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Distribution of climate suitability for viticulture in the United Kingdom in 2100

ECRC Research Report Number 177

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January 2017

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1. Introduction

Changes in temperature of the second half of the 20th Century led to significant changes in the areas of the UK suitable for high-quality viticulture. A warming climate and acceptable rainfall levels (although not without a number of risks to harvest yields) has made it possible for UK wine producers to produce high quality sparkling wine in the so-called 'golden triangle' south of London.

As the climate continues to change over the course of the 21st century through to 2100, the possibilities for UK viticulture will again continue to shift. While rising temperatures bring warmer growing seasons that may create potential opportunities for grape varieties that are currently widely planted in Europe to be grown in the UK, as well as having the potential to reduce the risk of spring frosts that inhibit bud growth, warmer climate conditions in the UK also bring a number of threats to UK wine growers. Chief amongst these threats are the increases in rainfall and the increasing risk of extreme weather events.

For the long-term development of UK viticulture, it is important to assess a range of possible climate futures for 2100. The potential for significant changes to climatic conditions will require long term changes in strategy, skills and human capital development and significant further research to mitigate risks and identify potential opportunities from adapting UK viticulture to climate change. We have analysed one potential climate change scenario based on three key variables for growing high quality wine grapes, based on a 'middle-of-the-road' projection of changing temperatures and rainfall for the UK for 2100 due to climate change.

Overall our findings suggest that, according to our estimates, that the UK may become an 'intermediate climate' wine region by 2100. It is currently a marginal, cool-climate region. However, some of the areas of the south of England may become either too hot, too wet, or both, to grow quality wine grapes in 2100.

2. Methodology

2.1. Study Design and Objectives

To estimate the areas of the UK that could potentially be 'growing areas' for different wine grape varieties in 2100, we considered the effect of temperature in the growing season, overall levels of rainfall throughout the year and the level of rainfall in the month of harvest.

To do this, we combined information about the temperature ranges for the growing season (April to October in the Northern Hemisphere) for each grape variety, long-term average climate data on temperature and rainfall for the UK, and climate

modelling of how temperature and rainfall in the UK are predicted to change through to 2100.

Therefore, we based our analysis on the following 3 variables that affect wine grape growing conditions;

- Average growing season temperature (average temperature between April and October): the tolerable temperature range varies by grape variety analysed.
- Average Annual Rainfall: we used one value for all grape varieties, based on several sources.
- Rainfall in the month of harvest: one of the biggest problems for UK viticulture is the threat of heavy rainfall in the month of harvest (currently October). We have used one value for all grape varieties, with estimates of tolerable rainfall levels estimated using several sources. We made the assumption that the month of harvest would stay as October.

2.2. Data Sources

- Grape vine growing season temperature: **Jones G V** 2008 'Climate change: observations, projections, and general implications for viticulture and wine production'. In: XII Congresso Brasileiro de Viticultura e Enologia, Bento Gonçalves. pp.55-67
- Current Climate Data of long-term average temperatures and rainfall: 1981-2005 monthly long-term average gridded datasets, Met Office CP09 climate data
- Climate Change Modelling for temperature and rainfall change for the UK through to 2100: KNMI Climate Explorer
- UK Annual Rainfall limit of 800mm: Skelton (2001), as cited in **Robinson J** 2008 The Oxford Companion to Wine, 3rd edition Oxford UnIversity Press, Oxford, 813pp.
- 1000mm Annual Rainfall limit for quality wine-growing regions: **Reynolds A G** 2010 Managing Wine Quality: Viticulture and Wine Quality Elsevier, 624pp.
- October Rainfall (Under current climatic conditions, wet autumns and autumn fruit rot are noted to be a particular risk for UK wines at the moment): Estimates for thresholds based on **Spellman G** 1999 Wine, weather and climate Weather 54(8) 230-239 and **Johnson H & Robinson J** 2009 The Concise World Atlas of Wine Mitchell Beazley, London, 352pp.

2.3. Analytical Approach

With assistance from Dr Matthew Owen of the Geological Survey of Denmark, we took the Met Office's CP09 1981-2005 'long term average' climate data (geographical data that gives average monthly temperatures and monthly precipitation figures for the period 1981 – 2005 as a measure of the current climate.

We transformed this data using a model of how UK average temperatures and average rainfall will change over the next 100 years using the 'RCP6.0' projection of temperature and rainfall changes. This produces monthly values, so we then averaged them over the required periods to calculate Apr-Oct temperature values,

Annual Precipitation and October Precipitation figures for 2100 under our climate model. The model used, from the KNMI Climate Explorer tool, takes a 'mid-range' scenario of the size of the increase in rainfall and the rise of temperatures in the UK over the next century through to 2100.

Using this data, we then created maps of the areas of the UK that could be estimated as potentially suitable for wine growing for nine different grape varities in 2100, using average values of the Apr-Oct growing season temperature range for each grape variety.

Given the increase in rainfall suggested by the model for 2100, we created two 'rainfall scenarios' for grape-growing in 2100. Firstly, a 'normal' scenario based on currently acceptable levels of rainfall for UK viticulture (annual rainfall of below 800mm, and an estimated October rainfall limit of 80mm (the latter is estimated based on current October rainfall averages for the UK and other major wine growing regions)). And secondly, a 'high threshold' scenario where UK winegrowers are able to adapt to higher rainfall levels (Annual rainfall of below 1000mm, October rainfall of below 100mm). The 'high threshold scenario' stays within currently acceptable levels of rainfall in other wine regions for both annual and harvest-month rainfall; the harvest-month rainfall in the Rhone valley is over 120mm, for example.

2.4. Outputs

The maps were produced using QGIS. Each map displays the area of the UK that is estimated to be a potential growing region for a particular grape variety: based on the intersection of the geographical data for annual rainfall, October rainfall and Apr-Oct temperature based on the thresholds we set for each variable. The 'Normal' threshold (800 mm annual, 80mm October) is shown in a dark colour, and the 'High' threshold (1000mm annual, 100mm October) is shown in a lighter colour.

