A GIS Analysis of New Zealand Terroir

Analyse SIG des terroirs viticoles de la Nouvelle Zélande

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Summary

This paper summarises a national survey of the geological setting of vineyards in New Zealand. We also provide an overview of climate, slope, aspect and varietals planted in New Zealand vineyards as a whole and for some individual regions.

New Zealand produces premium quality wines and its wine industry is growing rapidly. Growing degree days in the winegrowing regions range from 900 in cool Central Otago and Canterbury to over 1600 in the warmest region in the country, Auckland. Average growing season temperatures for the same regions range from approximately 14.3°C to 17.6°C. New Zealand vineyards are planted mainly on flat alluvial and glacial gravels with slopes of less than 3°. Rapid growth is pushing new plantings onto adjacent hillsides that are underlained by greywacke, schist and less commonly limestone. The expansion of the industry onto these different substrates will affect grape and wine characteristics; this provides significant opportunities to develop new styles of New Zealand ultra-premium wines.

Keywords: GIS, terroir, New Zealand, geology, soil, climate

Introduction

The New Zealand wine industry has experienced significant growth in the last ten years and produces some ultra-premium wines. From 1996 – 2004, New Zealand wines commanded the highest price per litre on the UK market (NZTE 2007). The vineyards that produce these premium wines are located in regions ranging from cool with ~900 growing degree days (GDDs) and an average growing season temperature of 14.3°C to warm with over 1600 GDDs and an average growing season temperature of 17.6°C. Each of these areas produce wines with their own unique profiles. Plantings throughout New Zealand are on a variety of soil types, and little work has been done to examine how soils and geology affect grape characteristics and wine attributes in a New Zealand context. Geology plays a part in the Appellation d'Origine Controlee (AOC) labelling system in France and geology and soils affect grape characteristics and wine attributes in other countries as well (e.g. Berry 1990; Wallace 1972; Brown 2006; Wright 2001; Noble 1979; Van Leeuwen et al. 2004, Wittendal 2004).

The use of geographic information systems (GIS) for precision viticulture and spatial analysis of winegrowing regions is providing increasing benefits to the industry. For example, Carey et al. (2003) show how data integrated into a GIS can be used to delineate zones of viticultural potential on both a micro and macro scale in South Africa, whereas Jones et al. (2004) show GIS can be used to analyze the terroir potential of the Umpqua Valley in Oregon. Aerial imagery combined with GIS has also been used for various other tasks including to analyze and manage phylloxera (e.g. Johnson et al. 1996), delineate areas of differing vigour (e.g. Johnson et al. 2001a, 2001b, 2003; Nemani 2001), analyze soil loss in modernized improperly managed vineyards (Martínez-Casasnovas and Sanchez-Bosch 2000), to profitably implement precision viticulture (e.g. Bramley et al. 2003) and to assess viticultural performance (Bowen et al. 2005) to name but a few. In this paper, we use GIS as a tool to georeference vineyard locations and compare this with existing databases to analyze the geology, soils and climate of vineyards in New Zealand.

This paper presents a national survey of the geology, soils, climate, slope and aspect setting of New Zealand vineyards. We also provide an overview of the varietals planted in NZ vineyards as a whole. Taken together, the results help define the terroir of the New Zealand wine industry in 2007.

Materials and Methods

Frontier Global Ltd conducted the 2006 Vineyard Survey for NZ Winegrowers. Vineyard locations are continually being georeferenced and integrated into a GIS, which allows for spatial analyses of plantings. This analysis was performed on the vineyard database as at early 2007. For the georeferenced vineyards used in this analysis, parcel centroids were created for the aspect and slope calculations. Legal land parcels were used, and the data analysis cannot determine where the vineyard is actually planted inside the legal land parcel. Different types of geology within a legal land parcel, for example, will be included in the calculations regardless of where the vines are actually planted within that parcel. In some places, single vineyards may overlap several different legal land parcels; each land parcel is treated as a separate entity in these analyses, even though all parcels may be managed as one contiguous block.

The geological data of New Zealand was sourced from GNS Science, (copyright reserved). The 2004 update of the 1:1,000,000 data series was used as this dataset is complete on a national scale. The aspect data was calculated using the Spatial Analyst Aspect function in ArcMap 9.1. The digital elevation model (DEM) used for this calculation is based on 40 m cell sizes created from Land Information New Zealand (LINZ) 20m contours and spot heights by GNS.

