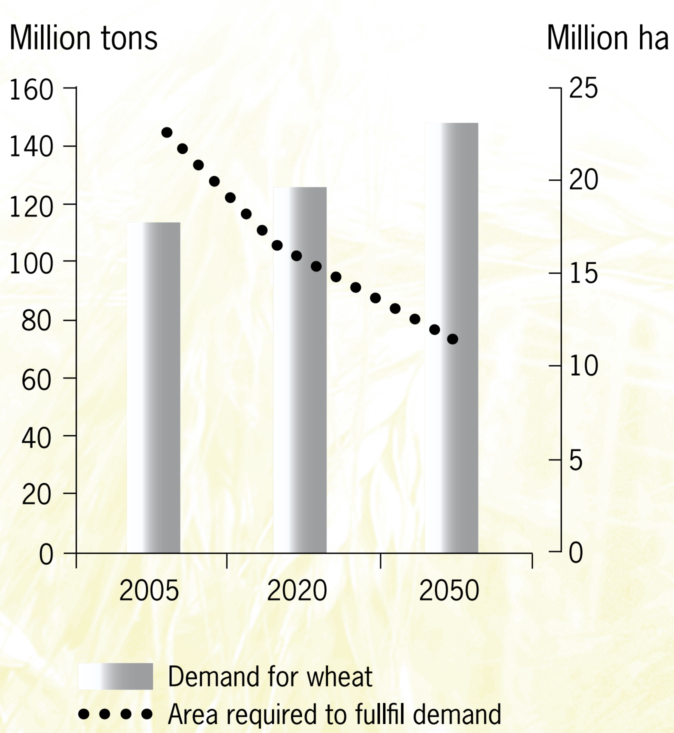


Figure 10.
Demand for wheat and corresponding area in EU27, based on competitiveness of arable production on global food markets in scenario A1 at three timeslices.

Legend

Each class one third of total wheat production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

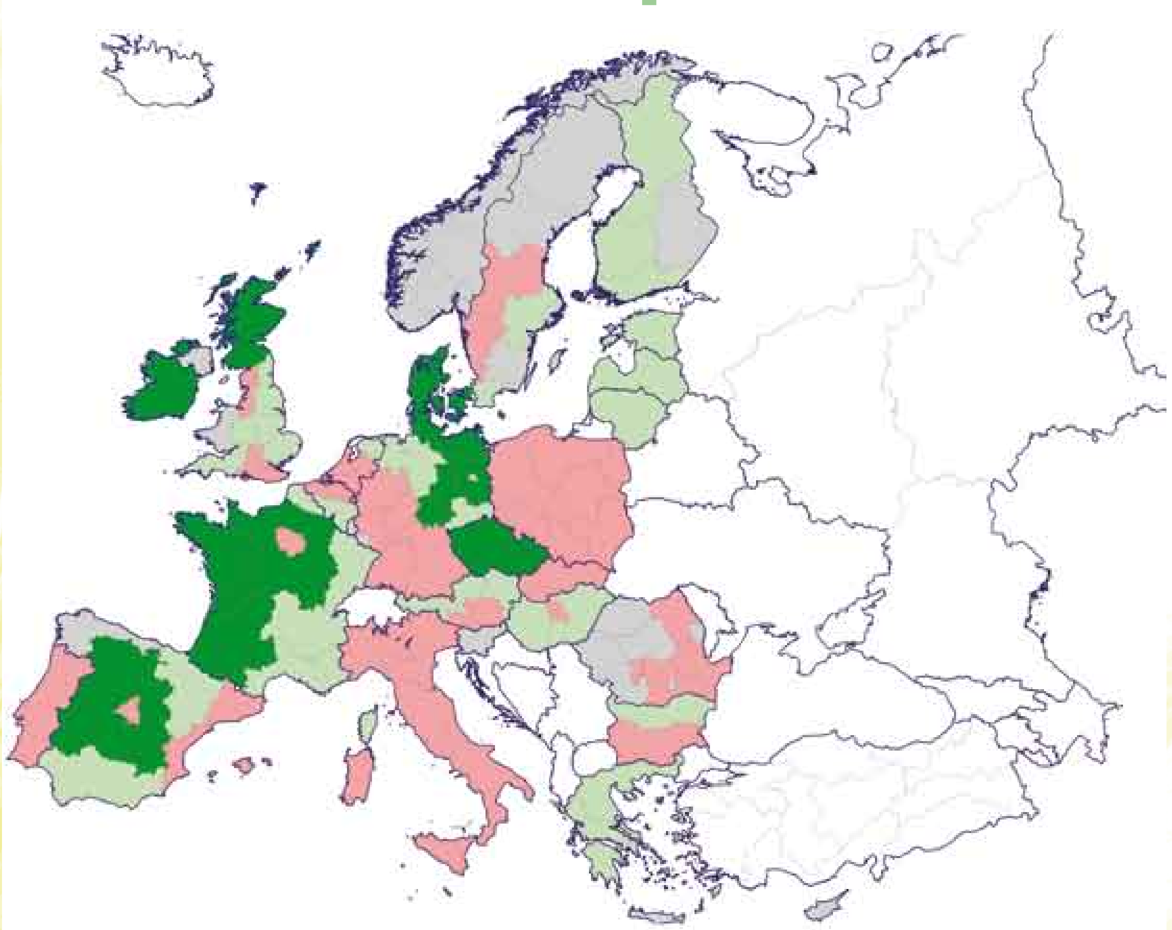
ESU/holding

- >=65
- 20 – 65
- <=20
- <0,1% of total EU27 ESU

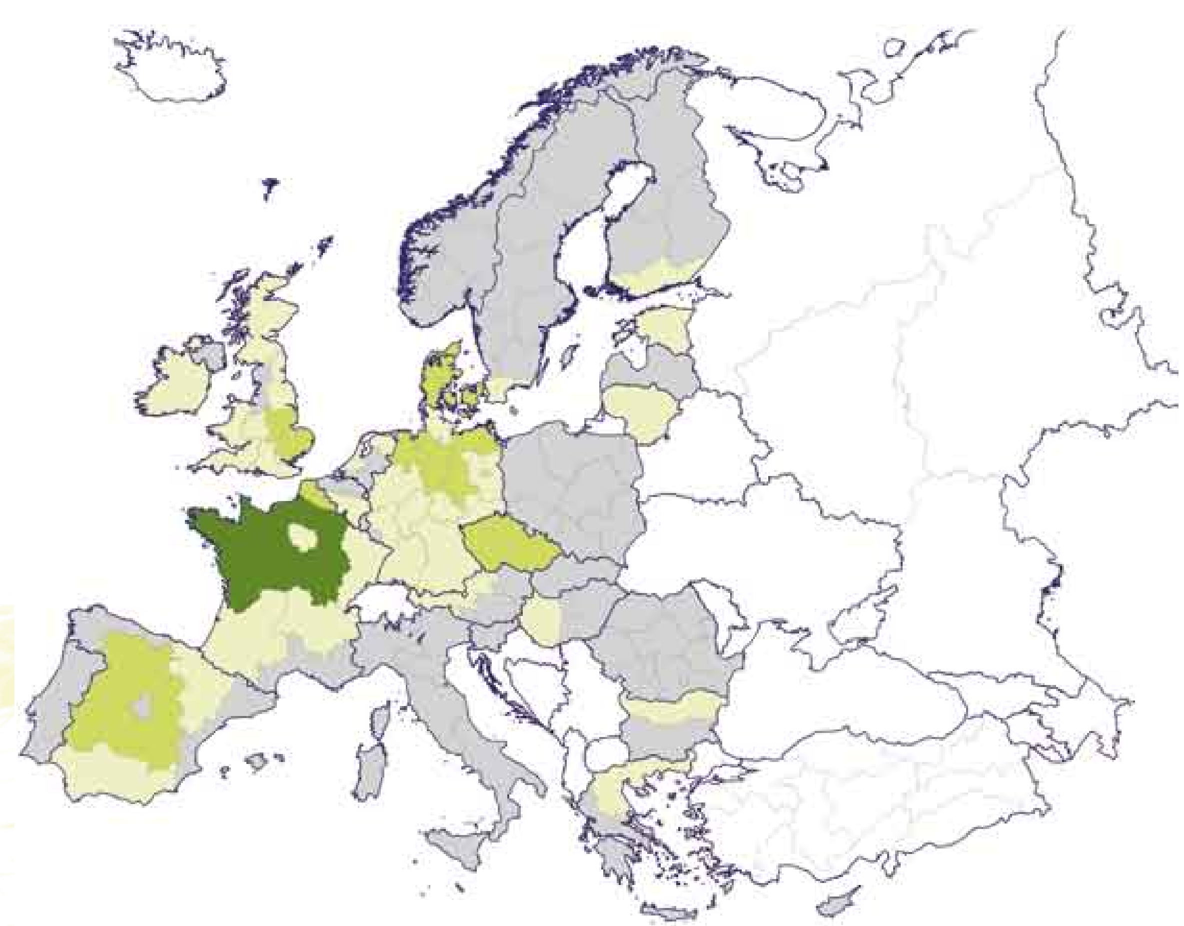
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 6. Wheat production regions in EU27 based on competitiveness within the

competitiveness



2050



If competitiveness in regional land markets is also in taken into account (Map 6, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale. In 2050 the most competitive regions are those with large holdings and a low population pressure. These occur in western France, Ireland, Denmark, Scotland, eastern Germany and the Czech Republic. In these regions the average size is 90 ESU/holding and the average population pressure is 1.6 inhabitants/agrarian ha. The regions with the least favourable prospects are in Poland, Slovakia, Italy, Portugal, eastern Spain, Flanders and the entire Rhine basin, i.e. western Germany and the Netherlands. These regions combine relatively small holdings (18.1 ESU/holding) with high population pressure (11.2 inhabitants/agrarian ha). Here the number of wheat farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market, France remains the most important wheat production area in the EU27 (Map 2050). The largest changes are found in the Rhine basin. The eastern and southern Netherlands and Nordrhein-Westfalen will lose wheat farms in favor of Wales and some regions in eastern and southern Europe. Moreover, a larger land area will be required (13.3 million ha instead of 11.5 million ha) because the most densely populated areas are among the most productive in the EU27 (Map 6, 2050).

global food market and the regional land market in **scenario A1** at 2050

Legend

Each class one third of total wheat production in 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

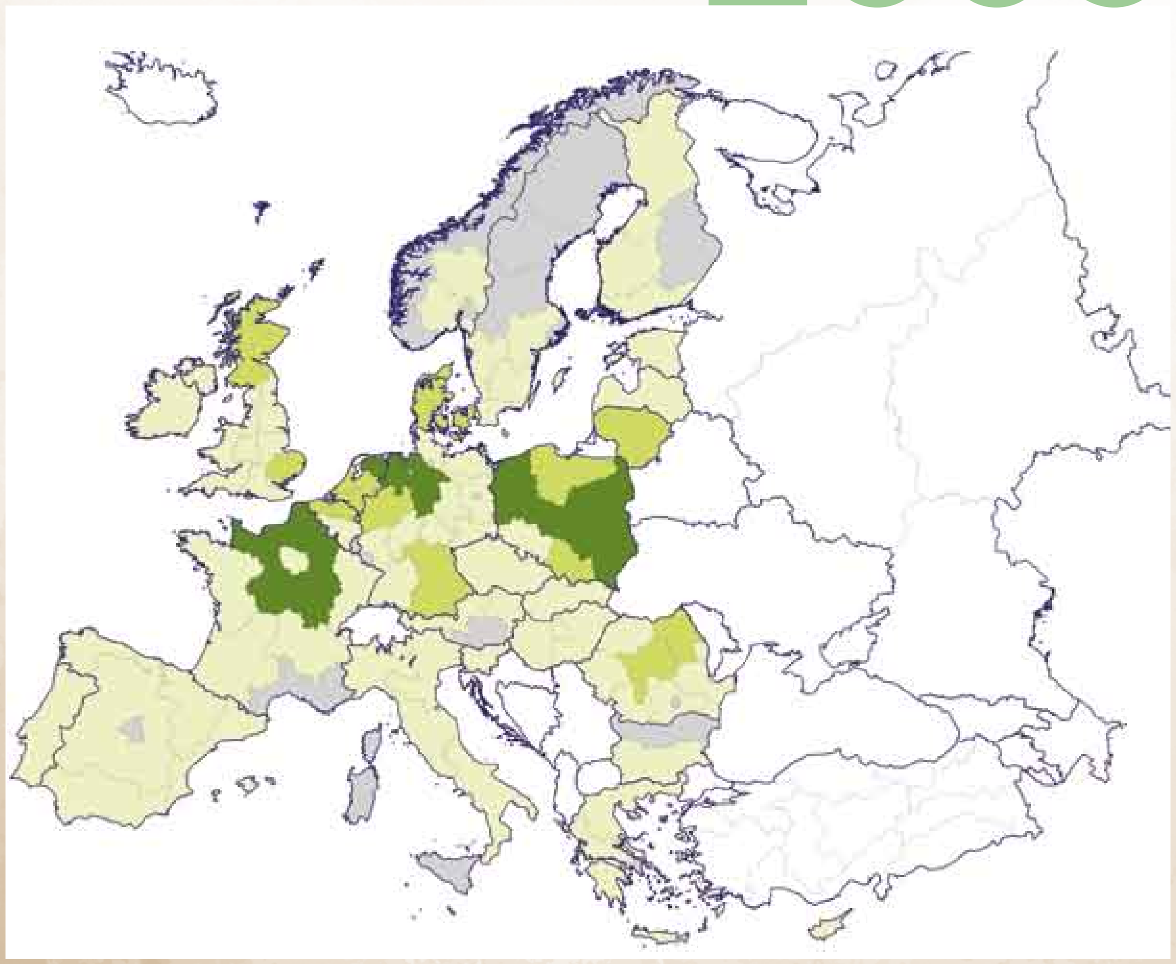
ESU/holding	Inhabitants/ha UAA
20 - 230	< 3
2 - 130	< 6
0 - 105	< 235

<0,1% of total EU27 ESU

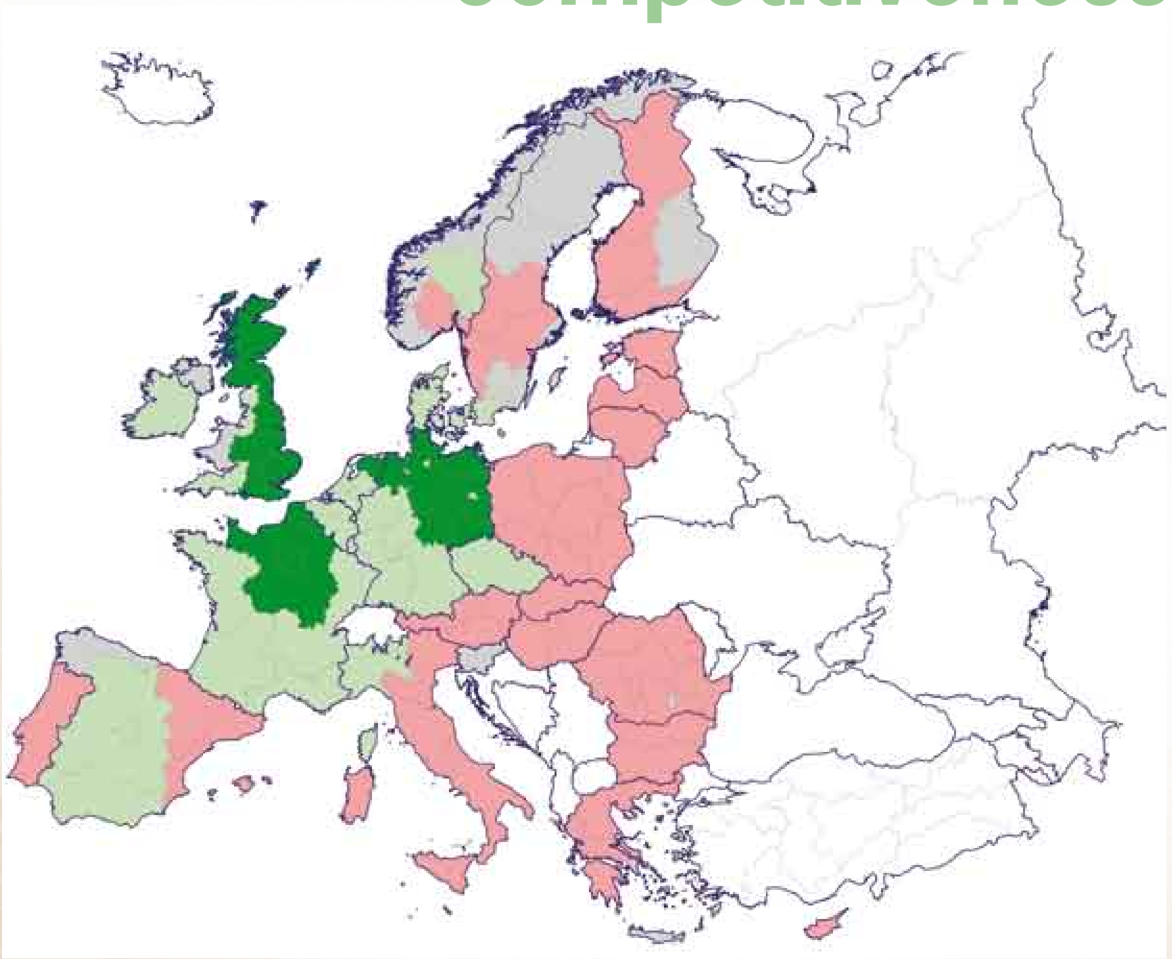
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 7. Potato production regions in EU27 based on competitiveness

2005



competitiveness



In 2005, one third of the total potato production was from northern France, northern Netherlands, Niedersachsen in Germany and Poland together (Map 7, 2005). The scenario predicts that there will be a surplus of potato land in 2020, and even more so in 2050 (Figure 6), because the productivity increase will exceed the increase in demand.

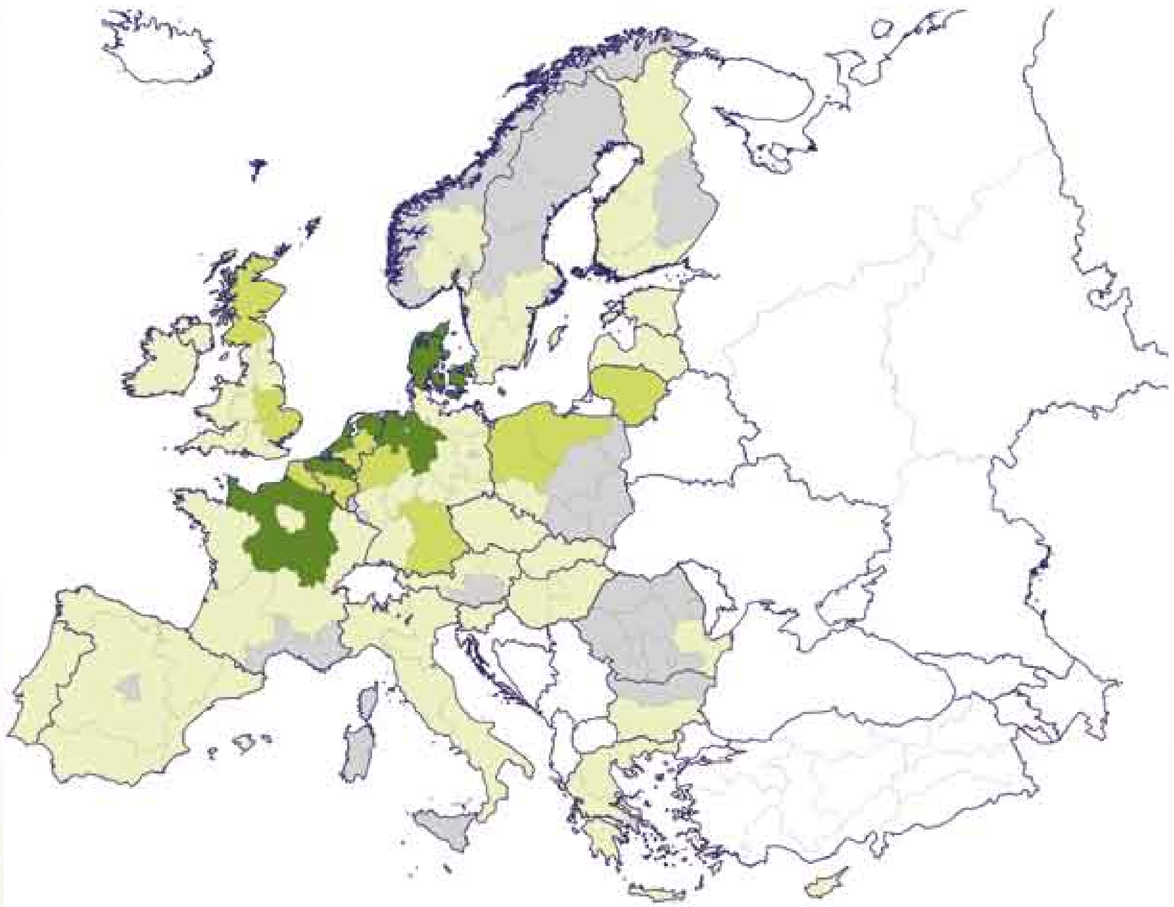
Because supply outweighs demand estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of potatoes in 2020 and 2050, it is necessary to consider how competitive regions are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

Firstly, competitiveness on the global food market was considered in isolation (Map 7, competitiveness). The regions with the most favourable prospects are north-western France, north-eastern Germany, northern Netherlands and eastern UK. In these regions, average size is 110 ESU/holding. Regions with the least favourable prospects are (with the exception of the Czech Republic) the new member states, Greece, Italy (except in the northwest), Portugal, eastern Spain and in the north Norway, Sweden and Finland. In these regions, the average size is only 8 ESU/holding, Hence, competitiveness within the EU27 regions varies enormously.

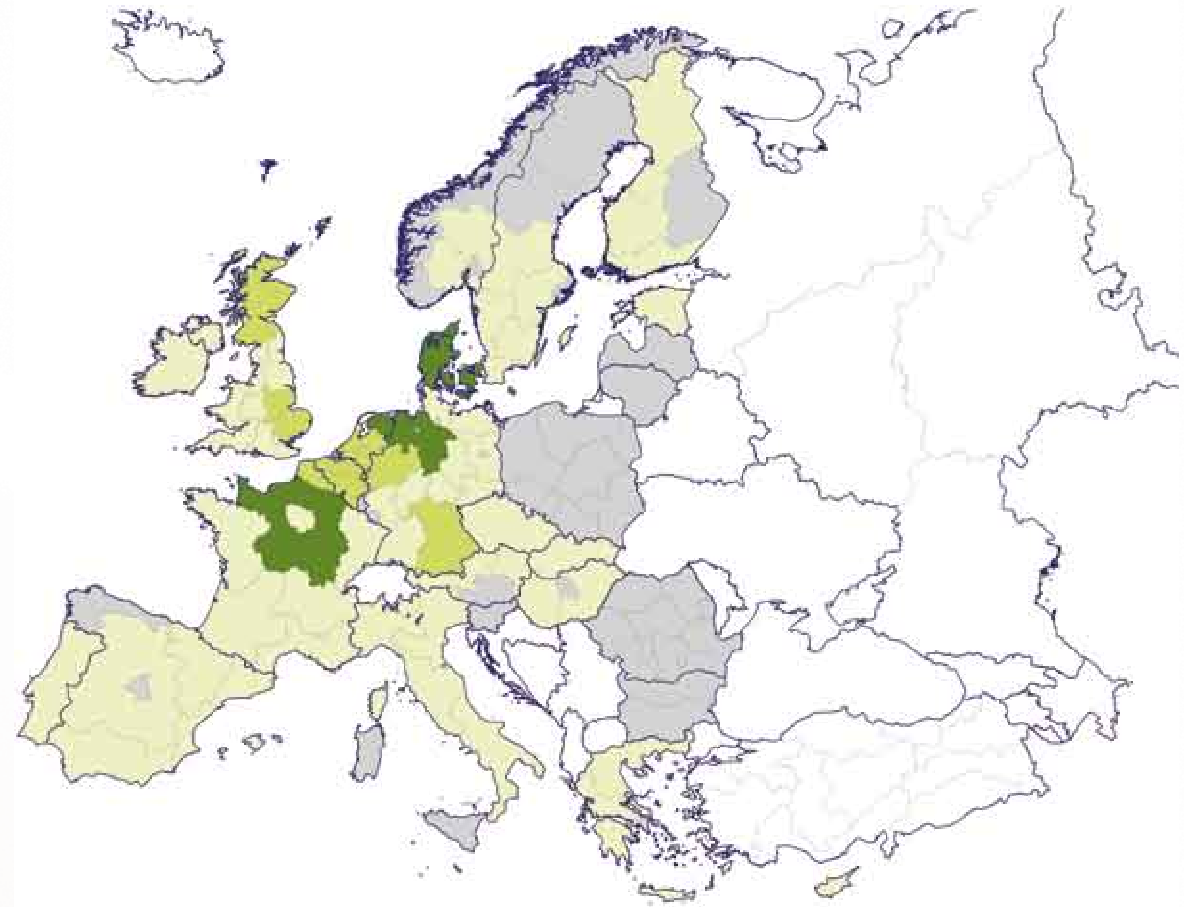
The regions with the least favourable prospects in 2020, which will most likely lose their potato farms, are eastern Poland and Romania (Map 7, 2020). The total demand of 56 million tons will be produced on 1.5 million ha (Figure 11). These areas will become available for alternative agrarian or non-agrarian activities. By 2050, western Poland, Slovenia, Bulgaria and north-western Spain will also go out of potato production (Map 7, 2050). In 2050, northern France, northern Netherlands, Niedersachsen in Germany and Denmark together will be capable of supplying more than one third of the total EU potato demand. The total demand of 67 million tons will be produced on 1.1 million ha (Figure 11).

within the global food market in **scenario A1** at three time slices

2020



2050



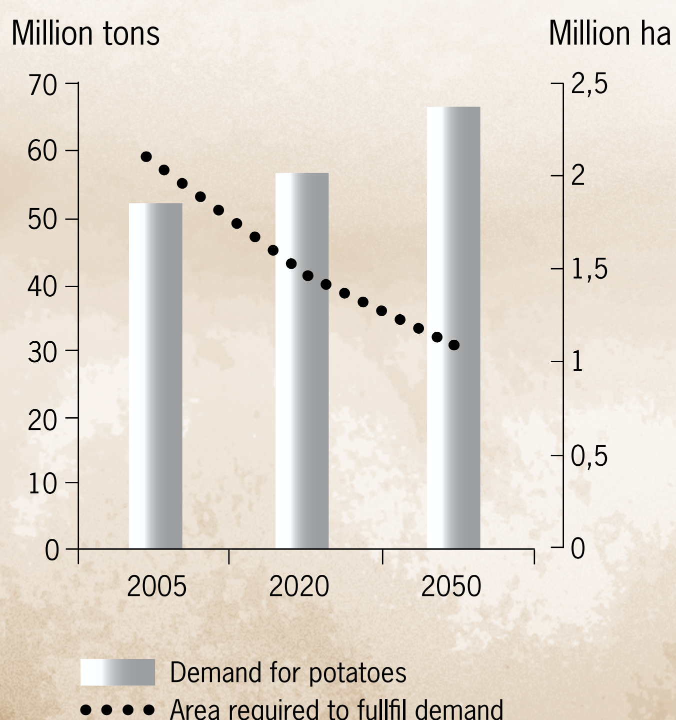


Figure 11.
Demand for potatoes and corresponding area in EU27, based on competitiveness of arable production on global food markets in scenario A1 at three time slices.

Legend

Each class one third of total potato production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

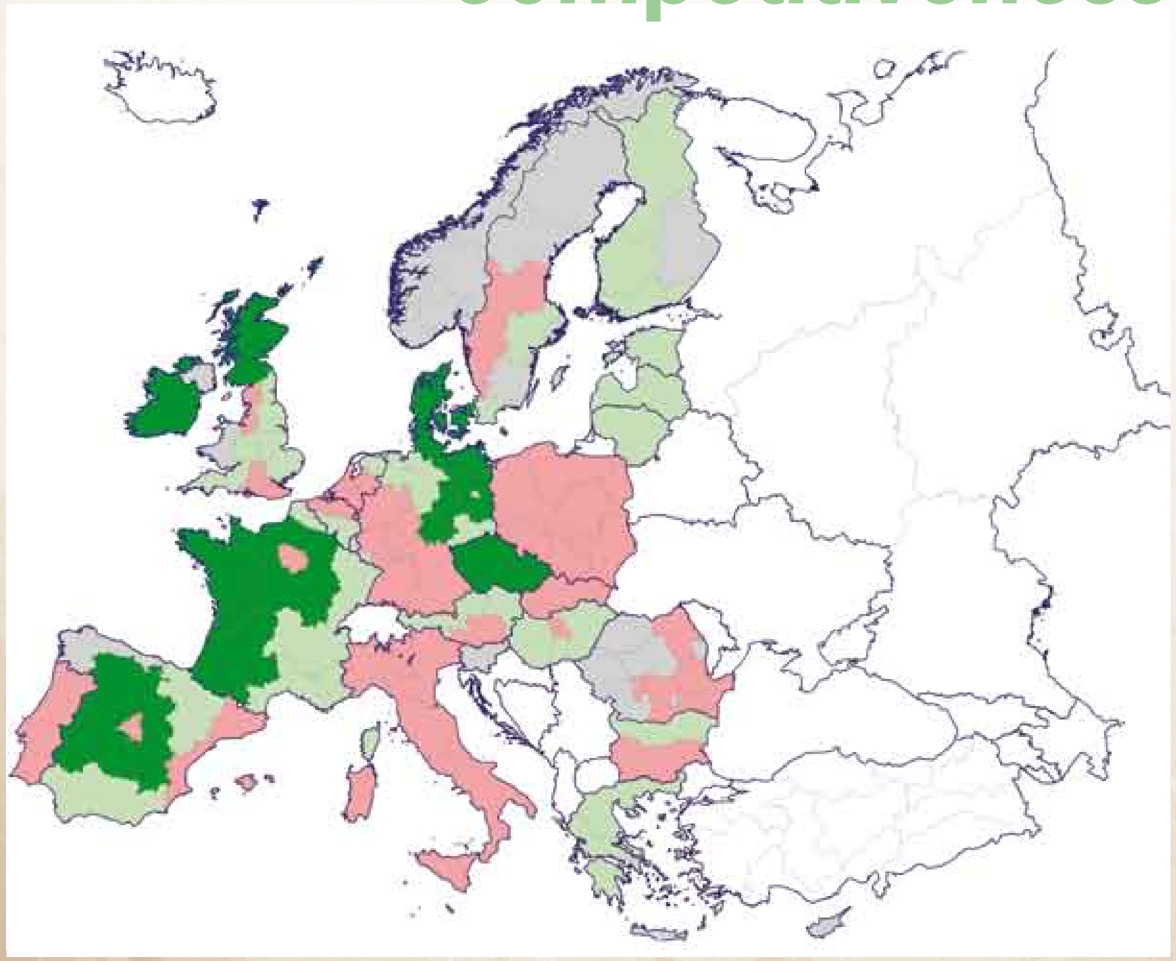
ESU/holding

- >=65
- 20 – 65
- <=20
- <0,1% of total EU27 ESU

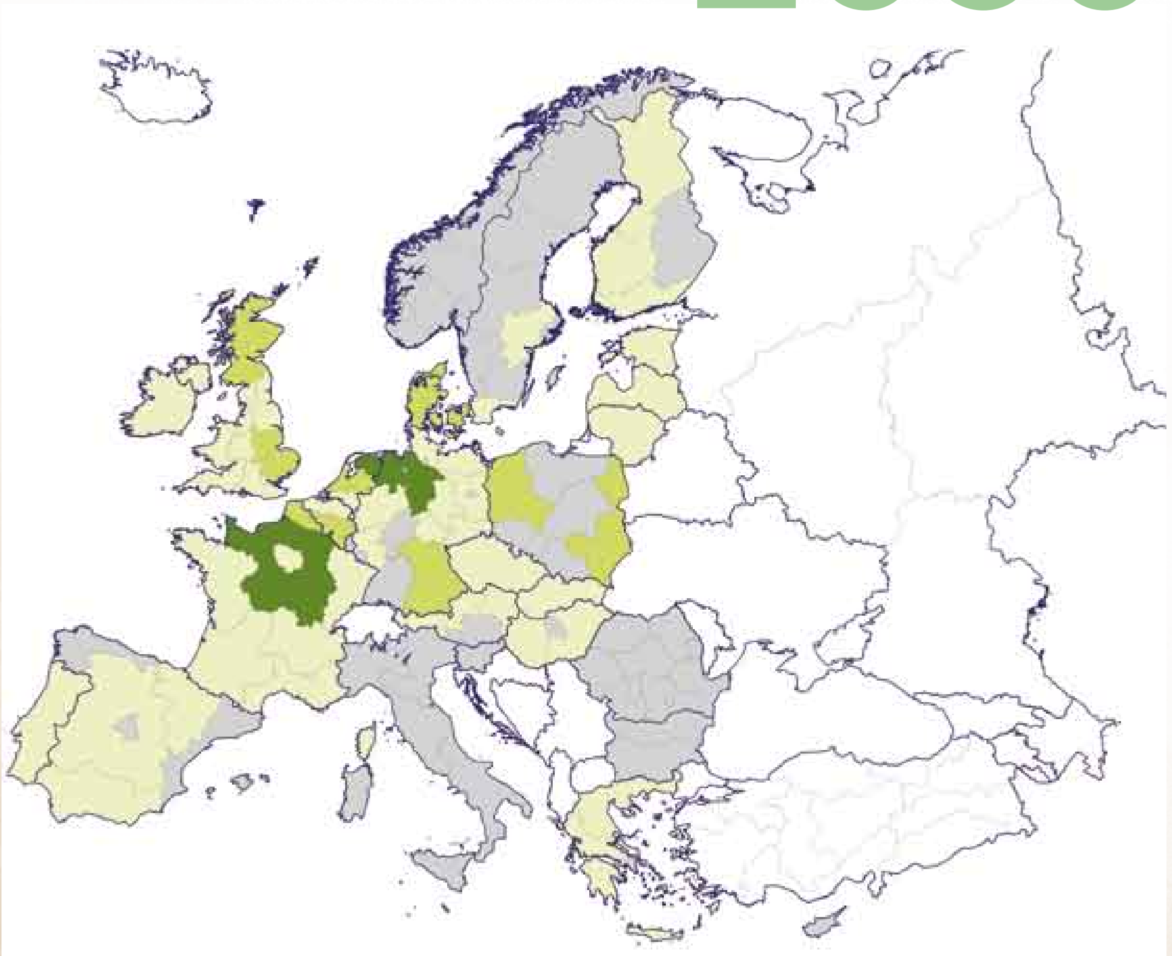
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 8. Potato production regions in EU27 based on competitiveness within

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 8, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale. In 2050 the most competitive regions are those with large holdings and a low population pressure. These occur in western France, Ireland, Denmark, Scotland, eastern Germany and the Czech Republic. In these regions the average size is 90 ESU/holding and the average population pressure is 1.6 inhabitant/agrarian ha. The regions with the least favourable prospect are in Poland, Slovakia, Italy, Portugal, eastern Spain, Flanders and the entire Rhine basin, i.e. western Germany and the Netherlands. These regions combine relatively small holdings (18.1 ESU/holding) with high population pressure (11.2 inhabitants/agrarian ha). Here the number of potato farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market we see a continuing concentration of production areas. Northern France, northern Netherlands and Niedersachsen will deliver one third of the total potato demand (Map 8, 2050). The largest changes are found in Denmark, the Rhine basin (the southern Netherlands and western Germany), eastern Spain and Italy. They will lose potato farms in favour of the Baltic States and some regions in Poland. Moreover, a larger land area will be required (1.4 million ha instead of 1.1 million ha) because the most densely populated areas are among the most productive in the EU27.

the global food market and the regional land market in **scenario A1** at 2050

Legend

Each class one third of total potato production in 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

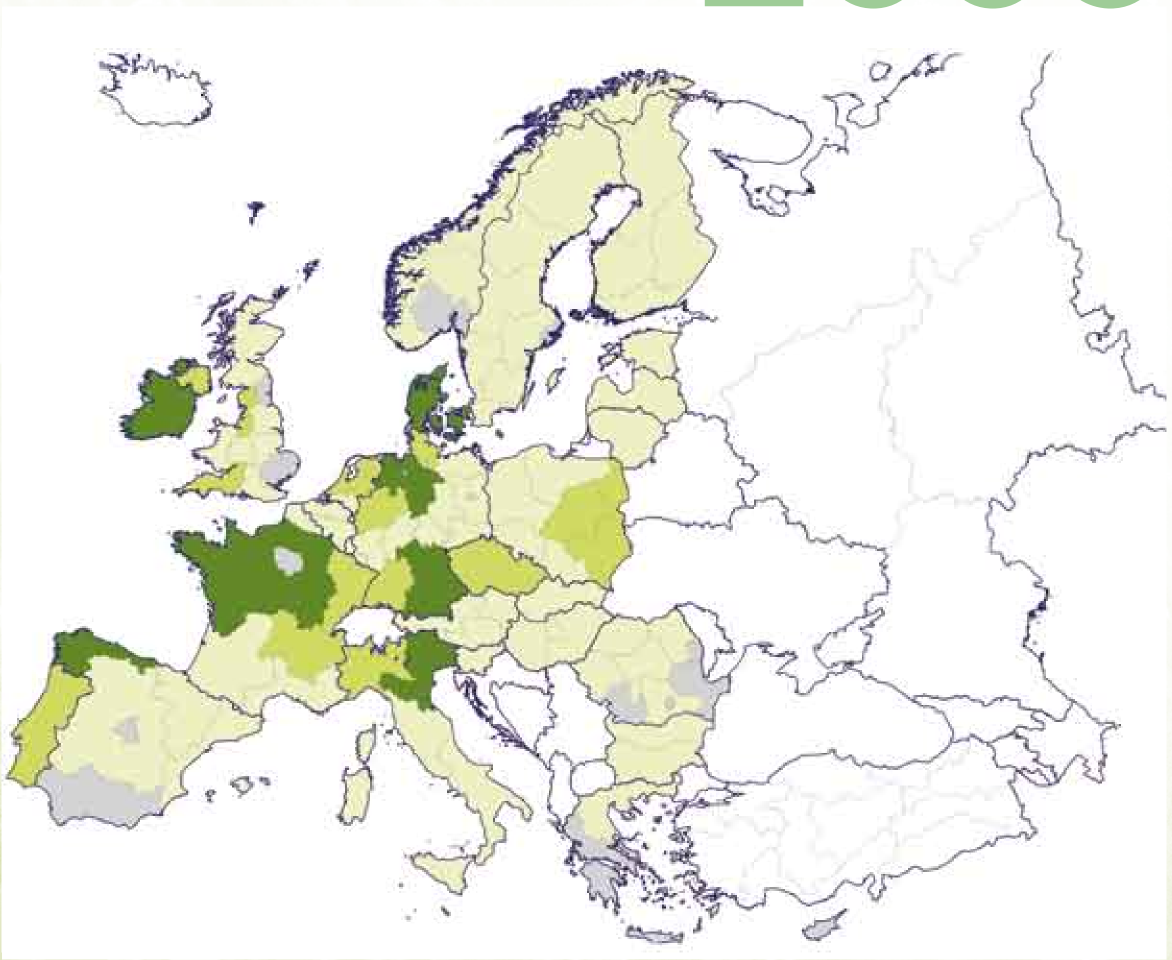
ESU/holding	Inhabitants/ha UAA
20 - 230	< 3
2 - 130	< 6
0 - 105	< 235

<0,1% of total EU27 ESU

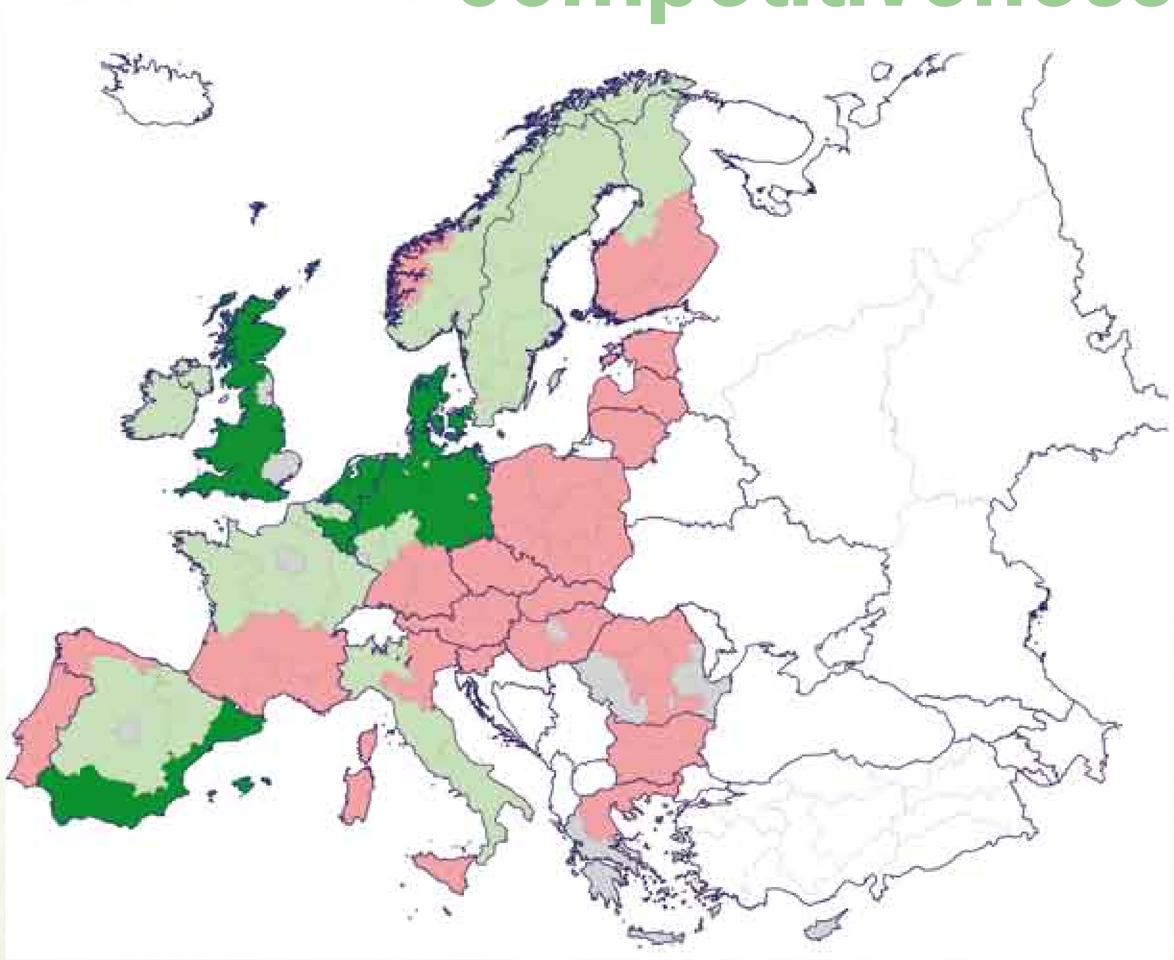
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 9. Milk production regions in EU27 based on competitiveness

2005



competitiveness



In 2005, one third of the total milk production was from Denmark, Ireland, north-western France, Niedersachsen and Bayern in Germany and northern Italy together (Map 9, 2005). The scenario predicts that there will be a minor surplus of milk production in 2020 and 2050 (Figure 8) because the productivity increase of grass c.q. milk will only slightly exceed the increase in demand.

