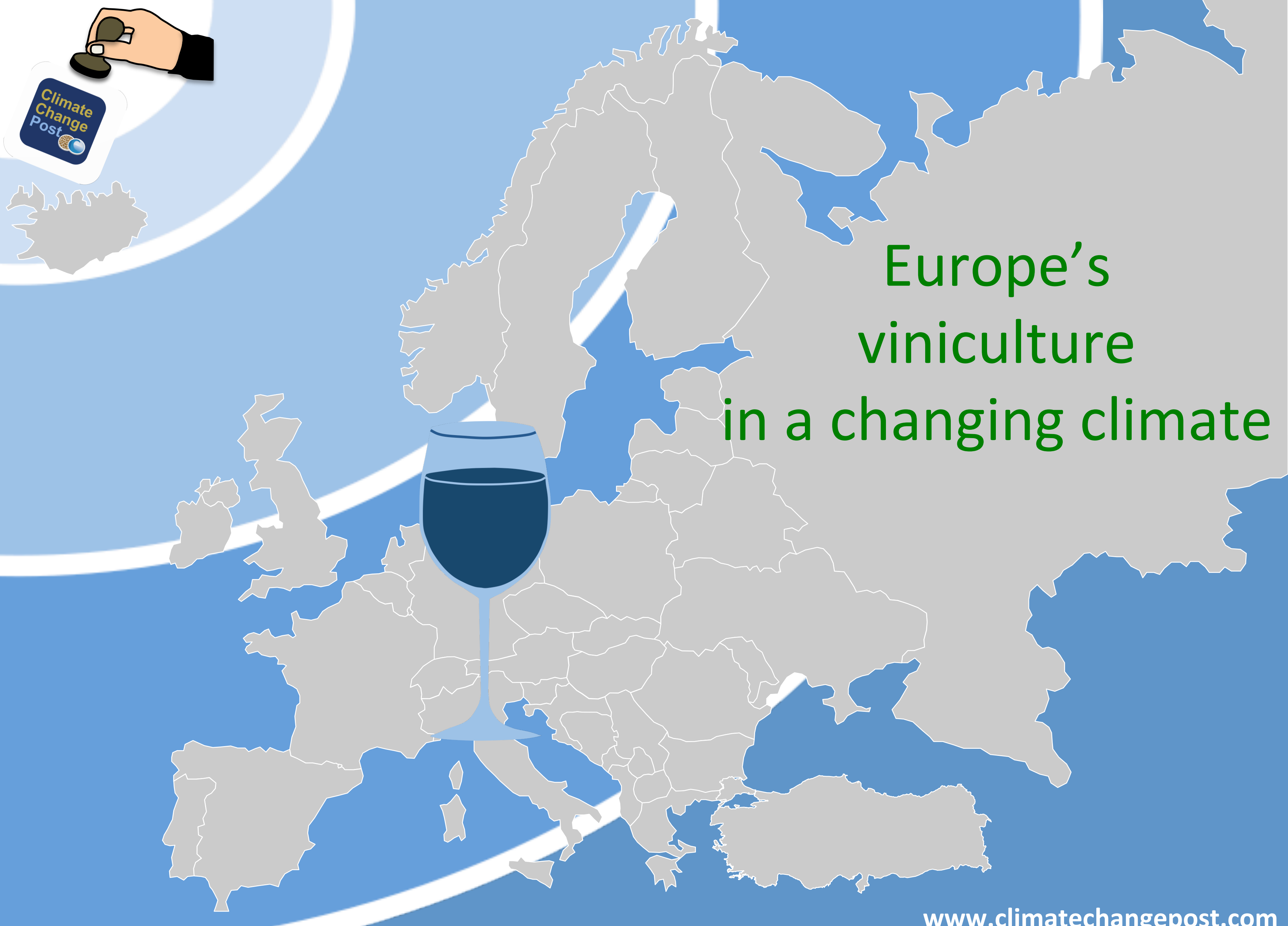
Europe's viniculture in a changing climate



