Land and wine

Competition from the New World, a changing climate and technological advances have threatened the Burgundian notion that the quality of wine depends on regional geography and culture. Only flexibility can keep the concept of *terroir* alive.

Cistercian monks began to make wine in the Clos de Vougeot region of Burgundy, France in the late Middle Ages (Fig. 1). Their traditions created the notion, described as *terroir*, that aspects of climate, geology and human culture create a unique characteristic in regional food and beverages, especially wine. The idea was advocated most strongly by the Burgundian cultural historian Gaston Roupnel[1] and cannot be defined in a quantitative manner. Nevertheless, *terroir* — as a cultural, place-based entity springing from centuries of connection between culture (epitomized by the Cistercians) and the cultivation of wine-grapes — was ideologically elevated to the level of an analytic explanation for the quality of certain wines by the mid-twentieth century. This Burgundian concept was so successful that in 1935 it led to the *appellation d'origine contrôlée* (AOC) — a French system that is still used to legally delineate geographical regions and regulate agricultural products (*produits du terroir*), and has been adapted for much of the food-obsessed world.

But the idea of *terroir* is not easily reconciled with mechanized wine production, New World winemaking (focused on wine variety rather than location) and the rise of precision agriculture, which makes use of non-traditional devices such as computer modelling and remote sensing that fall outside the classic idea of *terroir*. In addition, *terroir* is less obviously meaningful in a rapidly changing climate: if a region's characteristics, including temperature and precipitation patterns, lead to a unique quality of its produce, then rapid and severe change in these circumstances — as expected from global warming in many regions worldwide — must affect the outcome.

Not all facets of *terroir* that comprise the modern notion of the term are supported by scientific analysis, and those that are, such as rainfall and temperature, will probably change in the next few decades. In the face of the challenges from both technology and climate change, the most successful winemakers — either Old World or New World — will be those who achieve two goals simultaneously: the use of modern technology to optimize the making and marketing of wines, and the development and advertising of location and production processes that are unique to their product. To make *terroir* useful as a classification system and marketing tool in a sustainable twenty-first-century wine market, it needs to be defined more flexibly, allowing changes in location or in the varieties of grapes produced at a certain site.

The rise of *terroir*

Terroir achieved its greatest cultural resonance through ardent supporters in twentieth-century Burgundy. In the Burgundian sense, *terroir* is "everything that contributes to the distinction of a vineyard" (ref. 2). Burgundians originally developed the concept as an instrument for identifying the qualities of their wines in terms of geo–climatic origin and authenticated methods of production. However, in addition to marketing wine, Burgundians also used the concept to promote tourism, affirm regional traditions and obtain a comparative advantage over other wine-producing regions. Natural resources, historical memory, modern marketing strategies and revived cultural practices were assembled into an imaginative repertoire of wine festivals and gastronomical fairs that helped sell regional products in general and wine in particular.

In the early twentieth century, a time of debate on the relative importance of cultural versus physical geography, Paul Vidal de la Blache[3] (1845–1918) began to emphasize the importance of empirical and rigorous site studies — a theme that still exists in discussions of *terroir*. Although Vidal was unable to resolve the physical-versus-cultural argument, his emphasis on scientific factors presaged the late-twentieth-century rise of precision agriculture.

Still, for much of the twentieth century, the cultural (rather than the scientific) notion of *terroir* held prominence, largely

Figure 1 | 'The Vintner' (left) and 'The Clos de Vougeot' (right) showing idealized depictions of the rural wine making tradition — woodcuts by Louis William Graux. Reprinted with permission from ref. 1 (© 1936 Gallois family).

due to a marketing campaign rooted in Burgundy. This concept of *terroir* was soon expanded, largely by Roupnel[1], beyond its geo–climatic moorings and agrarian base to include the lived experience associated with grape growing and wine making. To this end, a Burgundian cultural identity was anchored in regional *terroir* and represented by an ideal folk type — the rustic Burgundian vigneron (Fig. 1).

