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Determining the relationship between climate variations and wine quality: the WEBSOM approach

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1. Introduction

Climate change has the potential to impact on all forms of agriculture and vegetation and the impact is predicted to be inconsistent across the globe. Thus the polarising debates on climate change, the phenomenon that has become to be famously known as 'global warming' or 'global climate change', has increased scientific and commercial interest immensely in this topic and predictions relating to it. The potential influence of climate variation on viticulture and enology is considered to be *dramatic* because grapevine varieties are among the most sensitive cultivated crops that thrive only under niche climate and environmental conditions. Historical viticulture records evidence the fact that the winemaker ability to produce premium quality wine is highly influenced by the environment and climate apart from the grapevine variety itself as described by a famous Mediterranean concept "*Terrior x cultiva*". Major variations in climate can even force shifts in whole wine regions. Minor or seasonal variations generally result in differences in quality among vintages. The historical data on the factors relating to climate and wine quality is proving invaluable in comparing contemporary data with the past and it is essential for any forecasting or prediction over time (Hansen, et al., 2001: Jones, 2005).

Literature reviewed for this research reveals that in the past viticulturists and winemakers introduced and developed subtle changes to cultivation practices and winemaking processes to turn the annual (or vintage-to-vintage) climate change effects, favourable for winemaking. This has been occurring over centuries to turn climate variation effects to grapevine growing advantage in an endeavour to produce finer wine labels. On the other hand, major shifts in cultivation methods in whole wine-producing regions have occurred in the past and it appears that all these happened in order to produce grapes with a higher percentage of sugar but without comprising the other aroma and colour pro-protein compounds in the berry ripening process. These characteristics of wine quality are considered to be the principal factors relating to climate for viticulture regions throughout the world. Irrigation, frost, wind and solar influences are also major factors in grape production and therefore, primary determinants of wine quality (Jones, 2005).

In view of the above facts, approaches based on modern knowledge discovery methods are now being increasingly investigated to improving our understanding on climate and environmental influences on wine quality. Sections 2 and 3 illustrate on some of the literature and our related

research in modelling wine quality using sensory data in both text and numeric formats. Section 3 details on the other novel methods being experimented at the Geoinformatics Research Centre (GRC), Auckland University of Technology (AUT) in New Zealand, to modelling the blended quantitative and qualitative grapevine phenology data that determines the sugar and protein components in grapes and its influence on the final wine product. Initial results of this research are outlined in this section. Consequently, the WEBSOM approach to mining unstructured data in other major problem domains is outlined. Section 4 illustrates the WEBSOM approach being investigated in the Centre to analysing sommelier comments in free text format with sample data set, extracted from a web magazine (Wine enthusiast, 2009), with an ultimate aim of modelling the climate change effects on grapevine phenology and wine quality. The final section proposes future research to model the effects of climate change in greater detail with larger data sets from more grape growing regions within New Zealand and Chile to study the climate change effects on the world's major wine regions in the southern hemisphere. From this analysis we expect to be able to predict the wine quality, style and appellations suitable for future climate change, short-/long-term, with data from climate models already developed.

2. The effects of climate change

Climate change is predicted to bring about significant modifications to all forms of agriculture and vegetation on earth at varying degrees (Atkins, et al., 2006). Its potential impact on Viticulture, the world's old and most expensive cultivated crop and *enology* based on the science that underpins it, is considered by many observers to be *dramatic* (Jones, et al., 2005). The recent model predictions relating to future climate change suggest that the effects to be inconsistent across the globe (severe in the northern hemisphere and mild in the southern) and also, to have a variable effect on different grapevine varieties. Grapevine phonology, such as crop budburst, *floraison*, *veraison*, and harvest, greatly depends on local weather conditions in different regions, and this is a major factor in determining wine vintage quality. For example, even over a single degree centigrade change in temperature is predicted to make the production of the world's famous Mediterranean wine appellations impossible. Grape varieties thrive under significantly narrow or niche climate and environmental conditions, and historical evidence as well suggests that the production of premium quality wine labels as highly prone to any change in current climate, annual as well as long term. Research findings with Australian grapevines and wines (Web, 2006) suggest that a change of grapevine varieties could be a way to overcome the effects of future climate change in that country's major wine regions. This would of course, be an extremely expensive exercise (Gutierrez, 2005), which is why objective scientific analysis for scenario building and prediction is of great significance at the moment.

The research discussed in this paper relates to the overarching research project, *Eno-Humanas* (www.geo-informatics.org) that is aimed at building models based on correlations between dependent and independent sets of diffident combinatorial data collected on the environment, climate and atmosphere, soil, terrain, moisture and plant responses in association with sensory perception data relating to flavour, odour and fruit robustness (Sallis, et al., 2008 : Shanmuganathan, et al., 2008). Hence, the title *Eno-Humanas*, is about the combination of precise ecological data and the less precise qualitative opinion data that comes from wine consumers. This paper relates to the imprecise data analysis aspect in that it analyses the descriptions of wine quality coming from experts; Master Wine Sommeliers.

3. Modelling grape wine using text based comments

This section of the chapter outlines some major methodologies from the literature on this topic and then discusses GRC research in wine quality and sensory data analysis. Finally, the WEBSOM approach and its applications are discussed.

3.1 Wine sensory analysis

The wine quality literature relating to sensory and chemical data analysis can be broadly categorised into the following:

1) Wine characterisation and discrimination using chemical and sensory properties: Most of the papers reviewed fall into this category. Wine of all main appellations, for example, champagne, chardonnay, and pinot noir, have been analysed with chemical sensory analyses, in search of better ways to identify the differences between the wines for use in classifying sub-appellations within the main ones. For example, in (Parr, et al., 2007) a distinctive New Zealand wine style Marlborough Sauvignon Blanc was classified by sensory characterisation and chemical analysis for selected aroma compounds for that wine type. In (Kontkanen, 2005) the differences that might be supportive for designating three sub-appellations of red Niagara Peninsula Bordeaux style were investigated using chemical and sensory analysis on forty-one commercially available wines. Similarly, (Vannier, et al., 1999) and (Gawel, 2001) looked at strategies a) to control champagne wine quality based on sensory and b) red table wine quality characterised by pleasing and complex mouth-feel sensations respectively.
2) Professional versus novice taster abilities. There are many studies in this area cited in the literature and another project within *Eno-Humanas* is considering this from an audio-mining perspective to elicit the degree of emphasis (passion) expressed about wine quality in recording of wine tasting by both professionals and novices.
3) Wine ratings, favourable climatic conditions and price fluctuations. Research on this subject described by Jones, et al., (2005) looked at climate and global wine quality factors and discussed a year-to-year comparison over a ten year period. It includes a description of wine quality factors in juxtaposition with prices and vintage ratings. Citing many earlier studies the authors of this work pointed out that the analysis of the relationships between climate variables and wine prices to be based on an underlying hypothesis that beneficial climate conditions would improve the wine quality and that in the past, these had in turn led to short-term price hikes. They also reflected that the unavailability of consistent price data for multiple regions and with different styles over many years was a shortcoming for any analysis on the study of long-term effects. They also pointed out that the vintage ratings to be a strong determinant of the annual economic success of a wine region based on analysis by (Nemani, 2001) but then went on to say that the ratings could be determinants of wine quality not necessarily a predictor based on (Ashenfelter, 2000) where ratings were described to be reflective qualitatively of the wine quality; they had same weather factors documented to be the determinants of the same wine quality.
4) Analysis of wine taster descriptions in free-text. There are not many studies of this kind cited in the literature. Of the studies revealed under this category, two major approaches are outlined herein. In (Brochet, 2001) authors analysed taster comments

by different wine experts using a software product called ALCESTE to study the structure of the language used by the experts in describing wines they tasted. In this study, the analysts grouped the word categories within different expert corpuses by calculating the χ^2 of co-occurrences of words and classified the categories into different classes, such as idealistic, odour, colour, somesthesic, taste and hedonistic. The study concluded that the language structure used by wine experts as not organised along their sensory dimensions instead with prototypes. When describing wine taste, experts tend to relate it to a prototype rather than stating its properties.

