

1 Highlights

2 Grape Quality and its Link to Regional Differences in the Aus- 3 tralian Winegrowing Industry

4 Author

- 5 • Comparative analysis of resource use, quality and quantity in Aus-
6 tralian winegrowing.
- 7 • Regional comparison of outcomes and resource use in Australian wine-
8 growing regions.
- 9 • Baseline models for comparing wine crops.
- 10 • Analysis of national, decade long data source.

Grape Quality and its Link to Regional Differences in the Australian Winegrowing Industry

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Abstract

1. Introduction

The Australian wine-growing industry is a rich and diverse landscape that is separated into multiple regions that help to describe the unique varieties and qualities that are produced there. While a great deal has been done regarding regional properties and traits, there has been little statistical insight into how regions differ due to a lack of cross-regional and in-depth data sources (Keith Jones, 2002; Knight et al., 2019). In this study we use Classification Trees to compare regional differences and how they relate to sustainable practices and grape quality. The site of a vineyard predetermines several physical parameters such as climate, geology and soil, making location a widely considered key determinant of grape quality (Abbal et al., 2016; Agosta et al., 2012; Fraga et al., 2017). This analysis addresses the knowledge gap regarding the effectiveness of regional level strategies employed in the wine industry and their relation to grape quality. Through the use of classification trees this study aims to highlight the key differences in sustainable practices at a regional level and how these practices relate to the different grades of grape quality.

32 *1.0.1. A figure sub-subsection*

33 **2. Methods**

34 *2.1. Data*

35 The Australian wine industry is divided into 65 regions, known as a Geo-
36 graphical Indicator Regions (GI Region). Each GI Region is used to describe
37 different unique localised traits of vineyards across Australia; with each hav-
38 ing its own mixture of climatic and geophysical properties (Halliday, 2009;
39 Oliver et al., 2013; SOAR et al., 2008). Each region is explicitly defined
40 under the Wine Australia Corporation Act of 1980 (Attorney-General’s De-
41 partment, 2010). The climatic properties of a GI Region are summarised by
42 Sustainable Winegrowing Australia (2021), where regions of similar climates
43 are amalgamated together into superset regions. The climatic regions were
44 utilised to illustrate similar trends and explain differences between sets of
45 regions. The data used in this analysis comes from Sustainable Winegrowing
46 Australia and covers the period 2015 to 2022. The dataset contained 3342
47 samples across 52 GI Regions and 1072 individual vineyards.

48 *2.2. Classification Trees*

49 Classification Trees were developed to discern the different practices within
50 regions and climates, comparing these relationships to those linked to grape
51 quality. This was done using the rparts and caret packages (Kuhn, 2008;
52 Terry Therneau and Beth Atkinson, 2022) in the R statistical programming
53 language (R Core Team, 2021). Three classifications were undertaken for
54 region, climate and grape quality. Climate was further classified into two
55 subcategories of rainfall and temperature, resulting in a total of 5 classifi-

cation trees being created. Classification trees were validated using K-fold cross validation. Each model was validated using 10 folds, utilising a random selection of different samples ten separate times to validate each of the classification trees. A summary confusion matrix was then constructed to show the class bias and overall accuracy of each tree.

3. Results

3.1. Model 1 GI Regions

The first Model was used to classify GI regions and resulted in an accuracy of 36.48% across 52 classes. The most prominent features used to classify regions were the types of water resources available (see Figure 1). Two regions, the Riverland and Coonawarra, were the most accurate classes being 92.74% and 96.97% respectively. These regions differ greatly in practice and geophysical properties, with the Riverland being a dry warm inland region and Coonawarra being a cooler, wet coastal region. However, they are both similar in operational scales, with vineyards being relatively large compared with other regions. The differences in resources and practices between these regions are also significant, such as the Riverland utilising the river Murray as a water source. Many of the regions had significantly lower reporting rates, resulting much poorer classification performance. The regions with the most samples performed the best (see Table 1). Notably bordering regions were routinely grouped together and misclassified as the same region, for example the two closest regions to Coonawarra, Padthaway and Wratttonbulley, were misclassified as Coonawarra even though they had 147 and 137 samples respectively. The same case was found for the Murray Darling, with 143 sam-

Table 1: Classification accuracy of the most prominent GI Regions.

	Accuracy	Predicted	Actual
Adelaide Hills	30.45%	95	312
Barossa Valley	51.00%	205	402
Coonawarra	96.97%	192	198
Langhorne Creek	22.84%	53	232
Margaret River	78.82%	201	255
McLaren Vale	52.89%	128	242
Riverland	92.74%	345	

80 ples, it was misclassified as the Riverland. These misclassifications are likely
81 due to the incredibly similar regional properties and close proximity these
82 regions have with one another. Other misclassifications were most likely due
83 to lower reporting rates with many regions being under represented.