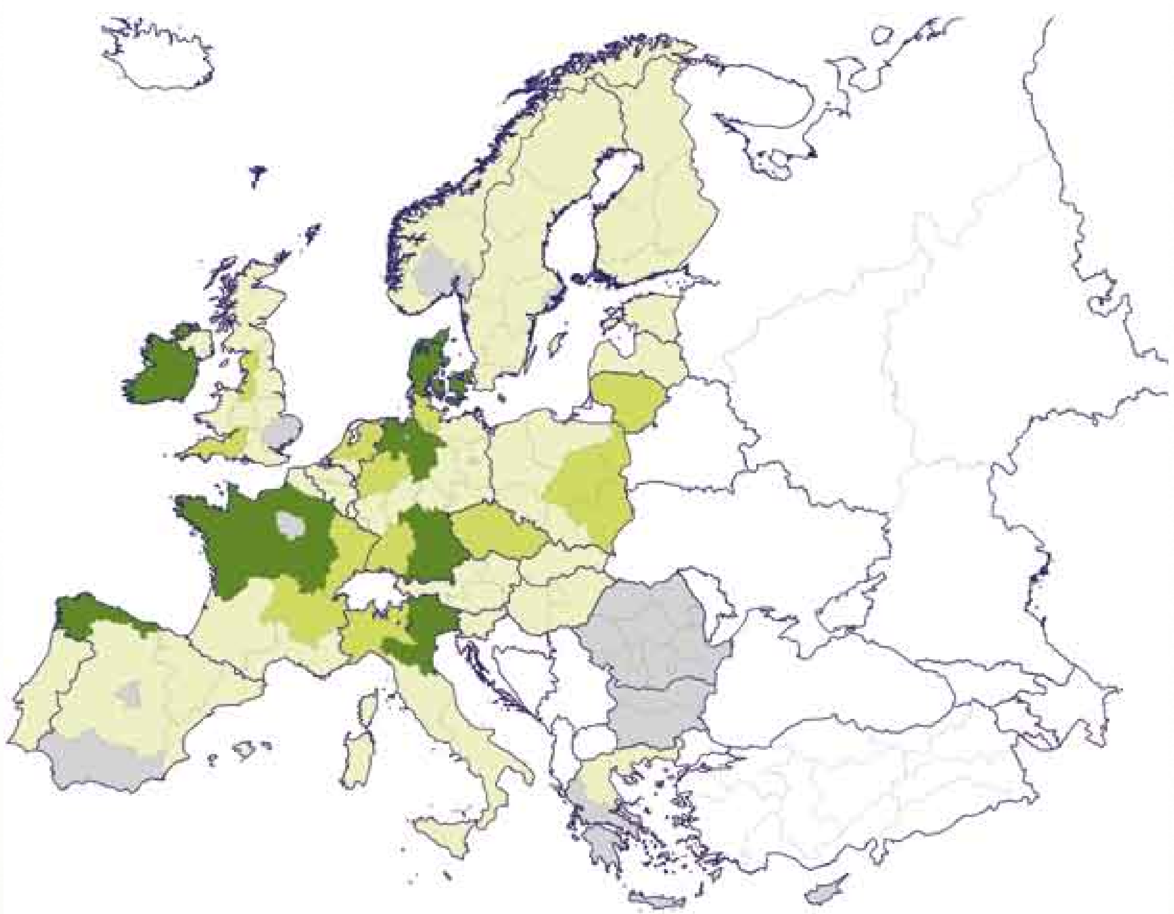
Because supply outweighs demand in scenario A1 estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of milk in 2020 and 2050, it is necessary to consider how competitive regions are, either within the global food market for dairy production alone, or in combination with competitiveness in regional land markets. This means that the regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

Firstly, competitiveness on the global food market was considered in isolation (Map 9, competitiveness). The regions with the most favourable prospects are northern Germany, the Netherlands, Denmark, the UK and south-eastern Spain. In these regions, average size is 126 ESU/holding. Regions with the least favourable prospects are the eastern European countries, Greece, Austria, southern Germany, southern France, Portugal and north-western Spain. In these regions, the average size is only 21 ESU/holding. Hence, competitiveness within the EU27 regions varies widely.

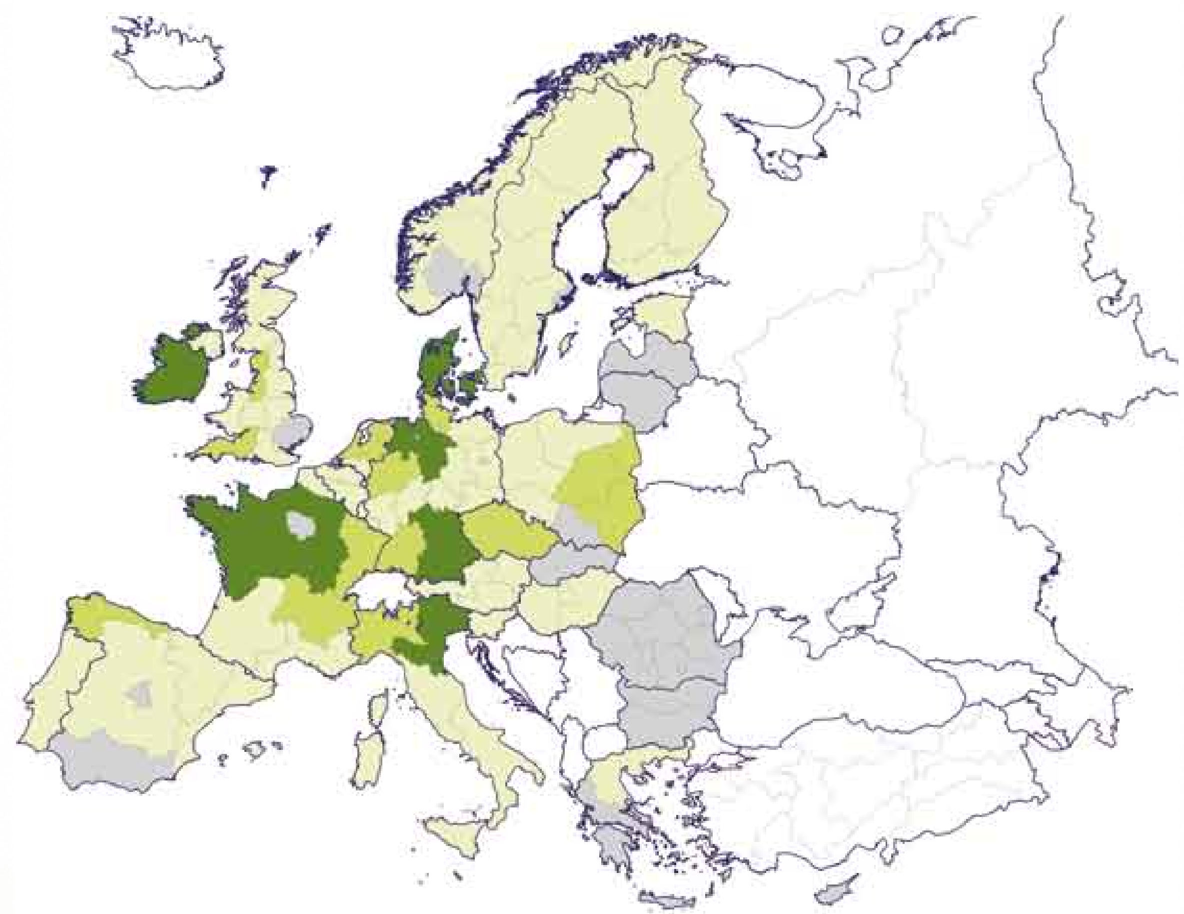
The regions with the least favourable prospects in 2020, which will most likely lose part of their milk production farms, are Bulgaria and Romania (Map 9, 2020). The total demand of 155 million tons will be produced on 21.3 million ha (Figure 12). By 2050, Latvia, Lithuania and northern Hungary will also go out of milk production (Map 9, 2050). The total demand of 160 million tons will be produced on 20.4 million ha (Figure 12).

within the global food market in **scenario A1** at three time slices

2020



2050



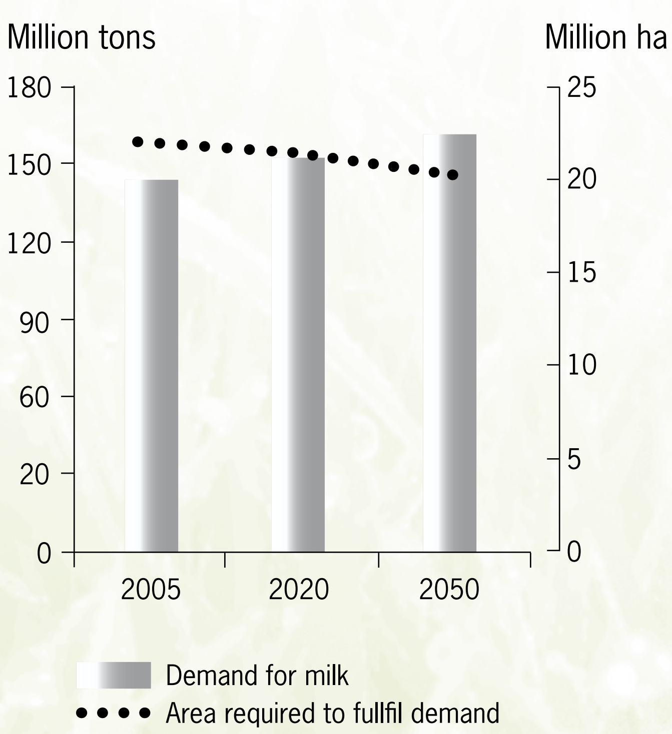


Figure 12.
Demand for milk and corresponding area in EU27, based on competitiveness of dairy production on global food markets in scenario A1 at three time slices.

Legend

Each class one third of total milk production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

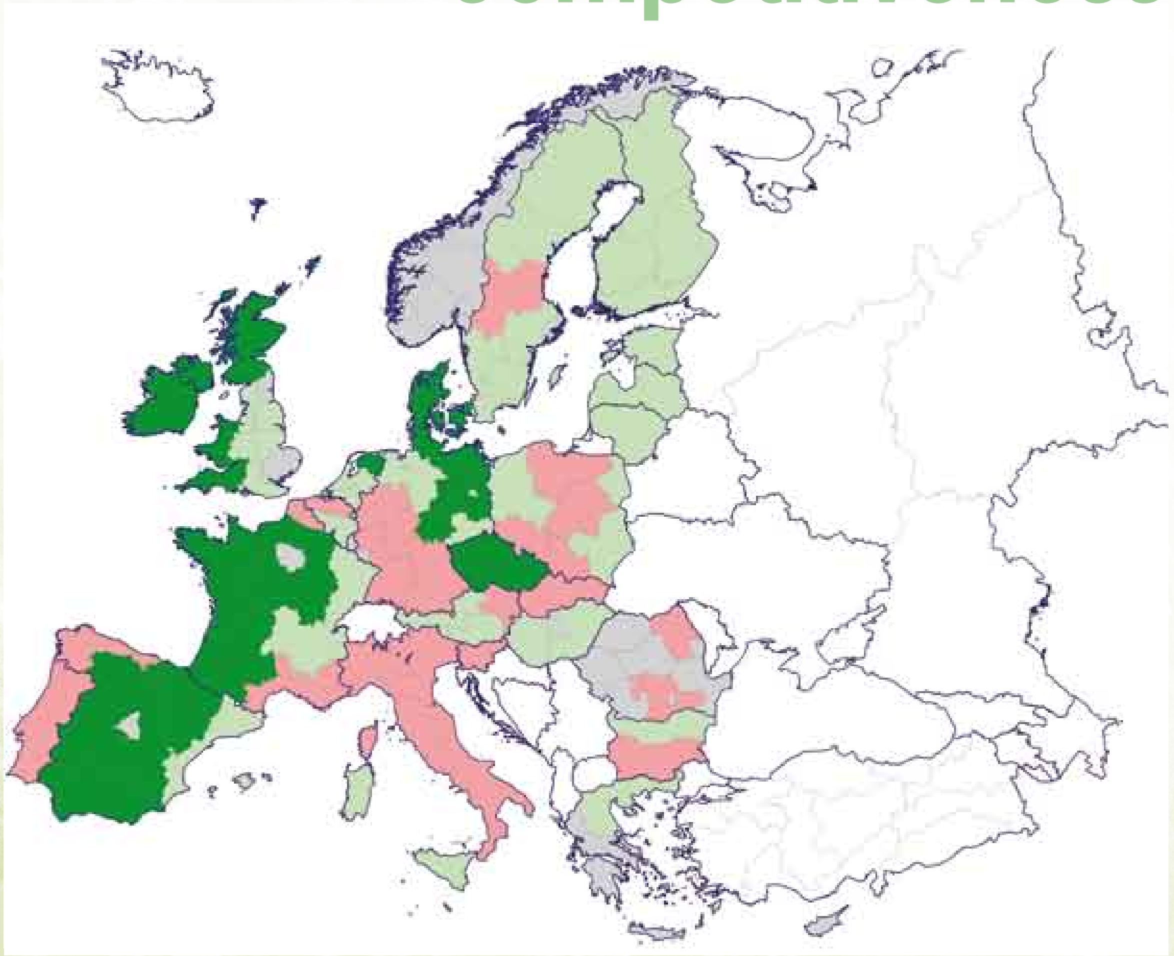
ESU/holding

- >=75
- 45 – 75
- <=45
- <0,1% of total EU27 ESU

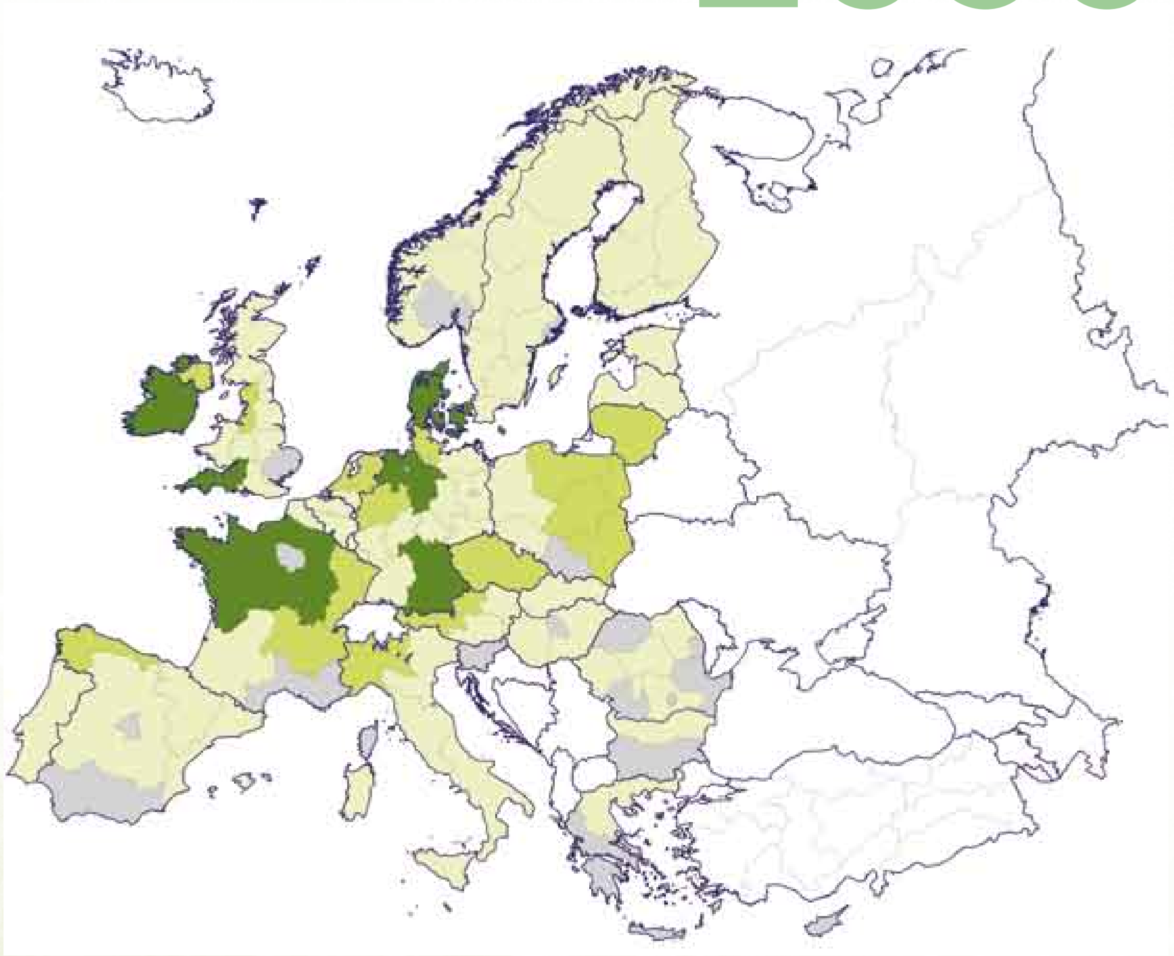
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 10. Milk production regions in EU27 based on competitiveness within

competitiveness



2050

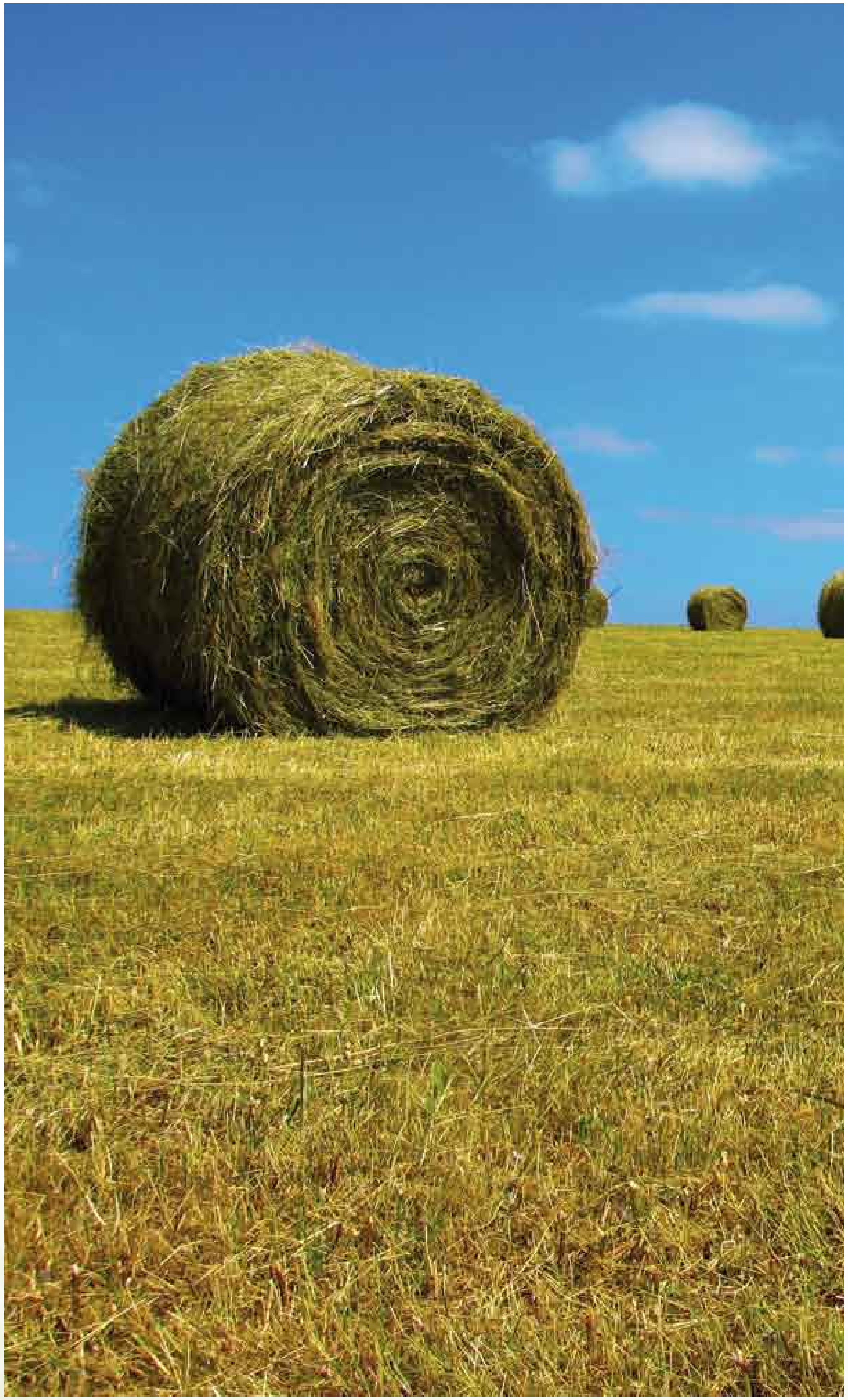


If competitiveness in regional land markets is also taken into account (Map 10, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale.

In 2050 the most competitive regions are those with large holdings and a low population pressure which are found in western France, Ireland, Denmark, northern and western UK, northern Netherlands, eastern Germany and the Czech Republic. In these regions, average size is 126 ESU/holding and average population pressure 1.7 inhabitant/agrarian ha. Regions with the least favourable prospect are central Poland, Slovakia, southern Bulgaria, Italy, Portugal, north-western Spain, Flanders, western Germany and southern France. These regions combine relatively small holdings (35.8 ESU/holding) with high population pressure (13.1 inhabitants/agrarian ha). Here the number of dairy farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market, only minor differences occur. This is due to the fact that the acreage in use in 2005 is hardly sufficient to fulfil the demand and no additional land was sought. Denmark, Ireland, north-western France, Niedersachsen and Bayern remain the main milk production regions (Map 10, 2050). The only difference occurs in north-eastern Italy that loses part of its milk production in favour of southern England. Also some regions in Eastern Europe become more competitive.

the global food market and the regional land market in **scenario A1** at 2050



Legend

Each class one third of total milk production in 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

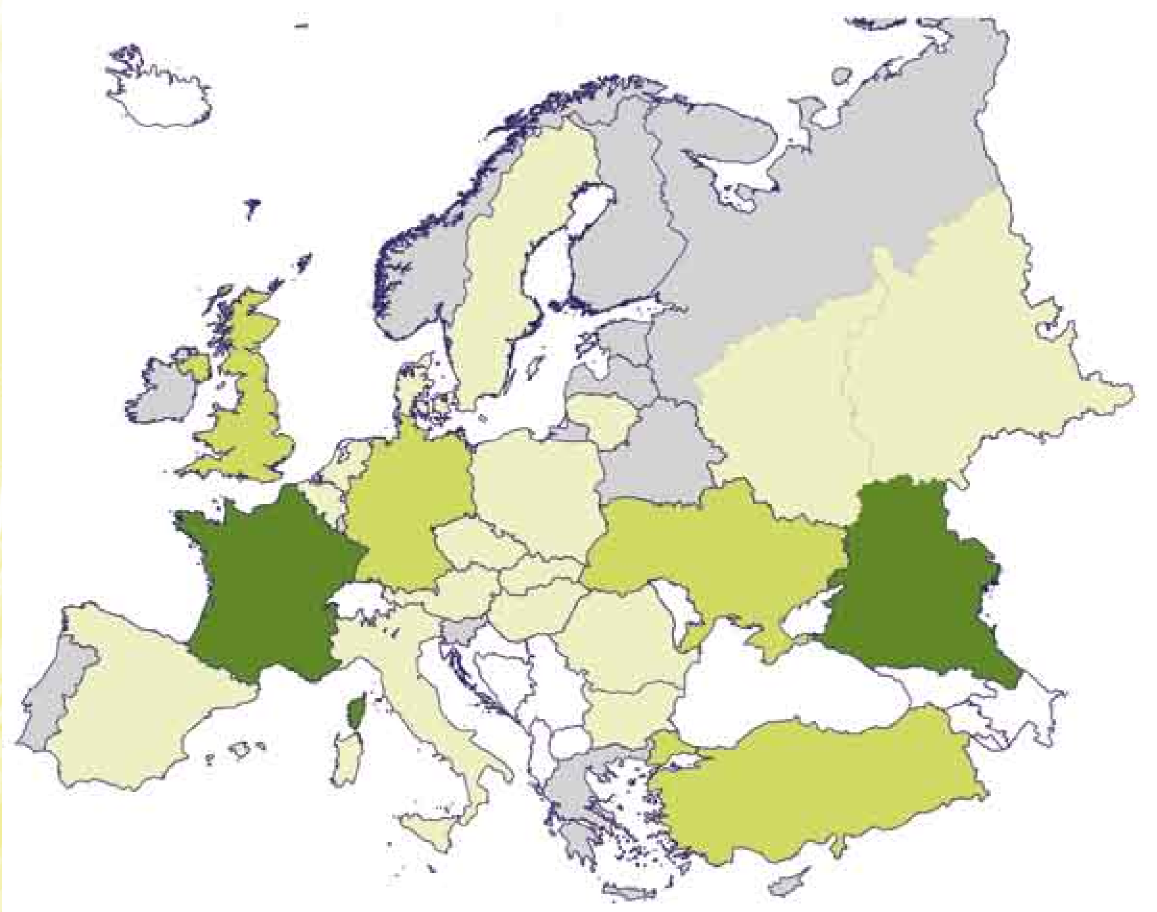
ESU/holding	Inhabitants/ha UAA
35 - 355	< 3
2 - 170	< 15
1 - 95	< 235

<0,1% of total EU27 ESU

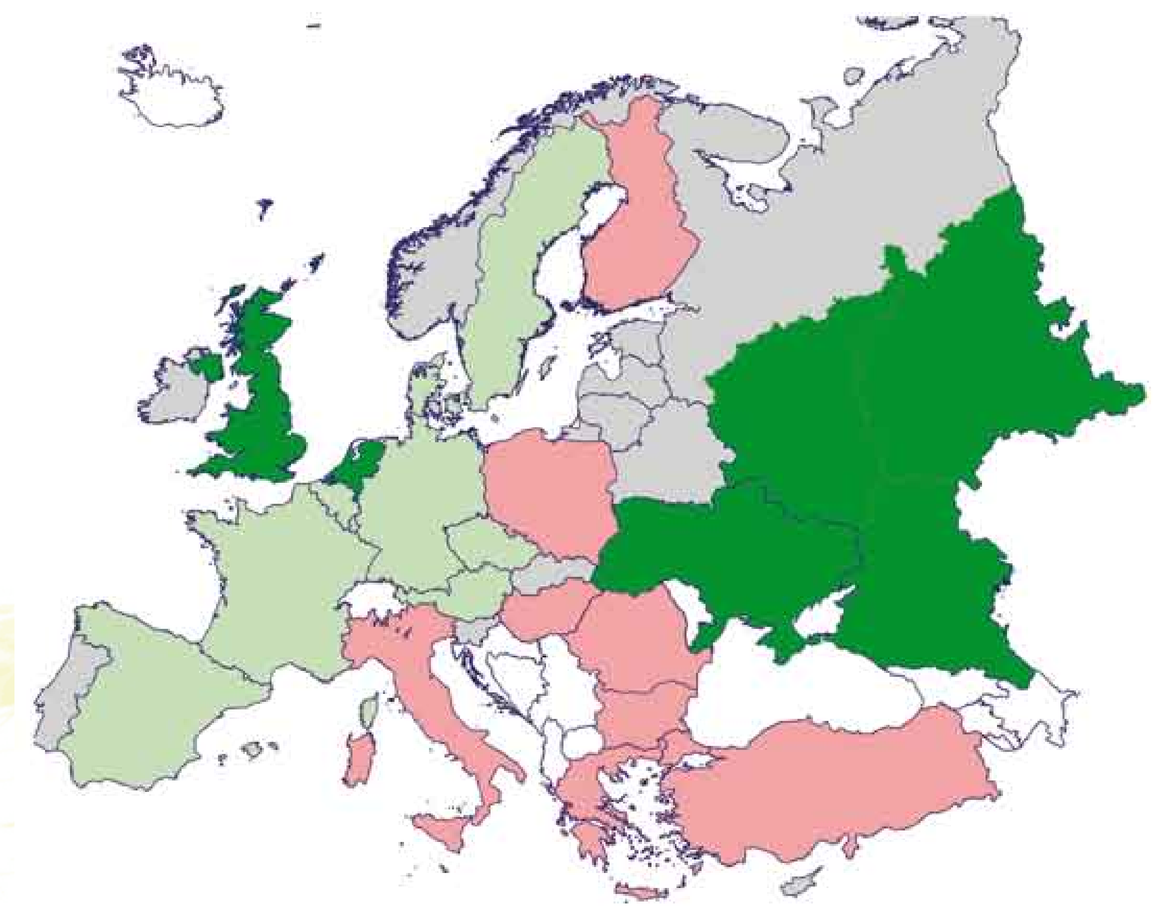
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 11. Wheat production regions in EU-Ural based on competitiveness

2005



competitiveness



In 2005, one third of the total wheat production was from France and southern Russia (Map 11, 2005). The scenario predicts that there will be a surplus of wheat land in 2020, and even more so in 2050 (Figure 5), because the productivity increase will exceed the increase in demand.

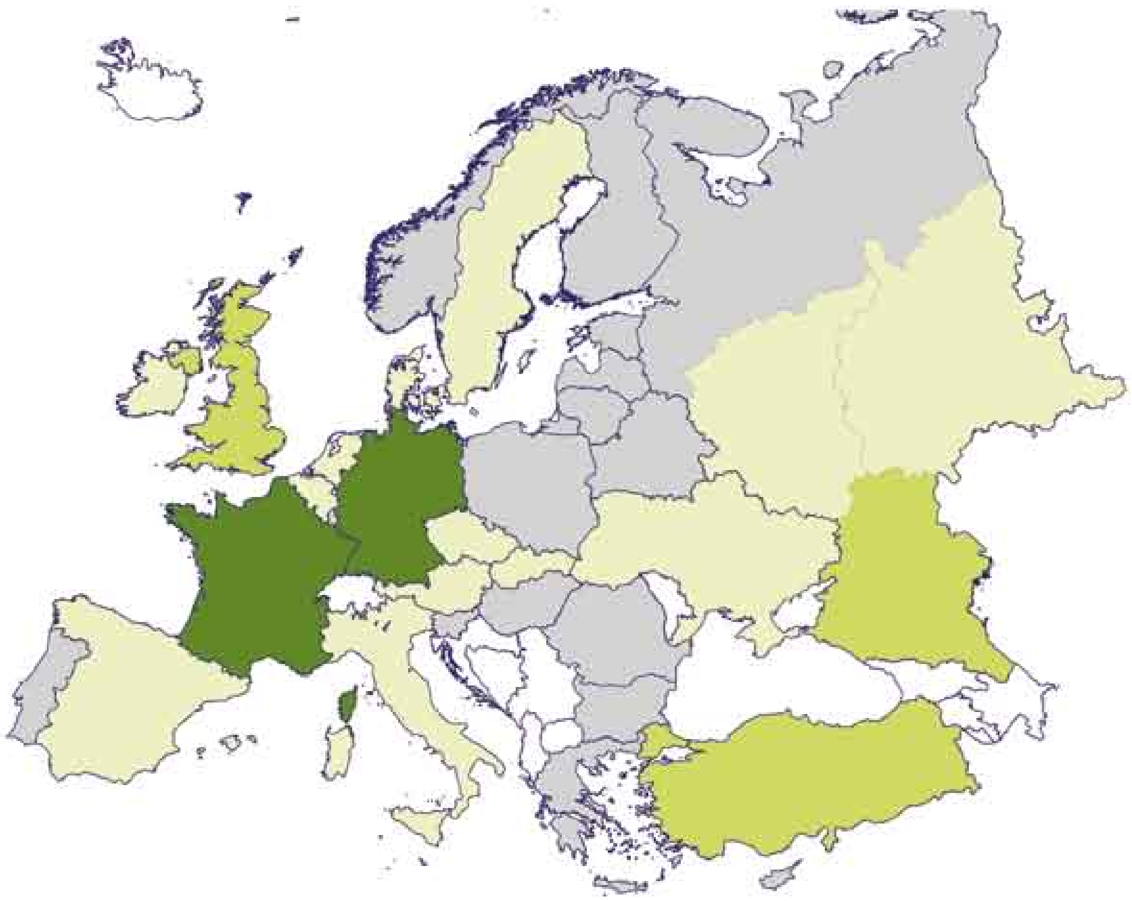
When supply outweighs demand estimates need to be made about where, in which regions or countries, production should continue. In order to (re)distribute spatially the supply and demand ratio of wheat in 2020 and 2050, it is necessary to consider how competitive regions or countries are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions or countries with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

Firstly, competitiveness on the global food market was considered in isolation (Map 11, competitiveness). The regions or countries with the most favourable prospects are the UK, the Netherlands, Ukraine and southern Russia. In these countries, average size is more than 1500 ESU/holding, due to very large arable farms in Ukraine and Russia. Regions or countries with the least favourable prospects are Italy, Finland, Poland, Hungary, Romania, Bulgaria, Greece and Turkey. In these countries, the average size is only 6 ESU/holding. Hence, competitiveness within the EU-Ural countries varies widely.

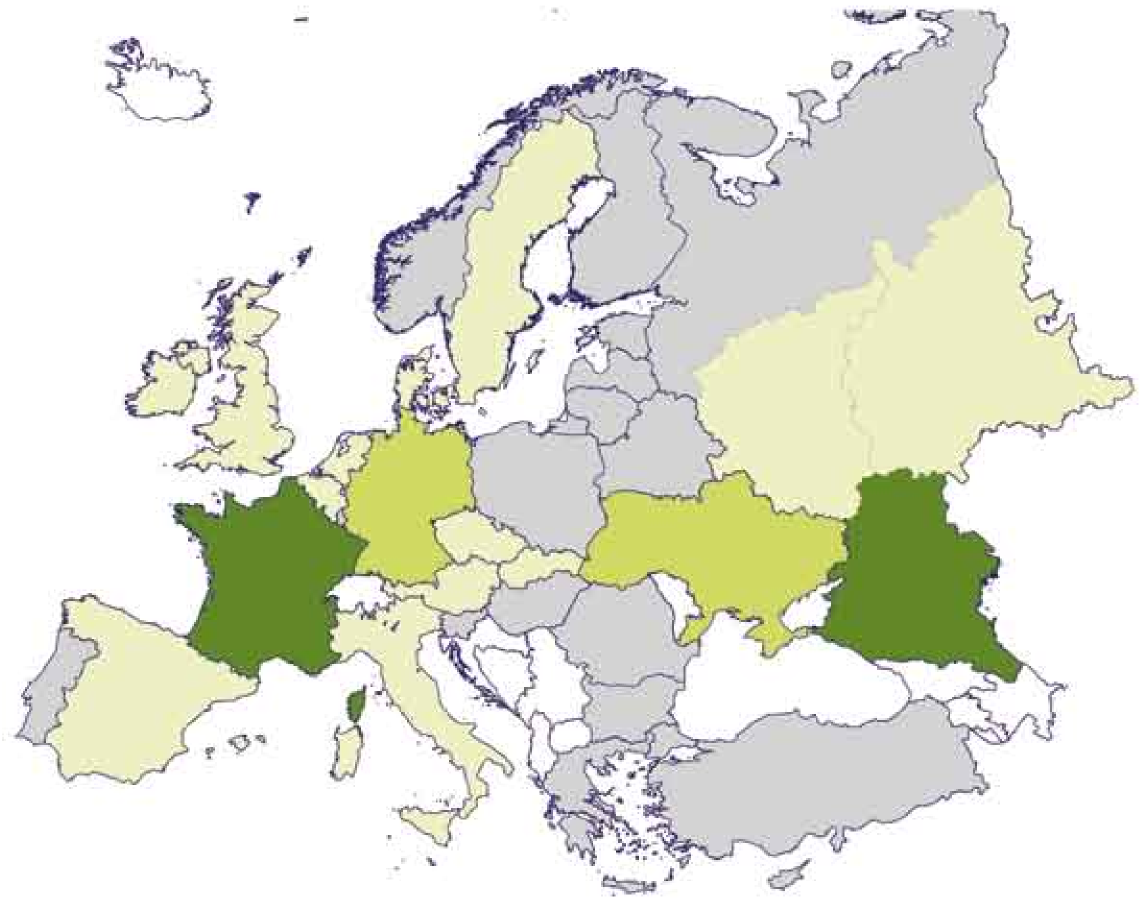
The regions or countries with the least favourable prospects in 2020, which will most likely lose their wheat farms, are the eastern European countries (except the Czech Republic and Slovakia), Ukraine, Turkey and southern Russia (Map 11, 2020). The total demand of 195 million tons will be produced on 48 million ha (Figure 13). By 2050 Turkey will also go out of wheat production (Map 11, 2050). These areas will become available for alternative agrarian or non-agrarian activities. In 2050, France, Germany, Ukraine and south Russia together will be capable of supplying two third of total EU-Ural wheat demand. The total demand of 260 million tons will be produced on 38 million ha (Figure 13).

within the global food market in scenario A1 at three time slices

2020



2050



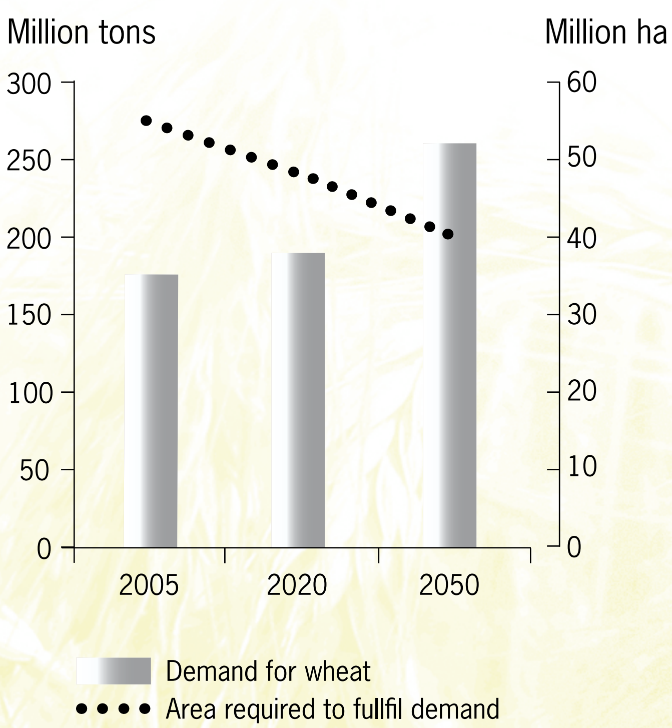


Figure 13.
Demand for wheat and corresponding area in EU-Ural, based on competitiveness of arable production on global food markets in scenario A1 at three time slices.

Legend

Each class one third of total wheat production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,5% of EU-Ural production

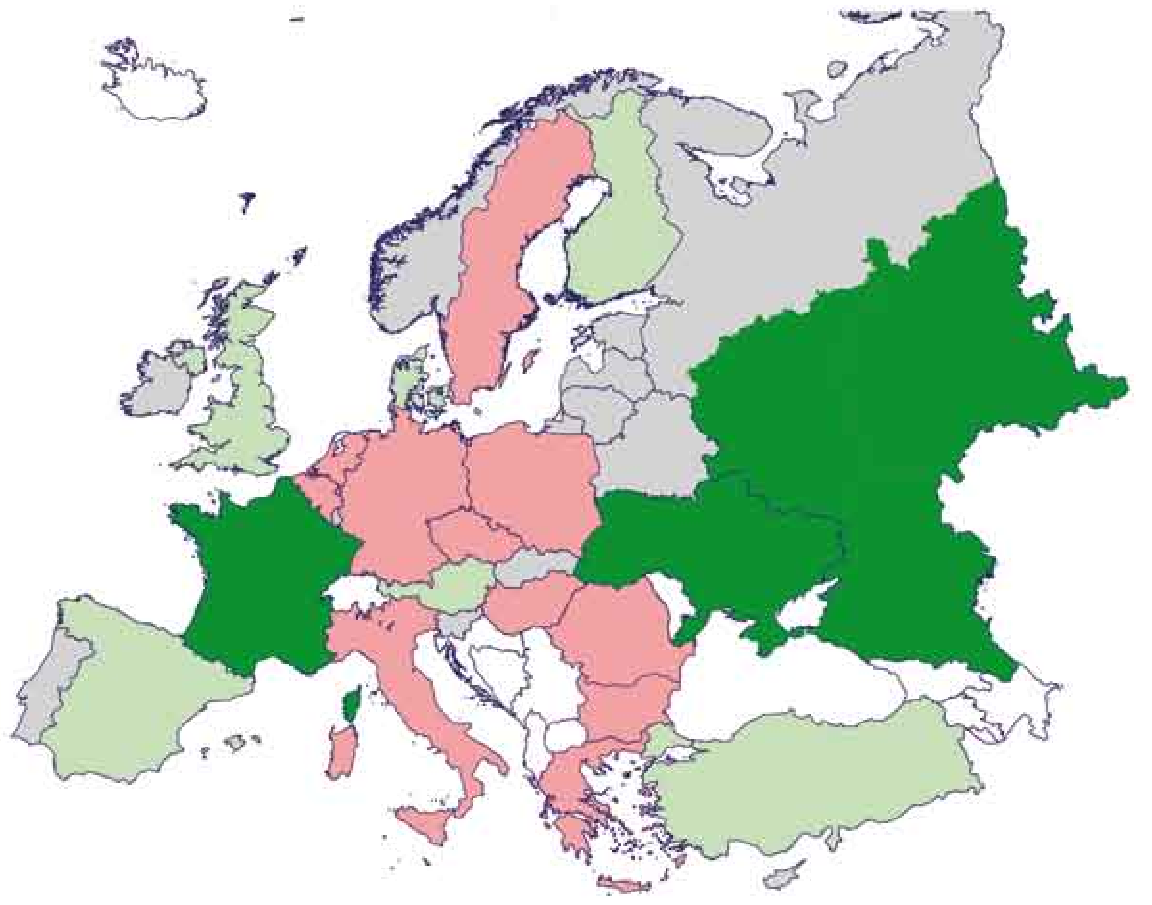
ESU/holding

- >=60
- 12 – 60
- <=12
- <0,5% of total EU-Ural ESU

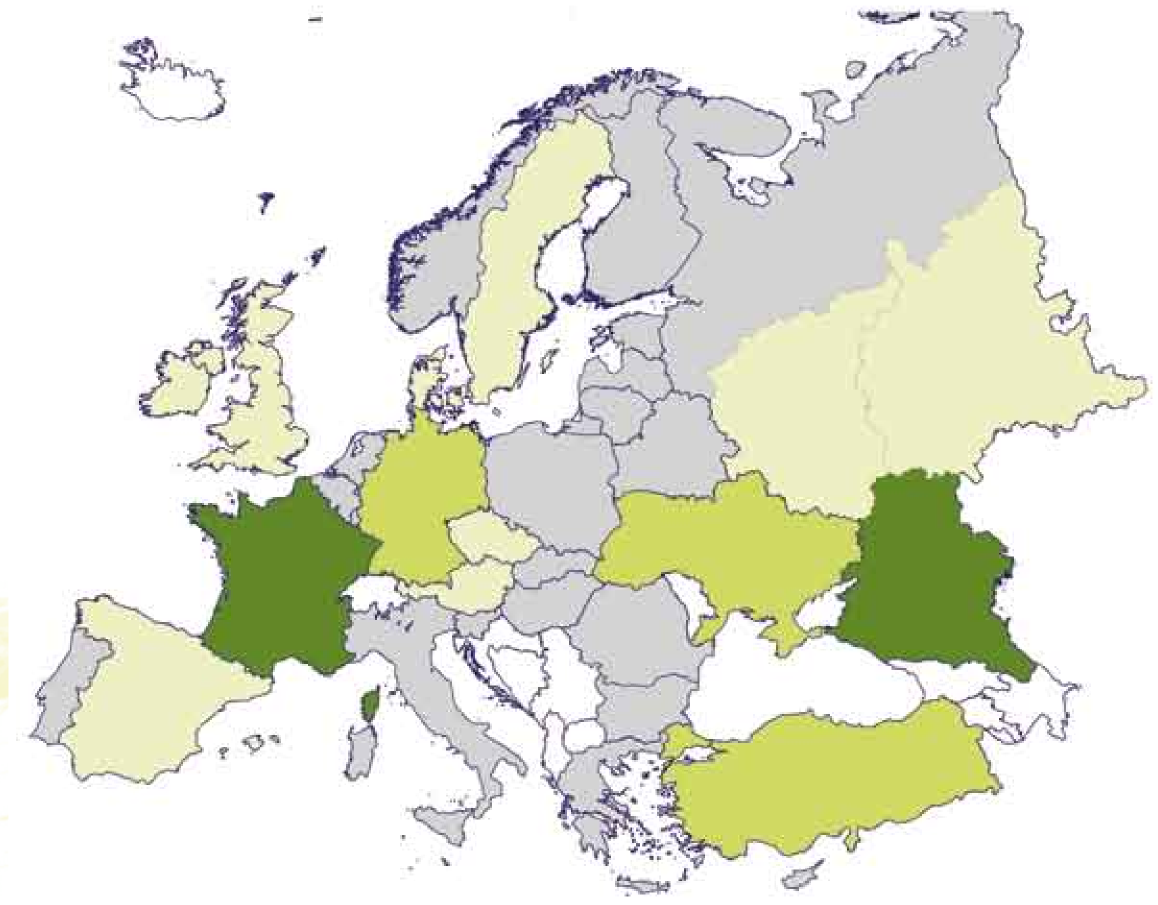
Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 12. Wheat production regions in EU-Ural based on competitiveness within

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 12, competitiveness) it will be seen that, in regions or countries with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale. In 2050 the most competitive regions or countries are those with large holdings and a low population pressure. These occur in France, Ukraine and southern Russia. In these regions or countries, the average size is more than 1600 ESU/holding and the average population pressure is 1.1 inhabitant/agrarian ha. The regions or countries with the least favourable prospect are Finland, the Netherlands, Belgium, Germany, the Czech Republic, Poland, Hungary, Romania, Bulgaria, Italy and Greece. These countries combine relatively small holdings (16.0 ESU/holding) with relatively high population pressure (5.6 inhabitants/agrarian ha). Here the number of wheat farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market, France, Germany, Ukraine, Turkey and southern Russia together will be capable of supplying two third of the total EU-Ural wheat demand (Map 12, 2050). The largest changes are found in the densely populated countries Belgium, the Netherlands, Italy and Slovakia. They will lose wheat farms in favour of Turkey. Moreover, a larger land area will be required (46.9 million ha instead of 38.4 million ha) because the most densely populated countries are among the most productive in EU-Ural.