In another interesting piece of work (Be´cue-Bertaut, et al., 2008), the researchers calculated synthetic liking scores by studying the correlations between pairs of original scores and word groups/counts in free text comments and then comparing these synthetic scores with the original ratings for the sample set of wines studied. The authors used multiple factor analysis to establish the correlations between each pair of comments and their respective liking scores.

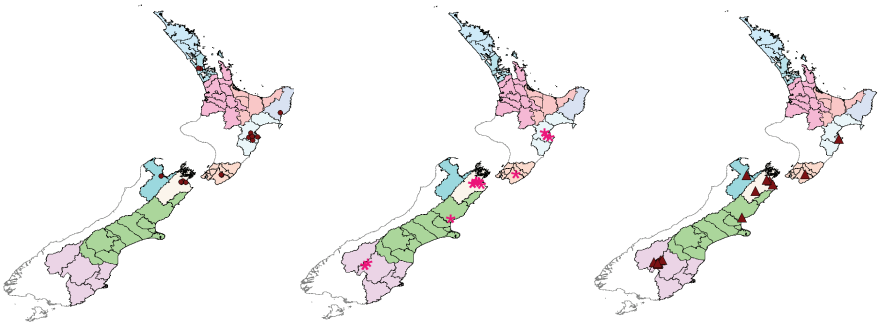
Research conducted at University of California Davis (Frøst, 2002) found that only 25% of wine liking ratings was linked to wine sensory descriptive data in a map created with statistical analysis results of the latter on y axis and ratings on x axis. The authors as well found some descriptors, such as "leather" and "sour", as having a negative effect on preference and wine tasters liked some descriptors, such as "vanilla/oak" and "canned vegetable", and noted even though 75% of the variations in liking could not be explained, the results should be read with caution.

3.2 GRC research: modelling New Zealand wine sensory properties

The section summarises previous GRC research conducted in text mining wine comments for studying the vintage variability in wine quality with sommelier comments that could be eventually extended for modelling the year-to-year climate change effects on wine quality.

3.2.1 New Zealand wine regions and wine styles

New Zealand's (NZ) wine industry continues to grow rapidly in total grapevine cultivation area as well as fine wine production for both domestic and export markets. With extremely diverse climate and environmental conditions combined with incredible enology skills, NZ wineries are able to produce finer quality wine with extraordinary flavours in a wide range of appellations exceeding global market standards. Even though NZ wine industry has a chequered history, in recent times the industry has been witnessing a rapid growth and this has increased the interest in scientifically understanding the link between the country's climatic/ environmental conditions (site specific attributes) and berry component formation, the overall impact on the ultimate end product, wine and its quality. The major NZ wine varieties, wine regions (fig. 2), varieties cultivated and ecological niche (climate, environmental, soil and topographic factors represented by vegetation) are presented in figs. 1a-d.



1a: Chardonnay 1b: Sauvignon Blanc 1c: Pinot Noir

Fig 1a-c: Maps showing major New Zealand wine regions and three major styles from the 95 NZ wine (comments) being analysed in this research. As seen in the maps Chardonnay crops are not cultivated in southern and similarly, Pinot Noir and Sauvignon Blanc are rare in northern New Zealand.

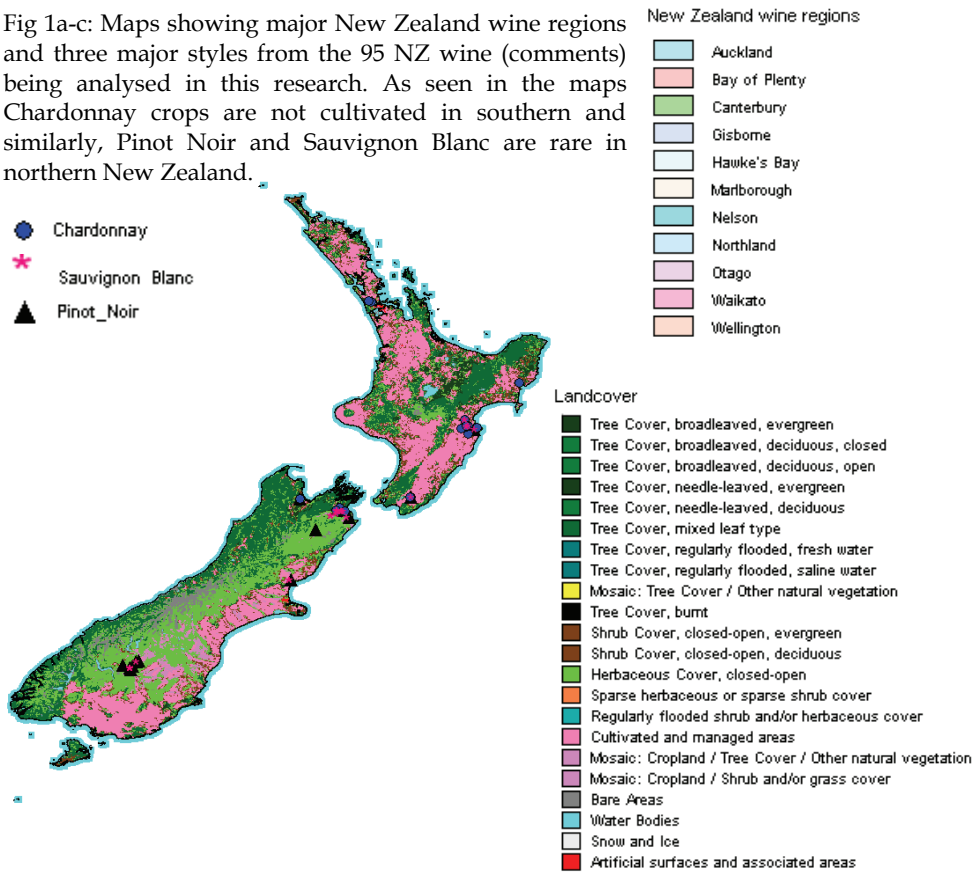


Fig 1d. Map of 3 major wine styles and NZ regional vegetation

NZ wine region	Appellations
Northland	Cabernet Sauvignon, Merlot and Chardonnay
Auckland	Cabernet Sauvignon
Waikato	Chardonnay, Riesling and Cabernet Sauvignon
Gisborne	Muller Thurgau, Chardonnay and Gewurztraminer
Hawkes Bay	Sauvignon Blanc, Chardonnay, Cabernet Sauvignon and merlot
Wellington	Shardonnays, Rieslings and Pinot Noir
Nelson	Rieslings and Chardonnay
Marlborough	Sauvignon Blanc, Chardonnay, Pinot Noirand Riesling, Pinot Gris, Gewurztraminer, Merlot and Cabernet Sauvignon
Waipara	Pinot Noir, Chardonnay Riesling and Sauvignon Blanc
Canterbury	Pinot Noir, Chardonnay, Riesling and Pinot Gris
Otago	Pinot Noir, Riesling and Chardonnay