Landcare Research Manaaki Whenua created an environmental classification of the whole of New Zealand. The Land Environments of New Zealand, or LENZ, classification is based on a set of 15 underlying climate, landform and soil variables. For an examination on a national-regional level, a map scale of 1:1,000,000 (LENZ level II classification) is recommended which is also consistent with the QMAP scale used in this analysis (Leathwick et al. 2002). The LENZ slope layer was used to calculate the slope of vineyards. This was created by Landcare Research using in house software from a 25m digital elevation model fitted to 20m digital contour data from NZMS 260 map series (Leathwick et al. 2002).

Climate data was sourced from the National Institute of Water and Atmospheric research (NIWA). Data from selected climate stations were used which were located in close proximity to vineyards in the studied regions. Due to data limitations, it was not always possible to select the ideal station and these data should be used to indicate general trends only.

All data on varieties planted and tonnage harvested are sourced from New Zealand Winegrowers, and based on data collected in 2006.

Results and Discussion

This section provides an overview of geology, slope, aspect, varietals planted, and climate data in New Zealand as a whole. New Zealand has ten viticultural regions and over 22,000 ha of vineyards (Figure 1). Marlborough is the largest viticultural region, accounting for just over 50% of total vineyard area, or just less than 11,500 ha. Hawkes Bay and Gisborne are the next largest regions occupying just under 20% and 9% respectively. These three regions account for just over 80% of all viticultural land in New Zealand.

