THE IMPACT OF GLOBAL WARMING ON ONTARIO'S ICEWINE INDUSTRY

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ABSTRACT

Ontario's wine regions lie at the climatic margins of commercial viticulture owing to their cold winters and short cool growing season. The gradual warming of northern latitudes projected under a human-induced climate change scenario could bring mixed benefits to these wine regions. On the one hand, climate change could moderate the severity of winter temperatures and extend the growing season and on the other, it could be jeopardize the production of internationally renowned icewines for which Canada is famous. This paper examines the trends in winter temperatures over the last forty years for the Niagara Peninsula wine region in Ontario. The study analyzes the occurrences of temperatures ≤ -8^{o} C in the months of November, December, January and February in which the frozen grapes are normally picked. The results of trend analysis showed a high degree of variability along with a weak declining trend in the number of picking days. Two major risks to icewine grapes are prolonged warm and wet conditions that could lead to rot and secondly, destruction of the crop by bird predators. The study also discussed the potential use of weather contracts to mitigate these risks.

Key Words: climate change, Ontario, icewine, impacts, weather contracts

INTRODUCTION

Ontario's main wine regions comprise the Niagara Peninsula and the adjacent regions of Lake Erie Northshore, Pelee Island and Prince Edward County. Although the Great Lakes moderate their climates throughout the year, these areas are often incorrectly perceived as being on the climatic limits of successful commercial viticulture, owing to their snowy winters and short cool growing seasons. Endowed with a favourable range of mesoclimates, topographies and soils, wine production has evolved slowly under a scrupulous system of site selection matched by suitable cold-tolerant international grape varieties. Still and sparkling wines of quality and distinction are produced in a wide range of styles mainly for the Canadian market. However, it is the icewine that uniquely combines the regions' climatic, viticulture and oenological attributes that first brought international recognition to the Canadian wine industry. Although cold winters are the norm for this semi-continental climate, global warming could threaten the stability of icewine production. On one hand, these regions are likely to benefit from a warmer climate that could extend the growing season and moderate the severity of winter temperatures. On the other, the production of the internationally renowned icewines could be jeopardized by unpredictably warmer spells during the first half of winter, when frozen grapes are typically harvested, after having experienced a number of freeze-thaw cycles.

Climate Change and Viticulture

The Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report in 2007 stated that there has been anthropogenic warming over the last 50 years averaged over each continent. The temperature increase is widespread over the globe, but is greater at higher northern latitudes. Average Arctic temperatures have increased at almost twice the global average rate in the past 100 years. Observed decreases in snow and ice extent are also consistent with warming. All of North America is projected to warm during this century, and the annual mean warming is likely to exceed the global mean warming in most areas. In northern regions, warming is likely to be largest in winter. It is very likely that cold days, cold nights and frosts could become less frequent over most land areas, while hot days and hot nights could become more frequent. Also predicted ~~are~~ is a very likely decrease in snow season length and snow depth in most of Europe and North America. (IPCC, 2007).

There exits now several studies that have analyzed the impacts of climate change and variability on viticulture (Kenny and Harrison, 1992; Stock et al., 2004; Jones and Goodrich, 2008), while others have examined temperatures trends (including the growing season average, maximum and minimum temperatures) the climatic characteristics of particular wine regions, grapevine phenology, grape composition and yield, and the resulting wine quality (Jones and Davis, 2000; Bindi et al.,1996). Several studies have projected a continued warming trend in the growing season, more frequent extreme temperatures, early budburst and an increase in the frost-free- period (Easterling et. al., 2000; Kramer, 1994; Duchene and Schneider, 2004).

In Canada, most northern agricultural regions are expected to experience warmer conditions, longer frost-free seasons and increased evapotranspiration. The national average temperature for the winter 2009/2010 was 4.0°C above normal, based on preliminary data, which makes this the warmest winter on record since nationwide records began in 1948. The previous record was 2005/2006 which was 3.9°C above normal. The climate is gradually becoming wetter and warmer in southern Canada throughout the twentieth century and in all of Canada during the latter half of the century. In southern Canada, spring temperatures have increased, greatly shortening the period of freezing temperatures suitable for snowfall while daily minimum temperatures, indicators of night-time temperatures, have increased significantly over the past century (Zhang et.al, 2002).