Fig. 2. New Zealand wine regions and appellations

3.2.2 text mining wine comments with SOM[1] techniques

Every wine label consists of vintage rating, wine details and comments provided by sommeliers that describe the wine colour, aroma, mouth feel and after taste in text format or in some case in audio clips. Both audio and text data (structured and unstructured) is also made available via web based wine catalogues and wine comments of 95 New Zealand vintages from a web magazine called *Wine Enthusiast* (Wine enthusiast, 2009) are analysed to model the vintage variability in the wine quality of these NZ wines. The following are the information generally found in wine vintage labels/ descriptions:

1. Name of the winery
2. Wine style:
3. Wine region
4. Vintage:
5. Rating

Initially, the 95 New Zealand wine comments obtained from *Wine Enthusiast* were separated into structured and text data. The text data was then pre-processed to remove stop words (such as a, the, is) and a matrix of 95 wines into 117 words (*lemmas*) was created. Of the 117 words very common and rare words were removed. Finally, using formula (1) weights (*wi*) for the selected words (wine descriptors) were calculated (fig. 3) The formula is from a well-known information retrieval system called Slaton's vector space model, which has been successfully applied to information storage and retrieval, such as a) local information from individual documents and b) global information from the collection of documents.

[1] Self-organising maps (SOMs) are single layered artificial neural networks (ANNs) that use an unsupervised training algorithm developed by Tuevo Kohonen based on the functioning of the cortex cells of the human brain (www.cis.hut.fi/research/som-research/teuvo.html). SOMs are very useful in exploratory data analysis where prior knowledge on the problem domain is limited. SOMs can project multi-D data onto low D displays with most of the topological details of the complex datasets preserved thus the SOM maps enhance analyst ability to visualise new knowledge embedded in the original data in the form of patterns and correlations.

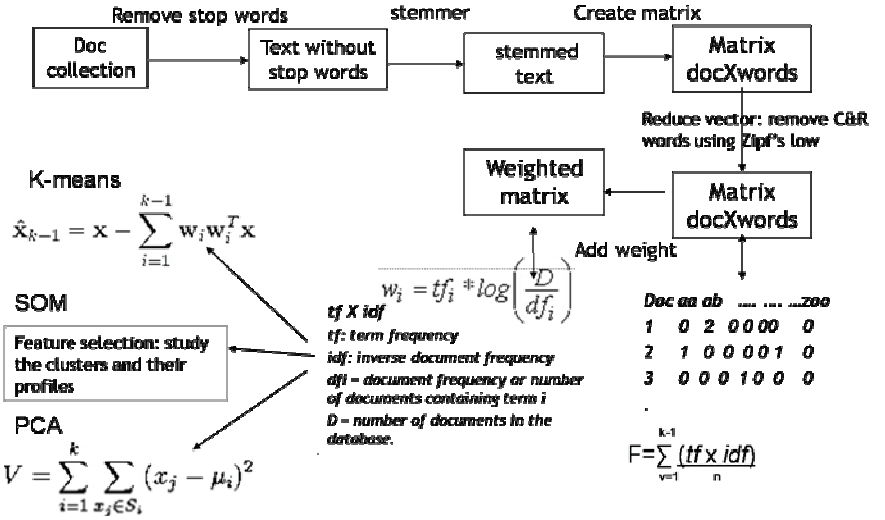


Fig. 3. Schematic diagram showing the steps followed in text mining 95 NZ wine comments.

$$w_i = tf_i * log\left(\frac{D}{df_i}\right) \quad (1)$$

Where,
tfi = term frequency (counts) or number of times a term *i* occurs in a document.
dfi = document frequency or number of documents containing term *i*
D = number of documents in the collection/database

A SOM (figs. 4 a and b) was created using 85 wine descriptors to see the vintage groupings within the 95 New Zealand wines analysed and are outlined here onwards.
The nine SOM clusters of 95 New Zealand wine descriptors show the wine groupings based on the descriptors used by sommeliers to describe the wines. The cluster profiles show the distribution of 85 wine descriptors and their relationships with wine style, region, rating and vintage. For example, cluster 7 wines (Figs. 4 a, b and 5a) are described using *ag_2* (age), *black_9* (black) *Cherri_12* (cherry), *chocol_13* (chocolate), *cinnamon_14* (cinnamon), *cola_17* (cola), *dri_21* (dried), *plum_63* (plum), *spice_74* (spice) and *structure_75* (structure). This cluster consists of Pinot Noir and Bordeaux Blend (BB) wines from Hawke's Bay, Waipara, Marlborough, Martinborough and Central Otago (Fig 5 b). Of these wines, Pinot Noir from Martinborough 2005 rated 93 (wine 8) fetched $ 60 per bottle and was described as "Since its debut in 2003 this has been one of New Zealand-s top Pinot Noirs combining power structure and complexity. Smoky and richly peppery at first it turns more floral with aeration and while it's big in the mouth it is also silky in texture. The black cherry plum vanilla and spice flavors fan out on the long layered finish. Drink now-2015". This shows that the correlations between wine ratings (descriptors) and regional aspects, such as climate and environmental of "*terroir*" as the French say, could be established however, currently there are not any conventional methods or approaches for this purpose.

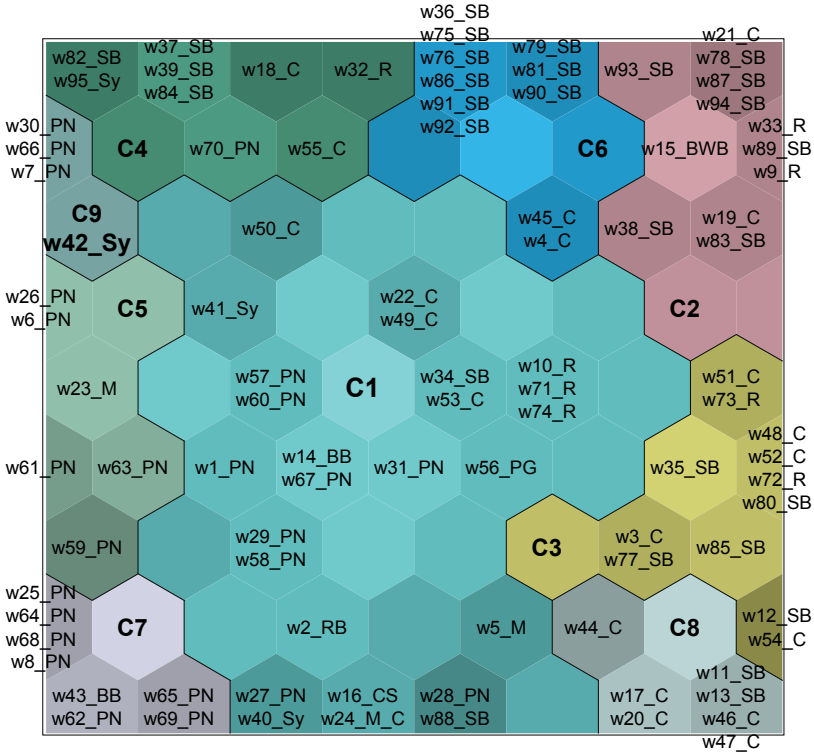


Fig. 4. a: SOM of 85 wine descriptors with 9 clusters. The descriptors obtained from sommelier comments provided for 95 NZ wines illustrate the quality of the vintage in terms of colour, aroma and flavour that are dependent on the grapes that is in turn dependent upon the weather that ripened them apart from winemaker talent and experience.