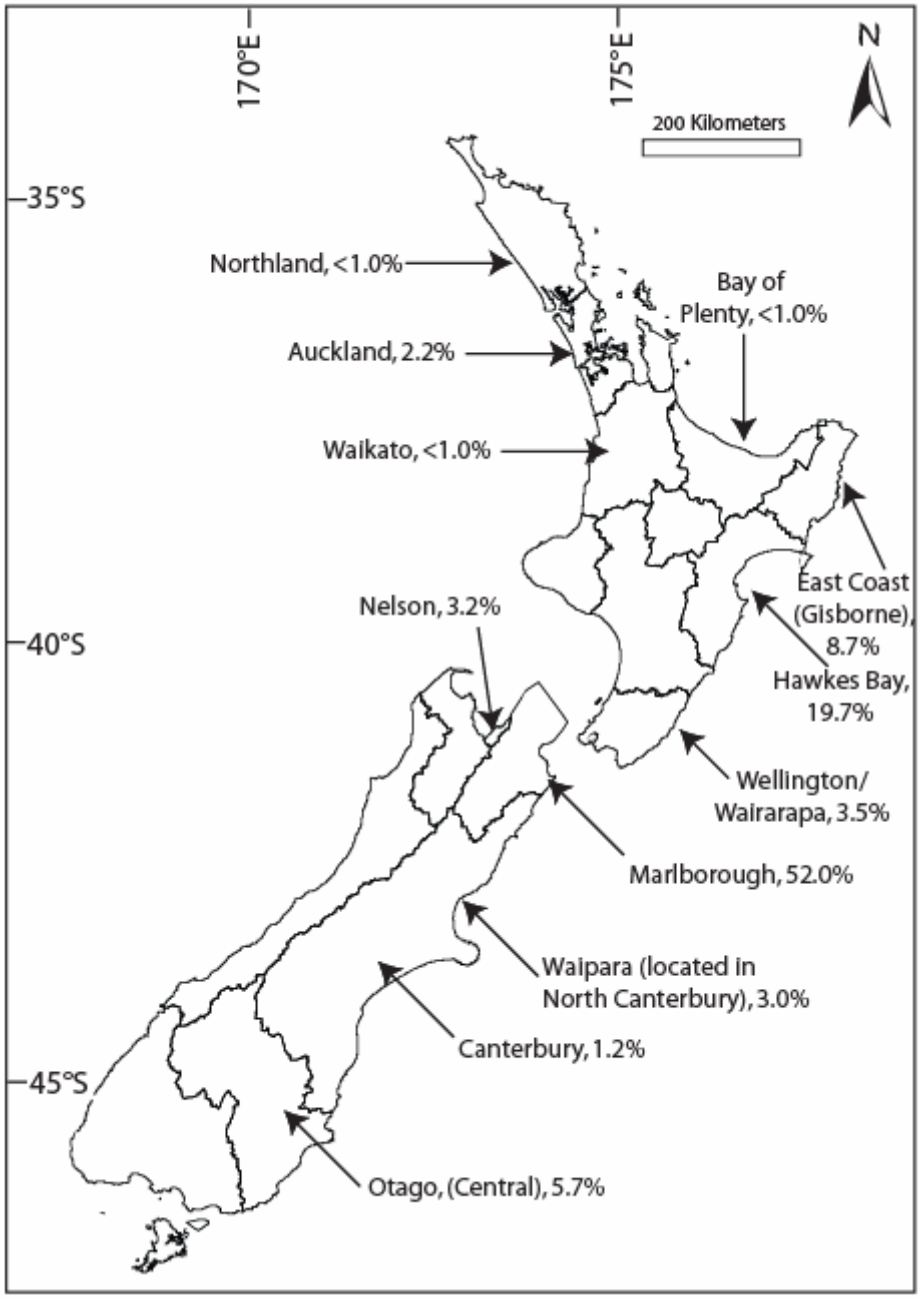

Figure 1 Map of New Zealand showing regions and % of total vineyard area

On a national scale, Sauvignon Blanc accounts for roughly 40% of land under vine (Figure 2A), yet accounts for just over 50% of harvested tonnage (Figure 2B). The difference can be attributed to high yields compared to other cultivars such as Pinot Noir, which occupies 18% of total acreage and accounts for only 12% of tonnage harvested. Chardonnay is the third major variety, occupying 17% of total land and 15% of harvested tonnage.

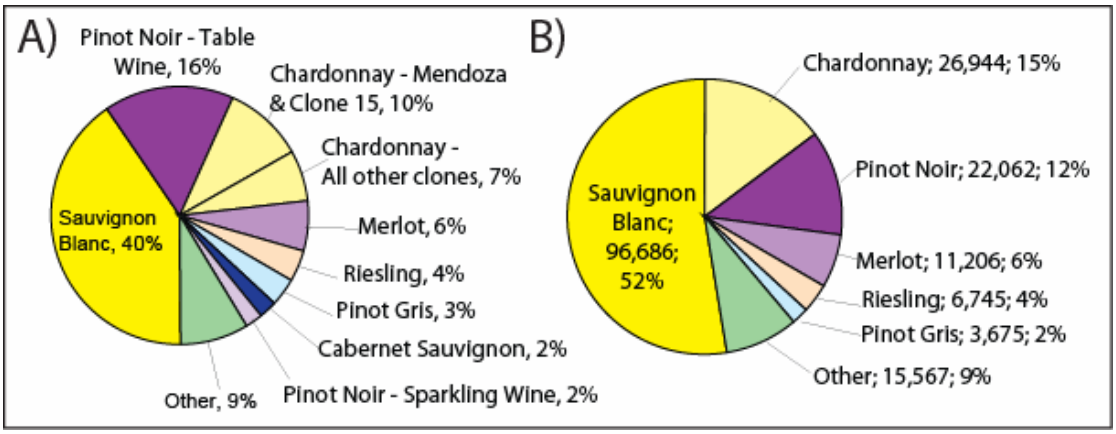

Figure 2 New Zealand wine industry data showing A) Plantings by variety as % of total, and B) 2006 tonnage harvested as % of total

Most New Zealand vineyards are planted on gravels or alluvium, although a few are on schist (9%) and greywacke (7%). In Marlborough, 50% of vineyards are on gravels, and 25% are on alluvium. Similarly, gravels underlie 90% of vineyards in Waipara, whereas alluvium underlies over 90% of the vineyards in Gisborne and Auckland. Central Otago vineyards occur on more varied geology, with 44% on gravels, and 49% on schist, which accounts for the 9% of national plantings on schist as this is the only place in New Zealand where schist underlies vineyards. The 7% of national plantings on greywacke reflects areas where vineyards are planted on hillsides that are underlain by this rock type, which is common and widespread throughout New Zealand. In contrast, although large parts of the north island are underlain by volcanic rocks, these areas are generally not favoured for viticulture as they commonly produce highly fertile soils that are more suitable for other types of agriculture.