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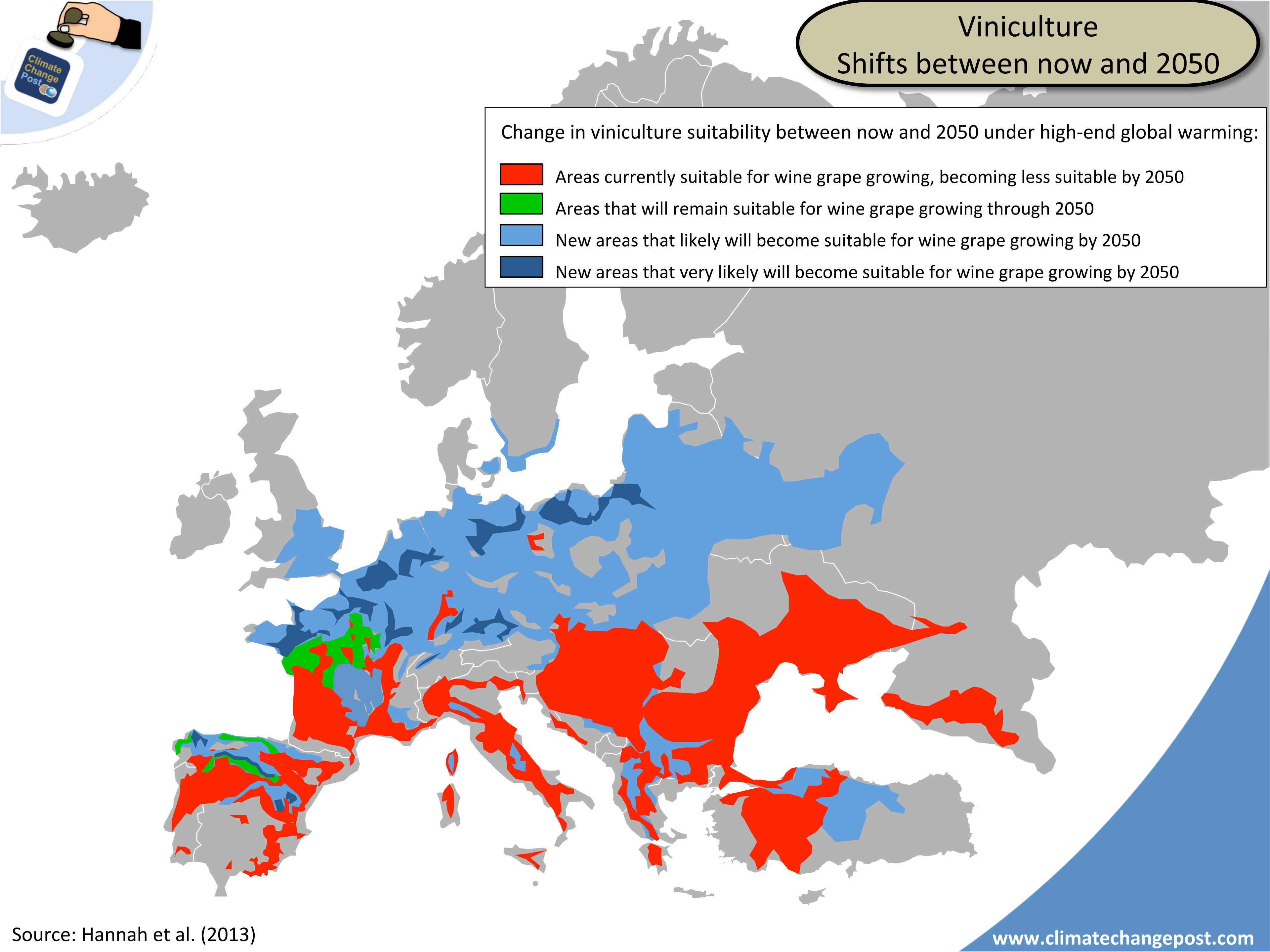
Climate Change Post
Viniculture
Shifts between now and 2050
Change in viniculture suitability between now and 2050 under high-end global warming:
Areas currently suitable for wine grape growing, becoming less suitable by 2050
Areas that will remain suitable for wine grape growing through 2050
New areas that likely will become suitable for wine grape growing by 2050
New areas that very likely will become suitable for wine grape growing by 2050
Source: Hannah et al. (2013)
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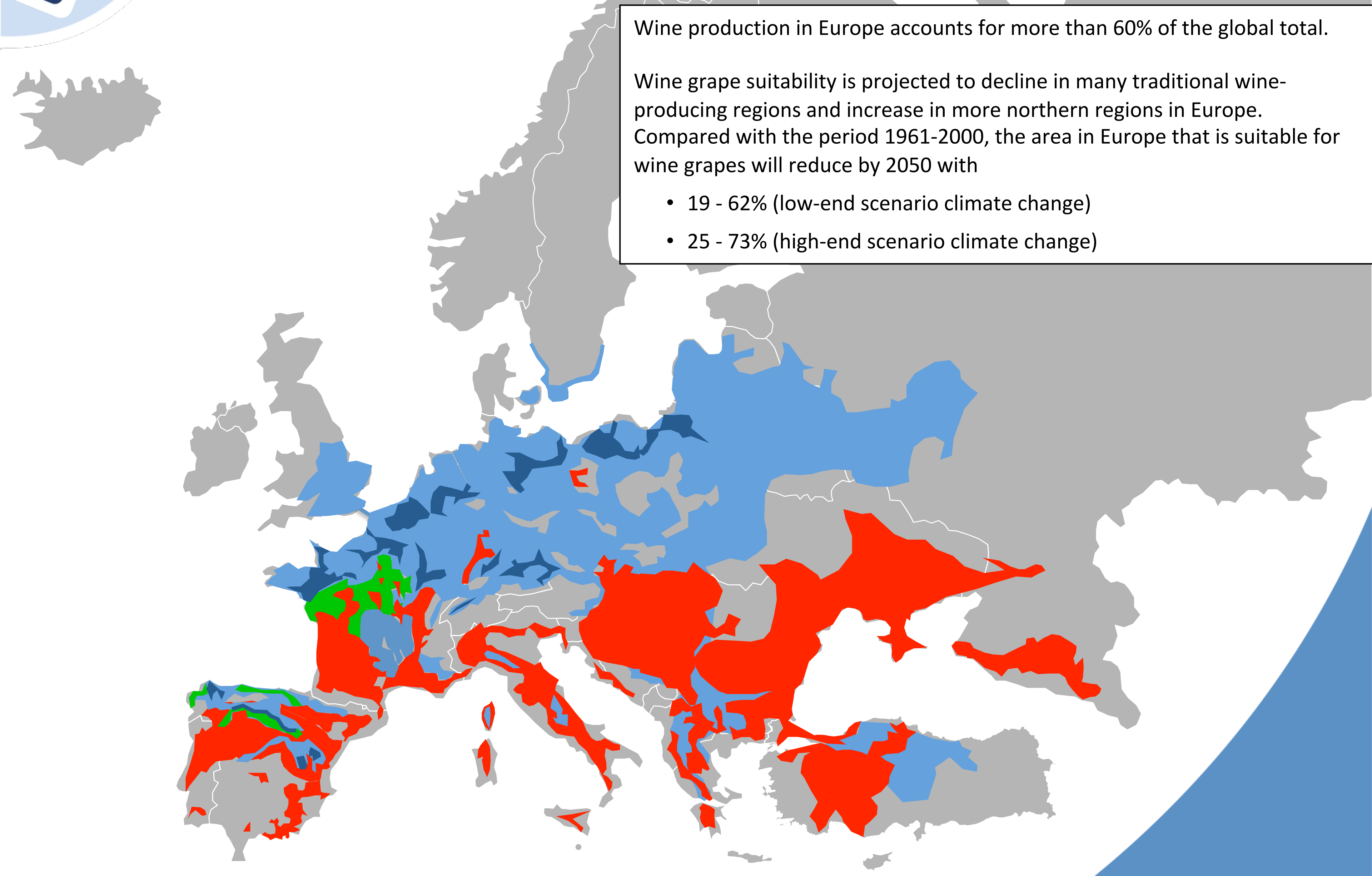
Viniculture
General picture: northward shift