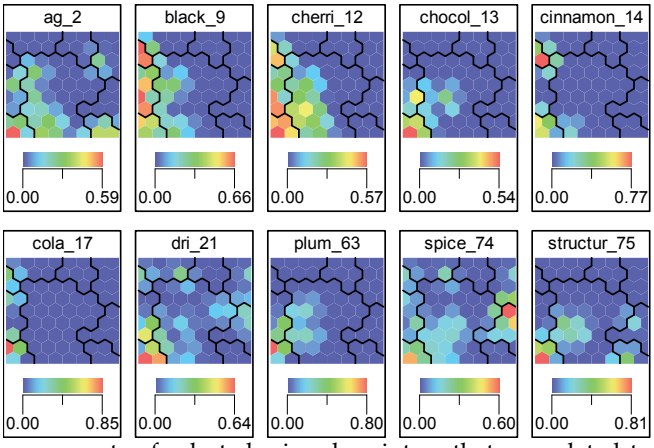


Fig 4. b: SOM components of selected wine descriptors that are related to cluster 7 Pinot Noir vintages

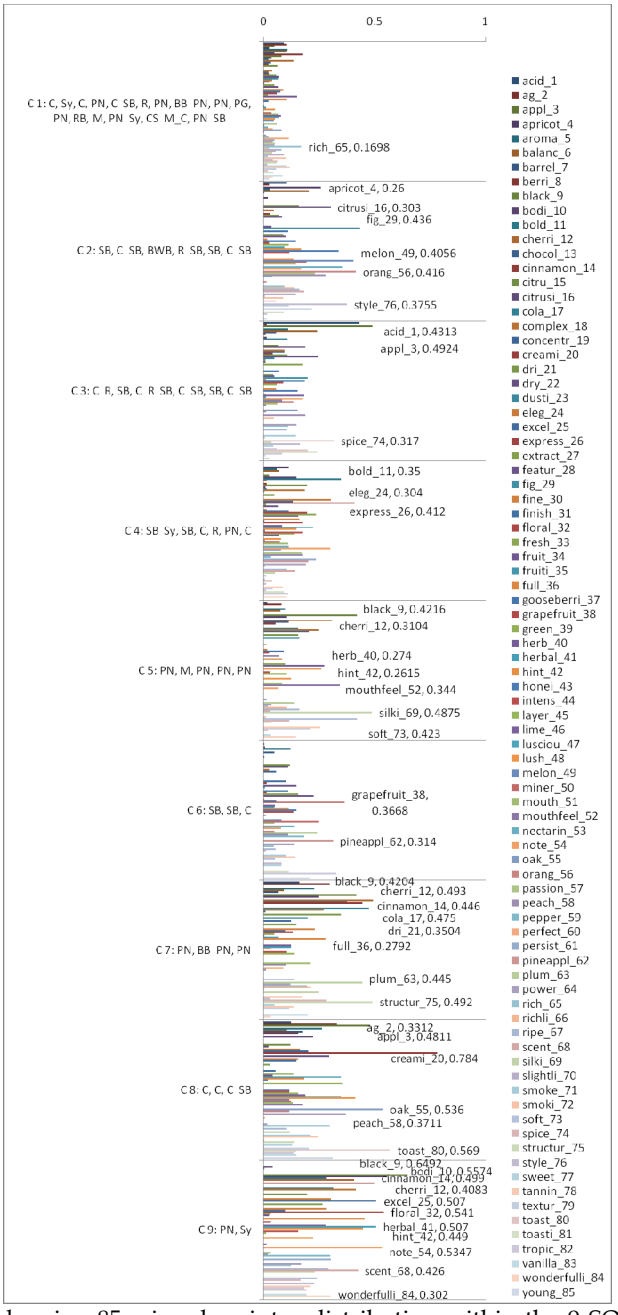


Fig. 5. a. Graph showing 85 wine descriptor distribution within the 9 SOM clusters. The SOM was created with 85 descriptors extracted from wine comments made by sommeliers for 95 New Zealand wines.

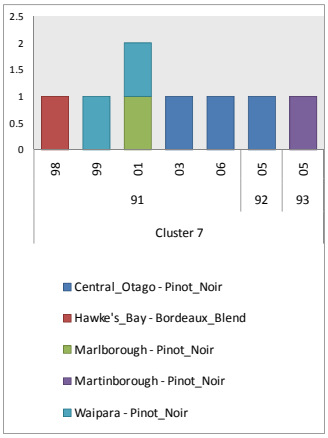


Fig. 5. b. Graph showing cluster 7 vintage, rating (x axis), count of wines (y axis), wine style and regional details.

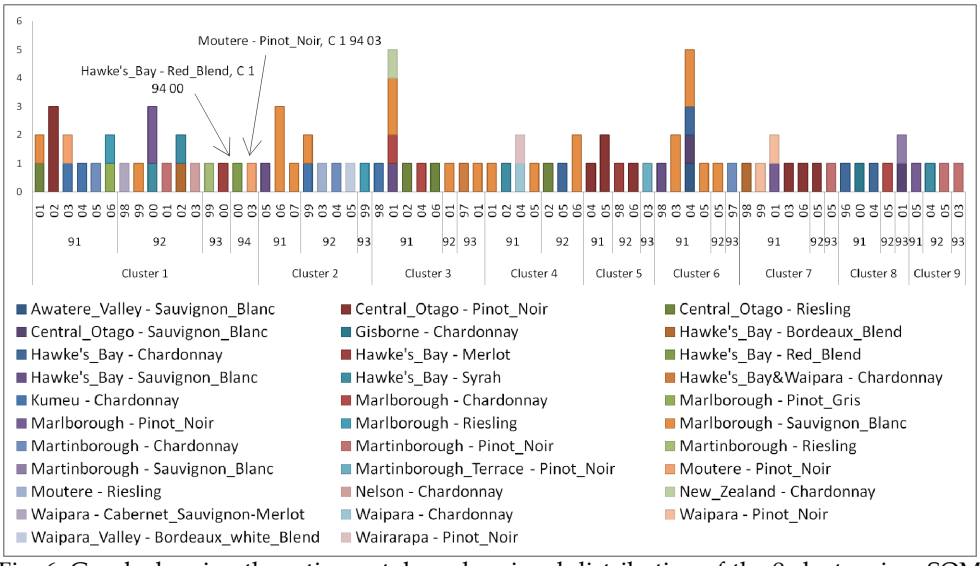


Fig. 6. Graph showing the ratings, style and regional distribution of the 9 clusters in a SOM created with 85 taster descriptors of the 95 New Zealand wines. X axis consists of (from top to bottom) year, rating and cluster no. y axis consists of the count of wines.