the global food market and the regional land market in **scenario A1** at 2050

Legend

Each class one third of total wheat production in 2050

Upper

Middle

Lower

<0,5% of EU-Ural production

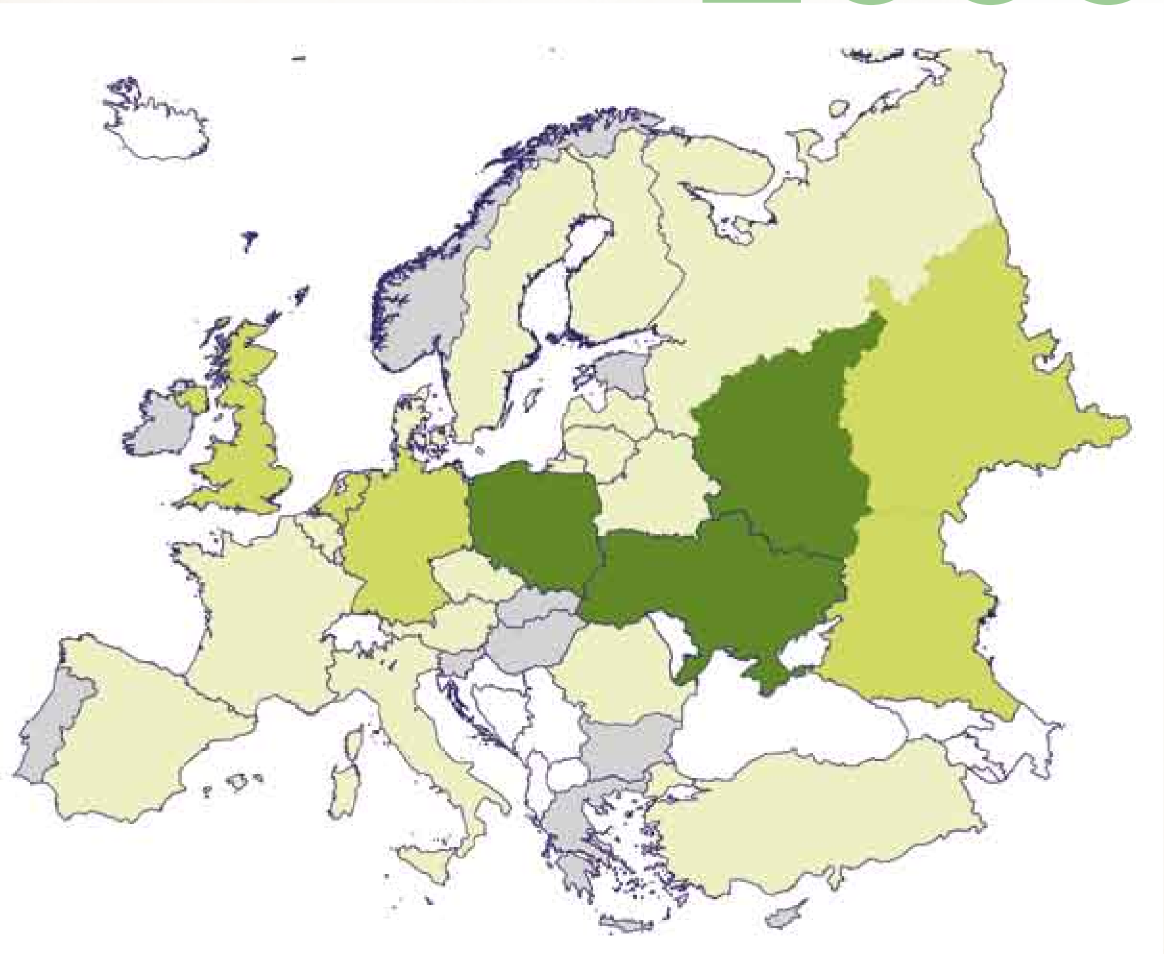
ESU/holding	Inhabitants/ha UAA
35 - 2500	< 2
1 - 95	< 4
1 - 60	< 40

<0,5% of total EU-Ural ESU

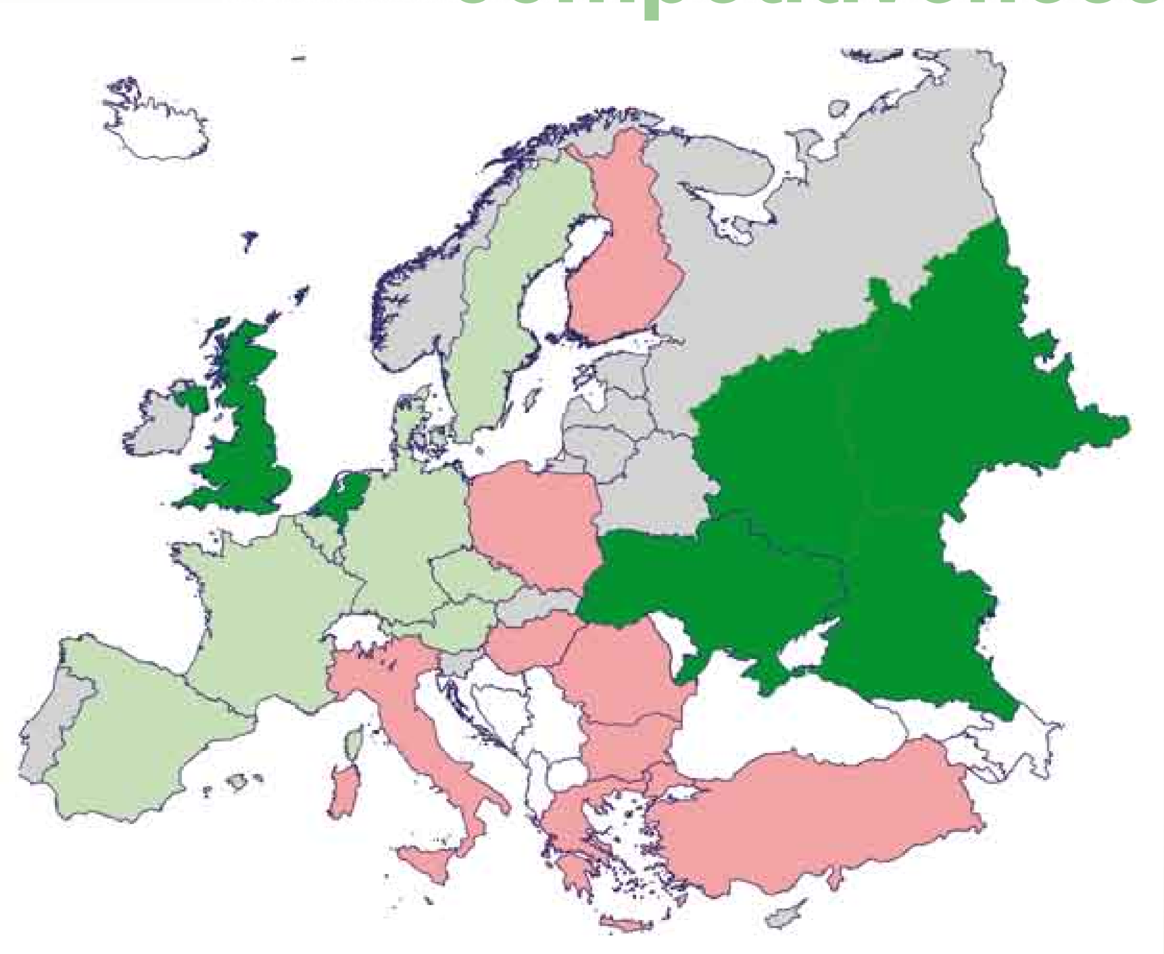
Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 13. Potato production regions in EU-Ural based on competitiveness

2005



competitiveness



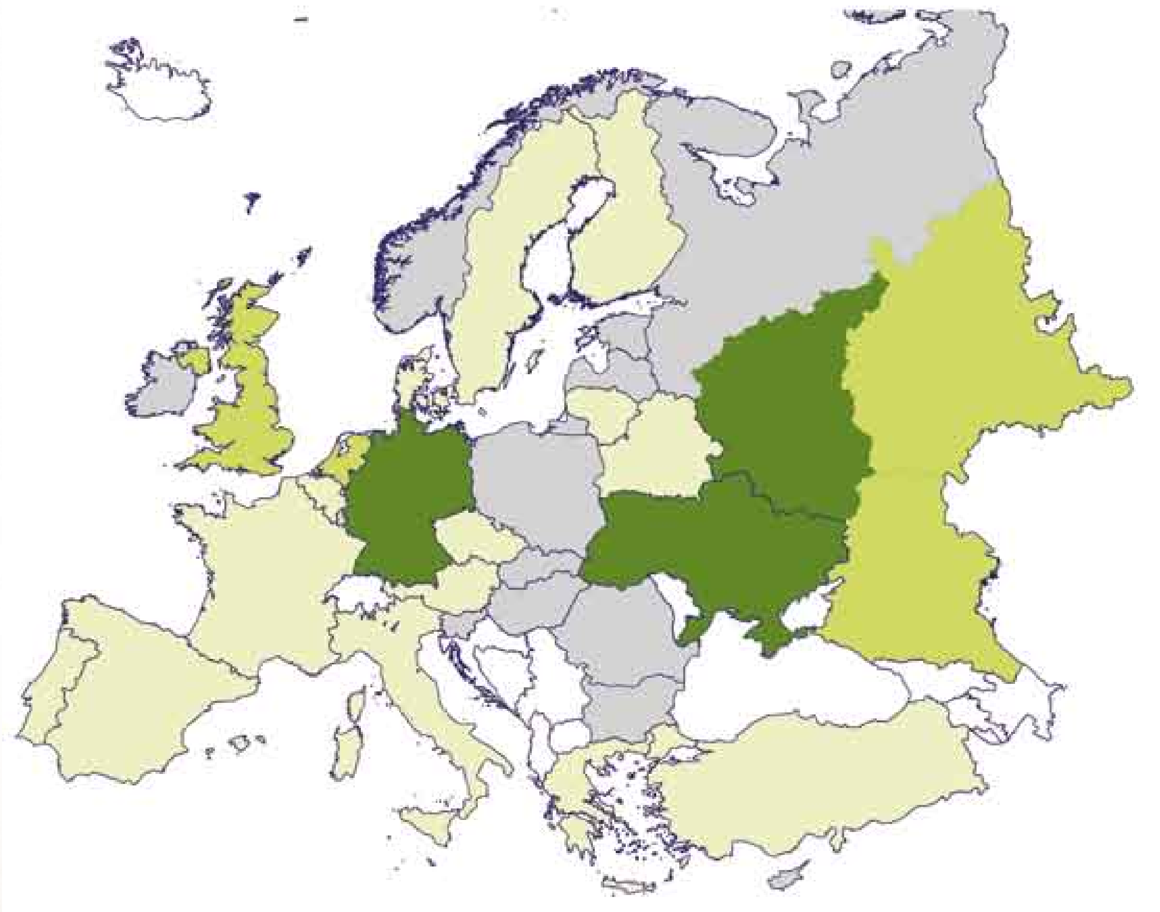
In 2005, one third of the total potato production was from Poland, Ukraine and western Russia (Map 13, 2005). The scenario predicts that there will be a surplus of potato land in 2020, and even more in 2050 (Figure 7), because the productivity increase will exceed the increase in demand.

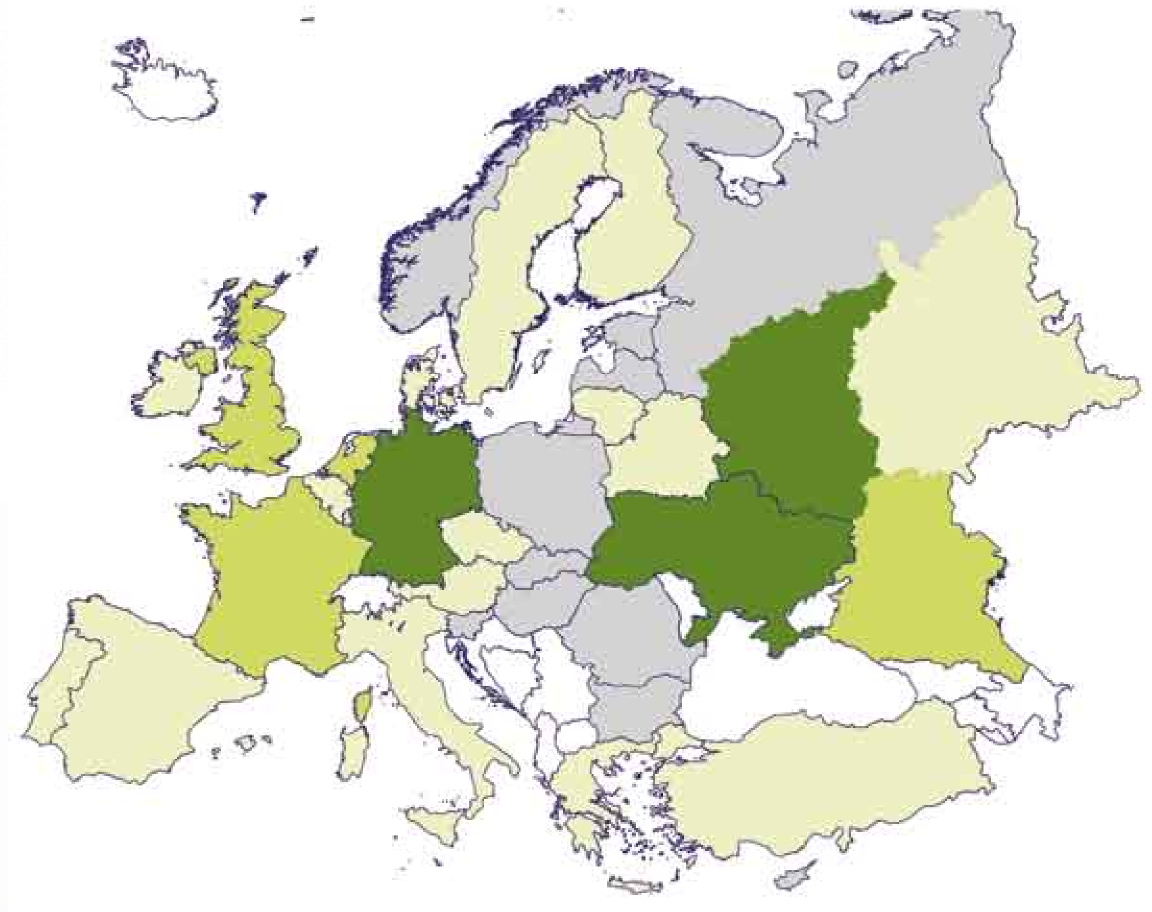
When supply outweighs demand, estimates need to be made about where, in which regions or countries, production should continue. In order to (re)distribute spatially the supply and demand ratio of potatoes in 2020 and 2050, it is necessary to consider how competitive regions or countries are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions or countries with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

Firstly, competitiveness on the global food market was considered in isolation (Map 13, competitiveness). The regions or countries with the most favourable prospect are the UK, the Netherlands, Ukraine and southern Russia. In these countries, average size is more than 1500 ESU/holding, due to very large arable farms in Ukraine and Russia. Countries with the least favourable prospects are Italy, Finland, Poland, Hungary, Romania, Bulgaria, Greece and Turkey. In these countries, the average size is only 6 ESU/holding. Hence, competitiveness within the EU-Ural countries varies widely.

The regions or countries with the least favourable prospects in 2020, which will most likely lose their potato farms, are Latvia, Poland and Romania (Map 13, 2020). The total demand of 98 million tons will be produced on 6.0 million ha (Figure 14). By 2050, Germany, Ukraine and western Russia will be capable of supplying more than one third of the total EU-Ural potato demand (Map 13, 2050). The total demand of 126 million tons will be produced on 6.0 million ha (Figure 14).

within the global food market in **scenario A1** at three time slices





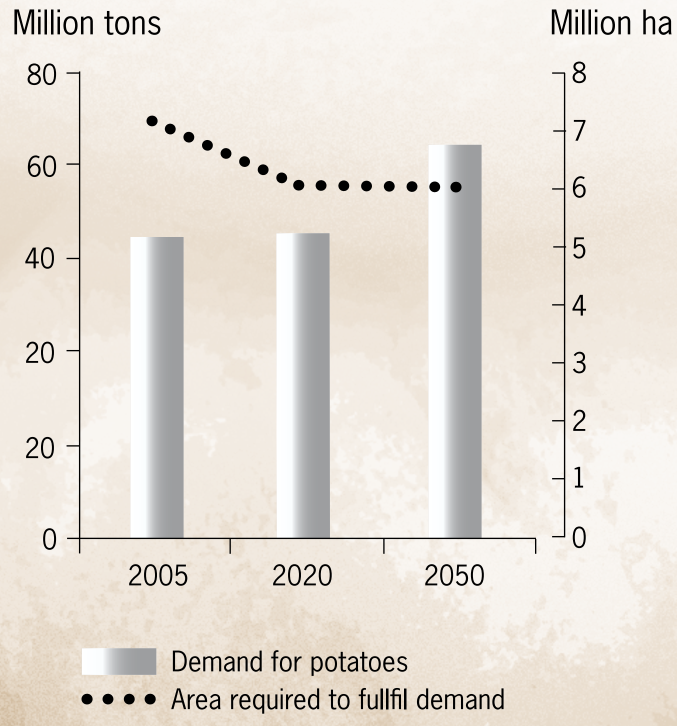
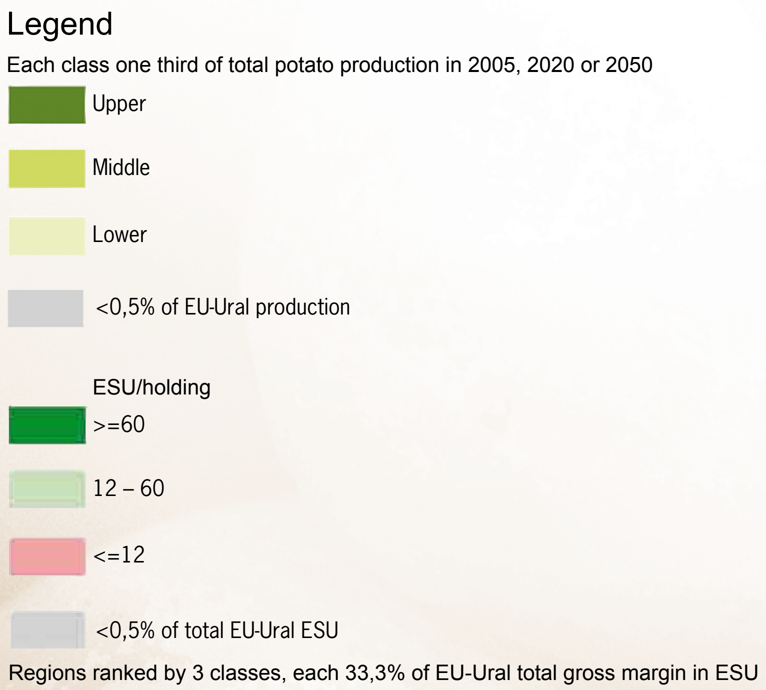
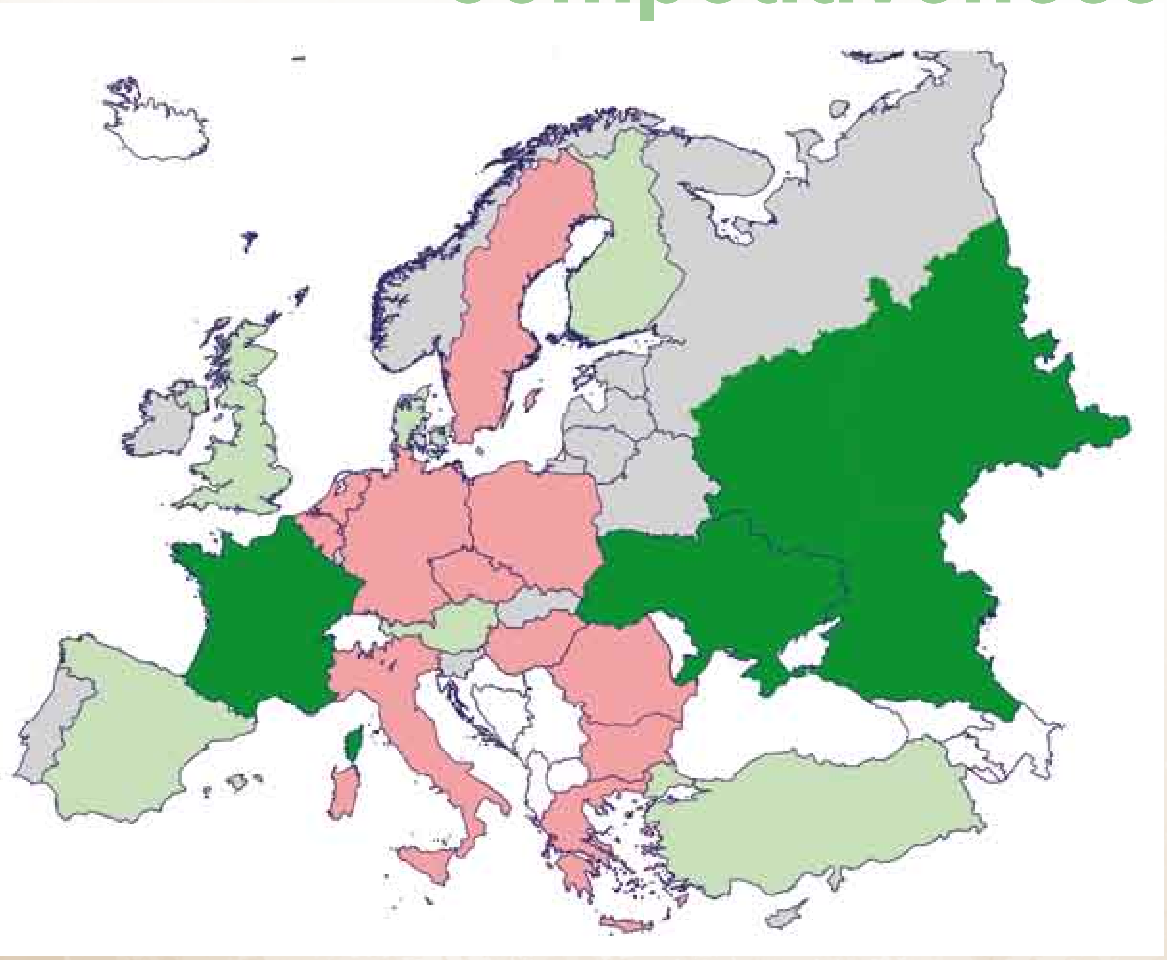


Figure 14.
Demand for potatoes and corresponding area in EU-Ural, based on competitiveness of arable production on global food markets in scenario A1 at three time slices.

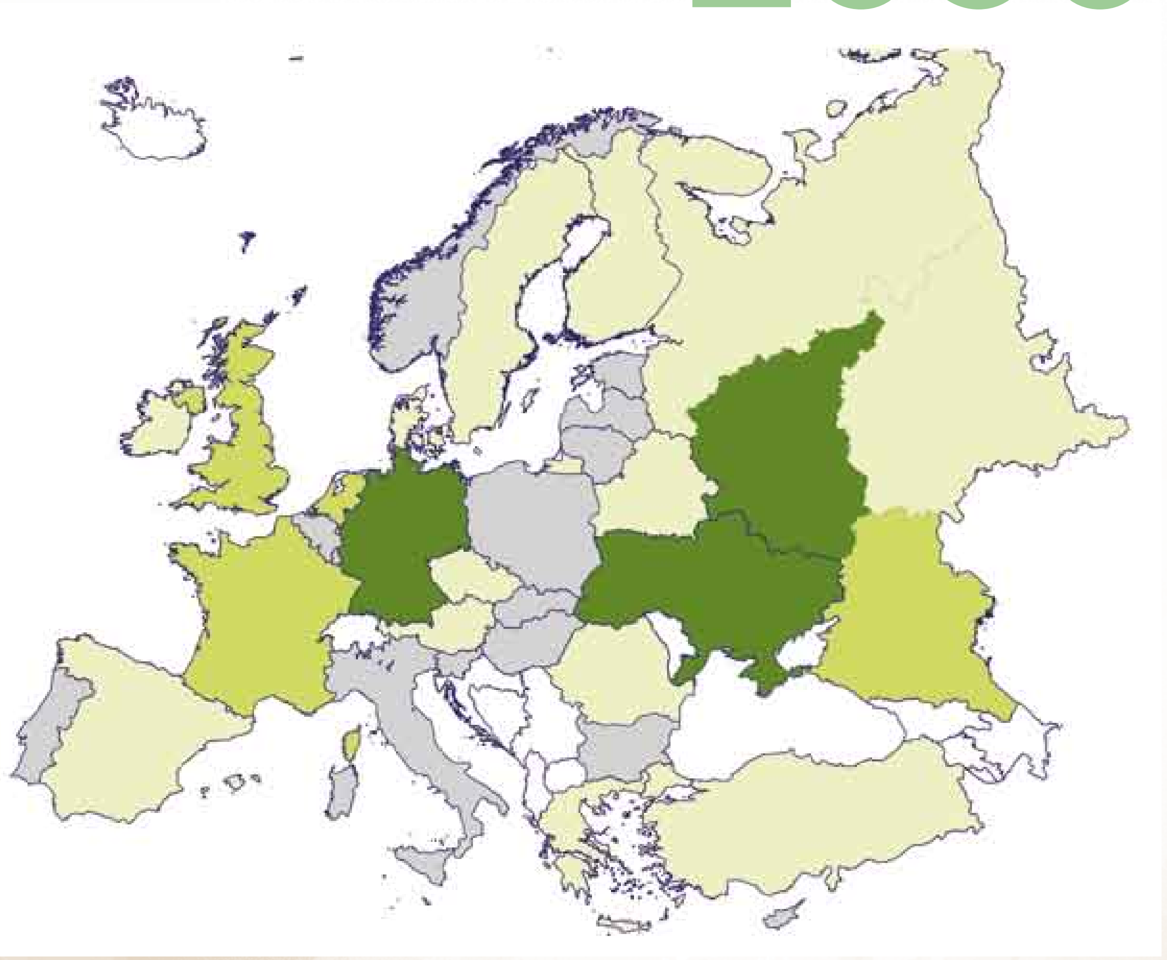


Map 14. Potato production regions in EU-Ural based on competitiveness within

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 14, competitiveness) it will be seen that, in regions or countries with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale. In 2050 the most competitive regions or countries are those with large holdings and a low population pressure. These occur in France, Ukraine and southern Russia. In these regions or countries the average size is more than 1600 ESU/holding and the average population pressure is 1.1 inhabitant/agrarian ha. The countries with the least favourable prospect are Finland, the Netherlands, Belgium, Germany, the Czech Republic, Poland, Hungary, Romania, Bulgaria, Italy and Greece. These countries combine relatively small holdings (16.0 ESU/holding) with high population pressure (5.6 inhabitants/agrarian ha). Here the number of potato farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market, the same countries, i.e. Germany, Ukraine and western Russia will be capable of supplying one third of the total EU-Ural potato demand (Map 14, 2050). The changes are found in the densely populated countries Belgium and Italy. They will lose potato farms in favour of Romania. Moreover, a larger land area will be required (6.3 million ha instead of 6.0 million ha) because the most densely populated areas are among the most productive in the EU-Ural.

the global food market and the regional land market in **scenario A1** at 2050

Legend

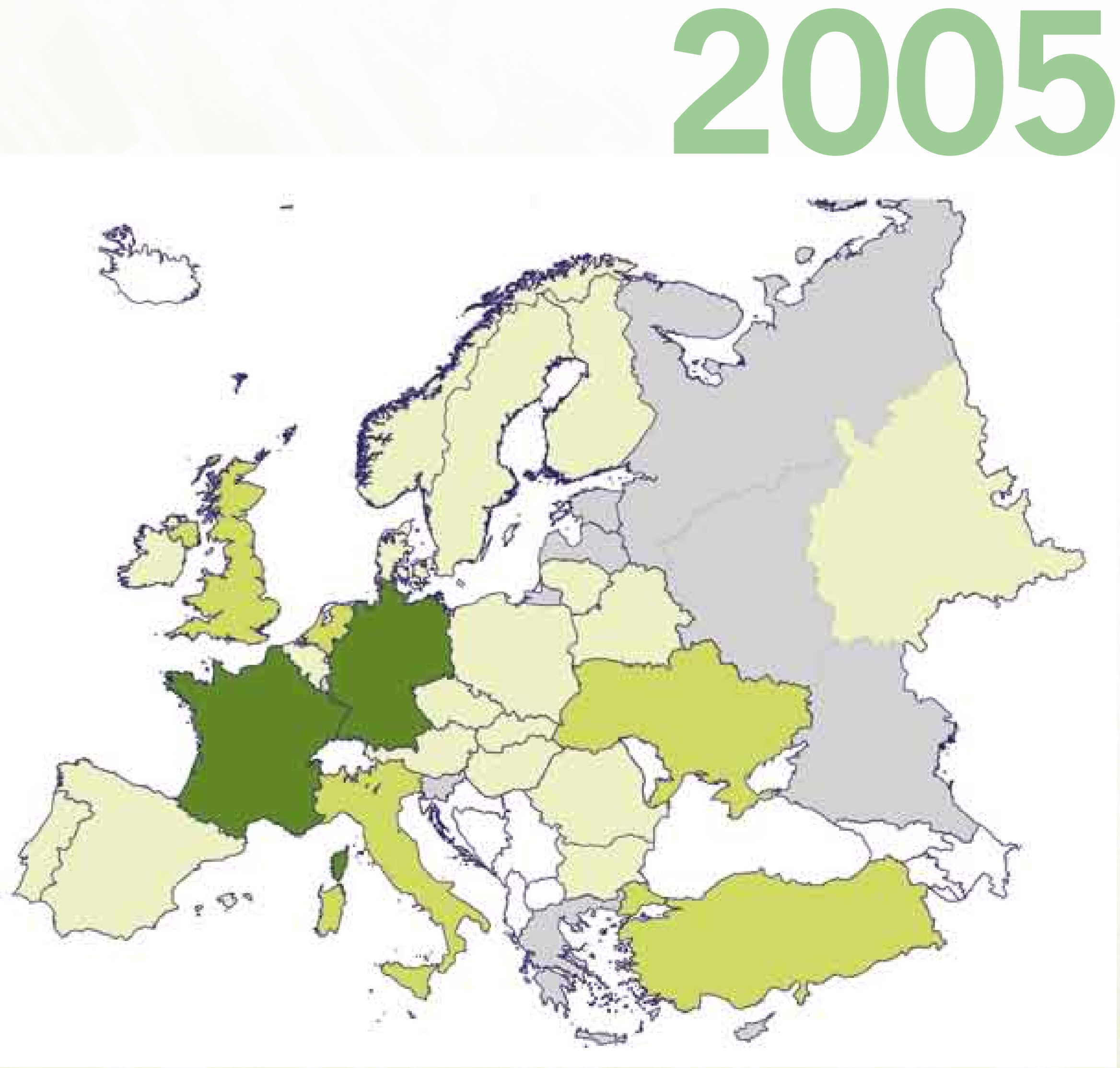
Each class one third of total potato production in 2050

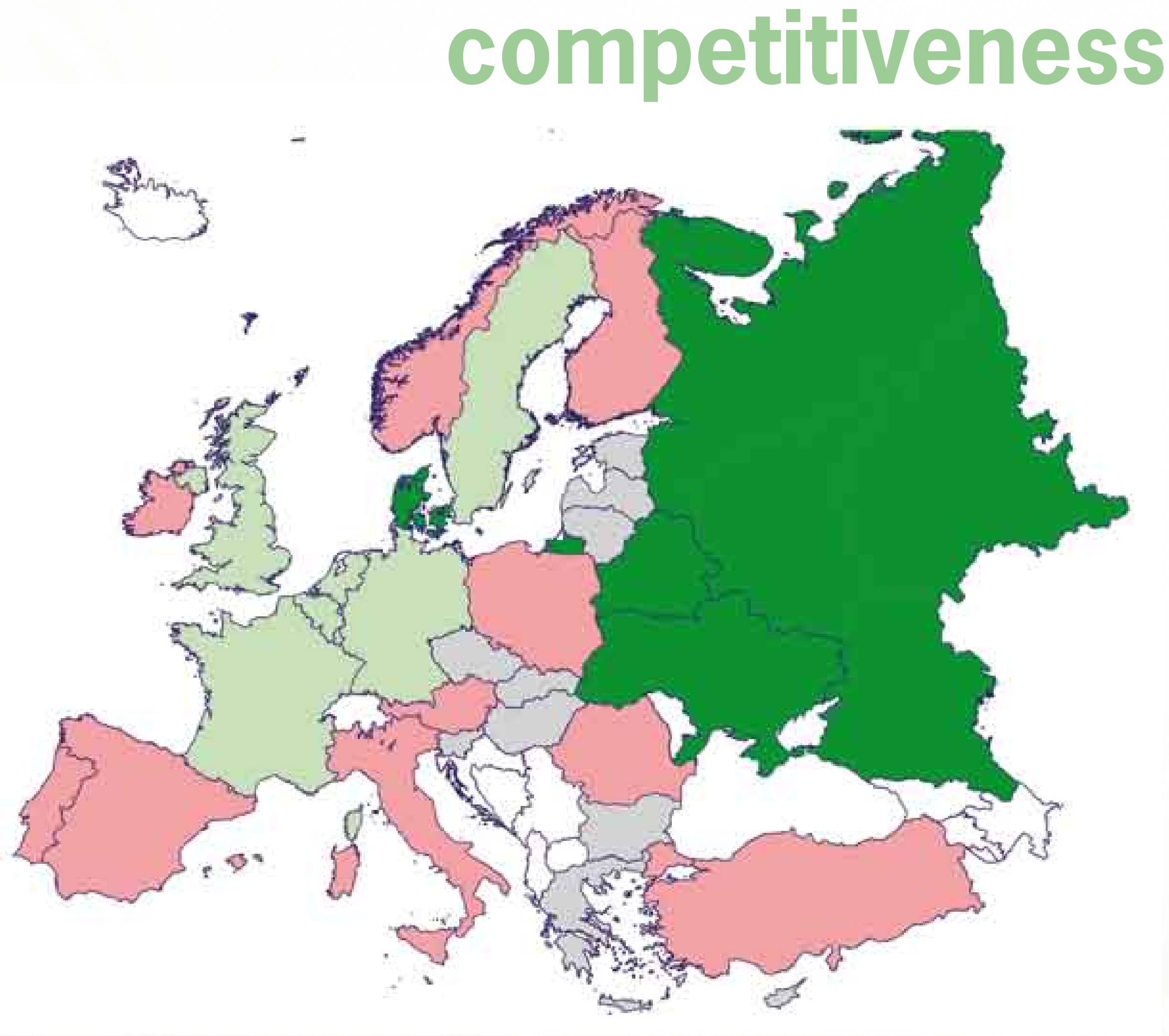
	Upper
	Middle
	Lower
	<0,5% of EU-Ural production

	ESU/holding	Inhabitants/ha UAA
	35 - 2500	< 2
	1 - 95	< 4
	1 - 60	< 40
	<0,5% of total EU-Ural ESU	

Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 15. Milk production regions in EU-Ural based on competitiveness





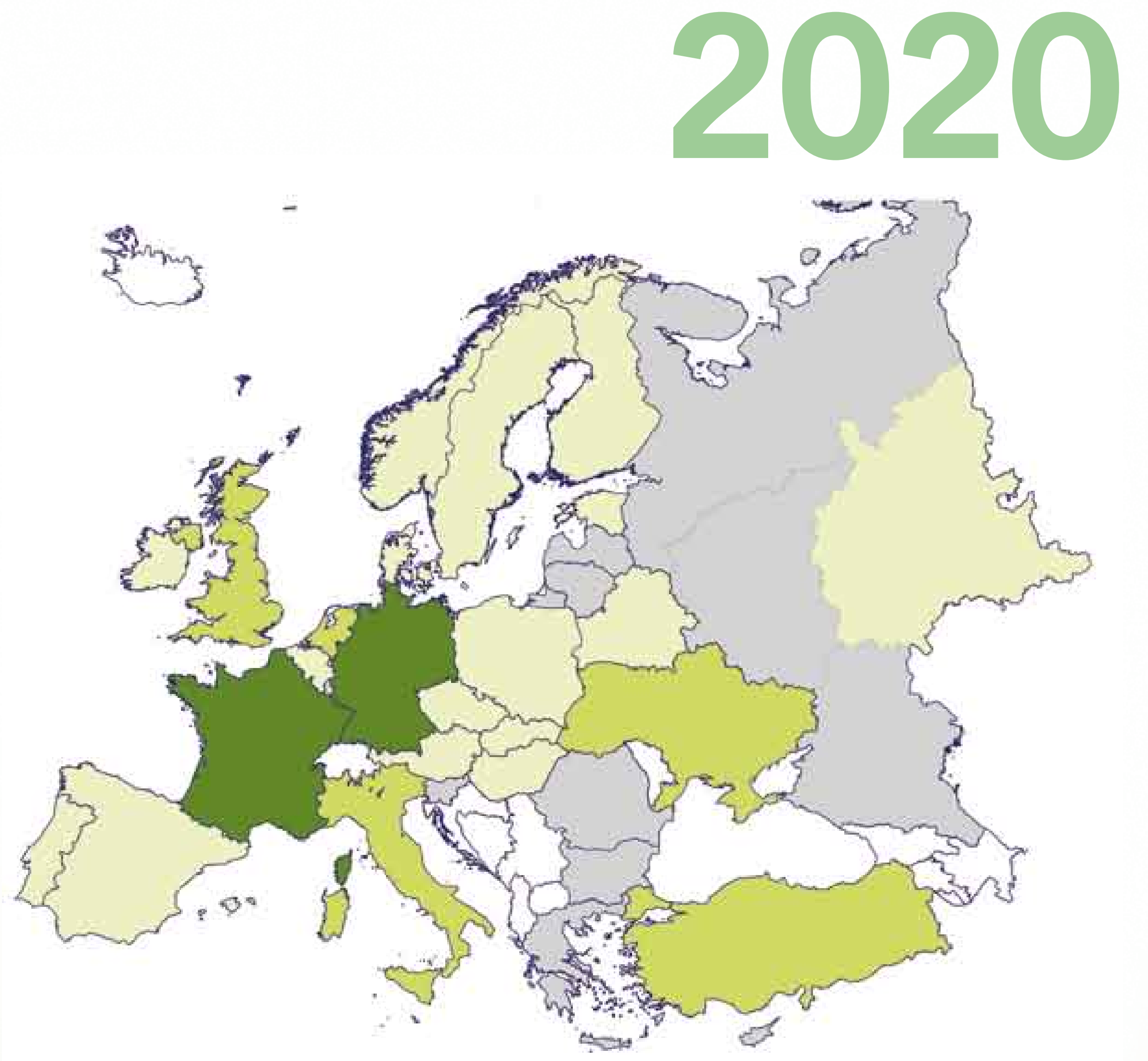
In 2005, one third of the total milk production was from France and Germany (Map 15, 2005). The scenario predicts that there will be a minor surplus of grassland for milk production in 2020 but a minor shortage of grassland for milk production in 2050 (Figure 9), because the productivity increase of grass and as a result, of milk, does not keep pace with the increase in demand.

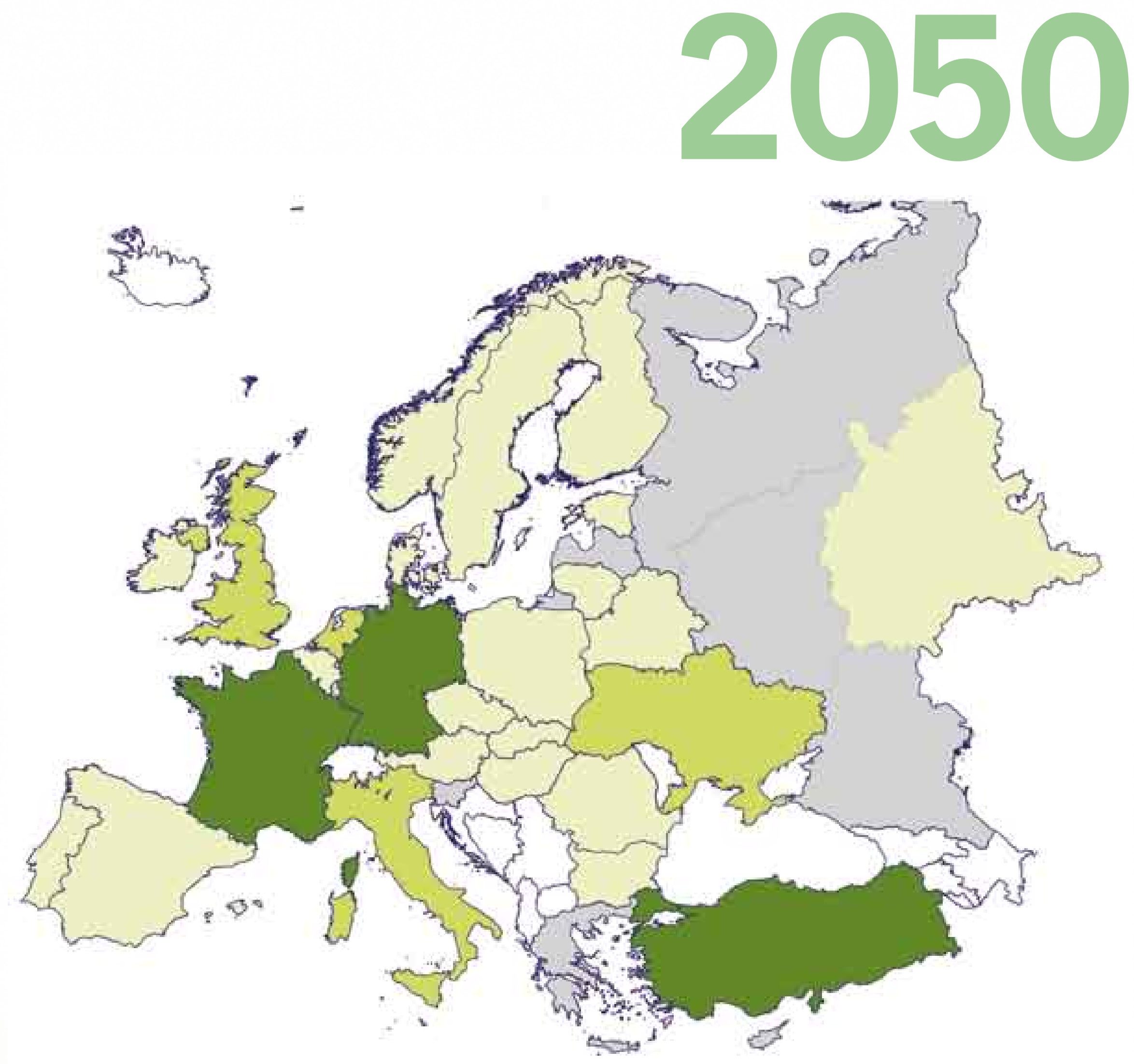
When supply outweighs demand estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of milk in 2020 and 2050, it is necessary to consider how competitive regions or countries are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production. In the event of demand exceeding the supply, there will be a shortage of land for milk production and all regions or countries will maintain their agricultural area in production. No attempt has been made to allocate surplus land.

Firstly, competitiveness on the global food market was considered in isolation (Map 15, competitiveness). The countries with the most favourable prospects are Denmark, Belarus, Ukraine and Russia. In these countries, average size is 450 ESU/holding. Countries with the least favourable prospects are Spain, Portugal, Italy, Ireland, Norway, Finland, Poland, Romania and Turkey. In these countries, the average size is only 23 ESU/holding. Hence, competitiveness within the EU-Ural countries varies widely.