Wine production in Europe accounts for more than 60% of the global total.

Wine grape suitability is projected to decline in many traditional wine-producing regions and increase in more northern regions in Europe. Compared with the period 1961-2000, the area in Europe that is suitable for wine grapes will reduce by 2050 with

- 19 - 62% (low-end scenario climate change)
- 25 - 73% (high-end scenario climate change)



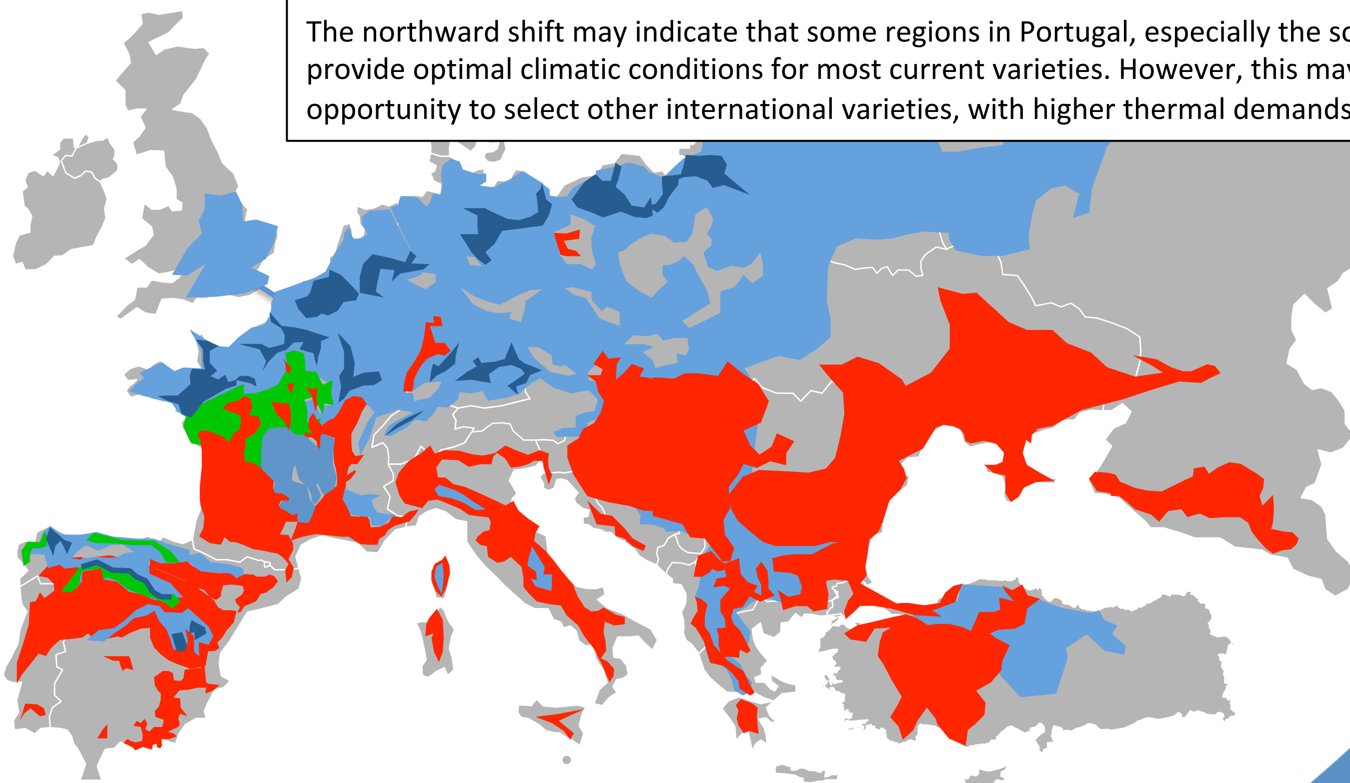
Viniculture
General picture: northward shift