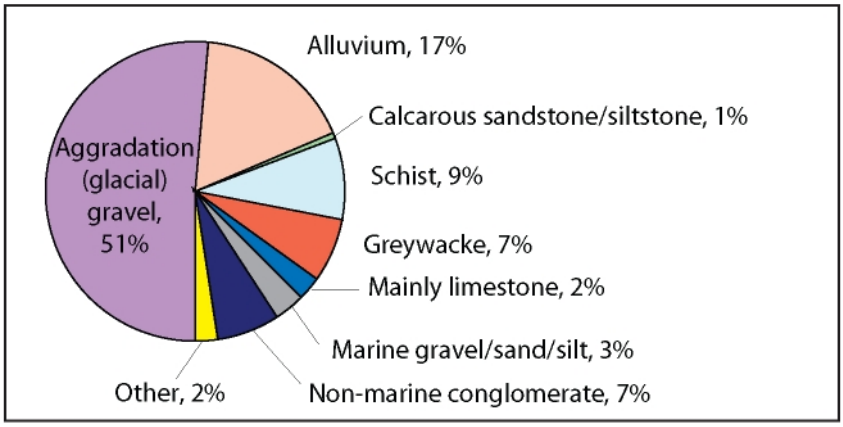

Figure 3 Geological distribution of New Zealand vineyards

Soils in the major winegrowing regions of New Zealand are derived from regional geology as mentioned above. Marlborough soils are mainly well-drained of moderate to high fertility. They are mainly from greywacke, alluvium and loess (45%), greywacke gravels and alluvium (20%), sedimentary alluvium (15%), and greywacke loess and colluvium (9%). Soils in the Hawkes Bay region are mainly well-drained with moderate to high fertility. They are from mixed alluvium (50%), sandstone and mudstone that is sometimes calcareous (30%), loess (10%) and minor areas of coarse greywacke (<5%). Gisborne has imperfect to poorly drained soils of low to moderate fertility from mixed alluvium. Central Otago has well-drained soils of moderate fertility. Soils in the region are from schist and greywacke (50%), schist alluvium and colluvium, alluvial and greywacke gravels with some loess (35%), and from loess derived from schist and greywacke (10%).

Most vineyards in New Zealand are on very flat land, with approximately 66% on land with a slope of <1° (Figure 4). Plantings on steeper land with a slope of greater than 5° only account for 7% of overall land under vine in the country. Approximately 40% of vineyards are planted on sites that are flat and

therefore have no aspect, whereas 34% face northeast, north and northwest, consistent with the northern aspect that is expected in the southern hemisphere (Figure 5).

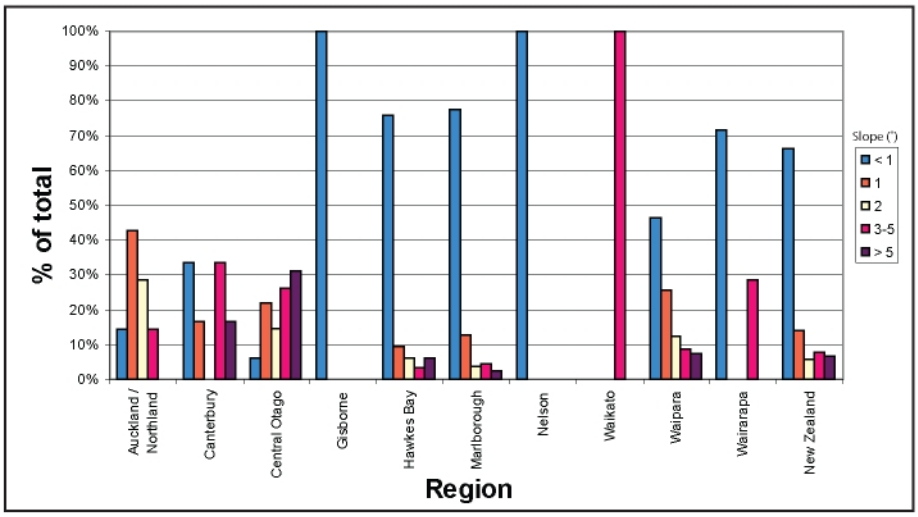

Figure 4 Distribution of vineyard slopes in the major regions of New Zealand

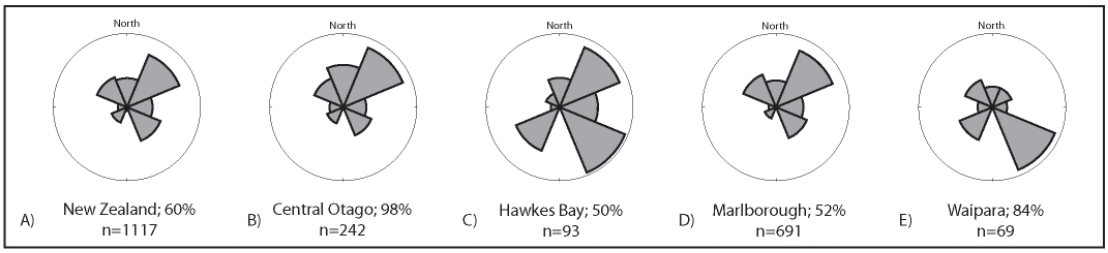

Figure 5 Aspects of vineyards in A) New Zealand and B-E) selected regions

In the New Zealand winegrowing regions, temperatures range from cool in the southern areas of Canterbury and Central Otago to intermediate-warm in other regions of the country. Solar radiation is also lowest in the southern-most regions where more vineyards are planted on steeper slopes. Annual water deficits vary from low in areas such as Auckland where irrigation is usually not required, to very high in Central Otago where irrigation is common, particularly in newly established sites. Most areas are classified as cool to intermediate based on Growing Degree Days (GDDs) within Amerine and Winkler (1944) regions I and II. Central Otago and Canterbury have the lowest GDDs with just over 900. Waipara, Wairarapa and the Bay of Plenty have GDDs ranging from 1000-1100, and Nelson is slightly warmer at just over 1100. Gisborne, Hawkes Bay, Northland and Auckland are the warmest regions having GDDs of 1390, 1410, 1500 and 1600 respectively.