Lithuania, Romania and Bulgaria will lose part of their dairy farms in 2020 (Map 15, 2020). The total demand of 190 million tons will be produced on 49 million ha (Figure 15). By 2050, these grasslands will be taken back into production but even then, there will be a shortage of land of 316.000 ha at least (Map 15, 2050; Figure 15).

within the global food market in **scenario A1** at three time slices





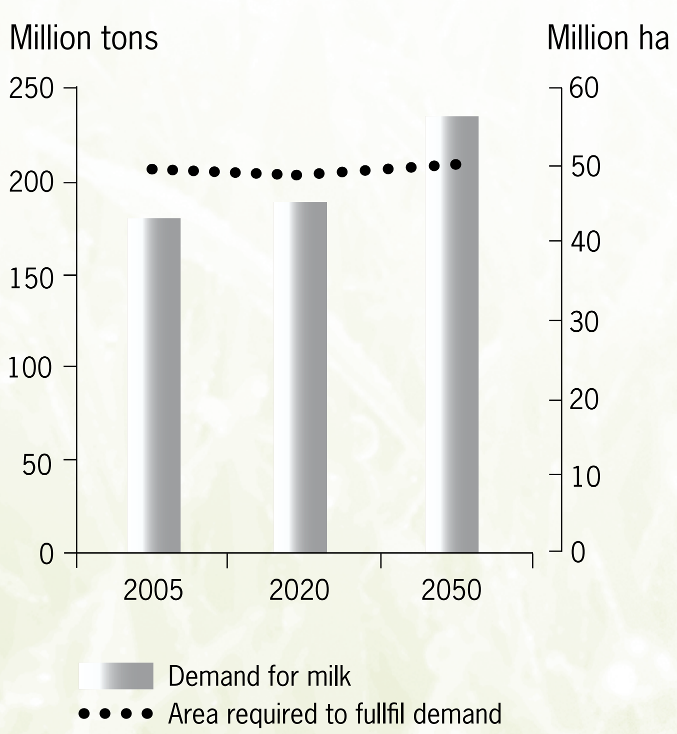


Figure 15.
Demand for milk and corresponding area in EU-Ural, based on competitiveness of dairy production on global food markets in scenario A1 at three time slices. The area required in 2050 is larger than the area available in 2005.

Legend

Each class one third of total milk production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,5% of EU-Ural production

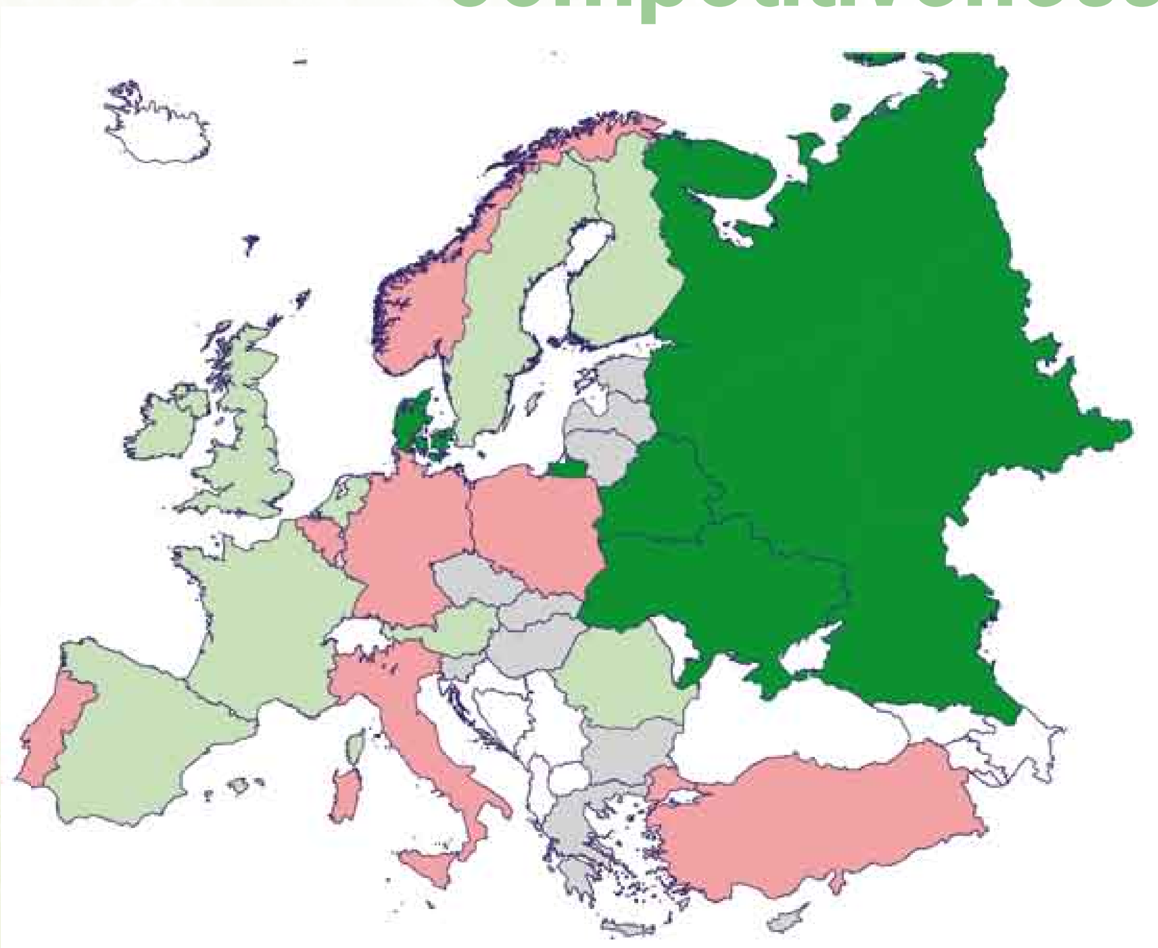
ESU/holding

- >=150
- 57 – 110
- <=57
- <0,5% of total EU-Ural ESU

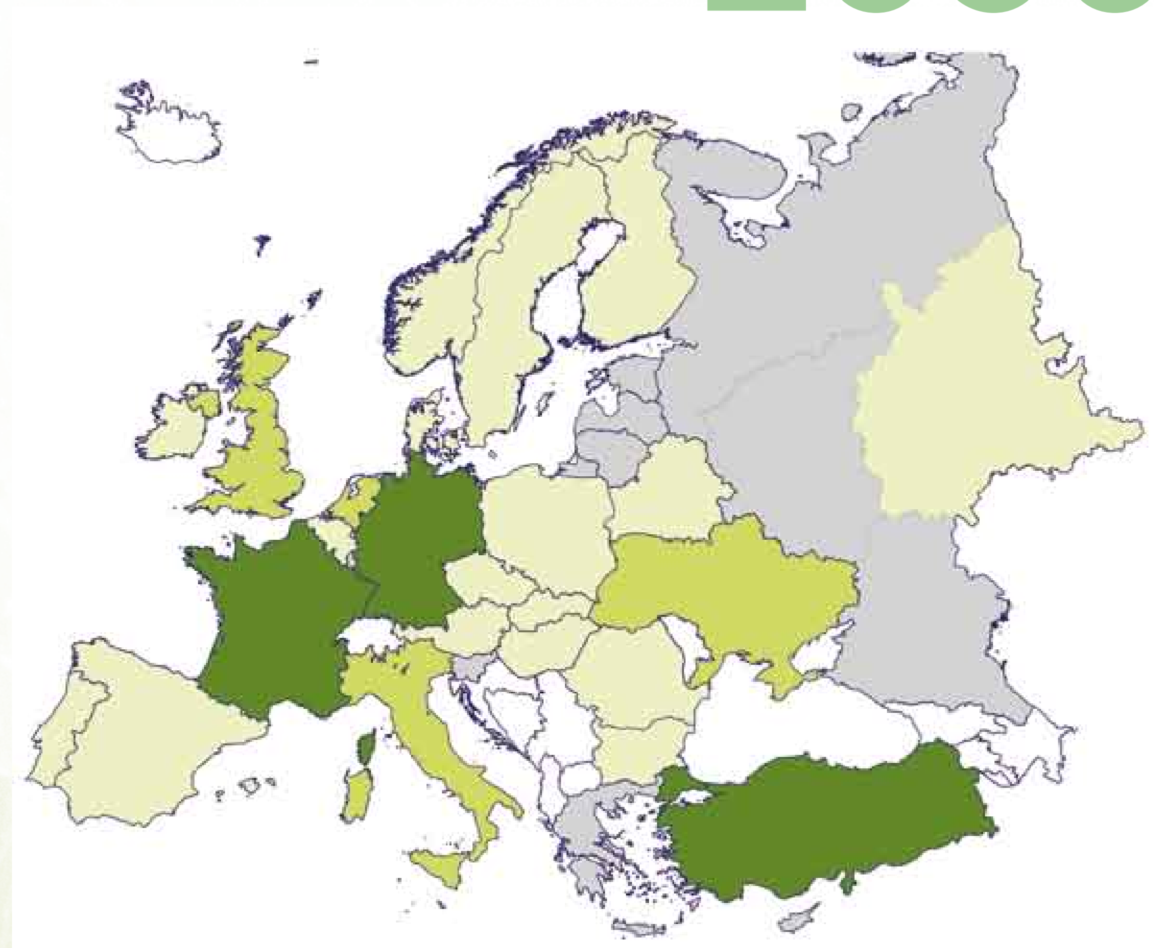
Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 16. Milk production regions in EU-Ural based on competitiveness within

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 16, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such countries will fall on the competitiveness scale. In 2050 the most competitive countries are those with large holdings and a low population pressure. These occur in Denmark, Belarus, Ukraine and Russia. In these countries, the average size is 450 ESU/holding and the average population pressure is 1.0 inhabitant/agrarian ha. The countries with the least favourable prospects are Norway, Belgium, Germany, Poland, Portugal, Italy and Turkey. These countries combine relatively small holdings (30.3 ESU/holding) with high population pressure (6.7 inhabitants/agrarian ha). Here the number of dairy farms will suffer the highest decrease, at least when supply would outweigh demand.

In comparison with the calculations based solely on competitiveness within the global food market, there are no differences because in both scenarios the demand for milk can not be met and no attempt has been made to allocate surplus land. All countries will maintain their grassland area in production (Map 16, 2050).

the global food market and the regional land market in scenario A1 at 2050

Legend

Each class one third of total milk production in 2050

(dark green)	Upper
(yellow-green)	Middle
(pale yellow)	Lower
(grey)	<0,5% of EU-Ural production

	ESU/holding	Inhabitants/ha UAA
(green)	130 - 600	< 2
(light green)	1 - 110	< 8
(pink)	1 - 75	< 40
(grey)	<0,5% of total EU-Ural ESU	

Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 17 Wheat productivity (tons/ha) in 2005

For 2050, it was predicted that wheat productivity would increase throughout Europe but southern Spain, south-western and central-eastern France, compared with 2005. There are large regional differences, ranging from -30% in southern Sweden to +80 in Estonia. These extremes are smaller than those in scenario A1.

The increases in productivity are the combined effect of changes in climate (precipitation and temperature), CO_2 and technology. Technology is the main determining factor (Figure 16). In comparison with the calculation is scenario A1, the total increases are smaller. When looking at changes in temperature and precipitation only, the productivity in 2050 compared to 2005 is likely to be lower in about 60 out of 125 regions. When the effects of CO_2 and technology are added, all but six regions show an increase in productivity. For example, in south-western France, effects of precipitation and temperature result in a productivity change of -30%, if the effect of CO_2 was added the change was only -25%, when technology was included the productivity increased to -5%.

The regions with the highest productivity for 2050 were found in Ireland (where almost 12 tons/ha could be achieved), followed by the United Kingdom, Germany (except Bayern), Denmark, the Netherlands, Belgium and northern France, where between 9 - 12 tons/ha could be achieved. The regions with the lowest productivity were Spain, Portugal, southern Italy, Estonia, Latvia, Belarus, Ukraine, Turkey and Russia. There, productivity reached no more than 3 tons/ha (Map 17).

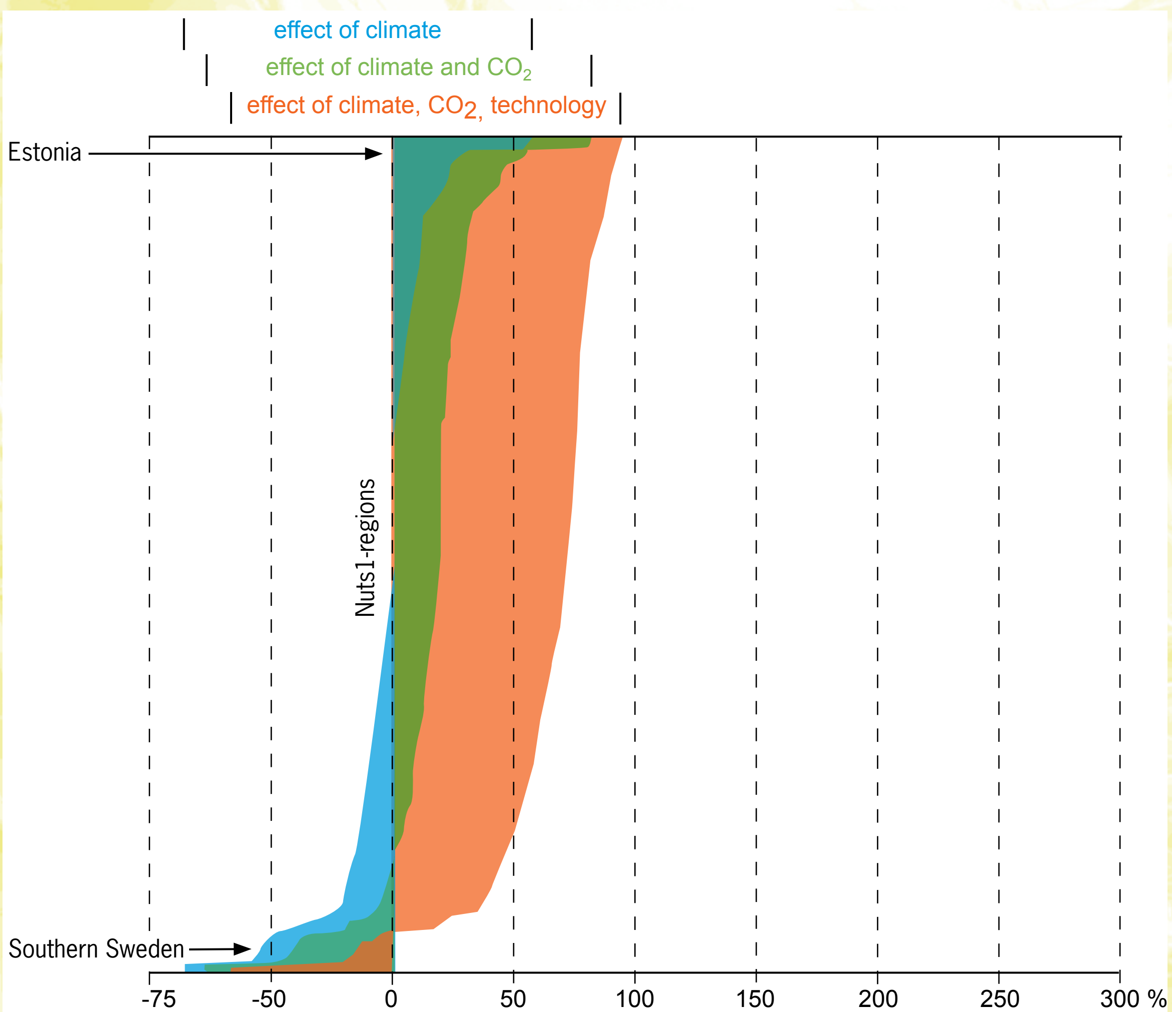
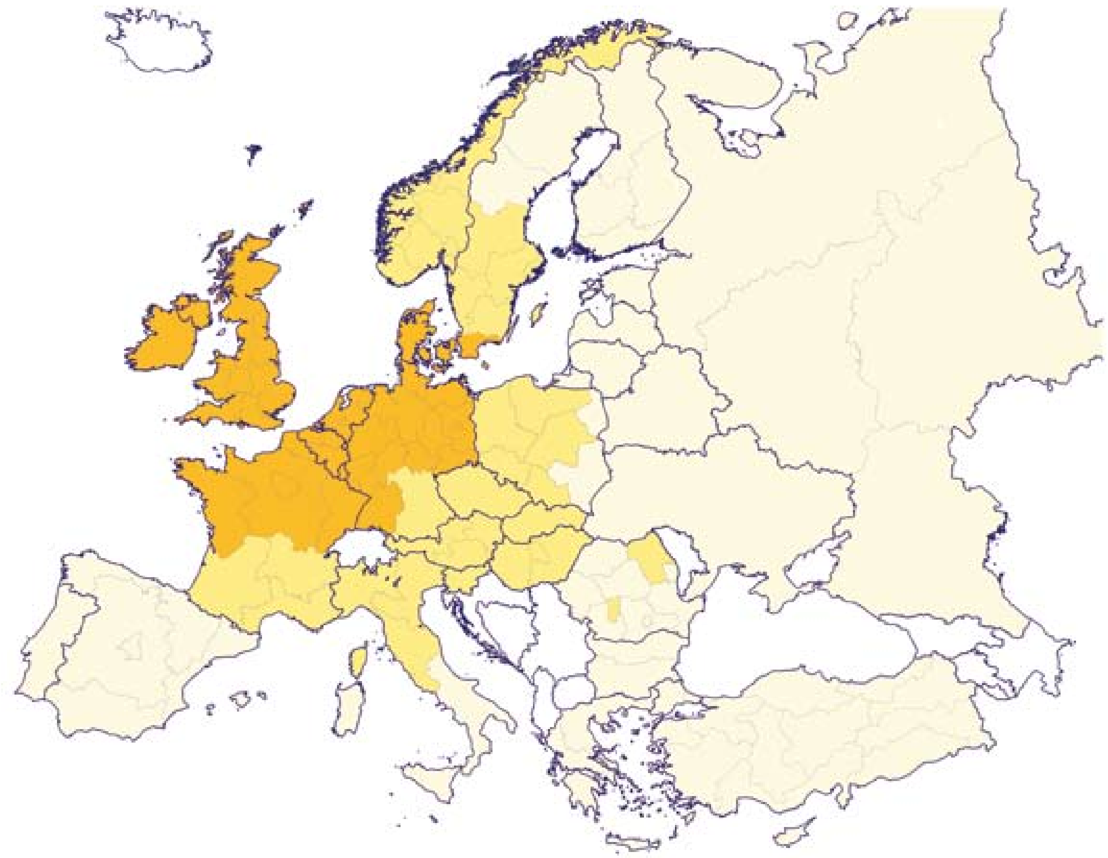


Figure 16. Changes (%) of productivity of wheat in European regions in 2050 compared to 2005 in scenario B2 as a result of climate (precipitation and temperature), CO_2 and technology.



By multiplying the area under wheat cultivation in 2005 by the productivity for each region, the total achievable wheat production in the EU27 was calculated, leading to a predicted 140 million tons in 2020 and 150 million tons in 2050. The production demand for wheat, determined by population size and economic growth, was estimated to be 125 million tons in 2020 and 190 million tons in 2050. For wheat in scenario B2 in the EU27, the production demand far outweighed the available supply in 2050 as can be seen in Figure 17.

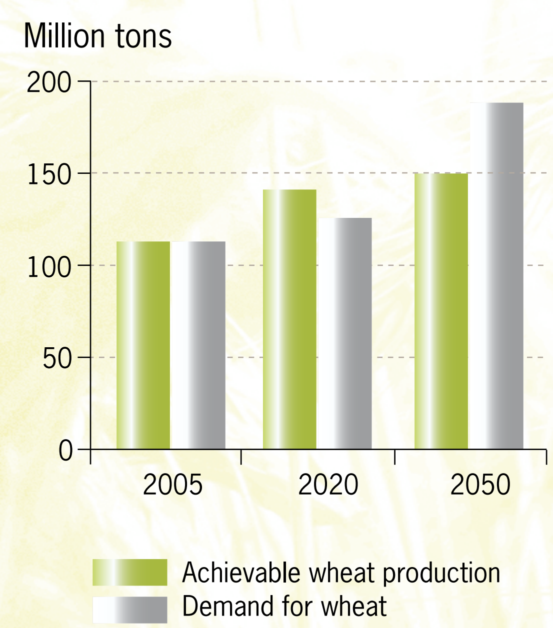
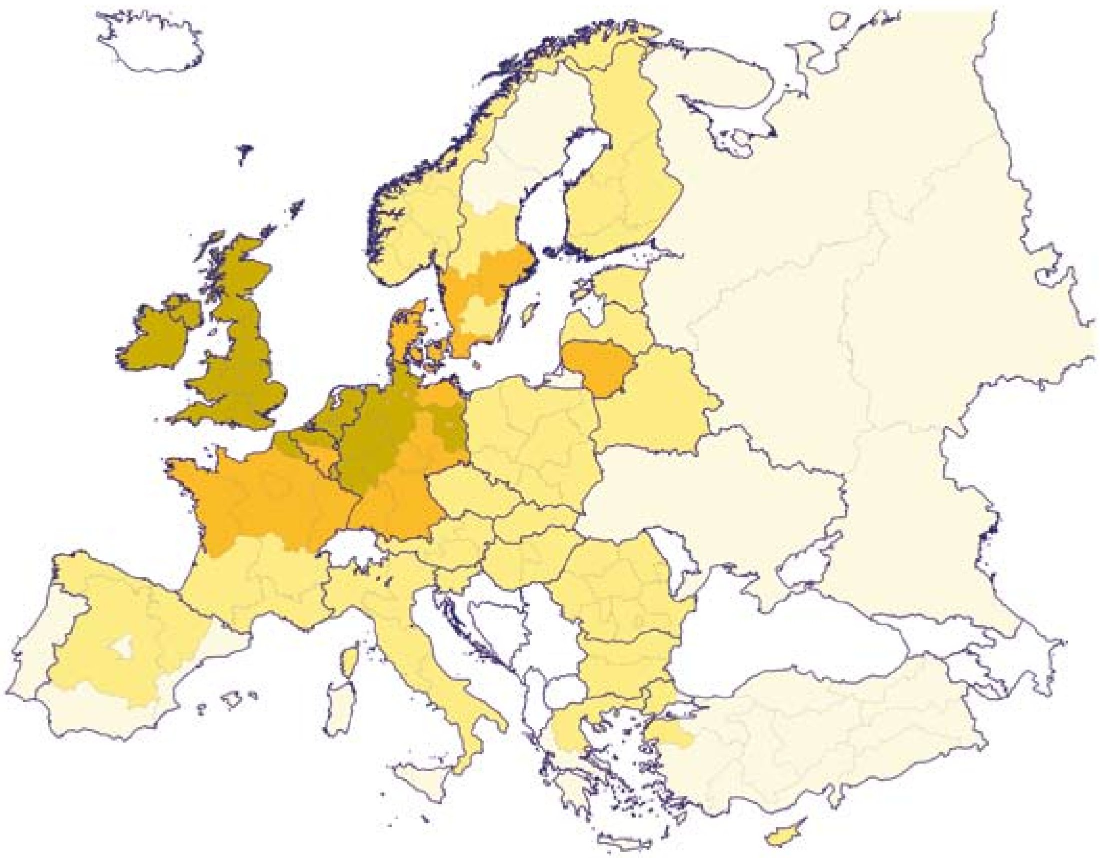


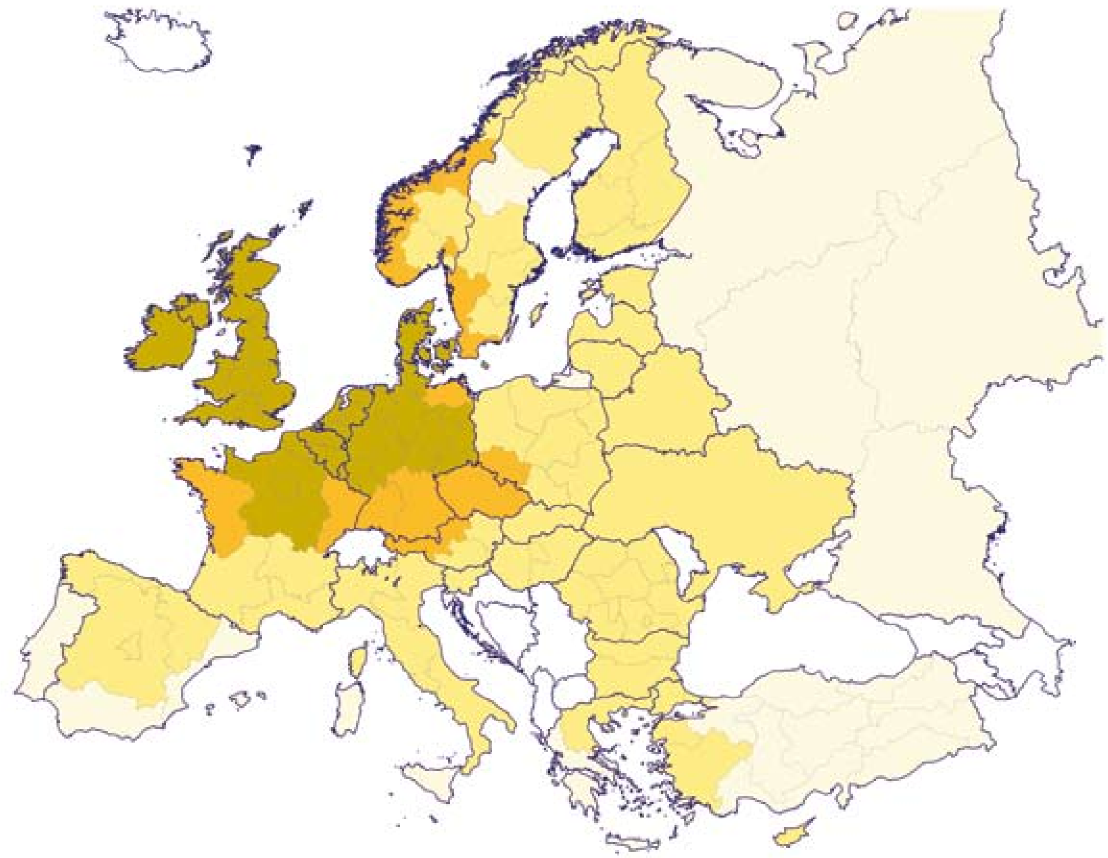
Figure 17. Achievable production of and demand for wheat in EU27 in scenario B2 at three time slices.

Europe in **scenario B2** at three time slices

2020



2050



National instead of regional data were used to calculate the achievable production of wheat in the EU-Ural. The total was calculated by multiplying the productivity per country by the national wheat production area in 2005. The achievable production predicted was 210 million tons in 2020, and 235 million tons in 2050. The demand for wheat, which is related to population size and economic growth, was estimated at 195 million tons in 2020 and 330 million tons in 2050. Therefore, in scenario B2 in the EU-Ural, the future production demand far outweighed the available supply in 2050, as can be seen in Figure 18.

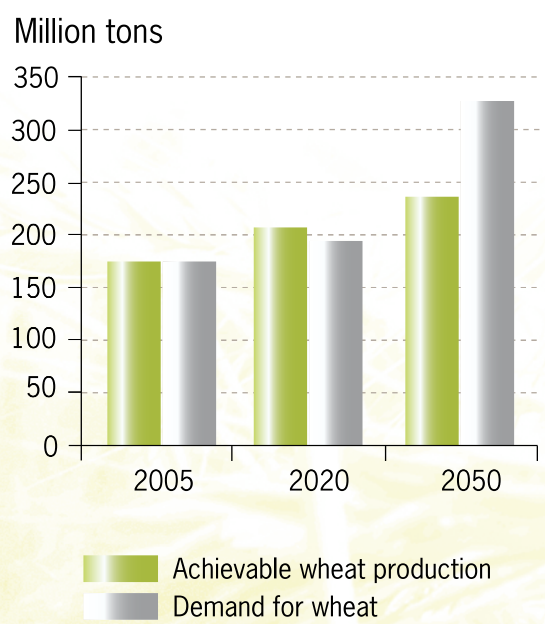


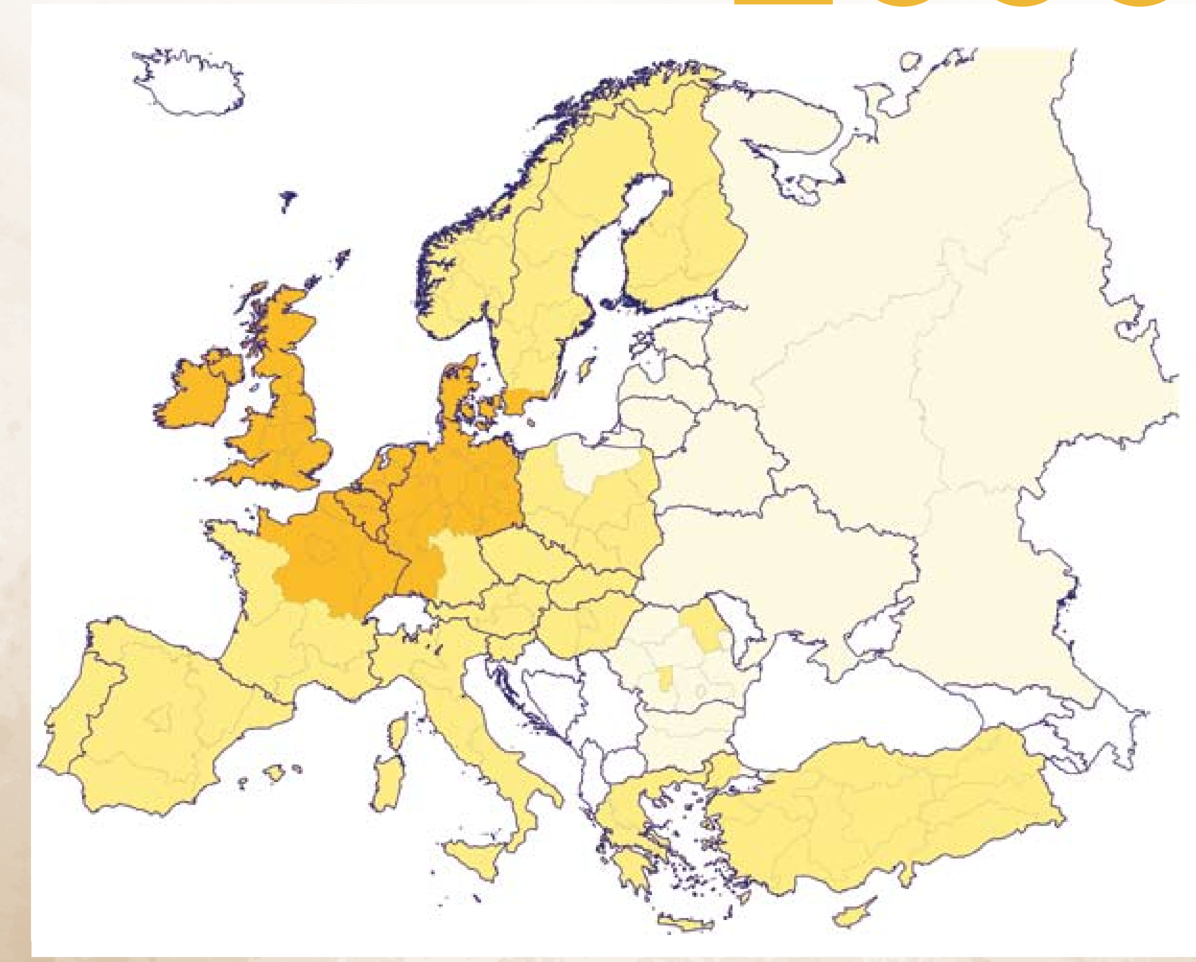
Figure 18. Achievable production of and demand for wheat in EU-Ural in scenario B2 at three time slices.

Legend

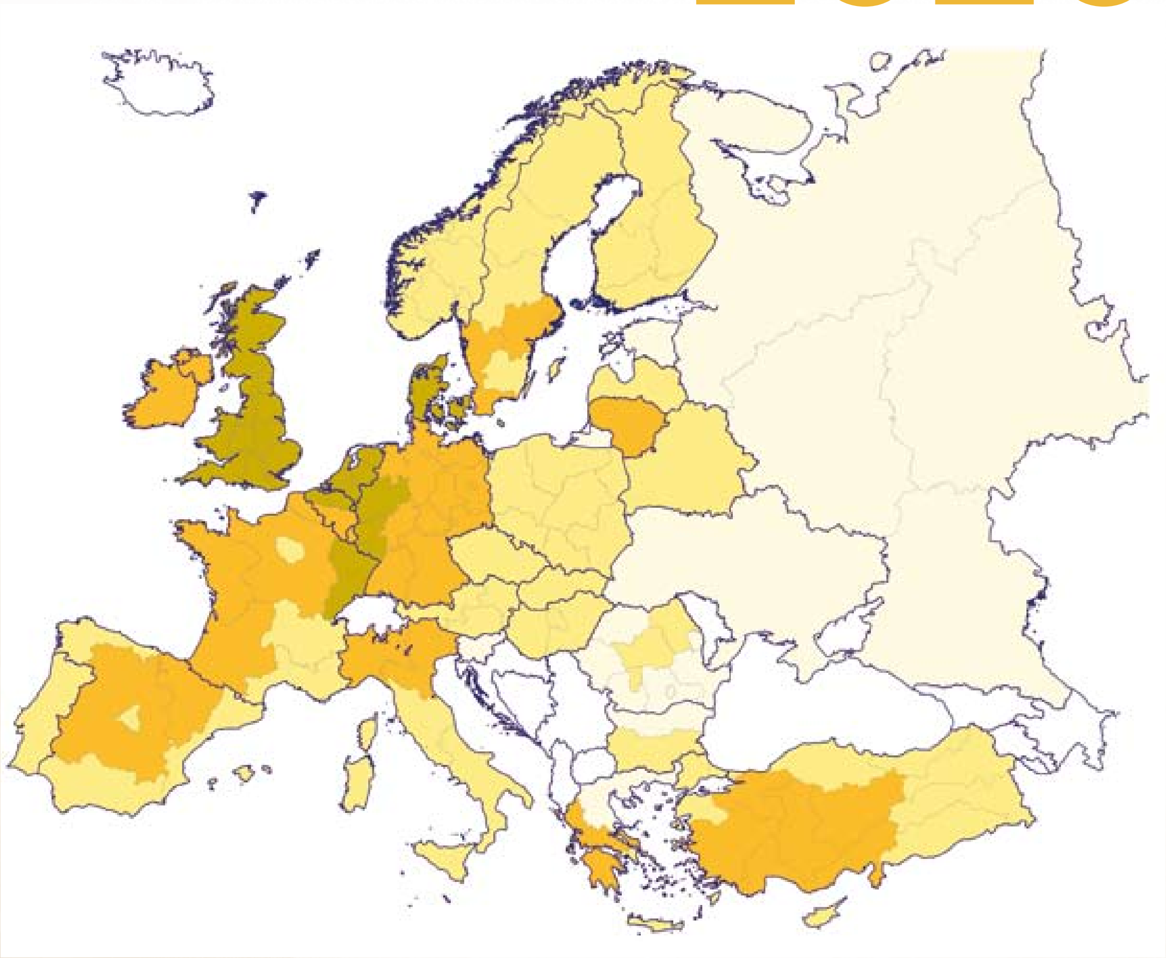
- < 3 tons / ha
- 3 - 6 tons / ha
- 6 - 9 tons / ha
- 9 - 12 tons / ha
- > 12 tons / ha

Map 18 Potato productivity (tons/ha) in Europe in **scenario B2** at three time slices

2005



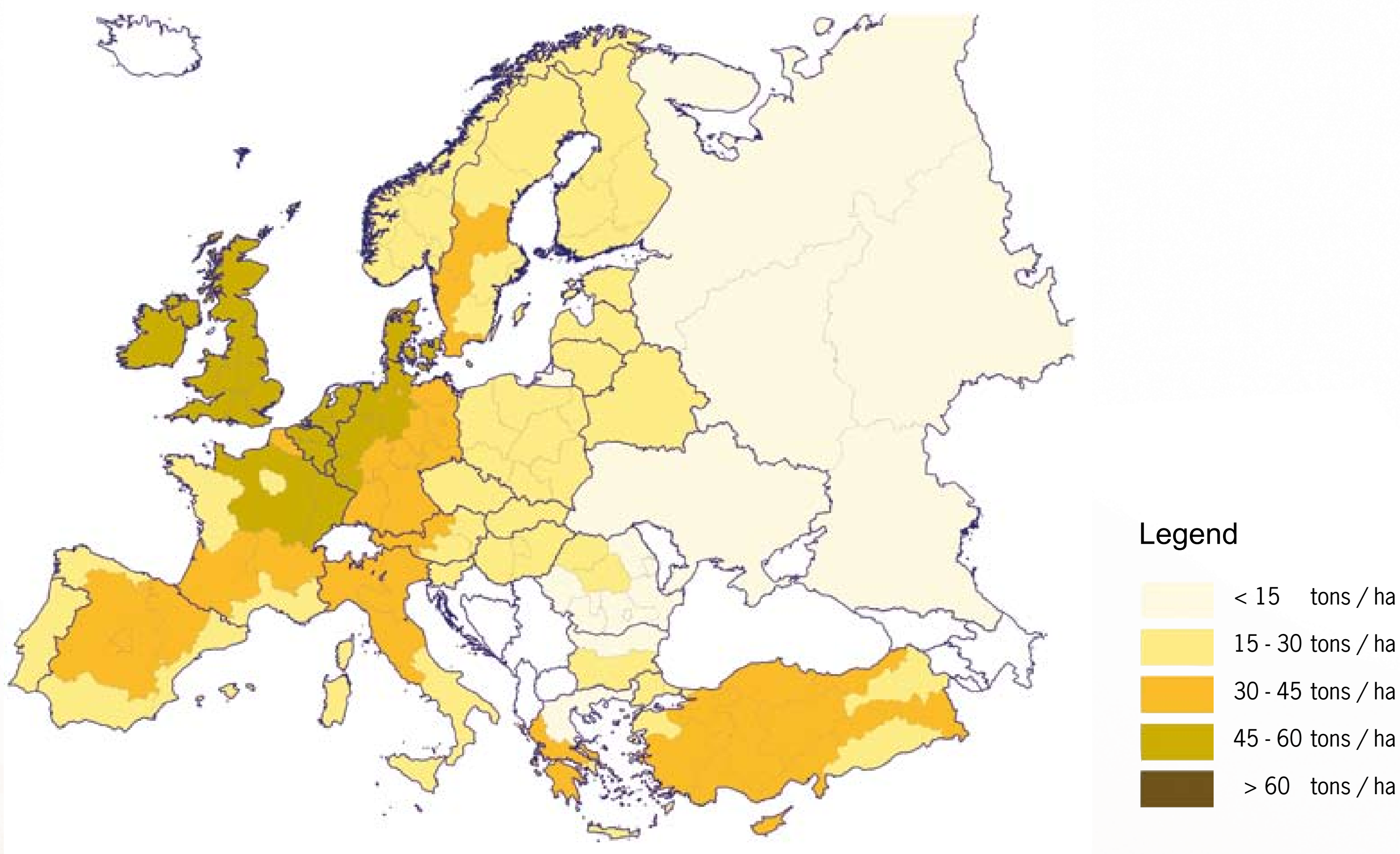
2020



For 2050, it was predicted that potato productivity would increase throughout Europe but some regions in southern and eastern Europe, compared to 2005. In comparison with the calculations in scenario A1, productivity is considerably lower. The highest productivity reached no more than 60 tons/ha, compared to 94 tons/ha in scenario A1. The regions with the highest productivity for 2050 were found in the United Kingdom, Ireland, Denmark, the Netherlands, Belgium, Germany (except Bayern) and northern and eastern France, where between 40 and 60 tons/ha could be achieved. The regions with the lowest productivity in 2050 were all eastern situated countries (Russia, Belarus, Ukraine, Czech Republic, Slovakia, eastern Poland, eastern Hungary and northern Bulgaria) but also southern France, northern Italy and northern Greece. There productivity reached no more than 15 tons/ha (Map 18).

These increases in productivity are the combined effect of changes in climate (precipitation and temperature), CO_2 and technology. When looking at changes in precipitation and temperature only, the productivity in 2050 is likely to be lower in more than half of the 125 regions. When the effects of CO_2 and technology are added, all regions but six show an increase in productivity. Technological improvement in Eastern Europe is less advanced than in the West, therefore a lower percentage is used for these countries with regard to potatoes. This technology gap remains for all time slices and as a result, in regions with a low technology development stage, effects of CO_2 and technology are not always able to compensate a decrease in productivity for potatoes due to precipitation and temperature effects. In the Czech Republic, Slovenia, Slovakia, and in some regions in Romania, Greece, Russia and Turkey, productivity in 2050 will be lower than in 2005. But also in regions with a high technology development stage, climate effects can not always be compensated. This is the case in southern France and north-western Italy.

2050



By multiplying the area under potato cultivation in 2005 by the productivity for each region, the total achievable potato production in the EU27 was calculated, leading to a predicted 65 million tons in 2020 and 70 million tons in 2050. The demand for potatoes, determined by population size and economic growth, was estimated to be 56 million tons in 2020 and 74 million tons in 2050. For potatoes in the B2 scenario in the EU27, the production demand outweighed the available supply in 2050, as can be seen in Figure 19.

Figure 19. Achievable production of and demand for potatoes in EU27 in scenario B2 at three time slices.

National instead of regional data were used to calculate the achievable production of potatoes in the EU-Ural. The total was calculated by multiplying the productivity per country by the national potato production area in 2005. The achievable production predicted was 110 million tons in 2020 and about 120 million tons in 2050. The demand for potatoes, which is related to population size and economic growth, was estimated at 100 million tons in 2020 and 140 million tons in 2050. Therefore, in the B2 scenario in the EU-Ural, the production demand outweighed the available supply for potatoes in 2050, as can be seen in Figure 20.