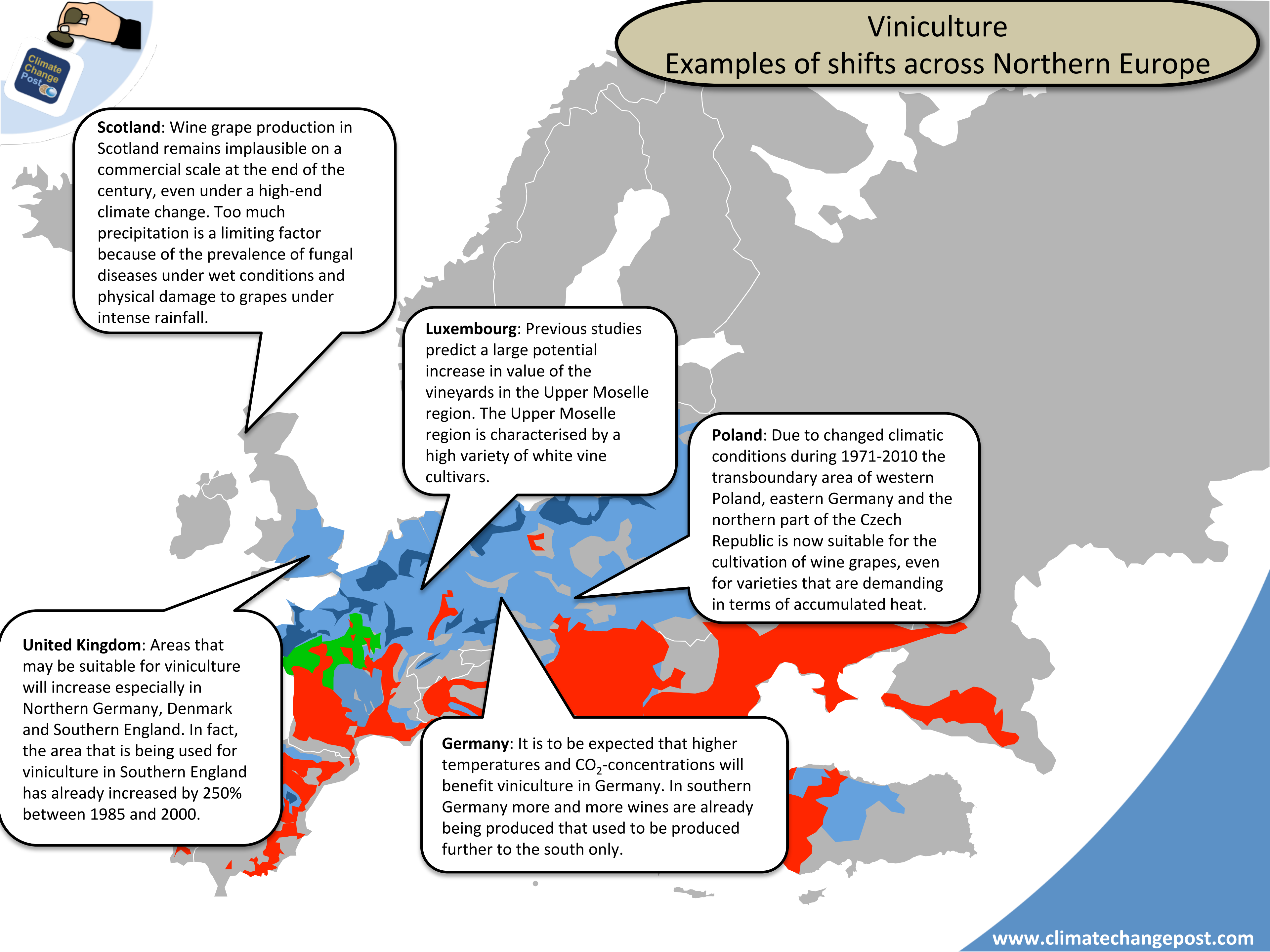
Example: northward shift optimal climate zones Portuguese grapevine varieties

