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Climate change and the Australian mix of winegrape varieties

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Introduction

It has long been claimed that Australia's mix of winegrape varieties is less than ideal for expressing and exploiting the terroir of its various wine regions. Hickinbotham (1947) believed seven decades ago that Australia's hot regions were not focused enough on varieties from warmer parts of Europe. Four decades ago Dry and Smart (1980) suggested that if the addition of acid had been outlawed in Australia, its hot regions would have been forced to at least add 'improver' varieties to their mix. More recently, McKay et al. (1999) felt that varieties from the hotter parts of Italy were under-represented in Australia. That same comment could be applied to varieties from other warm countries such as Spain, Greece and Cyprus. Questions are again being asked about the appropriate mix of varieties in Australia's cooler regions as they gradually warm with climate change (Smart 2020).

It is also notable that the national mix of varieties is becoming more concentrated on a few key (French) varieties, the so-called 'international varieties'. In 1990, the top ten varieties accounted for three-quarters of Australia's total vine bearing area, but now just the top five account for that share. Four of those top ten in 1990 were French, while now eight of the top ten are French, raising the share of French varieties from around half to 90%. Over that same period, the bearing area share of red varieties rose from 38% to two-thirds. These trends are similar to those in other New World countries, such that Australia's mix of varieties is becoming less distinct from the rest of the world's (Anderson and Nelgen 2020ab, 2021; Puga and Anderson, 2023) – notwithstanding the considerable media attention given to 'alternative' or 'emerging' varieties (Anderson and Puga 2023a).

The purpose of this study is to examine the changing mix of winegrape varieties in Australia to address the question: In light of key climate indicators and predictions of further climate change, how well-suited are the winegrape varieties planted in Australia's wine regions, and what is the nation's vulnerability to further climate change?

Data and methods

We use a comprehensive new database compiled by Anderson and Puga (2023b) which includes, for the first time, estimates of the bearing area of winegrapes (area, hereafter) in each of Australia's wine regions. This database also includes time series on production and price by variety and region, as well as a wide range of derived variables and indexes.[1] Anderson and Puga (2023c) describe this database and explain some of its key assumptions. As well, we rely on Remenyi et al. (2020) spatial data on climate and climate change projections for the Australian wine regions. With these two datasets, we do some simple descriptive statistical and graphical analyses.[2] Importantly, there is no perfect concordance between the regions in these two databases, meaning that some regions are left aside.

[1] An advantage of this database is that the prime names of its varieties are the same as those in Anderson and Nelgen (2020ab). Since that database includes information on the area by variety for virtually all wine countries, it allows one to compare Australia with other countries or the world as whole (e.g., Puga and Anderson (2023)).
[2] Puga et al. (2022a, 2023) provide insights on the possible impacts of climate change on grape quality and yields using similar data and more complex statistical analyses.

Fortunately for present purposes, these excluded regions represent a very small minority of the nation's winegrape area.

Results

The wine-growing regions in Australia cover a wide range of climates. However, most wine regions are relatively hot and dry, including those with larger areas (see Figure 1.A). The three major hot irrigated regions (Riverland, Riverina, and Swan Hill–Murray Darling) account for more than one-third of the nation's winegrape area and more than two-thirds of its crush. Even if leaving those three major regions aside, most of Australia's winegrape production takes place in regions that have relatively low precipitation and high temperatures when compared to the rest of the world's wine regions (Puga et al., 2022c). This can also be inferred from Figure 1.B, noting that some important wine-producing countries like Spain and Italy have lower growing season average temperatures (GSTs) than Australia.

[Location of Figure 1]

Nevertheless, the Australian winegrape area has now a lower GST than at the beginning of this century. Figure 2 uses 1997-2017 climate data to compare the cumulative distribution of area under a certain GST based on the area by region in 2002 and 2023. There is more planted under cooler (or less hot) regions than before. Indeed, during this period, the area-weighted average GST has decreased by 0.3℃.

[Location of Figure 2]

Figure 3 shows the recent evolution of the area, production, and revenue for what Jones (2006) considers 'cool' (less than 15℃), 'temperate' (15 to less than 17℃), 'warm' (17 to less than 19℃), or 'hot' (19℃ or more) regions for winegrape production. By this definition only Tasmania is considered 'cool'. Together with the 'temperate' and 'warm' regions, they have increased their area and revenue share – the opposite of what has happened with the 'hot' regions. Yet, the 'hot' regions account for a similar share of production to what they accounted for at the beginning of this century, which is usually more than four-fifths of the nation's total.