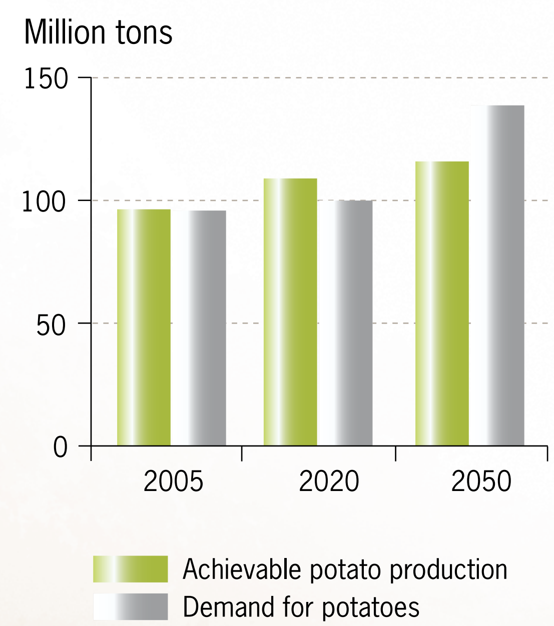
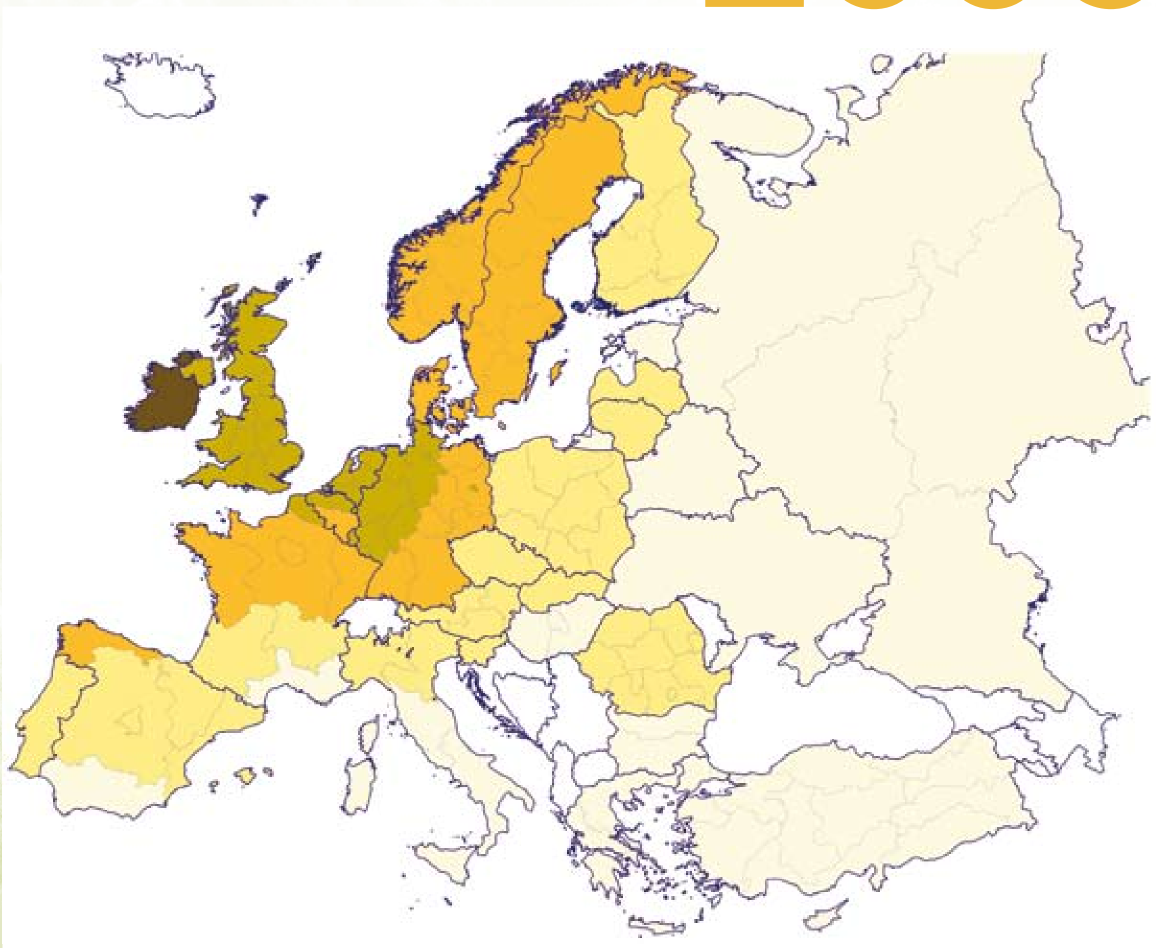


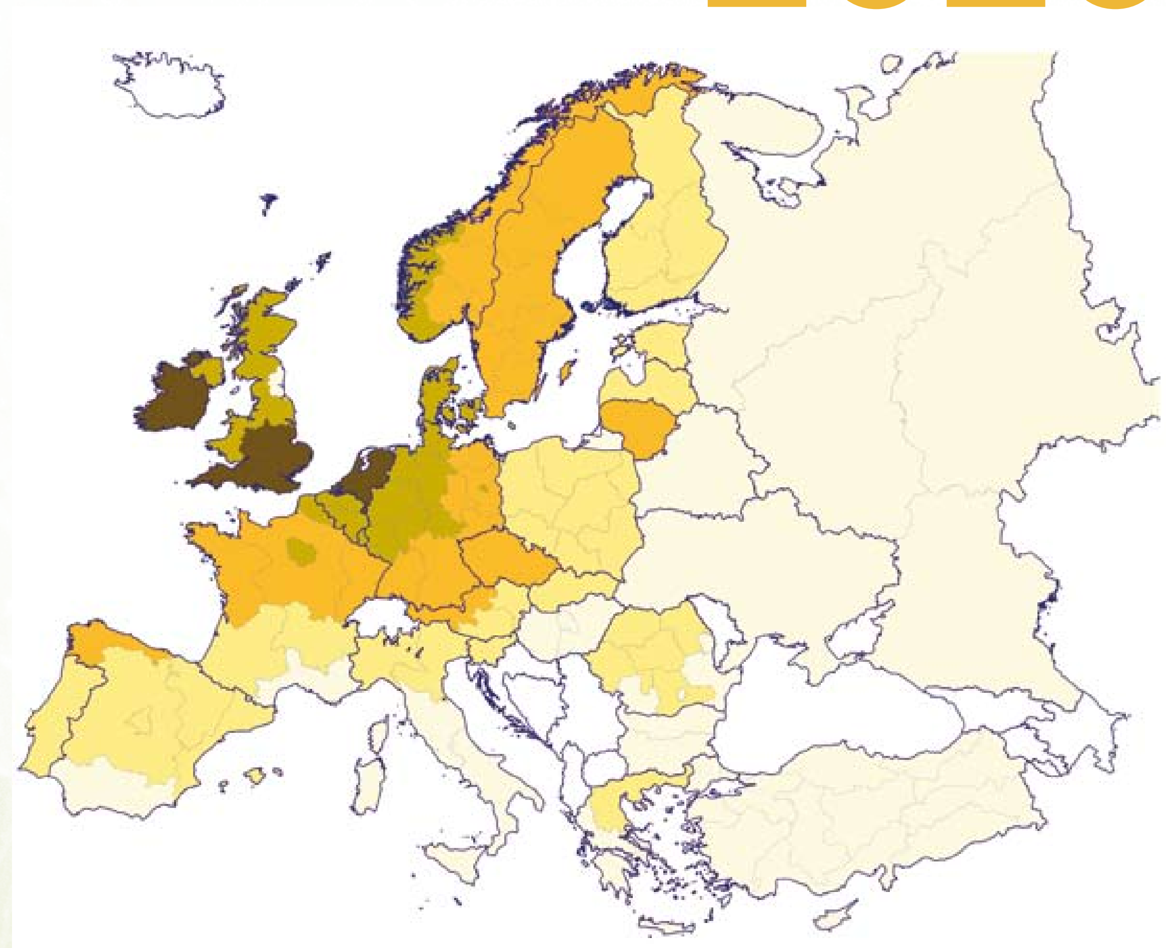
Figure 20. Achievable production of and demand for potatoes in EU-Ural in scenario B2 at three time slices.

Map 19 Grass productivity (tons/ha) in Europe in **scenario B2** at three time slices

2005



2020



For 2050, it was predicted that grass productivity would increase throughout Europe but in thirty regions. There are large regional differences, ranging from -50% in eastern France to more than 700% in Turkey and Russia. The latter is due to a very low productivity of grass of 0,1 ton/ha in 2005.

The increases in productivity are the combined effect of changes in climate (precipitation and temperature), CO_2 and technology. Contrary to wheat and potato, not technology but climate and CO_2 effects are the determining factors. The regions with decreasing grass productivity are eastern Austria, Portugal, northern and eastern Spain, north-eastern France, northern Greece, central Italia, the south of Poland, Romania, Slovenia, Slovakia, and some regions in Sweden and the Netherlands.
The regions with the highest productivity for 2050 were Ireland, England and Wales where between 7.5 and 10 tons/ha could be achieved. The regions with the lowest productivity in 2050 were the east European countries Russia, Belarus, Ukraine, Romania, Bulgaria, Hungary and Turkey but also south European regions in Greece, south-western Italy, southern France, Portugal and large parts of Spain. There productivity reached no more than 2 tons/ha (Map 19).

By multiplying the area under grass production in 2005 by the productivity for each region, the total achievable grass production per EU27 region was calculated. The achievable grass production is translated into achievable milk production. By adding up the regional milk productions, total achievable milk production in the EU27 was calculated leading to a predicted 155 million tons in 2020 and 150 million tons in 2050. The demand for milk, determined by population size and economic growth, was estimated to be 150 million tons in 2020 and 165 million tons in 2050. For milk in scenario B2 in the EU27, the production demand slightly outweighed the available supply in 2050, as can be seen in Figure 21.

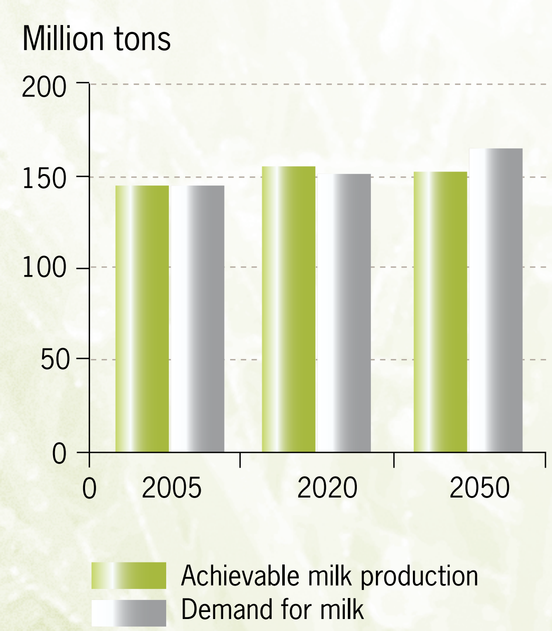
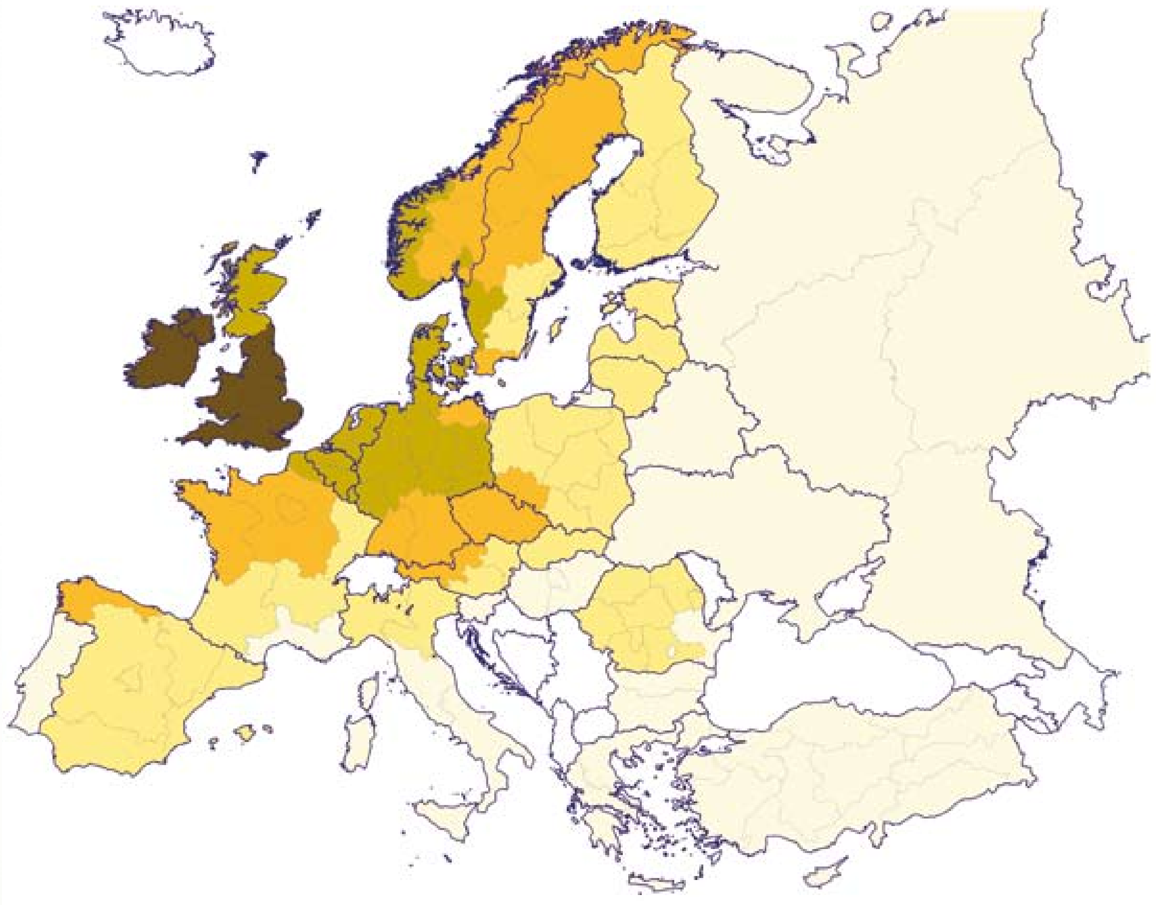


Figure 21. Achievable production of and demand for milk in EU27 in scenario B2 at three time slices.

2050



National instead of regional data were used to calculate the achievable production of grass in the EU-Ural. The national total was calculated by multiplying the productivity per country by its national grass production area in 2005. The achievable national production was translated into the national milk production. The achievable production predicted was 195 million tons in 2020 as well as in 2050. The demand for milk, which is related to population size and economic growth, was estimated at 185 million tons in 2020 and 260 million tons in 2050. For milk in scenario B2 in the EU-Ural, the production demand outweighed the achievable supply in 2050, as can be seen in Figure 22.

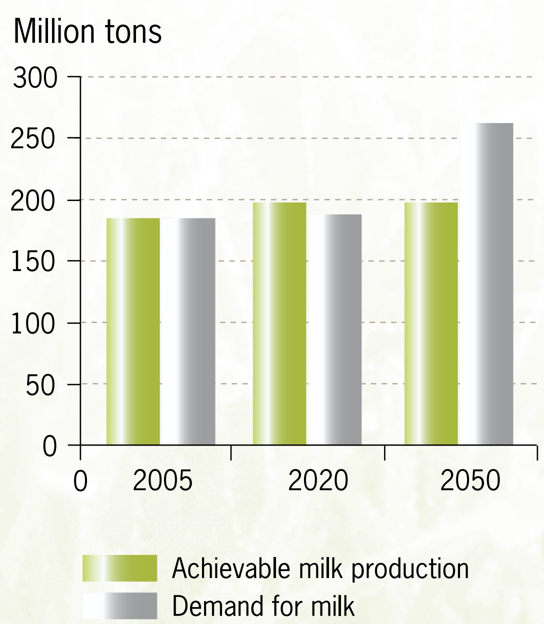


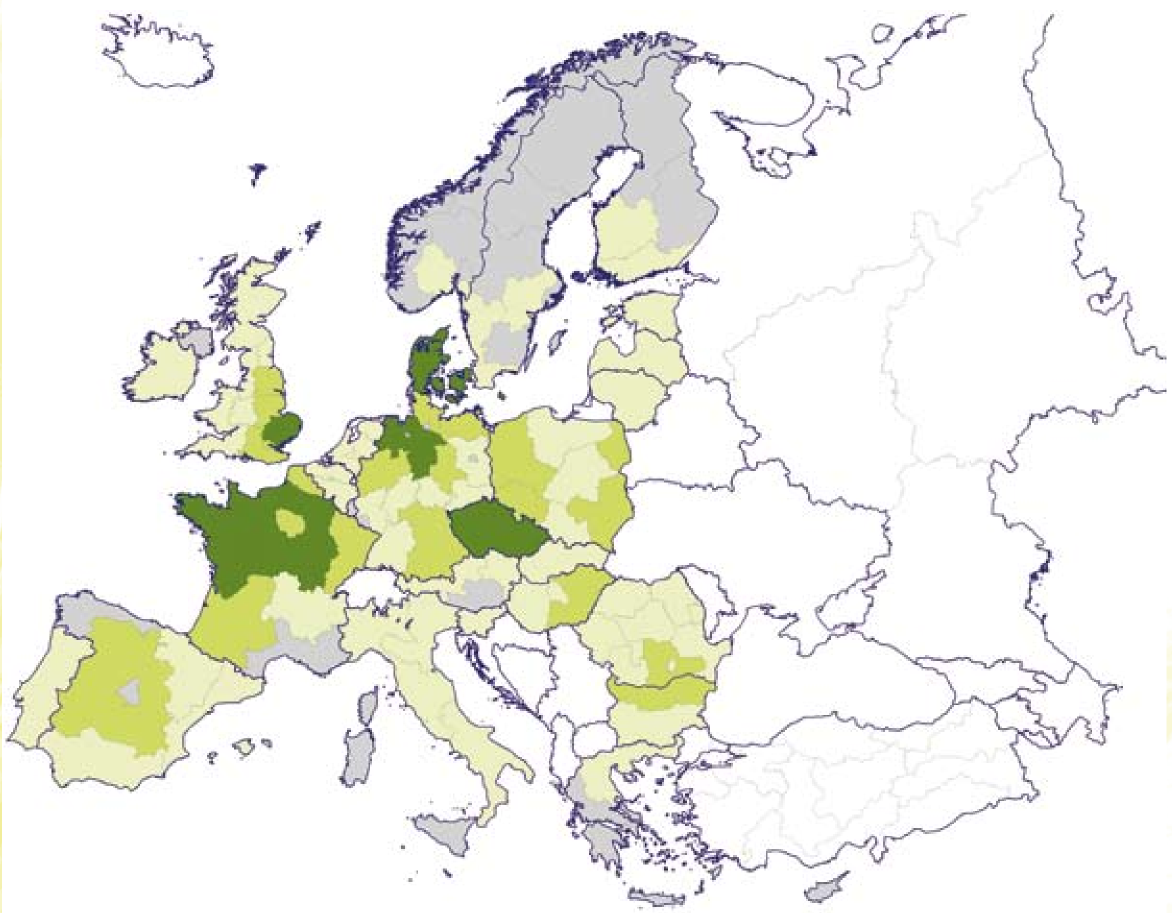
Figure 22. Achievable production of and demand for milk in EU-Ural in scenario B2 at three time slices.

Legend

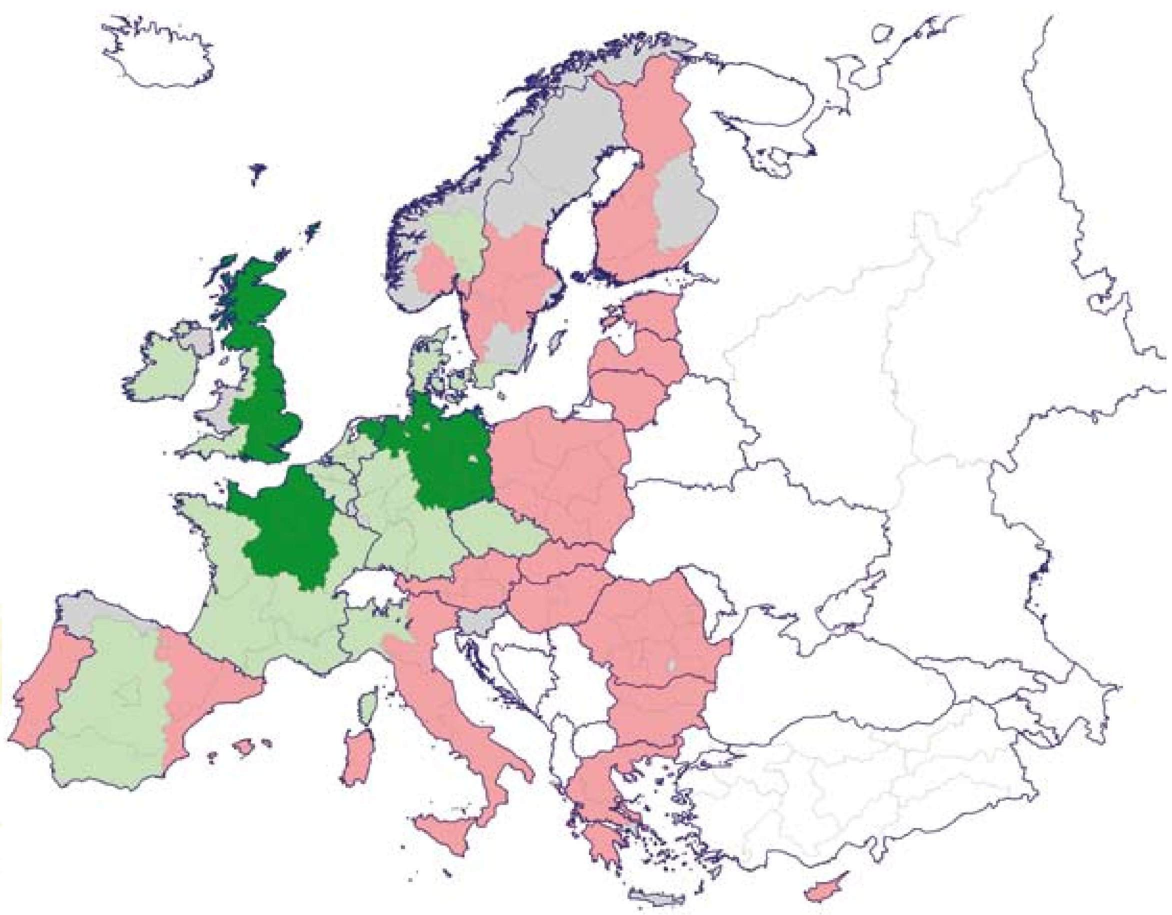
< 2 tons / ha
2 - 4 tons / ha
4 - 6 tons / ha
6 - 8 tons / ha
> 8 tons / ha

Map 20 Wheat production regions in EU27 based on competitiveness within the global

2005



competitiveness



In 2005, one third of the total wheat production was from Denmark, the Czech Republic, north-western France, eastern England and Niedersachsen together (Map 20, 2005). The scenario predicts that by 2020 the achievable supply will slightly outweigh the production demand (some 15 million tons). By 2050, the production demand will outweigh the achievable supply (Figure 17).

When supply outweighs demand (in 2020) estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of wheat in 2020, it is necessary to consider how competitive regions are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. The relative competitiveness order of regions is identical in scenario A1 and scenario B2. But in scenario B2, it is assumed that European and national governments will support regional agriculture hence – although competitiveness will play a role – it will be less pronounced. In comparison with the calculations in scenario A1, less land per region will be taken out of production, resulting in more regions being required to attain the required reduction of wheat land. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

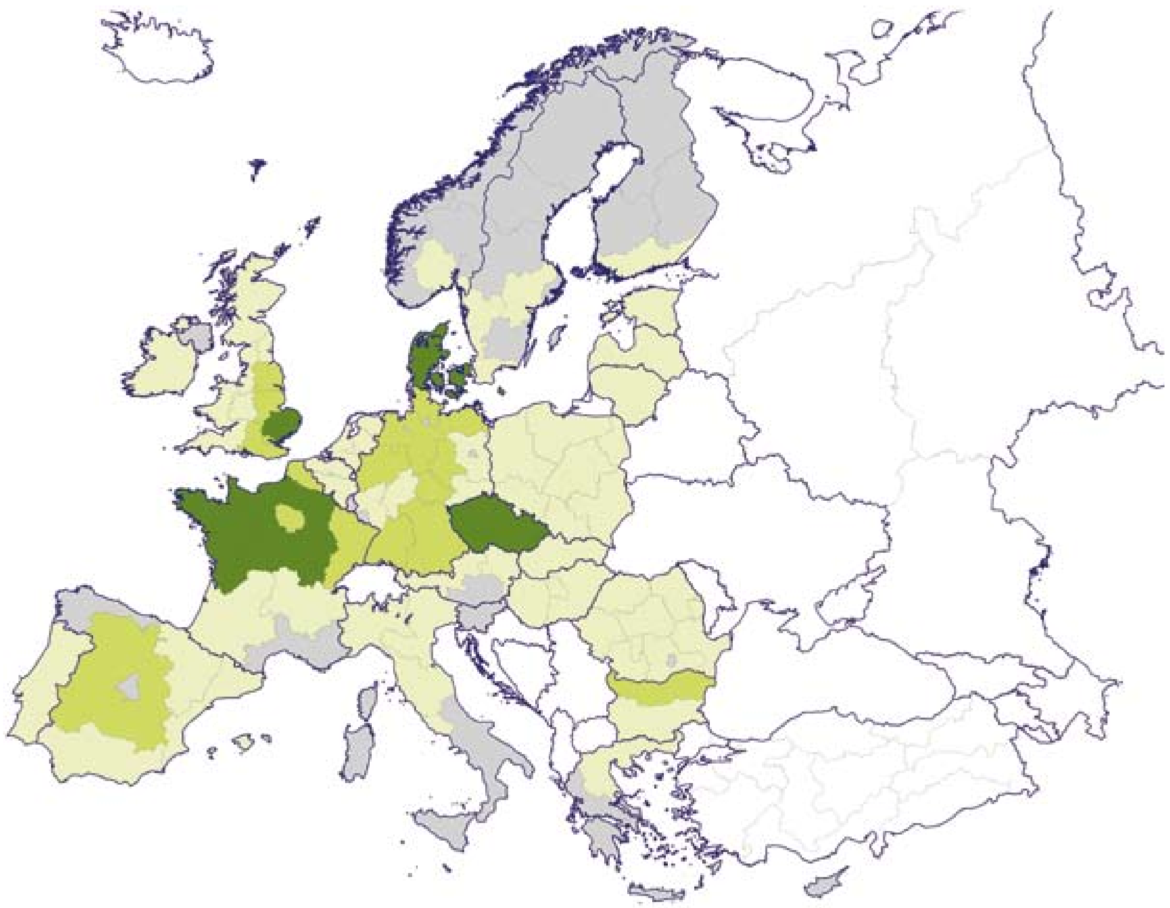
When demand outweighs supply (in 2050) there will be a shortage of land and all regions will maintain their agricultural area in production. No attempt has been made to allocate surplus land.

Firstly, competitiveness on the global food market was considered in isolation (Map 20, competitiveness). The regions with the most favourable prospect are north-western France, north-eastern Germany, northern Netherlands and eastern UK. In these regions, average size is 110 ESU/holding. Regions with the least favourable prospects are (with the exception of the Czech Republic) the new member states, Greece, south-eastern Italy, Portugal, eastern Spain and in the north Norway, Sweden and Finland. In these regions, the average size is only 8 ESU/holding. Hence, competitiveness within the EU27 regions varies widely.

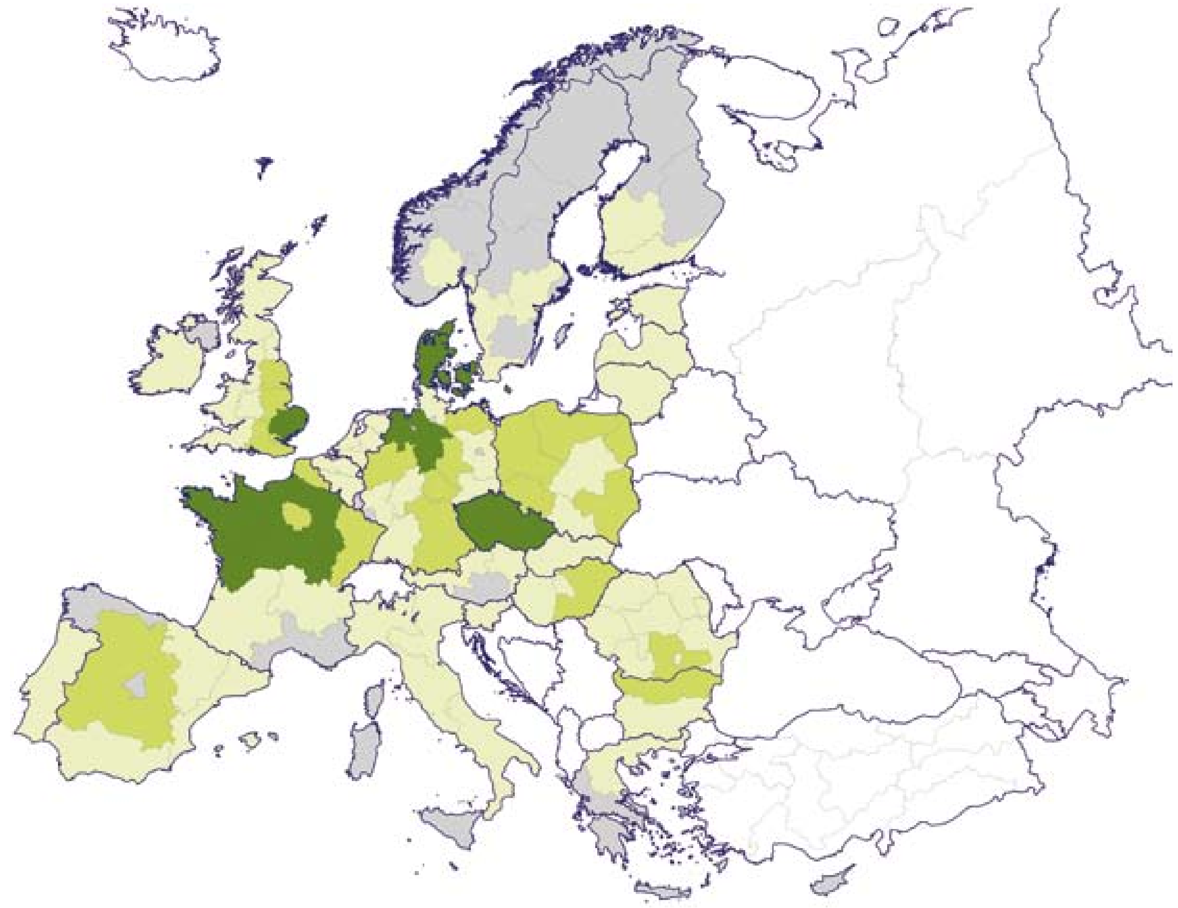
Southern Italy and Slovenia as well as a few regions in the east European countries Poland, Hungary and Romania will most likely lose their wheat farms by 2020 (Map 20, 2020). By 2050, when the production demand will outweigh the achievable supply, this wheat land will have to be taken back into production and even then there will be a shortage of wheat land of at least 3.2 million ha (Figure 23). At least, because the area is calculated supposing that the maximum productivity could be realised. In 2050, France, Denmark, the Czech Republic, north-western Germany and eastern UK together will be capable of supplying one third of the total EU27 wheat demand (Map 20, 2050).

food market in **scenario B2** at three time slices

2020



2050



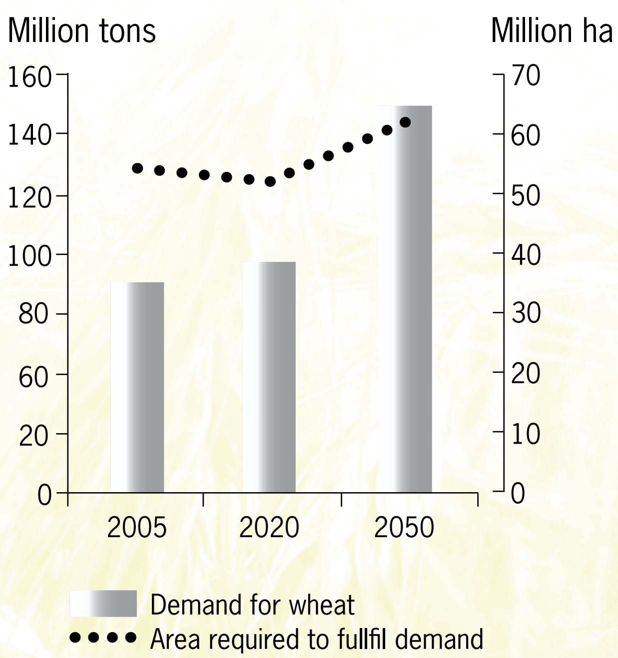


Figure 23.
Demand for wheat and corresponding area in EU27, based on competitiveness of arable production on global food markets in scenario B2 at three time slices. The area required in 2050 is larger than the area available in 2005.

Legend

Each class one third of total wheat production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

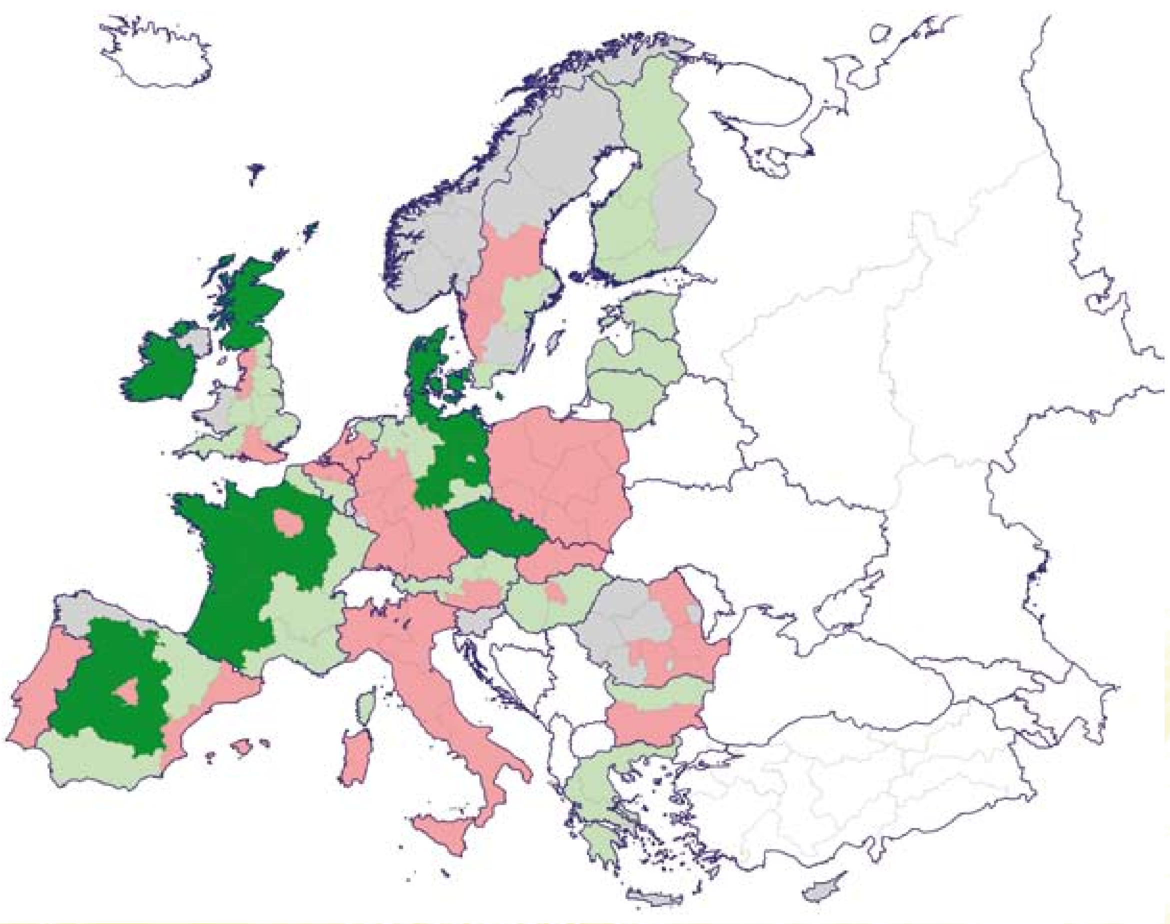
ESU/holding

- >=65
- 20 – 65
- <=20
- <0,1% of total EU27 ESU

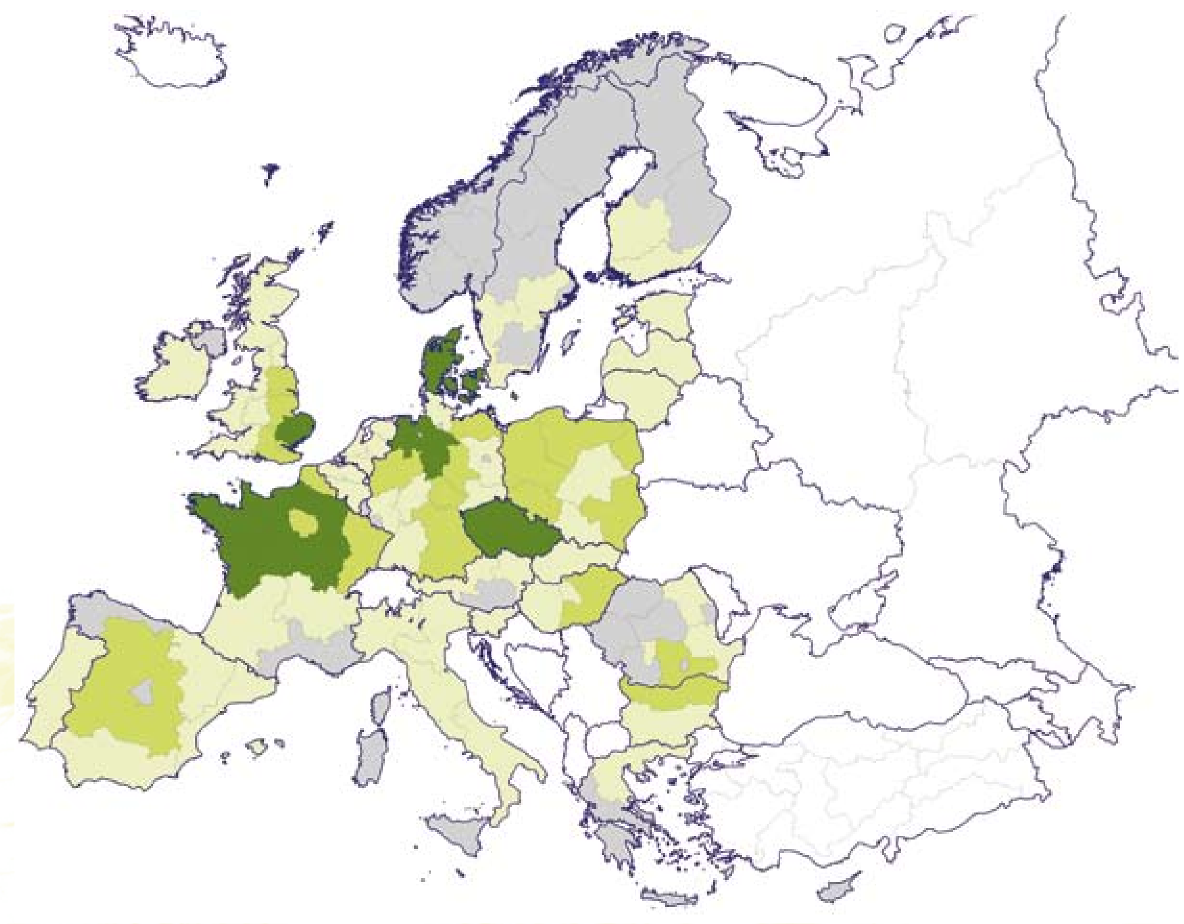
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 21 Wheat production regions in EU27 based on competitiveness within the global

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 21, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale. In 2050 the most competitive regions are those with large holdings and a low population pressure. These occur in western France, Ireland, Denmark, Scotland, eastern Germany and the Czech Republic. In these regions, the average size is 90 ESU/holding and the average population pressure is 1.6 inhabitant/agrarian ha. The regions with the least favourable prospect are in Poland, Slovakia, Italy, Portugal, eastern Spain, Flanders and the entire Rhine basin i.e. western Germany and the Netherlands. These regions combine relatively small holdings (18.1 ESU/holding) with high population pressure (11.2 inhabitants/agrarian ha). Here the number of wheat farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market, Map 20 and Map 21 hardly differ due to a shortage of land of at least 3.2 million ha. Therefore, these maps are similar to the situation in 2005 (Map 20, 2005).

food market and the regional land market in **scenario B2** at 2050

Legend

Each class one third of total wheat production in 2050

Upper

Middle

Lower

<0,1% of EU27 production

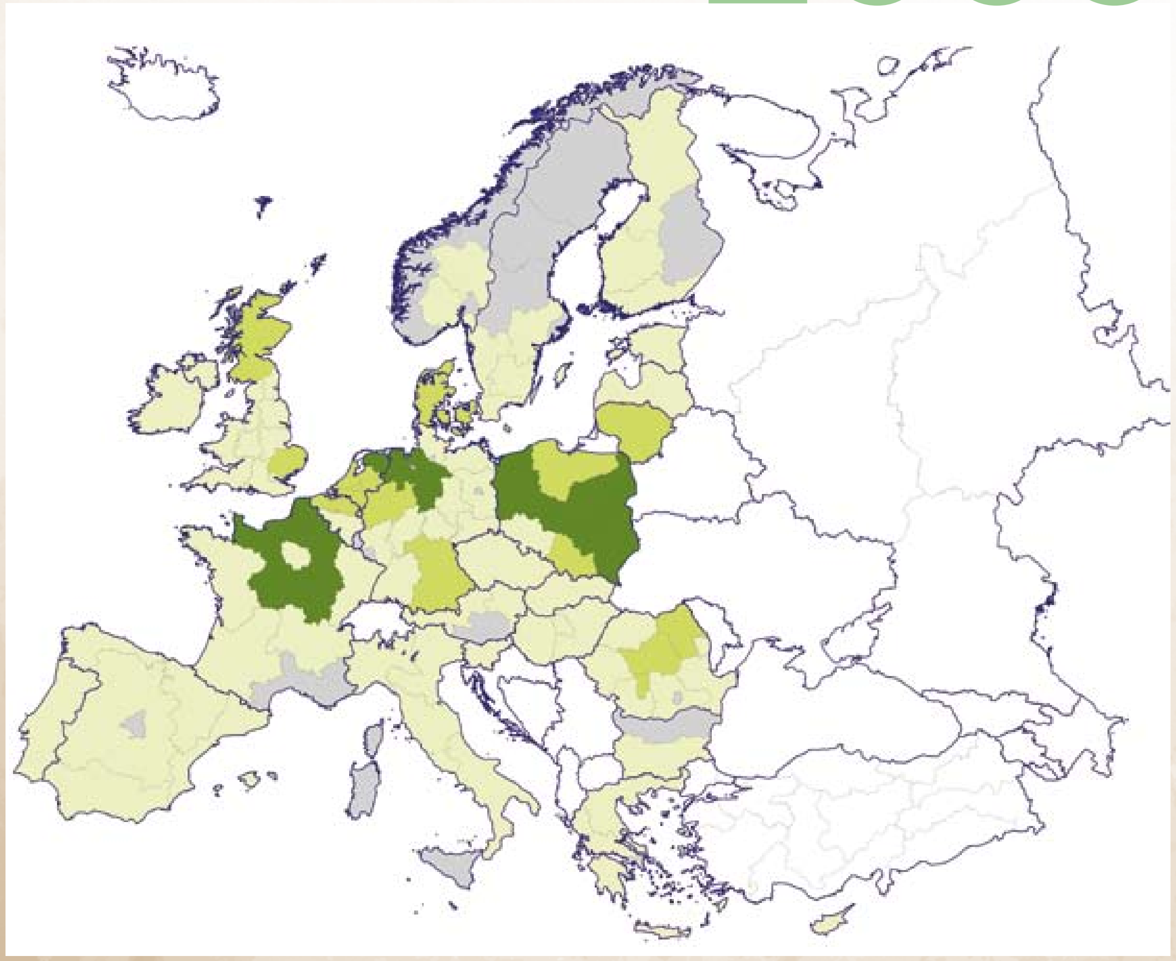
ESU/holding	Inhabitants/ha UAA
20 - 230	< 3
2 - 130	< 6
0 - 105	< 235

<0,1% of total EU27 ESU

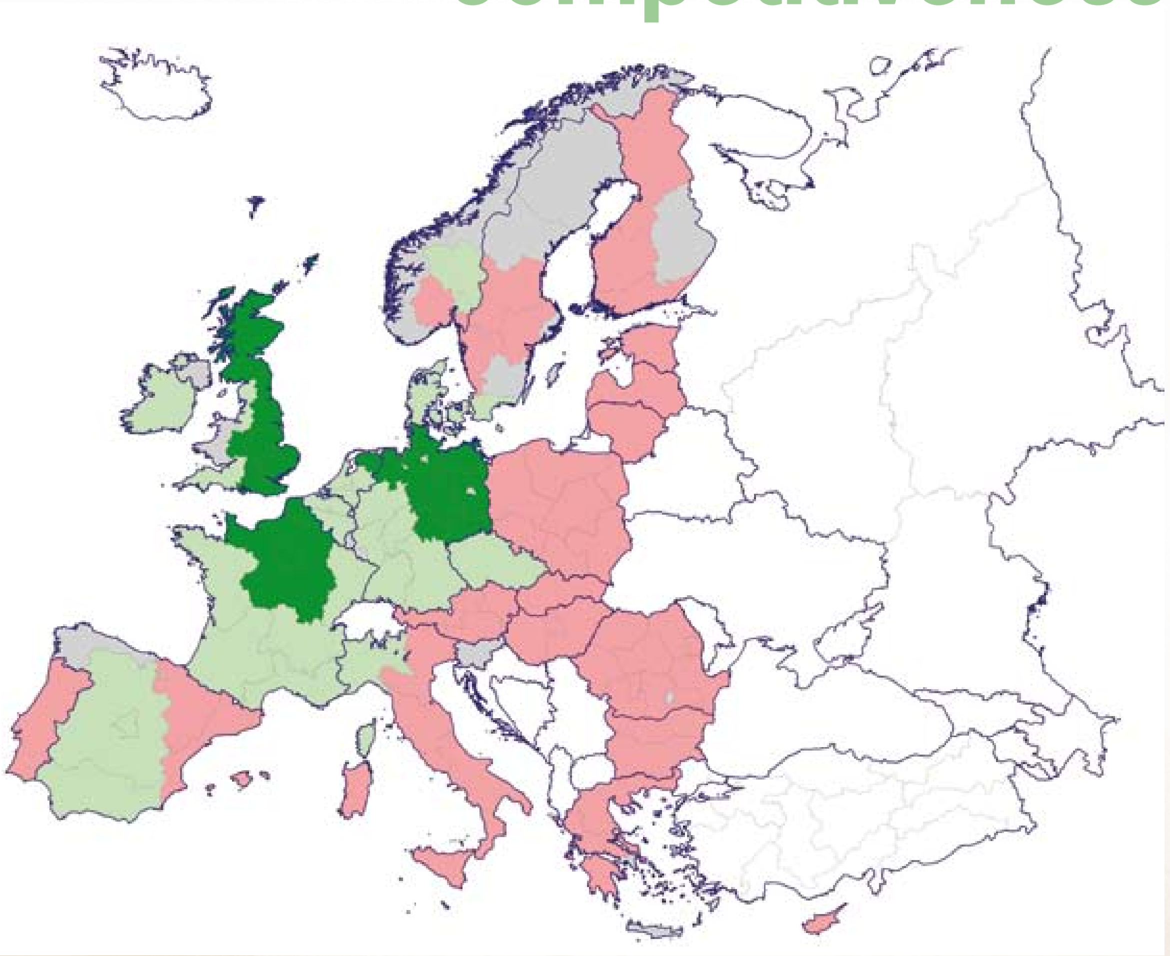
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 22 Potato production regions in EU27 based on competitiveness within the

2005



competitiveness



In 2005, one third of the total potato production was from northern France, northern Netherlands, Niedersachsen and the majority of Poland together (Map 22, 2005). The scenario predicts that by 2020, the achievable supply will slightly outweigh the production demand. By 2050, the production demand will outweigh the achievable supply (Figure 19).