The grape varieties mapped for their projected areas for 2100 are as follows (listed by temperature range, coolest to warmest);

- Pinot Gris/Grigio
- Riesling
- Pinot Noir
- Chardonnay
- Sauvignon Blanc
- Tempranillo
- Merlot
- Syrah
- Malbec

3. Results

Overall, large areas of the UK may be suitable for viticulture in 2100, mostly for white grape varieties and Pinot Noir. It appears that, under the future conditions in the models we used, Britain will not become suitable for warm climate grape varieties such as Sangiovese, Cabernet Sauvignon and Grenache/Garnacha.

There is a risk that current wine-producing areas in the south of England may become too wet or too warm for certain cool climate grape varieties, such as Pinot Noir. This grape is frequently a key element of high quality sparkling wine and this presents a potential long-term question for the British wine production.

The East of England appears much more amenable to wine production in 2100, whereas the West of England and Wales will be largely too wet. Large areas of Scotland will remain too wet and cool for wine grape growing, however there may be some areas of the South East of Scotland that could be potential locations for some cool-climate grape varieties, like Pinot Gris, Riesling or Gewürztraminer (not mapped).

Only certain areas of the South East of England show the potential to be suitable for intermediate climate red wine grapes such as Merlot and Tempranillo, with potential ‘pockets’ in Kent, Essex and Norfolk/Cambridgeshire.

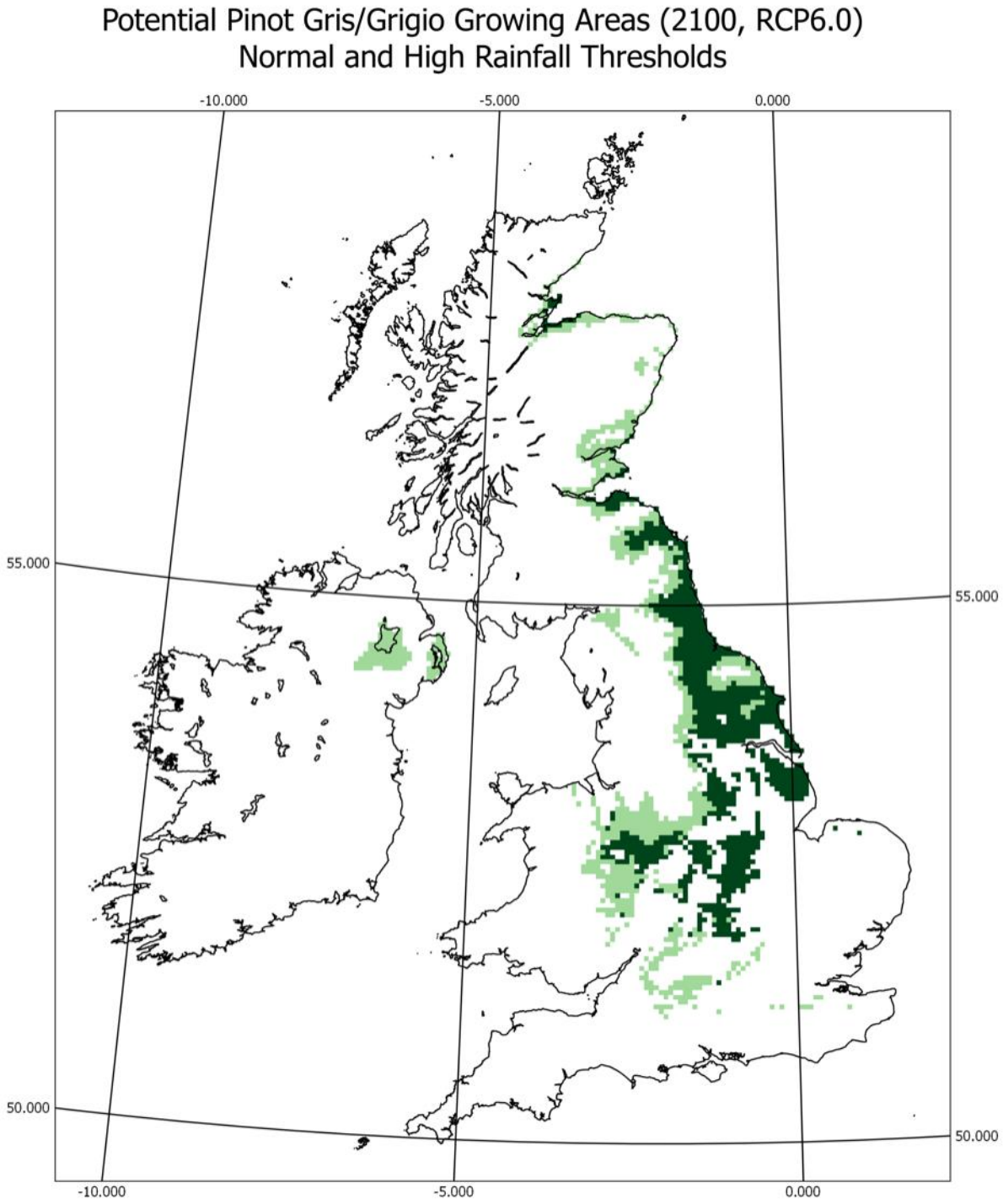

Fig 1. Potential growing areas for Pinot Gris/Pinot Grigio viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