[Location of Figure 3]

A question arises: How helpful have these changes been? Figure 2 also shows what Jones et al. (2006) consider the 'ideal' GST ranges for producing high-quality wine from the seven most planted varieties in Australia, which together account for more than four-fifths of the nation's area. True, there has been a lot of debate around these ranges, with research indicating that high-quality wine can be produced beyond the upper limits of these ranges (van Leeuwen et al., 2013). However, in a hedonic analysis of Australian wines, Oczkowski (2016) calculates the optimal GST for high-quality production of most of these varieties and shows that the optimal GST falls within the ranges suggested by Jones (2006), except for Sauvignon Blanc which falls only 0.2℃ above the upper limit. Looking at the cumulative GST distribution and these GST ranges suggests that much of Australia's winegrape production takes place in regions that may be too hot for producing high-quality wine with these key varieties.[3]

The first two columns of Table 1 show the area of each variety that falls (in 2023) and used to fall (in 2002) within the 'ideal' GST range of 12 key varieties. While the share of the area under the 'ideal' GST for these 12 key varieties has increased over this period, it still represents in aggregate only a bit more than one-third of the nation's total area of these varieties. And there are big differences across varieties: the area under 'ideal' GST ranges is

[3] That said, Puga et al. (2022b) show that much of the winegrape quality/price differences between cooler and hotter regions can be attributed to the nature of their production systems.

higher for some red varieties and lower for most white varieties. The white varieties include Chardonnay, which was also widely planted at the beginning of this century, as well as Pinot Gris, which is the most dramatic of the 'emerging' varieties (Anderson and Puga, 2023a).

[Location of Table 1]

With climate change, precipitation is projected to change in different directions across regions, while all of them are expected to become hotter and more arid (Remenyi et al., 2020). Figure 2 also shows how these climate change projections may change the cumulative distribution of area under a certain GST assuming the area planted in each region does not change. These distributions would be way further apart from Jones (2006) 'ideal' GST ranges for the most planted varieties. The third and fourth columns of Table 1 show the area of each variety that would fall within the 'ideal' GST range for 12 key varieties assuming their regional areas remain unchanged. Strikingly, this combined area share would decrease to 10% by 2050 and to 1% by the end of this century.

Implications and conclusions

This study shows that the climates of Australia's wine regions are relatively warm (or hot) and dry and that expected future climate change represents a major threat to high-quality wine production. This suggests Australian winegrowers will need to strengthen their adaptation efforts.

Winemaking strategies and technologies also can contribute to maintaining quality through new processes such as Accentuated Cut Edges (ACE) skin fragmentation and by lowering alcohol concentration with water addition (Kang et al., 2020). Membrane-based technologies also can be used to lower alcohol concentration in wines and increase their acidity (Dequin et al., 2017). However, these and other strategies will not be sufficient to adapt to the projected changes in climates. Thus winegrowers will need to consider more-appropriate plant materials and/or relocate their vineyards as long-term adaptation strategies (Santos et al., 2020).

Adaption strategies for vineyards that are already bearing consist of primarily changing varieties to those better suited to hotter conditions by top-grafting or replanting. When planting new vineyards, growers will want to choose plant material (i.e., varieties, clones, or rootstocks) that are more suitable for drier and warmer climates subject more often to extreme weather events. Indigenous varieties from places such as Cyprus have proven to be well-suited to hot climates and lower water availability, and may have the potential to be popular in the Australian wine market (Copper et al., 2019). Yet, during this century Australian vineyards have become more concentrated in a few (mostly French) varieties, better suited to cooler conditions. True, the area of so-called 'alternative' or 'emerging' varieties better adapted to heat has been increasing recently, but it still represents only a tiny fraction of Australia's winegrape area (Anderson and Nelgen, 2021; Anderson and Puga, 2023a).

Vineyard site selection is and will be even more important than in the past. In mainland states, only limited areas may have optimal temperatures for high-quality wine production from the nation's currently most-planted varieties. However, there are opportunities to plant in more appropriate climates at higher elevations and closer to the southern coastline where water availability may represent a smaller problem in the future (as compared with that for hot irrigated regions that draw on the Murray-Darling river system). While accounting for only 1 % of the nation's vineyard area, Tasmania will continue to represent an excellent opportunity for more high-quality winegrape production.