It is to be expected that current growing regions of varieties reflect their optimal climatic zones since growers have been selecting the varieties that best suit the regional climatic conditions. Climate change is expected to change the optimal zones for grape varieties.

Optimal zones for Portuguese varieties in Europe in the period 2041 - 2060, compared with 1950 - 2000, are to the north of current zones for all grapevine varieties: both a moderate and high-end scenario of climate change project an extension of these optimal zones throughout Europe, up to France, Germany, Hungary, Croatia, Serbia, Romania, Poland and Ukraine, depending on the grape variety.

The northward shift may indicate that some regions in Portugal, especially the south, will no longer provide optimal climatic conditions for most current varieties. However, this may also provide an opportunity to select other international varieties, with higher thermal demands.

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Viniculture
Examples of shifts across Northern Europe
Scotland: Wine grape production in Scotland remains implausible on a commercial scale at the end of the century, even under a high-end climate change. Too much precipitation is a limiting factor because of the prevalence of fungal diseases under wet conditions and physical damage to grapes under intense rainfall.
Luxembourg: Previous studies predict a large potential increase in value of the vineyards in the Upper Moselle region. The Upper Moselle region is characterised by a high variety of white vine cultivars.
Poland: Due to changed climatic conditions during 1971-2010 the transboundary area of western Poland, eastern Germany and the northern part of the Czech Republic is now suitable for the cultivation of wine grapes, even for varieties that are demanding in terms of accumulated heat.
United Kingdom: Areas that may be suitable for viniculture will increase especially in Northern Germany, Denmark and Southern England. In fact, the area that is being used for viniculture in Southern England has already increased by 250% between 1985 and 2000.
Germany: It is to be expected that higher temperatures and CO_2-concentrations will benefit viniculture in Germany. In southern Germany more and more wines are already being produced that used to be produced further to the south only.