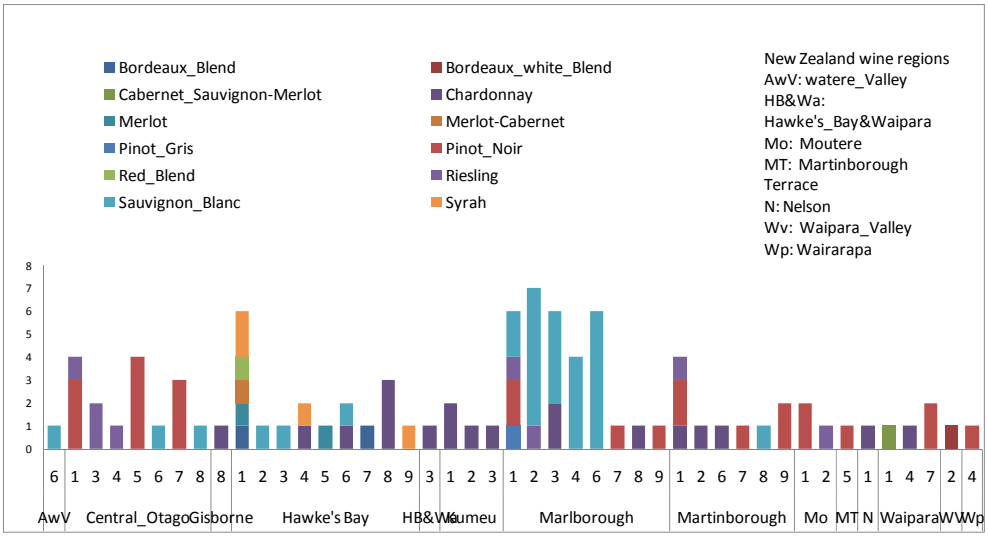


Fig 7. Graph showing the SOM cluster number and wine style distribution (x axis) within the regions relating to the 95 New Zealand wines. The SOM was created using 85 wine descriptor weights calculated based on formula 1 and procedures in Fig 1. Marlborough region consists of more Sauvignon Blanc (SB) wines. All of SB come from the central and southern regions of NZ, mostly from the central Marlborough region.

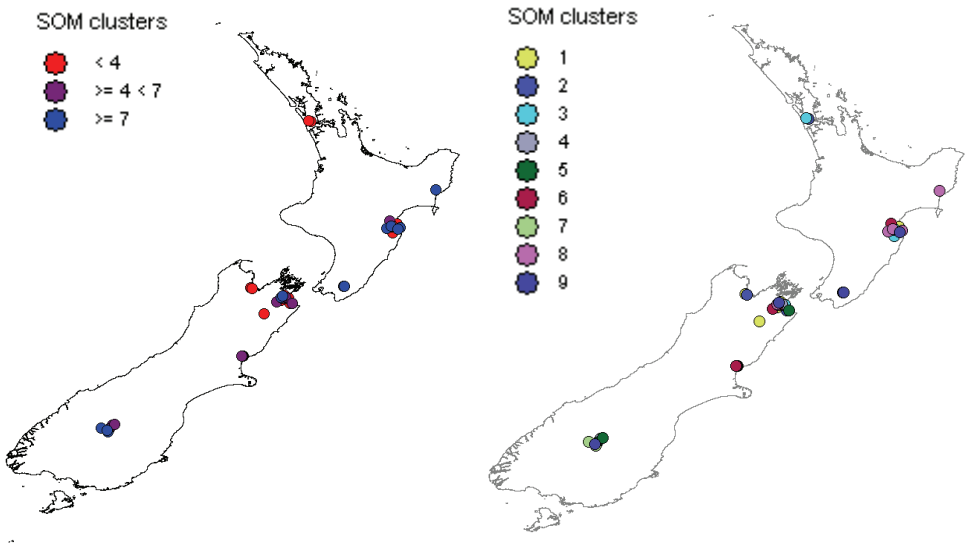


Fig. 8. Winery locations projected on NZ map based on a (left) : three and b (right) : nine clustering of the SOM created with 85 wine descriptors extracted from 95 NZ wine comments. The wine descriptor clustering interestingly reflects more of the aspects relating to winery's location rather than the style.

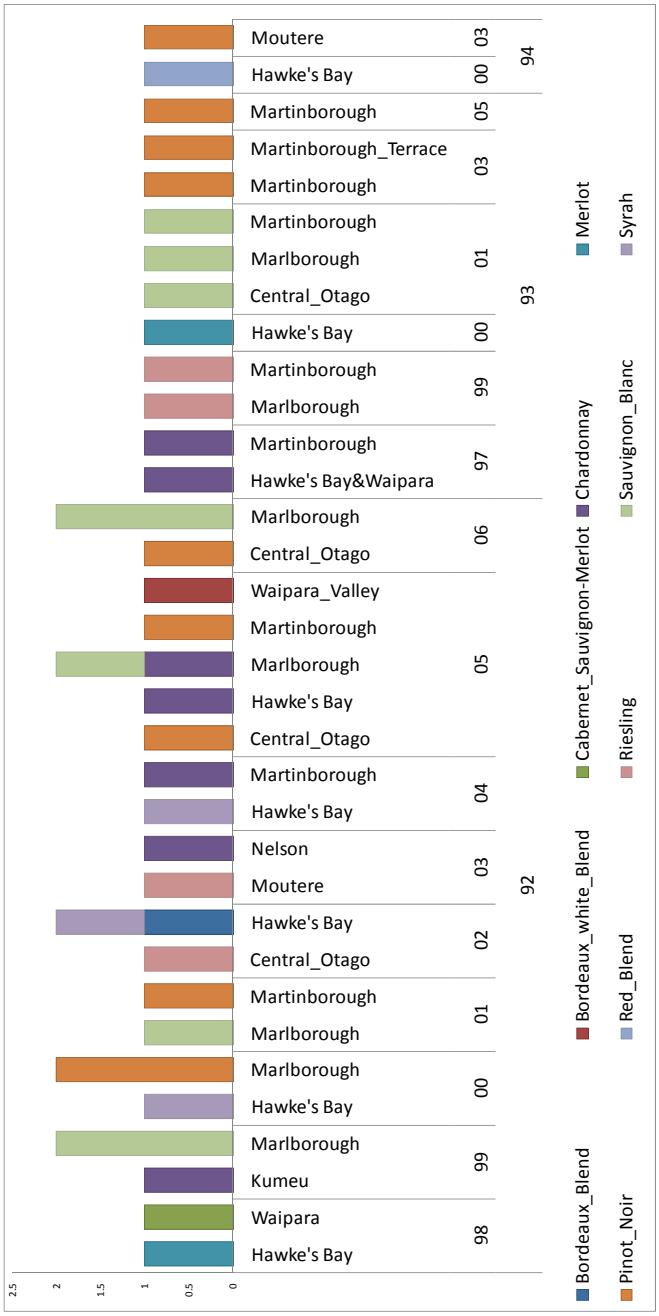


Fig. 9. Graph showing winery region, vintage, rate 92-94 (x axis) and wine style. Pinot Noirs from Hawke's Bay (2000) and Moutere (2003) were rated 94, both clustered in SOM cluster 1 (fig. 6).

Even though the SOM clustering of the 95 New Zealand wines based on the use of wine descriptors show the correlations between wine ratings, vintage and wine type, the clustering is more influenced by the regional aspects as seen in fig. 8.

3.4 WEBSOM approach and its applications

WEBSOM is an approach that provides an efficient methodology for full-text information retrieval and exploration of large collections of documents generally from websites. It uses SOM techniques to statistically analyse the relations between collections of words based on their co-occurrence in documents being analysed, and then based on the relationships, creates document maps. As the word co-occurrences are used as basic components for clustering, similar documents get clustered close to each other on the document map. The WEBSOM approach was first developed as a map of documents providing a good basis for search and exploration of documents (Lagus, 1996). WEBSOM applications include unsupervised (Kaski, 1996), partially supervised processing of newsgroups (Honkela, 1996), browsing interface for web pages for the exploration of document collections (Lagus, 1996) and as a method/ tool for data mining in textual databases (Lagus, 1996).