While this study is based on a supply-side analysis, changes in the demand for wine also will affect the Australian wine industry. In recent decades, the demand for wine has shifted towards higher-quality products (Anderson et al., 2018). If this shift in demand persists, the industry will be under even more pressure to adapt to the negative effects of climate change on wine quality.

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References

Anderson, K., & Nelgen, S. (2020a). *Database of Regional, National and Global Winegrape Bearing Areas by Variety, 1960 and 2016.* Wine Economics Research Centre, University of Adelaide. (First version by K. Anderson and N.R. Aryal, 2013, revised 2014.) https://economics.adelaide.edu.au/wine-economics/databases#database-of-regional-national-and-global-winegrape-bearing-areas-by-variety-1960-to-2016

Anderson, K., & Nelgen, S. (2020b). *Which Winegrape Varieties are Grown Where? A Global Empirical Picture* (revised ed.). University of Adelaide Press.

Anderson, K., & Nelgen, S. (2021). Internationalization, Premiumization, and Diversity of the World's Winegrape Varieties. *Journal of Wine Research,* 32(4), 247-61. https://doi.org/10.1080/09571264.2021.2012444

Anderson, K., Meloni, G., & Swinnen, J. (2018). Global Alcohol Markets: Evolving Consumption Patterns, Regulations, and Industrial Organizations. *Annual Review of Resource Economics,* 10(1), 105-32. https://doi.org/10.1146/annurev-resource-100517-023331.

Anderson, K., & Puga, G. (2023a). Which are Australia's Emerging Winegrape Varieties? WERC Wine Brief No. 41, November 2023. Forthcoming in *Wine and Viticulture Journal* 39(2), Autumn 2024.

Anderson, K., & Puga, G. (2023b). *Database of Australian Winegrape Vine Area, Crush, Price and Per Hectare Volume and Value of Production, by Region and Variety, 1956 to 2023*. Wine Economics Research Centre, University of Adelaide, September. https://economics.adelaide.edu.au/wine-economics/databases#australian-winegrape-vine-area-production-and-price-database-by-region-and-variety-1956-to-2022

Anderson, K., & Puga, G. (2023c). Two Decades of Grape Variety Trends in Australia's Wine Regions. *Wine and Viticulture Journal,* 38(2), 65–73.

Copper, A.W., Johnson, T.E., Danner, L., Bastian, S.E., …, & Collins, C. (2019). Preliminary Sensory and Chemical Profiling of Cypriot Wines Made from Indigenous Grape Varieties Xynisteri, Maratheftiko and Giannoudhi and Acceptability to Australian Consumers. *OENO One,* 53(2). https://doi.org/10.20870/oeno-one.2019.53.2.2423

Dequin, S., Escudier, J.-L., Bely, M., Noble, J., Albertin, W., Masneuf-Pomarède, I., …, & Sablayrolles, J.M. (2017). How to Adapt Winemaking Practices to Modified Grape Composition Under Climate Change Conditions. *OENO One,* 51(2), 201-14. https://doi.org/10.20870/oeno-one.2016.0.0.1584

Dry, P.R., & Smart, R.E. (1980). The Need to Rationalize Wine Grape Variety Use in Australia. *Australian Grapegrower and Winemaker,* 196, 55-60.

Hickinbotham, A.R. (1947). Problems of Viticulture. *Australian Brewing and Wine Journal* pp. 24-28, May 20 and pp. 23-25, June 20.

Jones, G.V. (2006), 'Climate and Terroir: Impacts of Climate Variability and Change on Wine', in *Fine Wine and Terroir: The Geoscience Perspective*, edited by R.W. Macqueen and L.D. Meinert, Geoscience Canada Reprint Series Number 9, Geological Association of Canada, St. John's, Newfoundland.

Kang, W., Binden, K.A., Wang, X., Muhlack, R.A., Smith, P.A., Niimi, J., & Bastian, S.E.P. (2020). Chemical and sensory impacts of Accentuated Cut Edges (ACE) grape must polyphenol extraction technique on Shiraz wines, *Foods,* 9(8), 1027. https://doi.org/10.3390/foods9081027

McKay, A. D., Crittenden, G., Dry, P.R., & Hardie, J. (1999). *Italian Winegrape Varieties in Australia,* Adelaide: Winetitles.