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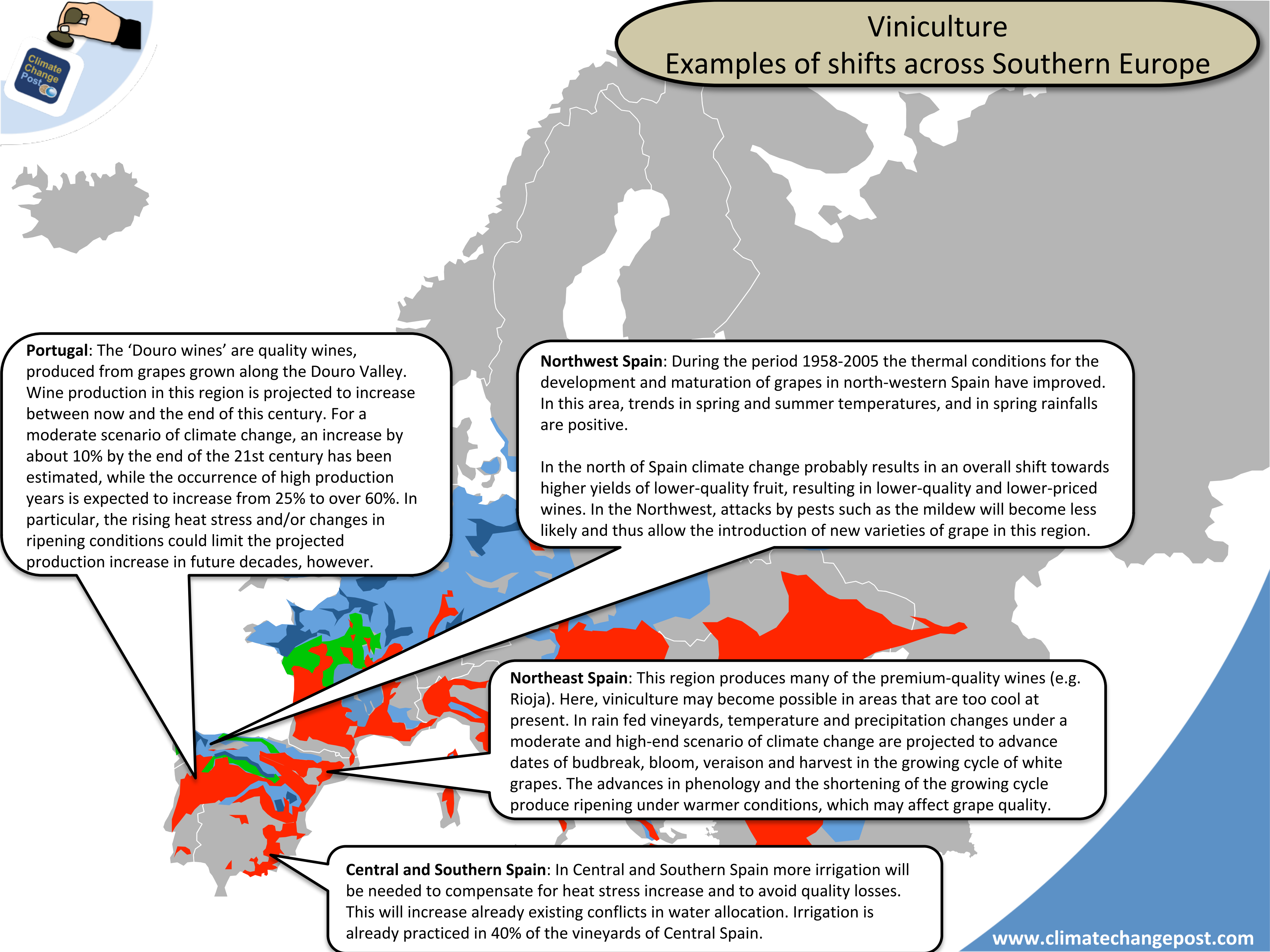
Viniculture
Examples of shifts across Southern Europe
Portugal: The 'Douro wines' are quality wines, produced from grapes grown along the Douro Valley. Wine production in this region is projected to increase between now and the end of this century. For a moderate scenario of climate change, an increase by about 10% by the end of the 21st century has been estimated, while the occurrence of high production years is expected to increase from 25% to over 60%. In particular, the rising heat stress and/or changes in ripening conditions could limit the projected production increase in future decades, however.
Northwest Spain: During the period 1958-2005 the thermal conditions for the development and maturation of grapes in north-western Spain have improved. In this area, trends in spring and summer temperatures, and in spring rainfalls are positive.
In the north of Spain climate change probably results in an overall shift towards higher yields of lower-quality fruit, resulting in lower-quality and lower-priced wines. In the Northwest, attacks by pests such as the mildew will become less likely and thus allow the introduction of new varieties of grape in this region.
Northeast Spain: This region produces many of the premium-quality wines (e.g. Rioja). Here, viniculture may become possible in areas that are too cool at present. In rain fed vineyards, temperature and precipitation changes under a moderate and high-end scenario of climate change are projected to advance dates of budbreak, bloom, veraison and harvest in the growing cycle of white grapes. The advances in phenology and the shortening of the growing cycle produce ripening under warmer conditions, which may affect grape quality.
Central and Southern Spain: In Central and Southern Spain more irrigation will be needed to compensate for heat stress increase and to avoid quality losses. This will increase already existing conflicts in water allocation. Irrigation is already practiced in 40% of the vineyards of Central Spain.
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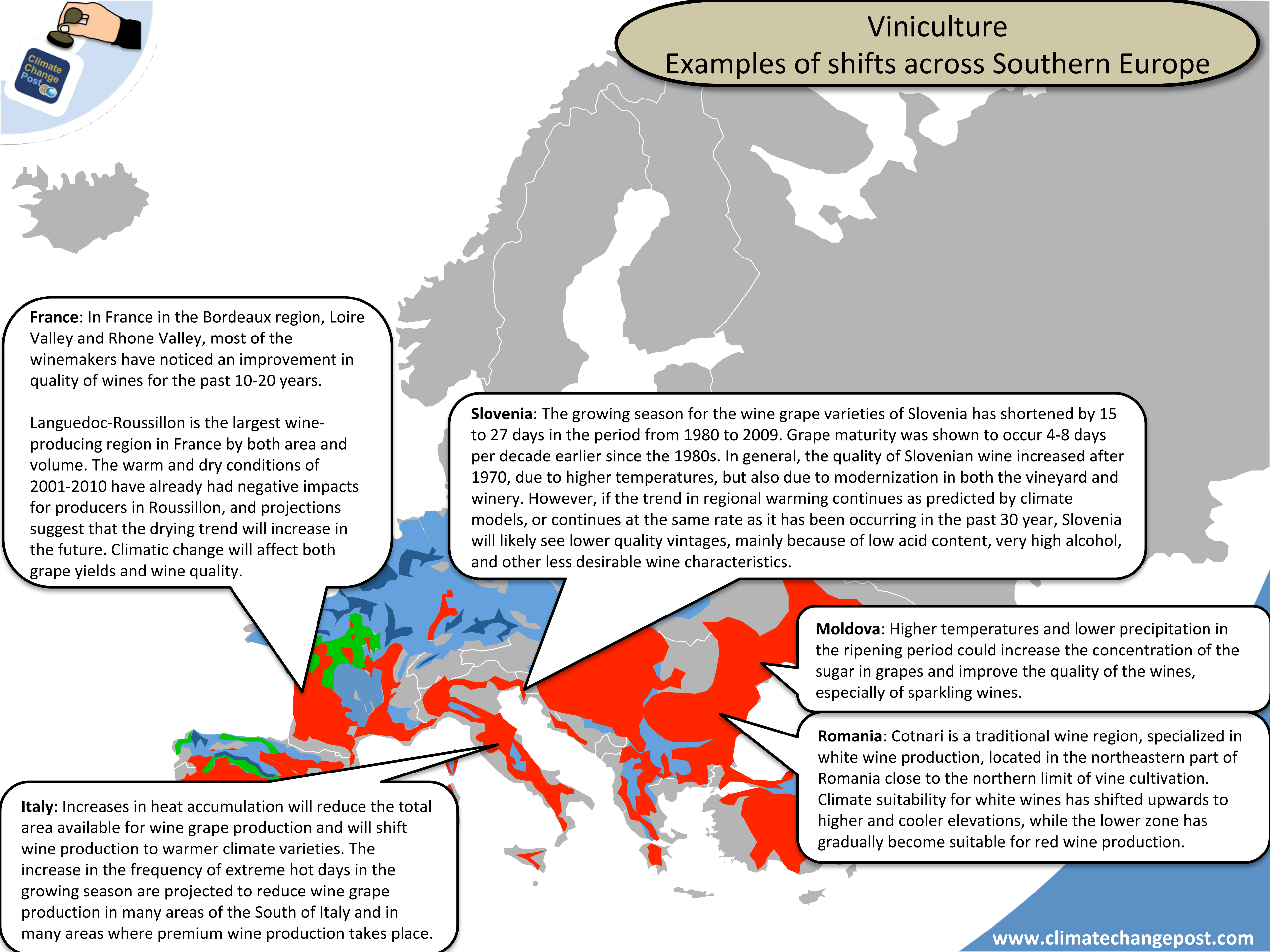
Viniculture
Examples of shifts across Southern Europe