The severity of winters has determined the distribution of perennial fruit and vine crops, but warmer winters are not altogether beneficial. Winter damage could actually increase in eastern Canada, due to reduced cold hardening during the fall, an increase in the frequency of winter freeze-thaw events, and a decrease in protective snow cover. Conversely, vine and orchard crops are expected to benefit from a decreased risk of winter damage. However, milder winter temperatures would reduce cold stress, while a decrease in late spring frosts would lower the risk of bud damage in many regions. Nonetheless, an increase in winter free-thaw events would decrease the hardiness of the trees, and increase their sensitivity to cold temperatures in late winter (Natural Resources Canada, 2002). Also damaging to perennial crops are temperature fluctuations within the winter season (repeated freeze-thaw cycles) and the annual variability that are characteristic of the climate of the Great Lake Region. Fig. 1 shows winter departures from the normal temperature with an increasing but highly fluctuating trend.

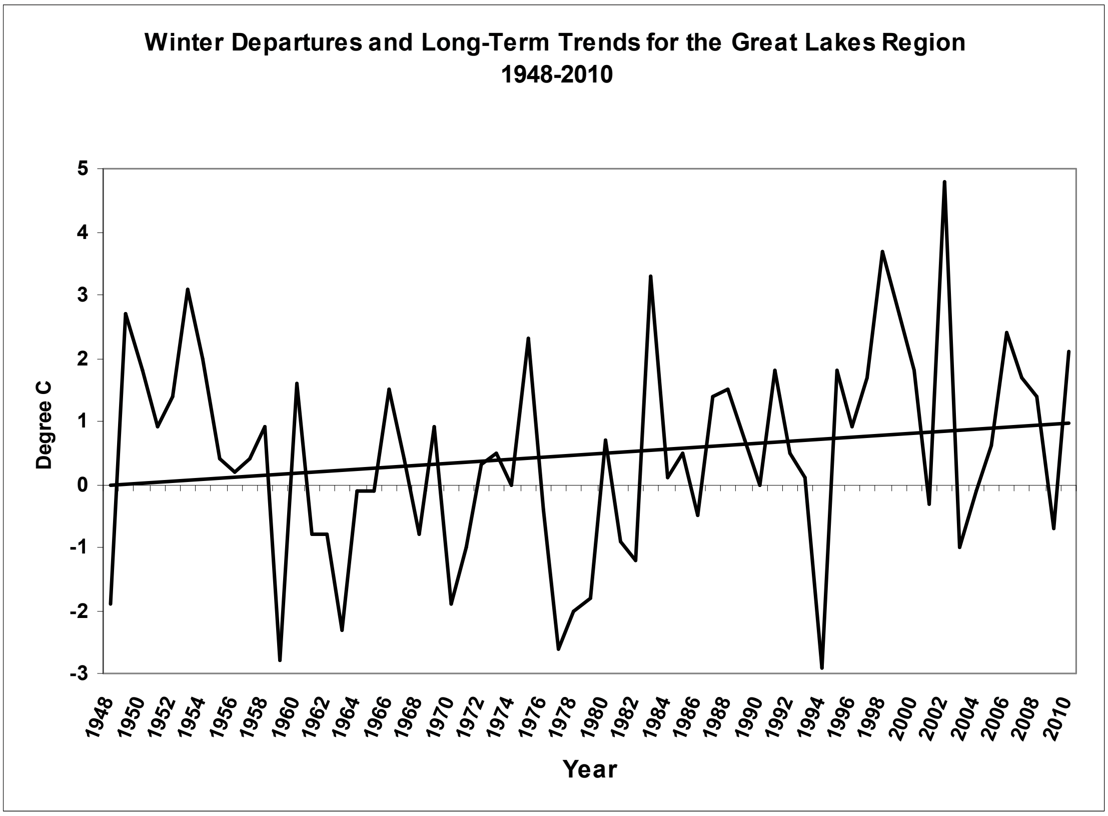

Figure. 1: Winter departures and long term trends in the Great Lakes region 1948 - 2010