Terroir was also the agent for a repertoire of popular festivals, such as the Gastronomical Fair of Dijon, the Paulée of Meursault, Saint Vincent parades and an annual wine auction at the hospice in Beaune. The Burgundian Pavilion at the 1937 World Fair in Paris was used to draw attention to the unique qualities of Burgundian wines and to suggest that they might be best consumed in an authentic setting. These events linked natural resources, historical memory and cultural participation, and helped create an imaginative and enduring marketing package (Fig. 2). Thus, although there are some scientific components, the traditional concept of *terroir* is at its heart founded on marketing needs that are based on a constructed cultural identity in a mythical rural Burgundy.

The *terroir* controversy

The agrarian French concept of *terroir* assumes a pre-eminent quality of French wines. When this assumption was first questioned in the late twentieth century, the historical concept of *terroir* also came under scrutiny. In retrospect, the process began at the Paris Wine Tasting of 1976, when a panel of largely French experts ranked Californian wines over France's best in both the red and white categories: the Stag's Leap 1973 Cabernet Sauvignon was rated above the heavy hitters from Bordeaux and the 1973 Chateau Montelena Chardonnay over the best white Burgundies. The triumphs of these wines kick-started the nascent boutique winery business in Napa Valley, California and globally shook the belief that the finest wines could be produced only in certain regions of France blessed with the perfect combination of climate, soil and culture.

Wines from the New World — originally the United States and Australia, but more recently also from Chile, Argentina and South Africa — were increasingly marketed by varietal, such as Cabernet Sauvignon, Chardonnay, Merlot or Sauvignon Blanc, rather than by chateau or vineyard as in the traditional Old World labels. Consumers embraced the more generic and easily understandable wines. This process, if films like *Mondovino* are to be believed, led to a fashion of a globally homogenous style of bold, fruity, strong wines with no character and a growing unfriendliness to food.

Terroir is a powerful controller of the perceived enjoyment of wine, independent of the sensory characteristics of the wine itself.

Slowly, the sense that wine styles are not unique to place or culture is spreading, and wine styles are increasingly viewed as broadly reproducible in any of the mid-latitude climates capable of producing fine wines. In this model, soil type and the critical role of the vigneron's long connection with the land are jettisoned in favour of the blunt instruments determining overall balance in any wine, such as liberal oak-based corrections of off-flavours, commercially induced fermentation techniques or liberal adjustments to the sugar-to-acid ratio. A controversy and debate resulted between the Old and New worlds, traditional versus industrial production and protectionism versus experimentation[4].

The science of *terroir*

Debates have long raged concerning which factors of *terroir* are most important for high-quality wine production (or the perception thereof). Possibilities included climate, soil, microbiology and culture, but scientific investigation has shown that weather and climate are the central determinants of wine quality[5]. High-quality wine-grapes may be produced at an average air temperature between 13 °C and 22 °C during the growing season (April–October in the Northern Hemisphere)[6]. Regional nuances of day–night temperature differences, frost frequency, cold duration and heat waves, in combination with the timing of moisture availability, are at least partially responsible for the production of flavour compounds such as malic acid, phenols and volatile organics that control wine taste, colour and aroma. A number of treatments such as canopy trellising (pruning), irrigation or frost prevention can be used to moderate the interaction of climate and the vine, but the overall climate forcing is difficult to override: there are no fine wines from Greenland or the Sahara.

It has long been thought that soil is a primary component of *terroir* and wine characteristics, but there is no consistent evidence to support such a claim[5]. Rather, it is probable that many of the posited geological elements of terroir — soil texture, depth, rock content, slope and aspect — are just some of the more important factors mediating the interaction between climate and the vine. Perhaps the central metric of this interaction is soil water content[7], which can be optimized to maintain the slightly stressed vines that produce the best grapes[8], across a wide range of soils.