84 3.2. Climate

85 Classifying the SWA climatic categorisation of the given regions had bet-
86 ter performance than the GI Regions, with 41.66% being classified correctly.
87 These categories were divided into 12 climatic classifications with 3 and 4
88 separate subsets for rainfall and temperature respectively. The decision tree
89 behaved similarly and over classified climates with higher response rates. The
90 results posed an interesting similarity with grape quality classifier, being in-
91 fluenced predominantly by water and area. The use of fungicide to separate

regions that were 'Very dry' and 'Damp' can be considered as indicative of the different practices required due to climatic pressure; fungicides being more prominent in cooler regions with greater rainfall due to the higher risk of disease pressure (Reynolds, 2010). This could also potentially explain the use of contractor tractor use to discern differences in grape quality, where the lack of contractor use to prevent disease could have led to lowered quality of grapes.

3.2.1. Rainfall

The rainfall decision tree showed a greater use of fungicides sprays to discern between damp and very Dry as shown in Figure 4; with the accuracy improving to 62% but was unable to effectively discern between dry and very dry regions (see Table 3).

3.2.2. Temperature

The classification of GI Regions by their temperatures (see Figure 5) showed similarities to the other trees, with a heavy reliance on the types of water resources used as dominant predictors. The use of contractors was again used to differentiate between warm and cool regions, likely being due to disease pressure. The temperature classification tree was only a minor improvement over the regional classification tree, with an accuracy of 49.26% as shown in the confusion matrix (see Table 4).

3.3. Model 3 Grape Quality

The classification of grape quality through its grade had an accuracy of 55.72% across 5 separate grades. There was a notable issue with the classification of B grade grapes when compared to A and C (see Table 2). The

116 classification tree itself shows similarities to that of classifying regions in
117 Model 1, with the type of water resource used being a prominent determiner.
118 Although not surprising the number of contractor tractor passes is new de-
119 ciding factor due disease and pests reducing the potential quality of a crop.
120 The prevalence of contractor use is greater in regions such as the Barossa
121 Valley and the McLaren Vale, this could be due to the difference in opera-
122 tional scales, with larger sites being more likely to have ownership of their
123 own equipment for weeding and spraying due to the cost benefit.

124 **4. Discussion**

125 The difference between grape quality is most notable between warm in-
126 land regions and coastal regions such as the Riverland and Coonawarra,
127 respectively. Grape quality is only described by a singular variable within
128 this study, however in reality it is driven by market demand and subject to
129 complex forces such as international market pressure, fire, pests and disease
130 (Wine Australia, 2022, 2021, 2020, 2019; Winemakers' Federation of Aus-
131 tralia, 2018, 2017, 2016, 2015, 2014, 2013, 2012). The decision trees were
132 able to offer some insights into the factors that influence grape quality and
133 regional contrasts that contribute to different qualities. The most promi-
134 nent being what readily available resources of each region were, particular
135 the types of water available. Heavy water consumption is often linked to
136 the mass production of grapes, where lower quality grapes are targeted in
137 a quantity over quality strategy. These types of business decisions are un-
138 fortunately obfuscated by lack of in-depth data regarding vineyard business
139 plans. Notably the literature shows that there are many complex decisions

140 to be made on the ground depending on many compounding factors that
141 influence both quality and yield ((Abad et al., 2021; Cortez et al., 2009;
142 Hall et al., 2011; I. Goodwin, et al., 2009; Kasimati et al., 2022; Oliver et
143 al., 2013; Srivastava and Sadistap, 2018)). There are also further differences
144 when comparing winegrowers to other agricultural industries as they are ver-
145 tically integrated within the wine industry, tying them to secondary and
146 tertiary industries, such as wine production, packaging, transport and sales.
147 This results in unique issues, where on-the-ground choices are influenced by
148 other wine industry’s decisions, such as the use of sustainable practices in
149 vineyards to sell in overseas markets; notably these interactions are further
150 complicated by some winegrowers being totally integrated into wine compa-
151 nies, while others are not (Knight et al., 2019). It is incredibly difficult to
152 attribute external business decisions to produced grape quality but it is im-
153 portant to acknowledge that some growers are contracted to produce grapes
154 of a particular grade; it is difficult to know whether another consumer may
155 have graded the grape quality differently paying more or less for the same
156 grapes given the opportunity to purchase them. It is difficult to untangle the
157 contributing factors to the success of winegrowers and the quality of grapes
158 produced without further specifics of choices made through out a season
159 (Leilei He et al., 2022).

160 **5. Conclusion**

161 The type and availability of water resources were a major contributing
162 factor when classifying grape quality and region. This was seen in the two
163 most accurately classified regions, Coonawarra and the Riverland, with the

164 Riverland predominantly utilising river water. Furthermore, the study high-
165 lighted the influence of water use, fungicide application, and contractor use in
166 differentiating grape quality, climate and region respectively. These models
167 provide insight into the complex dynamics between regional characteristics,
168 sustainable practices, and grape quality in the Australian winegrowing indus-
169 try. It is important to acknowledge that grape quality is subject to external
170 influences such as market demands and prior established business arrange-
171 ments. Further in-depth data and understanding are necessary to fully grasp
172 the nuances of decision-making and the interplay of factors impacting grape
173 quality.

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