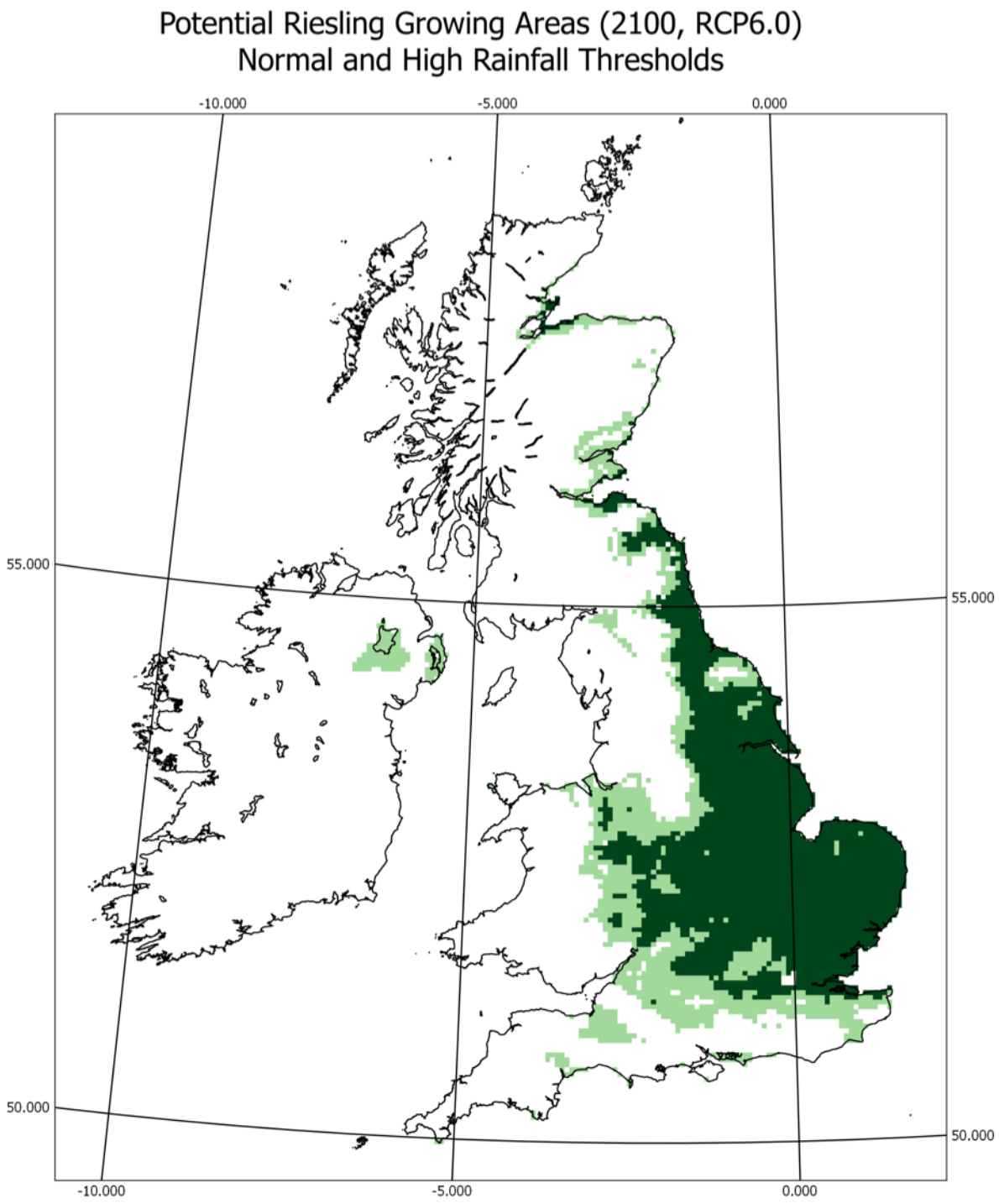

Fig 2. Potential growing areas for Riesling viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