In this research, WEBSOM is used to group wine descriptors that co-occur in sommelier comments to study the year-to-year variations that may exist between the descriptor-groups that best describe different features relating to vintage quality/ wine sub appellations in terms of appearance, aroma, flavour and mouth-feel.

4. The WEBSOM approach to analysing wine quality data

A WEBSOM was created to analyse the variability in the 95 NZ wine vintages used in the earlier GRC research and the results are discussed here onwards.

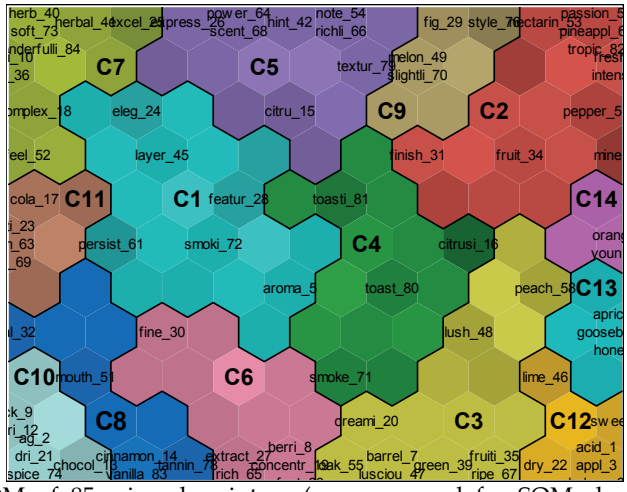
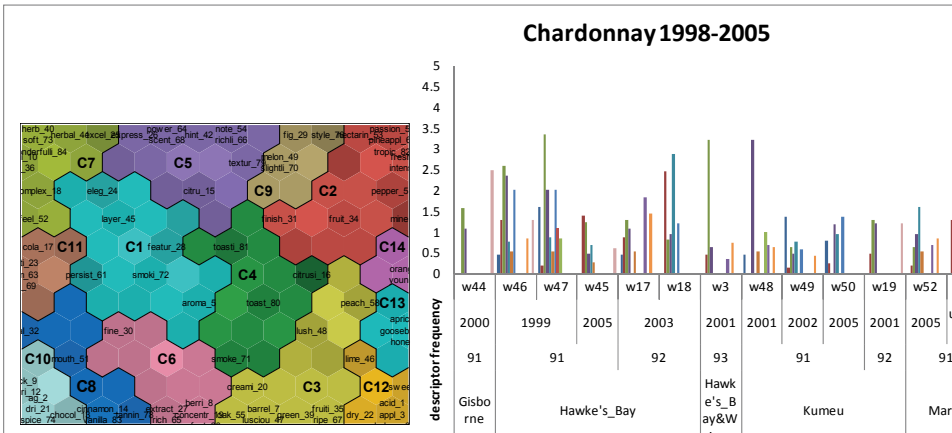


Fig. 10. WEBSOM of 85 wine descriptors (same as used for SOM clustering of wines) extracted from sommelier comments of 95 New Zealand wines.



descriptor frequency	w44	w46	w47	w45	w17	w18	w3	w48	w49	w50	w19	w52
	2000	1999		2005	2003		2001	2001	2002	2005	2001	2005
	91	91			92		93	91			92	91
	Gisborne	Hawke's_Bay					Hawke's_Bay&Waipara	Kumeu				Mar
Sum of C1 aroma_5 eleg_24 featur_28 layer_45 persist_61 smoki_72	0	0.45	1.58	0	0.45	0	0	0.45	1.36	0.79	0	0
Sum of C2 finish_31 fresh_33 fruit_34 grapefruit_38 intens_44 miner_50 nectarin_53 passion_57 pepper_59 pineappl_62 tropic_82	0	1.27	0.19	1.39	0.86	2.44	0.45	0	0.14	0.24	0.48	0.19
Sum of C3 barrel_7 creami_20 fruiti_35 green_39 lusciou_47 lush_48 oak_55 peach_58 ripe_67	1.57	2.57	3.34	1.24	1.28	0.8	3.2	0	0.64	0	1.28	0.64
Sum of C4 citrusi_16 smoke_71 toast_80 toasti_81	1.07	2.35	2.01	0.47	1.07	0.94	0.64	3.21	0.47	1.18	1.2	0.94
Sum of C5 citru_15 express_26 hint_42 note_54 power_64 richli_66 scent_68 textur_79	0	0.75	0.86	0.68	0	2.86	0	0	0.75	0.94	0	1.58
Sum of C6 berri_8 concentr_19 extract_27 fine_30 perfect_60 rich_65	0	0.53	0.53	0.27	0.53	0	0	0.53	0	0	0	0.53
Sum of C7 bodi_10 bold_11 complex_18 excel_25 full_36 herb_40 herbal_41 mouthfeel_52 soft_73 wonderfulli_84	0	2.01	2.01	0	0	1.2	0	0	0.57	1.37	0	0
Sum of C8 cinnamon_14 floral_32 mouth_51 tannin_78 vanilla_83	0	0	1.07	0	0	0	0	0	0	0	0	0
Sum of C9 fig_29 melon_49 slightli_70 style_76	0	0	0.83	0	0	0	0	0.98	0	0	0	0
Sum of C10 ag_2 black_9 cherri_12 chocol_13 dri_21 spice_74 structur_75	0	0	0	0	1.82	0	0.34	0.68	0	0	0	0.68
Sum of C11 cola_17 dusti_23 plum_63 silki_69	0	0	0	0	0	0	0	0	0	0	0	0
Sum of C12 acid_1 appl_3 balanc_6 dry_22 lime_46 sweet_77	0	0.83	0	0	1.43	0	0.74	0.64	0.42	0	0	0.83
Sum of C13 apricot_4 gooseberri_37 honei_43	0	0	0	0	0	0	0	0	0	0	0	0
Sum of C14 orang_56 young_85	2.48	1.28	0	0.6	0	0	0	0	0	0	1.2	0

Fig. 11. WEBSOM cluster profile of 20 Chardonnays within the 95 NZ wines. Higher frequencies of C2 & C3 show high rating (92/3).

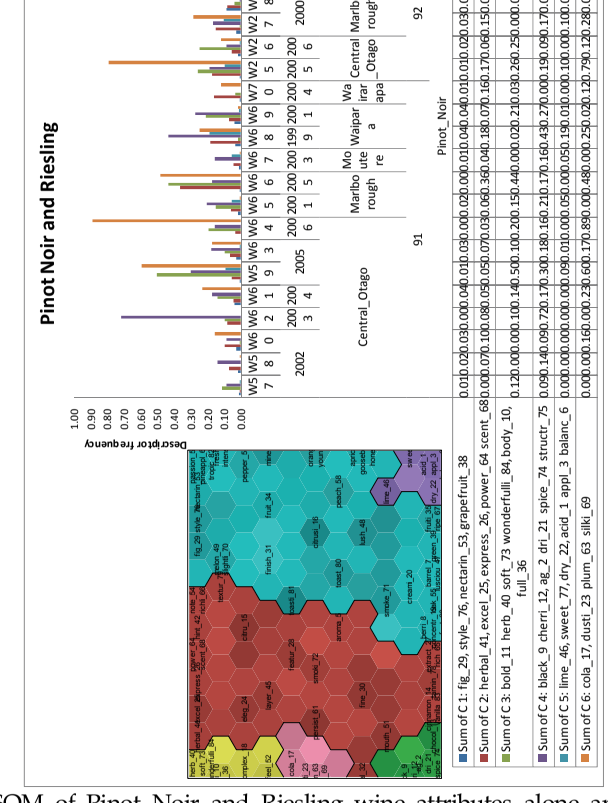
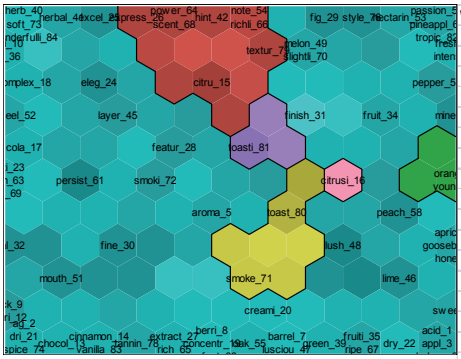