Icewine

The first icewine (Eiswein) is believed to have been made in Germany around 1794 in Franconia with the advent of early freezing temperatures before the grape crop could be harvested. Nonetheless, winemakers harvested and pressed the frozen grapes and fermented the juice to produce a sweet wine. Germany continued to produce icewine in an unregulated fashion until 1982 when it was formally granted its own quality category in the German Wine Law. Unlike the Canadian winters, the already moderate European winters now becoming increasingly warmer with climate change make icewine production in Germany and Austria highly risky.

In Ontario, icewines are made principally from the Vidal, Riesling, Cabernet Franc and Gewürztraminer grapes that must harvested in a frozen state at temperatures ≤ -8° C after November 15. The temperatures at picking time are limited from -8° C to -14° C, which also determines the maximum and minimum amount of juice that can be extracted. The optimum harvesting temperature is between -10° and -12° C. The ideal parameters for the pressed juice are between 38° and 42° Brix, between 120 and 150 L per ton according to the variety, titratable acidity of 10-12 g/l tartaric acid and pH between 3.1 and 3.3 (Ziraldo and Kaiser, 2007). According to the Vintners Quality Alliance Ontario (VQA), the finished wine must have a Brix of 35° or more, residual sugar of 125 g/l and a minimum alcohol content of 7 percent but not exceeding 14.9 percent by volume. Riesling and Vidal icewines exhibit typically rich aromas and flavours that are characteristic of ripe tropical fruits such as lychee, papaya and pineapple. The sweet but firm acidity of icewines, attributed to malic acid dominance, make them perfectly balanced.

This paper examines the trends in winter temperatures over the last forty years for the Niagara Peninsula Wine Region of Ontario that is also Canada's major producer of icewines. The study analyzes the occurrences of temperatures ≤ -8^o C in the months of November, December, January and February in which the frozen grapes are normally picked. Even though the grapes may be partially frozen on several occasions at higher minimum temperatures, the temperature at harvest must fall to -8^{o}C in order to be certified as icewine according to the Vintners Quality Alliance (VQA) standards. The ideal conditions should include dry and moderately cold conditions over a two week period with partial freezing, followed by a real freeze with daytime temperatures between -10^o C to -12^{o}C in the months of December and January.

DATA AND METHODS

To achieve the above objectives, the study examined daily climatic data for a representative climatic station located at Vineland in the Niagara Peninsula wine region of Ontario. This climatic station has a long history of reliable data going back to the 1880s and is located in an area that has remained essentially rural. This study utilized data for the 1977 to 2008 period retrieved from the Environment Canada's Online Climate Database. Data from this official source typically undergo rigorous quality checks before being released for public use. This period of analysis contains no missing records. The study examined the daily minimum temperatures for the months of December, January and February and the latter half of November. It included any day with minimum temperature ≤ -8^o C, the legally recognized lower threshold temperature that ensures that the grape is fully frozen on the vine for icewine.

The analysis of the occurrences of days with the threshold minimum temperatures for harvesting icewine grapes does not account for the length of the freeze event. For example, an event with ≤ -8^o C could have lasted under an hour while another event could have lasted for several hours. Records of hourly values suitable for icewine only began about fifteen years ago for the Niagara Peninsula wine region and less than ten years for the Lake Erie North Shore. In absence of long-term hourly values and for the purpose of this study, we defined an icewine event as one in which there were two consecutive days with minimum temperatures ≤ -8^o C. To determine any evidence of long-term trend and variability in the data, we analyzed the time series using simple linear regression. We analyzed the total number of events for individual months and the combined total for each winter season.