Climate change is affecting timing of grapevine phenology

Viniculture
Advancement in time

Viniculture is affected by climate change, mainly by a shift in the four basic grapevine developmental stages:

- Budbreak (start annual growth cycle)
- Flowering
- Véraison (beginning of maturation)
- Full ripeness (harvest)

Because of climate change these events occur earlier. Warmer conditions due to climate change are generally associated with shorter intervals between phenological events and earlier harvest dates.

Example Northern Europe
Vine phenology events, such as budburst and flowering, advanced by about 2 days/decade over the period 1951-2005 in Luxembourg and Germany. Budburst date and flowering events now occur earlier by about two weeks with respect to 1951.

Example Southern Europe
Vine phenology events have advanced in time 5-10 days per 1°C of warming over the last 30-50 years in Greece.

Climate change is affecting timing of grapevine phenology … and harvest dates advance

Viniculture
Advancement in time

Harvest advancement Europe
Recently, over 400 years (1600-2007) of harvest data from Western Europe (France and Switzerland) have been analysed. In this historical record, the year 2003 had earliest harvest date. 2003 was one of the worst summer heat waves in recent history. Average harvest dates were substantially earlier (about 10 days) in more recent decades (1981-2007) than in the previous 400 years.

Harvest advancement globally
Across the globe, harvest dates advance approximately 6 days per degree of warming. Harvest dates are closely connected to the timing of grape maturation, which is highly sensitive to climate during the growing season. The earliest harvests generally occur in years where the growing season experiences warmer temperatures and drought.

The main impacting climate variables are precipitation and temperature

Viniculture
Main climate parameters

High-quality wines are typically associated with early harvest dates in many of the cooler wine-growing regions, such as France, and are also favoured by warm summers with above-average early-season rainfall and late season drought. Overall, both precipitation and temperature contribute to wine quality and the timing of harvest. High winter rainfall has a positive impact during the growing stage, whereas higher temperatures during late spring are beneficial for the flowering and véraison stages.

Temperature is the most critical factor influencing wine grape phenology.

Temperature:
The maturation of grapes and the development of sugar and flavours are all determined by the average temperature during the growing season. Higher temperatures can lead to over-ripening, dryness, higher acidity and greater vulnerability to pest and disease, all of which affect wine quality.

Precipitation:
The style of a wine depends on its water content and how this evolves throughout the growing season, with or without irrigation. It is a crop that is able to adapt to water deficit, and an excess can actually lead to pest and disease. At the same time, low water levels can reduce the yield and alter the style of the final product.

Impacts on yields

Hot and dry summers
The main concern of producers is excessive summer water stress, leading to decreasing yields. It was estimated that yields in Languedoc-Roussillon could decrease by 26% by 2080 due to increased water stress alone.