When supply outweighs demand estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of potatoes in 2020, it is necessary to consider how competitive regions are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. The relative competitiveness order of regions is identical in scenario A1 and scenario B2. But in scenario B2, it is assumed that European and national governments will support regional agriculture hence – although competitiveness will play a role – it will be less pronounced. In comparison with the calculations in scenario A1, less land per region will be taken out of production, resulting in more regions being required to attain the required reduction of potato land. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

When demand outweighs supply there will be a shortage of land and all regions will maintain their agricultural area in production. No attempt has been made to allocate surplus land.

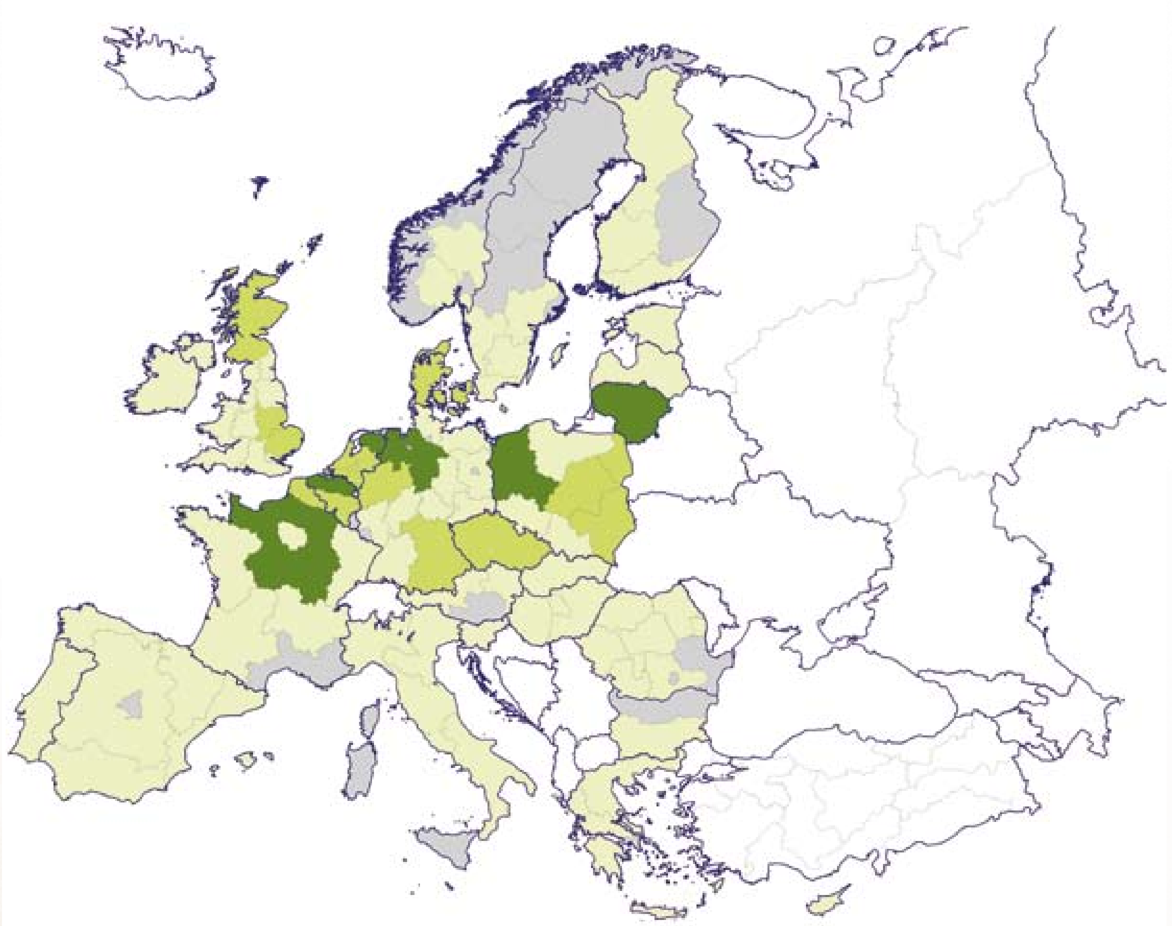
Firstly, competitiveness on the global food market was considered in isolation (Map 22, competitiveness). The regions with the most favourable prospect are north-western France, north-eastern Germany, northern Netherlands and eastern UK. In these regions, average size is 110 ESU/holding. Regions with the least favourable prospects are (with the exception of the Czech Republic) the new member states, Greece, south-eastern Italy, Portugal, eastern Spain and in the north Norway, Sweden and Finland. In these regions, the average size is only 8 ESU/holding. Hence, competitiveness within the EU27 regions varies widely.

A few regions in Romania and Poland will most likely lose (part of) their potato farms by 2020 (Map 22, 2020). By 2050, when the production demand will outweigh the achievable supply, this potato land will have to be taken back into production in 2050 and even then there will be a shortage of potato land of at least 135.000 ha (Figure 24). At least, because the area is calculated supposing that the maximum productivity could be realised. If only the minimum productivity could be realised, a surplus area of 625.000 ha is required.

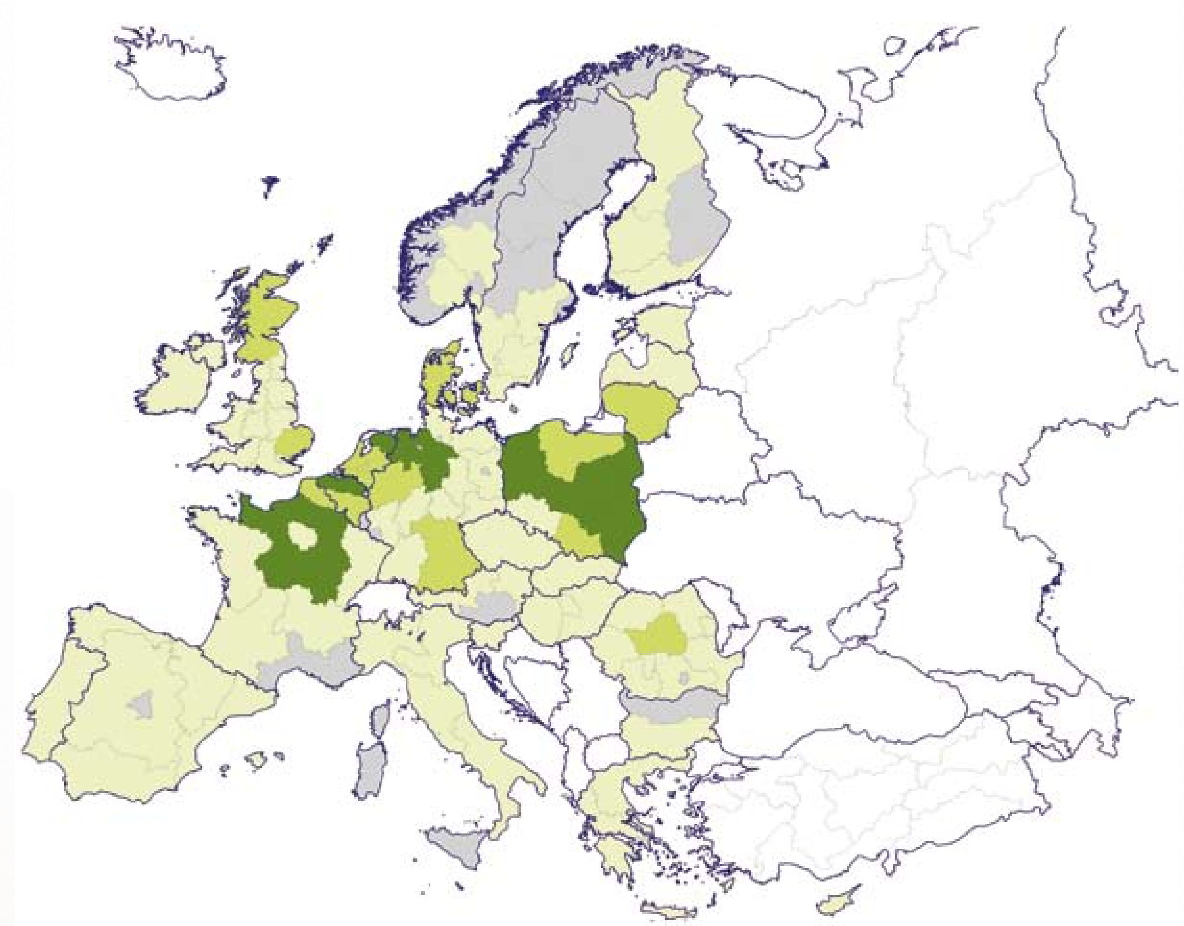
In 2050, France, Flanders, northern Netherlands, Nordrhein-Westfalen and Poland together will be capable of supplying one third of the EU27 potato demand (Map 22, 2050).

global food market in **scenario B2** at three time slices

2020



2050



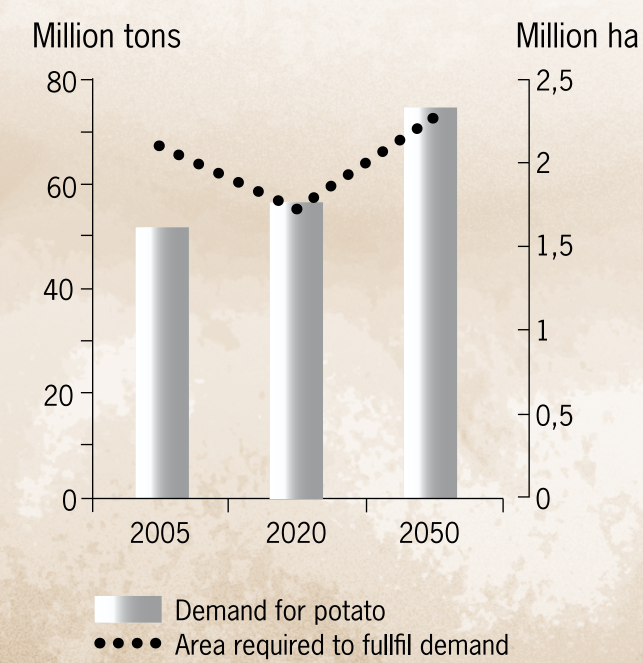


Figure 24.
Demand for potatoes and corresponding area in EU27, based on competitiveness of arable production on global food markets in scenario B2 at three time slices. The area required in 2050 is larger than the area available in 2005.

Legend

Each class one third of total potato production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

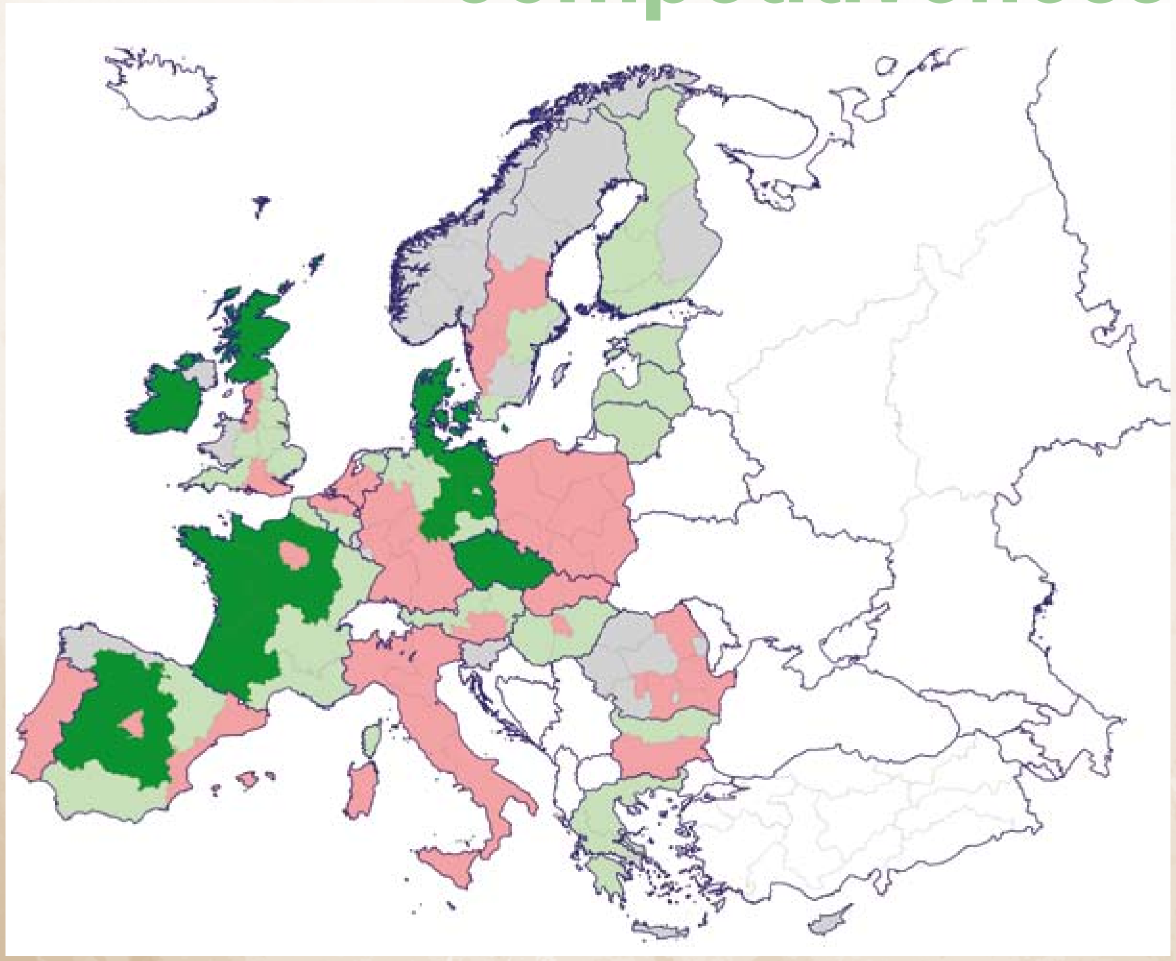
ESU/holding

- >=65
- 20 – 65
- <=20
- <0,1% of total EU27 ESU

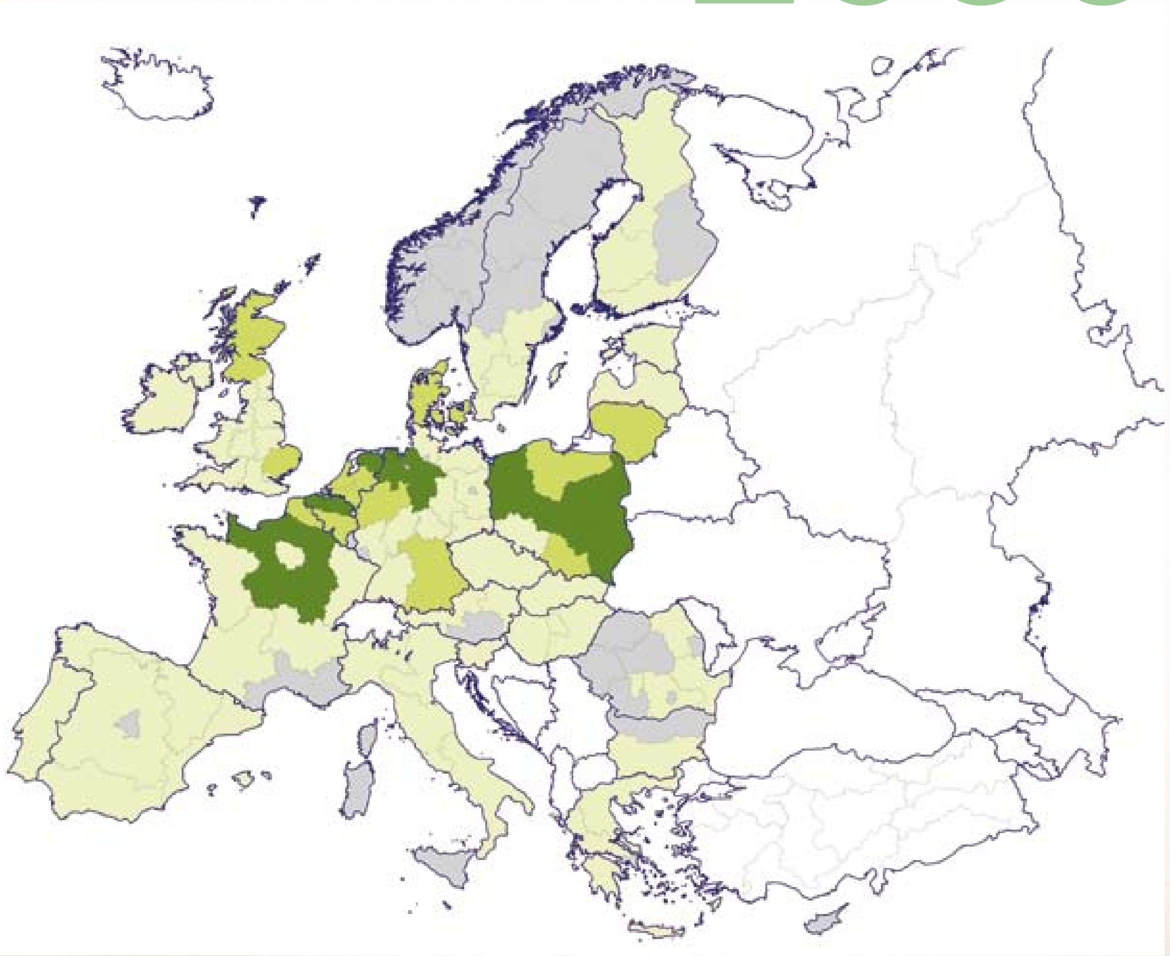
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 23 Potato production regions in EU27 based on competitiveness within the

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 23, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale. In 2050 the most competitive regions are those with large holdings and a low population pressure. These occur in western France, Ireland, Denmark, Scotland, eastern Germany and the Czech Republic. In these regions, the average size is 90 ESU/holding and the average population pressure is 1.6 inhabitant/agrarian ha. The regions with the least favourable prospect are in Poland, Slovakia, Italy, Portugal, eastern Spain, Flanders and the entire Rhine basin i.e. western Germany and the Netherlands. These regions combine relatively small holdings (18.1 ESU/holding) with high population pressure (11.2 inhabitants/agrarian ha). Here the number of potato farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market, Map 22 (2005) and Map 23 (2050) hardly differ due to a shortage of land of at least 135.000 ha and at maximum 625.000 ha. These maps are similar to the situation in 2005 (Map 22, 2005).

global food market and the regional land market in **scenario B2** at 2050

Legend

Each class one third of total potato production in 2050

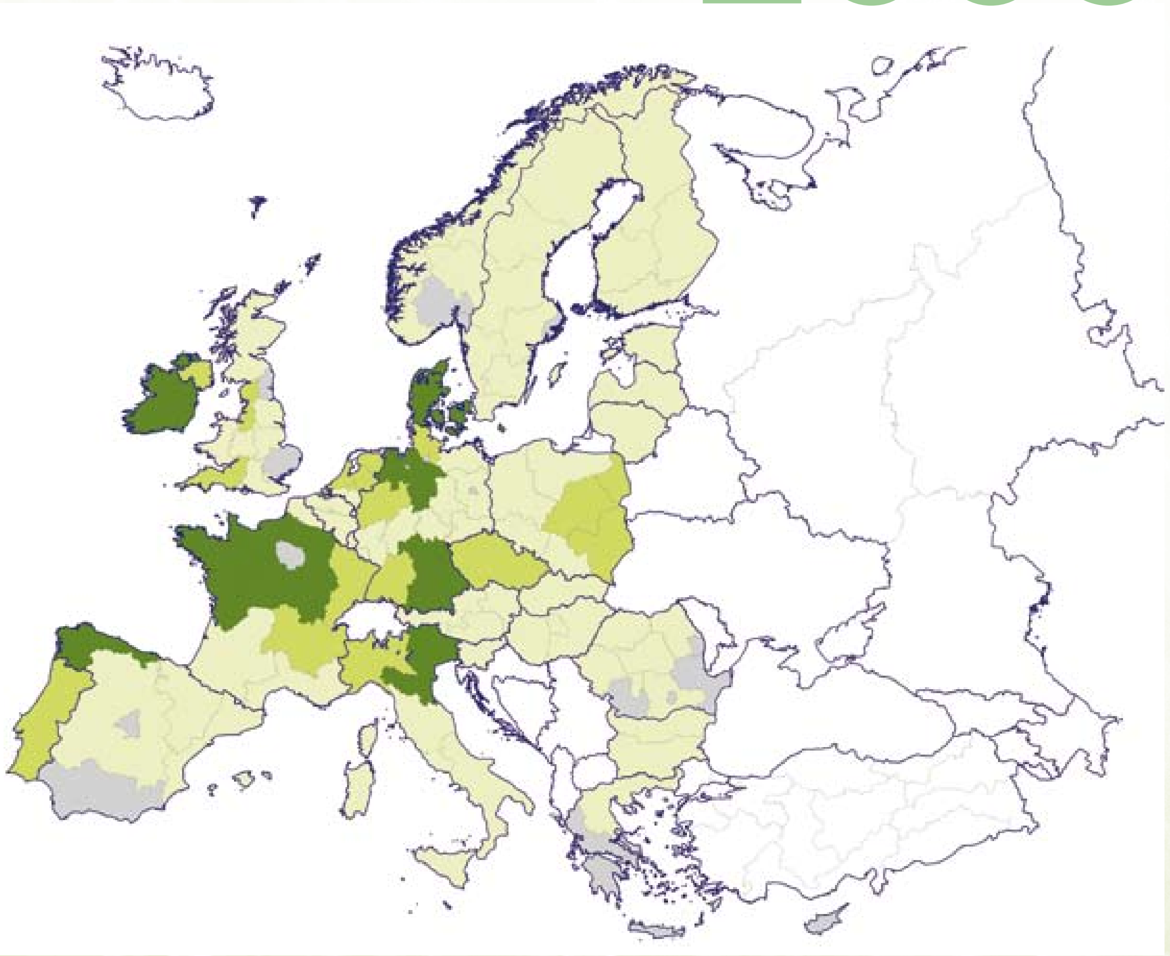
	Upper
	Middle
	Lower
	<0,1% of EU27 production

	ESU/holding	Inhabitants/ha UAA
	20 - 230	< 3
	2 - 130	< 6
	0 - 105	< 235
	<0,1% of total EU27 ESU	

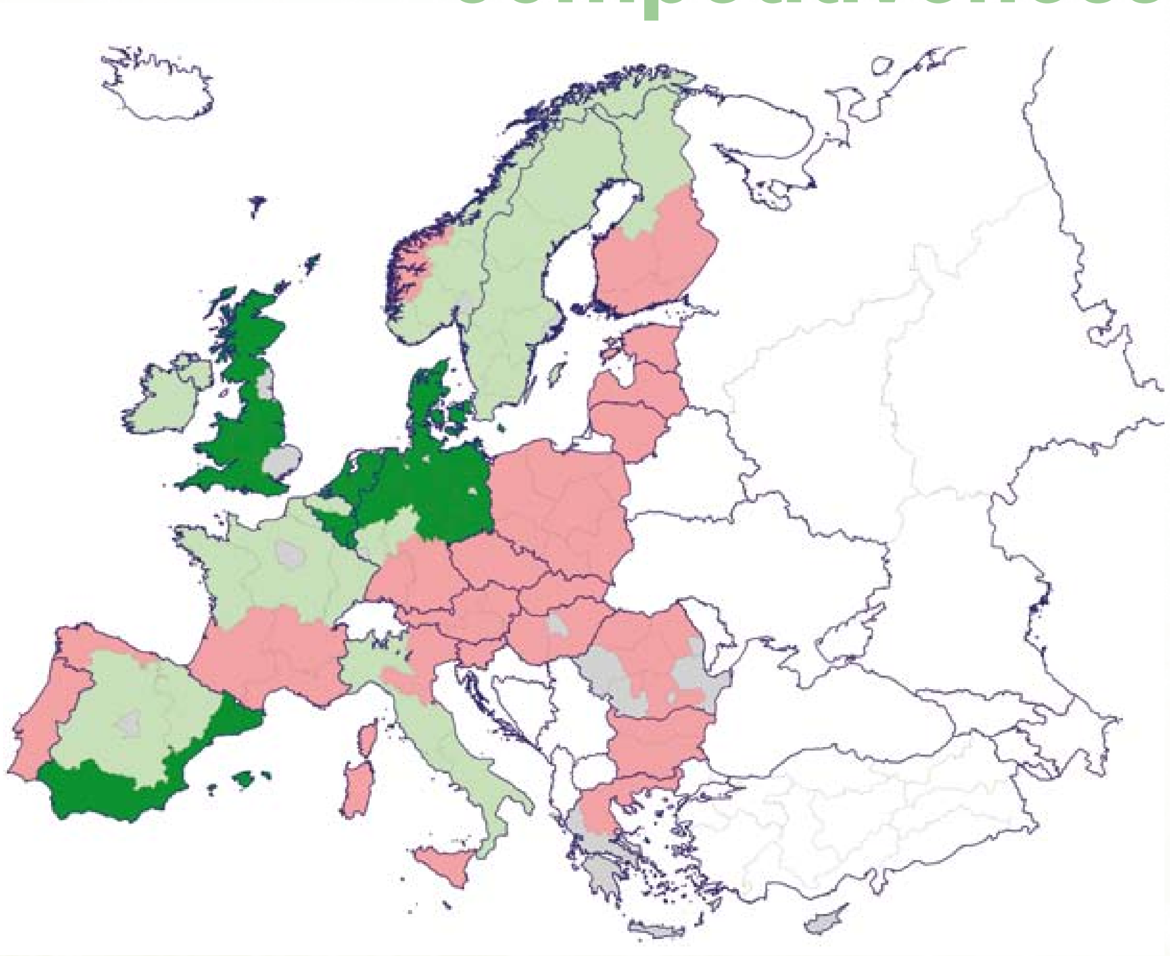
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 24 Milk production regions in EU27 based on competitiveness within the global

2005



competitiveness



In 2005, one third of the total milk production was from Denmark, Ireland, north-western France, Niedersachsen, Bayern and northern Italy together (Map 24, 2005). The scenario predicts that by 2020, there will be only a minor surplus of milk supply. By 2050, the production demand outweighs the achievable supply (Figure 21).

When supply outweighs demand estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of milk in 2020, it is necessary to consider how competitive regions are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus grassland and dairy holdings. The relative competitiveness order of regions is identical in scenario A1 and scenario B2. But in scenario B2, it is assumed that European and national governments will support regional agriculture hence – although competitiveness will play a role – it will be less pronounced. In comparison with the calculations in scenario A1, less land per region will be taken out of production, resulting in more regions being required to attain the required reduction of grassland. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

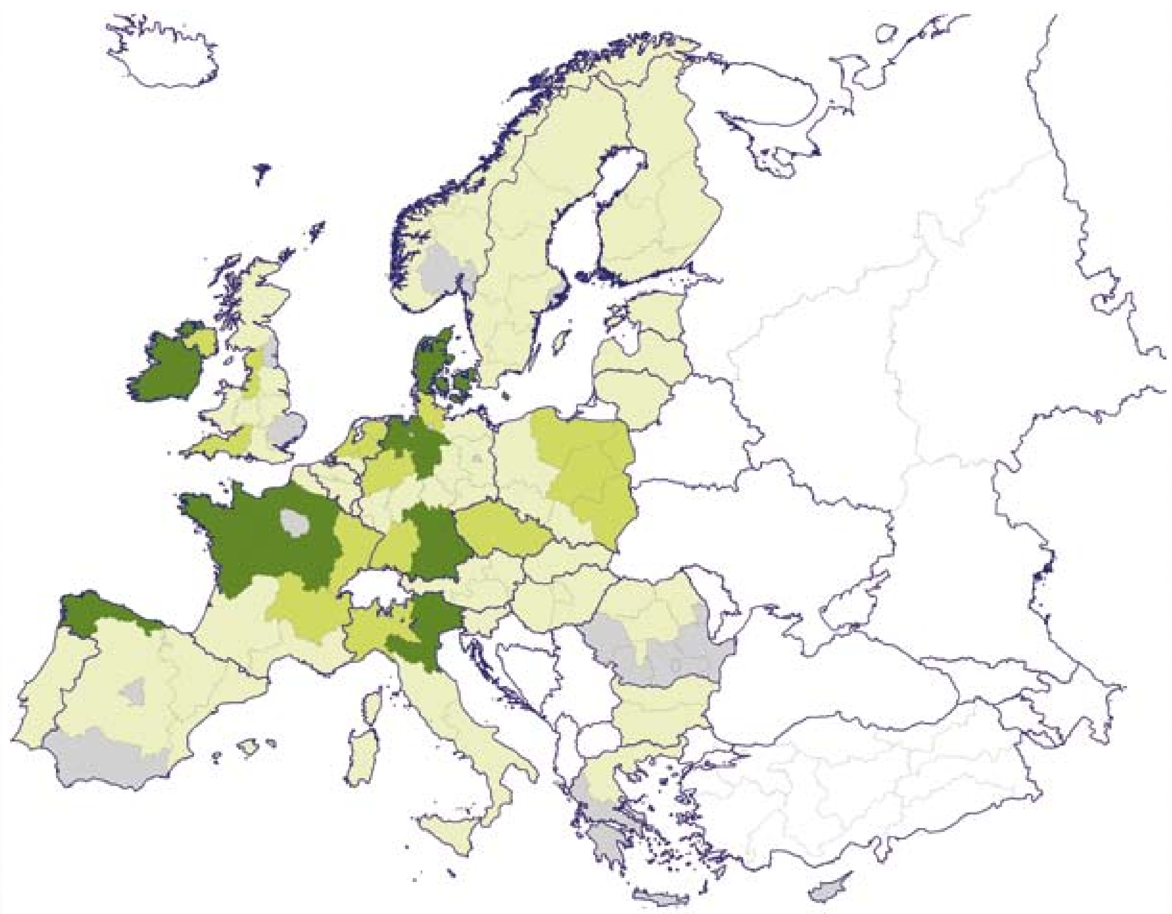
When demand outweighs supply there will be a shortage of land and all regions will maintain their agricultural area in production. No attempt has been made to allocate surplus land.

Firstly, competitiveness on the global food market was considered in isolation (Map 24, competitiveness). The regions with the most favourable prospect are northern Germany, the Netherlands, Denmark, the UK and south-eastern Spain. In these regions, average size is 126 ESU/holding. Regions with the least favourable prospects are the east European countries, Greece, Austria, southern Germany, southern France, Portugal and north-western Spain. In these regions, the average size is 21 ESU/holding. Hence, competitiveness within the EU27 varies widely.

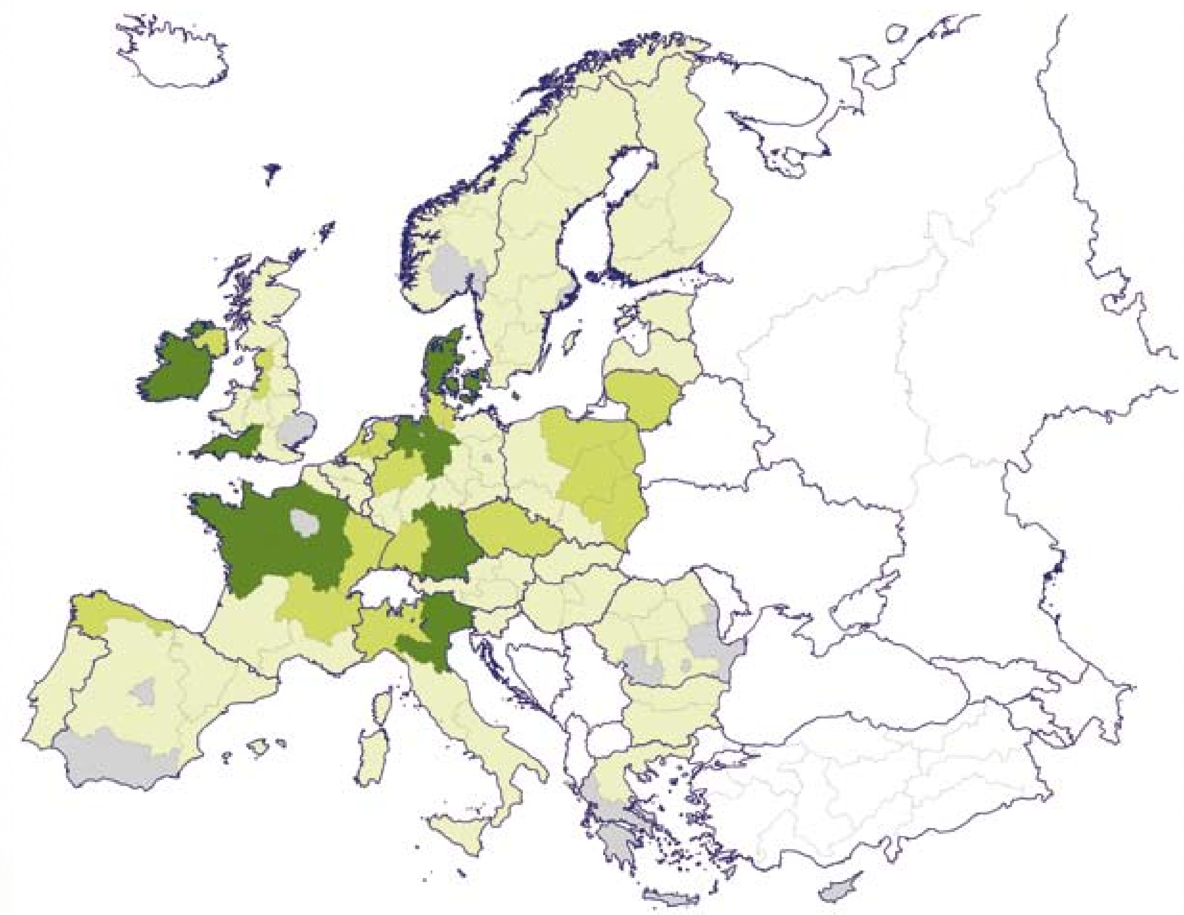
Besides some regions in Romania, all regions will keep their dairy farms by 2020 (Map 24, 2020). By 2050, when the production demand will outweigh the achievable supply, there will be a shortage of grassland of at least 4.6 million ha (Figure 25). At least, because the area is calculated supposing that the maximum productivity could be realised.

food market in **scenario B2** at three time slices

2020



2050



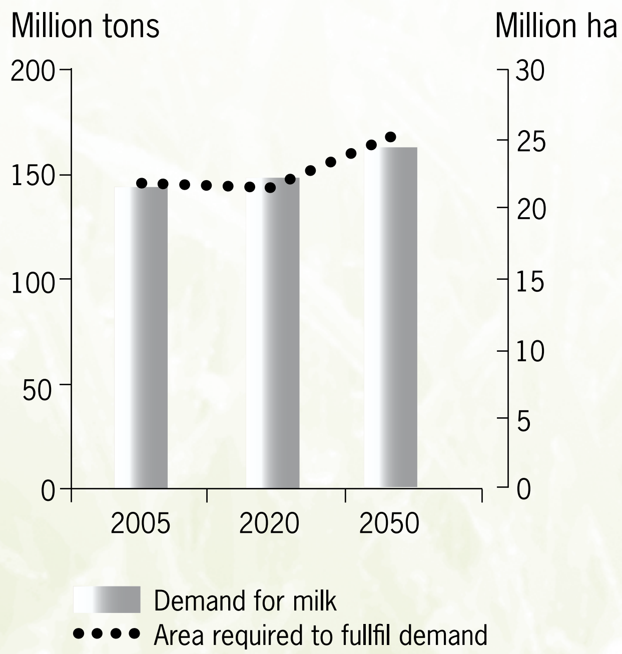


Figure 25.
Demand for milk and corresponding area in EU27, based on competitiveness of dairy production on global food markets in scenario B2 at three time slices. The area required in 2050 is larger than the area available in 2005.

Legend

Each class one third of total milk production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

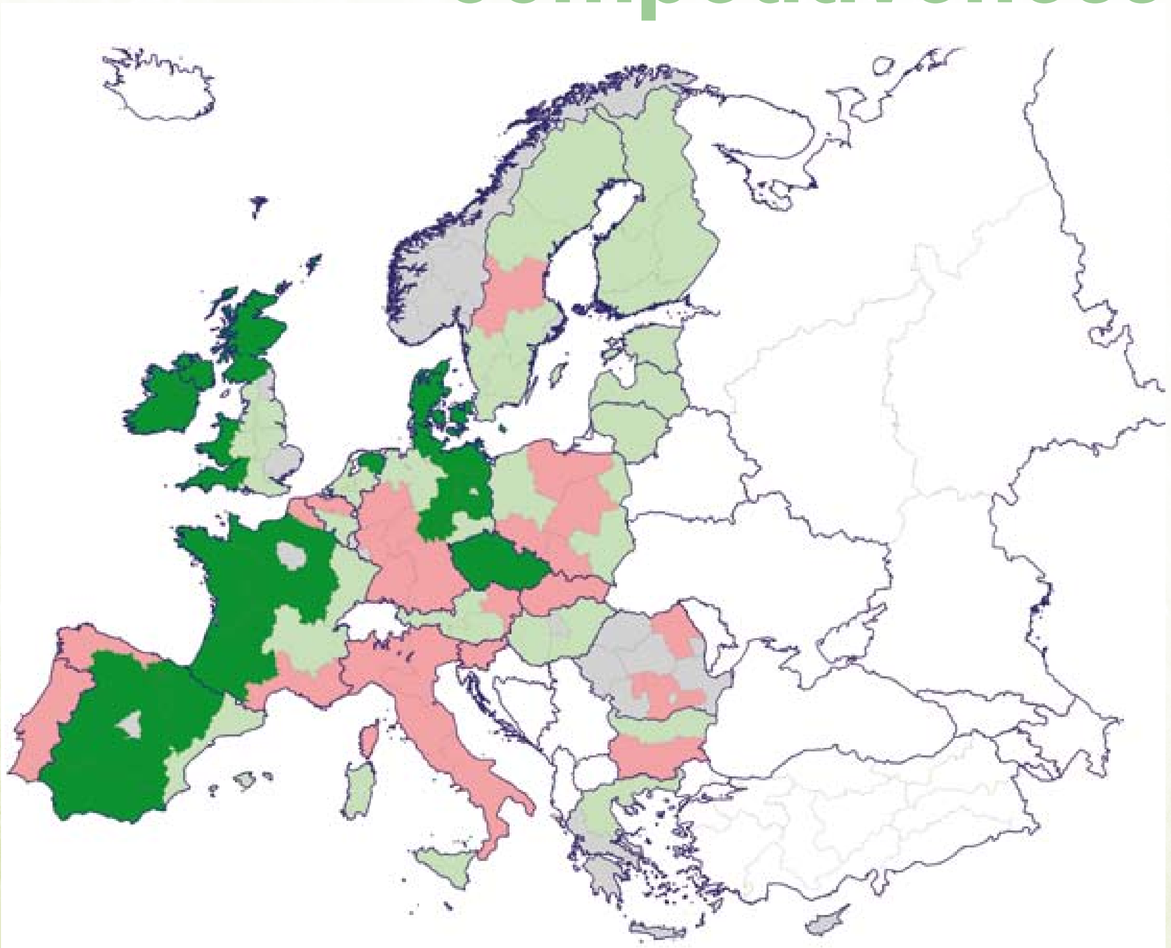
ESU/holding

- >=75
- 45 – 75
- <=45
- <0,1% of total EU27 ESU

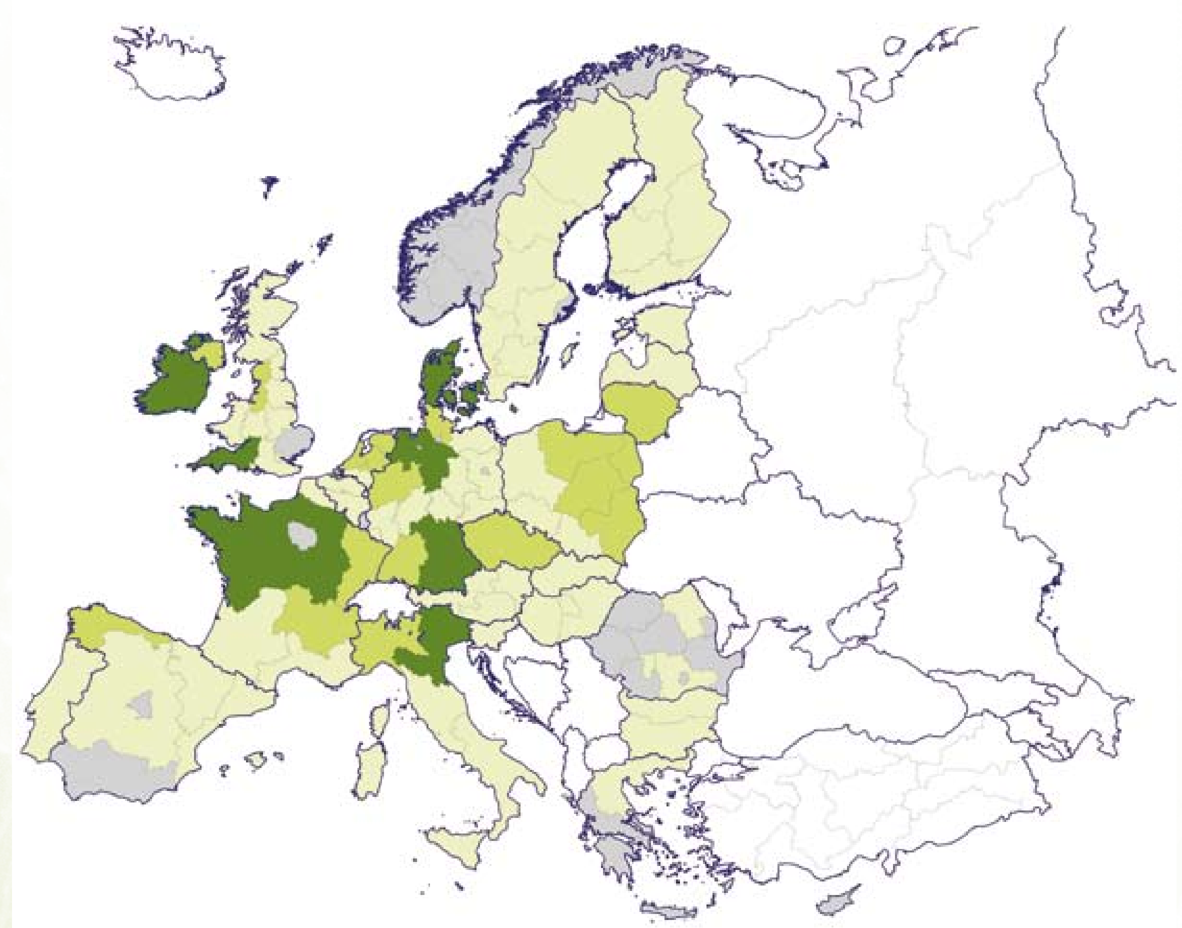
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 25 Milk production regions in EU27 based on competitiveness within the global

competitiveness



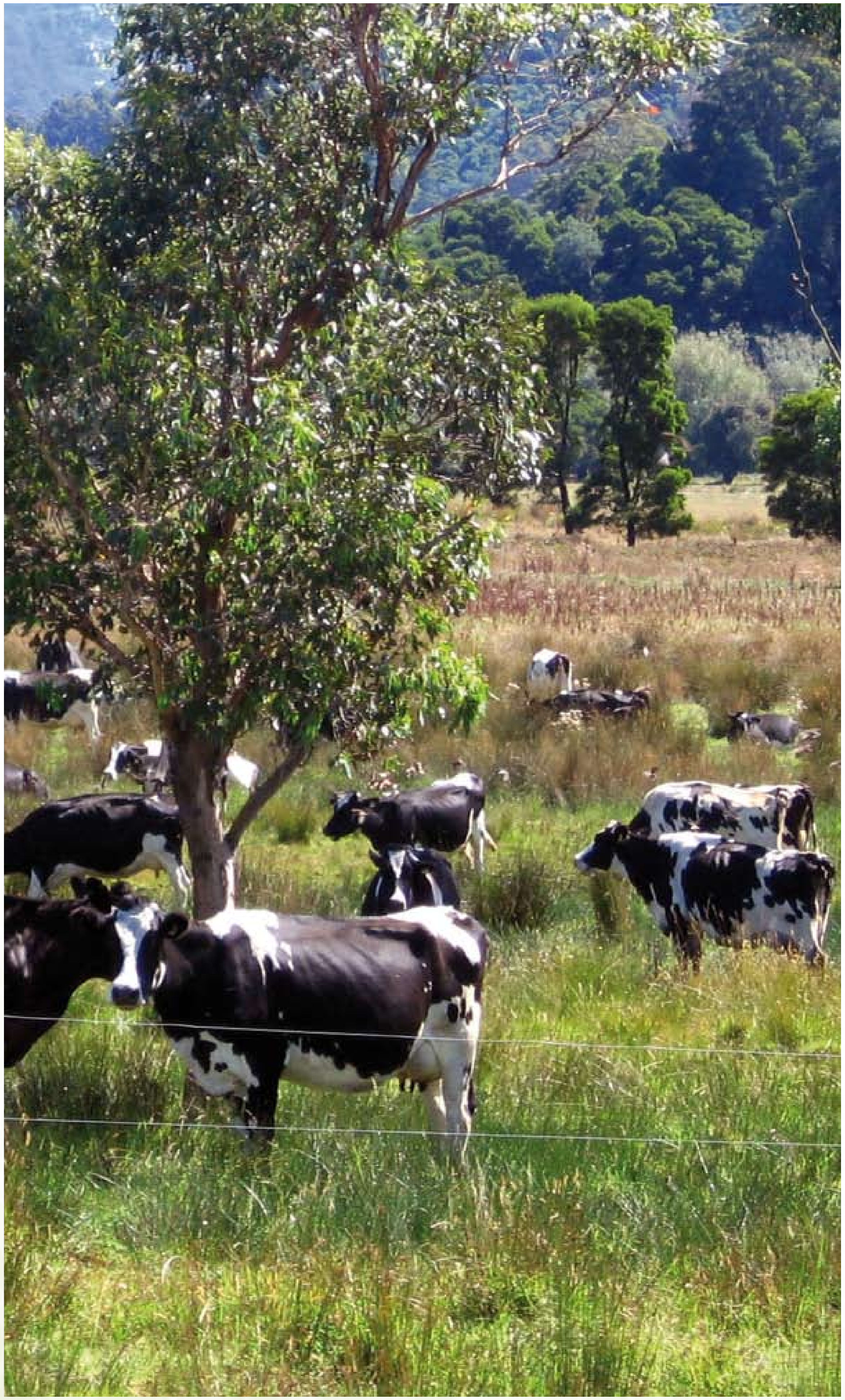
2050



If competitiveness in regional land markets is also taken into account (Map 25, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions will fall on the competitiveness scale. In 2050 the most competitive regions are those with large holdings and a low population pressure. These occur in western France, Ireland, Denmark, northern and western UK, northern Netherlands, eastern Germany and the Czech Republic. In these regions, the average size is 126 ESU/holding and the average population pressure is 1.7 inhabitant/agrarian ha. The regions with the least favourable prospect are in central Poland, Slovakia, southern Bulgaria, Italy, Portugal, north-western Spain, Flanders, western Germany and southern France. These regions combine relatively small holdings (35.8 ESU/holding) with high population pressure (13.1 inhabitants/agrarian ha). Here the number of dairy farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness within the global food market, the milk producing regions in 2005 and 2050 (Map 24 and Map 25) hardly differ due to a shortage of grassland of at least 4.6 million ha.