RESULTS AND DISCUSSION

Optimal Harvesting Period

November 15 marks the start of the official harvesting date of grapes for icewines. However, the record over the last forty years showed a total of twelve days experienced minimum temperatures ≤ -8^o C. Only one year (1989) had four consecutive days with ≤ -8^o C that were suitable for harvesting frozen grapes. An early harvest date means higher yields, since loss to predators, a longer hanging time and spoilage due to warmer temperatures can reduce yields and quality. Fig. 2 and 3 show the most suitable period for harvesting frozen grapes. It begins roughly from the beginning of the second week in January and extends to approximately the middle of February. This period has a slightly >50% chance of the occurrence of freezing temperatures ≤ -8^o C.

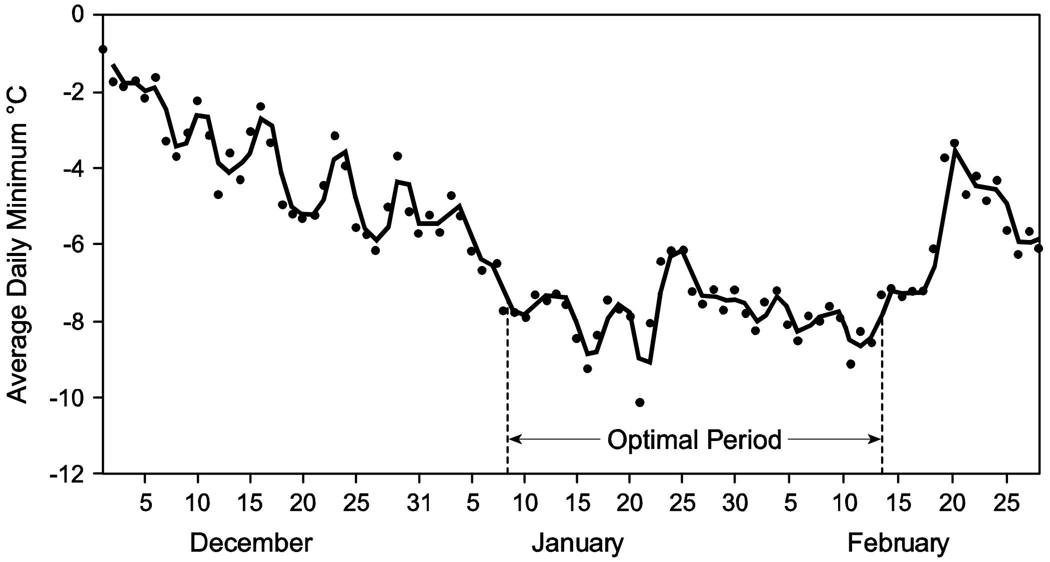

Figure 2. Average daily minimum temperatures for December to February for the period 1970-2007