Oczkowski, E. (2016). The Effect of Weather on Wine Quality and Prices: An Australian Spatial Analysis. *Journal of Wine Economics,* 11(1), 48-65. https://doi.org/10.1017/jwe.2015.14.

Puga, G., & Anderson, K. (2023). Concentrations and Similarities across Countries in the Mix of Winegrape Cultivars. *American Journal of Enology and Viticulture, 74*(1). https://doi.org/10.5344/ajev.2023.22067

Puga, G., Anderson, K., & Doko Tchatoka, F. (2022b). Impact of growing season temperature on grape prices in Australia. *Australian Journal of Grape and Wine Research, 28*(4), 651–657. https://doi.org/10.1111/ajgw.12566

Puga, G., Anderson, K., & Doko Tchatoka, F. (2023). The impact of climate change on grape yields: Evidence from Australia. *OENO One, 57*(2), 219–230. https://doi.org/10.20870/oeno-one.2023.57.2.7280

Puga, G., Anderson, K., Jones, G., Doko Tchatoka, F., & Umberger, W. (2022c). A climatic classification of the world's wine regions. *OENO One, 56*(2), 165–177. https://doi.org/10.20870/oeno-one.2022.56.2.4627

Puga, G., Anderson, K., Jones, G., & Smart, R. (2022a). *Climate change and the evolving mix of grape varieties in Australia's wine regions.* In Proceedings of the 14th International Terroir congress and 2nd ClimWine symposium. International Viticulture and Enology Society. https://ives-openscience.eu/13153/

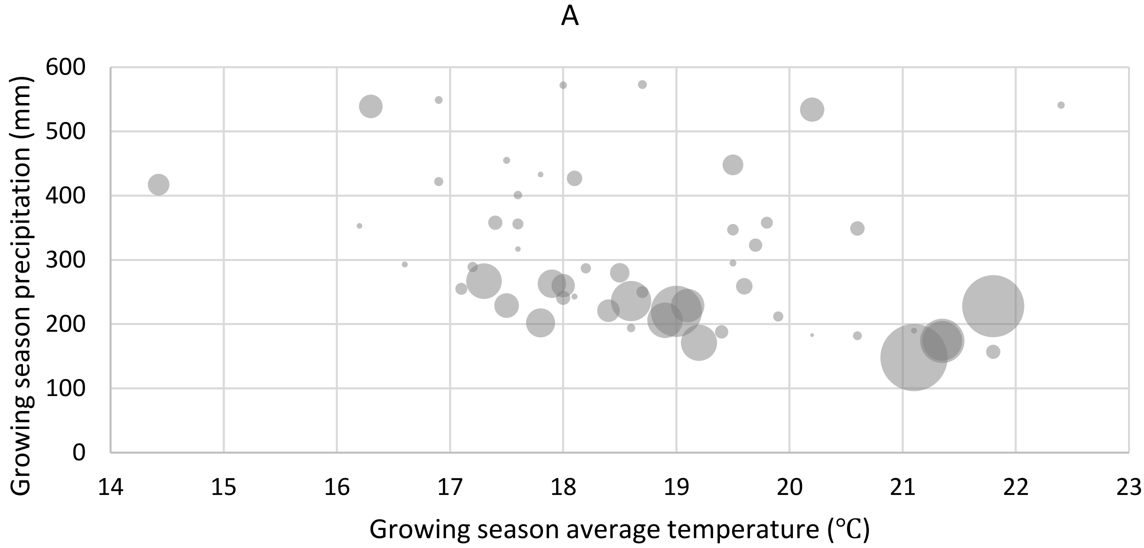
Remenyi, T. A., Rollins, D. A., Love, P. T., Earl, N. O., Bindoff, N. L., & Harris R. M. B. (2020), *Australia's Wine Future: A Climate Atlas*, Hobart: University of Tasmania. See wineaustralia.com/climate-atlas

Santos, J.A., Fraga, H., Malheiro, A.C., Moutinho-Pereira, J., Dinis, L.-T., Correia, C., Moriondo, M., Leolini, L., Dibari, C., Costafreda-Aumedes, S., Kartschall, T., Menz, C., Molitor, D., Junk, J., Beyer, M., & Schultz, H.R. (2020). A Review of the Potential Climate Change Impacts and Adaptation Options for European Viticulture. *Applied Sciences,* 10(9), 3092. https://doi.org/10.3390/app10093092

Smart, R. (2020). Have The Best Bordeaux Wines Been Drunk Already? A Reflection on The Transient Nature of Terroir, Using Case Study Australia. Paper presented at the 13th International Terroir Congress, 15-20 November, University of Adelaide.