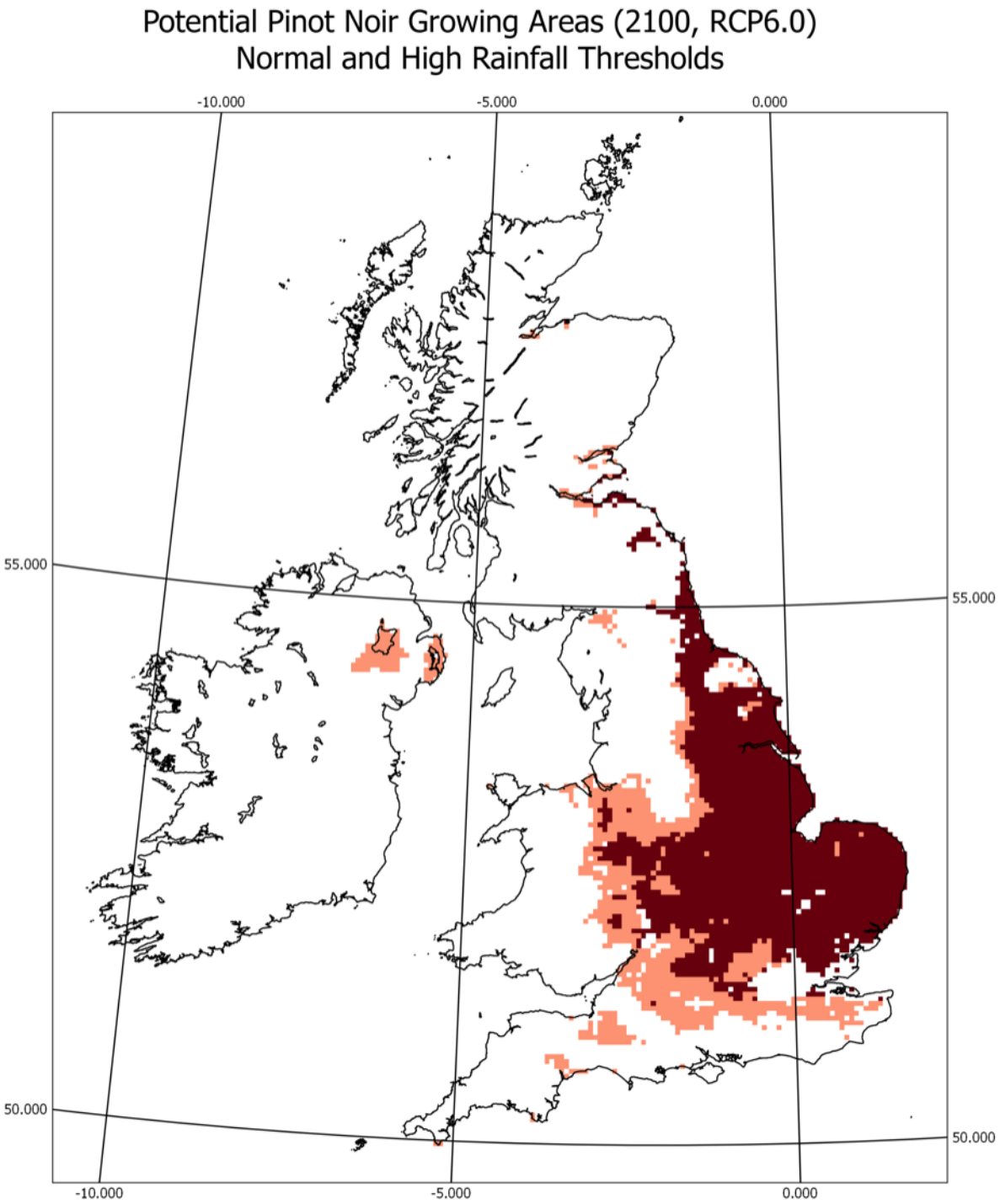

Fig 3. Potential growing areas for Pinot Noir viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

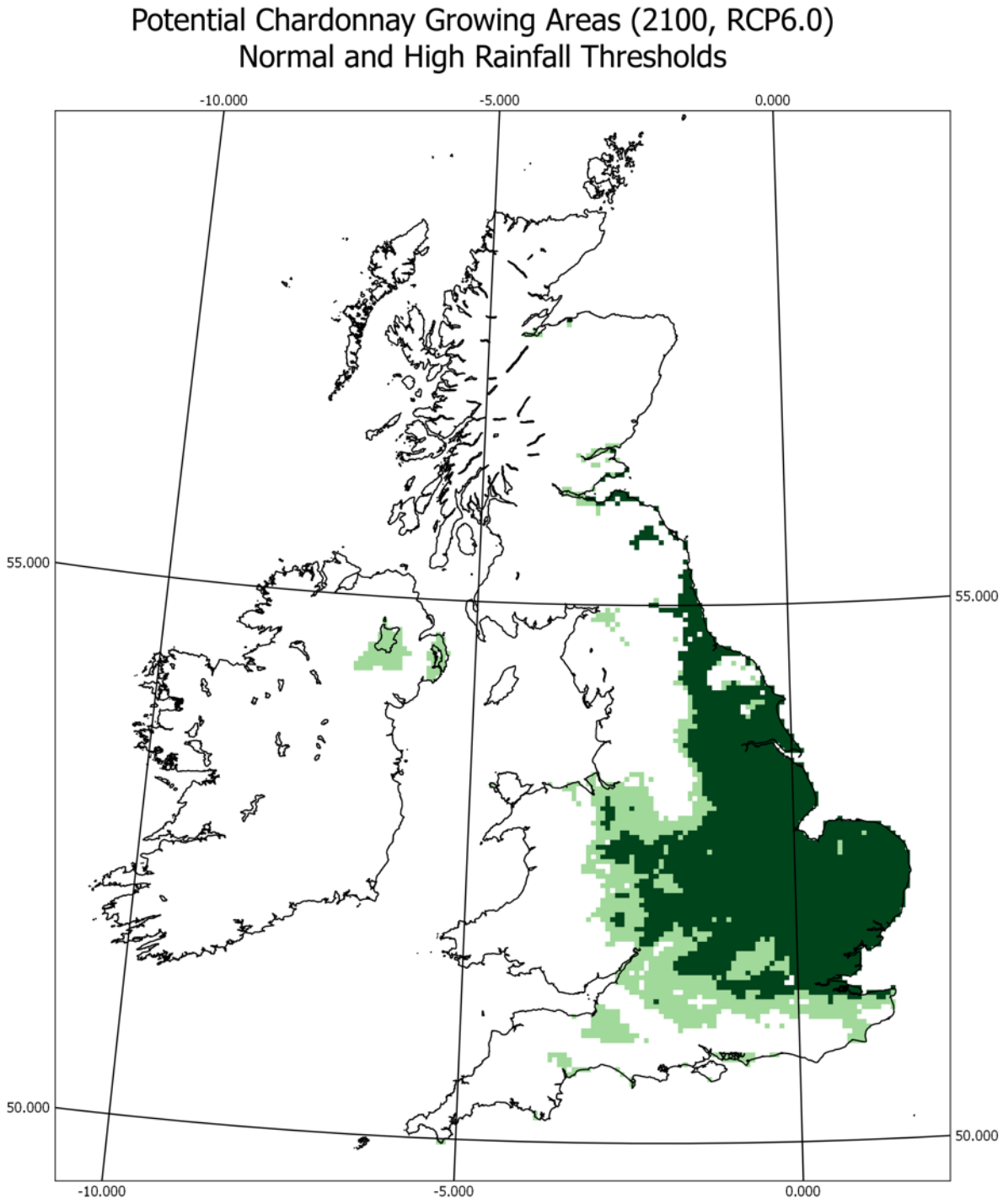

Fig 4. Potential growing areas for Chardonnay viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