Fig. 12. a: WEBSOM of Pinot Noir and Riesling wine attributes alone and b: graph of the WEBSOM cluster profiles. The cluster profiles of the selected "attributes" clearly indicate the descriptor frequencies that can be used for the characterisation of the vintages within and among the wine appellations. Pinots have more of C3 and C6 descriptors meanwhile Riesling wines have more of C5. The frequencies as well relate to ratings. W1 Pinot Noir (2003) rated 94 from Moutere consists of C2 and C4 descriptors alone. Pinots from other regions even though have higher frequencies for C2 and C4 descriptors they also have more of C3 and C6 descriptors. Hence, W1 is rated high for its sharpness or C3 and C6 could be imposing a negative impact on the overall rating.



WineNo	Region	C 1: bold_	C 2: expre	C 3: toast_	C 4: orang	C 5: toasti	C 6: citrusi
44	Gisborne	0.023	0	0.478	1.225	0.002	0.006
17	Hawke's_Bay	0.087	0	0.465	0	0.003	0.004
18	Hawke's_Bay	0.064	0.333	0.004	0	0.932	0.001
45	Hawke's_Bay	0.0428	0.0828	0.0014	0.2972	0.4651	0.0022
46	Hawke's_Bay	0.108	0.074	1.172	0.633	0.004	0.009
47	Hawke's_Bay	0.134	0.116	0.471	0.001	0.935	0.009
3	Hawke's_Bay	0.0584	0	0.3523	0.0018	0.0004	0.0019
19	Kumeu	0.026	0	0.002	0.594	0	1.183
48	Kumeu	0.046	0	0.468	0	0.933	1.184
49	Kumeu	0.0444	0.0891	0.002	0	0.4664	0.0003
50	Kumeu	0.0344	0.1216	0.583	0	0.0027	0.0034
20	Marlborough	0.12	0.074	0.008	0.005	0	0.005
51	Marlborough	0.0619	0	0.0037	0	0	0.0005
52	Marlborough	0.0404	0.195	0.0007	0.0015	0.9301	0.0035
4	Martinboroug	0.029	0	0	0.634	0	0.002
21	Martinboroug	0.057	0.569	0.003	0.003	0.932	1.184
53	Martinboroug	0.0294	0.0888	0	0	0	0.0006
22	Nelson	0.0167	0.2832	0.0009	0	0.4663	0.0007
54	New_Zealand	0.064	0	1.169	0.001	0.934	1.19
55	Waipara	0.0251	0.2222	0	0	0.0008	0.0004

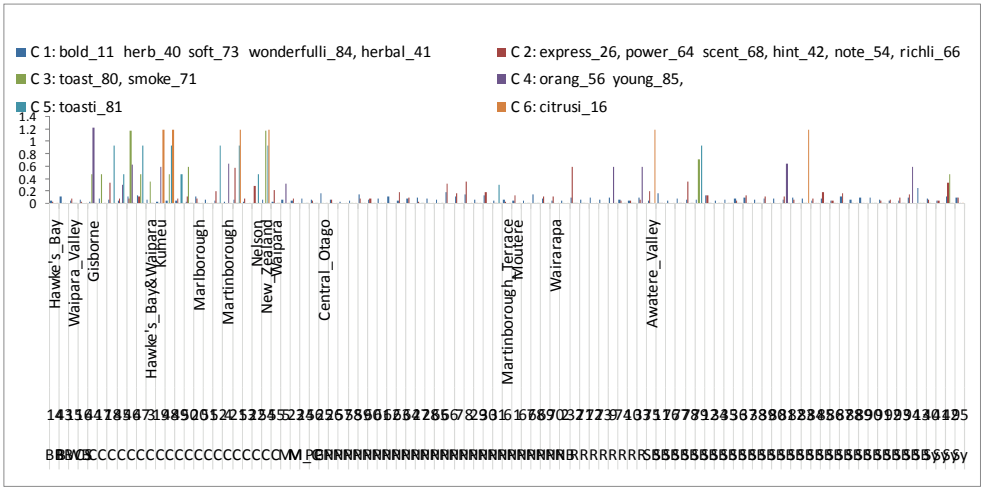


Fig. 13. a (top left) : WEBSOM with Chardonnay attributes (alone) and b: graph of the WEBSOM cluster profiles. The cluster profiles clearly indicate the descriptor frequencies that can be used for characterisation of the wines within and among the appellations. b (top right): table showing Chardonnay descriptor frequencies of the WEBSOM. c (bottom) : graph showing the Chardonnay descriptor frequencies of wines in all 95 NZ wines. W44 shows higher frequency (1.225) for C4 descriptors. Kumeu wines 18 (1999, rated 92) and 48 (1998, rated 91) show more of C6 (*citrussi_16*) whereas 49 (2004 rated 91) and 50 (2003 rated 91) from same wineries show more of C2 *express_26, power_64, scent_68, hint_42, note_54 and richli_66*.

The WEBSOM of all 85 words (fig. 9) give interesting patterns in the use of the descriptors by sommeliers:

1) Descriptors of clusters C8 (*cinnamon_14 floral_32 mouth_51 tannin_78 vanilla_83*) and C11 (*cola_17 dusti_23 plum_63 silki_69*) are not generally used to describe Chardonnay wines, they are used for Pinot noirs instead

2) Similarly, descriptors of C13 (*apricot_4 gooseberri_37 honei_43*) and C14 (*orang_56 young_85*) are not used for Pinots at all however sparingly used for Chardonnays.
3) Higher frequencies of C5 (*citru_15 express_26 hint_42 note_54 power_64 richli_66 scent_68 textur_79*) high ratings (92/3).
4) C 10 descriptors (*ag_2 black_9 cherri_12 chocol_13 dri_21 spice_74 structur_75*) are commonly used for Pinots
5) C4 descriptors (*citrusi_16 smoke_71 toast_80 toasti_81*) are not used at all to describe Pinots.

Based on the results of SOM technique and then the WEBSOM clustering of wines, both approaches investigated with the same set of 85 descriptors extracted from sommelier comments of 95 New Zealand wines, the latter seems be a better tool for modelling the year-to-year (vintage) variability within the wine descriptors. Even though with both methods it is possible to subdivide the main clusters and look for patterns for establishing the correlations between the descriptor frequency and different wine styles, vintages and ratings the WEBSOM approach gives more flexibility to choose wine attributes and drill down the analysis to within and among regions, appellations or vintages.