Smart, R. (2021). Act Now So Climate Change Does Not Ruin Your Grape and Wine Business. *Wine and Viticulture Journal,* 37(1), 46-53, Summer.

van Leeuwen, C., Schultz, H. R., de Cortazar-Atauri, I. G., Duchene, E., Ollat, N., Pieri, P., …, & Delrot, S. (2013). Why Climate Change Will Not Dramatically Decrease Viticultural Suitability in Main Wine-Producing Areas by 2050. *Proceedings of the National Academy of Sciences - PNAS,* 110(33), E3051–E3052. https://doi.org/ 10.1073/pnas.1307927110



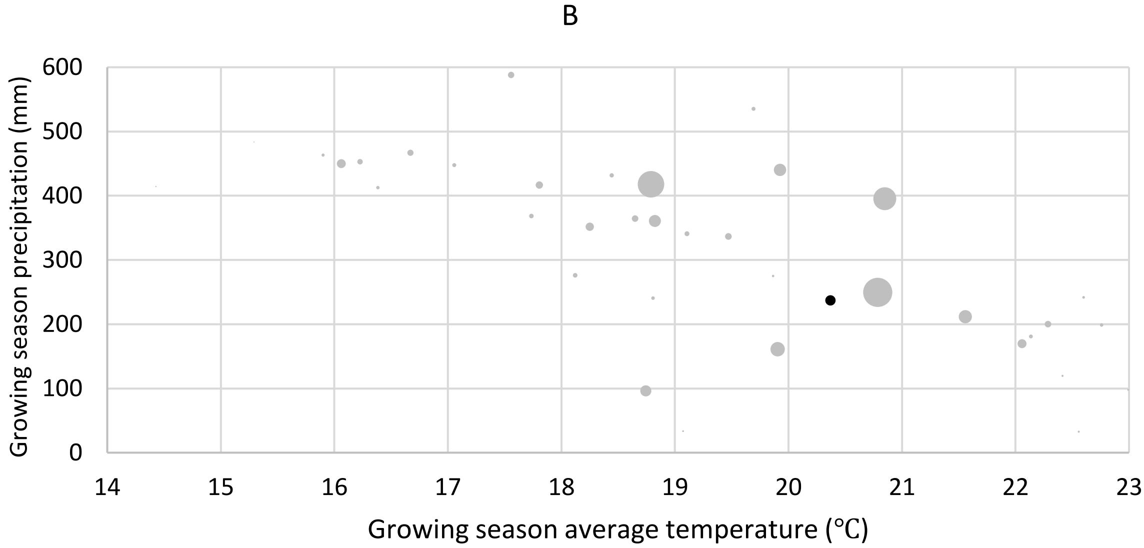


Figure 1: A- Growing season precipitation (GSP) and growing season average temperature (GST) of the Australian wine regions, with the size of each bubble being proportional to the winegrape area of each region; B- GSP and GST of the world wine countries, with the size of each bubble being proportional to the winegrape area of each country, and Australia being coloured black.

Source for A: Authors' compilation from data in Anderson and Puga (2023b). Source for B: Authors' compilation from data in Anderson and Nelgen (2020a) and Puga et al. (2022c). Notes for A: Some very minor regions with a growing season precipitation higher than 600mm are not plotted in this figure. Notes for B: The climate data is for the 1989-2018 and based on locations, hence different to the climate data from Remenyi et al. (2020) used in all other figures and analyses in this study (including panel A). GSP and GST are area-weighted averages across the regions of each country. There are some countries not plotted in this graph with higher GSP or with lower or higher GST, but all these countries have very small winegrape areas.