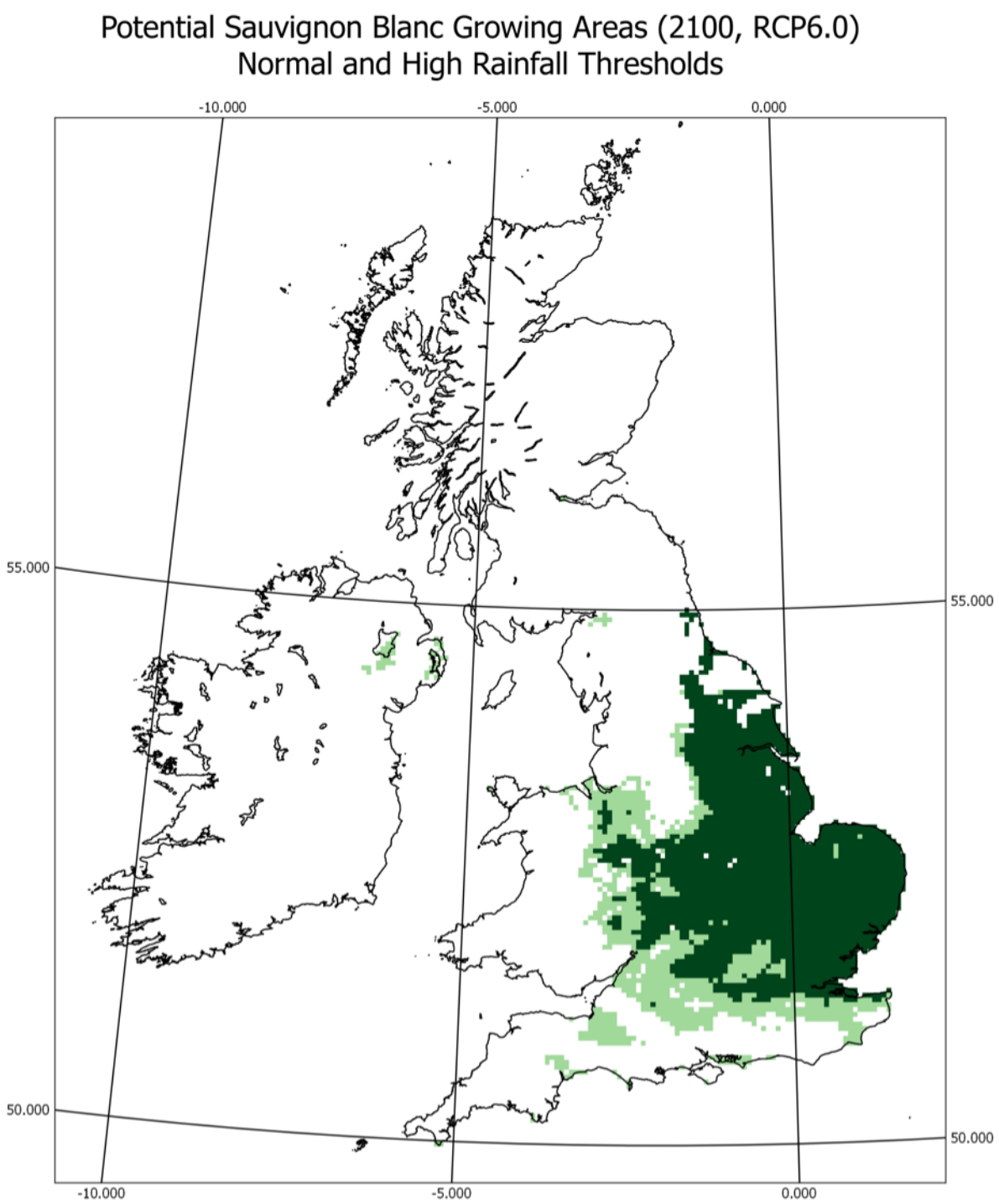

Fig 5. Potential growing areas for Sauvignon Blanc viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

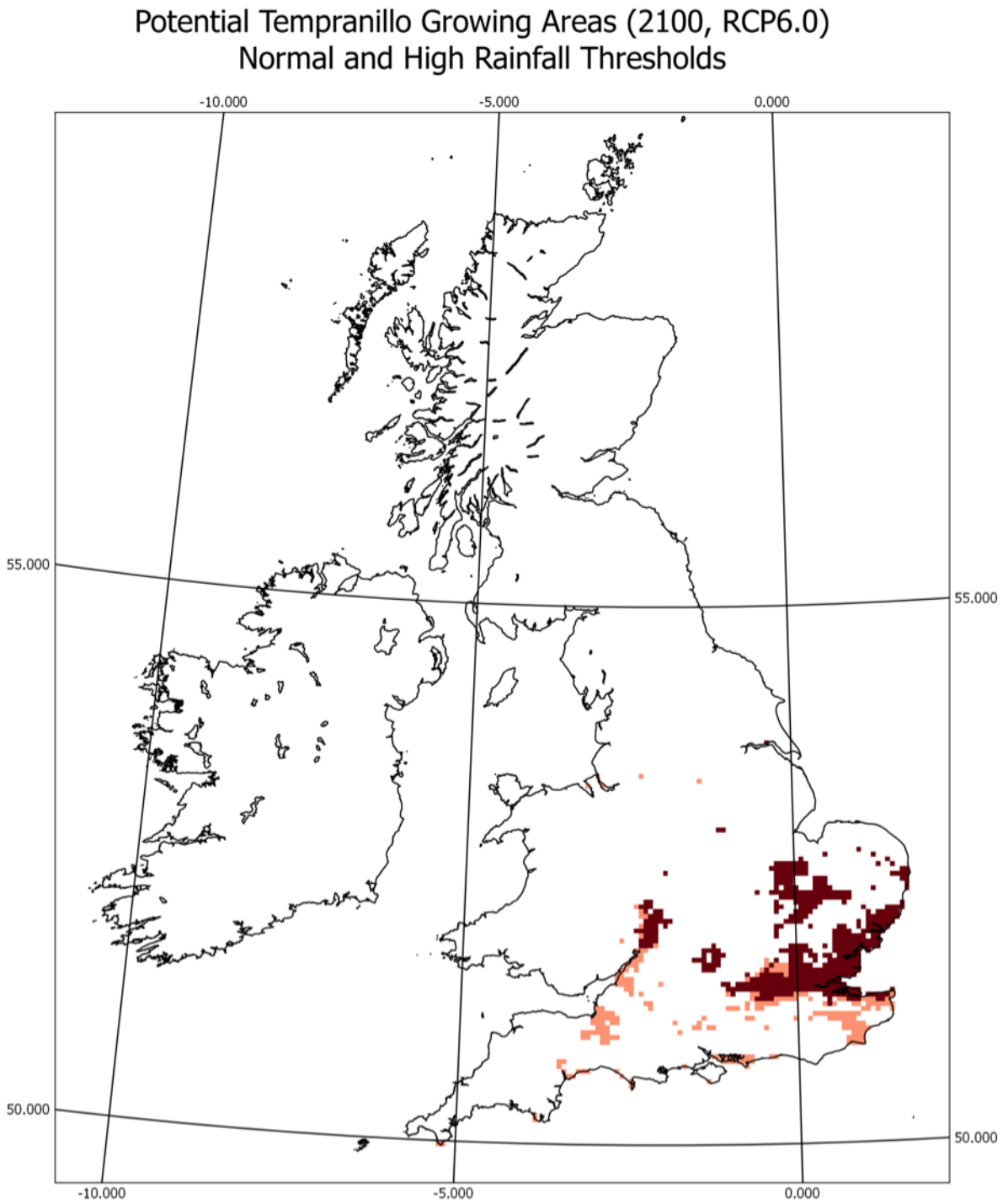

Fig 6. Potential growing areas for Tempranillo viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