The Latitude Temperature Index (LTI) was developed at Lincoln University and is useful in comparing climates in cooler regions (Jackson 2001). The LTI was calculated for each region as:

LTI = (mean temperature of the warmest month) * (60 – latitude)

LTI values below 380 are classified as the cooler Region I and are subdivided into IA (LTI = <190), IB (LTI = 190 – 270) and IC (LTI = 270 – 380). Wairarapa, Nelson, Marlborough and Waipara are the warmer districts in Region I with LTI values of IC. Canterbury and Central Otago are the coolest regions with LTI values of IB – IC, with most areas examined in Central Otago in the cooler IB.

Jones (2006) examined the relationships between phonological requirements and average growing season temperature for selected major winegrowing regions in the world producing premium and high quality wines. Comparing his results with our analyses indicates that varietals such as Pinot Noir, Riesling, Sauvignon Blanc, Gewurztraminer, and Pinot Gris should perform well in the cool climate regions of Central Otago, Waipara, Marlborough, and Wairarapa, and indeed they do. However, other varietals such as Viognier, Merlot, Malbec and Syrah produce award-winning wines from the

Gisborne and Hawkes Bay regions, even though climate data alone indicate that these areas are too cool for these varieties.

In cool climates, selecting a site with ideal subsurface characteristics may alter the local environmental conditions enough that varietals requiring a seemingly warmer climate would be able to ripen. Hawkes Bay is a classic example of this and is well-known for producing some of New Zealand's best red wines. Climate data in the region, however, would suggest that the region is too cool to ripen these varieties. Over 90% of vineyards in Hawkes Bay are planted on gravels. Pebbles and rocks in the soil absorb heat in the day and promote slow cooling at night resulting in warmer evening temperatures (Wright 2001). Stony soils that retain heat can add up to an extra 200 GDDs (Jackson and Schuster 2001), and this may at least in part explain why cooler regions can ripen some varieties that prefer warmer climates since a good soil will allow for the full but slow maturation of cultivars towards the end of the growing season (Seguin 1986, Deloire et al. 2005). Most New Zealand vineyards are located on alluvium and gravels, and the benefit of increased heat retention can be observed in winegrowing regions throughout New Zealand.

Conclusions

This research looks at the terroir of New Zealand vineyards in 2006-2007. New Zealand has ten major winegrowing regions, with Marlborough, Hawkes Bay and Gisborne accounting for 52%, 20% and 9% of total planted area respectively. Sauvignon Blanc accounts for 40% of land under vine, followed by Pinot Noir at 18%, Chardonnay at 17%, Merlot at 6% and Riesling at 4%. Over 75% of the vineyards in New Zealand are planted on alluvium and gravels that produce well-drained soils of moderate to high fertility.

Due to ease of management, New Zealand vineyards are mainly located on flat land, and therefore only 7% of vineyards in are located on land with a slope of over 5°. The steeper slopes in New Zealand are mainly located in Central Otago where 31% of vineyards in the region are located on land with a slope of >=5°. Approximately 57% of vineyards that are not located on flat land are on slopes facing northwest, north or northeast. Regions such as Hawkes Bay and Waipara, however, have vineyards facing southeast suggesting there were other factors contributing to site selection, even in such a cool climate. Cooler regions in New Zealand are known for producing premium wines similar to what is found in other comparable climates worldwide. Many red varieties, however, are grown in areas that are cooler than other climates producing these premium red wines elsewhere. The soils that many of these vineyards are located on are generally gravels which retain heat and release it at night. This may at least in part explain why these regions can ripen these varieties when climate data suggests otherwise.

As indicated elsewhere (e.g. Wilson, Meinert and Busacca 2002), geology and soils may exert a strong influence on the character of New Zealand wines and regional wine styles. The New Zealand viticulture industry is currently expanding from flat land in the valleys that is underlain by gravels and alluvium, onto surrounding hillsides with steeper slopes and varying aspects that are underlain by different geology and soils. Although we have documented the current framework of New Zealand vineyards, these changes may well produce new wine styles that reflect the evolution of New Zealand terroir.

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