food market and the regional land market in **scenario B2** at 2050



Legend

Each class one third of total milk production in 2050

- Upper
- Middle
- Lower
- <0,1% of EU27 production

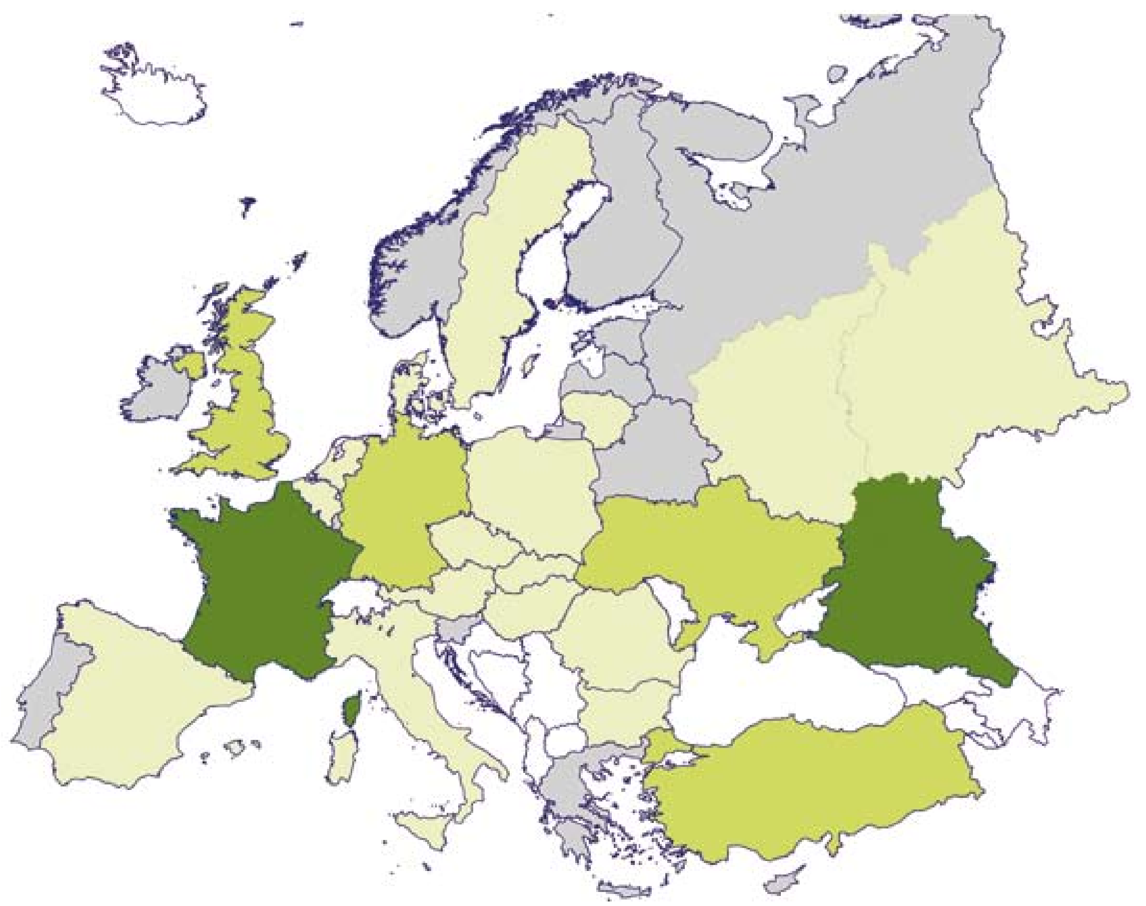
ESU/holding	Inhabitants/ha UAA
35 - 355	< 3
2 - 170	< 15
1 - 95	< 235

<0,1% of total EU27 ESU

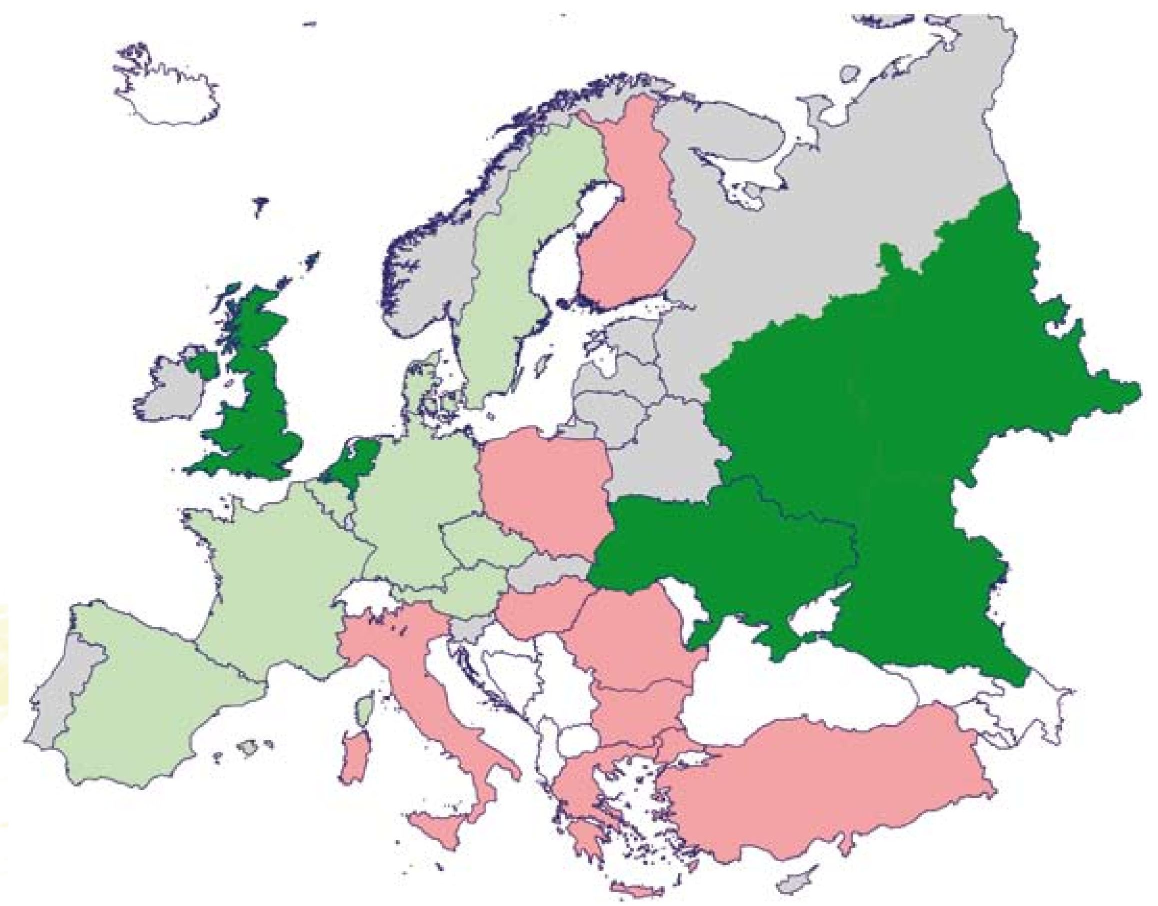
Regions ranked by 3 classes, each 33,3% of EU27-total gross margin in ESU

Map 26 Wheat production regions in EU-Ural based on competitiveness within the

2005



competitiveness



In 2005, one third of the total wheat production was from France and southern Russia. The scenario predicts that by 2020 the achievable supply will slightly outweigh the production demand. By 2050, the production demand far outweighs the achievable supply (Figure 18).

When supply outweighs demand (in 2020) estimates need to be made about where, in which regions or countries, production should continue. In order to (re)distribute spatially the supply and demand ratio of wheat in 2020, it is necessary to consider how competitive regions or countries are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions or countries with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. The relative competitiveness order of regions or countries in EU-Ural is identical in scenario A1 and scenario B2. But in scenario B2, it is assumed that European and national governments will support regional agriculture hence – although competitiveness will play a role – it will be less pronounced. In comparison with the calculations in scenario A1, less land per region or country will be taken out of production, resulting in more regions being required to attain the required reduction of wheat land. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production.

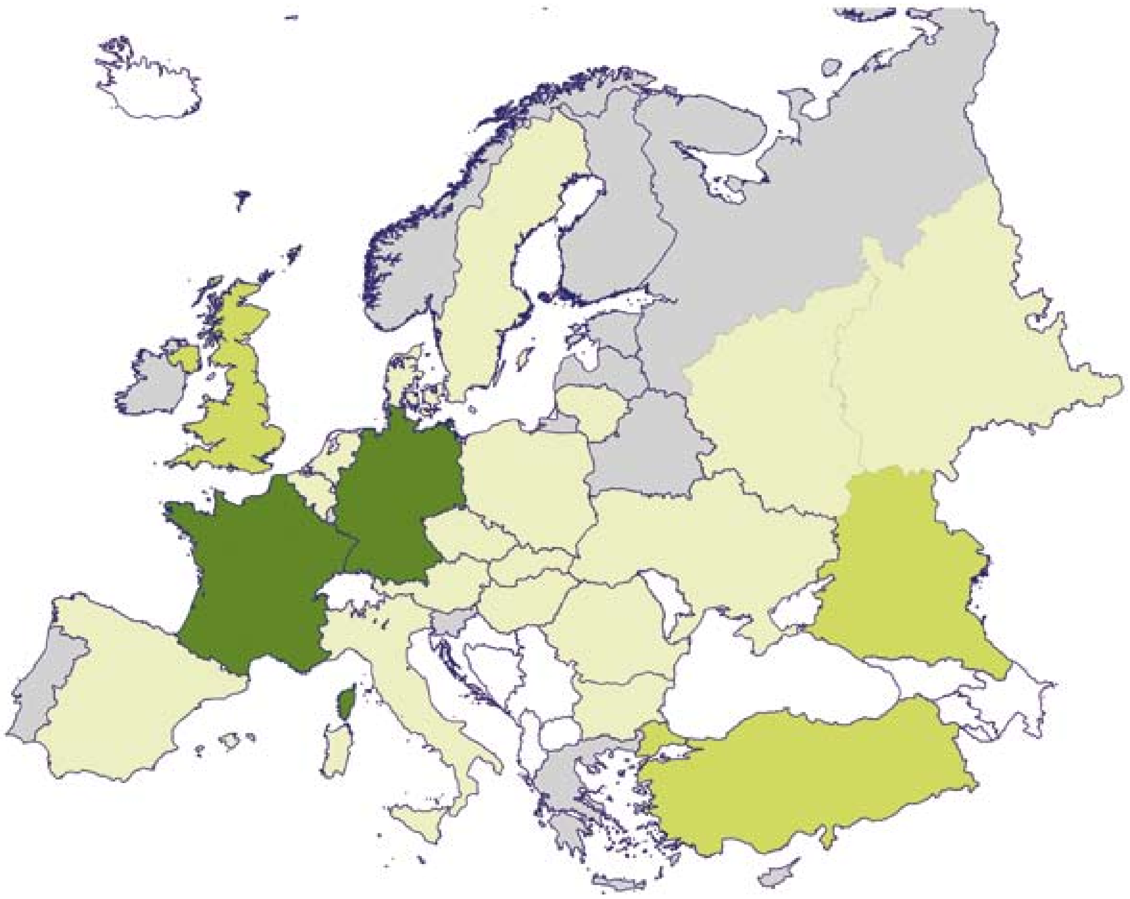
When demand outweighs supply (in 2050) there will be a shortage of land and all regions will maintain their agricultural area in production. No attempt has been made to allocate surplus land.

Firstly, competitiveness on the global food market was considered in isolation (Map 26, competitiveness). The regions or countries with the most favourable prospects are the UK, the Netherlands, Ukraine and southern Russia. In these countries, average size is more than 1500 ESU/holding, due to very large arable farms in Ukraine and Russia. Regions or countries with the least favourable prospects are Italy, Finland, Poland, Hungary, Romania, Bulgaria, Greece and Turkey. In these countries, the average size is only 6 ESU/holding. Hence, competitiveness within the EU-Ural countries varies widely.

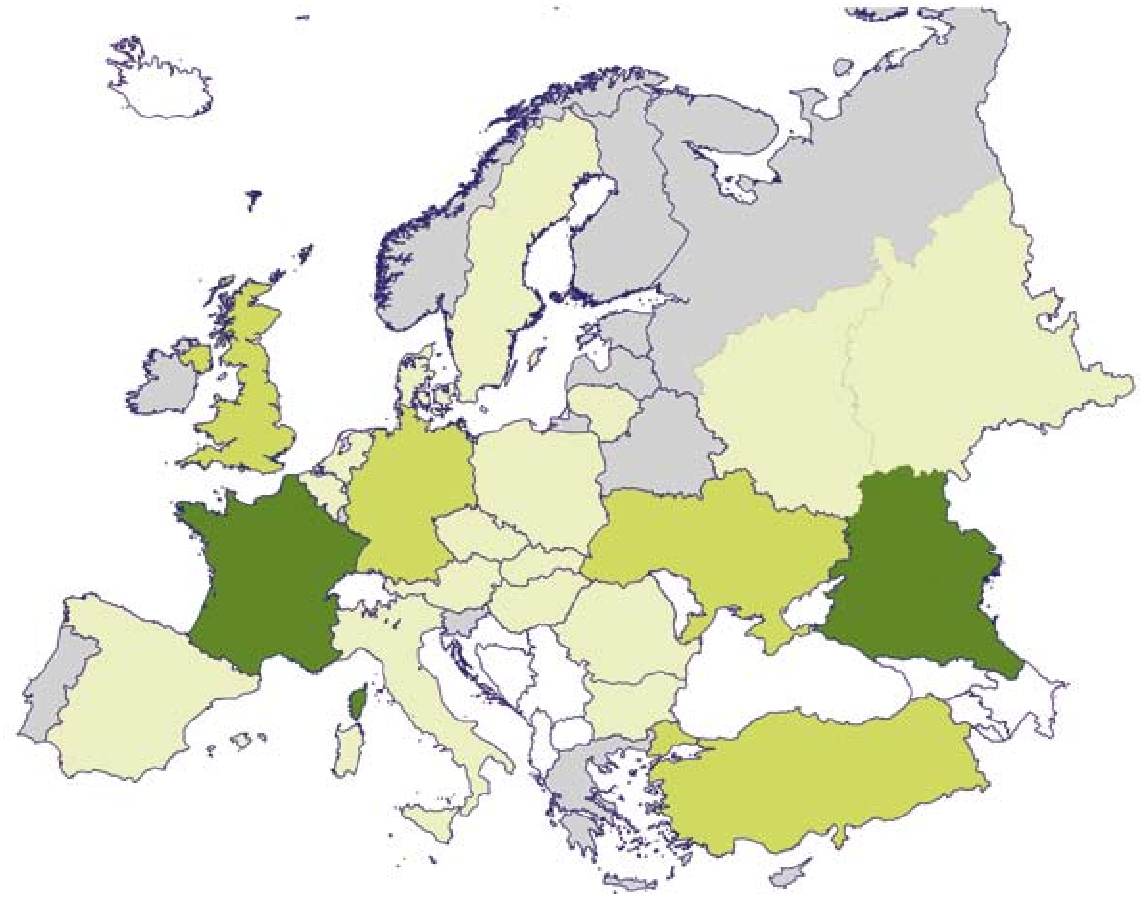
By 2020, France, Germany, the UK, Turkey and southern Russia together will be capable of supplying two third of the total EU-Ural demand (Map 26, 2020). By 2050, when the production demand far outweighs the achievable supply, there will be a shortage of wheat land of at least 8 million ha. At least, because the area is calculated supposing that the maximum productivity could be realised (Figure 26).

global food market in **scenario B2** at three time slices

2020



2050



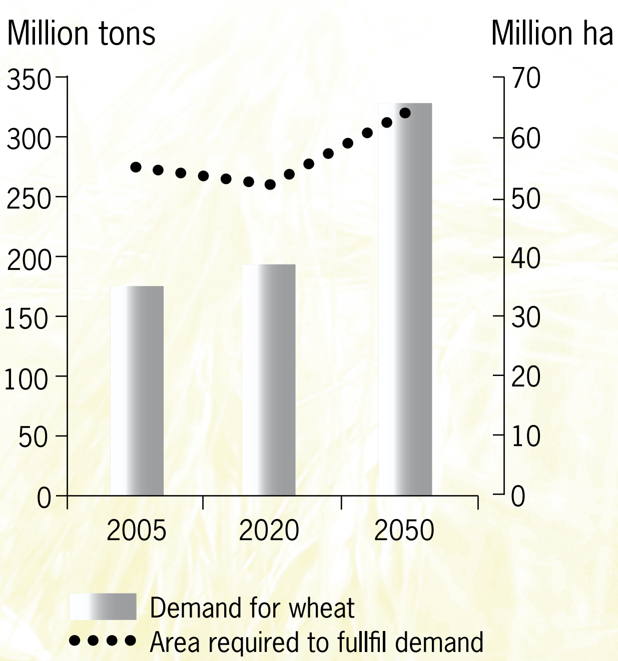


Figure 26.
Demand for wheat and corresponding area in EU-Ural, based on competitiveness of arable production on global food markets in scenario B2 at three time slices. The area required in 2050 is larger than the area available in 2005.

Legend

Each class one third of total wheat production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,5% of EU-Ural production

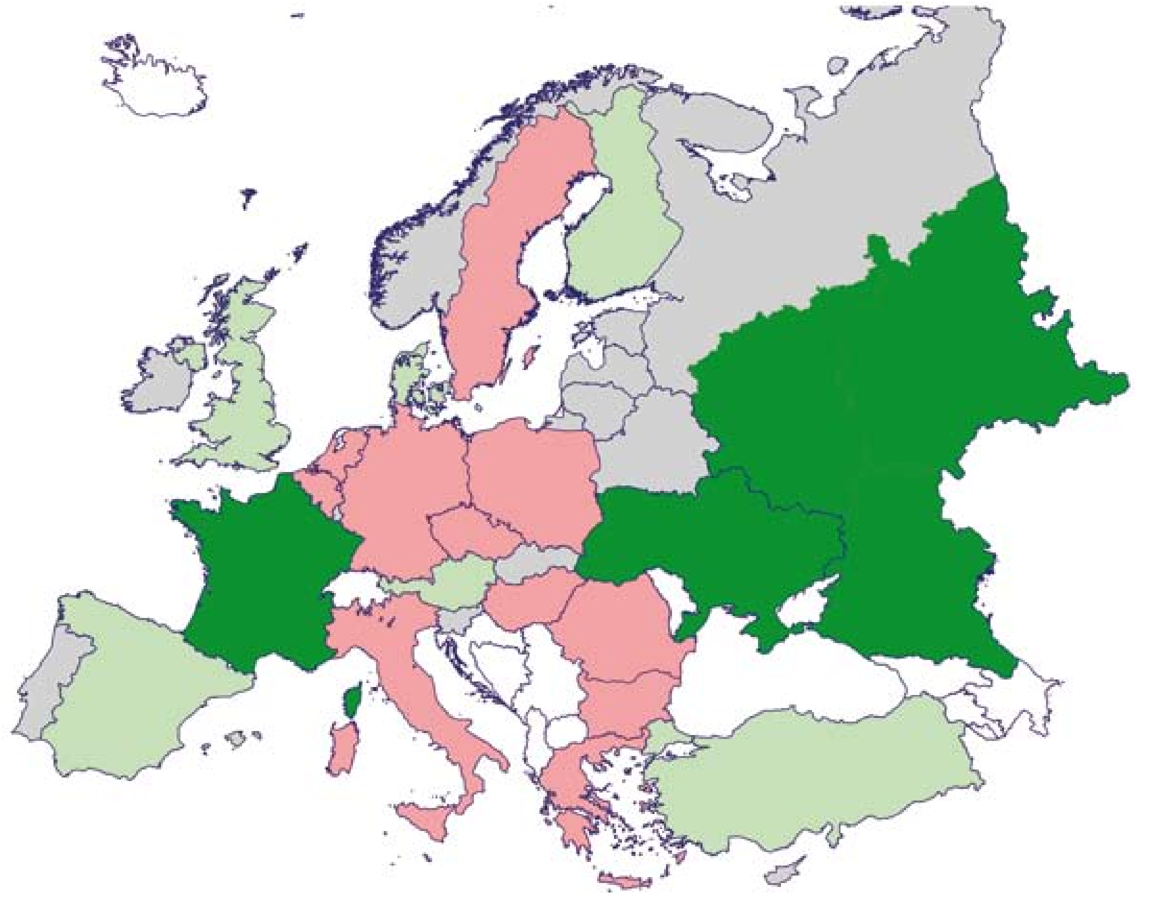
ESU/holding

- >=60
- 12 – 60
- <=12
- <0,5% of total EU-Ural ESU

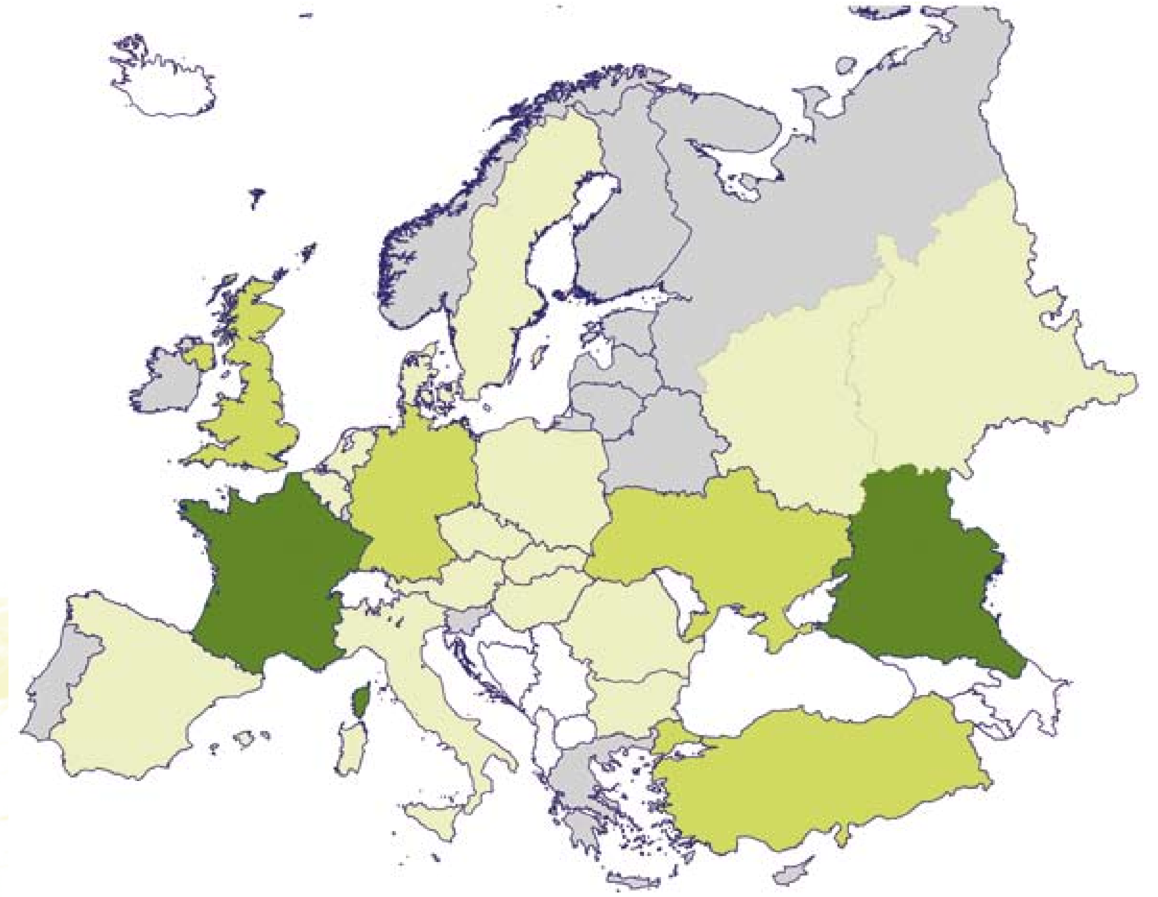
Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 27 Wheat production regions in EU-Ural based on competitiveness within the

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 27, competitiveness) it will be seen that, in regions or countries with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions or countries will fall on the competitiveness scale. In 2050 the most competitive regions or countries are those with large holdings and a low population pressure. These occur in France, Ukraine and southern Russia. In these countries, the average size is more than 1600 ESU/holding and the average population pressure is 1.1 inhabitant/agrarian ha. The regions or countries with the least favourable prospect are Finland, the Netherlands, Belgium, Germany, the Czech Republic, Poland, Hungary, Romania, Bulgaria, Italy and Greece. These countries combine relatively small holdings (16.0 ESU/ha) with high population pressure (5.6 inhabitants/agrarian ha). Here, the number of wheat farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land use.

In comparison with the calculations based solely on competitiveness on the global food market, also now there is a shortage of land of about 8 million ha. Therefore, there is no difference between Map 26 (2050), Map 27 (2050) and the situation in 2005 (Map 26, 2005).

global food market and the regional land market in **scenario B2** at 2050

Legend

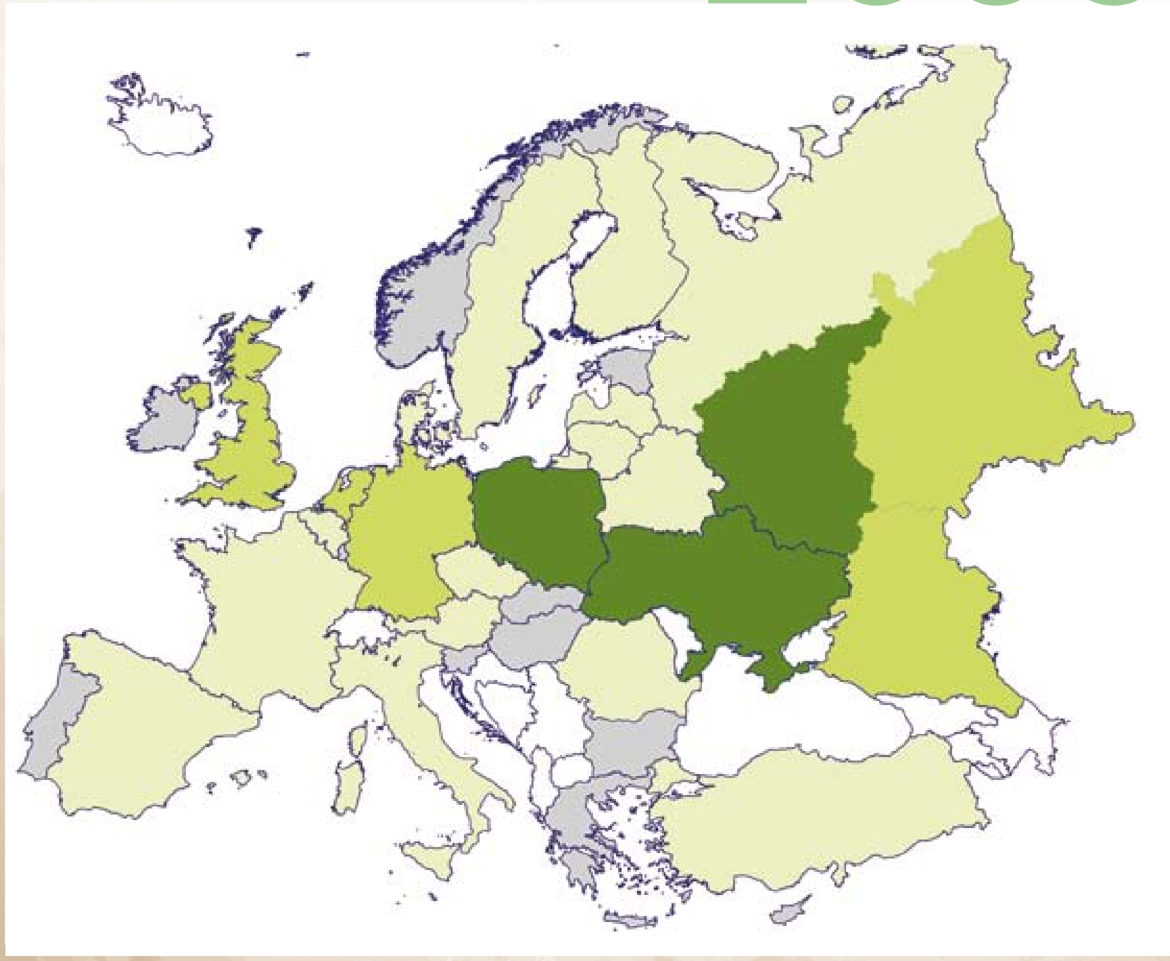
Each class one third of total wheat production in 2050

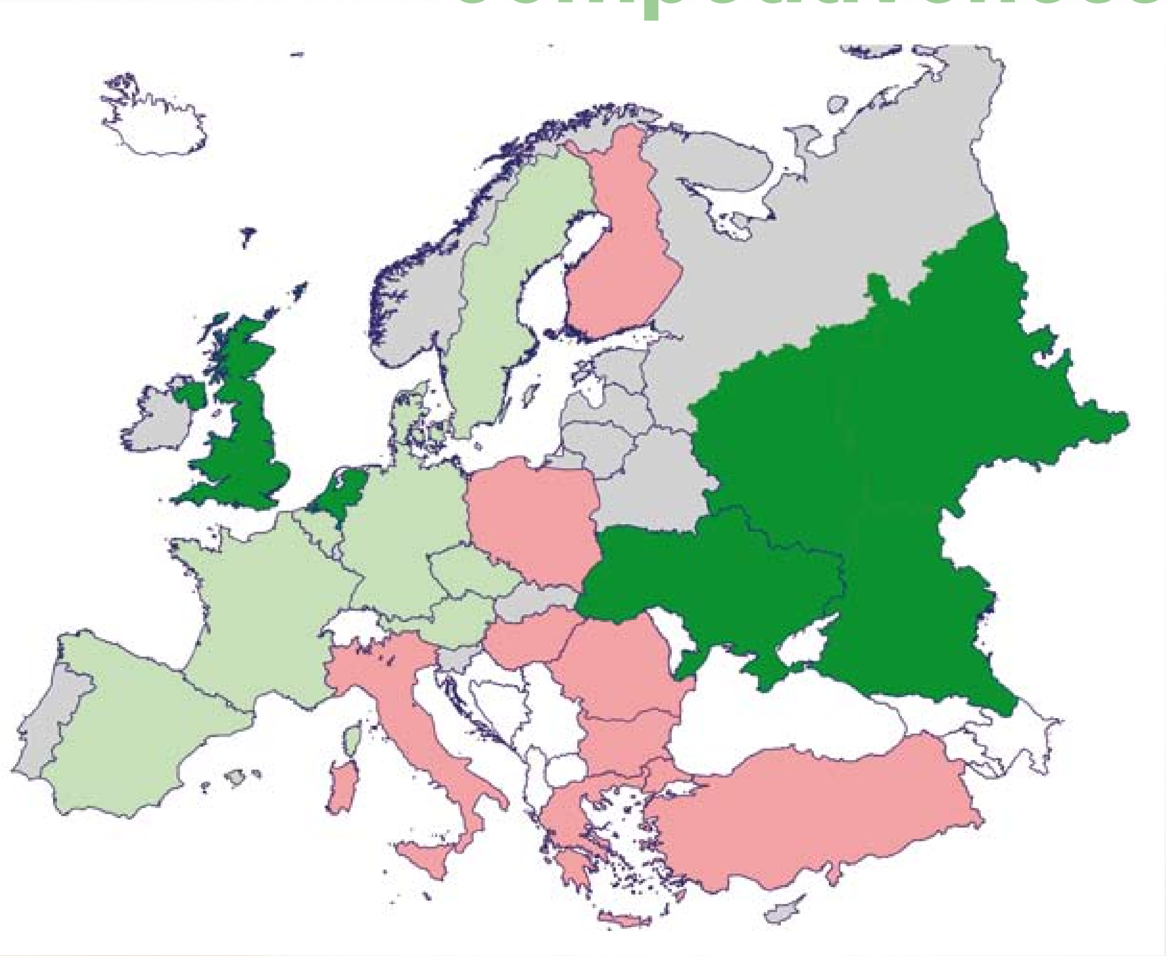
(dark green)	Upper
(yellow-green)	Middle
(pale)	Lower
(grey)	<0,5% of EU-Ural production

	ESU/holding	Inhabitants/ha UAA
(green)	35 - 2500	< 2
(light green)	1 - 95	< 4
(pink)	1 - 60	< 40
(grey)	<0,5% of total EU-Ural ESU	

Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 28 Potato production regions in EU-Ural based on competitiveness within the





In 2005, one third of the total potato production was from Poland, Ukraine and western Russia together (Map 28, 2005). The scenario predicts that by 2020, the achievable supply will slightly outweigh the production demand. By 2050, the production demand will far outweigh the achievable supply (Figure 20).

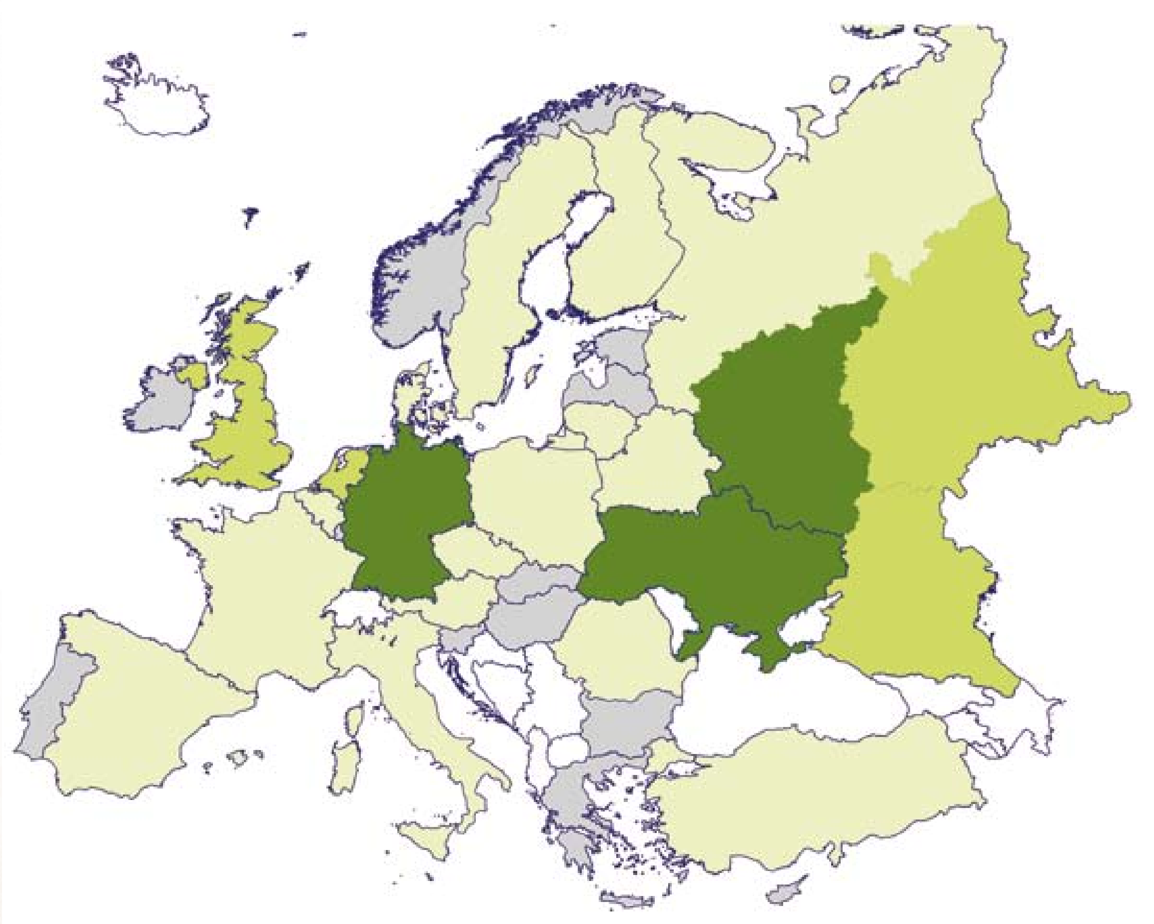
When supply outweighs demand (in 2020) estimates need to be made about where, in which regions or countries, production should continue. In order to (re)distribute spatially the supply and demand ratio of potatoes in 2020, it is necessary to consider how competitive regions or countries are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that the regions or countries with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. The relative competitiveness order of regions or countries in EU-Ural is identical in scenario A1 and scenario B2. But in scenario B2, it is assumed that European and national governments will support regional agriculture hence – although competitiveness will play a role – it will be less pronounced. In comparison with the calculations in scenario A1, less land per region or country will be taken out of production, resulting in more regions being required to attain the required reduction of potato land. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production. When demand outweighs supply (in 2050) there will be a shortage of land and all regions will maintain their agricultural area in production. No attempt has been made to allocate surplus land.

Firstly, competitiveness on the global food market was considered in isolation (Map 28, competitiveness). The regions or countries with the most favourable prospects are the UK, the Netherlands, Ukraine and southern Russia. In these countries, average size is more than 1500 ESU/holding, due to very large arable farms in Ukraine and Russia. Regions or countries with the least favourable prospects are Italy, Finland, Poland, Hungary, Romania, Bulgaria, Greece and Turkey. In these countries, the average size is only 6 ESU/holding. Hence, competitiveness within the EU-Ural countries varies widely.

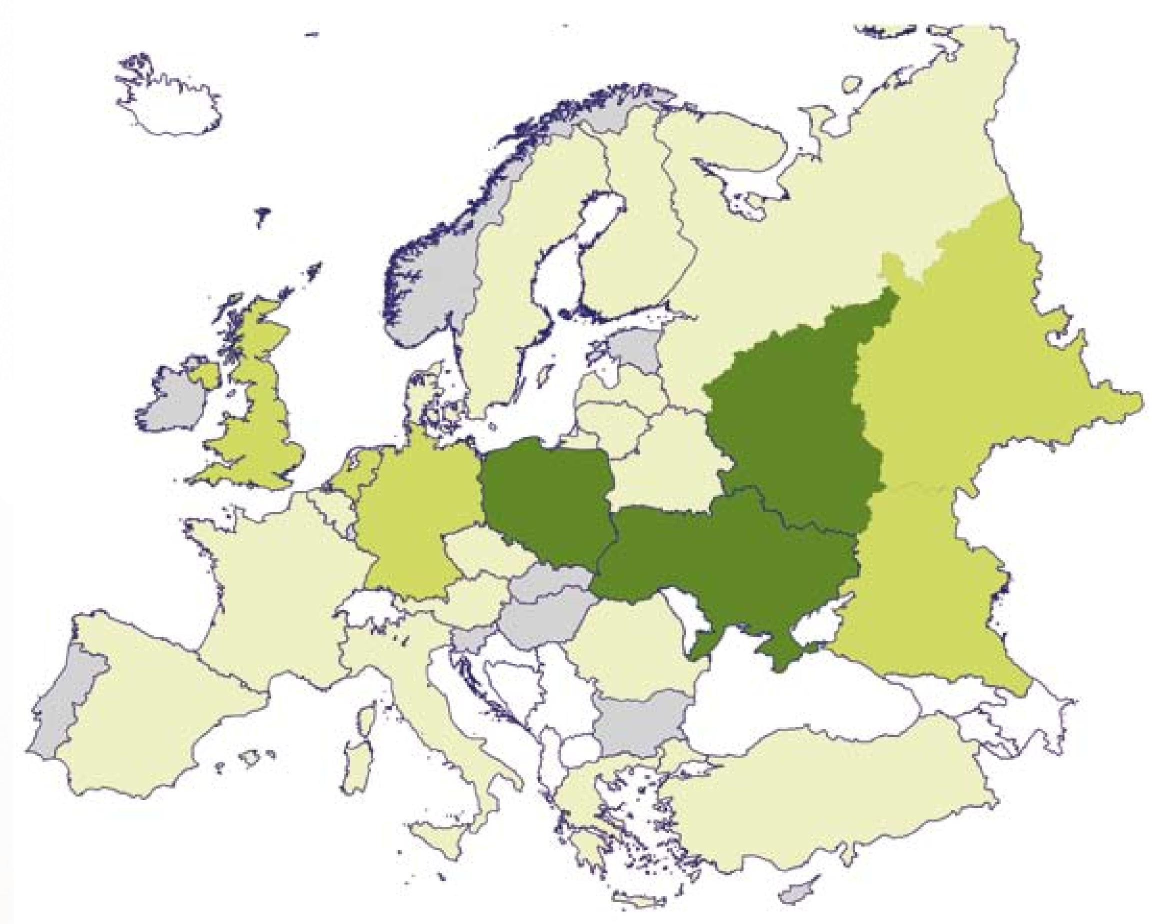
By 2020, one third of the total potato production will be from Germany, Ukraine and western Russia together (Map 28, 2020). By 2050, the production demand far outweighs the achievable supply (Figure 27) and there will be a shortage of potato land of at least 400.000 ha. At least, because the area is calculated supposing that the maximum productivity could be realised. In 2050, Poland, Ukraine and western Russia together will be capable of supplying one third of the total EU-Ural potato demand (Map 28, 2050).

global food market in **scenario B2** at three time slices

2020



2050



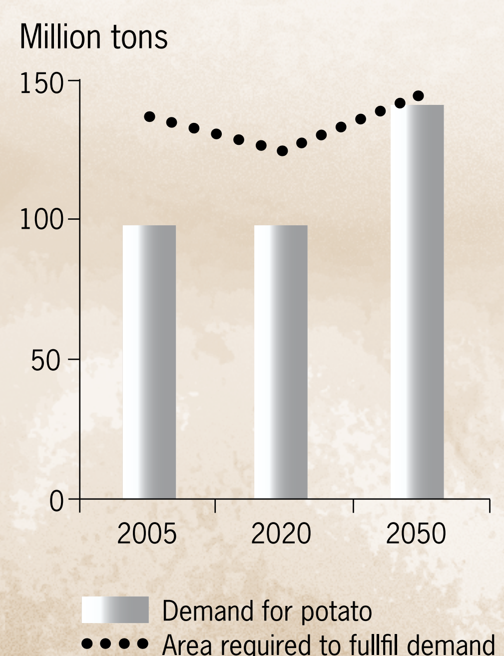


Figure 27.
Demand for potatoes and corresponding area in EU-Ural, based on competitiveness of arable production on global food markets in scenario B2 at three time slices. The area required in 2050 is larger than the area available in 2005.