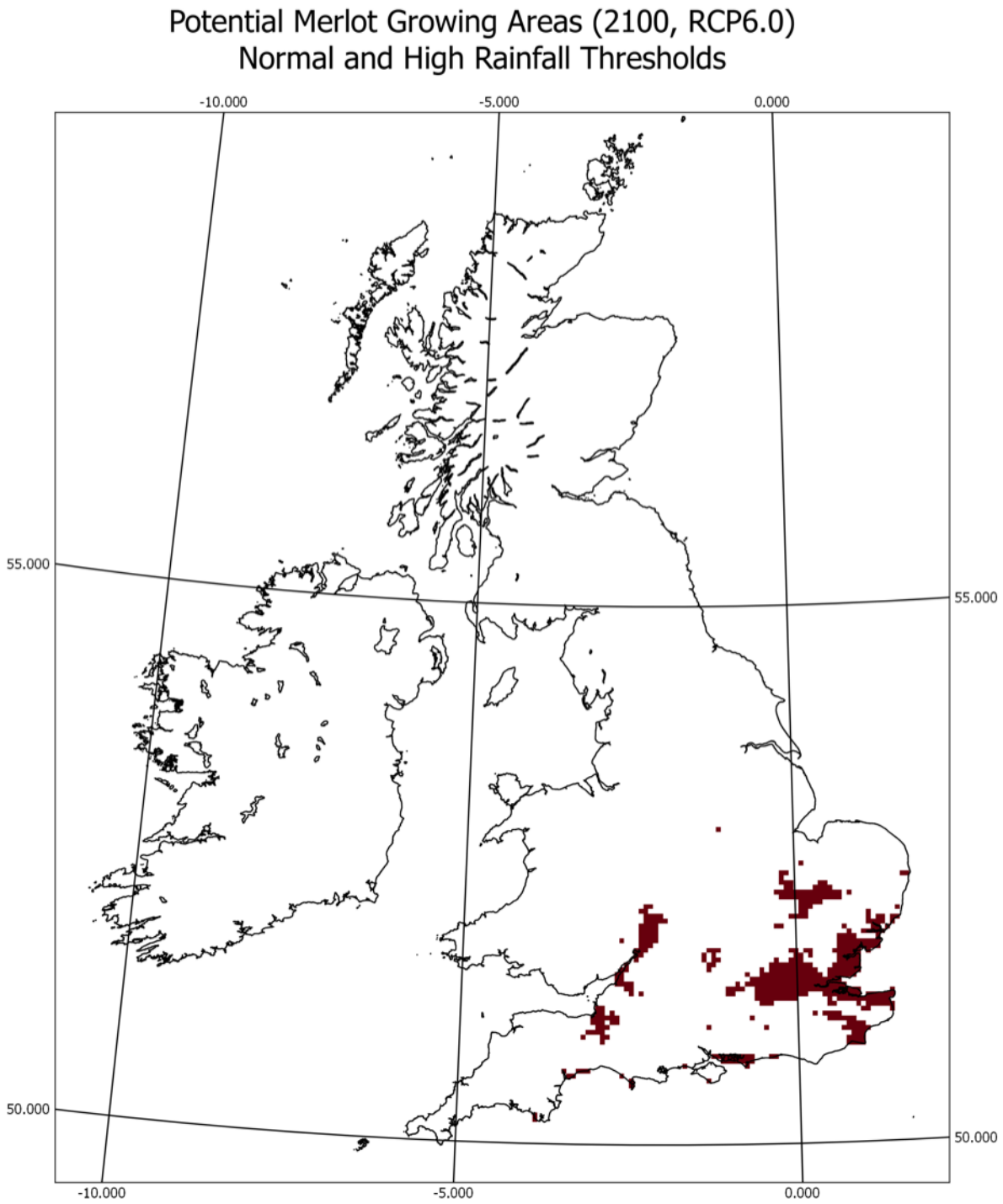

Fig 7. Potential growing areas for Merlot viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