Climate is clearly of prevailing importance. Some vineyards consistently produce fine wine, but when the vintage weather is just right, these sites produce not just fine, but excellent wine. As has become obvious from the great experiment of expanding wine production round the world, similar landscapes and soils will not grow the same grape variety to the same quality if the climate is different. Yet, locations with a similar climate but different landscapes and soils will garner varietal typicity and often similar quality.

Winemakers can influence or control some aspects of the natural *terroir* through interventions in the winery. Large-scale commercial winemakers usually initiate fermentation with applications of mass-produced strains of the yeast *Saccharomyces cerevisiae*. Traditional wine making, on the other hand, relies on a suite of wild yeasts and bacteria to convert grape sugars to alcohol. The wild yeasts, although more temperamental and subject to interannual variability, can produce a more nuanced wine with less potential for off-flavours.

Perhaps most remarkably, *terroir* — when represented by metrics of wine reputation and price — is a powerful controller of the perceived enjoyment of wine, completely and perversely independent of the sensory characteristics of the wine itself[9]. That is to say, in tastings where information is revealed piecemeal to the taster, the price, reputation and label of a wine dominantly control the ratings. The ability of a winemaker to create and maintain a reputation for high-quality wine, often with a sense of place and identity, may be as important as the taste of the wine itself.

Making wine in a changing climate

The union between a site with generally favourable characteristics for winemaking and the optimum choice of wine-grape for the particular climate creates the potential to produce fine wine. Climate change is causing dissent in this relationship[10]. Of course, climate has varied continuously throughout the history of winemaking, but the current rate of change is unprecedented, and is likely to challenge the geographically fixed concept of *terroir*. For a given wine style, a mere sliver

Figure 2 | A 'folklorized' map of Burgundy's winemaking Côte-d'Or region — by Louis William Graux. Reprinted with permission from ref. 1 (©1936 Gallois family).

of the ideal climate exists; in some areas, climate change is moving regions solidly into this golden climate, whereas other areas may be rapidly forced out of their optimum climate range[6]. An increasing frequency of extreme heat, which reduces acid levels and degrades secondary flavour compounds, will be particularly difficult to cope with.

It is clear then that *terroirs* as we know them will change, and that the best *terroir* for a specific variety today may be better for a different variety in the future. Winemakers may need to change from Riesling to Pinot Noir, from Pinot Noir to Syrah or from Cabernet to Nebbiolo. Genetic engineering or traditional breeding could help to adjust grape varieties to different conditions. However, with the changes in climate that are on the horizon it seems wise to adopt a geographically flexible twenty-first-century approach to *terroir*.

Beyond rigidity

Terroir of the future must embrace change, yet preserve the cultural connection (invented or not) between winemakers, the land and consumers. A rigid concept of a single varietal or wine style will probably not survive the next few decades. An increased use of technology and a geographically adaptive sense of place will probably characterize *terroir* in the twenty-first century, if the concept is to survive. Components of a flexible approach to *terroir* could include a technologically driven control of vine water stress and a focus on the unique, although changing, climate and microbiology of the vineyard. Alternatively, a historical or constructed sense of culture could be tied to the winemaker, but not necessarily to a precise wine region.

Development of a geographically flexible *terroir* will be challenging. However, a collection of tools under the heading of precision viticulture — including geographic information systems, global positioning systems, and remote sensing[11–13] — can help select and manage a geographically dispersed twenty-first-century *terroir*. Furthermore, it seems from some applied *terroir* research that these tools can help modify vineyard development and management practices, such that some aspects of *terroir* — soil water content and overall vine stress in particular — can be controlled or manipulated[14]. Taken together the goal would be to remove much of the traditional trial-and-error in site assessment and enhance the quality and perhaps yield of the product.

For traditionalists, such an approach will be anathema — it would encourage, for example, a range of holdings across the global distribution of climates capable of supporting a particularly cherished or valuable wine. Conversely, a flexible approach to *terroir* could be fantastically suited to a shifting range of wine styles at a particular location — as long as the winemaker can convince the buying public that this is a good idea. ❐

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