Frost risk
In a warmer climate the likelihood of frost events will reshape the distribution of grapevine varieties in Europe. The effect of frost events at bud break stage is the most important factor for the selection of grape varieties. Frost risk will be larger for varieties with early bud break than for those with late bud break.

A warmer climate leads to a general decrease of this frost risk especially in Mediterranean regions and on the northern fringes of Europe. This risk may increase in central and eastern Europe, however.

Unbalanced ripening may lead to lower wine quality

If higher temperatures initially improve ripening and thus lead to better quality wine, in the long term, with a continuous increase, they could result in a change in the aromatic profile of wines. The exceptionally warm and early growing season in 2003 is an experience on a large scale of what could become normal conditions.

Night temperatures during maturation are particularly important influences on quality. An increase in minimum temperatures during the growing season can have a negative impact on aromas and tannins, and thus on vintage quality. In August, from veraison to harvest, warm nights expose grapevines to a risk of a block in phenolic maturation, leading to excessive berry sugar content, which leads in turn to a need for post-harvest manipulation such as de-alcoholization.

Example: Loire Valley, northwest France
The berry composition of the 6 main white and red grapevine varieties changed significantly from 1960 to 2010, with higher sugar concentrations and lower acidity at harvest. It was concluded that these changes in berry composition were significantly influenced by the increases in temperature.

Example: Lower Franconia, Germany
The observed warmer seasons during 1949 to 2010 have resulted in greater ripening potential for the grape cultivars in this region. As a consequence, the sugar content increased while the acid component remained constant, resulting in a changed grape composition that has the potential to alter wine typicity and quality. In the long term, the balanced ratio of sugar and acid content will shift further in favour of the sugar component and may result in a loss of the traditional character of white wine produced in Franconia.

Impact on biodiversity

Climate change may cause establishment of vineyards at higher elevations that will increase impacts on upland ecosystems.

Attempts to maintain wine grape productivity and quality in the face of warming may be associated with increased water use for irrigation and to cool grapes through misting or sprinkling.

Soil erosion

Erosion of vineyard soils is an important issue in the Mediterranean area (Portugal, Spain, France, Italy and Greece). Estimates indicate that soil losses in vineyards currently represent about 9% of the income from grape sales.

Longer dry periods and greater rainfall concentration in a reduced number of events of higher intensity may affect the risk of erosion. More extensive droughts can remove the protective vegetation cover, leaving the soil more exposed to erosion, while more intensive rains can detach more soil and produce a severe increase in erosion rates.

A study for northeastern Spain has shown that if rainfall intensity increases by 10-20 % due to climate change, soil loss may increase by up to 57% in 2050.

Adaptation

Short-term measures

- Adjust pruning times and training systems, apply leaf sunscreens or vine shadings, implement cover cropping and tillage treatments.
- Implement controlled/deficit irrigation. Drip irrigation can be an efficient technique to compensate for an increased water deficit in Mediterranean vineyards.
- Improved cooling techniques, such as water-efficient micromisters or strategic vine orientation/trellising practices to control microclimates at the level of individual grape clusters, can greatly reduce water use demands.
- Protect against extreme weather events. Extreme weather events may cause tremendous damages to orchards and wine-yards of high economic value. Preventive actions include frost-protection by spraying, use of materials to protect against sun-burn, hail and frost, pesticides to provide protection against the pests that show up after extreme weather events.

Long-term adaptation

Barriers to adaptation measures and strategies

Adaptation

Short-term measures

Long-term adaptation

- Relocate to cooler areas. One way of adapting wine production to climate change would be the poleward movement of vinicultural regions, or relocate the grape production area uphill, where there is less climate impact on wine quality.
- Introduce new varieties. Select grapevine varieties that best fit projected future climate conditions in a certain area. Use ''exotic'' grape varieties that are drought resistant, to replace the current grape variety. "Managed retreat" to new varieties may reduce water use and upland habitat loss that might be associated with attempts to retain varieties.
- Improve rootstock and clonal selection
- Increase soil depths and water holding capacities

Barriers to adaptation measures and strategies

Adaptation

Short-term measures

Long-term adaptation

Barriers to adaptation measures and strategies

- Wine is usually produced within rigid, regionally-specific, regulatory frameworks that often prescribe, amongst other things, what grapes can be grown where, e.g., the French AOC or the Italian DOC and DOCG designations. Current regulations limit the spatial expansion of wine-producing areas.
- Where wine grapes are grown on highly fragmented blocks, the implementation of a collective irrigation system may be difficult. Furthermore, the current marketing strategy of terroir wines and the broader economic situation do not encourage any restructuring of the blocks. Also, there may be a lack of an historical cultural acceptance of the advantages of controlled deficit irrigation to produce premium wine.
- Consumers may not be willing to pay current day prices for red wines produced from other grape varieties.

Where nations have more liberal vineyard management practices, quality regulations and adaptation options, they may be more flexible in the face of change.

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