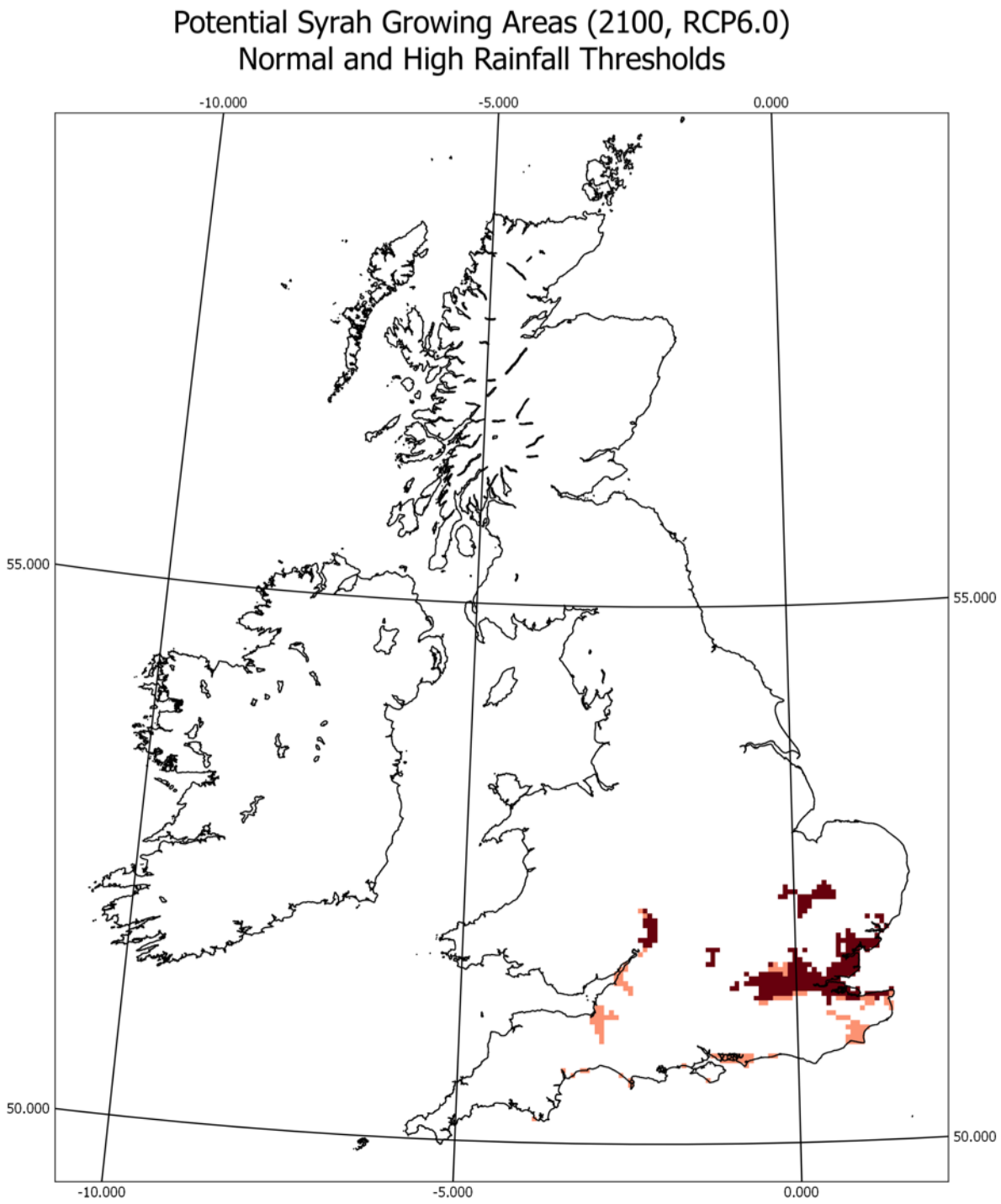

Fig 8. Potential growing areas for Syrah viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

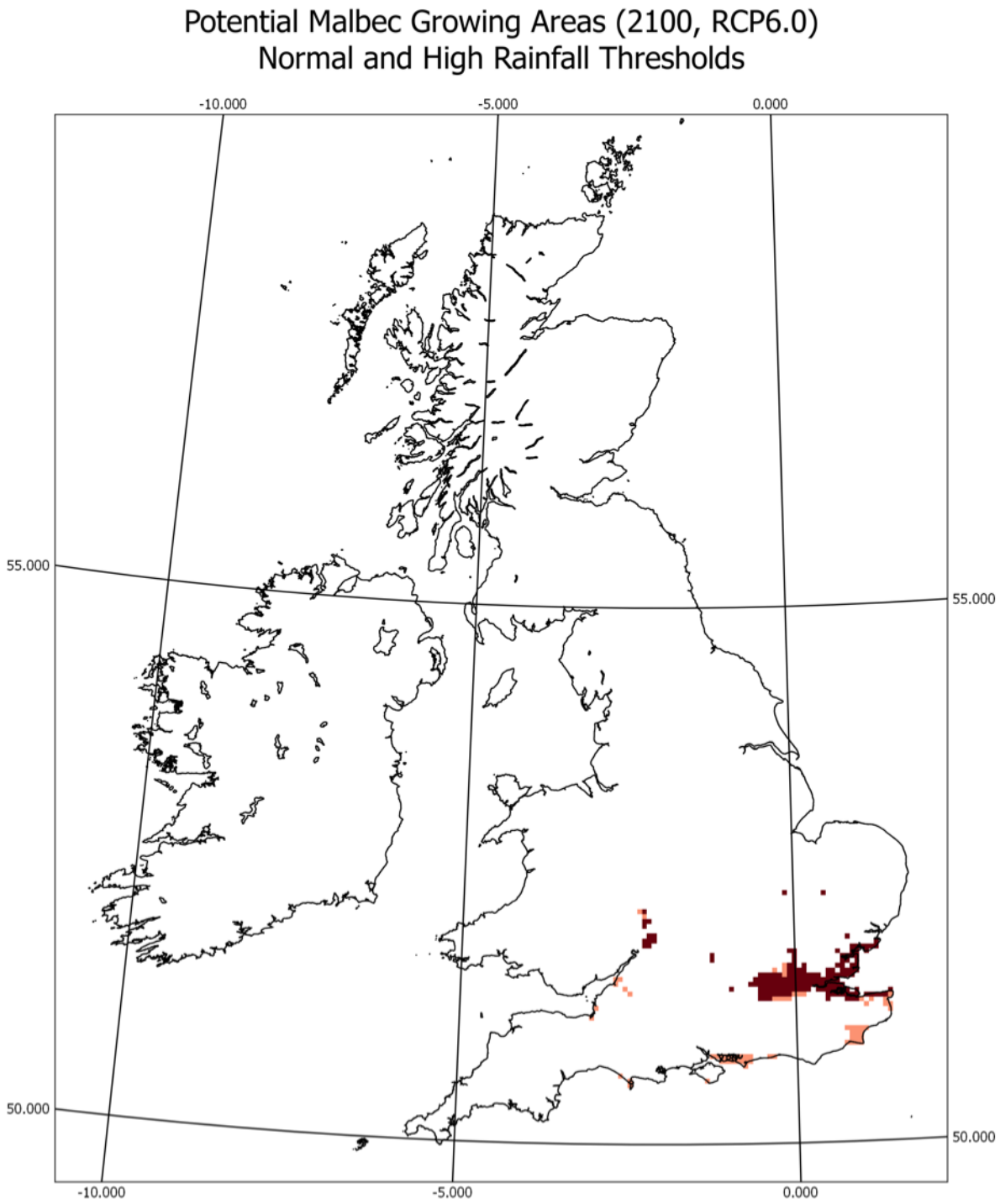

Fig 9. Potential growing areas for Malbec viticulture in the UK in 2100. Dark areas represent a normal threshold for rainfall (800mm annual, 80mm October), light areas represent a higher threshold (1000mm annual, 100mm October) if growers adapt to changing conditions. Changes in rainfall and temperature based on RCP6.0 scenario.