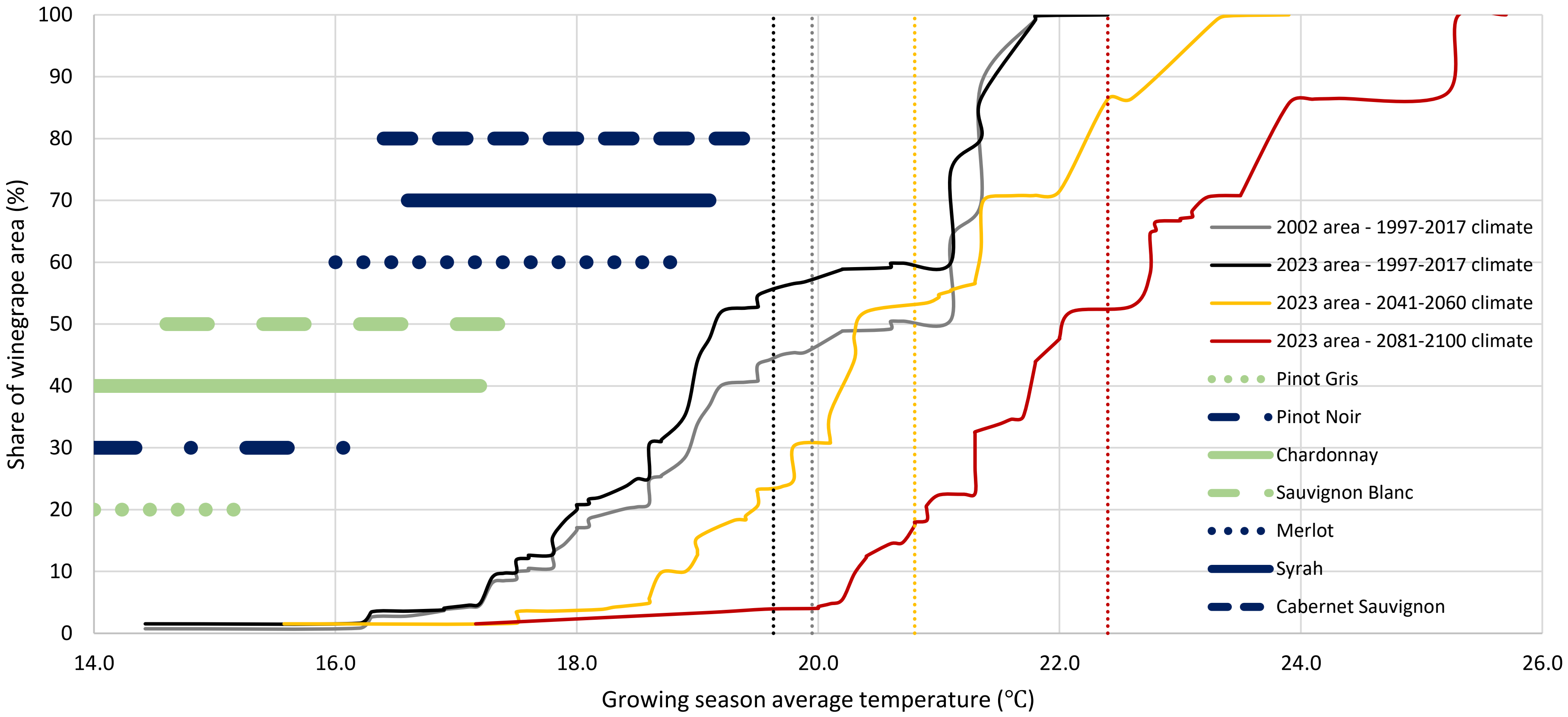


Figure 2: Accumulated winegrape area under a certain growing season average temperature (GST), based on either 2002 or 2023 regional areas, and the present, mid- or late-century climate projections from Remenyi et al. (2020); and Jones (2006) 'ideal' GST range for each of the seven most planted varieties in Australia.

Source: Authors' compilation from winegrape area data in Anderson and Puga (2023b) and climate data/projections in Remenyi et al. (2020). Notes: The seven thick horizontal lines for individual varieties represent Jones (2006) 'ideal' GST ranges for producing high-quality wine. The four vertical dotted lines represent the area-weighted GST for each area-climate combination (in terms of 2002 or 2023 regional areas, and 1997-2017, 2041-2060, or 2081-2100 climate).