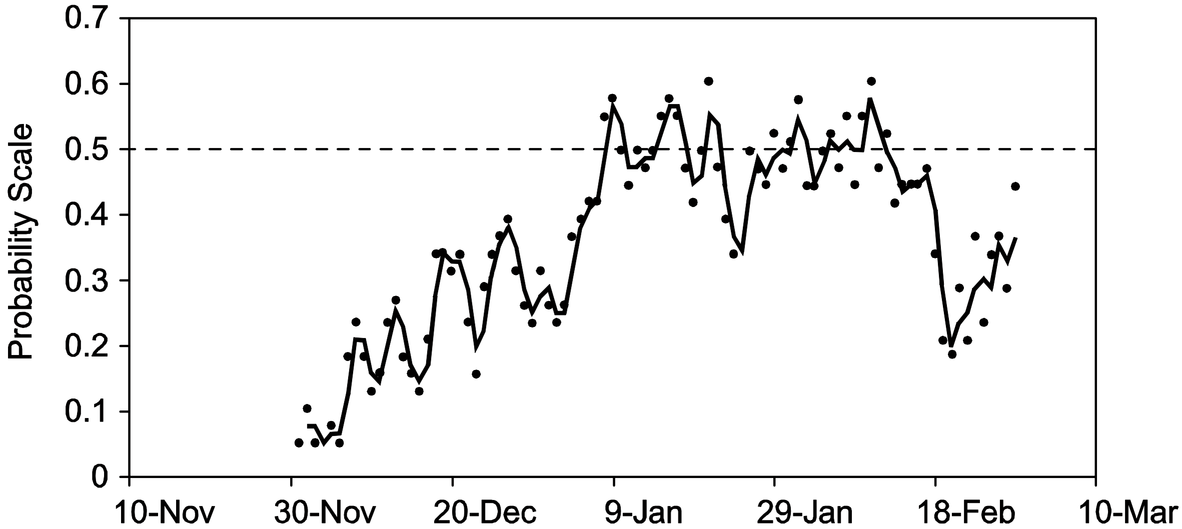

Figure 3. Probability of daily minimum temperatures ≤ -8° C for the period 1970-2007

Trends in Freezing Temperatures

Some winegrowers will harvest at -8° C, while others may await lower temperatures over a longer. An analysis of the frequency of days (Fig. 4) with freezing temperatures ≤ -8° C for the December to February period shows a high degree of inter-annual variability with a weak declining trend for the 1970-2007 period. Values range from a high of 50 in 1978 to a low of 11 in 2002 duration.

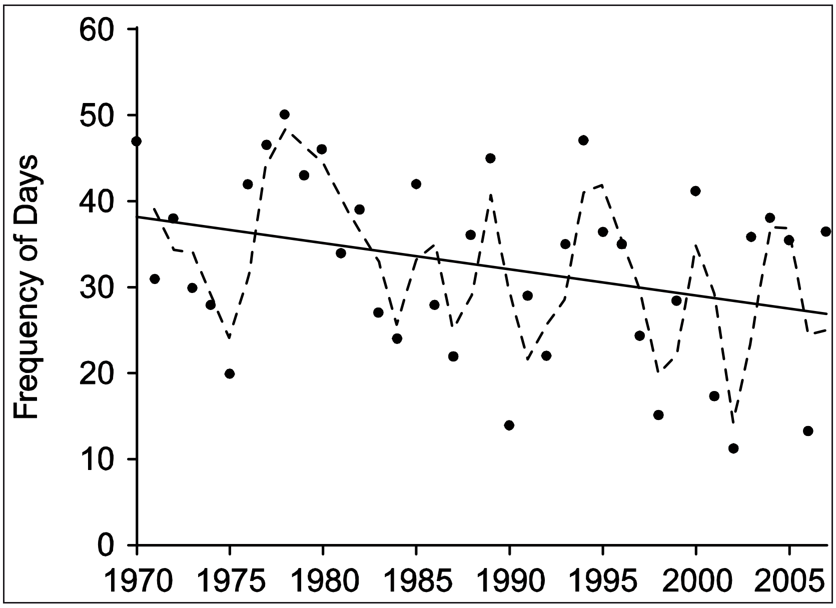

Figure 4. Frequency of days with ≤ -8°C between December and February for the 1970-2007 period

Trends in Icewine Events

We defined an icewine event as one with at least two consecutive days with ≤ -8° C. Trend analysis in Fig. 5 shows high inter-annual variability along with a declining trend for the three coldest months. The sharpest decline is observed in February followed by January and December, respectively.