Legend

Each class one third of total potato production in 2005, 2020 or 2050

- Upper
- Middle
- Lower
- <0,5% of EU-Ural production

ESU/holding

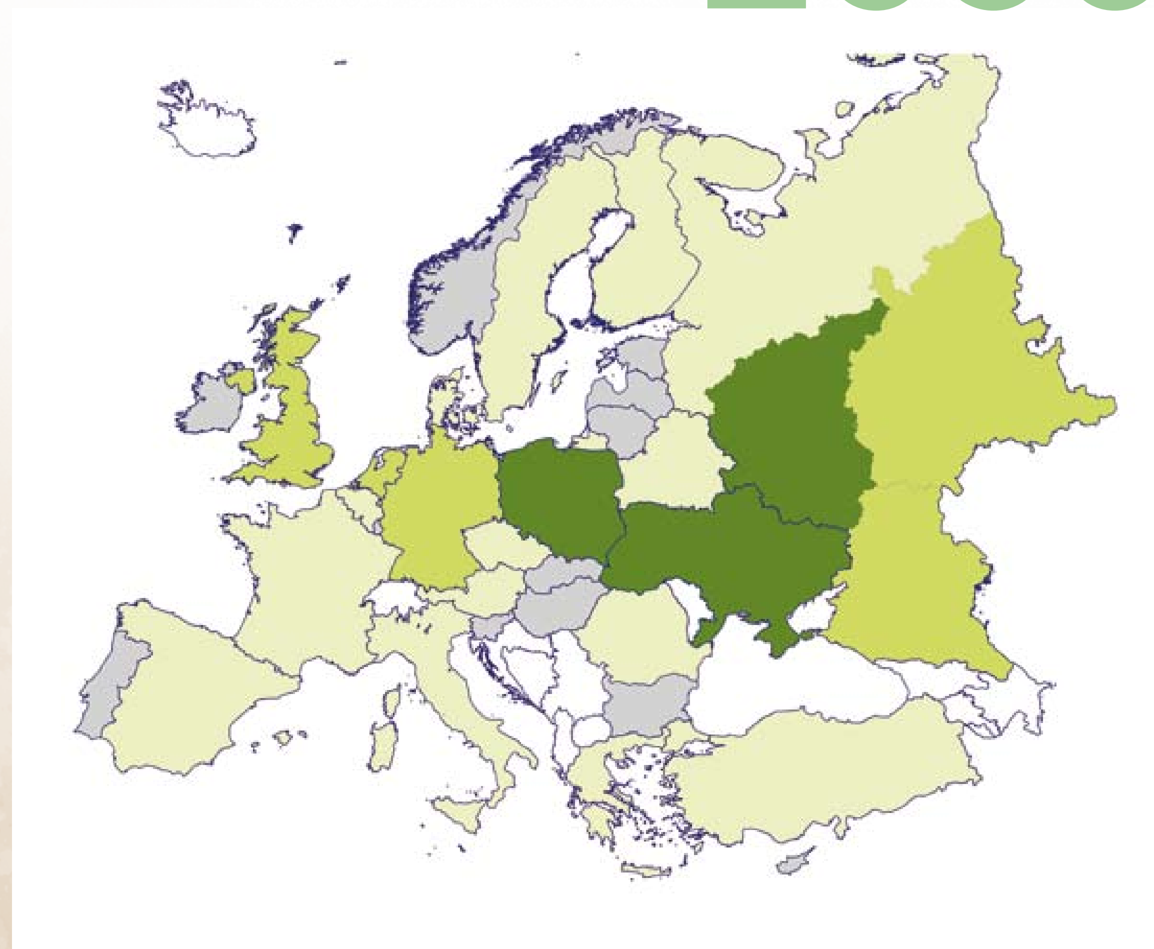
- >=60
- 12 – 60
- <=12
- <0,5% of total EU-Ural ESU

Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 29 Potato production regions in EU-Ural based on competitiveness within the

competitiveness

2050



If competitiveness in regional land markets is also taken into account (Map 29, competitiveness) it will be seen that, in regions or countries with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such regions or countries will fall on the competitiveness scale. In 2050 the most competitive regions or countries are those with large holdings and a low population pressure. These occur in France, Ukraine and southern Russia. In these countries, the average size is more than 1600 ESU/holding and the average population pressure is 1.1 inhabitant/agrarian ha. The regions or countries with the least favourable prospect are Finland, the Netherlands, Belgium, Germany, the Czech Republic, Poland, Hungary, Romania, Bulgaria, Italy and Greece. These countries combine relatively small holdings (16.0 ESU/ha) with high population pressure (5.6 inhabitants/agrarian ha). Here, the number of wheat farms will suffer the highest decrease, which will provide opportunities for alternative agricultural and non-agricultural land use.

In comparison with the calculations based solely on competitiveness on the global food market, the maps hardly differ due to the shortage of land of about 400.000 ha and are similar to the situation in 2005 (Map 28, Map 29).

global food market and the regional land market in **scenario B2** at 2050

Legend

Each class one third of total potato production in 2050

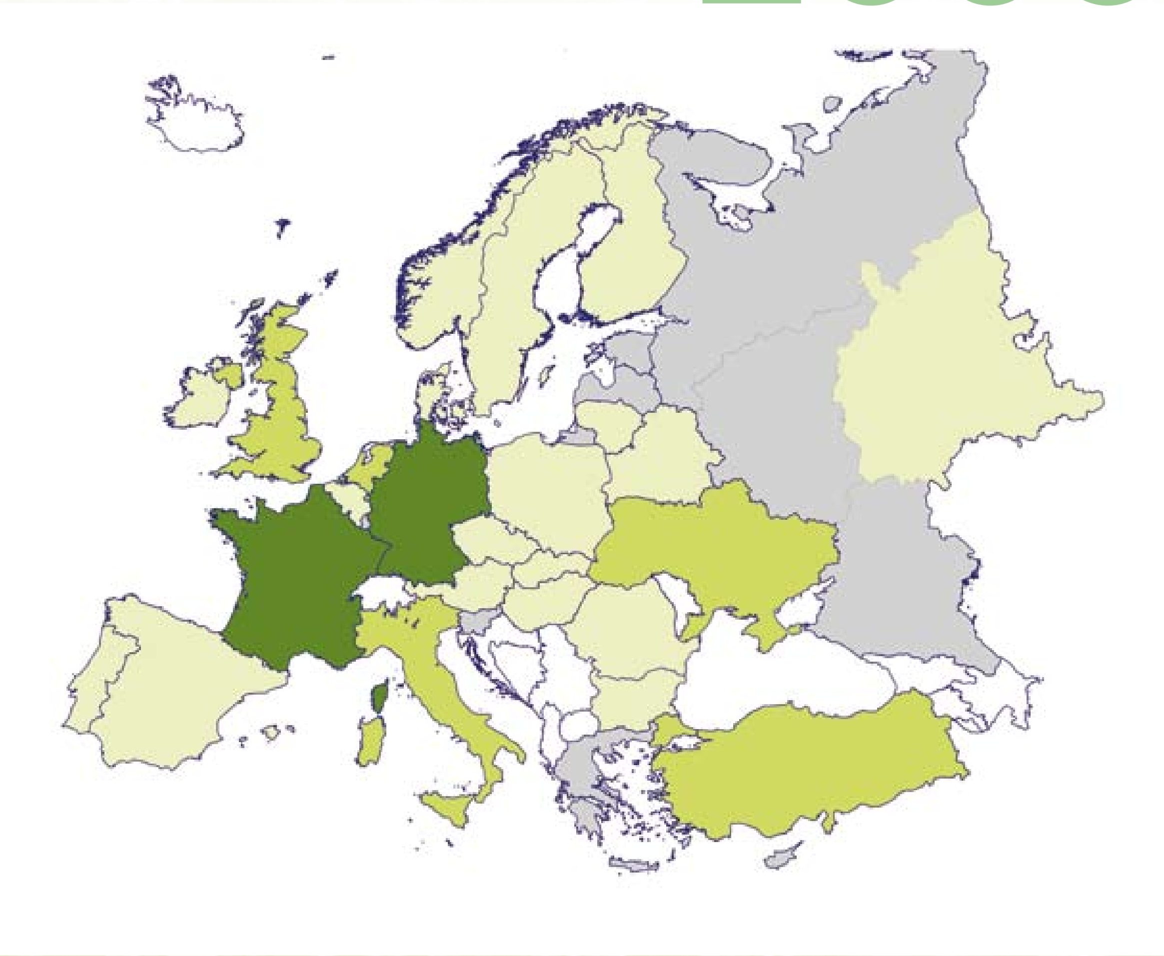
	Upper
	Middle
	Lower
	<0,5% of EU-Ural production

	ESU/holding	Inhabitants/ha UAA
	35 - 2500	< 2
	1 - 95	< 4
	1 - 60	< 40
	<0,5% of total EU-Ural ESU	

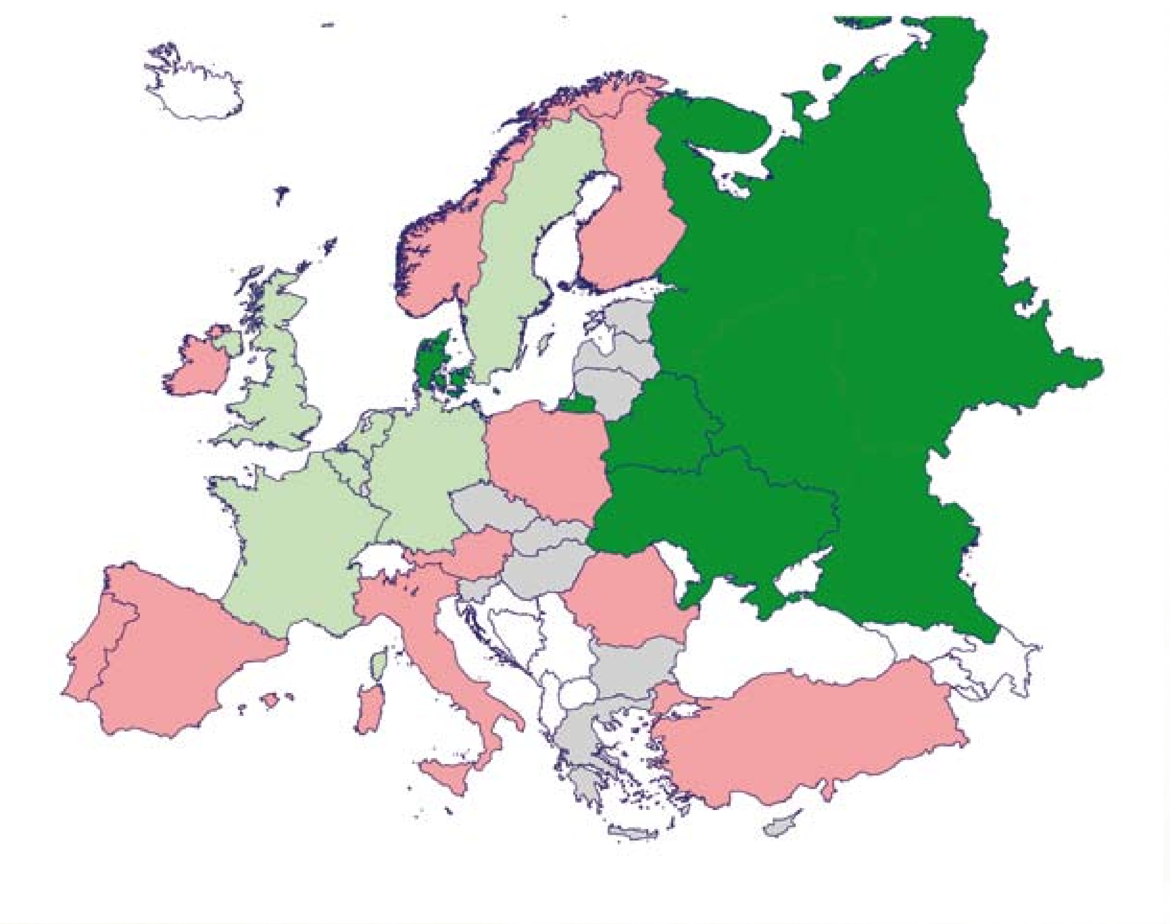
Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Map 30 Milk production regions in EU-Ural based on competitiveness

2005



competitiveness

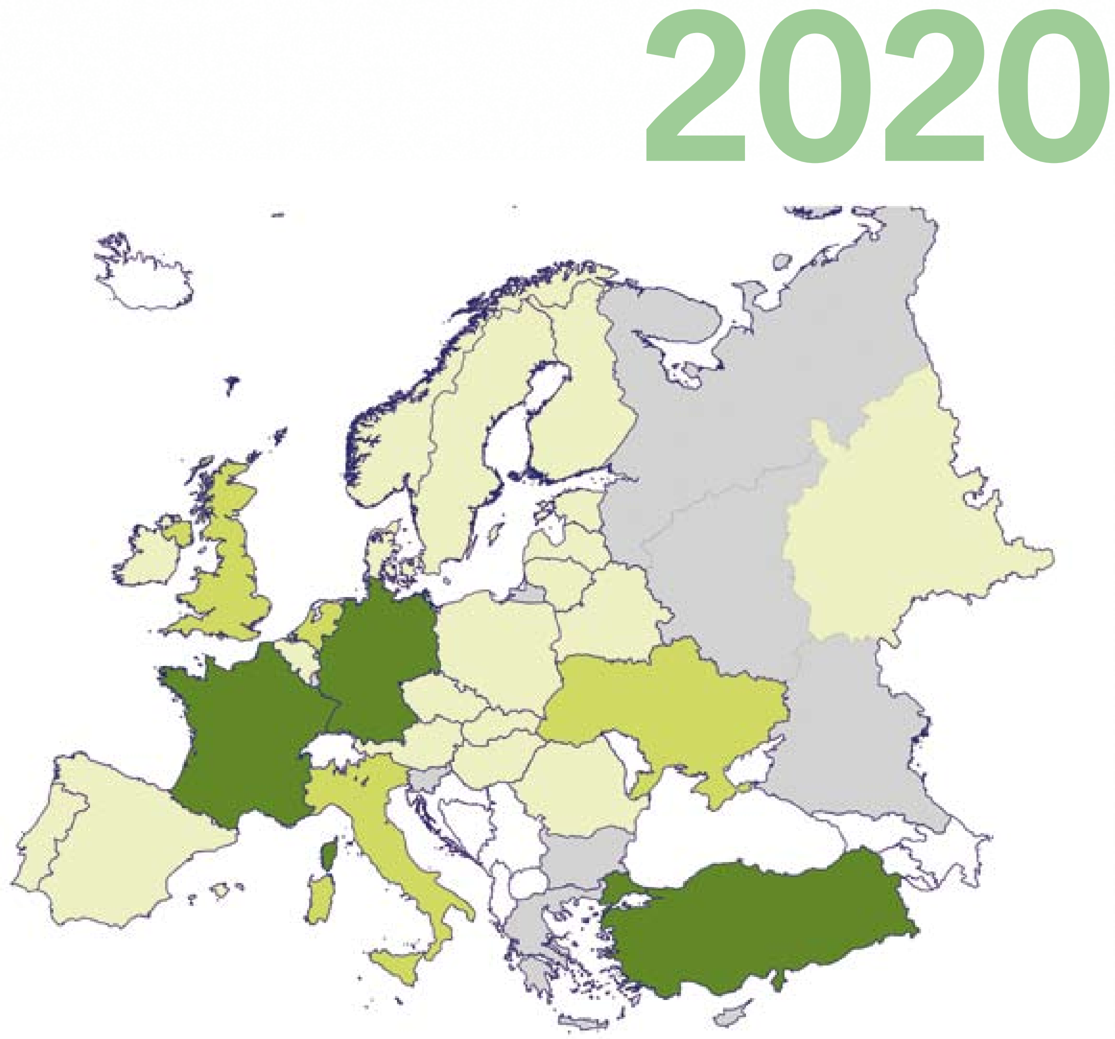


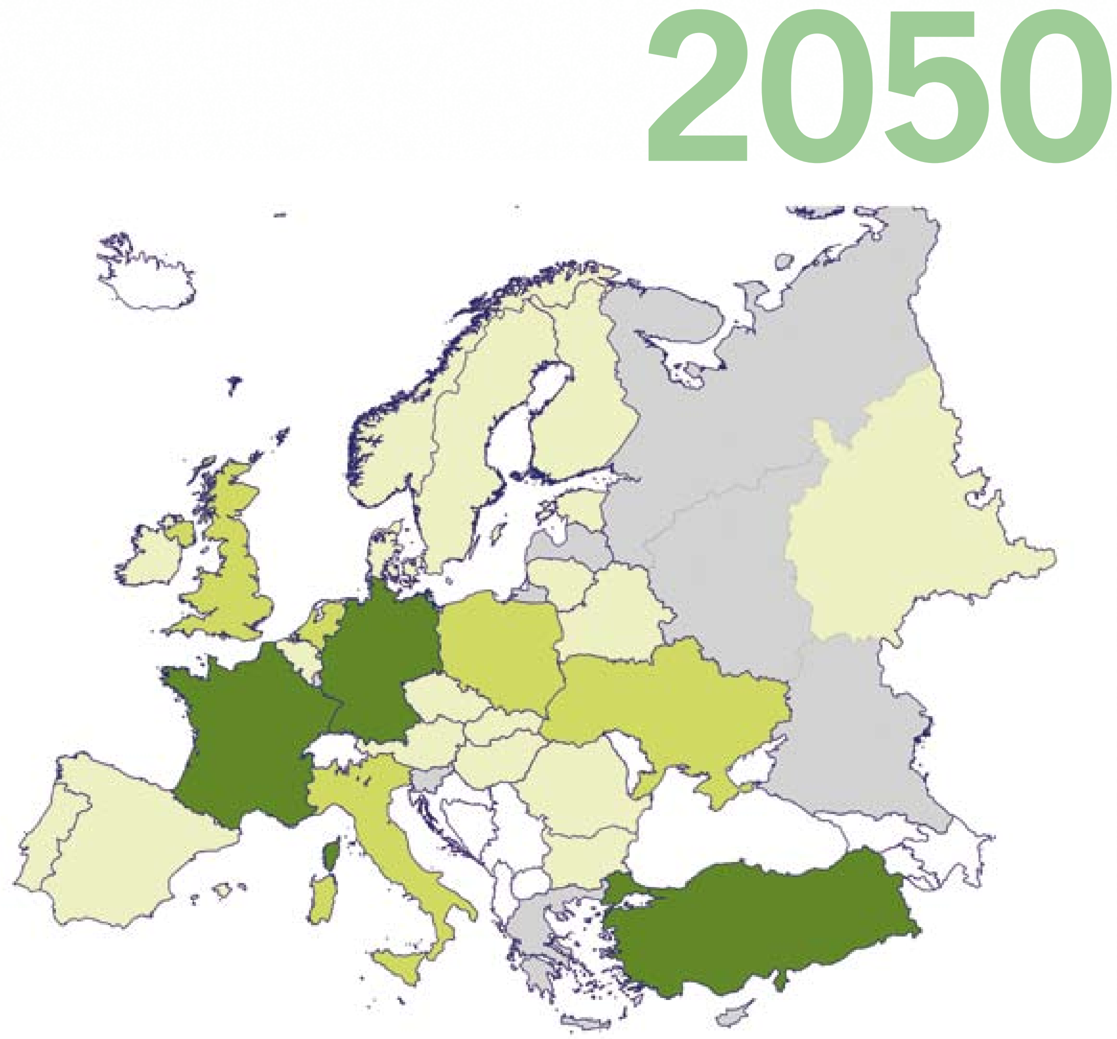
In 2005, one third of the total milk production was from France and Germany (Map 30, 2005). The scenario predicts that by 2020, the achievable supply of milk will slightly outweigh the production demand. By 2050, the production demand will outweigh the achievable supply (Figure 22).

When supply outweighs demand (in 2020) estimates need to be made about where, in which regions, production should continue. In order to (re)distribute spatially the supply and demand ratio of milk in 2020 it is necessary to consider how competitive regions or countries are, either within the global food market alone, or in combination with competitiveness in regional land markets. This means that regions with the smallest farms (lowest ESU/holding) and/or the highest population pressure (highest inhabitants/agrarian ha) have the least favourable prospects and will be the first to lose production and thus cultivated land and holdings. The relative competitiveness order of regions or countries is identical in scenario A1 and scenario B2. But in scenario B2, it is assumed that European and national governments will support regional agriculture hence – although competitiveness will play a role – it will be less pronounced. In comparison with the calculations in scenario A1, less land per region or country will be taken out of production resulting in more regions being required to attain the required reduction of grassland. Once achievable supply and demand are in equilibrium, no more land will need to be taken out of production. In the event of demand exceeding the supply (in 2050), there will be a shortage of land for milk production and all regions or countries will maintain their agricultural area in production. No attempt has been made to allocate surplus land.

Firstly, competitiveness on the global food market was considered in isolation (Map 30, competitiveness). The countries with the most favourable prospects are Denmark, Belarus, Ukraine and Russia. In these countries, average size is 450 ESU/holding. Countries with the least favourable prospects are Spain, Portugal, Italy, Ireland, Norway, Finland, Poland, Romania and Turkey. In these countries, the average size is only 23 ESU/holding. Hence, competitiveness within the EU-Ural countries varies widely.
By 2020, Estonia, Latvia and Bulgaria will most likely lose their dairy farms (Map 30, 2020). By 2050, when the production demand will outweigh the achievable supply, there will be a shortage of grassland for milk production of at least 16.5 million ha (Figure 28). At least, because the area is calculated supposing that the maximum productivity could be realised.

within the global food market in **scenario B2** at three time slices





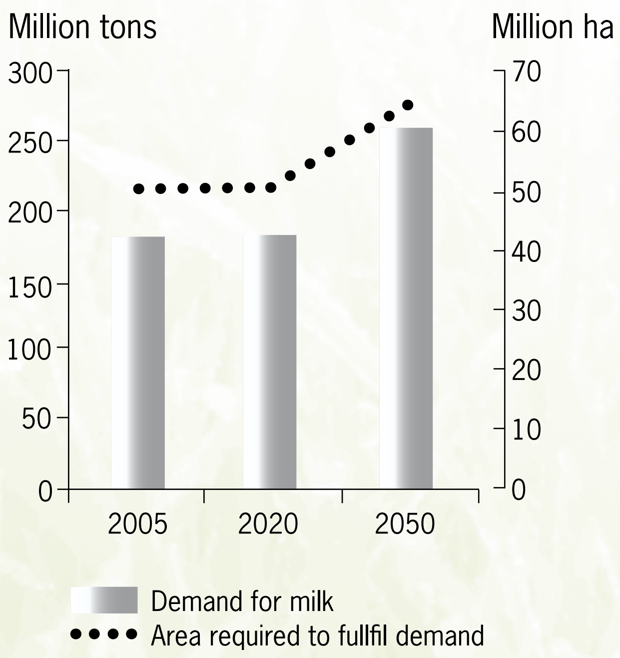
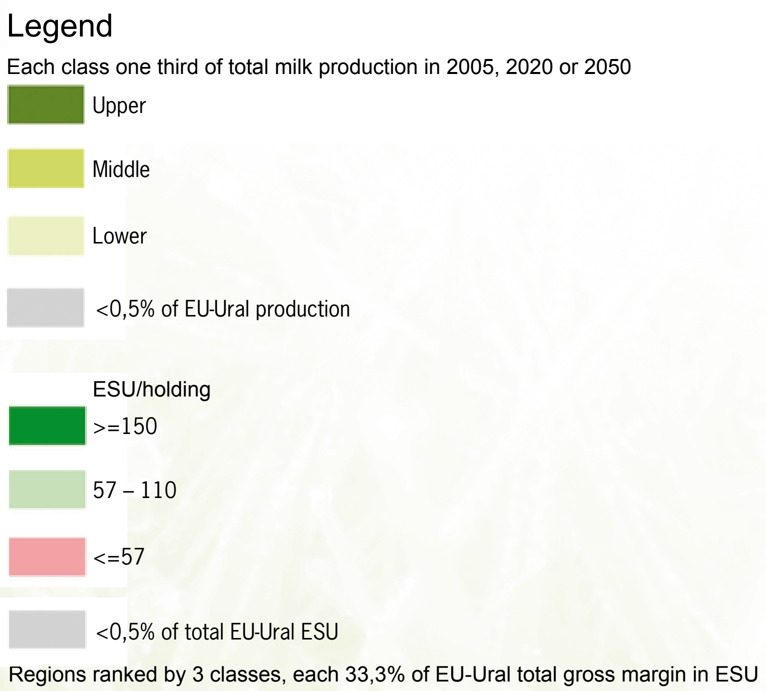
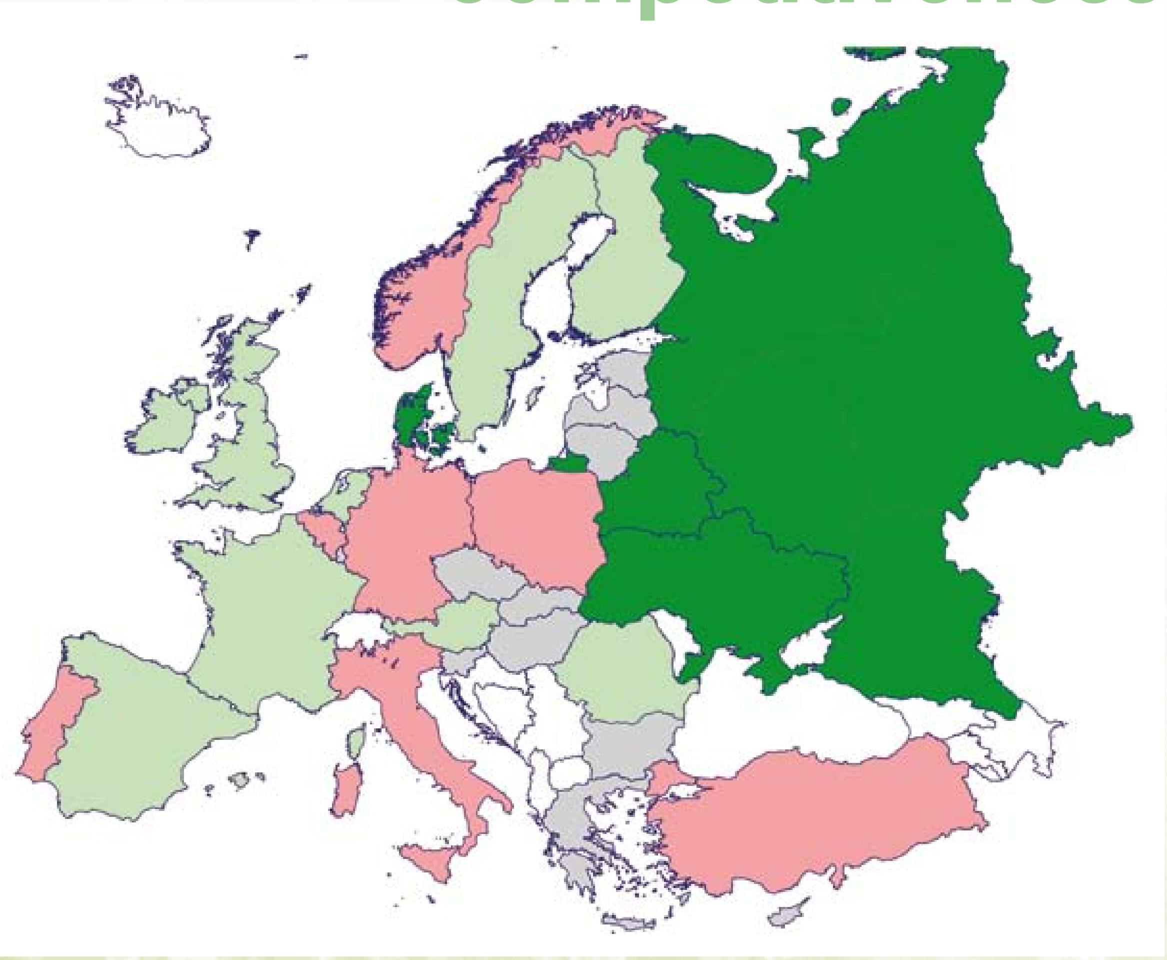


Figure 28.
Demand for milk and corresponding area in EU-Ural, based on competitiveness of dairy production on global food markets in scenario B2 at three time slices. The area required in 2050 is larger than the area available in 2005.

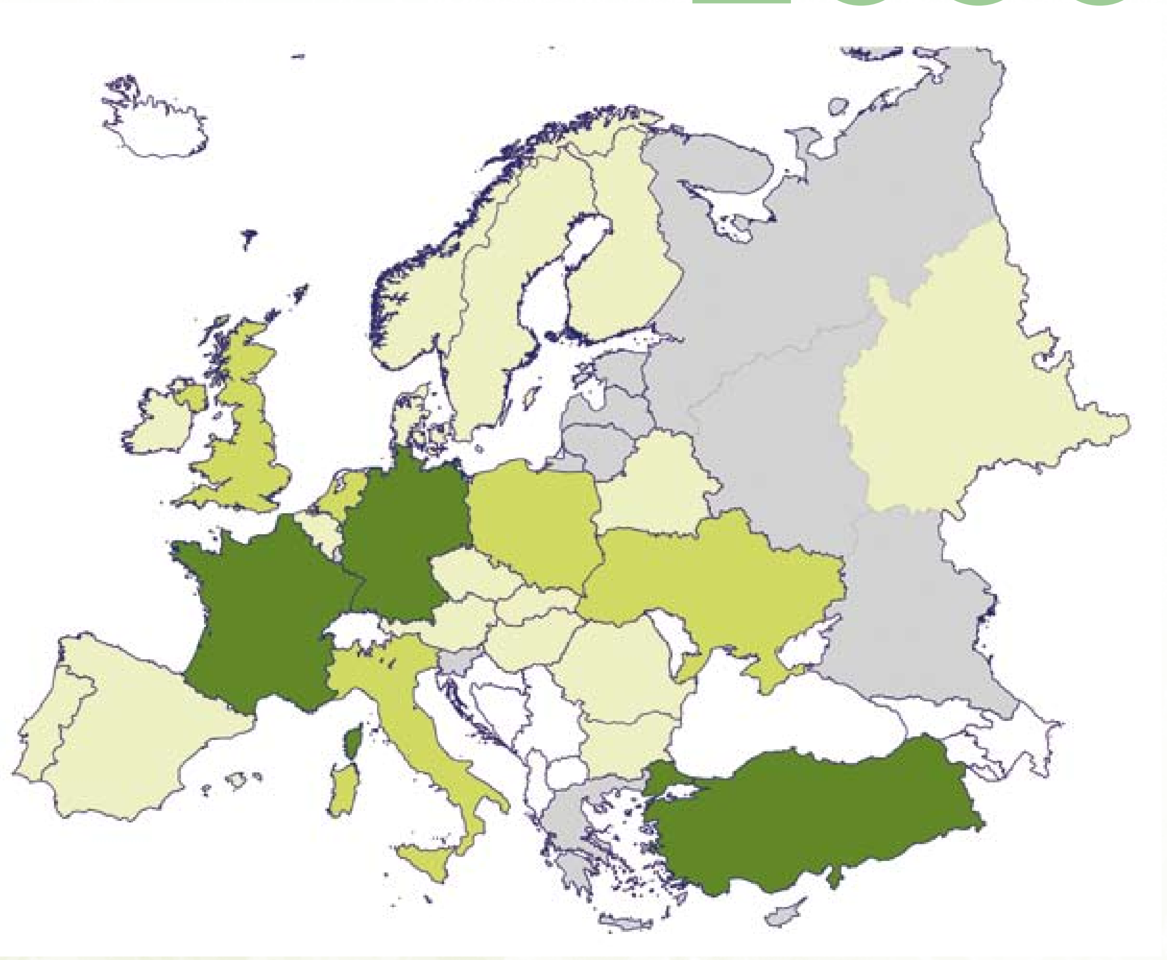


Map 31 Milk production regions in EU-Ural based on competitiveness within the global

competitiveness



2050



If competitiveness in regional land markets is also taken into account (Map 31, competitiveness) it will be seen that, in regions with high population pressure, agriculture is competing for space against other functions, such as housing and recreation. Therefore such countries will fall on the competitiveness scale. In 2050 the most competitive countries are those with large holdings and a low population pressure. These occur in Denmark, Belarus, Ukraine and Russia. In these countries, the average size is 450 ESU/holding and the average population pressure is 1.0 inhabitant/agrarian ha. The countries with the least favourable prospects are Norway, Belgium, Germany, Poland, Portugal, Italy and Turkey. These countries combine relatively small holdings (30.3 ESU/holding) with high population pressure (6.7 inhabitants/agrarian ha). Here the number of dairy farms will suffer the highest decrease, at least when supply would outweigh demand, which will provide opportunities for alternative agricultural and non-agricultural land uses.

In comparison with the calculations based solely on competitiveness on the global food market, also now there is a shortage of land of at least 4.6 million ha. Therefore, the maps of 2050 are similar to the map of 2005 (Map 30, Map 31).

food market and the regional land market in **scenario B2** at 2050

Legend

Each class one third of total milk production in 2050

- Upper
- Middle
- Lower
- <0,5% of EU-Ural production

	ESU/holding	Inhabitants/ha UAA
	130 - 600	< 2
	1 - 110	< 8
	1 - 75	< 40
	<0,5% of total EU-Ural ESU	

Regions ranked by 3 classes, each 33,3% of EU-Ural total gross margin in ESU

Discussion

In this section the focus will be on two issues. The first relates to the results and underlying assumptions. The second relates to the crucial question, faced by farmers and agricultural regions in the EU, of whether it is possible to remain competitive in a liberalising (free) market and, in general, whether European agriculture can remain viable in the future.

1. Results and underlying assumptions

Two contrasting scenarios were constructed, which depended on socio-economic developments and climate change. These were based on the Special Report on Emissions Scenarios (SRES) framework (Nakićenović et al, 2000). These scenarios cover a wide range of future development paths. The results, i.e. crop productivity, regional competitiveness and the (re)distribution of production regions, are linked to the underlying assumptions in each scenario and should not be considered as predictions of the future. These assumptions will be discussed in the following section.

Scope for future changes in crop productivity

The estimations of crop productivity were based on the statistical approach developed for various crops for the EU15 member countries (Ewert et al, 2005). The team elaborated this approach for the EU27 member states and then additionally for the regions up to the Urals. The main drivers of change in productivity are technological development, increased CO2 concentration and climate change.

Increases in crop productivity are particularly high for the A1 scenario. They follow the extrapolation of the trend line derived from historical data (1961-2000). Although the increases in the observed yield varied substantially between crops and countries, further analysis of the data revealed that differences in relative yield changes between crops and countries were surprisingly small and tended to converge with time. This principle was used in the calculation of future productivity.

Technology is the most important driver of productivity changes and increases due to technological development were considered equal for all regions and all crops. An exception was made for potatoes, since increased production resulting from technology is lower in the new member states. This too was based on historical data.

Productivity increases in the B2 scenario were estimated to be much smaller than in A1, because of lower CO2 concentrations and less technological development.

Scope for future demand

Data on the predicted future demand of food crops and milk were calculated with the Global Trade Analysis Project (GTAP) model (van Meijl et al, 2006). The major driving variables were assumptions on population and Gross Domestic Product per capita (GDP), which were obtained from the Organisation for Economic Co-operation and Development (OECD) Economic Outlook (2005). Other data required to run the model originated from the Food and Agricultural Organisation (FAO, 2006). The methods presented in van Vuuren et al (2006) were used to downscale these input data to national and regional levels.

The GTAP calculations showed considerable difference in the production demand between the two scenarios. For wheat in EU27, for example, the demand amounted to 150 million tons in scenario A1 and 190 million tons in B2. However, the population of 560 million people in scenario B2 was some 40 million lower than in A1. The reason for this was not clear, although in B2 more wheat might be exported from the EU27 due to favourable market conditions for wheat production in EU27. Each scenario thus presents extremes: in A1, there is high productivity combined with relatively low demand, which is the reverse of the situation in B2.

Instead of using GTAP, demand predictions from FAO or OECD could have been used, plus or minus a given percentage per scenario in which case, an indication of the sensitivity of land use for a range of production demands could have been ascertained.

Competitiveness maps

The results presented in the competitiveness maps, give relative information. By using the ranking values of the regions, no judgement was expressed on the absolute value of a given indicator in classifying as favourable a region's competitive prospects. In this comparative analysis, judgement was made on whether the prospects for a given region were more or less favourable than elsewhere. By classifying the regions into three classes, each comprising 33% of the EU-total of ESUs, individual rankings were omitted. The maps represent the competitiveness of the arable sector (wheat and potatoes) or the dairy sector (milk) in 2020 and 2050.

To define the competitiveness of holdings in 2050, two variants are presented. In the first variant, only competitiveness within the global food market is considered, while in the second, the competitiveness in the local land market is also included. The difference is that the competitiveness of agricultural holdings is lower in regions where serious population pressure has resulted in high land prices. Land prices are likely to become relevant in 2050, because by that time it should be apparent that the population has a well-filled, global food basket, and that the EU is capable of self-sufficiency in a range of crops. When a significant area of agricultural land has become redundant, agrarian land use will lose its favoured status and a greater opportunity will arise for non-agrarian claims; hence regional land markets will be liberalised.

Adjustment of production to demand

When supply exceeded demand, individual rankings were used to determine in which regions farms were most likely to be taken out of production.

In both scenarios, in a given region, the values for ESUs per holding were decisive for the amount of land to be taken out of production. For each region, the average economic size (ESU) of its holdings was compared to the average size of those in the regions with the most favourable prospects (ranking number 1). In scenario A1, the area of land remaining in production was proportional to the ratio of the two. It was assumed that the area of land taken out of production in scenario A1 would be twice as much as in B2, because it was assumed that, in the latter scenario, national authorities would still provide financial help to farms. (We had no hard arguments to choose for twice as much, so it would be wise to carry out a sensitivity analysis by varying the predicted percentage in both scenarios.) Because this was a relative comparison between regions, it could be assumed that the area of land taken out of production would be greatest in the regions with poor prospects for competitiveness. Therefore, the results provide a good indication of which regions are most likely to suffer through changes in the market and climate.

In the event of demand exceeding supply, which was the case in 2050 for all crops in scenario B2, no additional land was sought. Current information and methods do not permit a robust assessment of the effect on agricultural expansion of the combined impact of market and climate change.

Production regions

The maps use three classes, each representing one third of the total demand, to show the production regions for wheat, potatoes and milk. The regions producing less than 0.1% of total production are coloured grey. The dark green colour covers a minority of regions. These have a combination of highly competitive regional holdings and/or very productive land and/or a large area of the respective crop. The light green colour covers the majority of the regions, which have a combination of low competitiveness of regional holdings and/or land with low productivity and/or few hectares of the respective crop.
The whole region was coloured in, not merely the hectares actually used for wheat, potatoes or grass.

An argument could have been made for the results to be presented on an equal square base. However, this would not have taken into account the fact that competitiveness is not limited to production alone, but also includes the entire complex of agro business. These industries have to compete in the world market and need growth. They are still related to national countries or administrative regions, which benefit from employment opportunities, and prosper financially when there are large production units in the neighbourhood.

2. Is there a threat to the future of agriculture in Europe?

The question to be answered is whether agriculture can remain viable in the future when faced with changes in both climate and the market. This will largely depend at what scale the answer is required. At a European level food production is secure, even in the most extreme climate scenario and in a free market. However, at a lower scale, consequences could be serious for individual regions.

Wide variability in regional production due to differences in productivity and competitiveness of regions.

There are considerable differences between regions with respect to estimated impacts of climate and market change.
In scenario A1, regions in north-western Europe will, in general, increase their arable production, because of climatic conditions having a positive impact on productivity, combined with their relatively high competitiveness. Conversely, regions in southern and eastern Europe will face a significant reduction in arable production. This will result from a combination of serious adverse impacts from climatic conditions and reduced competitiveness, due to market liberalisation. As a result large areas will become redundant and alternatives will need to be found. The possibilities include other agrarian activities, which are able to withstand the changing climatic and market conditions, and also non-agrarian activities. Particularly in countries where the agricultural sector is a major employer, efforts will be needed to avoid the social problem of high unemployment.
In scenario B2, the differences in regional production are also significant. However, in contrast with scenario A1, hardly any land abandonment will occur.
Regional differences in milk production are less pronounced compared to arable production, due to more modest increases in grass productivity.

Possible policy reaction in regions differs per region

1. Need of support for agricultural innovation
   Regions whose agriculture sector has proved to be robust, and which are capable of delivering together at least one third of the production in both scenarios, can expect their agriculture to withstand changes in market and climate. Entrepreneurs (producers) and policy makers can be confident that investments aimed at strengthening the agricultural sector will not be wasted. On the condition that it is used for innovation in sustainable production, European policy makers can try to channel part of the Common Agricultural Policy (CAP) budget devoted to agricultural production (first pillar and first axis of the second pillar) to these regions.

2. Need of support for conservation of nature, landscape and water, and for provision of alternative employment.
   Regions shown to have relatively weak agriculture in both scenarios can expect to encounter poor future prospects in that sector. Depending on the situation, different reactions are possible.
   Regions with low agro-chemical inputs could have favourable conditions for high biodiversity. Policy makers could help by ‘greening’ part of CAP budget to stimulate and maintain the agricultural systems in these regions with intrinsic high biodiversity value.
   In regions with relatively weak agriculture and high employment related to the agro business complex, future employment will need to depend mainly on non-agricultural sectors. Developing alternative employment should therefore be at the forefront of rural policies.

Future of agriculture in individual regions under climatic extremes

Thus far, only gradual climate change has been considered. How changes in extremes might alter the results is not clear. For example, in northwest Europe, climate change will also involve pronounced variability, with summer droughts, wet periods, severe precipitation events, hail storms, wind storms and fewer cold spells. Due to rising sea levels, progressive salinisation can also be expected in coastal zones. Because no information on extreme climate events is available at the European scale, an EU wide assessment is not possible. An in depth study of The Netherlands is planned for the future, to determine which extreme climate events have the potential to disrupt severely (and possibly eventually destroy) any of the main agricultural sector activities, and on what timescale. The crucial task of this study will be to determine the threshold at which it will become impossible for sectors and farmers to adapt any further. In assessing these risks farmers will have an important voice.

Conclusions

An approach was developed to assess the future of agricultural production regions in Europe under changing market and climate conditions. Three crops were analysed (wheat, potatoes and grass) for two scenarios from 2005 until 2050. The approach was simple, and based on estimates of the productivity of crops and estimates of production demand for these crops and products. Subsequently, crop production was adjusted to the demand, based on competitiveness of regional agriculture within global food markets and/or regional land markets.

The results suggest that in 2050 there will be wide variability of regional production in Europe. This was particularly so in a liberalised scenario (A1). The most favourable regions were the less densely populated areas in north-western Europe (parts of France, northern Germany and northern Netherlands). It was mainly due to a combination of substantial increases in productivity and very competitive arable and dairy sectors. The least favourable regions were in eastern and southern Europe. A decrease in productivity (or too small an increase), combined with low competitiveness, was responsible for this. In a more regional scenario (B2), the differences were less extreme.

Because the increase in demand for the various crops/products was smaller than the increase in productivity in the liberalised scenario (A1), large areas became superfluous and could be used for alternative agrarian or non-agrarian activities. This need was larger in southern and eastern European regions. It calls for a policy relevant to the local situation. In the more regional (B2) scenario, there was a larger increase in demand and a much smaller increase in productivity, resulting in too little land to supply the demand. No attempt was made to seek additional land to remedy this shortage.

If the countries up to the Urals were included, except for France and/or Germany, the relative importance of the western European countries decreased in favour of the Ukraine and some Russian regions. Their importance was not so much the result of high productivity but rather of large farms with good prospects for high competitiveness.

These results are the basis for further research. Until now, the effects of climate variability and extreme events have been ignored. In addition, only three sectors/crops are analysed. The future work will move from the European scale and concentrate on The Netherlands and its agrarian regions and/or municipalities. Firstly, the consequences for wheat, potato and grass of the increasing climatic variability (i.e. summer droughts, wet periods, heavy precipitation, hail and wind storms, and decreased cold spells) will be investigated, with the help of experts and local farmers. Secondly, other crops relevant for the Netherlands will also be included in the analyses. Finally, adaptation options will be considered, in collaboration with the farmers, to allow them adjust to these climatic and market conditions. To facilitate these adaptations, the requisite national, regional or private policies will require particular attention.

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This project (A12; How can agriculture adapt to changes of both climate and market; definition study) was carried out and funded (50%) in the framework of the Dutch National Research Programme Climate changes Spatial Planning. It was co-financed by the Ministry of Agriculture, Nature Conservation and Food Quality

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