5. Conclusions

The paper looked at the SOM and then WEBSOM based clustering approaches to modelling the year-to-year (vintage) variability within 95 New Zealand wines using 85 taster descriptors extracted from web based sommelier comments provided for the NZ wines. The results of this initial research favour WEBSOM approach for establishing the vintage variability within wines from New Zealand's major regions as well as within a region with all or selected attributes (relating to a single wine style , such as Chardonnay or Pinot Noir). Further research is already underway to investigate the variability among vintages from New Zealand and Chilean wine regions with WEBSOM approach using larger sample sets of sommelier comments. This will enhance a broader understanding on the climate effects on different wine styles and vintages from both countries' wine regions and from a comparative perspective as well on the effects in two major wine producing regions in the southern hemisphere.

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7. References

Ashenfelter, O., & Jones, G.V., (2000). The demand for expert opinion: BordeauxWine. VDQSAnnual Meeting, d'Ajaccio, Corsica, France. October, 1998. Published in Cahiers Scientifique from the Observatoire des Conjonctures Vinicoles Europeenes, Faculte des Sciences

Atkins, T. A., & Morgan, E. R., (2006). Modelling the effects of possible climate change scenarios on the phenology of New Zealand fruit crops ISHS Acta Horticulturae 276: II International Symposium on Computer Modelling in Fruit Research and Orchard Management ???

Be´cue-Bertaut , M., A´ lvarez-Esteban, R., and Page` S, (2008). Rating of products through scores and free-text assertions: Comparing and combining both. Food Quality and Preference vol. 19 pp. 122–134. 133

Brochet F., and Dubourdieu, D., (2001). Wine Descriptive Language Supports Cognitive Specificity of Chemical Senses. Brain and Language Vol. 77, Issue 2, May 2001: 187-196 .

Frøst M. B., and Noble, A., (2002). Preliminary study of the effect of knowledge and sensory expertise on liking for red wines. American Journal of Enology and Viticulture. vol. 53(4) :275-284

Gawel, R. I. P., Characterizing the astringency of red wine: a case study (2001) Food Quality and Preference vol 12: 83-94.

Gutierrez, A. P., Luigi, P., Ellis, C. K., and d'Oultremont, T., (2005). Analysis of climate effects on agricultural systems. Report published by California Climate Change Center CEC-500-2005-188-SD pp 28 + appendices A1-7

Hansen, A., and Dale V., (2001). Biodiversity in US Forests under Global Climate Change. Ecosystems vol. 4 161–163

Honkela, T., Kaski, S., Lagus, K., and Kohonen, T., (1996). Newsgroup exploration with WEBSOM method and browsing interface. Technical Report A32, Helsinki University of Technology, Laboratory of Computer and Information Science, Espoo. WEBSOM home page. http://websom.hut.fi/websom/

Jones , G. V., [et al.] (2005). Climate and Global Wine Quality. Climatic Change by Springer vol. 73:319–343.

Jones, G. V., "How Hot Is Too Hot?" (2005). Wine Business Monthly, February 2005. pp 1-4.

Jones, G.V., Making Wine in a Changing Climate (2004) Geotimes, August 2004, Vol. 50, No. 7, 22-27

Kaski S., Honkela, T., Lagus, K. and Kohonen, T. (1996). Creating an order in digital libraries with self-organizing maps. [Conference] // Proceedings of World Congress on Neural Networks (WCNN-96) http://websom.hut.fi/websom/

Kontkanen D R Canadian terroir: sensory characterization of Bordeaux-style red wine varieties in the Niagara Peninsula (2005). Food Research International vol. 38: 417–425.

Lagus, K., Honkela, T., Kaski, S. and Kohonen, T. (1996). Self-organizing maps of document collections: A new approach to interactive exploration [Conference] // Knowledge Discovery and Data Mining (KDD-96) https://eprints.kfupm.edu.sa/64289/

Lagus, K., Honkela, T., Kaski, S., Kohonen, T., (1996). Creating an order in digital libraries with self-organizing maps [Conference] // proceedings of STeP'96. Jarmo Alander, Timo Honkela and Matti Jakobsson (eds.) , Publications of the Finnish Artificial Intelligence Society: 73-78.. -

Lagus, K., Kaski, S., Honkela, T. and Kohonen, T. (1996). Browsing digital libraries with the aid of self-organizing maps. [Conference] // In Hopgood, B., editor, in proceedings of Fifth International World Wide Web Conference, Paris, volume posters, 71-79.. -

Nemani, R. R., White, M. A., Cayan, D. R., Jones, G. V., Running, S.W., and Coughlan, J. C. (2001). Asymmetric climatic warming improves California vintages. - Clim. Res. Vol 19:25–34.

Parr, W. V., Green, J. A., White, K. G., and Sherlock, R. R., (2007). The distinctive flavour of New Zealand Sauvignon blanc: Sensory characterisation by wine professionals. Food Quality and Pref vol. 18:849–861.

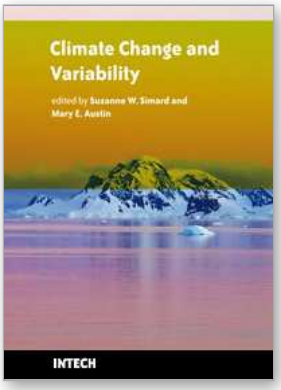
Sallis, P.J., Shanmuganathan, S., Pavesi, L., and Jarur, M. (2008). A system architecture for collaborative environmental modelling research [eds] McQuay Waleed W. Samari and William. - A publication of the IEEE, New Jersey, USA. ISBN: 978-1-4244-2248-7, Irvine, California, May 19-23 2008 pp 39-47 :

Shanmuganathan, S., Ghobakhlou, A., and Sallis, P., Sensor data acquisition for climate change modelling (2008). WSEAS Circuits & Systems, Issue 11, Volume 7, Nov. 2008. ISSN: 1109-2734 pp 942-952.

Vannier, A., Bruna, O. X., and Feinberg, M. H., Application of sensory analysis to champagne wine (1999). Characterisation and discrimination. Food Quality and Preference vol. 10:101-107.

Web, L. B., (2006). The impact of projected greenhouse gas-induced climate change on the Australian wine industry, PhD thesis, School of Agriculture and Food Systems, University of Melbourne pp 277.

Wine enthusiast (2009). Wine enthusiast magazine. www.winemag.com/buyingguide/search.asp?db= [Online]



Climate Change and Variability

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Climate change is emerging as one of the most important issues of our time, with the potential to cause profound cascading effects on ecosystems and society. However, these effects are poorly understood and our projections for climate change trends and effects have thus far proven to be inaccurate. In this collection of 24 chapters, we present a cross-section of some of the most challenging issues related to oceans, lakes, forests, and agricultural systems under a changing climate. The authors present evidence for changes and variability in climatic and atmospheric conditions, investigate some the impacts that climate change is having on the Earth's ecological and social systems, and provide novel ideas, advances and applications for mitigation and adaptation of our socio-ecological systems to climate change. Difficult questions are asked. What have been some of the impacts of climate change on our natural and managed ecosystems? How do we manage for resilient socio-ecological systems? How do we predict the future? What are relevant climatic change and management scenarios? How can we shape management regimes to increase our adaptive capacity to climate change? These themes are visited across broad spatial and temporal scales, touch on important and relevant ecological patterns and processes, and represent broad geographic regions, from the tropics, to temperate and boreal regions, to the Arctic.

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