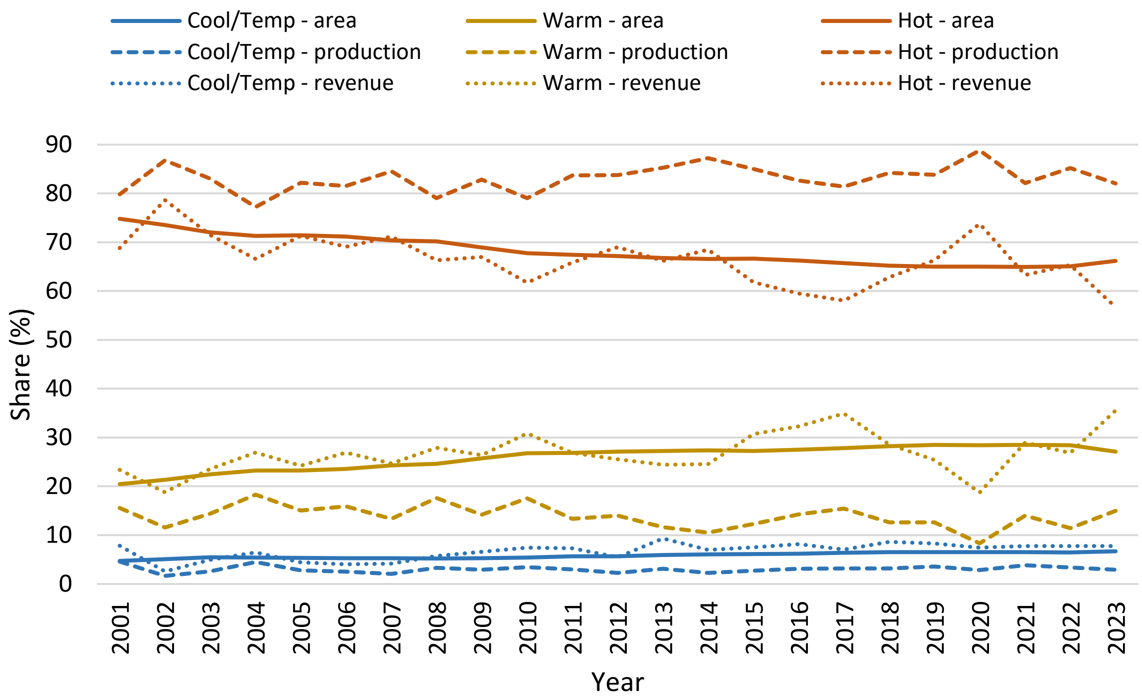


Figure 3: Evolution of the shares of area, production, and revenue by climate type.
Source: Authors' compilation from winegrape area data in Anderson and Puga (2023b). Notes: The climate types are based on what Jones (2006) considers 'cool' (less than 15°C), 'temperate' (15 to less than 17°C), 'warm' (17 to less than 19°C), or 'hot' (19°C or more) for winegrape production.

Table 1: Shares of Australian winegrape area in 2002 and 2023 within what Jones (2006) considers the 'ideal' growing season average temperature range for high-quality wine production of 12 key varieties

Climate data: **Surface year:**	**1997-2017** **2002 (%)**	**1997-2017** **2023 (%)**	**2041-2060** **2023 (%)**	**2081-2100** **2023 (%)**	**Area 2023** **(%)**
Cabernet Franc	49	57	19	1	0.2
Cabernet Sauvignon	54	61	23	1	18.4
Chardonnay	7	7	3	3	14.8
Côt (Malbec)	36	27	5	0	0.4
Garnacha Tinta (Grenache)	55	77	0	0	1.3
Merlot	29	22	7	0	5.6
Pinot Gris	0	3	0	0	3.4
Pinot Noir	12	19	18	0	4.2
Riesling	3	5	4	0	2.2
Sangiovese	26	57	18	7	0.3
Sauvignon Blanc	16	6	4	3	4.4
Syrah (Shiraz)	39	49	7	0	30.1
All of the above	33	36	10	1	85.3

Source: Authors' compilation from data in Anderson and Puga (2023b) and Remenyi et al. (2020).
Notes: The 'ideal' growing season average temperature (GST) ranges are based on what Jones (2006) considers optimal for producing high-quality wine. 'All of the above' are area-weighted averages.