4. Discussion

The model for climate change (temperature and rainfall) can be considered a 'middle-of-the-road scenario' – a further 2.2 degrees of warming by 2100 on top of changes in temperature already measured over pre-industrial levels from the 1981-2005 long-term climate average, and a 5.6% increase in rainfall by 2100.

Our analysis suggests that it is possible that Britain will move from a marginal, cool climate wine region to an intermediate climate one. This broadly fits with the existing changes in the climate some studies have noted over the last century, where Britain has already become less 'marginal' and more successful as a cool-climate region for wine production, most notably for 'traditional method' sparkling wines in the South of England (see Nesbitt A, Kemp B, Steele C, Lovett A & Dorling S (2016)).

A mid-range scenario for project climate change by 2100 has the potential to hugely change what wines can be produced in the UK, and where: changing the grapes that are viable in the UK, opening up new areas to viticulture, and potentially rendering current areas of wine production too warm or too wet.

As much as changing temperatures, changing rainfall will be a significant issue for British winegrowers. It appears that we may have a wetter, perhaps more 'continental' climate with many areas in the south of England having higher levels of annual rainfall than the currently-estimated upper threshold of 800mm. However, some excellent wine regions receive up to 1000mm (Reynolds, 2010); hence why we chose to map a higher threshold scenario too.

However, it should be noted that, with autumn rainfall being one of the largest risks for UK wine growers currently, this would involve significant adaptation. British winegrowers will certainly have to deal with higher rainfall as well as higher temperatures. This is not an unsurmountable challenge, and the distribution of rainfall will also change. This is far more difficult to model and we have not included it in our analysis. For example, if autumn becomes a lot wetter than currently, this could be dangerous for British viticulture, notwithstanding a warmer climate.

> The findings perhaps suggest that there could be significant climate change implications for other wine producing regions; both threats from increases in temperature and changes in rainfall in established wine regions and widening or even fundamentally shifting the 'climate envelope' for wine production. There are signs from this study that there is the potential for significant risks to wine production in 'marginal' areas at the limit of the climate range. Significant growing season temperature increases in wine regions in continental Europe would put wine producers at risk of not being able to produce wine from the same varieties that have been historically used.

4.1. Limitations

If the month of harvest moves forward with higher temperatures, that may affect the harvest month rainfall levels. The month of harvest could move forward to September from October, depending on Spring conditions and ripening conditions; but this is impossible to estimate with the data available. September harvests could be one way of counteracting heavy autumn rains, if warmer temperatures in the ripening period allows sufficient fruit maturity in time.

Soil has not been considered as most wine grapes will grow with most soil types, except very loamy soils. The style of wine and quality will vary with the soil type. However, certain areas may not have a large number of potential vineyard sites if the soil is predominantly loam-based.

There is the potential that climate change may shift weather patterns in such a way that affects the annual cycle of wine production (summers are too dry, autumns are too wet, spring frosts become stronger, rainfall becomes less predictable leading to huge annual variations in 'vintage' quality and vineyard productivity, etc.) in ways that it has not been possible to model in this study. This may change the prospects for wine production across the country. Changes in weather and climate-related risks may also significantly affect what wine production may be possible and where.

This study provides an analysis of one potential scenario for UK wine production, based on the three variables modelled, and there are a number of other potential scenarios relating to wine production and a changing climate between now and 2100. Other models or scenarios could produce different projections for wine production areas, depending on different variables (such as slope, aspect, soil types, spring frost risk, risk of prolonged below-freezing temperatures in winter, higher/lower changes in temperature and rainfall, etc). Whole regions within the UK identified on the basis of the three variables analysed in this study may, with future research, contain a limited number of potential vineyard sites due to these variables and others.

5. Concluding Remarks and Future Research

This exploratory study suggests that the 'wine map' of the UK is likely to change significantly during the 21st century. With this transformation, there will be both risks and opportunities which will be unevenly distributed across the country. While large areas of the UK may present favourable climatic conditions for wine production, current areas of production of sparkling wine in the UK may face temperature or rainfall levels that preclude their ability to continue to produce high quality sparkling wines.

Further research is therefore required to create other projections of climate change for different scenarios for viticulture in the UK. It would also be apposite to re-produce similar analyses with future models of temperature and rainfall change as they are released. There is also a need for further analysis of the future of the UK sparkling wine industry in the south of England; producers need to understand the scale of the

threat to the industry and how many years these vineyards will remain within the temperature range acceptable for cool climate, low sugar viticulture for high quality sparkling wine.

Further analysis of other major wine producing regions is required; if levels of temperature rise and increases or decreases in rainfall in this order occurred in other major wine producing regions and nations in Europe would be change the production possibilities significantly and pose potentially a large risk to the wine industry in some European countries.

As a better picture of the potential pathways for UK wine producers emerges, based both on projections and a better understanding of climate change that has taken place already, there will be a need to develop adaptation strategies for wine growers to help them adjust to higher rainfall levels in the UK, in particular. Such strategies could also be applicable in other (currently) cool climate viticulture areas that are likely to experience significant change over the next century.

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7. Acknowledgements

The authors would like to thank Dr Matthew Owen and Dr Chris Brierley for their advice and assistance during this project. This project was also completed with the support and input of Laithwaite's Wine, part of Direct Wines Ltd.