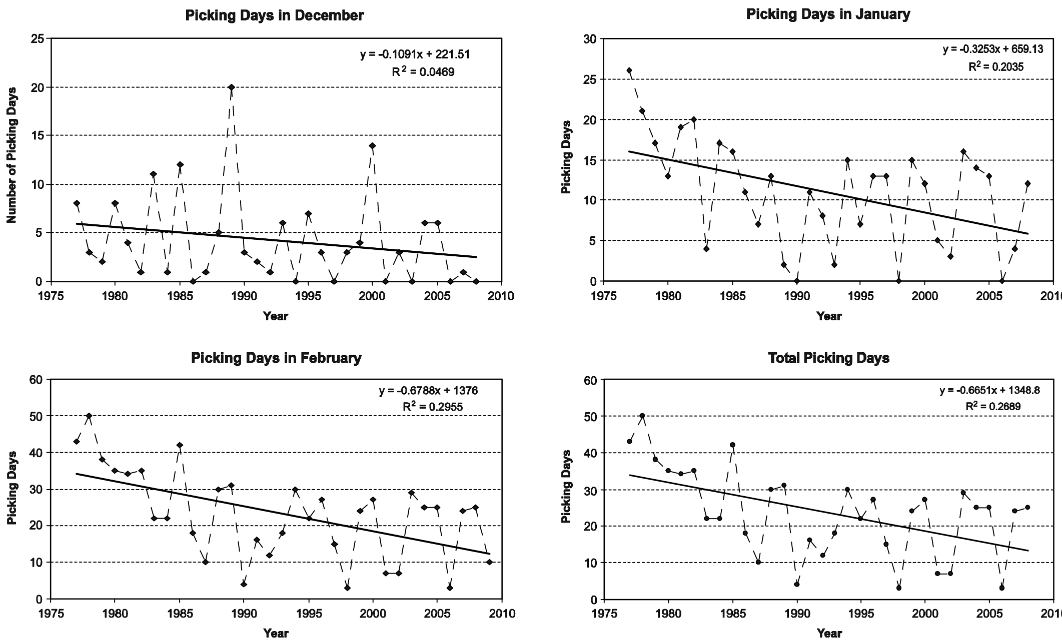

Figure 5. Temporal distribution of icewine events (picking days) for the months of December, January and February for the 1970-2007 period

MANAGING THE RISKS OF GLOBAL WARMING

In addition to the declining trend observed in the number of picking days, Fig. 5 also appears to provide some indication of increased inter-year volatility, particularly in the months of January and February, from 1990 onward. This is consistent with the results of Cyr and Kusy (2007) who, in a study of estimated annual hours of icewine harvesting time, find some evidence of increased volatility from the early 1990's onward.

Although adaptation strategies in terms of viticulture, to mitigate crop loss due to the impact of increasingly warm and wet conditions may be developed, the increased volatility can create uncertainty in terms of the year-to-year expenditures associated with such methods. Cyr and Kusy (2007) considered the potential use of weather contracts for hedging such economic risks, particularly with respect to icewine harvesting. Although weather derivative contracts first began trading in the mid 1990s the availability of such contracts for hedging specialized weather risks has only developed substantially in recent years. This growth is partly due to the increased awareness of the risks resulting from global warming and the potential role of weather contracts in mitigating some of them (Chicago Mercantile Exchange, 2009). Many issues still remain problematic in terms of the use of weather contracts however, including the identification of appropriate statistically models for estimating future weather variability as well as other issues critical to the pricing of such contracts. In addition the practical application of such contracts requires an assessment of the correlation of specific weather events faced by a producer to those associated with a nearby weather station employed as the basis of the contracts.

CONCLUSIONS

Like many agricultural sectors, the viticulture industry is highly sensitive to the weather. Major risks at the production level are attributed to occurrences of extreme events and random variability in key weather variables. The study analyzes the occurrences of temperatures $\leq -8^{o}$ C in the months of November, December, January and February in which the frozen grapes are normally picked. The results of trend analysis showed a high degree of inter-annual variability along with a weak declining trend over the last forty years in the number of days suitable for harvesting the frozen grape. Two major risks to icewine grapes are firstly, prolonged warm and wet conditions that could lead to rot and secondly, the destruction of the crop by bird predators. In the short-term, producers can hedge their risks by buying weather contracts, while modelling long-term changes in the regional climate could help to determine appropriate adaptive strategies.

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